Olea ferruginea Royle, Indian olive: an underutilised fruit tree crop of north-west Himalaya

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Olea ferruginea Royle, Indian olive: an underutilised fruit tree crop of north-west Himalaya.

Abstract — Introduction. *Olea ferruginea* Royle, generally known as Indian olive, grows widely in the Himalayas from Kashmir to Kumaun up to an altitude of 2400 m. It is a multipurpose, zero-waste, evergreen tree species. It yields a number of useful items including quality fodder, firewood and edible fruits. The leaves, bark, roots, fruits and seeds of this plant are used for treatment of various diseases. The fruits are also a source of olive oil. However, to the best of our knowledge, no study has been carried out to determine the olive oil contents of the fruits and seeds of *O. ferruginea* and the quality of the oils. **Materials and methods**. Therefore, investigations were undertaken to determine the olive oil contents and the quality of the oils in the fruits and seeds in terms of fatty acid composition. Four populations of *O. ferruginea* (Kolibehar, Saioond and Kais from the Kullu district, and Thalaut from the Mandi district of Himachal Pradesh) were selected as the sources of fruits and seeds. **Results and discussion**. The selected sites differed in respect to their geographical characteristics. The olive oil content was considerably higher in the fruits than in the seeds. The olive oil contents in the fruits varied from 20.67% to 27.40%, with the Thalaut population exhibiting the highest oil content. The olive oil content in the seeds varied from 7.5% to 12.5%; the oil content was the lowest in fruits of the Saioond population and the highest in the Thalaut population. In all the populations, monounsaturated oleic acid was predominant; oleic acid ranged from 61.6% to 66.9% in the fruit oil and 64.4% to 67.2% in the seed oil. Differences in the fatty acid composition between the seed and fruit oils were also seen. **Conclusion**. Our study suggests that the fruits of *O. ferruginea* may be a potential source of olive oil. Thus, sustainable use of this potential of the tree could be useful in the socio-economic development and environmental conservation of the areas where it grows.

India / *Olea ferruginea* / fruits / seeds / olive oil / fatty acids / lipid content

Olea ferruginea Royle, l'olivier indien : une espèce fruitière sous-utilisée du nord-ouest de l'Himalaya.

Résumé — Introduction. *Olea ferruginea* Royle, généralement connu sous le nom d'olivier indien, pousse largement dans l'Himalaya, du Cachemire au Kumaun, jusqu'à une altitude de 2400 m. C'est une espèce arboricole polyvalente, sans déchet et à feuilles persistantes. Elle donne un certain nombre de produits utiles, dont du fourrage de qualité, du bois et des fruits comestibles. Les feuilles, écorces, racines, fruits et graines de cette plante sont utilisés pour le traitement de diverses maladies. Les fruits sont aussi une source d'huile d'olive. Cependant, à notre connaissance, aucune étude n'a été effectuée pour déterminer la teneur en huile d'olive des fruits et des graines d'*O. ferruginea* et la qualité de ces huiles. **Matériel et méthodes**. La teneur en huile et la qualité des huiles des fruits et les graines d'*O. ferruginea,* quant à leur composition en acides gras, ont été étudiées à partir de collectes. Quatre populations de *O. ferruginea* (populations Kolibehar, Saioond et Kais du district de Kullu et population de Thalaut du district de Mandi, État d'Himachal Pradesh) ont été choisies pour collecter des fruits et des graines. **Résultats et discussion**. Les sites sélectionnés ont différé quant à leurs caractéristiques géographiques. La teneur en huile d'olive a été considérablement plus élevée dans les fruits que dans les graines. La teneur en huile d'olive dans les fruits a varié de 20,67 % à 27,40 %, la population de Thalaut présentant la plus haute teneur en huile. La teneur en huile dans les graines a varié de 7,5 % à 12,5 %, cette teneur a été la plus faible dans les fruits de la population de Saioond et la plus élevée dans la population de Thalaut. Quelle que soit la population considérée, l'acide oléique mono-insaturé a été prédominant, sa teneur allant de 61,6 % à 66,9 % dans l'huile des fruits et de 64,4 % à 67,2 % dans celle des graines. Des différences de composition en acides gras entre les huiles des graines et de fruits ont également été observées. **Conclusion**. Notre étude suggère que les fruits d'*O. ferruginea* pourraient être une source d'huile d'olive. De ce fait, la gestion durable d'une telle utilisation de l'arbre pourrait être utile au développement socio-économique et à la préservation de l'environnement des zones où il pousse.

