World Journal of Agricultural Research, 2020, Vol. 8, No. 2, 32-38
Available online at http://pubs.sciepub.com/wjar/8/2/2
Published by Science and Education Publishing
DOI:10.12691/wjar-8-2-2

Underutilized Natural Gum and Resin Resources in Ethiopia for Future Directions and Commercial Utilization

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Received April 06, 2020; Revised May 08, 2020; Accepted May 15, 2020

Abstract The drylands of Ethiopia are well known for their natural gum and resin producing tree and shrub species such as *Acacia, Boswellia, Commiphora* and *Sterculia.* The production and trade volumes of gums and resins in the country showed a declining trend since 2010. The present review work is focused on availability of alternative underutilized tree and shrub species to indicate the diverse gum and resin market opportunities. Several Sub-Saharan African countries are producing gum and resin products from diversified species. Gum arabic is collected from *Acacia senegal* (L) Willd, *Acacia seyal* DEL, and *Acacia polyacantha* Willd species. Three countries namely Sudan, Nigeria, Chad contribute about 97% to the international market, while Ethiopia's contribution is 0.9%. World demand for karaya gum from *Sterculia setigera* DEL is about 7,000 tonne and in Africa, Senegal is the leading exporter. Despite the huge resources of *A. senegal, A. seyal* and *A. polyacantha,* Ethiopia producing very low quantity, and gum is collected from natural oozes of trunks or branches. *S. setigera* is also found in the country, although gum karaya is not yet under production. South and south eastern parts of Ethiopia hosts abundant species of *Acacia, Boswellia* and *Commiphora.* Gum-resin products are collected from natural exudates by herdsmen, women and children while herding and doing other activities, indicating its adverse effects on quality and quantity. Very small proportions of Myrrh and gum opopanax enter the local market. Other constraints are, lack of appropriate institutions, infrastructure, tapping technologies and market information. Therefore, appropriate policy formulation, research and development interventions, are recommended for supporting sustainable management, production and marketing of products.

Keywords: *deforestation, oleoresin, marketing, species diversity, tapping, value addition*

Cite This Article: Wubalem Tadesse, Tatek Dejene, Gizachew Zeleke, and Getachew Desalegn, "Underutilized Natural Gum and Resin Resources in Ethiopia for Future Directions and Commercial Utilization." *World Journal of Agricultural Research*, vol. 8, no. 2 (2020): 32-38. doi: 10.12691/wjar-8-2-2.

1. Introduction

In Africa, where 60% of rural dwellers are poor, dry forests represent important resources base for livelihoods and economic development. About 320 million people in the continent depend on dry forest resources to meet many of their basic needs [1]. Dry forests and woodlands in sub-Saharan Africa, despite their fragility, are endowed with rich biodiversity and provide versatile economic and ecological benefits to the society [2]. Commercialization of NTFPs in the region offers an opportunity for income generation and livelihood diversification. The drylands of East Africa, in particular, are known for their potential and long tradition of extraction and commercialization of natural gum and resin products. Exudates from the genera *Acacia, Boswellia* and *Commiphora* has been used for both domestics and the international markets [2].

Drylands of Ethiopia are dominated by ecologically and socio-economically important species of the genera *Acacia, Boswellia, Commiphora* and *Sterculia*. Particularly, Frankincense, obtained from different *Boswellia* species, Myrrha and Opopanax from diverse *Commiphora* species and Gum arabic of *Acacia* species are among the many dry forest based export products of the country. In almost all dryland areas of Ethiopia, gums and resin bearing species occupies significant portion of the land mass [3,4]. About 13 species of *Acacia*, 16 species of *Commiphora* and six species of *Boswellia* are known as potential yielders of commercial gums and resins in Ethiopia. Among these, gums from two species of *Acacia* and gum

resins from three-four species of *Commiphora* and five species of *Boswellia* are currently produced commercially [5].

