

## Executive Summary

Natural Gums of commerce in the Republic of Sudan (RoS) encompass:

- (a). Gums from *Acacia* trees namely Gum Hashab from *Acacia senegal*, Gum Talha from *Acacia seyal* and Gum Kakamut from *Acacia polyacantha*,
- (b). Gums from broad-leave trees namely: Frankincense Gum from *Boswellia papyrifera*, Gum Karaya from *Sterculia setigera* and African Myrrh (Luban) from *Commiphora africana*,
- (c). Gum Guar (Cluster bean gum) from the herb (*Cyamopsis tetragonoloba*),
- (d). Gums of promising potential from other *Acacia* trees and shrubs grown in RoS

Those in-charge of Sudan's Forest Service were keen and expressed their interest in the Hashab tree (*Acacia senegal*) since the 1950s. They progressively developed a comprehensive "Protocol" for its Silviculture and Management through applied research by Forest Research Centers, university academic staff, post-graduate students and practice of forestry practitioners. They standardized and perfected the process of tree selection, seed collection and storage, nursery techniques, raising of seedlings, transplanting in forests and tree formations, seed broadcasting together with processes of tapping, gum collection, cleaning, grading and subsequent processing.

Focused research on Hashab trees and Gum Arabic production commenced shortly after the country's independence in 1956 in two synchronized activities:

(A). When the Director of Forests at the time, Dr. Mohamed Kamil Shawgi established a section in the Forests Department (FD) for Gum Arabic Research for which he employed European and other expatriates to whom he attached young Sudanese forestry graduates and technicians from the ranks.

(B). Dr. Shawgi financed Dr. D M W Anderson of Edinburgh University, Scotland, UK in 1959 to commence research in the chemistry of Gum Arabic. From that beginning Professor Anderson became one of the most prominent in gum chemistry. Together with his associates from various nationalities including Sudanese, they published a multitude of books and hundreds of papers in renowned journals.

Recruitment of expatriates and sending of Sudanese students to study in European, American, Australian, Indian and Pakistani universities to obtain degrees in Forestry and attachment of Sudanese to expatriates together with finance to the likes of Anderson was entirely from the Government of the recently independent Sudan and FD budget.

The assignment of the Gum Arabic Research Division of the FD, Forests Research Centre (FRC) and subsequently Gum Arabic Research Centre (GARC) of Agricultural Research Corporation (ARC) was defined into two approaches:

- (a). Research in chemistry of Gum Arabic with the objective of identifying new usages to increase demand.
- (b). Research in all aspects of Gum Arabic production in the field to be conducted by GARC.

The GARC commenced in the context of assigned tasks to conduct detailed surveys in the Gum Belt (GB) across the country during the first period 1958-1961. Besides enumerating problems that face gum producers, GARC started to conduct experiments in means of propagating Hashab tree. Numerous specimens of Gum Arabic were collected and dispatched to Edenborough University for research on characteristics by Dr. Anderson.

Conducted experiments included various aspects of propagation such as natural regeneration, nursery practices and general silviculture together with the impact of biological and natural agencies on growth and development of the tree. A substantial portion of this research was done under supervision of Dr. Mohamed Obeid Mubarak of the Botany Department, Faculty of Science, UoK, back in 1969.

Research and studies subsequently followed through funding from the Government of the Sudan (GoS), development partners, United Nations agencies and global and local Non-governmental Organizations (NGOs).

The bulk of ensuing studies were for obtaining post-graduate certificates; Masters or Ph.Ds., mostly in the UoK and recently established universities and a limited number in foreign universities such as the University of Helsinki in Finland; Universities of Wales and Edenborough in UK, and Dresden in Germany, while some were in the context of implementation of donor - assisted developmental projects.

