Date Palm Byproducts: History of Utilization and Technical Heritage

Hamed El-Mously and E. A. Darwish

Abstract The date palm abundantly exists in North Africa, The Arab Peninsula and Iran. The first emergence of date palm dates back to 4000 B.C. in Mesopotamia. This long history, along with the high renewability rate, has led to the accumulation of a rich technical heritage associated with the utilization of all the secondary date palm products, including whole leaves (midribs, leaflets), petioles, spadix stems, coir, date kernels and trunks. Midribs have been used in roofing, fencing, furniture making, and manufacturing crates and coops. Leaflets have been used in making mats, baskets and bags. Coir has been used in making ropes, nets, bags, brooms and fly whiskers. Spadix stems have been used in making brooms and household sieves. In addition, fibers obtained from spadix stems have been used for tying agricultural crops. The palm trunk has been used as windows lintels, beams and columns in construction. Moreover, trunks have been used as a wood substitute in furniture making. This chapter reveals the technical heritage associated with several traditional uses of the secondary date palm products to satisfy the human needs in the Arab region. In addition, geometrical description of these secondary products and the procedures of their preparation are included.

Keywords Date palm · Traditional handicrafts · Midribs · Coir · Spadix stem

1 Introduction

The local materials are the material milieu by virtue of which cultures were able to express themselves. Proceeding from the historical perspective, the different cultures of the world were born and developed in company with different materials. Who could deny the relation between the ancient Egyptian culture and papyrus, lotus,

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lime stone and granite, nor between the Asian cultures and bamboo, rattan and rice? It is extremely important to capture the relation between culture and local materials as an important asset for development. The linking between development and local materials means that you are building on the existing culture of interaction with these materials, i.e., you are not beginning a development from a zero datum, but with what people—members of each local community—have at hands (the local materials), as well as in minds (psychological familiarity with these materials, and technical heritage, associated with their production, manufacture and use in the different walks of life). In this concern the date palm (Phoenix Dactylifera L.), represents an eloquent example. It is an authentic element of the region's flora, which accompanied our historical march for thousands of years.

As a resource, the date palm could be seen as a system of renewable materials including the primary and secondary products. The date palm is associated with a very rich technical heritage being a product of thousands of years of accumulated expertise of interaction between the diverse local communities and the date palm material system for the satisfaction of various basic material needs.

This technical heritage includes appropriate technologies that may be of contemporary value for peasants in rural areas such as preservation of date in clay jars as food for the whole year and the use of palm midribs and trunks in roofing. In addition, the technical heritage represents a software of its own right, resounding a world of adaptation with the environment and cultural expressiveness, and thus; inspiring to think, imagine and innovate in harmony with the environment and culture.

2 Date Palm: A Basic Element of the Flora of the Arab Region

It may be difficult to record the first emergence in history of the date palm (Phoenix dactylifera L.), but it was well known 4000 years BC, where it was used to build the moon temple near to Ore, south of Iraq (Johnson 2011). The second proof of the deep-rootedness of the date palm comes from the Nile valley, where the date palm was taken as the symbol of the year and the palm midrib as a symbol of the month in the hieroglyphic Egyptian language. But the cultivation of the date palm in Egypt was 2000–3000 years later than Iraq.

The date palm was one of the pivots of economic and, hence, social and cultural life in this region from ancient times. In ancient Egypt the heads of pillars in temples were made resembling the growing top of the date palm. The date palm appeared frequently on walls of temples in different contexts revealing its significance in life in Egypt. The palm leaves were fundamental in ancient Nubian and Upper Egypt houses. The roofs were constructed by split palm trunks and leaves and the interior walls were covered by palm leaves ornaments (Azzam 1960). Until now, date palm constitutes a basic element in several surviving traditions in Nubia and South Egypt, where a palm tree is planted every time a child is born (El-Mously 2001). So when

he becomes an adult, the date palm will has grown into many palms that will be the basis of his new life after marriage. As a result, date palm has played a major role in the formation of the culture and heritage in Egypt until the present day (Bekheet 2013).

Economically, date palms are a major part of the life-supporting plantations in every village in Upper Egypt (El-Mously 2001; Bekheet and Elsharabasy 2015). Moreover, the annual products of date palm are being utilized in many traditional crafts by the cultivators and craftsmen in Egypt (Darwish et al. 2019b); thus playing a huge role in sustaining the rural societies against the immigration to urban cities, as date palm related crafts and cultivations support over one million families in Egypt (Bekheet and Elsharabasy 2015).

Thus, the significance of date palm does not only depend on the multiple uses of the fruit in food, spirits, pharmaceutical, cosmetic and medicinal products, but also on the large number of the secondary products that have been widely used in construction and handicrafts(Bekheet and Elsharabasy 2015). Palm midribs and trunks have been used for roofing in a fashion that still survives in the western oases and the poor rural areas in Egypt (Ahmed 2014; Darwish et al. 2019b). Hence, the technical heritage associated with the products of date palm pruning is still thriving as their cheapness and abundance qualified them to be the favorable raw materials for several traditional industries with a know-how that goes back to ancient Egypt (Darwish et al. 2019b).

This technical heritage thrives only because of the high adaptability of date palm in the Arab region environment. The date palm can survive in a wide range of temperature from −15 to 60 C (Barreveld 1993). Direct sunlight helps palm leaves become stronger, taller, and thicker and helps them grow faster (Zaid and de Wet 2002; El-Mously 2018). Moreover, a date palm provides shade and protection for crops and tolerates high levels of heat and salinity as date palm cultivation is found along the seashore in Egypt (El-Mously 2001). In addition, date palms need less water and maintenance and are less prone to diseases than other trees (El-Mously 2001). Thus, the date palm has represented an eloquent example of the sustainable use of renewable material resources as illustrated in Fig. 1.

3 Distribution of Date Palms in the World

The historical roots of date palms cultivation still have a huge impact on the present situation of date palm distribution in the world. Historically, date palm cultivation originated in Iraq (Munier 1973). Now, the Sahara, North Africa, the Arab Peninsula and Iran acquire the most dense date palm plantations in the world as shown in FAO world map of the annual date production (Barreveld 1993). Latest FAO statistics of the number of date palms showed that Saudi Arabia, Algeria, Iran, Iraq and Egypt hold the highest ranks in date palm numbers in the world as shown in Fig. 2 (El-fadda and Abu Ayana 2017).

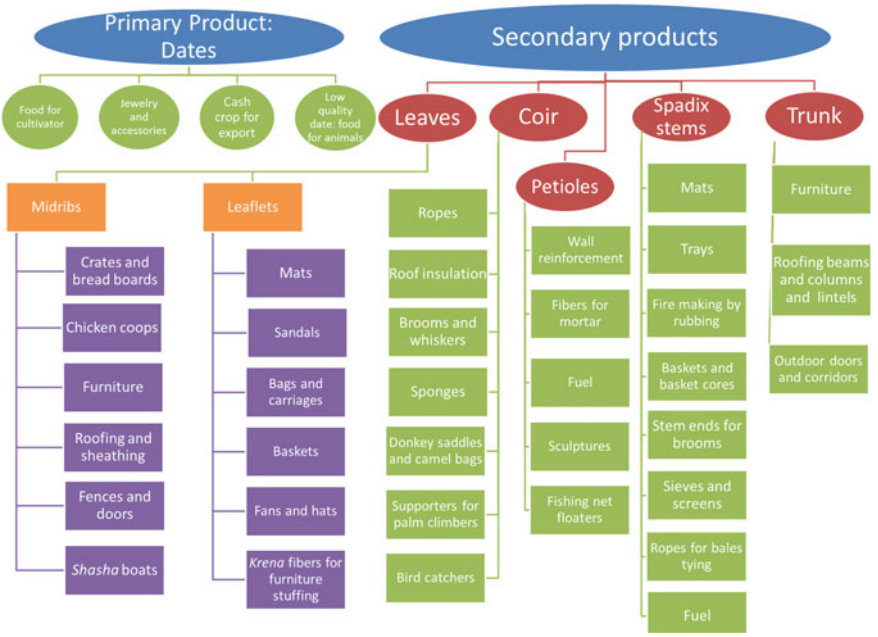

Fig. 1 Traditional Forms of Using Date Palm Byproducts

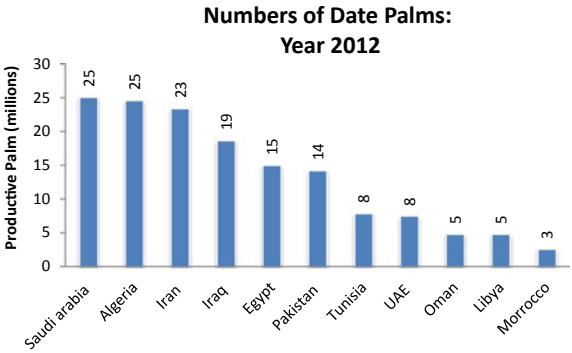

Fig. 2 Distribution of date palms in the world (El-fadda and Abu Ayana 2017)

4 Date Palm Byproducts

Date palms (Fig. 3) can live up to 100 years and over, reaching the height of maximum 24 m.

