“Tracing Ancient Healing Practices Through the Hibiscus”

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ABSTRACT

By studying traditional healing practices, we can provide new information that may help solve archaeological mysteries as well as offer new perspectives to modern medicine. For example, Hibiscus tea has long been in use throughout Africa and Asia, yet little research has been done into the origins of this medicine and whether early cultures traded that information. Trichomes and plant morphology of three species of Hibiscus native to Africa, China and India (*Hibiscus sabdariffa, Hibiscus rosa-sinensis, and Hibiscus syriacus)* were studied using microscopy. The results were compared to known medicinal claims and ancient documents including trade maps and iconography.

INTRODUCTION

The history of the hibiscus plant as a medicinal plant can be traced back several millennia to ancient Egypt and across to China through the use of comparisons between plant anatomy, iconography, published literature and archaeological records. While some species of hibiscus are native to certain regions, their incorporation into indigenous healing practices suggest that access to non-native species may have been introduced through trade. Their form may have been as dried calyces or leaves for tea infusions. It is also possible that whole plants may have been transported using known land and maritime trading routes. The hibiscus is a plant that has been valued by many cultures over the centuries for its industrial as well as its medicinal uses. Since *H. sabdariffa*, an African species, was used by countries as far east as China, is it possible the Chinese learned about the healing properties of the hibiscus plant from ancient Egyptians?

Hibiscus sabdariffa is a species native to Africa whose fibers, leaves and flowers, especially the calyces, have provided a multitude of beneficial uses. The plant is an annual, perennial herb or woody-based sub-shrub, growing up to 2-2.5 m (7-8 ft). The leaves are deeply lobed (3-5 lobes), 8-15 cm long and arranged alternatively on the stems.[1] The flowers are 8-10 cm in diameter, white to pale yellow with a dark red spot at the base of each petal. Flowers have a stout fleshy calyx at the base that is approximately 1-2 cm wide and become fleshy and bright red and enlarge to 3-3.5 cm as the fruit matures. It takes about 6 months to mature.[2] The hibiscus flowers, particularly the red calyces of *H. sabdariffa*, were used in ancient healing practices by African traditional medical practitioners (TMPs) and eventually incorporated into traditional Chinese medicine (TCM). African medicine dates back to the dawn of history to ancient Egypt, or Kemet, and is preserved through the TMPs. Among the many floral remedies, TMPs would make a drink by soaking *H. sabdariffa* leaves in water until the liquid turned sour. Then, it was administered to a young child to treat measles.[3] Beverages in Africa made from *H. sabdariffa* are used as a cooling herb, providing relief during hot weather by increasing the flow of blood to the skin surface and dilating the pores to cool the skin.[4] In West Africa, the leaves and powdered seeds are used in meals.[3] Chinese folk medicine suggests a tea made from the calyces of the *H. sabdariffa* can treat liver disorders and high blood pressure.[5] The Chinese also use the seeds for their oil as well as for their medicinal properties.[5] Other claims made for hibiscus tea, also known as roselle in Africa and China, or karkade in Arabia, include relieving coughs, increasing urination, and killing bacteria.[5] Though the species *H. sabdariffa* is used the most for hibiscus tea, other species which have red calyces, such as *H. acetosella*, are also used.[4]

Figure 1: Red calyces of the *H.sabdariffa* with some trichomes visible. (Swapan, 2012)

Hibiscus rosa-sinensis, also known as China rose, is native to China and the most visibly recognized species of the Hibisceae tribe. Its medicinal uses include treating respiratory problems, skin disorders and fevers.[7] Though it is native to China, studies show the anthocyanins extract of this species grown in Egypt proved pronounced cytotoxic activities against hepatoma and breast cancer cell lines.[8] The Rose of Sharon, or *H. syriacus*, is a native species of India. Most of its medicinal applications are topical, such as an emollient to soften and smooth skin, but it is also prescribed internally to treat digestive disorders.[7]

What determines the medicinal properties of certain plants can be explained through scientific research pertaining to trichomes. Trichomes are the tiny hairs on plants, either singular or multicellular, that act as a defense mechanism. The trichome shape can be associated to a particular plant species and has been used in taxonomy for identification.[9] More specifically, the presence or absence of peltate hairs and their form, size and color could be used in distinguishing between genera and species.[10] Early horticulturists, tradesmen, and scientists were limited in their scope of study to viewing specimens with only the naked eye. The advent of the microscope has enabled scientists to more accurately identify species by more specific biomarkers, such as trichomes and pollen, which are unique to each plant species. Anatomical features are widely used in systematics for identification, for placing anomalous groups in satisfactory positions in classification and for indicating patterns of relationship that may have been obscured by superficial convergence in anatomical features and morphology.[11] By using microscopy evaluations on other Hibiscus plant features, such as the stomata on leaves and flower components, studies showed that these bases provide some justification for the description, identification and collection of plant species.[12]

It is generally accepted that the "agricultural revolution" that transformed hunter-gatherer societies into settled agricultural communities occurred circa 10,000 BC. The history of western agriculture can be traced to ancient Egypt. Knowledge of the history of Egyptian agriculture and horticulture can be gleaned from the archaeological record supported by surviving written Egyptian documents, temple inscriptions, as well as commentaries from antiquity including those of the Greek historian Herodotus (484-425 BCE), the philosopher Theophrastus (372-288 BCE), and the books of Genesis and Exodus in the Hebrew Bible.[13] An example of a Biblical account of agriculture and trade is the story of Joseph, a young Israelite who was sold into slavery by spice traders and taken to Egypt. Tools, irrigation methods, potted plants, and more are depicted on many ancient Egyptian artifacts. Plant iconography, therefore, becomes a valuable resource for investigations on horticultural technological practices; crop history including evolution under domestication; crop dispersal; lost and new traits; and genetic and taxonomic information.[14] Sometimes the pottery itself is evidence of agriculture. The appearance of early ceramics in ancient China has been linked to the importance of cereals, suggesting the emergence of agriculture. The lack of botanical remains, however, has been the most serious obstacle to research into the beginnings of agriculture in ancient China. Rice, two varieties of millet, foxtail (Setaria italica) and broomcorn (*Panicum milaceum*) have been identified at Neolithic sites at Yangshao dating to 8000 B.P.[15] Domesticated rice was identified in the eighth-millennium B.P. Jiahu site of the Huai River valley and in seventh-millennium B.P. sites in the Yellow and Wei River.[16] History and the archaeological records show it would only be a matter of time before cultures would begin trading their agricultural goods, paving the way for land and maritime trade routes.