#### **Stock-taking of Research Accomplishments:**

To date (2019), research in RoS on trees, shrubs and herbs producing natural gums of commerce comprehended:

##### **Hashab (*Acacia senegal*):**

Research focused mostly on aspects of (i). Silviculture, (ii). Tree improvement including tissue culture, Anatomy and Physiology, (iii) Production and Productivity, (iv). Collection and Post-harvest activities, (v). Hashab tree in Agro-silvo-pastoral Systems, (vi). Socio-economic aspects, (vii). The role of forest trees in general, especially gum-producers and more specifically Hashab trees in Sustainable Rural Development, (viii). Trade, Marketing and Export of Gum Arabic, (ix). Chemistry and Applications of Gum Arabic, (x). Industrial Applications of Gum Arabic, (xi). Nutritional, Medicinal and Pharmaceutical Applications of Gum Arabic and (xii). Constraints of Gum Arabic Production in RoS.

The cumulative knowledge generated on tree selection, seed handling, nursery techniques, transplanting, silvicultural treatment, tapping, gum collection,

processing and trading together with accumulated traditional knowledge and norms on the subject matter, formed the building blocks of what came to be referred to as “Agro-Sylvo-Pastoral-System” and “Gum Arabic Production Protocol”

It can be concluded that through initiatives and interventions that spawned a ‘sovereign’ relationship for RoS with Hashab tree, a full-fledged silviculture, management and production, trade and applications ‘protocol’ has been established for *A. senegal* in RoS.

#### **Talh (*Acacia seyal*):**

The first scientific study on *A. seyal* was for an award of M. Sc. by Babiker Fadl Alla Mohamed in the Faculty of Science, UoK in 1963. That was followed by many others on such aspects as morphology, impact of *Bruchid* seed borers on seed germination and wood quality, seedling raising and transplanting, regeneration in clay plains of Sudan, tapping and gum production and characteristics of charcoal from Talh. Many academic based publications focused on various chemical characterization, functional properties, and fractionation of Talha gum.

All in all, and despite all the benefits and services rendered by the Talh tree to Sudanese environment and economy, the tree has not been accorded its due consideration in research or field practices in the country. A start has been made towards formulating silviculture, management, production, trade and applications ‘protocol’ for *A. seyal* in RoS.

#### **Kakamut (*Acacia polyacantha*) subsp. *campylcantha*:**

Only a limited number of studies have been conducted on Kakamut encompassing such aspects as impact of tapping tools and implements on gum production, toxicity and urinary and action on blood sugar and body weight of diabetic laboratory rats. Preliminary trials were also related to its application in confectionary products. Thus, work on formulating a silviculture, management production, trade and applications ‘protocol’ for *A. polyacantha* has not been started in RoS.

#### **Frankincense Gum (*Boswellia papyrifera*):**

Those in-charge of Sudan’s Forest Service were keen and expressed their interest in the silviculture and management of the Tarag Targ tree (*Boswellia papyrifera*) since the 1950s. Through applied research by FRC, staff and post graduate students in Sudanese and other universities and practice by forest practitioners, vegetative propagation of the tree through stumps was perfected. As a result, two stands were established in Garri Reserved Forest in Blue Nile State.

Some tapping trails were conducted without conclusive results. In the aftermath of events in Somalia and the Horn of Africa towards the 1980s, some Ethiopian/Somali groups came to Sudan and coached people in Blue Nile and Kas area in Darfur on tapping, harvesting and post-harvest operations of Frankincense Gum.

#### **Gum Karaya (*Sterculia setigera*):**

During the mid-1990s, the Sudanese forests authorities expressed keenness and interest in the production of Tartar Gum. Through support from the Gum Arabic Company of Sudan and the French Company Iranex some tapping trials were conducted in Blue Nile State and South Kordofan with no conclusive results. A few studies on propagation were recently conducted by researchers in GARC together with others in the context of M. Sc. degrees in Kordofan University.

The situation as it stands in this respect, is that there is not even a start towards a 'protocol' for silviculture or management of the tree in RoS. To date, three technologies on propagation, tree management and tapping were released by ARC.

**African Myrrh (Gum Luban) from (*Commiphora africana*):**

To date no formal structured research has been conducted or reported on silviculture, management or even propagation of *Commiphora africana* in RoS.

**Guar -Cluster bean gum- (*Cyamopsis tetragonoloba*):**

A plethora of studies have been conducted on Guar gum in Sudanese universities and research centers commencing in the 1995s. Perhaps the most salient, relevant and conclusive ones include those on breeding, field operations, harvesting, characterization and applications.