Frankincense obtained from *B. papyrifera* is the main commercialized product, representing more than 70% of the Ethiopia's natural gum and resins production, export volume and the amount of revenue [4]. However, the leading frankincense producing tree species, *B. papyrifera*, over the decades is facing uncertain future/lacking regeneration due to several and interrelated anthropogenic and environmental challenges mainly expansion of agricultural lands, overgrazing, population increase and the ever-growing demand for construction and fuel wood, forest fire, pests and diseases, unsustainable resource utilization. are among the major challenges affecting *B. papyrifera* regeneration in Ethiopia [4,6,7]. Studies made on the population dynamics, population structure, ecological physiology, growth dynamics indicated that *B. papyrifera* is declining at alarming rate and will disappear in five - six decades unless serious measures are considered. The volume of frankincense production is also expected to halve in 15-20 years, if the current management practices continues as it is [6].

The production and trade volumes of gums and resins in Ethiopia have been increasing between 1998 and 2007 [5]. However, production and export data of natural gum and resin resources shows an overall declining trend, and so does value of the export [8]. It is time to search for other alternative and underutilized potential tree and shrub species for natural gum and resin production and commercialization. Therefore, the present review work is focused on the availability of alternative potential species namely *A. Senegal*, *A. seyal*, *A. polyacantha*, *S. setigera* and Oleo gum resin producing different introduced *Pinus* species. The species distribution and characterization of their products thereby diversifies opportunities to find new market niches.

2. Major Natural Gum and Resin Producing Species in African Countries

Several Sub-Saharan African countries are producing and commercializing natural gum and resin products from diversified dry land tree species to national and international markets. *A. Senegal*, *A. seyal*, *A. polyacantha*, *S. setigera*, Oleo gum resin from *Pinus* species are among the widely used for production and commercialization of natural gum and resin products [9].

African countries export about 100,000 tonnes of gum arabic annually, and demand is projected to reach 150,000 tonnes by 2020. World export demand for karaya gum is about 7, 000 tonnes, of which Senegal exports about 1,000 tonnes. The global export demand for Frankincense is estimated at about 10,000 tonnes per year. The principal exporters of aromatic resins are Ethiopia (3,000 tonnes), Kenya (2,361 tonnes), Somalia (1,200 tonnes) and Eritrea (400 tonnes). Globally, the resource potential of gums and resins far exceeds production [10].

Gum Arabic. Commercial gum arabic is collected from a number of *Acacia* species, of which *A. senegal, A. seyal, and A. polyacantha* are the most widespread in the gum belt. Gum arabic or acacia gum is a tree gum exudate and has been an important part of commerce since ancient times. The trees grow widely across the Sahel belt of Africa situated in the north of the equator up to the Sahara Desert and from Senegal in the west to Somalia in the east [10]. African countries export about 100,000 tonnes of gum arabic annually, and demand is projected to reach 150,000 tonnes by 2020 [10]. Sudan is one of the biggest gum arabic producers in the world and produces more than 80% of the total world gum Arabic (Table 1).

Gum karaya. The genus *Sterculia* is a native of dry deciduous forests of tropical climates. It is found in the Sudano-Sahel and in the Sudan-Guinea zones: Togo, eastwards to Sudan and Somalia, East Africa, Angola Gambia, Nigeria, Senegal, Ethiopia, Eritrea, Kenya, Malawi, Tanzania. Sudan has very large areas of Sterculia in Africa [11]. World export demand for karaya gum is about 7,000 tonnes [10]. In Africa, commercial production of Gum karaya is taking place in Senegal, which is the world-leading exporter (around 1,000tonne/year) [12,13].

Oleoresin. Oleoresin or resin from pine plantations is being produced from different African countries. Kenya from *P. elliottii*, *P. caribaea*, and *P. radiata;* South Africa from *P. elliottii* and *P. caribaea*; Zimbabwe from *Pinus elliottii*; Uganda from *P. caribaea*; Malawi from *P. elliottii* and *P. kesiya*; Zambia from *P. merkusii* and *P. kesiya*; Tanzania from *P. elliottii* and *P. caribaea [13]*. Management of the pine species for resin in addition to timber has a definite added economic advantage both at community (provides employment) and national (import substitution or foreign exchange) levels and an incentive to sustainable forest management based on the principle of multiple uses [13].

Table 1. Exports of Gum arabic (ton) from different African countries from 2001-2010 [10].