Documents, archaeological findings, among other items, give clues to how plants and knowledge of their medicinal use may have been introduced to various cultures. An epistle in which the Egyptian scribe Sinuhe penned the following description about Yaa, the name for Israel (ca 2000 BCE):

"It was a goodly land called Yaa. Figs were in it and grapes, and its wine was more abundant than its water. Plentiful was its honey, many were its olives; all manner of fruits were upon its trees."[17]

Other written records contain plant references within their own *Materia Medica*, a term coined from the documented medicinal usage of plants written by Dioscorides between CE 60 and 78 entitled *De Materia Medica*. Other ancient medical literature include the Artharvaveda, which is the basis of traditional Indian medicine (Ayurvedic); the Eber Papyrus by Egyptians (1550 BCE), and the *Pen Ts'ao Ching Classic of Materia Medica* written around 200 CE.[18] Even older records are preserved in temple reliefs, ceramics, stone carvings, and other natural materials that stand the test of time. A temple at Deir el-Bahri, Egypt ca. 1500 BCE shows ships of Queen Hatshepsut's fleet landing at Punt (northeastern coast of Africa) with exotic merchandise for Egypt. Images show tame baboons, potted plants, possibly stated for incense.[19] Sometimes it is more difficult to assess if a plant, such as the Hibiscus, had been imported or was introduced. There are three paintings by imperial painter LiTi from the 12th century Sung dynasty that contain "Hibiscus" in their titles. The Great Cat on the "Rocks and Hibiscus" detail does not have an exact date but is stated as being painted by Li Ti during the 12th century AD under the Sung Dynasty in China. (Figure 2)[20]

Figure 2

Two other paintings by Li Ti include "The Red Hibiscus" and "The White Hibiscus" signed by Li Ti in 1197 AD. (Figures 3 and 4)[21]

Figure 3

Figure 4

Iconography, such as crop images, is also one of the unequivocal tools for assessing the historical presence of botanical taxa in a particular region and is an especially valuable resource for determining morphological changes of crops from antiquity to the present.[14]

Many plants were traded throughout the ancient world in various forms, from the flowers to the leaves and even seeds, for not only agricultural use but also for consumption. An example is tea. Recently recovered artifacts at ancient sites are being analyzed for traces of plant materials, such as tea leaves. Large modern reference collections are used to compare and contrast microfossil morphology and biomolecular components of these ancient remains to modern standards of tea and related plant species.[21] The earliest tea (*Camellia sinensis L.)* discovered to date is evidence for one branch of the Silk Road reaching as far as the Tibetan Plateau.[22] The Silk Road, or Silk Route, was used to trade between East Africa and Arabia through to Rome and as far east as China. The term *Silk Roads* is sometimes extended to include the sea routes that linked the Mediterranean, Africa, the Indian subcontinent, southeast Asia, and China[23] (see Figure 5).

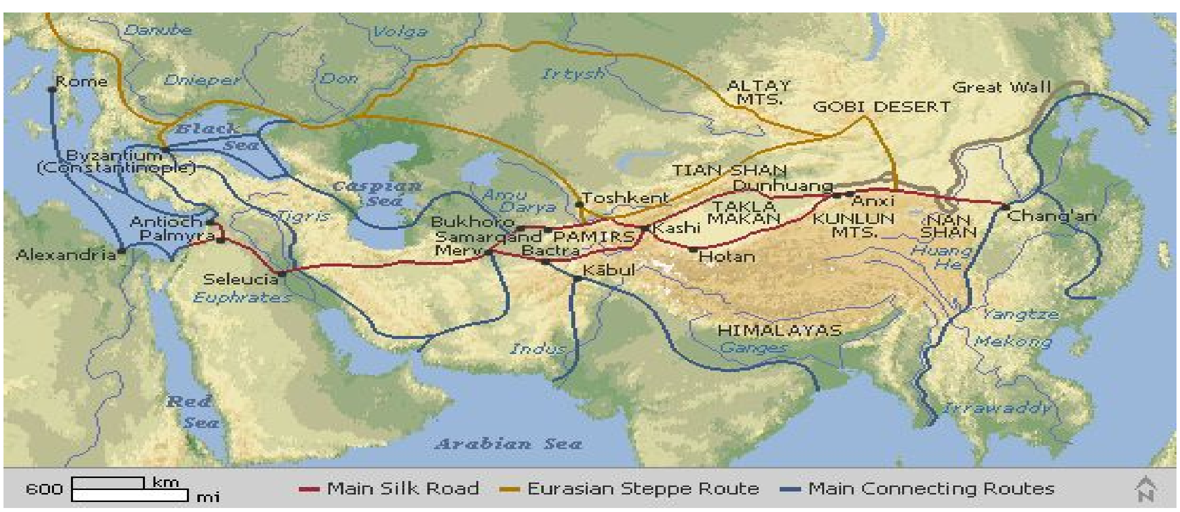


Figure 5 "Map of Great Silk Road Contains Many Routes". Retrieved from http://acansrs.org/Map.html

By comparing gathered information from the past with current botanical knowledge, it is possible to piece together a clearer picture of how medicinal knowledge came into existence. Early written descriptions are often ambiguous and the confusion of plant names in ancient documents makes the image essential to determine the precise species involved plus providing information on the presence of morphological characters that may be unclear from the text.[12] The question should be raised how we might recognise and integrate historical evidence offered by knowledge that is 'non-disciplined' and often described as "'indigenous', 'traditional' or 'folk' ways of knowing .These 'alternative' knowledge forms may have valuable information about histories of plant transfers and environmental change in regions and places. They may be mentioned in passing in folk legends and nature myths in some environmental history narratives. Environmental histories of botanical exchanges need to develop new analytic perspectives that look for evidence outside the conventional archival sources or socio-ecological models of biological 'imperialisms' and 'invasions' [24]