Fig. 3 A date Palm

4.1 Benefits of Pruning

In average, 13 leaves, 13 petioles and 7 bunches are cut per date palm in the annual pruning process (Agoudjil et al. 2011). Annual pruning is necessary for the following (Bekheet 2013):

- Achieving the most suitable symmetry to guarantee the upright standing of the palm.
- Removing abnormal and dead tissues that may take the nutrition from the fruits.
- Stimulating fruit production and flowering necessary for pollination.
- Decreasing the threat of catching fire when the leaves become dry.
- Getting rid of dry and yellow leaves especially if they were infected.
- Removing the thorns and excess leaves that would obstacle the processes of pollination or harvesting.
- Allowing the sunlight reach the fruits for high quality of the photosynthesis process.
- Collecting the products of pruning that represent abundant raw materials for several traditional forms of utilization.

Fig. 4 A climber works on removing excess leaves during the pruning process while supported by a climbing belt made from date palm coir

4.2 Timing and Procedure of Pruning

The annual time of pruning varies from a place to another, but is mainly one of those 3 timings: in autumn after the harvest, in the beginning of spring in the pollination time, and in the ripening time of the leaves in the summer.

Special and trained workers usually perform the annual process as shown in Fig. 4. It begins with the removal of the 3-year old dry leaves using a sharp knife. The cutting should be 10–12 cm above the petiole and the cutting direction should be down-up so the slope of the petiole would expel rainwater.

4.3 Products of Pruning of the Date Palm

The products of the annual pruning process of the date palm are as follows.

4.3.1 Date Palm Leaves

12–15 new leaves are formed annually by a date palm (Barreveld 1993). The life of each leaf ranges from 3 to 7 years (Zaid and de Wet 2002). The length of the palm leaves ranges from 3 to 6 m (Zaid and de Wet 2002). Naturally, each fruit cluster of weight of 8–10 kg is supported on one leaf (Zaid and de Wet 2002). Annual pruning procedures remove the dry leaves in order to provide better access for the crown for harvesting, in addition to save more nutrition for the fruits (Darwish et al. 2019a, b). A whole date palm leaf is shown in Fig. 5.

At the location of the palm leaf near to the trunk, there are sharp spines with lengths that can reach up to 20 cm (Zaid and de Wet 2002). These spines are usually used as sewing needles in traditional weaving (Barreveld 1993; El-Batraoui 2016). The spines taken from three leaves are shown in Fig. 6.

Fig. 5 A Date palm leaf

Fig. 6 Spines taken from 3 leaves

Fig. 7 A date palm midrib

4.3.2 Date Palm Midribs

The dominance of date palm midribs over the total quantities of the products of pruning granted them a well-developed surviving technical heritage in traditional handicrafts and architecture in Egypt and the Arab region (Eldeeb 2017; Darwish et al. 2019b). Midribs are the main ribs of the whole leaves. They extend from their root at the trunk to the last leaflet (Barreveld 1993). The base begins with a triangular shape and the cross section becomes narrower and less triangularly shaped with higher density towards the upper end of the leaf (Barreveld 1993; Elmously 2005). A date palm midrib is shown in Fig. 7. Curved bases of the midribs are often trimmed and used as fuel resource (Barreveld 1993). The curved base and its cross-sections are shown in Figs. 8, 9 and 10.

4.3.3 Date Palm Leaflets

Each leaf contains 120–240 leaflets (Barreveld 1993). Leaflets are used in woven baskets, ropes, mats, fans and sandals. Date palm leaflets are shown in Fig. 11. Date palm leaflets collected from three leaves are shown in Fig. 12.

4.3.4 Date Palm Spadix Stem

Spadix stems are the trimmed stalks of an empty date bunch. The stems grow carrying the relatively heavy weight of the date (El-Mously 2001; Barreveld 1993). As a result, the stems adapt by acquiring notable a high tensile strength and a high fiber ratio (Barreveld 1993). In addition, the fibers in a spadix stem are long and preferred as the main material for several traditional uses (El-Mously 2001). A date palm spadix stems, cross-section of the spadix stem are shown in Fig. 13 and Fig. 14 respectively.

Fig. 8 Base of midrib

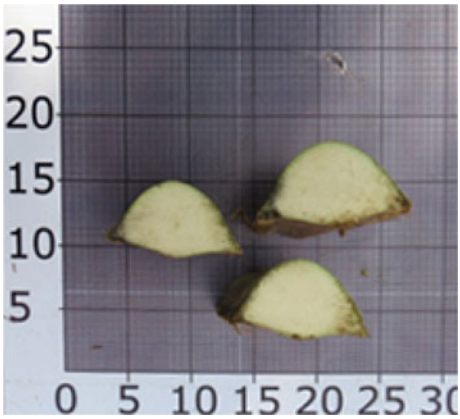

Fig. 9 Cross section at the beginning of the base of the midrib

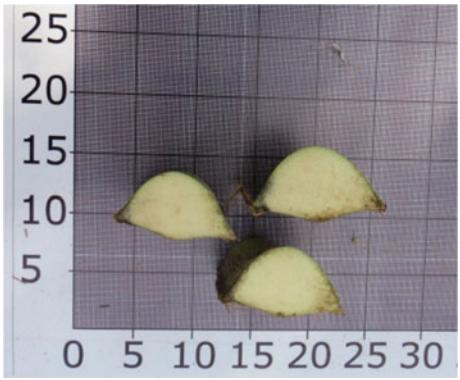

Fig. 10 Cross section at the end of the base of the midrib

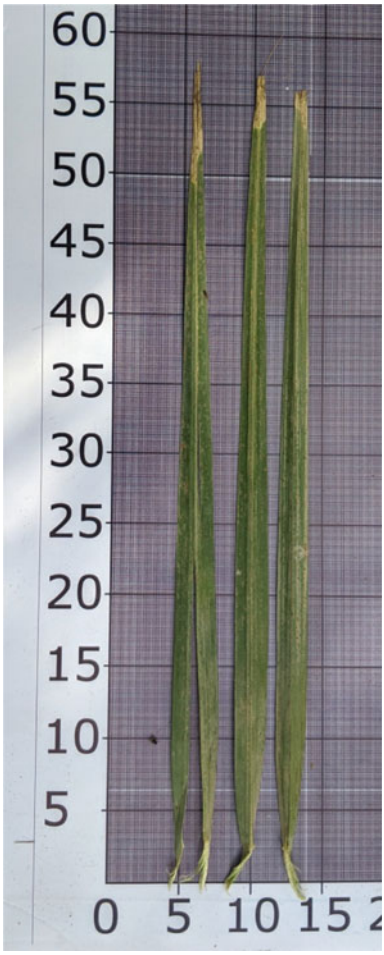

Fig. 11 Date palm leaflets

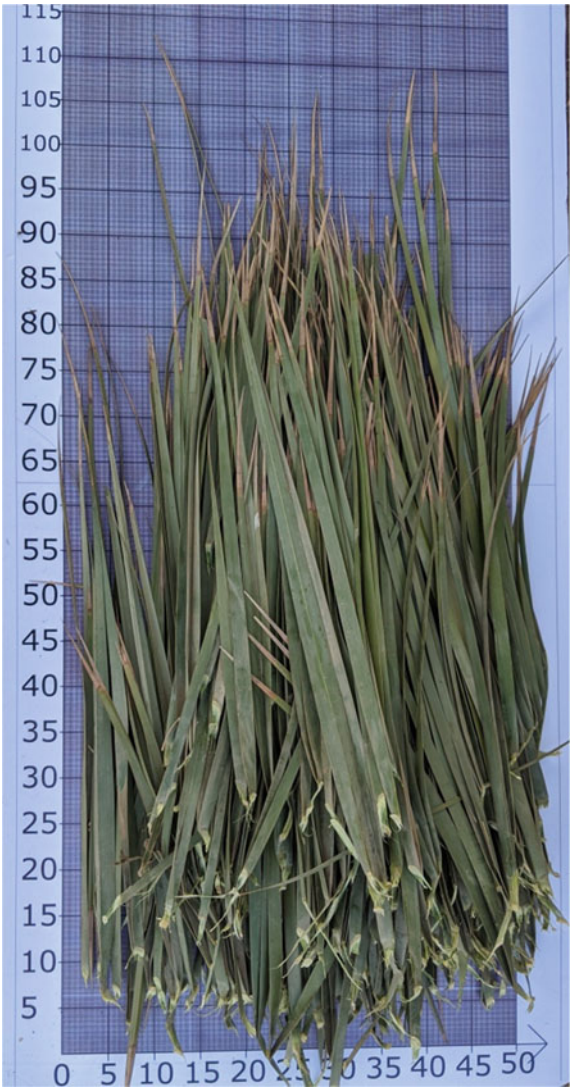

Fig. 12 Date palm leaflets collected from 3 leaves

4.3.5 Date Palm Coir

Coir originates from the tender tissue that covers the new date palm leaves as they come out and grow (Barreveld 1993). After the growth, the tissue remains attached to the trunk of the palm. This tissue turns into a brownish coarsely—woven fabric, the coir, after drying and can be torn away during the annual pruning (Barreveld 1993). It is used for protecting the newly planted offshoots, shadings, brushes and fishnets. Date palm coir is shown in Fig. 15.

