SYNTHESIS OF THE DEVELOPMENT IN GUMS AND RESINS SUB-SECTOR IN KENYA

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ABSTRACT

Gums and resins of commercial value in Kenya include: gum arabic; myrrh; hagar; and frankincense. This paper synthesizes what has been done and achievements made in the sub-sector since 1988 as well as future prospects. The aim was to inform private and public institutions interested in the gums and resins and policy makers. The key achievements in this sub-sector included taxonomic, ecological and chemical characterization of gums and resins, characterization of soil physico-chemical properties, establishment of genetic diversity and population structure of *Acacia senegal and* piloting of plantation development of *A. senegal. Other achievements were in* resource assessment and mapping, market chain analysis, capacity building of stakeholders and feasibility studies on the potential for commercialization of the processing of the products. The potential annual production is 16,291 t and 10,134 t for gum Arabic and resins, respectively, with main markets in Europe (gum Arabic) and Asia (gum resins). Kenya's exports are about 59 t and 2446 t for gum Arabic and resins, respectively. Incapacity to bulk enough quantities mainly collected from the wild and lack of reliable suppliers humber export. The government prepared the gums and resins regulations which was awaiting gazettement at the time of this review. From the synthesis, it is concluded that the developments made in the sub-sector have not translated into volumes marketed. More efforts therefore are necessary to stimulate and enhance volumes collected and marketed.

Keywords: frankincense, gum arabic, hagar, myrrh, production, resins, marketing

INTRODUCTION

Plant gums and resins include gum arabic from *Acacia senegal* (L.) Willd. or *Acacia seyal* Del. and commercial gum resins such as Myrrh from *Commiphora myrrha* (Nees) Engl., Hagar from *Commiphora holtziana* Engl. and Frankincense from *Boswellia neglecta* S. Moore. Currently, gums and resins are produced in at least seven ASAL Counties in Kenya namely: Marsabit, Wajir, Garissa, Mandera, Turkana, Samburu and Isiolo (Muga *et al.*, 2017). Investment in gums and resins has dual potential of environmental conservation and generation of wealth to uplift the living standards of the local communities in the dry lands. They serve as raw materials for enterprise development thus providing opportunities for trade and employment generation.

Two major regional projects, namely Acacia Operation and Acacia Gum with Kenya as one of the beneficiary countries were implemented between 2004 and 2011 to improve the gums and resins subsector and build capacity of producing communities. Key achievements from the two projects and other initiatives in the sub-sector include: Taxonomic, ecological and chemical characterization of gums and resins (Chikamai BN and Gachathi FN. 1994, Gachathi and Muga, 2009, Chikamai, and Hall, 1995, Chikamai, 2001, Chiteva *et al*, 2013); review and synthesis on the state of knowledge of Boswellia species and commercialisation of frankincense (Chikamai, and Kagombe. 2002); characterization of soil physico-chemical properties of different varieties of *A. senegal* (Lelon *et al*., 2010); preliminary resource assessment and mapping of gums and resins producing species in Kenya (FAO, 2005, Chikamai and Hall, 1995); piloting of production and management of *Acacia senegal* trees (Keya *et al*., 2008, Muga, 2013); traditional ecological knowledge associated with *Acacia senegal* management and gum arabic production (Wekesa *et al*., 2010); capacity building of extension agents and communities in some of the producing counties in production, processing and marketing of gums and resins (Chikamai *et al*., 2010, Muga *et al*., 2010) and studies on genetic diversity in Kenyan populations of *Acacia senegal* (L) Wild (Chiveu, 2008, Omondi, *et al.*, 2010, Omondi *et al*.,2016, Omondi *et al*., 2018). Resource assessment and mapping have also been carried out in major production Counties (Muga *et al*., 2012, Muga *et al*., 2014, Luvanda *et al*, 2014, Muga

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et al., 2016, Luvanda *et al*, 2016 and Muga *et al*., 2017). The traditional ecological knowledge and its application in the management of *Acacia senegal* trees in Isiolo and Samburu counties has been documented (Wekesa *et al*., 2010). The market chains of gum arabic, the stakeholders participating in the management and marketing of *Acacia senegal* products and the constraints to gum arabic production and collection within the Kenyan drylands have also been documented (Wekesa *et al*., 2010). Gum arabic yield in different varieties of *Acacia senegal* has also been studied (Wekesa *et al*., 2009). Draft protocols for sustainable wild harvesting of *Acacia senegal* var. kerensis and *Commiphora holtziana* have also been developed (Muga *et al*., 2017). A review of the policy environment for gums and resins has also been carried out . Similarly, through these past initiatives, major barriers that limit the realization of full potential for the gums and resins in the dry lands of Kenya have been identified and classified as ecological and climatic issues, socio-economic factors, technological barriers and policy as well as institutional barriers (Gachathi *et al*., 2010; Muga *et al.,* 2017). The government has also prepared the gums and resins regulations that were waiting gazetement. This paper summarizes the data on primary production, harvesting and post-harvest handling, value addition, trade and marketing of gums and resins, research and development within the sub-sector, policy environment, challenges and opportunities.