Country	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Sudan	7949	34382	13217	27444	33079	23149	n/a	37860	36636	48598
Nigeria	0	0	0	n/a	n/a	1314	14463	14124	40862	34780
Chad	12891	9161	9672	12044	14188	17816	11860	16219	9417	9509
Ethiopia	830	875	381	234	111	317	956	614	622	909
Tanzania	843	693	1252	1361	1169	965	1031	935	631	824
Cameroon	571	592	338	264	371	413	310	151	520	510
Senegal	121	0	0	213	323	475	610	836	935	330
Mali	482	750	704	52	28	17	29	1308	703	275
Burkina Faso	2	0	21	18	81	n/a	90	57	63	83
Kenya	23	0	92	23	32	28	75	165	41	75
Eritrea	n/a	n/a	116	49	495	38	688	419	350	51
Somalia	26	12	4	70	714	92	473	513	50	47
Niger	2	20	38	43	42	73	67	66	44	44

3. Underutilized Potential Natural Gum and Resin Producing Tree/Shrub Species in Ethiopia

3.1. *A. senegal* and *A. seyal*

A. senegal and *A. seyal* are mainly found widely distributed in *Acacia-Commiphora* (small-leaved) deciduous woodlands. The vegetation type is located between 900-1900 m.a.s.l. found in the Rift Valley, eastern and south-eastern lowlands of Ethiopia [14,15,16].

The physic-chemical characteristics of the gum arabic produced in Ethiopia agrees well with values of same quality characteristics of gum arabic reported from Sudan and other exporting countries, and also conforms well to international standards in all aspects. Indeed, it is possible to utilize the gum arabic resource of the Central Rift Valley of Ethiopia for commercial and/or industrial purposes [17].

[18] introduced tapping and evaluated the gum arabic yield from natural stands of *A. senegal* and the growth of six provenances in different parts of the country. Tapping was done with a specially designed axe and special tool "Sunki". Trees were tapped to give strips of relatively similar depth, width and length. Yields recorded were comparable to those reported for the Sudan, the leading producer of gum arabic. Thus, tapping trees during the appropriate months and at the appropriate positions can enhance the production of gum arabic from natural stands of *A. senegal*. They recommend tapping of branches starting from October when the leaf color begins to change [18].

Despite the high potential of the resource base, the current annual production and export of gum arabic from Ethiopia is very low [5,11]. This is due to the lack of proper production technique. Current production is based mainly on collection of gum from natural oozes from tree trunks or branches. Moreover, knowledge of establishment techniques, yield and quality of gum from different provenances, optimum age for tapping, phenological records and silvicultural management requirements of the species are limited or lacking [18].

Therefore, this multipurpose dryland species has to be promoted, by introducing tapping techniques utilized in Sudan and tested in Ethiopia and maximize their utilization potential in the country by compensating the critical challenge faced on *B. papyrifera*, the main natural gum producing tree species in the country.

3.2. *Acacia polyacantha* Willd

A. polyacantha is a widespread acacia found from India to tropical Africa. In Ethiopia, commonly found in wooded grassland, deciduous woodland and bushland and riverine forests of Shoa, Gonder, Gojam, Western Tigray, Ilubabor, Kefa, Gamo Gofa and Sidamo areas, 500-1,600 m [19]. *B. papyrifera* and *A. polyacantha* grow in dry *Combretum Terminalia* woodlands and wooded grass-lands in the north [20]. Even though, the species is found in different drylands of the country, gum is not produced and commercialized in the country so far.

3.3. *Sterculia setigera* DEL

In Ethiopia, it is found in association with *Acacia-Commiphora*-woodland, wooded grassland and bush land, on rocky slopes or black cotton soil, dry riverine forest extending from 700-1900 m.a.s.l. [4,11]. The species is among the most ecologically important woody species in *Combretum-terminalia* woodlands, mainly in Metema area with the highest Importance Value Index [20].

Even though, *S. setigera*, is abundant throughout the country, gum karaya is not yet under commercial production and marketing in Ethiopia [5]. The species use has been limited to its wood products.