Fig. 13 A date palm spadix stem

4.3.6 Date Palm Petioles

A petiole is the base of the leaf that is left after pruning on the trunk (Barreveld 1993). This leaf base is usually trimmed and removed after drying during the pruning process in the next year. The petioles lack high density that is needed for durable applications (Zaid and de Wet 2002). A date palm petiole and cross-sections are shown in Figs. 16, 17 and 18.

4.3.7 Date Kernel

Date kernels are the pits of the dates. They constitute about 10% of the weight of the fruit (Almana and Mahmoud 1994). Their sizes and colors vary according to the type of cultivar (Barreveld 1993). Fresh seeds are used for breeding and propagation,

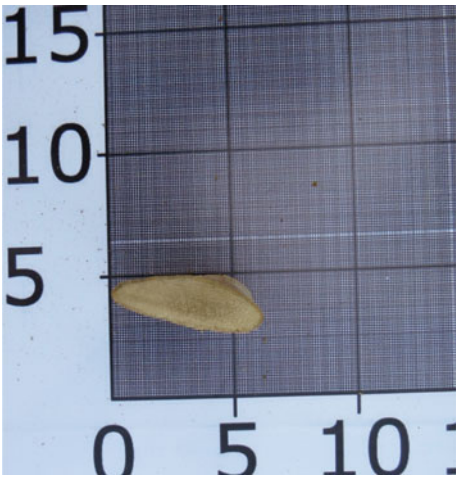

Fig. 14 Cross section of a date palm spadix stem

Fig. 15 Date palm coir

animal feed for their high dietary fiber content such as phenolic acids and flavonoid (Peterson and Dwyer 1998; Mirghani et al. 2012). The palms grown by seeds are of unknown species. They represent approximately 27% of the whole number of palms in Egypt (Bekheet and Elsharabasy 2015). A pair of date kernels is shown in Fig. 19.

Fig. 16 Date palm petiole

Fig. 17 Cross-section of the beginning of the petiole

4.3.8 Date Palm Trunk

The availability of palm trunks depends on the end of the useful life cycle of the tree. The trunk is the vertical and cylindrical stem of the palm. It consists of tough vascular bundles glued together with cellular tissues (Zaid and de Wet 2002). Hence, the trunk is covered with the bases of the old dry petioles; however the surface of old trunks is mostly softened by the weather (Zaid and de Wet 2002). Date palm trunks are shown in Fig. 20.

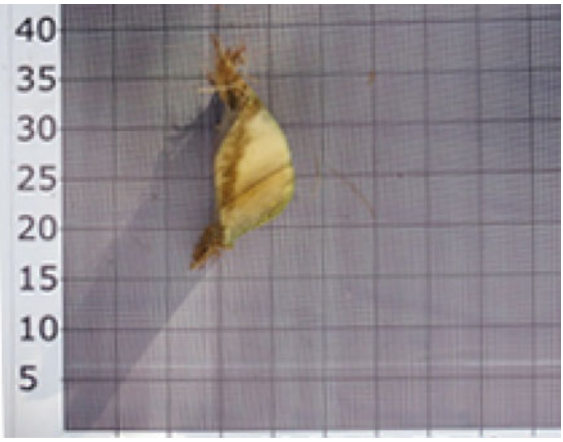

Fig. 18 Cross-section of the end of the petiole

Fig. 19 A pair of date kernels

4.4 Estimation of the Quantities of the Annual Pruning of a Date Palm

Date palm products of annual pruning include the midribs, the leaflets, the spadix stems, the coir and the petioles (Elmously 2005). In addition, date palm trunk is considered a valuable byproduct that is mostly used as a substitute of timber (Elmously 2019). In the Arab Gulf region, the annual pruning process produces the average of 6–8 leaves. The weights of the whole leaf, petiole and spadix stem are

Fig. 20 Date palm trunk

0.43 kg, 0.50 kg and 0.50 kg respectively. In Egypt, the quantities of the products of the annual pruning and percentages are shown in Table 1.

Table 1 Products of the annual pruning of date palm (Siwi Species) (10% moisture content-air dried mass) in Egypt (El-Mously 2001)

Quantity available annually	Palm midribs	Palm leaflets	Spadix stems	Coir	Petiole	Total (Kg/palm)
Per palm, dried Kg (mature female)	15	14.6	9	1.56	14	54.2
Percentage	27.6	26.9	16.6	2.8	25.8	100

According to the data shown in Table 1, the quantities of the products of annual pruning of date palms in Egypt pruning are estimated to be approximately 810 thousand tons, which represents a huge material base for a wide spectrum of industries.

5 Traditional Forms of Palm Leaves Utilization

5.1 Traditional Wickerwork Wall Construction

Previous studies predicted that the roofs of the small houses of the workers in ancient Egypt were made of mats of whole palm leaves rows covered with a paste of mud that was so thick that it could be rain-proof (Azzam 1960; Darwish et al. 2019b). This wickerwork technique is still used till now in some rural houses in Egypt.

The plan of the early Egyptian house of a worker was about 3 * 5 m, with walls of a wickerwork of palm leaves that were coated on the inside and outside with mud paste. The maintenance of the gaps that would form as the mud gets old were filled over and over with more layers of mud until the thickness of the walls would reach 20–30 cm as shown in the excavations (Azzam 1960). In a similar manner, the roof was covered with whole palm leaves and straw, with a cover of beaten earth mud (Darwish et al. 2019b). The sole function of the roof was to shelter from heat, sun and dusty winds, regardless of the rain which was considered too scarce to build a more costly type of roof (Azzam 1960; Darwish et al. 2019b). This type of roofing and walling can still be found in some houses in poor rural villages in Egypt.

5.2 Simple Outdoor Sheathing

The roots of using date palm leaves, in layers over a secondary net for roof and wall sheathing, extend back in traditional rural huts that can be seen today in Egypt and UAE (Darwish et al. 2019b).

In that type of wall sheathing, structural nets, made from reeds or date palm midribs are fixed between the structural poles of the hut. Then, the whole date palm leaves are connected together using threads to make mats called *Sedda* or *hassir* (Fig. 21). Finally each mat is fixed by threads to the nets to create a dense sheathing which offers a highly-efficient heat conservation method for the indoor environment of the hut (Darwish et al. 2019a, b).

For roof sheathing, the method relatively resembles thatching technique. The *Sedda* mats are fixed by thread in accumulative layers over the sloped roofing structural grid or a stiff net made from date palm spadix stems or reeds (Fig. 22).

Fig. 21 Whole date palm leaves Sedda

Fig. 22 Sheathing by whole date palm leaves over spadix stem nets supported by wooden poles

5.3 Sheds and Partitions

Fences, simple sheds and privacy partitions have been simply built by planting the leaves vertically in the soil and tying them together with two horizontal rows of leaves bundles by ropes as shown in Fig. 23 (Barreveld 1993; Darwish et al. 2019b). In addition, leaves have been used in roofs by laying them across the ceiling beams that are usually made from palm trunks. The thickness of layer of the leaves may reach up to 20–30 cm and then mud is poured above this layer in the present day (Darwish et al. 2019b) (Fig. 24). This method is clearly inspired by the ancient wickerwork walls discussed earlier.