New scientific breakthroughs in analyzing ancient plant DNA may provide even further clues in the area of plant transfers. As mentioned before, comparisons of plant usage and transfer can be obtained through direct evidence from iconography, oral and written records and archaeological discoveries but now the direct identification of species and genotypes can also be gathered through palaeogenetics. Specimens of sclerechyma tissue of fruits or seeds, herbarium samples, woody plants, and even pollen in some cases are candidates for DNA analysis. Analyzing soil diaspore banks can also provide a record of plant histories within several centuries. Pollen, as with trichomes, are used for identifying species; however, unlike trichomes which can deteriorate over time, the outer walls of pollen grains are more resistant to chemical and physical assault.[25] Palaeogenetics, therefore, in combination with historical literature, records, artifacts, iconography, and other remnants from the past with current biological and botanical data, could shed new light on the history of ancient medicine as to where and when this mysterious knowledge of healing originated.

The main purpose of this research is to examine three species of Hibiscus: *H. sabdariffa*, native to Africa; *H. rosa-sinensis*, native to China; and *H. syriacus*. These species were selected due to their similarity in medicinal use, namely Hibiscus tea, which is made from the red calyces of the *H. sabdariffa*. While many species of the Hibiscus do have red calyces, not all of them have been for medicinal purposes. Therefore, basedon historical records, the floral anatomy was examined. Specifically, floral organ development and leaf trichomes. This detailed anatomical study revealed the potential identification of the hibiscus species depicted in the available iconographical and archaeological record. The study also helped to identify the possible hibiscus species mentioned in historical documents when botanical images were not available or the images were not detailed enough to identify. Thus, the results showed that the medicinal and topical use of the three species of Hibiscus studied - *H. sabdariffa, H. rosa-sinensis* and *H. syriacus* - could be substantiated as the floral anatomy does show presence of trichomes, especially on the calyces. The anatomical study revealed detailed features that helped to better identify the Hibiscus species depicted in Li Ti's paintings as well as other archaeological and historical iconography. This study showed that non-native species most likely were introduced several hundreds of years before the present using known horticultural techniques at the time of their introduction.

Materials and Methods

Plant Collection. The specimens of *H. sabdariffa* and *H. rosa-sinensis* were in-ground specimens located at the University of Northern Iowa's Botanical Center (Cedar Falls, IA, USA) greenhouse. Two potted specimens, *H. syriacus* 'Helene' and *H. syriacus* 'Blushing Bride', were purchased from Lowe's Garden Center (Waterloo, IA, USA). It is impossible to compare the exact plants that would have been growing in this regions of the world due to availability, hybridization and other biological factors that may have emerged over time. Therefore, these specimens were selected to represent the closest relative to ancient Hibiscus plants that would have been found in Africa and Asia.

Documentation of General Morphology. Photographs were taken of several views of each plant species: *H. sabdariffa, H. rosa-sinensis, H. syriacus* 'Helene' and *H. syriacus* 'Blushing Bride' on the first day of the study (June 5, 2017). Closeups included closed calyces, leaves, and overall presentation of the plant. Photographs were taken as flowers emerged, including branches showing developmental progressions of calyces to opened flowers.

Specimen Collection and Preparation. All four plants were photographed at the beginning of the study. Careful attention was given to flowers, calyces, leaves and developmental stages of flowers on each plant. Branches of the *H. syriacus* 'Helene', *H. syriacus* 'Blushing Bride' and *H. rosa-sinensis* that contained several stages of floral development were collected using sterilized pruning shears, tray, damp paper towels to keep specimens moist. A wilted flower from *H. rosa-sinensis* which had fallen at the time of collection was placed on the collection tray and carefully cleaned in the lab with water. Photographs were taken on June 9, 2017 of a spent floral bloom of *H. rosa-sinensis* showing the wilted bloom measured approximately 1 cm wide at the base, 2 cm at the widest section of the closed wilted bloom, and 8.75cm long in length. A photograph of an *H. rosa-sinensis* flower was taken on June 12, 2017 showing the floral specimen measured approximately 8 cm from stem to the base of the calyx with the flower itself measuring approximately 10 cm from the base of the calyx to the tip of the stigmas. A photograph of the *H. syriacus* 'Blushing Bride' flower was taken on June 28, 2017 showing an approximate diameter, or width, of 4 cm.

Specimens not analyzed immediately were preserved in mason jars containing 70% ethanol and then labeled. Specimens that were awaiting dissection and microscopic analysis were placed upon a tray with paper towels moistened in water. The plant specimens retrieved were carefully placed on the tray in between thin layers of the moistened paper towels. Dissection tools included size 4 and 5 forceps, dissecting scalpel, and a single blade razor. Specimens were placed on Kim-Wipe tissues for dissection before being transferred to dry mount glass slides. No slip covers or dyes were used.

Microscopic Analysis. The laboratory portion of the study was conducted at the University of Northern Iowa, Cedar Falls, IA using an Olympus SZX7 compound microscope. The microscope was connected to a Dell Computer using ProgRes Capture Pro software to record microscopic images. Specimens of *H. rosa-sinensis*, *H. syriacus* 'Helene' and *H. syriacus* 'Blushing Bride' were viewed and photographed at various magnifications between 0.8x and 5.0x; the majority of images being viewed between 0.8x and 2.0x magnification. The floral parts, particularly the calyces and reproductive areas, were viewed for signs of trichomes. Floral areas with red pigmentation were examined and photographed. Photos of these red-pigmented areas included plantar cross-sections of the base of the *H. rosa-sinensis*, the petal bases of both *H. rosa-sinensis* and *H. syriacus* 'Helene', and the stigmas of *H. rosa-sinensis*. Interior and exterior sections of the floral reproductive areas of *H. rosa-sinensis* and *H. syriacus* 'Helene' were examined and photographed. Cross-sections of these two species revealing the ovules and ovaries were examined and photographed. Pollen grains on *H. rosa-sinensis* were photographed. Various trichomes on all species of Hibiscus were carefully examined and photographed, including floral anatomies of fresh and wilted flowers of *H. rosa-sinensis*.