**Outlook = Strategy:**

Identified research gaps deemed to require special focus in RoS National Research Strategy for Natural Gums (NRSNGs) and envisaged Sudanese agencies to undertake such research are portrayed in table (A).

**Table (A): Research gaps requiring special focus in RoS National Research Strategy for Natural Gums (NRSNGs) and envisaged Sudanese agencies to undertake such research**

Tree species	Research/Practice	Assigned Agency
<b>A. Resource Base</b>		
<i>A. senegal</i>	Basic research in aspects of Biochemistry, Gummosis and Nanotechnology	Sudanese Universities
<i>A. senegal</i>	<ul style="list-style-type: none"> <li>▪ Water harvesting to improve tree establishment on hard-textures soils.</li> <li>▪ Continuation of research on efficiency of nodulation and N-fixation of gum producing <i>Acacias</i>.</li> <li>▪ Continuation of research on Agroforestry (AF) options for gum producers' in different production domains.</li> <li>▪ Research to complete genetic resources' map.</li> <li>▪ Continue in-situ conservation research.</li> </ul>	+ Gum Arabic Research Centre of Agricultural Research Corporation, + Other authorized Research Centers

	<ul style="list-style-type: none"> <li>▪ Verification and adoption research to improve producers' tree-management skills.</li> <li>▪ Gum quality in relation to soil type.</li> </ul>	
<i>A. senegal</i>	Field Practice of Silviculture and Management of the Hashab tree <i>A. senegal</i> .	Forests National Corporation.
<i>A. seyal</i>	Silviculture & Management of the Talh tree	+ Gum Arabic Research Centre of Agricultural Research Corporation, + Other authorized Research Centers
<i>A. seyal</i>	Field Practice of Silviculture and Management of the Talh tree <i>A. seyal</i> .	+ Forests National Corporation at Federal and State levels, + Private Sector Enterprises, + Civil Society Organizations.
<i>A. seyal</i>	Entire Protocol of production, trade, marketing & application of Gum Talha.	Relevant Line Ministries of Agriculture & Forests, Trade & Industry.
<b>Other <i>Acacia</i> Trees producing gums of commercial potential namely Kakamut (<i>Acacia polyacantha</i> subsp. <i>campylacantha</i>) and Shubahi (<i>A. laeta</i>)</b>	Silviculture & Management of Trees producing Gums of commercial potential such as <i>A. campylacantha</i> and <i>A. laeta</i> .	+ Gum Arabic Research Centre of Agricultural Research Corporation, + Other authorized Research Centers.
	Basic research in aspects of Biochemistry, Gummosis and Nanotechnology.	Sudanese Universities
	Field Practice of Silviculture and Management of other <i>Acacia</i> Trees and Shrubs producing Gums of commercial potential such as <i>A. campylacantha</i> and <i>A. laeta</i> .	+ Forests National Corporation at Federal and State levels, + Private Sector Enterprises, + Civil Society Organizations.
	Entire Protocol of production, trade, marketing, and application of Gums of commercial potential from Trees, Shrubs and herbs grown in RoS.	Relevant Line Ministries of Agriculture & Forests, Trade & Industry

<b>Trees producing Resins such as Frankincense or/ Rutrut (<i>Boswellia papyrifera</i>), Tartar (<i>Sterculia setigera</i>) and Africa myrrh (Luban) (<i>Commiphora africana</i>)</b>	Silviculture and Management of trees producing Resins such as <i>Boswellia papyrifera</i> , <i>Sterculia setigera</i> and <i>Commiphora africana</i> ,	+ Gum Arabic Research Centre of Agricultural Research Corporation, + Other authorized Research Centers.
	Field Practice of Silviculture and Management of Trees producing Resins such as <i>Boswellia papyrifera</i> , <i>Sterculia setigera</i> and <i>Commiphora africana</i> .	+ Forests National Corporation at Federal and State levels, + Private Sector Enterprises, + Civil Society Organizations.
	Entire Protocol of production, trade, marketing, and application of Gums other than Gum Arabic and Resins of commercial potential from Trees, Shrubs and herbs grown in RoS.	Relevant Line Ministries of Agriculture & Forests, Trade & Industry
	Basic research in aspects of Biochemistry, Gummosis and Nanotechnology	Sudanese Universities
<b>Control of organisms impacting the production of Gums and Resins</b>	Basic and applied research on Biology of Biotic Agents and aspects of A-biotic Agents	Sudanese Universities
	Applied research and field practice of Biotic Agents and aspects of A-biotic Agents	+ Forests National Corporation at Federal and State levels, + Private Sector Enterprises, + Civil Society Organizations.
<b>Inventory of Forests and Trees producing Gums &amp; Resins</b>	Applied research and field practice of Forest and Tree Inventory and mapping	+Sudanese Universities + Forests National Corporation at Federal and State levels, + Private Sector Enterprises, + Civil Society Organizations.
<b>Genotyping and molecular</b>	✓ Gene mapping of all species and strains	+Sudanese Universities