Fig. 23 Traditional palm leaves fence

Fig. 24 Date palm leaves over wooden poles for roofing in a storage house in Menya, Egypt

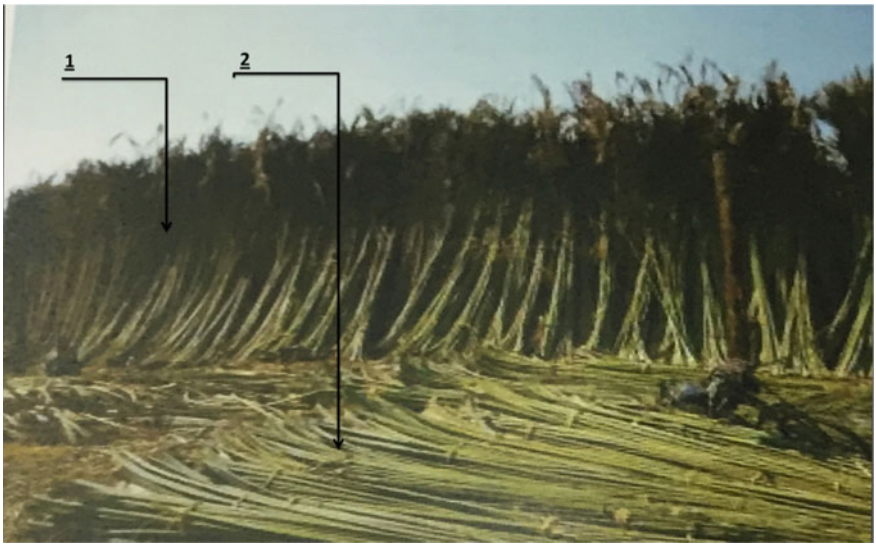

Fig. 25 Drying of date palm midribs. 1: Vertical drying. 2: Horizontal drying

6 Traditional Forms of Palm Midribs Utilization

6.1 Preparation of Midribs

Firstly, the leaflets are stripped from the midribs. The leaflets are to be used later in stuffing furniture. In Egypt, the leaflets are removed from the midribs manually. However in the Arabian Gulf region, the green leaves are laid on the ground, where the goats and sheep would feed on the leaflets, leaving the midribs stripped completely from the leaflets. Then, the midribs are laid vertically for 2–3 weeks to dry with the cut facing down to expel all humidity by gravity. For other purposes where long and straight midribs are needed, the midribs are laid horizontally for 4–6 weeks. Finally, the dried midribs are gathered in bundles: bundles of 5 for handicrafts and bundles of 25 for construction (Darwish et al. 2019b) (Fig. 25).

6.2 Traditional Crates and Bird Coops

Generally the practical quality of the crate is more important for the crate maker than the aesthetic value. The piercing technique used in making crates dates back to the late Roman period in Egypt (Wendrich 2009). A professional crate maker uses his big toe to hold a palm midrib as he punctures and drives a tin tube to create holes into the midrib piece. A light bread board uses only 2 midribs maximum, while heavy-duty

chicken coops and fruit crates use 4–5 midribs (El-Batraoui 2016; Darwish et al. 2019b). The majority of the used midribs in crate making in Egypt depend on the Nile Valley in Upper Egypt for the hardness and durability of the palm midribs there.

The used midribs for bread boards, crates and coops are usually only 3 weeks old to have the proper ductility needed for work. Then, they are sprayed lightly with water to gain moderate flexibility and the midribs are shaved lightly by a knife to clean any thorns or bumps (El-Batraoui 2016, p.). Then, the midribs are cut to the desired sizes by a wide sharp knife over a wooden chopping block. Then, the crate maker marks the points where the holes are to be punctured. These holes are driven in the midrib pieces using a sharp thin iron hollow pipe and a mallet (Barreveld 1993; Darwish et al. 2019b). The assembly of the crate is usually from the bottom up, where the punctured horizontal elements are laid on the ground and vertical members are fixed upright those holes (Barreveld 1993; El-Batraoui 2016; Darwish et al. 2019b). Additional punctured horizontal elements are driven down the vertical elements repeatedly as beams of the box to the top (El-Batraoui 2016). Finally, all the edges are hammered to level them (Barreveld 1993). The horizontal elements are almost green, whereas the vertical members are almost dry. With the drying of the horizontal members, their joints with the vertical members become very tight providing rigidity to the crate. Details of making a standard chicken coop and a bread board are shown in Fig. 26 and Fig. 27 respectively.

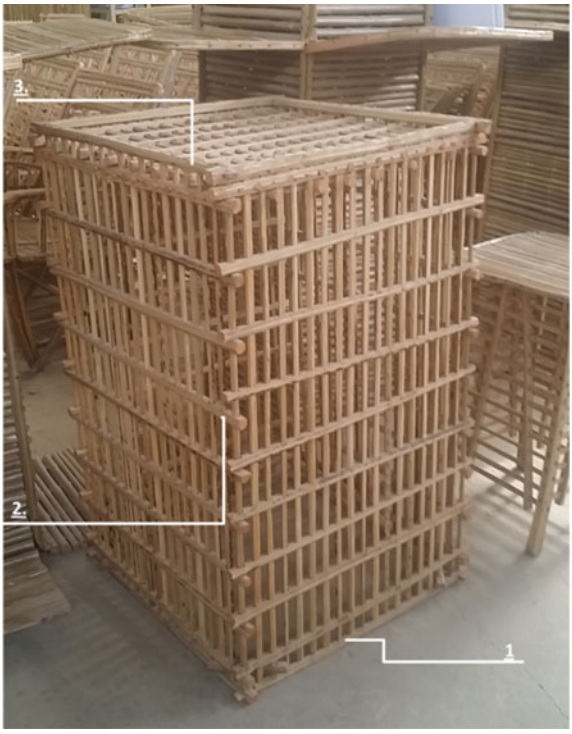

Fig. 26 Details of a standard date palm midribs chicken coop. 1: The vertical members are fixed through the holes of the bottom horizontal members at the base. 2: Secondary pre-punctured horizontal members are driven down to tie the vertical members. 3: The vertical members are leveled by the top horizontal members

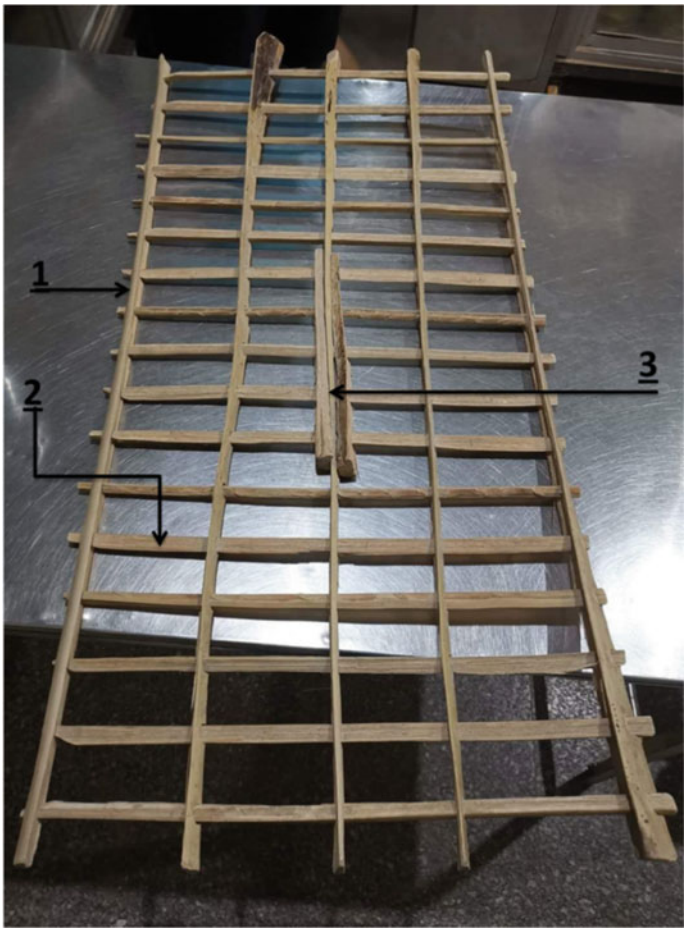

Fig. 27 Details of a date palm bread board. 1: the longitudinal members are cut to standard shapes and punctured at a specific spacing. 2: the transverse members are hammered through the punctured holes of the longitudinal members by friction. 3: additional members are added in the middle to prevent excessive deformation under the loads in the middle

This method is adopted in making crates, coops, cages, and sometimes sliding doors (Barreveld 1993; Darwish et al. 2019b). Sometimes, the crates are lined with palm leaves in the cases of their use for delicate products. This art is developed in more artistic and sophisticated products such as ornaments and furniture.

6.3 Traditional Handmade Furniture

Historically, date palm midribs were used as girders, fixed across the timber frame to build beds in ancient Egypt, above which a woven mat made from spadix stem fibers were fixed to make the mattress as shown in Fig. 28.

Later, furniture makers, often called "artists", give high aesthetic value to their products as the piercing technique becomes more sophisticated (Wendrich 2009; El-Batraoui 2016). Unlike crates, furniture design has no specific standard design and may vary from a place to another. Generally, the midribs are cut according to the desired elements and sizes of the design. The legs of a chair are usually cut from the wide section of the midrib, and the frame and the latticework are made of stiff dry midribs, while the armrests and seats are made from green midribs to facilitate bending (El-Batraoui 2016; Darwish et al. 2019b). Then the elements of the armrest, seat and back are cut respectively.

