Flax for seed or fibre use? Flax capsules from ancient Egyptian sites (3rd millennium BC to 2nd century AD) compared with modern genebank flax accessions

Sabine Karg (Sabine.Karg@fu-berlin.de)
Free University of Berlin: Freie Universitat Berlin
https://orcid.org/0000-0002-1011-4859

Chiara Spinazzi-Lucchesi
University of Copenhagen: Kobenhavns Universitet

Axel Diederichsen
Plant Gene Resources of Canada

Research Article

Keywords: Linum usitatissimum L., capsule morphology, ancient Egypt, modern genebank accessions

Posted Date: June 13th, 2023

DOI: https://doi.org/10.21203/rs.3.rs-3035924/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License. Read Full License

Version of Record: A version of this preprint was published at Genetic Resources and Crop Evolution on November 13th, 2023. See the published version at https://doi.org/10.1007/s10722-023-01753-y.
Abstract

In order to determine whether ancient Egyptians had already selected and cultivated very specialized flax types according to their purpose for textile or oil production we compared archaeobotanical flax finds that are kept at the Botanical Museum of the Free University in Berlin, Germany with diverse genebank accessions kept at the Plant Gene Resources of Canada (PGRC). The main result was that fibre flax was most probably already cultivated in Egypt during the the 3rd millennium BC, whereas in all later periods an intermediate flax and/or oil type was in use. The collaboration between archaeobotanists and genebank curators shows how knowledge about ancient usage of plants can be generated by interpreting observations made on ancient findings using characterization data obtained from diverse genebank material.

Introduction

Plant finds from archaeological sites can in most cases be determined to species level but rarely to the level of infraspecific groups with particular features. Flax (Linum usitatissimum L.) is one of the founder crops for agriculture in the Near East (Weiss and Zohary 2011). Flax comprises two main usage groups with distinct phenotypes: fibre flax types that deliver long, unbranched stems, and linseed types that produce more and larger seeds for direct consumption or oil extraction (Körber-Grohne 1987).

The main objective of this study is to discuss the question whether the archaeological flax finds from Egypt represent oil- and/or fibre flax. We compared their measurements with similar measurements of recently grown flax of 2926 genebank accessions maintained by the Canadian national genebank, Plant Gene Resources of Canada located at Saskatoon, Province Saskatchewan.

The collaboration between archaeobotanists and genebank curators and methods used in this study could be applied to many other cultivated plants in order to better understand their historic usages.

Flax seeds contain high concentrations of the polyunsaturated fatty acids – linoleic acid omega-6 (ω-6), as well as α-linolenic acid omega-3 (ω-3). Both fatty acids are essential nutrients for humans that have to be ingested, as our body is not able to synthesize them. Technically it is possible to obtain oil from crushed seeds by boiling them in water. After the liquid has cooled down and the solid plant tissues have removed, the oil can be skimmed. This process was reconstructed from findings of linseed remains in prehistoric vessels, as for example the find at Tel Beth-Shean in Israel as discussed by Kislev et al. 2011 and by Cassuto et al. 2022.

Archaeological finds of cultivated plants are relevant for the understanding of their evolution (Helbæk 1959). In flax, it still remains unclear, whether the seed use, due to its seed oil content, or the stem-fibre use has been the first. The determination which flax type one has at hand allows to understand the cultural context of an archaeological finding much better. Other evidence helps understanding ancient agricultural practices and use of flax: wall paintings in the tombs of Sennedjem (TT 1) and Ipuy (TT217)
in Deir-el Medina in Thebes (beginning of 19\textsuperscript{th} dynasty, 13\textsuperscript{th} century BC) clearly show a tall growing flax that was obviously harvested in a green stage which suggests that flax grown for fibre use is depicted.