Results and Analysis

Figure 6. Mature flowers Photographs of (a) *H. rosa-sinensis* and (b) *H. syriacus* ‘Helene’ taken from the University of Northern Iowa’s greenhouse from the actual plants used in this study. (c) Image of *H. sabdariffa* shown here for a morphological comparison as *H. sabdariffa* blooms were not available during the season of this study. The *H. sabdariffa* image was retrieved from http://www.malvaceae.info/Genera/Hibiscus/rosella4.jpg

The *H. rosa-sinensis* flower shows a strong presence of carotenoids with its vivid orange sepals, bright pink-red style and red stigmas. (Figures 6a and 11a). Despite *H. rosa-sinensis’* presence of red coloring, the calyces of this species, as well as *H. syriacus* ‘Helene’ and ‘Blushing Bride’, had green calyces. (Figures 7a, b and c). The shape of *H. sabdariffa’s* calyx (Figure 7a) was similar to *H. rosa-sinensis* (Figure 7c); however, the epicalyx on the *H. sabdariff*a was much shorter compared to the calyx of *H. rosa-sinensi*s.

(a) (b) (c)

Figure 7. A comparison of calyces. (a) The calyx of *H. sabdariffa* (Swapan 2012). (b) The calyx of *H. syriacus* ‘Helene’. (c) The calyx of *H. rosa-sinensis*.

Evidence for trichomes for around the red-pigmented petal bases was carefully examined. The *H. rosa-sinensis* petal base displayed the brightest red pigmentation. The petal was smooth with no presence of trichomes. (Figure 8a). The petals of *H. syriacus* 'Helene' (Figure 8b) and 'Blushing Bride' (Figure 8c) showed darker, deeper shades of red. Trichomes were concentrated around the base of *H. syriacus* 'Helene' (Figure 8b) while trichomes were present throughout the entire petal of *H. syriacus* 'Blushing Bride' (Figure 8c).

(a) (b) (c)

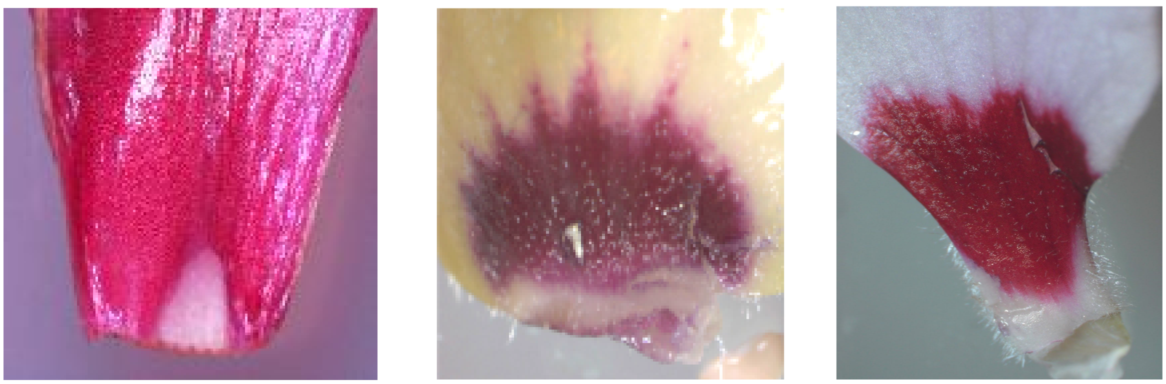


Figure 8. Presence/absence of trichomes at base of petal. (a) *H. rosa-sinensis* shows no signs of trichomes at the base of the petal. (b, c) *H. syriacus* 'Helene' and 'Blushing Bride" shows a presence of trichomes concentrated near the base of the petal. (Magnification = 0.8x)

Presence of red pigmentation was also examined around the floral bud apex of *H. rosa-sinensis* (Figure 9a), *H. syriacus* 'Blushing Bride' (Figure 9b) and *H. syriacus* 'Helene' (Figure 9c). The floral bud of *H. rosa-sinensis* (Figure 9a) showed light red pigmentation throughout the bud while the buds of *H. syriacus* 'Blushing Bride' (Figure 9b) and 'Helene'(Figure 9c) showed red pigmentation only near the apexes. Both buds of *H. rosa-sinensi*s and *H. syriacus* 'Blushing Bride' showed trichomes disbursed over the entire floral bud (Figures 9a and 9b) while *H. syriacus* 'Helene' did not show any presence of trichomes. The surface of this bud was smooth with reflective qualities.

(a) (b) (c)

Figure 9. Stage 1 Floral bud apex. (a) *H. rosa-sinensis* and (b) *H. syriacus* 'Blushing Bride' showing presence of trichomes on the abaxial side of the petals; red pigmentation is lightly distributed throughout the closed floral bud of *H. rosa-sinensis*. (c) *H. syriacus* 'Helene' shows no signs of trichomes on closed floral bud; red pigmentation is minimal at the upper tip of both *H. syriacus* species. (Magnification = 0.8x)

The reproductive centers for *H. rosa-sinensis* and *H. syriacus* 'Helene' were examined and morphology compared (Figure 10). The photos show the centers of both species at similar developmental stages. Each developmental stage of the flower was numbered 1 - 6 with Stage 1 being the oldest and most developed bud to Stage 6 which represented the youngest and smallest buds. The floral centers shown in Figure 10 represents Stage 2 floral development. As mentioned before, strong levels of carotenoids were present in *H. rosa-sinensis* (Figures 10a and 10b). The strong yellow and red coloring of the anthers and stigma suggest daytime pollinators would likely be butterflies and birds, particularly hummingbirds given the shape of the mature flower. *H. syriacus* 'Helene' appeared lacking in carotenoids as the anthers and stigma were primarily a creamy-white color (Figures 10c and 10d). This suggests pollinators would more likely be various nocturnal insects, such as moths, and possibly hummingbirds given the shape of the mature flower. Trichomes are barely visible on the tops of the stigmas (see Figures 10b and 10d).