Inde / *Olea ferruginea* / fruits / graine / huile d'olive / acide gras / teneur en lipides

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1. Introduction

Olea ferruginea Royle (syn. *O. cuspidata* Wall. Ex G. Don), generally known as Indian olive, is one of the six species of *Olea* found in India, growing widely in the Himalayas from Kashmir to Kumaun up to an altitude of 2400 m [1, 2]. This species is also found in Afghanistan, Nepal and Pakistan. It can grow in marginal and wastelands where the soil is unsuitable for other plants. For this reason, *O. ferruginea* has been used as a stock in grafting experiments with *O. europaea*. It is a multipurpose, zero-waste, evergreen tree species as its different parts are used for different purposes such as quality fodder, firewood, edible fruits and treatment of various ailments.

Its leaves and bark are used as antiperiodics in fever and debility [1]. Its leaves are also used in toothache, astringent medicines, mouth ulcer, demulcents, gonorrhoea, sore throat, hoarse voice, and as a tea beverage, mild digestive aid, antiseptic and anthelmintic [3, 4]. The timber is heavy and used for making agricultural implements [1].

The fruits are edible, pickled, and used as appetisers, emmenagogues, antidiabetics and a source of olive oil rich in oleic acid, and they are used in typhoid, jaundice, biliousness, scabies, burning of the eyes, toothache and caries of the teeth [4, 5]. The oil is useful in cooking, rheumatism, joint pains, malaria, gonorrhoea, skin diseases and cosmetics [5, 6]. The root is used in asthma, scorpion sting, rheumatism and headache [7].

Table I.
Geographical characteristics of different populations of Indian olive (*Olea ferruginea* Royle), which were collected to study the olive oil content and quality of their fruits and seeds.

Population (India)	Altitude (m)	Aspect	Latitude (N)	Longitude (E)
Kais	1422	West	32°01'23"	77°08'18"
Kolibehar	1160	South-East	31°54'95"	77°07'57"
Saioond	1220	East	31°54'41"	77°09'51"
Thalaut	957	North-East	31°42'53"	77°12'06"

Several studies have shown that the olive fruits and leaves contain a very high amount of polyphenols and antioxidants which are credited with many health benefits [8–10]. Sultana and Ata have recently isolated, from chloroform extract of *O. ferruginea*, a biologically very important compound, oleanolic acid, involved in various activities such as antitumour, antioxidant, anti-inflammatory, antipruritic, antiallergic, antiviral and immunomodulatory [11]. However, to the best of our knowledge, no study has been undertaken to determine the olive oil content of the fruits and stones (endocarp plus seed, hereafter referred to as seeds) of *O. ferruginea* and the quality of the oils in terms of fatty acid composition. Therefore, our investigation was undertaken to determine the contents of olive oils in the fruits and seeds of *O. ferruginea* and their fatty acid composition.

2. Materials and methods

Fully ripened fruits of *O. ferruginea* were collected from randomly selected phenotypically superior trees during August–September. Four different populations of *O. ferruginea*, three in the Kullu district (Kolibehar, Saioond and Kais) and one in the Mandi district (Thalaut) of Himachal Pradesh state (India) were selected as the sources of fruits and seeds. The altitude, latitude, longitude and aspects of the four selected sites were recorded (*table I*). Growth parameters such as plant height, diameter at breast height, and leaf length, breadth and leaf area (individual leaf) of the selected trees at each site were measured to find out whether there is any relation between the olive oil content and growth parameter data.