From archaeological sites located North of the Alps we have several findings of flax seed crusts in ceramic vessels dated to the 4\textsuperscript{th} and 3\textsuperscript{rd} millennium BC, as for example at the site Zürich-AKAD/Seehofstrasse and Yverdon-Avenue des Sports. In the lake dwelling site Bodman at Lake Constance (Bodensee) crushed flax seeds were found in a vessel (Karg 2013). Large linseeds in that region are interpreted as having been used for oil production, and small-seeded seeds for textile production (Herbig and Maier 2011; Karg 2022).

In Egypt, the fibre use of flax fibre has been widely documented due to textile findings including the fact that mummies are wrapped with flax bandages (Heer 1872; Herzog 1929). Flax was used for producing textiles from at least the Neolithic period. In fact, the first evidence comes from the Fayyum site A and is dated to around 5000 BC (Jones and Oldelfield 2006). Other early findings belong to the Badarian period (4400-3800 BC), when linen textiles were used in burials, as well as mats and skin elements (Brunton and Caton-Thompson 1928, 40). From the Predynastic period (3800-3100 BC) onwards, linen textiles became common findings in burials, mostly for covering the body but also as grave goods (Jones 2008). During the early Pharaonic period (3100-2100 BC) a highly developed technical production of extremely high-quality textiles and fine yarns, including the “ultra-fine yarn” is seen (Cooke and el-Gamal 1990).

Having two very distinct usage in flax has led to morphologically distinct flax types, commonly referred to as fibre flax and linseed, respectively. Taxonomists have, based on studies of world collections of flax in genebanks, described the diversity in flax and distinguished infraspecific groups that reflect these distinct usage groups based on amongst others, capsule features (Kupla and Danert 1962). Genebanks as reservoirs of the genetic diversity of cultivated plants offer excellent opportunities to assess the archaeological findings of remains of cultivated plants for identification. The great genebank pioneer and crop plant researcher N.I. Vavilov pointed already out that crop plants are documents of greatest relevance for historical research, similar to archaeological artefacts (Vavilov 1926).

**Materials and Methods**

We used desiccated preserved flax remains from Egyptian sites dating from the 3\textsuperscript{rd} millennium BC to the 2\textsuperscript{nd} century AD (Figure 1 and Table 1) that were collected at the end of the 19\textsuperscript{th} century by Georg Schweinfurth, a German pioneer of archaeobotany and textile archaeology (Finneiser et al. 2010). These finds are today kept in several museums. In the framework of a grant given by the German Research Council (DFG), Dr. Renate Germer registered the plant collections of Schweinfurth that are archived in museums in Berlin (Germer 1988). From several letters we learn that Schweinfurth must untiringly have tried to enhance the knowledge about the well-preserved plant finds from the Egyptian burial chambers (Schweinfurth 1895, 35), a dedication that is also reflected in the high-quality packing of the archaeobotanical finds, as shown in figure 2.
Flax finds (seeds and capsules) that are kept at the Botanical Museum in Berlin-Dahlem

The Botanical Museum at the Free University of Berlin holds brilliantly preserved flax seeds and capsules from several archaeological excavations in Egypt which were used in this study.

The original labelling of the boxes in which the finds are kept was translated into English by the first author of this article. In addition, the total number of seeds and capsules is given. We also mention if the finds were photographed. The sites are listed according to their age by starting with the oldest sample. If available, more information on excavation and context of findings are also provided. The following listing is justified in order to simplify the retrieval of the single finds and excavations in case of future investigations to be carried out by other researchers.

Abusir el-Meleq, S.Schw. Nr. 169 dated to 2925 - 2700 BC

Original box: "Linum us. v. crepitum L. Abusir Melaq. Protohist. Gräber. (…II Dyn.) 1906 Dr. G. Möller“.

Linum us. v. crepitum L. Abusir Melaq. Protohistoric graves (…2nd dynasty) 1906 Dr. G. Möller.

Content: Four flax capsules and four seeds. All measured and photographed.