(a) (b) (c) (d)

Figure 10. Stage 1 Floral reproductive centers showing stigmas and anthers. (a, b) *H. rosa-sinensis* floral centers shows stigmatic papillae that are concentrated on the red stigmas. (b) High magnification of stigma. Both stigmas and anthers show strong levels of carotenoids. (c, d) *H. syriacus* 'Helene' also shows a concentration of stigmatic papillae on the stigmas. (d) High magnification of stigma. (Magnification = 0.8x)

A mature *H. rosa-sinensis* was dissected and the stigma examined for signs of trichomes (Figures 11a-11-e). Pollen grains were attached to some of the trichomes (Figures 11a, 11b and 11d) and found concentrated on the anthers (Figure 11c). The pollen was yellow in color and spherical with small spikes extending out from the pollen grain (Figure 11b). Individual pollen grains were occasionally removed and briefly examined for morphology and texture as both trichomes and pollen grains are used to identify species.

(a) (b) (c)

(d) (e)

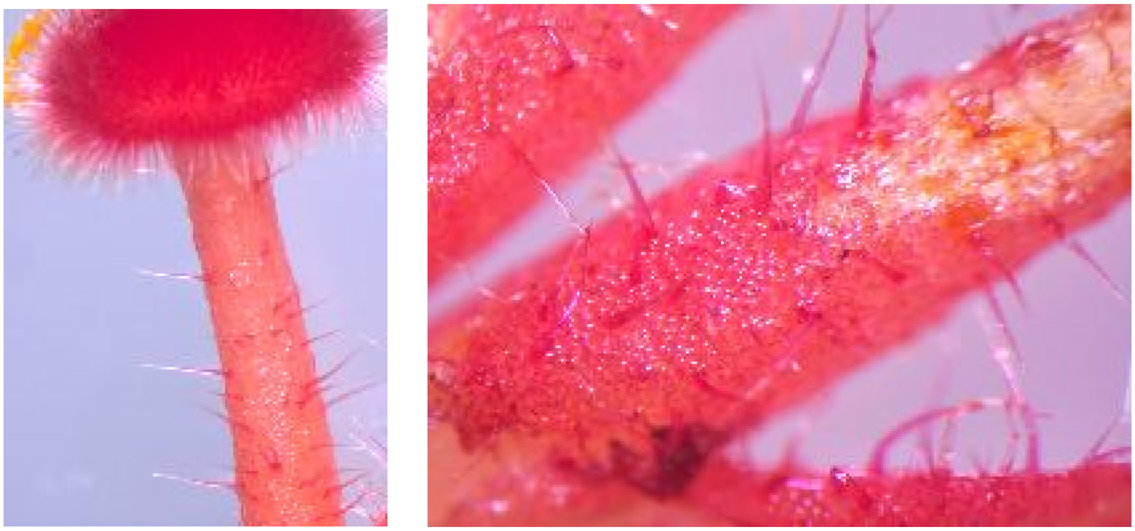


Figure 11. Pollen grains and trichomes of *H. rosa-sinensis*. (a, b) Pollen grains are shown located on the trichomes of the red stigmas. (c) Pollen grains were also found concentrated on the open anthers. (d) Trichomes are shown located on the stalk of the stigma. (d, e). Magnification of 11a, 11b = 0.8x; 11c, 11e = 4.0x; 11d = 1.25x)

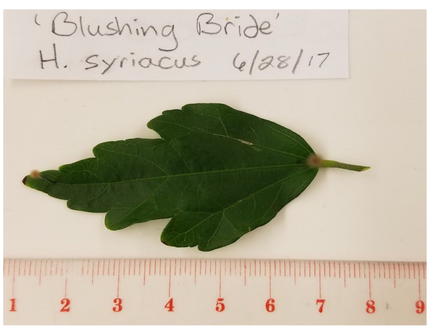
The trichomes on the *H. rosa-sinensis'* stigmas were glass-like silica, semi-clear with traces of red pigmentation. Hibisceae is not known for its fragrance as most of the plant species give off little to no order; therefore, these trichomes are probably not osmophores. Instead, they may be glandular as some species are used for medicinal purposes. The red presence is most likely due to anthocyanin pigmentation and flavonoids. Studies have been conducted on the red anthocyanin pigments from plant sources to test their medicinal benefits, including in the areas of cardiovascular diseases and cancer.[26]

(a) (b) (c)

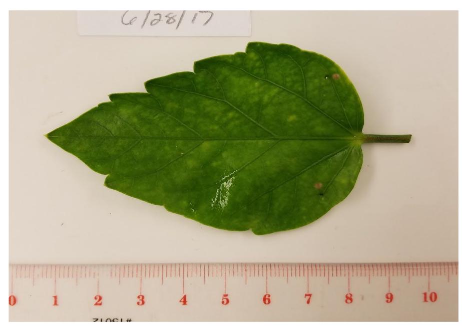
Figure 12. Mature leaf morphology (a) *H. rosa-sinensis*; (b) *H. syriacus* 'Helene'; and (c) *H. sabdariffa*. All plants have simple leaves with marginal serrations (a and b). (c) *H. sabdariffa* leaves have smooth margins.