<b>characterization of all-Natural Gums producing Trees and Shrubs</b>	✓ Gene bank of all germplasm of from all provenances	+ Forests National Corporation at Federal and State levels, + Private Sector Enterprises, + Civil Society Organizations.
<b>Socio-economic, value-chain, trade and export of Gums and Resins</b>	Applied research and field practice of value-chain analyses, trade and export of Gums and Resins	+Sudanese Universities +Relevant Line Ministries of Agriculture & Forests, Trade & Industry, +Other authorized Research Centers
<b>B. Applications</b>		
<b>Chemistry of Gums</b>	<p>Molecular, Chemical, and physico-chemical characterization of natural gums from trees, shrubs or herbs currently producing natural gums of commercial importance or have the potential to do so, not hitherto characterized, namely:</p> <p><b>Acacias:</b>          Gums from          (1). <i>Acacia sieberana</i> (KuK), (2). <i>A. raddiana</i>, (3) <i>A. abyssinica</i>, (4). <i>A. elatior</i>, (5). <i>A. reficiens</i>, (6). <i>A. etbaica</i> (Arad), (7). <i>A. nubica</i> (Laot), (8). <i>A. tortilis</i> (Sammar, Seyal), (9). <i>A. drepanolobium</i> (Soffar Aswad), (10). <i>A. gerrardii</i> (Salgam), (11). <i>A. paolii</i>, (12). <i>A. macrothyrsa</i>, (13). <i>A. fistula</i> (Suffar), (14). <i>A. hockii</i>, (15). <i>A. ehrenbergiana</i> (Sallam), (16). <i>A. nilotica</i> (Sunt, Garad), (17). <i>A. kirkii</i>, (18). <i>A. dolichocephala</i>, (19). <i>A. horrida</i>, (20). <i>A. mellifera</i> (Kitir), (21). <i>A. laeta</i> (Shubahi), (22). <i>A. heterophylla</i>, (23). <i>A. polyacantha</i> (Kakamut); (24). <i>A. macrostachya</i>, (25). <i>A. persiciflora</i>, (26). <i>A. asak</i> (Assag, Hag), (27). <i>A. ataxacantha</i>, (28). <i>A. brevispica</i>, (29). <i>A. schweinfurthii</i>, (30). <i>A. pentagona</i>, (31). <i>A. albida</i> =<i>Faiherbia albida</i> (Haraz).</p> <p><b>Broad Leaves:</b>          (1). Frankincense Gum from <i>Boswellia papyrifera</i>,</p>	Sudanese Universities