For the measurements of growth parameters, ten plants were randomly selected at each site. Plant height and diameter at breast height were measured using measuring tape. For the measurement of leaf dimensions (length, breadth and leaf area), ten leaves each were collected from the basal, middle and upper portions of each tree to get a better picture of leaf dimensions. The

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length and breadth of the leaves were measured with a ruler. The growth data were statistically analysed according to Mather [12].

The fruits were soaked in water for 24 h and then washed thoroughly under tap water to remove the pulp (the exocarp and the mesocarp of the fruit) from the fruits. The fruits and seeds were air-dried for 7 days at room temperature, and then used for the determination of olive oil content and fatty acid composition following the standard techniques: the AOAC Official Method (2005) and AOCS Official Method (1998), respectively. For the determination of the oil content in the samples, we extracted 2 g of powdered sample in each case with ether in a Soxhlet apparatus for 16 h, and the results were expressed as percentage of dry weight. The fatty acid composition was determined using a gas chromatograph (Shimadzu 2010 with AOC 20i auto-injector and GC solution software) after the fatty acids were transformed into methyl esters (FAMEs). For the preparation of FAMEs, an aliquot of 0.2 g of extracted oil was saponified with 0.5 N NaOH and we derivatised the fatty acids to methyl esters using 14% BF_3-methanol solution. After completion of the reaction, hexane was added and the hexane layer passed through anhydrous sodium sulphate. The injected volume was 1 µL. The injection was performed with a split ratio of 20:1. The temperatures of the column oven, injector and detector were kept at (210, 250 and 270) °C, respectively. In another experiment, we took 5 kg of fruits of Kolibehar and mixed fruit populations (the fruits of Kolibehar, Saioond and Kais populations) to an industrial-type local oil mill to find out how much olive oil can be obtained using the local oil mill. The fatty acid composition of the local oil mill-extracted oil was determined following the AOCS Official Method (1998).

3. Results and discussion

The selected sites differed in respect to their geographical characteristics (*table I*). There were differences in growth data of selected trees among the four populations, with the Kolibehar population showing the maximum tree height, diameter at collar height and leaf dimensions (*table II*). However, the differences in growth data were not statistically significant.

The content of oil in the fruits and seeds of the four different populations of *O. ferruginea* was considerably higher in the fruits than in the seeds (*table III*). The olive oil contents in the fruits varied from 20.67% to 27.40%, with the Thalaut population exhibiting the maximum fruit oil content, whereas the minimum oil content was observed in the fruits of the Kolibehar and mixed fruit populations. The olive oil contents in the world's most prominent olive oil varieties have been reported to vary from a minimum of 13% to a maximum of 28% [13]. This shows that the olive oil content of *O. ferruginea* in the fruits of the Thalaut population is on par with that of the world's most prominent olive oil cultivar. On the other hand, the oil contents in the seeds varied from 7.5% to 12.5%; the oil content was the lowest in seeds of the Saioond population and the highest in the Thalaut population. The data clearly indicate that, in all the

Table II.
Growth parameters of the plants of selected populations of Indian olive (*Olea ferruginea* Royle), collected to study the olive oil content and quality of their fruits and seeds (n = 10).

Population of *O. ferruginea*	Tree height (m)	Diameter at breast height (cm)	Leaf length (cm)	Leaf breadth (cm)	Leaf area (cm^2)
Kais	5.00 ± 0.56	17.37 ± 4.37	7.00 ± 1.49	1.60 ± 0.31	11.20 ± 2.23
Kolibehar	5.68 ± 0.78	21.41 ± 4.12	7.06 ± 0.95	1.94 ± 0.41	13.70 ± 2.14
Saioond	5.44 ± 0.66	19.23 ± 3.48	7.00 ± 0.92	1.75 ± 0.21	12.25 ± 2.78
Thalaut	4.66 ± 0.33	15.61 ± 2.87	6.71 ± 0.61	1.72 ± 0.23	11.54 ± 1.75

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populations, the pulp contains the highest content of olive oil, as the seed in the present study also includes the endocarp. Similar results were obtained by Moussaoui *et al.* [14].