The mature leaves of *H. rosa-sinensis*, *H. syriacus* 'Helene' and *H. sabdariffa* were photographed on the plant (Figure 12) and individually (Figure 13). Each leaf was examined carefully. This was necessary to establish a basis of comparison for iconographical purposes. All three species have simple leaves with moderate to minimal serrations and arranged alternatively. The specimen of *H. sabdariffa* (Figure 13c) showed leaves that were ovular with small serrations mid point to the tip (Figure 13c). *H. sabdariffa* had the most oblong of the four leaf specimens with smooth margins. The leaf from *H. rosa-sinensis* (Figure 13b) was ovular but wider that *H. sabdariffa* with more pronounced serrations. The leaves on *H. rosa-sinensis* plant (Figure 12a) were more reflective than the other Hibiscus species. Both *H. syriacus* species, 'Helene' and' Blushing Bride', were of a darker green with pronounced serrations and tri-lobed. Of the two *H. syriacus* species, 'Blushing Bride' (Figure 13d) was clearly more tri-lobed than 'Helene' (Figure 13a).

(a)



(b)



(c)

(d)

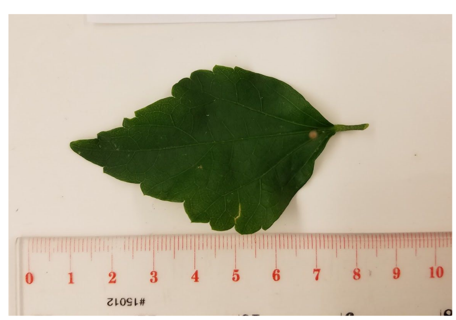


Figure 13. Leaf Specimens. (a) *H. syriacus* 'Blushing Bride'; (b) *H. rosa-sinensis*; (c) *H. sabdariffa*; and (d) *H. syriacus* 'Helene'.

A careful examination of the plants showed some morphological traits present in the paintings by LiTi (Figure 14). The "Rock and Hibiscus" detail painted by LiTi in the 12th century (Figure 14a) shows flowers similar to *H. syriacus* with an emerging bud showing similar coloring (Figure 14b) but the leaves in the painting are five-lobed (Figure 14a) and not tri-lobed (Figure 14c).

(a) (b) (c)

The flowers in LiTi's 'White Hibiscus', signed in 1197 AD, are double-flowered, pale in color with wide, 3- to 5-lobed leaves. The calyces are green and shown close to the flower (Figure 14d). *H. syriacus* 'Blushing Bride' also has double flowers and leaves that look similar in shape. The calyces are also green and close to the blooms. (Figure 14e and 14f). The leaves in LiTi's painting are similar to *H. syriacus*. It is possible there are serrations in the painted leaves but the image does not make that clear. This may be due to the retrieval method or wear from exposure over time. LiTi's painting suggests the Hibiscus depicted in the painting was woody with angled upright growth or a sturdy vine.

(d) (e) (f)

Figure 14. Iconographical comparison of 12th century paintings to *H. syriacus*. (a) “Hibiscus and rock” detail by LiTi during the 12th century Sung dynasty. (b, c) *H. syriacus* ‘Helene’ flower, calyces and leaves show similarities to “Rock and HIbiscus” painting except for the differences in leaf serrations. (d) “White Hibiscus” signed by LiTi in 1197 AD. (e, f) *H. syriacus* ‘Blushing Bride’ showing flowers, calyces and leaves.

Discussion

The origins of ancient medicine and healing practices is mysterious, often becoming the basis for mythological legends and folklore. ‘Nectar of the gods’, ‘bread of angels’, and other terms are sometimes used to describe foods with healing properties. Because healing itself is considered to have sacred roots, it is very difficult to pinpoint medicinal origins from the past. We are left to the archaeological record with its images carved in stone, painted on walls, or perhaps related in some epic poem. Sometimes descriptions of plants are both written and drawn in early ‘medicas’. Since most healing practices incorporate the use of plants with medicinal properties, it seemed fitting to select a common plant-based remedy whose origins span from Africa to Asia: Hibiscus tea.

Hibiscus tea, also known as Roselle or Karkade, is made from the red calyces of the *H. sabdariffa*, a species of hibiscus that is native to Africa. Domestication of Roselle has been traced to western Sudan to over 6,000 years ago.[27] Sudan is adjacent to the south of Egypt, which is significant because the Egyptians have a continuous 6,000 year history of agriculture. The knowledge of Egyptian agriculture and horticulture can be obtained from the archaeological record and supported by surviving written Egyptian documents, temple inscriptions, and commentaries from the historian Herodotus (484-425 BC), the philosopher Theoprastus (372-288 BC), and the books of Genesis and Exodus from the Hebrew Bible.[13] It would not be unreasonable to suggest that the Sudanese could have learned agriculture and domestication from the Egyptians, given the proximity of their countries. There is ample archaeological evidence of domestication for both regions dating to around 4,000 BC. By domesticating crops, a culture can control the amount and availability of a desired plant species. Plants will reproduce provided the conditions necessary for germination are met. Iconography from ancient tomb murals, temple reliefs and other archaeological artifacts suggest early Egyptians had the knowledge and capability to not only grow a variety of crops but also import new species. Dr. Jules Janick (Purdue University) points out in his research that Egypt was an aggressive culture who "continuously incorporated technology as well as new crops from the Fertile Crescent (present day Israel, Jordan, Lebanon, Syria, and Iraq) as well as Africa."[13] While *H. sabdariffa* is native to many tropical conditions, it is primarily grown in western Sudan, particularly in Kordofan and Darfur using traditional farming methods exclusively under rainfed conditions. Sudanese farmers consider "karkade" as famine food because of its hardiness under harsh growing conditions.[31] The northern part of Nigeria has cultivated and distributed *H. sabdariffa* due to its favorable climate.[32] Since the seeds of this hibiscus species can easily be grown from seeds, *H. sabdariffa* would have, therefore, made an excellent candidate for trade as it could have been transported in seed form across land and possibly by sea.