Primary Production of Gums and Resins in Kenya

Gums and resins are produced mainly in seven ASAL Counties, namely: Marsabit, Wajir, Garissa, Mandera, Turkana, Samburu and Isiolo. Other counties with the resources are Kitui, Mwingi and Meru. The areas with high probability of the presence of these resources in the country are illustrated in Figure 1.

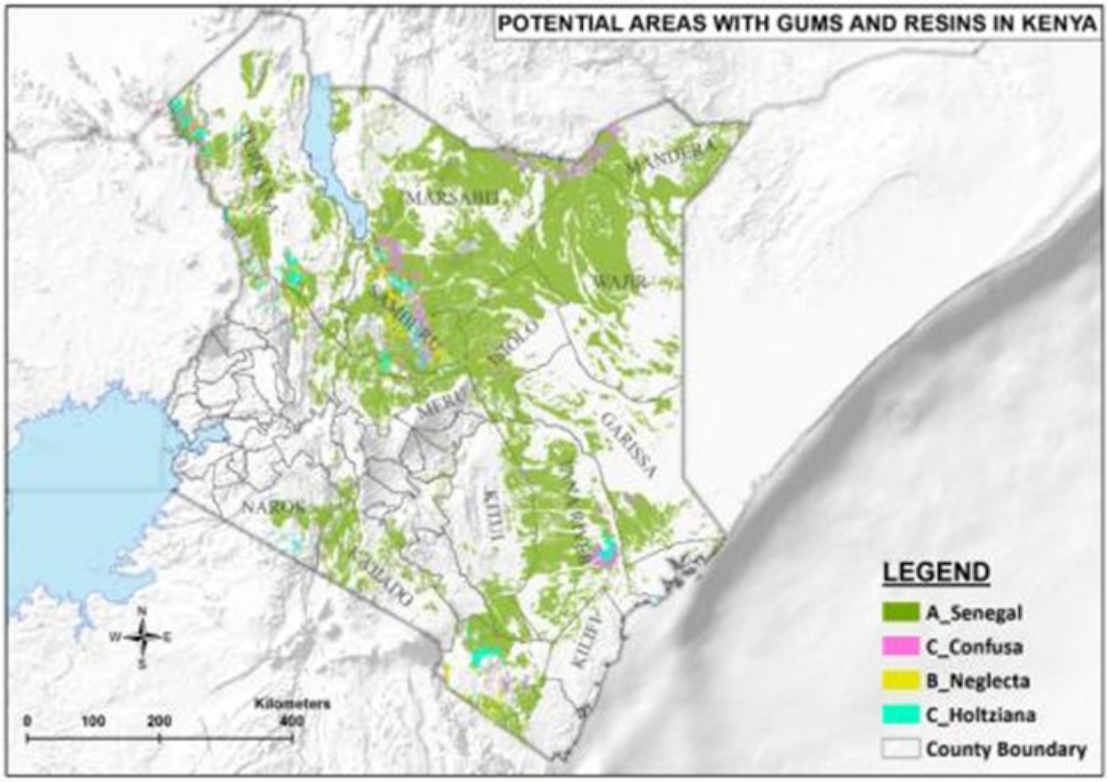


Figure 1. Probability map for gums and resins resources in Kenya (Muga *et al*., 2017)

Based on resource assessment studies, the potential annual production for gum arabic (from *Acacia senegal* only) is about 16,291 t (Table 1) against 1,510 t while that for resins (myrrh and opoponax) is about 10,135 t against 3631 t (Luvanda *et al*., 2014, Muga *et al*., 2016 and Muga *et al.,*2017).

essential oils from myrrh, Olibanum (Frankincense) and Opoponax (Hagar) through steam distillation process. Lubanchem Limited has an efficiency level of 70%, resulting in a yield of essential oils of 5% for myrrh and 6% for Olibanum and Hagar. A gum resins processing plant has also been constructed in Wajir through the support of