Several studies have shown that the contents of olive oil and fatty acid composition may be greatly influenced by several factors such as cultivar/variety, pedoclimatic conditions, agronomic treatments, harvesting time, season, storage and the extraction processes used [14–19]. The differences in the olive oil contents of fruits and seeds among the four populations in our study may be partly attributed to the differences in edaphic and climatic conditions of the sites as the sites differ in respect to the aspect, altitude and latitude, but not to the growth data of the different populations (*tables I, II*). Further, the main fatty acids of the olive oils of fruit and seeds of *O. ferruginea* measured in our study were palmitic (C16:0), palmitoleic (C16:1), stearic (C18:0), oleic (C18:1), linoleic (C18:2), linolenic (C18:3), arachidic (C20:0), gadoleic (20:1) and behenic (C22:0) acid (*tables IV, V*). It is well known that the profile of fatty acids varies greatly in vegetable oils and they play an important role in human diets and health. Several Dietary Advisory Bodies recommend a balanced intake of saturated fatty acids, monounsaturated fatty acids and polyunsaturated fatty acids [20]. Our data showed that the profile of fatty acids in the fruit oils among the four populations does not vary considerably (*table IV*); in all the populations, monounsaturated oleic acid was predominant (ranging from 61.6% to 66.9%), followed by saturated palmitic acid (ranging from 10.9% to 17.2%) and polyunsaturated linoleic acid (ranging from 13.4% to 15.6%). The levels of saturated fatty acids in the fruit oils varied from 13.2% (Kolibehar) to 21.0% (Thalaut), whereas unsaturated fatty acids varied from 78.9% (Thalaut) to 86.8% (Kolibehar). The ratio of monounsaturated fatty acids to polyunsaturated fatty acids in the fruit oils among the four populations varied from 4.05 (Kolibehar) to 4.89 (Kais). From our data, it is evident that the oil of *O. ferruginea* fruits, like many *O. europaea* cultivars, is also rich in monounsaturated fatty acids [14, 20], which are known to reduce harmful low-density lipoprotein and total cholesterol without changing the levels of beneficial high-density lipoprotein cholesterol in the body [21].

In all the populations, the olive oil of *O. ferruginea* seeds contained the highest amount of monounsaturated oleic acid, ranging from 64.4% (Kais) to 67.2% (Kolibehar), but, in contrast to the oil of *O. ferruginea* fruits, the oils from the seeds contained markedly more polyunsaturated linoleic acid than saturated palmitic acid (*table V*). The seed oil was also characterised by low contents of monounsaturated

Table III.
Olive oil content (% by dry weight) in the fruit and seeds of four different populations of *O. ferruginea,* collected in the north-west of India.

Population	Fruit	Seed
Kais	21.0	8.1
Kolibehar	20.0	9.2
Saioond	22.5	7.5
Thalaut	27.4	12.5
Mixed fruit population[a]	20.67	Not available

[a] Kais, Kolibehar and Saioond.

Table IV.
Comparison of fatty acid profile (% by dry weight) in the fruits of four different populations of *O. ferruginea*, collected in the north-west of India.

Fatty acid composition	Population			
	Kais	Kolibehar	Saioond	Thalaut
Oleic acid	66.9	66.3	65.1	61.6
Palmitic acid	14.2	10.9	15.7	17.2
Linoleic acid	13.4	15.6	13.7	14.7
Stearic acid	3.4	2.0	2.8	3.4
Palmitoleic acid	0.7	0.8	1.4	1.7
Arachidic acid	0.6	0.3	0.3	0.4
Linolenic acid	0.5	1.6	0.6	0.6
Gadoleic acid	0.4	Not detected	0.3	0.3
Erucic acid	Not detected	2.5	Not detected	Not detected

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palmitoleic and polyunsaturated linolenic acids and high content of saturated arachidic acid compared with the fruit oil. The oil of *O. ferruginea* seeds contained saturated behenic acid, which was absent in the fruit oil. Compared with the fruit oils, the seed oils exhibited considerably lower contents of saturated fatty acids and a higher ratio of unsaturated to saturated fatty acids, except in the Kolibehar population. Variations in the fatty acid composition and contents of the oils extracted from different parts of olive fruit have been reported [14, 22].