The same tools of crates making are used here also to make the lattices and the arabesque forms of the armrests and back. Then, all the plates of armrest, seat and back are fixed over the frame that is made of repeated vertical posts and horizontal beams upon which the seat is to be fixed with nails as seen in the figures. 4 cm nails are used to fix the armrests together and 10 cm nail is used to fix the armrests to

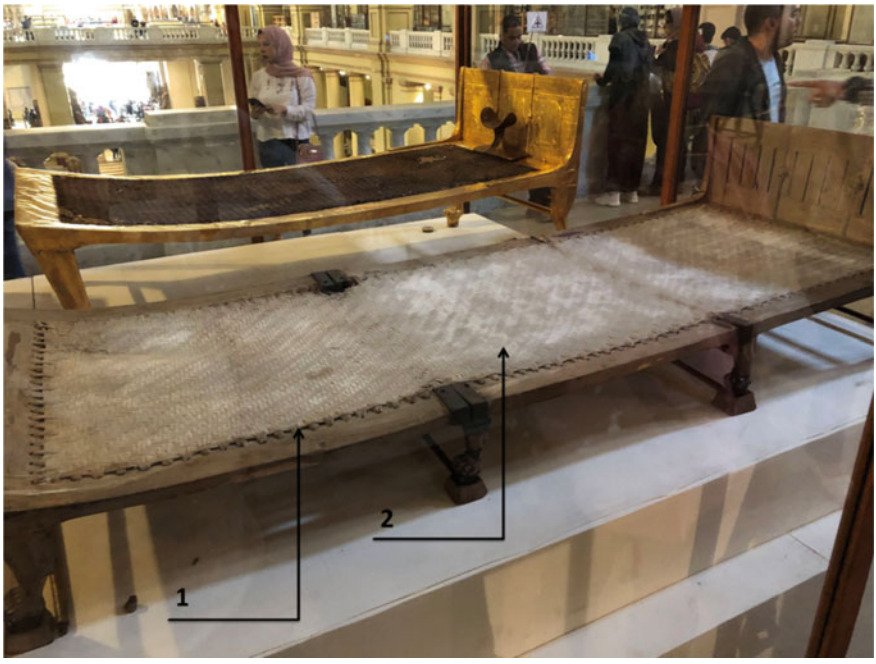

Fig. 28 An ancient Egyptian bed, New Kingdom. 1: Date palm midribs girders. 2: date palm spadix stem woven mat, Egyptian Museum in Cairo

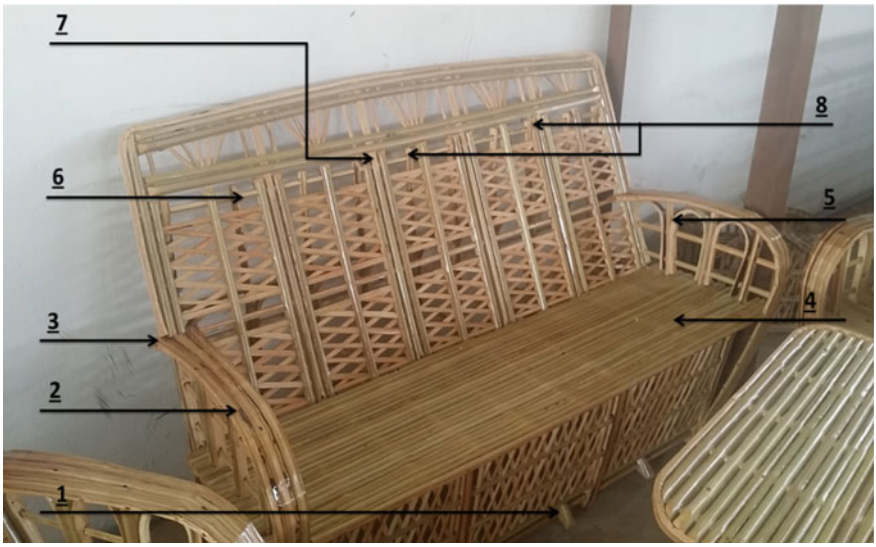

Fig. 29 Details of a standard date palm midribs chair. 1: The legs that bear the chair weight are assembled by horizontal beams through pre-punctured holes along the legs. 2: The armrest members are bent and joined using nails, then fixed to the legs on both ends. 3: Fixation of the armrest to the rear legs using nails. 4: The seat is assembled by nails over cantilever beams protruding from the legs. 5: Lattice with bent midribs to fix the seat to the armrests. 6: Horizontal beam to join main legs and secondary lattice columns. 7: The back is pre-assembled as a lattice using pre-punctured holes. 8: The Secondary lattice columns fix the back to the legs by friction through the lattice

the seat (El-Batraoui 2016; Darwish et al. 2019b). High quality products often use specials keys from the midribs in order to assemble the green members firmly so that they do not disassemble with drying. The whole set of plates are produced in maximum 3 days and are assembled to make a chair or a table in less than a day (El-Batraoui 2016). Details of making a standard chair are shown in Fig. 29.

6.4 Rural Wall and Roof Sheathing

Most of the traditional forms of utilizations of date palm midribs focused on their use in sheathing, such as in Arish Houses in UAE (Piesik 2012). Date palm midribs are connected by three rows of ropes to make *Sedda*. This *Sedda* mat has been used to be sheathing between the main structural system elements which used to be made of wooden poles or palm trunks (Darwish et al. 2019b). The natural narrowing geometry of the midribs controls the design of *Seddas*. The assembly of a *Sedda* depends on laying each midrib where its wider end is between the narrower ends of two adjacent midribs.

Fig. 30 Roofing using palm midribs over a series of tree branches as beams, Fayoum, Egypt

The wall sheathing mats are usually fixed by ropes to the columns and side bracings of timber along the mats with maximum spacing of 3 m to ensure the planarity and verticality of the mat (Darwish et al. 2019b). In simple roofing, the midribs are laid in perpendicular layers over a series of local tree branches as beams as shown in Fig. 30. Furthermore in roofing of an outdoor corridor, shown in Fig. 31, these *Seddas* are supported by timber beams by ropes and covered with thick mud layer to increase the thermal and moisture resistance of the roof.

6.5 Doors and Windows

In a manner that is similar to wall sheathing by date palm midribs, date palm midribs have been used in door making using the technique of binding by rope (Wendrich 2009). In ancient Egyptian doors and windows (Fig. 32), the midribs were bound by ropes to form a single layer that was reinforced with diagonal midrib bracings. Loam remains can still be found over the bracings to enhance the coherence between the bracings and the doors. The teeth of the wooden locks were reported to be made from date kernels.

Traditional date palm midribs doors that can still be found now in rural areas in Egypt are clearly inspired by their precedents as shown in Fig. 33. However, the main differences are: wooden posts are used as a frame to which the midribs are fixed by

Fig. 31 Ceiling of an outdoor corridor made of date palm midribs supported by wooden planks, North Sinai, Egypt

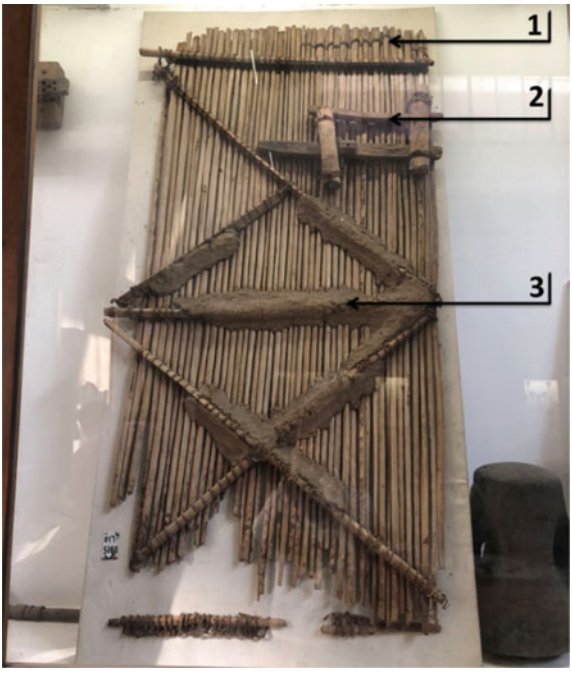

Fig. 32 An ancient Egyptian date palm midribs door, Old Kingdom, Egyptian Museum in Cairo. 1: The binding technique using coir ropes. 2: Wooden lock with date kernels teeth. 3: Using loam as a cohesive between the bracings and the door

Fig. 33 A traditional date palm midrib door in Fayoum, Egypt

nails, the bracings are fixed onto the midribs layers by nails instead of ropes, and no loam is used to stick down the bracings to the door.

6.6 Fencing

Fencing by date palm midribs *Seddas* is one of the simplest and most spontaneous methods of building fences. Fences made by date palm midribs can be classified into simple and lattice fences. Simple fences depend on the planting of the midribs Seddas in the soil and fixing the fences using ropes to wooden poles at the corners

Fig. 34 A simple date palm midribs fence

(Fig. 34) This kind of fences works only as a temporary outdoor partition element without resisting any loads (Darwish et al. 2019b).