TABLE I - POTENTIAL PRODUCTION OF GUMS AND RESINS IN KENYA

County	Gum Arabic	Myrr	Frankincense	Hagar (Opoponax)
Isiolo	6,818.8	-	-	3,752.2
Samburu	4,771.9	-	-	-
Turkana	4,700	-	-	-
Wajir	-	644.8	1,800	1,978.5
Garissa	-	-	-	1,959
Total	**16,290.7**	**644.8**	**1,800**	**7,689.7**

Harvesting and Post Harvest Handling

Harvesting of Gum arabic

Harvesting of gum arabic in Kenya is done by natural exudation though studies have shown that tapping can increase yield by between 42% and 110% (Wekesa *et al*., 2015). The main gum collection season in Kenya is December-March and June-September (Muga *et al.,* 2017). An average of 4 to 7 kg/day of gum arabic is collected per person per day (Gachathi *et al.,* 2010).

Harvesting of Gum resins

Hagar and frankincense are harvested from the wild from exudations caused by insects, animal damage or nature while myrrh is mainly tapped. Tapping is done using a special axe in the dry seasons (three weeks after the rains) mainly in May – October and occasionally in January-March (Muga and Chikamai, 2016). A small back area of about 3 cm wide and 10 cm long is removed from the tree stem starting from the base and first collection made after 21 days (Muga and Chikamai, 2016). An average of 5-6 kg of gum/resins is collected per person per day (Gachathi *et al.,* 2010).

Value Addition

A study by Muga and Chikamai (2016) reported that most of the gums and resins produced in Kenya are exported in raw form except for a small quantity that is processed for essential oils. There are three processors of gum resins in Kenya namely: Lubanchem Limited, Northern Gums Limited and Arbor Oils of Africa Ltd, which extract

the Economic Stimulus Programme under the Vision 2030 for value addition, but is yet to be operationalized (Muga *et al.,* 2015; Muga *et al.*, 2017). For gum arabic, it is only Arid Land Resources Limited (ALRL) that carries out value addition to gum arabic by grinding the product and grading it before exporting (Muga and Chikamai, 2016).

Trade and Marketing of Gums and Resins

Gums and resins are marketed through the local, national and export marketing outlets. The collectors who are mostly cattle herders and women members of the communities within producing sites sell their collections averaging 10 kg perperson to local dealers who mostly operate grocery or hides and skins business shops at local market centres. The volumes bulked are then sold off to national dealers. The merchandise is then sold to manufacturers or exported.

The current annual world demand for gum arabic is about 100,000 t against a current supply of about 70,000 t which is projected to reach 150,000 t by 2020 (Muller and Okoro, 2004). Annual exports of gum arabic have been a paltry 58.8 t which reached a peak of 165 t in 2008 valued at US$ 151,715.8. The exports are mainly to Germany. However, there is a huge internal market that takes about 100 t annually. The annual world demand for gum resins is estimated at 2,500 t. The low export volumes are partly due to capacity to bulk enough quantities and lack of reliable suppliers. The gums are collected from the wild mostly by cattle herders compromising volumes and reliability of supplies.