In summary, based on the oil content data, it may be suggested that the fruits of *O. ferruginea* may be a potential source of olive oil. Though the content of monounsaturated oleic acid in the oil is less than 70% in all the populations, oleic acid content could be enhanced using agronomic practices and/or breeding programmes [14–20] as the profile of the fatty acids in olive cultivars is known to be influenced by these practices. Further, it has several other uses and medicinal values. It is also a potential tree for afforestation of degraded lands under rainfed conditions. Thus, sustainable use of this potential of the tree could be useful in the socio-economic development and environmental conservation of the areas where it grows.

Table V.
Comparison of fatty acid profile (% by dry weight) in the seeds of four different populations of *O. ferruginea*, collected in the north-west of India.

Fatty acid composition	Population			
	Kais	Kolibehar	Saioond	Thalaut
Oleic acid	64.4	67.2	65.5	66.8
Linoleic acid	21.9	17.9	21.9	19.0
Palmitic acid	8.7	11.0	8.0	9.0
Stearic acid	2.9	2.5	3.0	3.1
Arachidic acid	0.6	0.4	0.6	0.7
Gadoleic acid	0.5	0.3	0.3	0.4
Behenic acid	0.5	0.3	0.2	0.5
Linolenic acid	0.4	0.2	0.4	0.3
Palmitoleic acid	0.1	0.2	0.1	0.2

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Olea ferruginea Royle, el olivo indio: una especie frutera infrautilizada del noroeste del Himalaya.

Resumen — Introducción. *Olea ferruginea* Royle, generalmente conocido bajo el nombre de olivo indio, crece en abundancia en el Himalaya, desde Cachemira hasta Kumaon, hasta una altitud de 2400 m. Se trata de una especie arborícola polivalente, sin desecho y con hojas persistentes. Ofrece bastantes productos útiles, tales como forraje de calidad, madera y frutos comestibles. Las hojas, cortezas, raíces, frutos y semillas de esta planta se emplean para el tratamiento de diversas enfermedades. Asimismo, los frutos son una fuente de aceite de oliva. Sin embargo, que sepamos, no se ha realizado ningún estudio para determinar ni el contenido de aceite de oliva procedente de los frutos y de las semillas de *O. ferruginea* ni la calidad de dichos aceites. **Material y métodos**. A partir de cosechas, se estudió el contenido y la calidad del aceite procedente respectivamente de los frutos y de las semillas de *O. ferruginea,* en relación con su composición en ácidos grasos. Se seleccionaron cuatro poblaciones de *O. ferruginea* (poblaciones Kolibehar, Saioond y Kais del distrito de Kullu y población de Thalaut del distrito de Mandi, en el estado de Himachal Pradesh) para recolectar frutos y semillas. **Resultados y discusión**. La diferencia de los sitios seleccionados residía en sus características geográficas. El contenido de aceite de oliva fue considerablemente mayor en frutos que en semillas. El contenido de aceite de oliva en los frutos varió entre un 20,67 % y un 27,40 %, la población de Thalaut presentó el mayor contenido de aceite. El contenido de aceite en las semillas varió entre un 7,5 % y un 12,5 %, constatándose el menor contenido en los frutos de la población de Saioond y el mayor en la población de Thalaut. Independientemente de la población, el ácido oléico monoinsaturado fue predominante, su contenido oscilaba entre el 61,6 % y el 66,9 % en el aceite de los frutos y entre el 64,4 % y el 67,2 % en el de las semillas. Asimismo, se observaron diferencias en la composición de ácidos grasos entre los aceites de semillas y frutos. **Conclusión**. Nuestro estudio sugiere que los frutos de *O. ferruginea* podrían suponer una fuente de aceite de oliva. De ahí que la gestión sostenible de este tipo de rendimiento del árbol podría ser útil en el desarrollo socioeconómico y en la preservación medioambiental de las zonas en las que crece.

India / *Olea ferruginea* / frutas / semilla / aceite de oliva / ácidos grasos / contenido de lípidos

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