3.4. Oleoresin Commercial Products from *Pinus* Species

Fast growing exotic tree species including 15 *Eucalyptus*, *Acacia* and *Pines* species were introduced to Ethiopia during 1895 [21]. *Pinus patula* Schldl. et Cham. and *Pinus radiata* D. Don are the two *Pine* species widely planted for timber production in different parts of the country. *Pinus caribaea* Morelet was first introduced around Bonga in 1975, to study the performance, in areas with the altitude ranging of 1,500 to 1,700 m. The species is also planted in Suba forest. The species has the potential to be planted as an alternative to *Pinus patula* on similar sites [22].

The chemical composition obtained from resins of *P. Caribaea* and *P. radiata* growing in Ethiopia were investigated. Twenty compounds were identified representing ca 92-99% of the total oil. α andß - pinene were the main components of *P. radiata*, representing 83.1% of the total oil. As α andß - pinene are important intermediate in the manufacture of synthetic aroma compounds and flavouring ingredients. *P. caribaea* and *P. radiata* resins may serve as good source of these compounds [23].

Table 2. Production and export of natural gums and resins (Tonnes) from Ethiopian dry lands between the years 2007 to 2016 [8]

Year	Tigray type olibanum	Other gums and resins	Gum arabic	Total production	Export quantity	Export value USD
2007-08	9,200	500	700	10,400	4,533	6,486,038
2008-09	7,400	400	500	8,300	3,550	7,942,418
2009-10	7,700	400	500	8,600	3,606	10,310,780
2010-11	8,500	400	1800	10,800	4,478	13,051,120
2011-12	8,500	400	1200	10,100	4,051	12,429,00
2012-13	7,000	400	700	8,000	3,105	10,678,848
2013-14	7,900	400	900	9,200	3,711	12,636,783
2014-15	ND	ND	ND	ND	2,971	10,561,285
2015-16	ND	ND	ND	ND	3,082	10,188,734

Table 3. *Pine* species introduced to Ethiopia for research purposes and having potential for ole-resin production

No.	Species	Established	Location	Source
1	*Pinus maximinoi* H.E. Moore	1983	Aman-Fanika	[24,25]
2	*Pinus kesiya Royle ex Gordon*	1983	Bonga-Kejaraba	[24,25]
3	*Pinus devoniana* Lindley *(Pinus michocana)*	1975	Beletechaka	[24,25]
4	*P. caribaea* Morelet	1975	Bonga-Kejaraba	[22,24]
5	*P. oocarpa* Schiede ex Schltdl	1975	Bonga-Kejaraba	[22]
6	*P. patula*	1983	Aman-Fanika and Bonga-Kejaraba	[24]
7	*P. radiata*	1968	Munessa Shashemene	[26]

Even though, there is no formal tapping and resin extraction from *Pinus* trees in Ethiopia, it is common to see debarked and, hence, damaged pine stems at Bonga site mainly for resin extraction [24]. This clearly indicates the possibility of introducing tapping methods to potentially resin producing pine species in Ethiopia. Lists of available *Pinus* species in experimental plots are presented in Table 3.

3.5. Other Potential Species in South and South-eastern Ethiopia

Several studies confirmed the existence of potential gum and resin bearing species of *Acacia*, *Boswellia* and *Commiphora* species in different parts of South and south-eastern regions of the country. These regions support more diverse species, and hence greater opportunity for marketing of different products [3,7,27,28]. Numerous studies confirm that oleo-gum resins obtained from the vegetation resources in the region play significant role in the economy of rural households and in the country.

Resins from *Boswellia rivae* (Engl.), *B. ogadensis* (Vollesen), *B. neglecta* (S. moore) and *B. microphylla* (Chior.) are collected and traded as frankincense in these areas (Lemenih et al. 2003).Next to frankincense, gum-resins from four *Commiphora* species namely *Commiphora africana*, *C. myrrh*(syn. C. molmol), *C. habessinica, and C. schimperi* were the major products collected and utilized in Southern Ethiopia [1]. The botanical origin of opopanax also known as scented myrrh is *C. guidottii*, a species found in abundance in eastern Ethiopia and Somalia. The highly pleasant aromatic oil of *B. pirottae*, an endemic species of Ethiopia, is distinguished by a high content of trans-verbenol (15.5%) and terpinen-4-ol (14.6%) [29]. Gum arabic obtained from *A. Senegal*, gum talha from *A. seyal* are also potentially available in these areas [30,31].