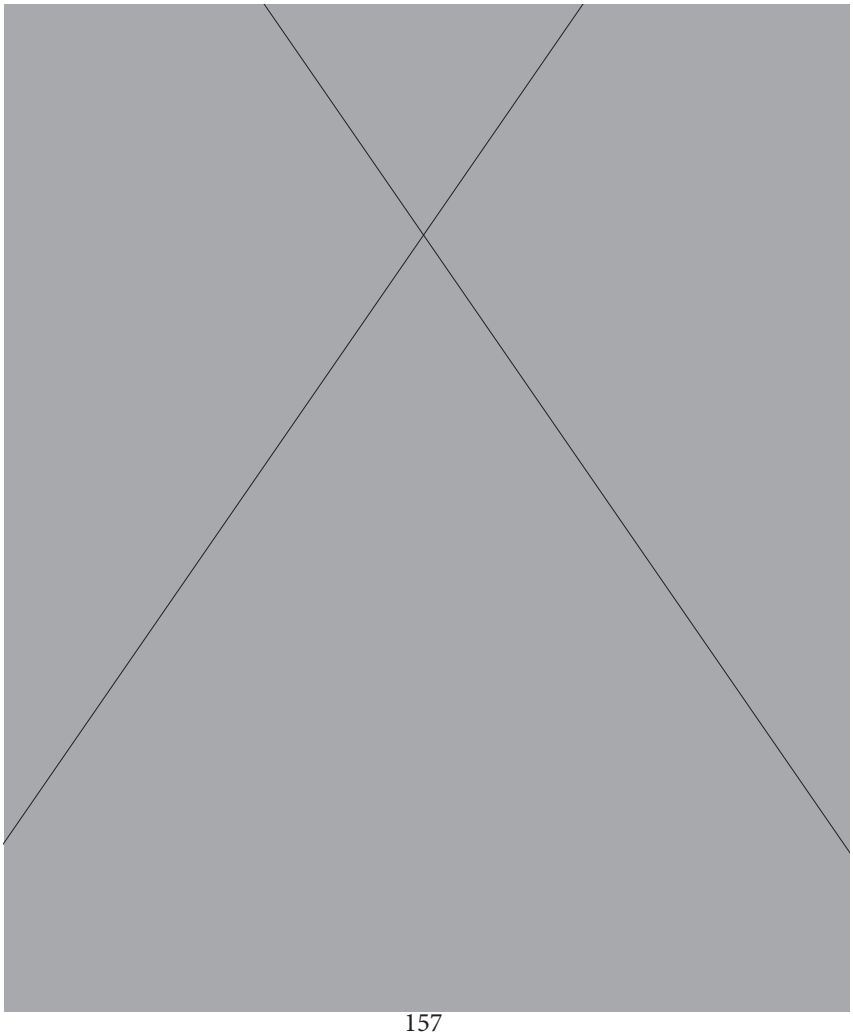
Kenya is the third largest exporter of resins (myrrh, hagar and frankincense) after Ethiopia and Somalia. Export volumes of gum resins averaged 2,446 t per annum (2005-2015) and reached a peak of 3,687 t in 2012 valued at US$ 4,010,726 and sold mainly to Pakistan, Vietnam, China, Hong Kong and India. The key challenge with marketing of resins just like gum arabic is unreliability in supplies and low bulking capacities by dealers.

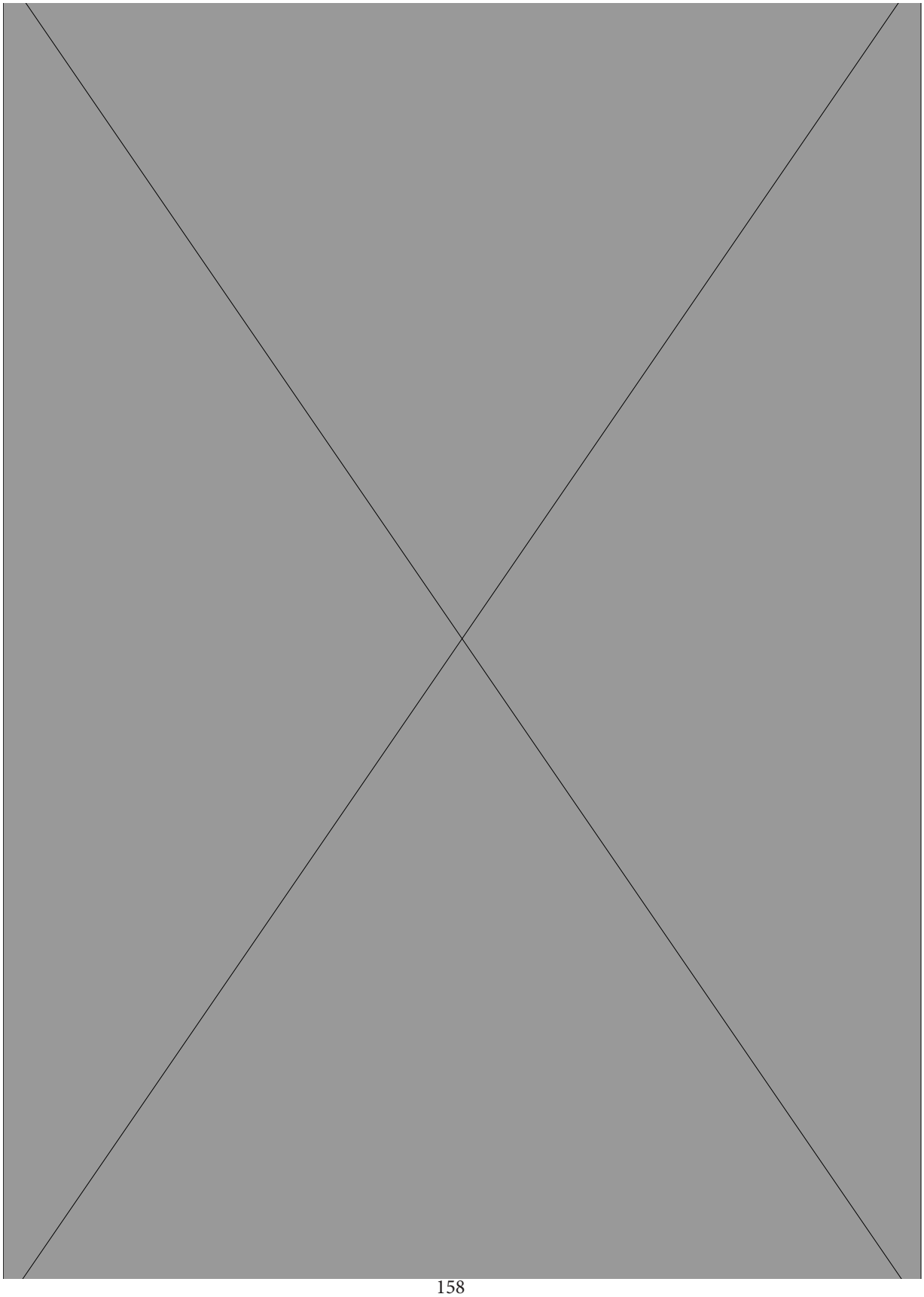
Research and Development Within the Sub-Sector