On the other hand, lattice fences are stiffer and sturdier because they consist of date palm midribs lattices that are tied together with ropes. In the UAE, the date palm midribs lattices have a heritage of being used as walls in traditional summer Arish Houses (Piesik 2012; Eldeeb 2017). This lattice is used in relatively heavier weight of fencing between interval structural columns, made of steel or timber, along the walls and in the corners to ensure verticality as shown in Fig. 35. The Egyptian version of lattice fences is heavily inspired by the traditional diagonal lattice of the reed huts in Manzala lake region in Northern Egypt (Helal 1989). The midribs are

Fig. 35 A lattice date palm midribs fence, Ain, UAE

Fig. 36 Diagonal date palm midribs lattice in an outdoor fence, New Valley, Egypt

arranged in a diagonal lattice and fixed with nails to a timber frame as shown in Fig. 36.

This type of fencing can carry the loads of additional wall sheathing and can remain durable and functional for relatively longer periods of time (Eldeeb 2017; Darwish et al. 2019b).

6.7 Boats

Ancient evidences have been found that indicate the use of date palm midribs in boats that go back to the Early Bronze Age in in a fashion that is still common to the present day in the Arab Gulf region, known as the date palm midribs-based *Shasha* raft-boats (Vosmer et al. 2003). Evidences of ancient Magan boats, named after the ancient name of the Arab gulf, were found in the coasts of Kuwait in 1980s. The evidences showed solidified chunks of bitumen, dating back to the Ubaid period (5300–4700 BC) in Kuwait, with the impression of thin parallel longitudinal grooves (Johnson 2016), suggesting that the bitumen was used as a waterproof cover over the date palm midribs or reeds used in building the boats (Carter 2002). Ur III text (dating back to 2100 BC) listed the use of palm-fiber ropes cured with fish oil to tie the reed bundles used in building Mesopotamian boats which are finally also caulked with bitumen (Ray 2003).

Fig. 37 A *Shasha* boat sailing in the sea

Traditional *Shasha* boats (Fig. 37), small raft-boats made from date palm midribs, are still used to the present day for fishing and short distance travelling and racing sports in the UAE (Johnson 2016). The basic material of the boats is date palm midribs after removing the leaflets. The midribs, 150 midribs required for 1 *Shasha* boat, are soaked in saline water for a week until they are manageable and then they are dried overnight (Johnson 2016). Secondly, they are tied together with a date palm coir ropes to make a mat as shown in Fig. 38. Then the mats are fixed tightly to a frame made from local acacia wood with cross beams and side beams to create the hull. Thirdly, the base of the boat is lined with date palm petioles to create buoyancy. Fourthly, more date palm midribs are fixed over the petioles with date palm coir ropes to create the deck of the *Shasha* (Johnson 2016).

Fig. 38 Building a *Shasha* boat from date palm midribs

6.8 Bats and Discs

A traditional household utensil in the Egyptian village is the baking bat, *Matraha.* Baking bats were used to spread the bread dough and bring it into and from the oven. Greco-Roman baking bats depended on the sewing technique which used parallel strings of date palm leaflets by a needle and thread over a network made of shredded and pierced date palm midribs using the piercing technique (Wendrich 2009). The midribs also were used for the bat handles and reinforcement. Such technique was clearly demonstrated in discs, fans and baking bats as shown in Fig. 39. This ancient technique of baking bats is still inherited to the present day. Traditional baking bats now depend on the piercing technique. Rigid midribs are connected by perpendicular midribs that are driven through pierced holes, without the need of sewn leaflets as shown in Fig. 40.

The same piercing technique is used in simple doors and fences, where the vertical midribs are pierced and bounded together by horizontal midribs passing through the pierced holes as shown in Fig. 41.

Fig. 39 Baking bats made from sewn date palm leaflets fixed onto a date palm midrib frame, Greco-roman period, Egyptian Museum in Cairo

Fig. 40 A traditional baking bat made from pierced date palm midribs

6.9 Miscellaneous Uses

Other miscellaneous uses of midribs are for making fishing rods and supporters for growing grape vines (Barreveld 1993). In addition, bent midribs that cannot be used in crates or furniture have been used traditionally as a source of light charcoal, especially the thick petioles at the base of the midrib (Barreveld 1993).

7 Traditional Forms of Palm Leaflets Utilization

Date palm leaflets are the secondary product of the preparation of the midribs as discussed earlier. As the second most abundant pruning residue, date palm leaflets have acquired a widely spread technical heritage that still thrives to be one of the main sources of income of many families in Fayoum, Sinai and Nubia (El-Batraoui 2016). The well-sustained rich cultural background of Fayoum, Sinai and Nubia has led to the continuity of the date palm leaflets heritage in the field of handicrafts to the present day.

Fig. 41 A simple fence door made form pierced date palm midribs, New Valley, Egypt

Nubia, in South Egypt and North Sudan, is one of the regions where the art of weaving date palm leaflets still thrives. The weaving technique of date palm leaflets have been used since the ancient Egyptian traditions in making many traditional products such as hats, baskets and mats (Barreveld 1993). This technique still thrives because it only needs braiding the leaflets with hand without any other special tools (El-Batraoui 2016).

7.1 Traditional Preparation of Date Palm Leaflets

The leaflets are manually removed from the midribs and are laid in the sun for 2–3 days to get rid of fungus and insects, while in summer it is enough to lay the leaflets in the shade to prevent discoloring (El-Batraoui 2016). Then, each leaflet is split by fingernails into several strips and soaked in saline water for a day to become more flexible. This water may be dyed with vegetable dyes to make various colored strips.

Another method used now for dying the strips is soaking the strips in dyed boiling water with a small amount of salt in it until the desired hue is achieved (El-Batraoui 2016).

7.2 Bags, Mats and Baskets

In ancient Egypt, several techniques were employed to use date palm leaflets in making various household accessories as shown in Fig. 42.

After preparation, leaflets are plaited and interwoven together to produce the desired shape according to one or more of the following techniques.

7.2.1 Plaiting Technique

Plaiting is the ancient Egyptian technique where several strands are woven into fabrics by interlacing them with a set of perpendicular strands (Wendrich 2009). The ends of the strands were usually folded into the fabric. This method was widely employed in ancient Egypt basically in making bags and sandals as shown in Fig. 43.

Another traditional form of using date palm leaflets that is deeply rooted in the Bedouin culture in South Sinai in Egypt is the *Sousel, shown in* Fig. 44. The *Sousel* consists of two plaited tubes that are designed to contain two dates, so that every morning, the children would present the *Sousel* with the two dates to their parents as they awaken them in the morning.

This traditional and artistic method in Egypt is more evolved today in making Hassir, depending on weaving the leaflets strips together along their lengths on a

Fig. 42 Ancient Egyptian household utensils made from date palm leaflets, Old Kingdom, Egyptian Museum in Cairo. 1: Protective discs made by the sewing technique. 2: A box made by coiling technique. 3: Protective disc made by looping technique. 4: A basket lid made by looping technique

Fig. 43 Ancient Egyptian sandals from the Middle Kingdom. Egyptian Museum in Cairo

planar desk (El-Batraoui 2016). *Hassir*, a hand-made mat, is made from natural fibers such as reeds and palm leaflets using the traditional plaiting technique. These strips are arranged in 2 diagonal perpendicular grids, then the strips are woven together (Fig. 45). This type of mats depends extensively on high artistic qualities and on high quality leaflets that are preferably just pruned to gain less brittle fibers with high elasticity in work (Barreveld 1993).

In a more modern method, leaflets strips are used after soaking in water to increase their flexibility. Then, every 3 strips are used to make plaited strand that is sewn by machines with thread side to side with the other strands until the wanted area is completed (Barreveld 1993; El-Batraoui 2016). Finally, the edges are bent and sewn to secure the ends of all the strands (Fig. 46). Hence, the used leaflets are not required to be as fresh as in the first type of mats. This type of mat is much lighter than the first type. Therefore, the first type is used for flooring mats and fans as shown in Fig. 47, while the second type is used for ornaments, bags and hats as shown in Fig. 48.

7.2.2 Coiling Technique

The coiling technique depends on creating a coil using a stiff material on which the strands are to be wrapped around (Wendrich 2009). In the ancient Egyptian period, the coiling technique was used mostly in making baskets and plates. Light plates (Fig. 49), probably used as thermal protector below hot pots, were made by wrapping full-size leaflets around coils made from coiled leaflets bundles.

Fig. 44 A *Sousel*, made from plaited date palm leaflets

Traditional trays inherited this technique in making decorative handles that are actually made from spadix stem core on which full-size leaflets are wrapped as shown in Fig. 50.

7.2.3 Looping Technique

When the strands wrapped around the coiled core are linked and intertwined in loops, the technique used is called Looping (Wendrich 2009). This ancient Egyptian technique was widely employed in making sturdy baskets and sandals as shown in Figs. 51, 52, 53 and 54.