In northern frankincense production areas (from *B. papyrifera*), there are many private and state companies engaged in the production and marketing of gum and resins, and they create seasonal employment opportunities for the tapping, collection, and grading of frankincense. However, natural gum and resin products from southern region are collected from natural exudates and no tapping at all [3,20,30]. The producers are mainly herdsmen, women and children, and they do the collection side by side with herding and doing other activities. Once collected, the products transported to available markets and/or soled to occasionally appearing buyers at village level [3]. This indicates its adverse effect on the quality and quantity of gum produced and thus on the role that it could play both at local and national levels. Moreover, the mixing up of gums and resins of different *Commiphora* species for increasing trade volume is a common phenomenon of adulteration, resulting in poor quality which again severely affecting marketing of gums and incenses in Borena [3]. Furthermore, other identified constraints in south and southern Ethiopia are: (i) lack of appropriate institutions and capacity, (ii) infrastructure facilities, (iii) appropriate tapping technologies, (iv) access to market, (iv) market information and fair markets prices, (vi) established cooperatives, etc. [27].

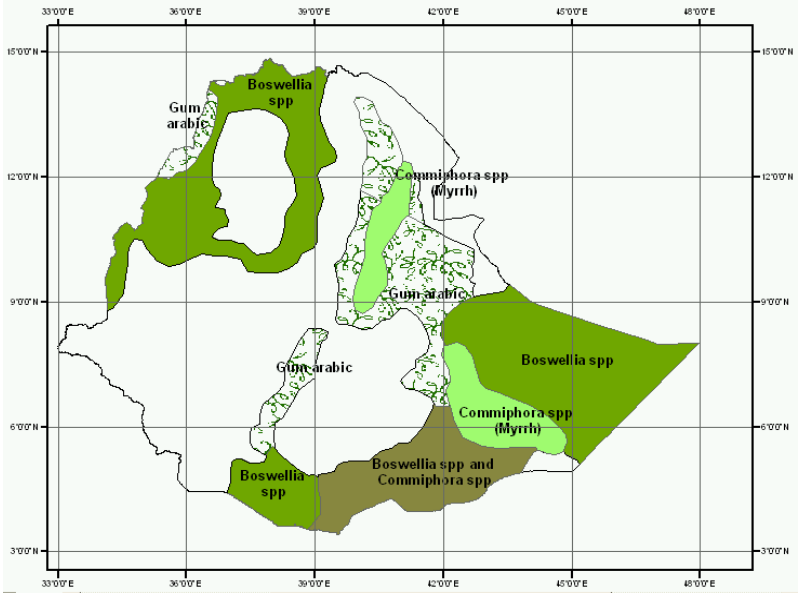

Figure 1. Distribution of natural gum and resin bearing species in Ethiopia [34]

In north Ethiopia gum and resin production is an established and relatively intensive practice, organized commercial production started in 1940s; access and harvesting rights are controlled by formal institutions. But in the south gum and resin production is relatively new and less intensive; organized commercial collection is recent, but subsistence production has long history and access and harvesting rights are part of the traditional grazing land management [32].

Therefore, establishing and strengthen relevant institutions (government and non-government) has paramount importance for sustainable management and utilization of gum and resin resources; support extension service aid development of a supply chain that could generate more cash for the poor [28]. It would also be beneficial to develop suitable tapping, processing, and handling technologies that could add value to the products [1] and for promoting the sustainable management of woodland resources through organized production and commercialization of high value oleo-gum resins [33]. Hence, development of innovative technologies and infrastructure remains as key issues [28] that need intervention measures.

Hence, appropriate policies and institutions are crucial for achieving the sustainable and socially acceptable harvesting of gum and resin resources. Policy and institutional reforms should revolve around gender equity, community-based resource management, and secure land tenure and tree ownership, with the aim of facilitating equal access to and control over benefits from the use of these resources. Equally important are the provision of incentives and the empowerment of resource users in accessing markets to seize the opportunities presented by regional and global markets for gums and resins [10].