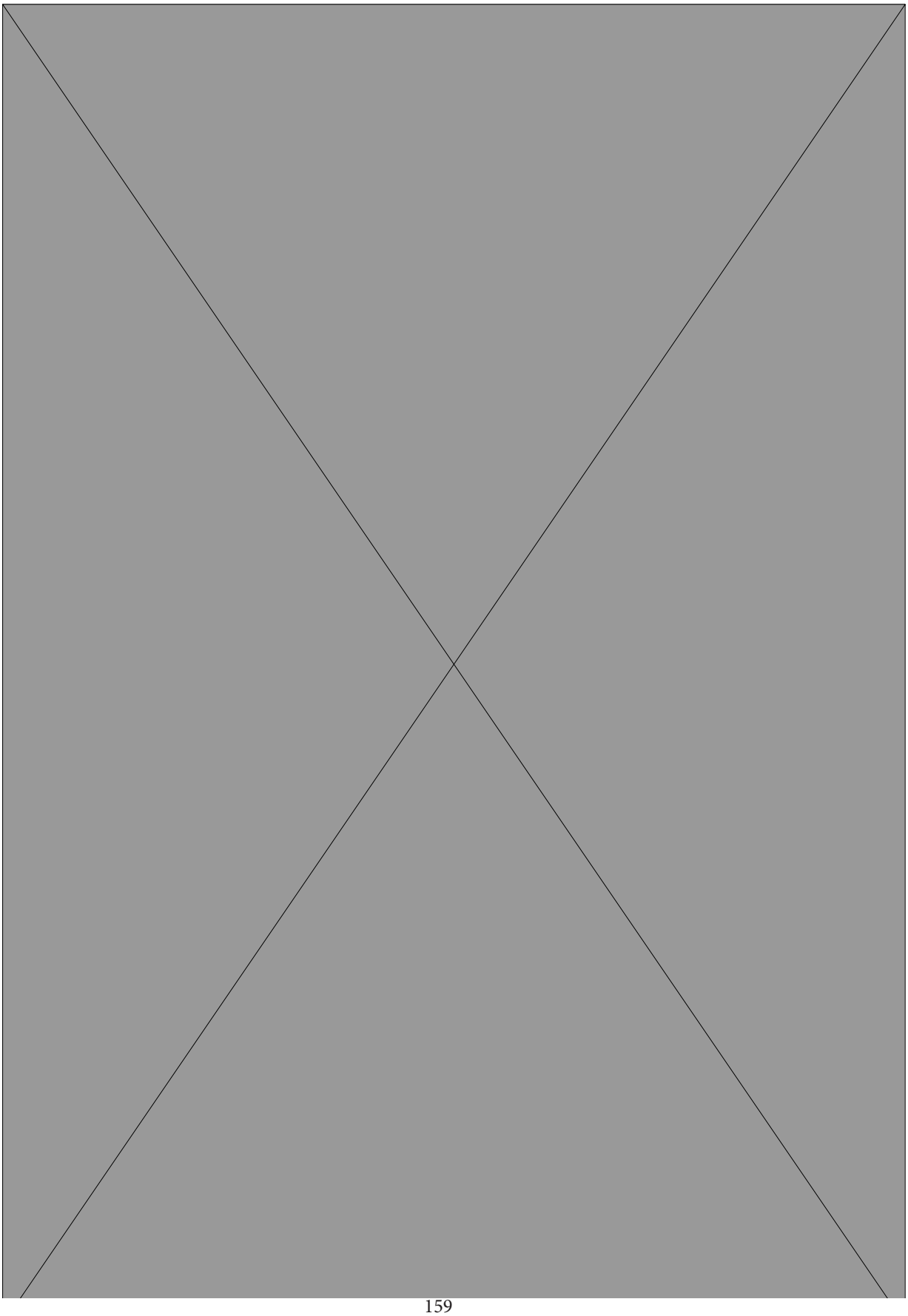
A number of research and development initiatives have been undertaken since the 1990s through various projects. Some of the key areas of focus have been: Taxonomic and ecological characterization of the producing species, chemical characterization of the gums and resins, resource assessment and mapping, piloting production and management of *Acacia senegal* trees and training and capacity building. Each of these is briefly described below.