This technique is inherited to the present day in making sturdy vase-shaped baskets. Sturdy baskets, shown in Figs. 55 and 56, are made by using dense cores made from date palm spadix stem fibers (Barreveld 1993). These cores are coiled in a spiral form according to the desired shape of the basket. Then, shredded leaflet are wrapped around the spiral cores continuously to link them together while also

Fig. 45 Rolled date palm leaflet Hassir mats

being intertwined. The handles of the baskets are also made from shredded leaflets, wrapped over spadix stem cores, as in the simple coiling technique, in order to provide adequate support while carrying. The bottoms of heavy baskets and heavy-duty plates are made using the same method but with additional sewing in order to fasten the looping of the leaflets over the core made of leaflets bundles as shown in Figs. 57 and 58.

7.2.4 Sewn-Plaits Technique

Tri-plaited strands of date palm leaflets are made according to the needed length (Fig. 59). Then, the strands are sewn together by a large needle using a strong Doum palm *(Hyphaene thebaica)* fiber-based thread or from fibers extracted from the leaflets (Barreveld 1993; Wendrich 2009) (Fig. 60). The skills of the craftsman significantly affect the quality of the product; the stiffness of a bag increases as long as the plaiting is fine and the strands are narrow with tight sewing (Barreveld 1993). Therefore, using freshly pruned leaflets is highly preferred. This technique can also be used in making modern bags (Fig. 61) and mats (Fig. 62).

Fig. 46 Machined date palm leaflet stable mat

Fig. 47 Fans made from woven date palm leaflets with wool embroidery

Finally when the strands are stacked spirally and sewn together, ropes made from date palm coir are added as handles. These bags come in different shapes and volumes, where the largest bags, *Quffa*, (diameter of 50 cm at the bottom and the height of 75 cm) can be used for coal and sand transportation with up to 35 kg capacity (Barreveld 1993). A *Quffa* requires a plaited strand of 10 cm width and 15 m length (Barreveld 1993). Therefore, the bottoms of these heavy duty bags require reinforcement by date palm spadix stem discs made by the coiling technique.

Fig. 48 A hat made from plaited date palm leaflets

Fig. 49 Light date palm leaflet plates, Middle Kingdom, Egyptian Museum in Cairo

7.3 Krena Fibers

Low quality leaflets have been traditionally used as stuffing material for bedding, cushions and mattresses, known as *Krena* (Barreveld 1993). The whole leaves here are dried on the ground and then, the leaflets are collected and soaked in water to soften. The soaked leaflets are then fed into a rippling machine in order to make them into fine threads in order to be dried and baled for later uses (Barreveld 1993). These bales can be used for stuffing of furniture or for thick ropes.

Fig. 50 Coiled decorative date palm leaflets handles

Fig. 51 Date palm leaflets baskets dating back to the New Kingdom, Egyptian Museum in Cairo

Fig. 52 A date palm leaflets basket dating back to the Middle Kingdom, Egyptian Museum in Cairo

Fig. 53 Ancient Egyptian sandals made by looping technique, New Kingdom, Egyptian Museum in Cairo

Fig. 54 Rolled mat and sandals made from date palm leaflets using the looping technique, Old Kingdom, Egyptian Museum in Cairo

Fig. 55 A reinforced basket made from date palm leaflets and spadix stem cores

7.4 Miscellaneous Uses

Leaflets have been arranged and tied to make simple hand brooms and fly whisks as shown in Fig. 63. Heavy duty ropes are also made using high quality leaflets (Fig. 64). The leaflets here are shredded into 2–3 mm wide strips (Barreveld 1993). Those strips are soaked and made into a strand. Then the strands are plaited to make the final ropes (Barreveld 1993).

Fig. 56 Reinforced plates and trays made from date palm leaflets and spadix stem cores

Fig. 57 Sewing the shredded leaflets around the core in a basket bottom

8 Traditional Forms of Palm Spadix Stem Utilization

Spadix stems acquire recognizable tensile strength because of their natural function of carrying the weight of date through the season. Therefore, several handcrafts products that require durability depend on date palm spadix stems as the main raw material.

Fig. 58 A basket with handles made from shredded leaflets around leaflet bundles core using the looping technique

Fig. 59 Plaiting a palm leaflets strand

Fig. 60 Sewing the spiral strands in a Quffa

Fig. 61 Spiral strands in a date palm leaflet bag

8.1 Preparation of Date Palm Spadix Stem

Spadix stems are firstly soaked to soften the stems and then they are hammered with broad-faced hammers to loosen the fibers. Then, the fibers are stripped away

Fig. 62 Spiral strands in a date palm leaflet mat

Fig. 63 A broom made from shredded leaflets, 4th Century A.D., Egyptian Museum in Cairo

Fig. 64 Date palm leaflets ropes, New Kingdom, Egyptian Museum in Cairo

longitudinally by hand from the basal end of the stalk to the other end (Barreveld 1993).[1]

8.2 Household Accessories

The ancient Egyptian twining technique depended on twisting rows of leaflets or ropes around perpendicular sets of spadix stems strips in order to create a stiff disc (Wendrich 2009). Such technique is demonstrated in the sieve shown in Fig. 65.

Utilizing the same technique of making spadix stem *Hassir*, smaller woven patches are made using the shredded fibers from the spadix stems on looms. Those patches are sturdy on their own and can be used to make tissues boxes, table cloths, bags (Fig. 66) and lamp shades (Fig. 67).

[1] A modern method of preparation that is used now in Egypt for faster products is laying the spadix stems on the asphalt roads to be run over by cars and trucks in order to disassemble the fibers of the stems for further use.

Fig. 65 A sieve made from date palm spadix stem, Roman period. Egyptian Museum in Cairo

Fig. 66 Tables cloths, tissues boxes and bags made from woven spadix stem fibers

8.3 Sturdy Baskets

Being stiffer than leaflets, stronger type of baskets (Fig. 68) can be made from thick coiled date palm spadix stems that is sewn and twined with wool threads.

Fig. 67 Lamp shades amp made from woven spadix stem fibers

8.4 Heavy Duty Mats

The method used in making mats is inspired by the ancient Egyptian weaving technique that depended on interlacing strands, which were tensioned on a loom, with perpendicular strands (Wendrich 2009). The fibers of the spadix stems are passed and pressed in between the tensioned threads in the machine. Consequently, the fibers are woven in an orthogonal net until the needed area is completed. The resultant mat (Fig. 69) is highly durable and can be used directly over the soil and in the outdoors.

8.5 Decorative Trays

The disassembled spadix stem fibers can be gathered to be strips that are woven to create a durable bottom for household trays and saucers (Fig. 70). The sides of the trays are created by wrapping shredded leaflets over fixed decorative spadix stems elements. The method of making the handles for the spadix stem trays, shown in

Fig. 68 A basket made from coiled date palm spadix stems

Fig. 69 Rolled date palm spadix stem *mats*

Fig. 70 A decorative cup saucer

Fig. 71 Decorative trays made from woven spadix stems strips

Fig. 71, is clearly inspired by the ancient Egyptian simple coiling technique discussed earlier in Sect. 7.2.2 Coiling technique.

9 Traditional Forms of Palm Petioles Utilization

Petioles have been used as bordering walls around open wells when the usual brick are not available (Dowson et al. 1978). In this method, the petioles are sharpened at the thinner end and hammered closely until a firm and dense wall is formed. The low density of petioles led to their use as floaters for the fishermen nets and traditional

Fig. 72 A sculpture from date palm petioles

Shasha boats (Popenoe 1973; Barreveld 1993; Johnson 2016). In construction, petioles have been used as vertical sticks that are hammered into the ground to line and stiffen the bond between mortar and mud walls (Popenoe 1973; Barreveld 1993). In handicrafts, date palm petioles offer a suitable soft medium to make distinctive sculptures as shown in Figs. 72 and 73. However, the most prominent use of petioles in the present day is using them as a fuel (Barreveld 1993).

10 Traditional Forms of Palm Coir Utilization

Date palm coir ropes are traditionally known to acquire sufficient strength (Popenoe 1973; Barreveld 1993) as they were the favorite type of ropes for sailing in the UAE (Piesik 2012), although no reliable data has been found regarding the actual mechanical properties of this type of ropes. Coir ropes can be made in different diameters for various uses such as tying, handling and binding (Barreveld 1993). Moreover, ropes can be made into nets that can carry heavy loads for transportation over camels in rural areas (Barreveld 1993).

Other miscellaneous traditional uses of coir include being a fuel source, making fishnet, basket handles, brushes, bedding and shading live plants and offshoots (Barreveld 1993). In addition, raw coir is used as stuffing for the spaces between the date palm trunk beams and midribs in the roofing of traditional rural houses in

Fig. 73 A sculpture from date palm petiole

Egypt (El-Tawil 1989; Ahmed 2014). This coir increases the overall thermal insulation of the roof which enhances the indoor air quality (El-Tawil 1989). Furthermore, date palm coir, among fibers extracted from reeds, is a basic element in the mixture of the traditional wickerwork mortar and plaster in the rural houses in Egypt(Helal 1989). In addition, the poor in Upper Egypt use when making pillows a core made from coir in order to save cotton to decrease the costs of the pillows.