	<p>(2). Gum Karaya from <i>Sterculia setigera</i>,,  (3). African myrrh = Gum Luban from <i>Commiphora africana</i>,  (4), Other broad leaf trees and shrubs  <b>Herbs:</b>  (5). Gum Guar (Cluster bean gum) from the herb (<i>Cyamopsis tetragonoloba</i>).</p>	
<b>Industrial uses</b>	<ul style="list-style-type: none"> <li>➤ Physico-chemical functionalities</li> <li>▪ Emulsification in different scenarios</li> <li>▪ Stabilization capacities of different gum types</li> <li>▪ Effectiveness in glue and adhesiveness of different gum types in paper and wood applications</li> <li>▪ Uses in modern printing and lithography applications</li> </ul>	<p>+Sudanese Universities  +Centre for Industrial Research &amp; Consultations.</p>
<b>Food &amp; Nutrition</b>	<ul style="list-style-type: none"> <li>✓ Microencapsulation powers of gum molecules for precious vitamins</li> <li>✓ Microencapsulation powers of gum molecules for commercial flavors and colors</li> <li>✓ Microencapsulation powers of gum molecules for commercial essential fatty acids</li> <li>✓ Potential of gum molecules in preservation and keeping properties of ready to cook products and frozen preparation (pizza and pastries)</li> <li>✓ Trials on glazing properties of gum molecules for commercial production of biscuits and cakes</li> <li>✓ Applications of different mixes and recipes of natural gum varieties on the resultant viscosity of final products in industrial and food applications</li> <li>✓ Trials on gum-cereals recipes and formulations on nutritional values</li> <li>✓ Trials on gum-legumes recipes and formulations on nutritional content</li> <li>✓ Uses of gum products for food fiber fortification</li> <li>✓ Uses of gum products for ready to</li> </ul>	<p>+Sudanese Universities  + Food Research Centre of ARC,  + Centre for Industrial Research &amp; Consultations  + Sudanese Standards Metrology Organization,  + Sudan Medical Council,  + Sudan Medical Specializations Board,  + National Medicines and Poisons Board,  + Sudan Veterinary Council,  + Animal Resources Research Corporation,  + Sudanese Consumers Protection Society.</p>

	use therapeutic foods “RUTFs” for malnutrition	
<b>Colonic digestion</b>	<i>In-vitro</i> research on Digestion of Gums in the colon in simulated gut	+Sudanese universities + Ministry of Health
	<i>In-vivo</i> research on Digestion of Gums in the colon of experimental animals and humans	+ Sudan Medical Council, + Sudan Medical Specializations Board, + National Medicines and Poisons Board, + Sudan Veterinary Council, + Animal Resources Research Corporation.
	Assessing specific probiotic strains for their selective digestion of different natural gum types	
	Physiological and biochemical profiles of specific beneficial metabolites and their therapeutic and health potential in experimental animals and humans	
	<i>In vivo</i> trials addressing impacts of specific gum molecules in colonic balance in favoring normal gut flora versus specific pathogenic strains	
<b>Medicinal and Pharmaceutical uses</b>	Clinical investigation of digestion products of specific metabolites of Gums in the human colon	+Sudanese universities + Ministry of Health + Sudan Medical Council, + Sudan Medical Specializations Board, + National Medicines and Poisons Board, + Sudan Veterinary Council, + Animal Resources Research Corporation
	Impacts of various types of gum molecules on specific immune markers in scenarios of inflammation	
	Impacts of various types of gum molecules on specific immune markers in scenarios of microbial infection and pathogenesis	
	Impacts of various types of gum molecules on metabolic syndrome	
	Role of various types of gum molecules on management of cardiovascular diseases	
	Role of various types of gum molecules on management of diabetes mellitus	
	Efficiency of various types of gum molecules on body weight management and obesity	
	Role of various types of gum molecules on management of colorectal cancer	
	Application and molecular impacts of various types of gum molecules in different stages of renal disorders	
	Potential applications of various gum molecules in toothpaste formulation	
	Potential applications of various gum	

	<p>molecules in skin cosmetics formulation</p> <p>Potential applications of various gum molecules in wound plaster formulation</p> <p>Gum molecules and their Nano applications as carriers for different drug delivery systems</p> <p>Uses of gum products for oral rehydration solutions "ORS" formulation</p>	
<b>Processing of Gums and Resins</b>		<p>+ Private Sector Enterprises,</p> <p>+ Universities,</p> <p>+ Research Centers</p>
<b>Promotion and Awareness raising Extension campaigns</b>	<ul style="list-style-type: none"> <li>➤ Awareness raising and Extension</li> <li>➤ Promotion</li> </ul>	<p>+Sudanese Universities</p> <p>+ Research Centers,</p> <p>+ Line Ministries,</p> <p>Mass Media</p>