Taxonomic and Ecological Characterization of gums and resins species

The key gum arabic producing species in Kenya, *Acacia senegal* and *Acacia seyal* have been characterized in terms of their taxonomy and ecology (Gachathi and Chikamai 1994; Chikamai, 2001; Gachathi and Muga, 2009). The potential adulterants have also been identified (Gachathi and Muga, 2009). *Acacia senegal* has three varieties namely: *Acacia senegal* var. *senegal* (Figure 2), *Acacia senegal* var. *kerensis* (Figure 3), and *Acacia senegal var. leiorhachis* (Figure 4). *Acacia senegal* var. *kerensis*, is the main source of commercial gum arabic in Kenya. Variety *senegal* occurs in areas of relatively higher rainfall, produces gum on tapping in some areas but has not been developed commercially. Variety *leiorhachis* is more restricted but its potential for gum production has not been established. Other sources of gum arabic are Acacia seyal var. seyal (Figure 5) and *Acacia seyal* var. *fistula* (Figure 6).







Gum arabic

The chemical characteristics of the three varieties of *Acacia senegal* have been studied by Anderson *et al.* (1990), Chikamai and Banks (1993), and Mhinzi and Mrosso (1997). The studies indicate that variety *kerensis* has a similar protein and nitrogen content (2.9 % and 0.44 %) to variety *leiorhachis* and higher values than variety *senegal* (2.3 % and 0.34 %, respectively) and also a higher intrinsic viscosity (21.9 ml/g) than variety *senegal* (16.0 ml/g) but lower values than variety *leiorhachis* (23 ml/g).

Commiphora holtziana gum resin when solvent extracted followed by a combination of chromatographic separation techniques on hexane extract of a sample from Wajir, led to the isolation and characterization of a new compound, 11–hydroxy-γ-muurolene 1 (Chiteva *et al*. 2013). In addition, two known compounds, (1E)-2-methoxy-8,12 epoxygermacra-1(10),7,11-triene-6-one 2 and (1E)-3-methoxy-8,12-epoxygermacra-1,7(8),10(15),11-tetraen-6one 3 were also characterized. A total of 14 compounds were identified by the comparison of the mass spectra with data available in the GC – MS library. Both