10.1 Plaited Ropes and Bags

Date palm coir was used as the main source of fibers for ropes by plaiting technique since ancient Egypt as shown in Fig. 74 (Wendrich 2009). The same technique is still employed to the present day as shown in Fig. 75.

Plaited coir ropes were employed in miscellaneous uses such as hangers (Fig. 76), fire wicks (Fig. 77), balances (Fig. 78), fishing nets (Fig. 79) and bags (Fig. 80) in ancient Egypt. In the Roman period, the coir fibers were simply rolled by hand to make wigs as shown Fig. 81.

Fig. 74 A coir rope, New Kingdom period, Egyptian Museum in Cairo

Fig. 75 Ropes made from date palm coir

10.2 Cattle Accessories

The well-developed ancient Egyptian expertise in making the coir ropes made them strong enough to be used in bags and agricultural plows. The weaving technique, interlacing strand using a loom, was used in ancient Egypt in saddles and blindfolds for cattle as shown in Fig. 82. The same technique is still used in the present day

Fig. 76 A coir wall hanger, Old Kingdom, Egyptian Museum in Cairo

Fig. 77 A coir wicks with traces of oil, Middle Kingdom, Egyptian Museum in Cairo

Fig. 78 Coir ropes in a balance, Middle Kingdom, Egyptian Museum in Cairo

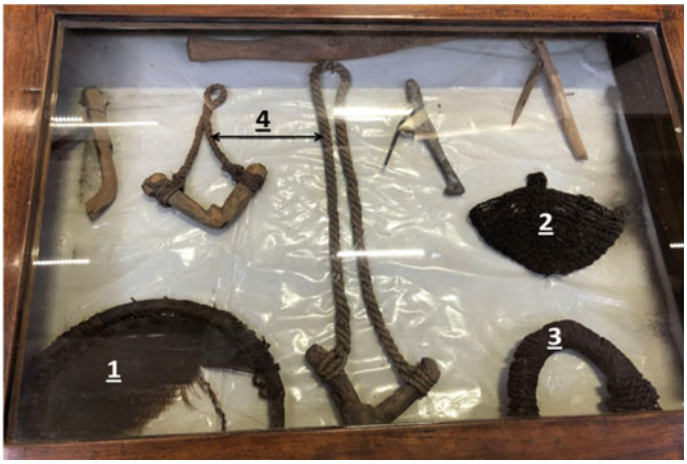

Fig. 79 Date palm coir fishing products, Middle Kingdom, Egyptian Museum in Cairo. 1: Fishing net. 2: Bait bag. 3: safety ropes. 4: Darts

in making camel bags, donkey saddles, supporting belts for palm climbers and bird traps as shown in Fig. 83, Fig. 84, Fig. 85 and Fig. 86 respectively.

Fig. 80 A plaited bag made from coir, Old Kingdom, Egyptian Museum in Cairo

Fig. 81 A coir wig from the Roman Period, Egyptian Museum in Cairo

Fig. 82 Date palm coir cattle accessories, Old Kingdom, Egyptian Museum in Cairo. 1: A buffalo saddle. 2: Blindfold. 3: Bridle. 4: Plaited ropes for collecting water utensil

Fig. 83 Weaving a camel bag from date palm coir using a loom, Fayoum, Egypt

11 Traditional Forms of Palm Date Kernels

Preparation procedures of kernels vary according to the type of use. They can also be pressed to yield edible oil, roasted to make coffee, and heated to make charcoal (Barreveld 1993; Johnson 2016). Prior to using kernels in jewelry, the kernels are extracted, washed, soaked in dyes and dried 48 h (Mirghani et al. 2012). Then, the

Fig. 84 A donkey saddle made from woven date palm coir

Fig. 85 Belts for palm climbers made from woven coir

kernels are holed and stringed together by thread to make jewelry, necklaces, prayer beads (Fig. 87) and bags (Fig. 88) (Popenoe 1973; Johnson 2016).

Fig. 86 A bird catcher made from woven coir and spadix stem

12 Traditional Forms of Palm Trunks Utilization

Date palm trunks have been known to be strong and durable, which qualified the trunks to be used as timber substitutes. In Fig. 89, a worker is confidently ascending to a truck while using a trunk as stairs. Moreover, the worker is carrying a bundle of twenty midribs, with a total weight of approximately 40 Kg. Yet, the natural coarse surface of the trunk offers the needed friction for his bare feet. As a result, date palm trunks were found to be used in the fields which require high durability and stiffness such as construction and furniture elements.

12.1 Traditional Construction

Date palm trunks have also been used as columns and beams in traditional housing in many rural areas in Egypt and the Arab region. The most primitive forms of using

Fig. 87 A prayer bead made from date palm kernels

date palm trunks in construction were as simple door, sheds of outdoor corridors and simple roofing as shown in Figs. 90, 91 and 92.

In Siwa Oasis in the western desert in Egypt, the technical heritage of using date palm trunks in construction evolved to demonstrate a spontaneous cleverness in terms of changing the assembly of the trunks according to the covered span (El-Tawil 1989). In this method, date palm trunks were halved or quartered to work as beams supported by load-bearing walls made from Kershef soil in the Siwa oasis (Ahmed 2014), or from mud bricks in the Nile Valley. The types of roofs were as follows:

1. Primary roof: for rooms with spans of 2–3 m, roofing depended on using planks from the palm trunks supported by the walls in the transverse direction. Then the spaces between the trunks were filled by 10–20 cm thick mortar and date palm coir for intermediate floorings or roofing (El-Tawil 1989).
2. Secondary roof: for rooms with spans of 4–5 m, additional beams are added where each beam consists of two halves of a trunk laid adjacently on the curved side. Above these beams, longitudinal planks of trunks are laid together on which the roofing layers are added as described earlier (El-Tawil 1989).

Fig. 88 A bag made from date palm kernels

3. Tertiary roof: for halls with spans 58 m, main full trunk beams are supported on walls and piers, above which the beams of the secondary roofs and roofing layers are added (El-Tawil 1989).

In a simpler and more recent fashion, date palm trunks are used as visible columns and beams in light huts. In this method, special workers peel the outer tough surface to achieve an organized surface to handle during construction (Fig. 93). Then, the columns are made of whole trunks (Fig. 94), while beams generally consist of quartered trunks that may be arranged back-to-back as in the traditional roofing method in the western oases in Egypt (Fig. 95), or the trunks are shaped into rectangular cross-sections for beams and columns to achieve a modern and sophisticated design as shown in Fig. 96.

12.2 Traditional Furniture

Trunks are shaped into blocks that act as the armrests and supporters of tables and chairs (El-Mously 2001). The fixation methods used are very similar to those used

Fig. 89 A worker ascending on a date palm trunk, carrying his own weight and the weight of a 20-midribs bundle, Asiut, Egypt

Fig. 90 A traditional door made from date palm trunk planks, Fayoum, Egypt

Fig. 91 Using date palm trunks as beams in an outdoor corridor, Arish, Egypt

Fig. 92 Using date palm trunks as beams with date palm midribs ceiling in a simple roof, Arish, Egypt

Fig. 93 Peeling and squaring a date palm trunk

Fig. 94 Using date palm trunks as columns and rafters in a date palm midrib hut

Fig. 95 Quartered date palm trunk beams that support date palm midribs roof

Fig. 96 Squared date palm trunk beams and columns in a modern date palm midribs hut

in timber furniture. The coarse vascular structure of the trunk gives the furniture a rustic look (Fig. 97) that is desirable in various touristic projects.

13 Conclusion

It is clear from the aforementioned that the date palm byproducts enjoyed a long history of utilization in many regions in the world, especially in the Arab region, extending for thousands of years. Relying basically on the periodical pruning (palm

Fig. 97 Furniture made from date palm trunk

service) activity they represented a sustainable material base for the satisfaction of basic material needs of the local populace: in shelter, furniture, agricultural equipment, transportation and household utensils.

The technical heritage, associated with the date palm byproducts reveals a generic perception of the date palm as a whole resource, whereby all the elements of the resource were-according to the available level of technology-efficiently used for the satisfaction of the basic human needs. It also reveals, though implicitly, a huge body of traditional knowledge about the properties and behavior-under different environmental and loading conditions-of these byproducts. The wide spectrum of uses of different palm byproducts reveals a high degree of innovation and, sometimes, high levels of skills seemingly unattainable at our present contexts.

It is also clear from the aforementioned that this technical heritage operated- and still operates-as a force of inspiration to develop new techniques for processing of date palm byproducts and innovative products made from them. But as mentioned in the introduction the most valuable in the technical heritage is that it acts as a software for discovering in future new environmentally and culturally tuned routs of utilization.

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