There is evidence that ancient Egyptians did transport plants in various forms. During the 20 year reign of Queen Hatshepsut of Egypt (1473-1453 BC), she had commissioned many expeditions to explore new lands and traded with other cultures. One of these cultures was Punt. A wall relief in the temple of Queen Hatshepsut at Deir el-Bahir in Egypt shows the queen's fleet landing at Punt off the northeastern coast of Africa with exotic merchandise, including potted myrrh plants.[14] Myrrh (*Commiphora myrrha*) produces an aromatic resin that is used for medicinal and religious purposes. The Ebers Papyrus, thought to have been discovered in the necropolis outside of Thebes, provides evidence that Egyptians used myrrh for medicinal purposes. Myrrh (*Commiphora myrrha*), like *H. sabdariffa*, is a shrubby tree native to the eastern Mediterranean, Ethiopia, Somalia, and the Arabian peninsula.[34] It is plausible that if small trees were imported by boat from nearby countries, hibiscus varieties such as *H. sabdariffa* may have eventually been exported for trading purposes for as much the same manner and reason as myrrh.

The main trade routes used by ancient civilizations were the Silk Routes and Spice Routes. The Spice Routes were also known as the maritime Silk Routes. Spices from China, such as cinnamon, were transported to the Middle East using the Spice Route as far back in time as 2000 BC. Cinnamon is made from the inner bark of *Cinnamomum verum,* which is considered "true" cinnamon. It is interesting to note that cinnamon, myrrh and hibiscus are all wooded plants prized for their religious and medicinal value. Both myrrh and cinnamon were transported along maritime passages. These routes start as far northeast as the Korean Peninsula, follow along the Chinese coastline to the Indian Ocean in the Bay of Bengal, head east through the Arabian Sea, travel northwestward through the Red Sea along Sudanese and

Egyptian coastlines and finally end westward into the Mediterranean Sea. Traveling such long distances with valuable plant cargo is astonishing given the amount of humidity from seawater and changes in climate. It may be that the ancient Chinese, Arabs and Egyptians used their advanced technology with plants to develop a way to preserve plant specimens in various forms such as bark, seeds, dried, leaves, etc. for trade. The Spice Route may help to explain how cultures throughout Southeast Asia, the Middle East and Africa all use Hibiscus tea. Given the long distance between Egypt and China, it would be more feasible to transport seeds versus potted plants. Many spices come in seed form such as sesame. Seawater may corrupt the viability of some seeds to sprout but if the seeds were placed in large containers, it is possible the seeds in the innermost part of the container could stay dry enough to germinate under the right conditions.

Evidence that tea was used and perhaps transported as far north as the Tibetan Plateau by way of the Silk Route emerged in 2015. Traditional tea is made from the dried leaves of the *Camellia sinensis.* It would have been transported in much the same way as other spices often come dehydrated. Dehydration would be necessary to prevent spoilage from mold and bacteria. Using new technology to analyze DNA through chemical biomarkers, remnants of tea (*C. sinensis)* were found at the Han Yangling Mausoleum located north of Xi'an. The Chinese traded with Tibetans for medicinal plants as far back as the Tang Dynasty (618-907 AD); however, consumption of tea has been traced back to 59 BC during the Western Han Dynasty.[22] It is during the Han Dynasty that the Silk Route began to be established, beginning as far east as Xi'an, China and expanding as far west as Genoa, Italy near Rome. There are recorded trading routes in addition to the Silk Route linking Xi'an to eastern seaports, such as those in the Shangtung Peninsula, Quanzhou, and Guangzhou. As DNA testing becomes even more refined, paleogenetics may be able to link the use and trade of tea from Xi'an to ancient ports along the trade routes. The DNA testing used on the plant remnants at the Han Yangling Mausoleum was able to identify the species as *C. sinensis.* This is a significant breakthrough in technology because if paleogenetics is able to identify a particular species of plant, it is then possible to revisit other archaeological sites along the Silk and Spice Routes and test any available plant remains to trace the journey of medicinal plants across ancient cultures by identifying them through biomarkers, thus helping to ascertain their possible origins.

The use of trichomes in this study was for identificational and functional purposes. According to U.A. Essiett and E. S. Iwok, the "presence of various types of glandular and eglandular trichomes is a characteristics feature of the genus *Hibiscus*. Scientific interest in plant trichomes is based on their functional and taxonomic importance and on the economic usefulness of some trichome-generated products; in that the presence or absence of peltate hairs and their form, size and color could be used in distinguishing between genera and species, but also their corresponding parts, thus being important in pharmacology, archaeobotany, paleobotany and agronomy."[12] Trichomes were observed using microscopy as they are visible epidermal hairs which can produce chemicals associated with the plants medicinal properties or its fragrance.[9] The stigmas of the *H. rosa-sinensis*, for example, were red with trichomes (stigmatic papillae) concentrated on the tips. Higher magnification provided more detailed information on cell patterns and red pigmentation often due to anthocyanin, a flavonoid. Flavonoids, with their antioxidant properties, make up 20% of the *H. sabdariffa's* calyces.[40] In many cases, trichomes can be observed without the need for a microscope. Both trichomes and pollen grains can be used to determine a particular plant species; however, individual pollen grains cannot be seen without the use of an electron microscope.

Today's technology in the laboratory can reveal many characteristics of trichomes, especially with microscopes and computers, but early cultures, especially before the common era, would have less advanced tools at their disposal. Ancient tradesmen from Egypt and China may have instead used primitive lenses to observe plants. The oldest lens found so far is the Nimrud Lens, dated to 750-710 BC. Austen Henry Layard discovered the Nimrud Lens in the area of the ancient Assyrian city of Kalhu around the Nineveh plains in northern Mesopotamia.[37] Layard dismisses the lens as simply an ornamental piece of glass, but H.C. Beck challenges that assumption. He claims it has only be assumed that magnifying glasses are a recent invention. A lens is simply a polished piece of glass with a curved surface. A mirror, also called looking-glass, is a reflective surface that is also made from glass with the oldest found made from ground and polished obsidian (a volcanic glass). These first known mirrors of antiquity were recovered near Konya in south central Turkey. They have been dated to approximately 6,000 to 5,900 BC and had surfaces which were slightly convexed.[39] Technology was available to ground and polish glass with curved surfaces 2,000 years before Egypt or China established an advanced agricultural system. It is possible, therefore, that magnifying glasses of a primitive nature may have been used to look for distinguishing features on plants to identify and separate them into specified groups and uses. Differentiating between safe and poisonous plants would have been critical as many look similar at first glance, much like the coral and milk snakes.