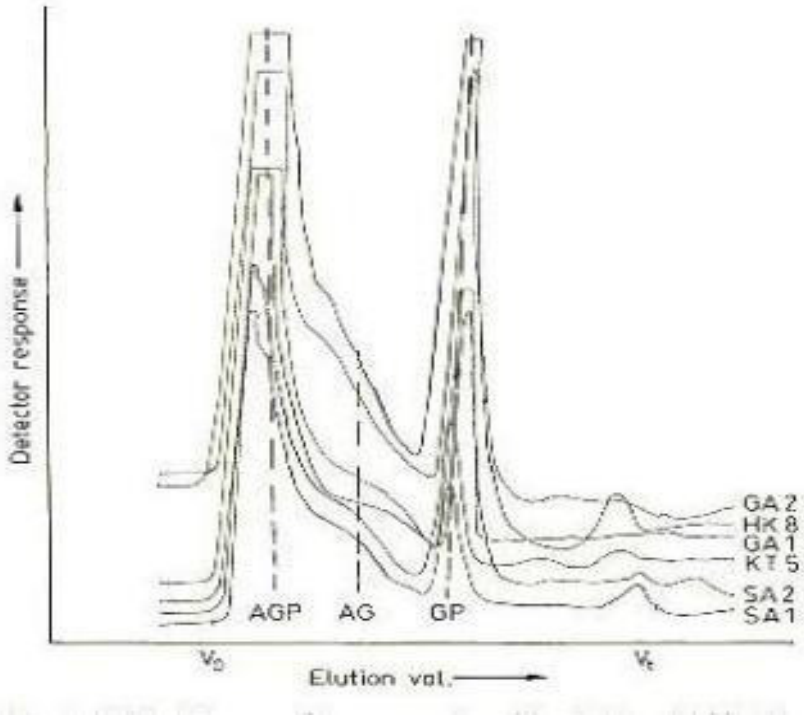


Figure 17. GPC elution profiles as monitored by UV
(Source: Chikamai *et al*., 1994)

When the molecular characteristics were examined (Chikanai *et al*., 1994) the two varieties var *senegal* and *kerensis* showed the same chemical characteristics typical of *Acacia senegal* though var. *kerensis* showed a more enhanced absorbance peaks of the UV profile caused by the high protein content (Figure 17). These differences reflect the natural variability that exists in the different varieties and presents opportunities for the development of specific niche markets for each type of gum.

dichloromethane and hexane extracts from both Isiolo and Wajir populations showed antibacterial activity. In addition, the hexane extract from Wajir population showed antifungal properties. The acetone extract from Wajir population showed antibacterial properties. Activities were observed against Fungi, Gram (+) bacteria and Gram (-) bacteria. Pure compounds did not show any activity (Chiteva *et al*. 2013).

Piloting plantation production and management of Acacia gums

Plantation production of *Acacia senegal var.kerensis* has been piloted through the support of the Acacia Operation Project, a regional project, funded by the Italian Cooperation through Food and Agriculture Organisation (FAO) and implemented in 2004-2007. Through the application of a mechanized water harvesting Technology (Vallerani System), pilot sites were established in Marsabit and Samburu counties (FAO, 2010). A total of 2,485 trees survived in one of the most promising pilot sites (18.6 ha in size) at Laisamis. An assessment of the *Acacia senegal* trees at about 4 years indicated a mean height of 59.4 cm (ranging from 30 to 235 cm) and a mean diameter at ground level of 10.6 mm (ranging from 5 to 32 mm). However, there were challenges of protection of the pilot sites from domestic and wild animals resulting in the destruction of a number of trees (FAO, 2010).

Genetic diversity and population structure of gums and resins producing species

Studies on the genetic diversity of the Kenyan populations of *Acacia senegal* using nuclear and mitochondrial microsatellite markers have also been carried out from which higher genetic diversity and little population structuring were detected (Omondi *et al*., 2010). Similarly, morphological characterization of the Kenyan populations of *Acacia senegal* has also been completed and data analysis underway. Characterization of the populations using randomly amplified polymorphic DNA (RAPD) has also been accomplished showing high genetic diversity (Chiveu *et al*., 2008). Mating systems and effect of anthropogenic disturbance on genetic diversity has shown that the species is predominantly outcrossing and is vulnerable genetically to human disturbances (Omondi *et al*., 2016, 2018)

Effect of soil chemical characteristics on gum quality

The effect of chemical properties of soils on gum Arabic elementary compositions from *Acacia senegal* variety *kerensis* in Samburu and Marsabit Counties has been studied (Lelon *et al*., 2010). Chemical properties of soils were found to be major factors that influenced the gum arabic quality. The studies indicate that the pH of gum varied ($p < 0.05$) with soil pH in all the sites. Organic carbon in gum arabic from Merille (0.15%) was significantly higher than those in Logologo (0.073%), Laisamis (0.055%) and Sereolipi (0.027%). Soil nitrogen content in Merrile (0.30%), Laisamis (0.4%) and Logologo (0.8%) were significantly correlated ($p < 0.05$) to the nitrogen (0.31 - 0.32%) in gum Phosphorus. Gum arabic from Sereolipi (700.2 ppm) and Merrile (705.2 ppm) were significantly higher than in Laisamis (412.2 ppm) and Logologo (412. 2 ppm). The pH (4.5 - 4.54) and nitrogen content (0.31 - 0.32%) in gum arabic from Merrile, Laisamis and Logologo are within the international standards (pH 4.2 - 4.8) and (0.24 - 0.41%).