4. Value Addition and Marketing

Underutilization and lack of value addition restricts appropriate utilization of Ethiopia's dry forest products and other resources. Therefore, most of the NTFPs products are commercialized without value addition and the country forced to import value added products with huge foreign currencies. The technologies used in the collection of gums and resins, and attempts to add value, have remained back-warding and largely unchanged for decades. Value-adding activities are limited to cleaning, sorting and grading. Therefore, it is necessary to improve production and processing aspects. Attributes considered in grading gums and resins are size, colour, source area and content of impurities [35]. Therefore, value addition and strengthening marketing information system to the natural gum and resin products should be promoted in order to increase foreign currency and employment opportunities.

While the international market prices of raw gum arabic continue to fluctuate the international prices of processed gum arabic is either stable or increasing. Poverty reduction in the producing countries of gum arabic can only be achieved through gum arabic only if value is added to this product through processing to enable them obtain higher profits [36]. In marketing, demand requirements of stable supply in quantity and quality deserve more attention. This will require organizational and capacity building for all actors in the chain. The marketing system needs to encourage different types of value addition, in particular quality upgrading by the producers. This could even lead to employment creation and an increase in revenues. The creation of associations or other forms of coalition has the potential to increase producers' bargaining power and their willingness to collect more and better gum [37].

5. Conclusions and Recommendations

Deforestation and forest degradation are among the repeatedly reported major challenges seriously affecting dry forest resources of Ethiopia. Agricultural expansion, re-settlement, unsustainable product harvesting, free grazing, lack of natural regeneration of tree species, etc. are among the major consequences of deforestation and un-sustainable utilization. Due to these interrelated challenges in dry forest resources, the socio-economic and ecological contribution of natural gum and resin products obtained from these forests are severely affected. In Ethiopia, scholars concur that there is a general lack of awareness among policy makers and associated institutional constraints (e.g. property rights over forests and their products) are negatively affecting an optimal economic use of dry forests for livelihoods and export promotion. This is leading to their conversion and deforestation through investments and resettlement programs that instigate cropland expansion. Therefore, policy makers should critically evaluate their decision making processes related to resettlement and agro-business investment programs in the frankincense and other gum-resin bearing species harboring woodlands.

Ethiopia hosts very diverse and potential natural gum and resin producing species, and historically is among the first in commercializing those products since millennia. However, currently the country depends on a single species *B. papyrifera* and its frankincense product, where the species faces uncertain future of disappearance, and hence its annual production and exports are in a declining trend. Whereas, other sub Saharan African countries are diversifying their natural gum and gum production from diversified species of *Acacia*, *Boswellia*, *Commiphora*, *Sterculia* and Pines besides strengthening their institutions by giving more attention to the sector and its socio-economic potential and environmental importance.

Therefore, taking into account the enormous socio-economic and ecological contributions of dry forest resources in general and natural gum and resin sector in particular, the Ethiopia has to sustainably manage and utilize its high value and renewable natural resources by strengthening its institutions, infrastructures including processing and marketing of the exportable products. The absence of appropriate institutions and governance mechanisms, ecological knowledge of the different species, and technical support might also lead to irreversible resource degradation from over-exploitation of very limited species, while other potential species have been still untouched or underutilized.

In the face of the increasing national and international demand for natural gum and resins and the subsequent

emerging opportunities, appropriate policy formulation and research and development interventions, has to be put in place for supporting sustainable exploitation of commercial natural gum and resin production while ensuring conservation and development of the resource base. Sustainable management of natural gum and resin resource potentials requires an integrated enabling policy and institutional framework to safeguard social and environment concerns associated with the commercialization of the natural products from communal lands. Promote value addition of gum and resin products will significantly contribute to product diversification and hence job creation and import substitution. Organized production and market information system management must be in place and should not be haphazard. Besides, Integrated and in-depth research on alternative mechanisms and methods for the best species *B. papyrifera* regeneration, which is endangered now recommended.

Acknowledgments

We are grateful SUSTFUNGI project for the financial support that has been provided for the trip and the stay of Wubalem Tadesse and Gizachew Zeleke to Spain, and the Forestry Research Center (CIFOR) of the National Institute of Agricultural research (INIA) for hosting and arranging to them literature review database facilities.

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