Iconography is another important tool to trace botanical origins. Looking at images of plants and comparing them to real plants proved helpful when examining artwork containing hibiscuses. The "Rock and Hibiscus" detail painted by the Imperial Chinese painter LiTi was of primary focus in this study. It is the oldest Chinese pictorial representation of a hibiscus, painted in the 12th century during the Sung Dynasty. The painting shows a cat perched upon a limb of a plant identified as a hibiscus. LiTi is not one of the more prominent Chinese dynastical painters, but his work is of importance to this study because of three of his paintings: "Rock and Hibiscus", "White Hibiscus" and "Red Hibiscus". No date is assigned to the first painting but the other two are signed by LiTi in 1197 AD. Little is known about LiTi outside of Richard Edwards' biography of the artist. Edwards recorded that LiTi served under four emperors and "was skilled in painting flowers and birds, bamboo and rocks, indeed, quite capturing their essential life" working through to the end of his life to "affirm the endlessly fascinating reality of tiny carefully selected subjects, the continuing ability to recapture their significant life."[35] This is significant when using iconography to identify the hibiscus plants in LiTi's paintings.

At first glance, the flowers in the "Rock and Hibiscus" painting look very similar to *H. syriacus*. The base of the petals have similar dark pigmentation, though the pattern of the contrasting pigments are slightly different. However, the leaves in LiTi's painting are 5-lobed leaves with clearly serrated edges whereas the leaves in the *H. syriacus* species tend to be 3-lobed and not as clearly serrated. This was the case with the two species of *H. syriacus* in this study. *H. sabdariffa* can have leaves ranging from shallow to deeply palmated and can be 3-, 5- even sometimes 7-lobed in shape.[36] This leaf morphology matches the leaves depicted in LiTi's painting; the flowers of the *H. sabdariffa* species, though, are not a match as the *H. sabdariffa* flowers have pale yellow petals, with an occasional pink or red suffusion, and a single dark red eye.[33] The hibiscus in the painting shows flowers with red pigmentation at the base of each petal, not a continuous pattern of red to form a "single red eye". Many other pictorial images of hibiscus varieties were compared but no exact match was found. This could be explained by the deliberate or unintentional cross-hybridization of various hibiscus species. Around 404 alien plant species in 32 provinces have been introduced into China. Of those, three-fifths of the alien plants were intentionally introduced from 139 BC to the current time.[37] It may be possible that the painting of LiTi's "Rock and Hibiscus" represents an earlier ancestor to either *H. syriacus*, *H. sabdariffa*, or a similar hibiscus species. It is also quite possible that the plant LiTi painted was not a true hibiscus at all but a plant with similar features.

Even though *H. rosa-sinensis* is said to be native to China, *H. sabdariffa* and *H. syriacus* have now been cultivated in China: *H. sabdariffa* in Fujian, Guangdong, Hainan, Taiwan and Yunnan;[29] *H. syriacus* also in Fujian, Guizhou, Hainan, as well as Hebei, Henan, Hubei, Hunan, Jiangxi, Shaanxi, Shandong, and Xizang;[30] and *H. rosa-sinensis* in Fujian, Guangdong, Guangxi, Hainan, Sichuan, Taiwan, Yunnan. Without recorded dates of plant introductions or discoveries, it is very difficult to determine whether the plant arrived intentionally through trade and exploration or accidental transfer. *H. sabdariffa* is known by many names throughout Africa (e.g. Sudan, Mali, Egypt, Gambia, Senegal, Burkina Faso, Ghana, Benin, Guinea-Bissau, Niger, Zambia, Nigeria) and Asia (i.e. China, Thailand, India, Iran, Malaysia). All of these regions were part of the Silk and Spice routes. It is very possible that pollen from one region may have been transferred to another through traveling merchants. It is also possible that the Chinese, like the Egyptians, created plant gardens for ornamental and agricultural purposes. Defining medicinal plants as agricultural or ornamental poses a challenge as some medicinal plants, such as *H. sabdariffa*, can be grown for trade and thus categorized as medicinal. The hibiscus is often included in gardens as a showcase specimen, so it might be considered ornamental.

Conclusions

The use of plants for medicinal purposes dates back several millennia. Tea is perhaps one of the oldest forms of plant medicines. Hibiscus tea is no exception. Herbal infusions made from *H. sabdariffa* have been used throughout Africa, Asia, the Middle East and the subcontinent of India. While many herbal treatments may have arisen through local knowledge by healing practitioners, it is possible that some were introduced through trade using land and maritime routes such as the Silk and Spice Routes. Dating the usage of herbal teas such as hibiscus tea is possible through new technologies in paleobotany and plant archaeology. Revisiting excavations of ancient civilizations and applying both DNA testing for residual traces of botanical masses and iconography to identify botanical taxa from carved reliefs, pottery, paintings, etc., could provide additional knowledge as to the origins of traditional medicines of the past as well as today.

There is still much work to be done. Future research will include comparing the medicinal background of Imhotep, the Father of Egyptian medicine, Askeplios (Asclepius), the god of Greek medicine, and Shennong, the Father of Chinese medicine. All three are considered both mythical and historical in their respective cultures. The Ebers Papyrus, The Shen Nong Ben Cao Jing (translated as The Divine Farmer's Materia Medica) and the origins of Greek medicine leading up to Dioscorides De Materia Medica will be examined for similarities. The ancient trade routes will continue to serve as a guide to see if it was indeed possible that ancient cultures would have traded medicinal goods. Further research into the idea that medicinal knowledge itself would have been considered tradeworthy will be investigated. This study shows that the possibility of early cultures exchanging medicinal knowledge, materials and plants exists. As we look deeper into the ancient past, the knowledge we gain may shed light into new ways of looking at healing practices both then and now. Perhaps the secret to curing diseases, such as cancer, are found in the sands of time and are simply waiting to be rediscovered.

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