Training and capacity building

Since 2005, KEFRI in the framework of the Network for Natural Gums and Resins in Africa (NGARA) and in collaboration with Gums and Resins Association (GARA) has spearheaded the formation of at least 80 gum producer associations. In collabaration with Ewaso Ngiro North Development Authority (ENNDA), Acts-CRM Facility and National Agriculture and Livestock Extension Programme (NALEP) 387 people have been trained on the production, harvesting, post-harvest handling and marketing of gum arabic with the ultimate objective of providing an alternative livelihood source (income generation) for the local community.

Policy Environment

A review of the existing policy and legislative environment affecting the production, utilization and marketing of gums and resins resources in Kenya was done to examine the extent to which the existing policies and legislation framework address concerns of stakeholders in the sub-sector (Luvanda and Muga, 2013). A number of challenges and opportunities with respect to the policies and legislations in the sub-sector have been identified. The review established that Kenya has no legal and policy framework that that explicitly deals with gums and resins. The existing policies and legal frameworks, have certain provisions that are relevant to promotion of production and marketing of gums and resins, but do not effectively address several aspects of the problem. It is established that the existing laws and policies require harmonization, coordination and re-alignment to Vision 2030 and the constitution of Kenya in order to be clear on the gums and resins sub-sector. The government was preparing the gums and resins regulations that were waiting gazettement to help regulate the sector .

Challenges and Opportunities

The key challenges for the sub-sector are:

- Poorly developed markets and marketing systems resulting in low prices at the producer level
- Destruction of gum and resin producing trees for firewood, fencing and fodder
- Insecurity in some of the producing areas interfere with gum collection, storage and trade
- Low production of gum arabic due low adoption of best practices and land and tree tenure issues
- Low export volumes are partly due to lack of capacity to bulk enough quantities and lack of reliable suppliers
- Inadequate data on the resources, trade and marketing
- Lack of clear policies and strategies on development of gums and resins
- Inadequate incentives including access to credit by producers and traders
- Frequent and prolonged droughts affect gum production
- Un-regulated production system with collections from the wild resulting in unreliable supplies

Opportunities for Promoting Commercialization of gums and resins

- *Acacia senegal* var. *kerensis* gum from Kenya has high specific rotation, nitrogen content and molecular weight compared to that from *Acacia senegal var senegal* and can be used as a food dietary fiber, a stabilizer/ thickener in viscous food such as yoghurt, cheese, jam among othere. This provides a niche market for Kenyan gum arabic
- The promulgation of the new constitution has opened new opportunities for all sectors including gums and resins sub-sector especially in the devolved governments
- County governments have an opportunity to develop a legal framework to establish a county statutory board with the mandate to oversee investment and development of gums and resins sub-sector in each producer county.
- Operationalization of the gums and resins rules, currently under development, would help in streamlining the sub-sector
- The Forest Conservation and Management Act 2016 has provisions that can support the development of the sub-sector
- Presence of NGARA secretariat in Kenya can help in providing useful linkages and market access. Strengthening GARA by supporting implementation of the 2016-2020 strategic plan would be a starting point in reforming the sub-sector. A strong GARA would lobby the government for enabling policies and assist them in the establishment and strengthening of the producer associations
- At least three cooperative societies exist that could be used to market gums and resins
- The demand for gum resins from Kenya in the export market is higher than the supply
- Development of market information systems on market access, requirements and price trends
- Strengthening of producer associations/ cooperative societies would help the local communities' access credit and negotiate for better prices in line with prevailing market prices
- Value addition through establishing medium processing plants (steam distillation or extraction plants) that will result in export of semi processed commodities
- Establishment of plantations and promotion of management practices for the trees in the wild

CONCLUSION AND WAY FORWARD

The major barriers that limit the realization of full potential for the gums and resins in the dry lands of Kenya have been identified and classified as ecological and climatic issues, socio-economic factors, technological barriers and policy as well as institutional barriers. These have led to low exports of the commodities relative to the resource potential. Challenges of low export volumes are also partly due to inadequate capacity for production and value

addition, incapacity to bulk enough quantities, lack of reliable suppliers and weak market linkages. It is therefore necessary to mitigate the identified challenges and take advantage of the existing opportunities to commercialize the gums and resins production and trade for improved livelihoods of vulnerable producers/collectors.

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