Context of finding: Abusir el-Meleq, excavations of Georg Möller of the Proto-dynastic cemetery in 1905-1906. Flax capsules are only reported in tomb 12, positioned in front of the face of the deceased (Scharff and Möller 1926, 115).

Abusir, S.Schw. Nr. 388 dated to 2510 - 2460 BC

Label on original box: "Nr. 17 Linum us. L., Fundamentopfer des Sahu-re V. Dynastie. 1910”.

Number 17 Linum us. L., basement offering of Sahu-re, 5th dynasty. 1910.

Label placed in box: Borchardt 1909.

Content: Flax capsules and capsule fragments, no flax seeds, two additional seeds, one is probably Coriandrum.

General photograph, flax capsule cross section and capsule basis photographed, in each case the outer- and the inner part.


Dra Abu el-Naga, S.Schw. Nr. 165 dated to 1994 - 1781 BC

38 Linum us. L. the capsules were placed in a bowl in a grave dated to the 12th dynasty for Dra Abu’l Negga, Theben. Discovered by Mariette.

**Content:** 28 flax capsules were measured and photographed through the glass lid of the sealed box.

**Context of finding:** Auguste Mariette conducted several excavations in Dra Abu el-Naga (Western Thebes, modern Luxor) between 1957 and 1962 but has never published a full report (Miniaci and Quirke 2008).

**Thebes, S.Schw. Nr. 171 dated to 1552 - 1295 BC**

**Original box:** „Fruchtkapseln von Linum us. L. aus einem Speicher von Priesterwohnungen, Theben 1911, XVIIIth Dyn. Gefunden von Dr. G. Möller.”

Capsules of Linum us. L. from a store in the home of a priest, Theben 1911, 18th dynasty. Discovered by Dr. G. Möller.

**Content:** Three entire flax capsules and five capsule fragments. All are measured and photographed.

**Context of finding:** Georg Möller was active in 1911 in the area of Sheikh Abd el-Qurna (Western Thebes, modern Luxor). His works are currently under study by the Ägyptisches Museum und Papyrussammlung in the project “Ausgrabungen auf dem Westufer von Theben (1911; 1913).”

**Sheikh Abd el-Quma, S.Schw. Nr. 170 dated to 1188-1069 BC**

**Label on original box:** „Linum usitatissimum. Gefunden zu Schech Abd el Quneh Theben in einem Grabe der XX Dynastie, der als Speicher diente dessen Inhalt in Vergessenheit gerieth man fand daselbst… Ardeb (?) Leincapseln.”

Linum usitatissimum found at Schech Abd-el-Querneh in Theben in a grave of the 20th dynasty. The grave was used as a granary in antiquity but later forgotten. 1885. 8 Ardeb (?) flax capsules.

**Content:** One entire flax capsule and one capsule fragment, both are photographed.

**Context of finding:** In a tomb of the 20th dynasty. Considering the similar description of number 166 (see below), it might belong to Gaston Masperos excavation as well.

**Sheikh Abd el-Quma, S.Schw. Nr. 166 most probably dated to 1189 - 1069 BC**

**Original box:** „Nr. 19 Linum usitatissimum. Gefunden in einem Grabe zu Schech Abd-el-Qurneh, Theben, das im Alterthum bereits als Speicher diente und in Vergessenheit gerieth man fand daselbst ... Ardeb Leincapseln 1885 Gurna Maspero“ (see label on figure 2).

Number 19, Linum usitatissimum found in a grave at Schech Abd-el-Querneh in Theben. The grave was used as a granary in antiquity but later forgotten... Ardeb flax capsules 1885 Gurna Maspero.
Content: approx. 500 uncharred flax capsules most of them entirely preserved, few breakages, approx. 120 seeds mostly still attached to the capsules. The sample contained furthermore ceramic fragments, uncharred bones, stones (mortar droppings?), a few uncharred cereal grains from barley, twisted pods from small seeded legumes, a few stems, 2 charred fragments of probably olive stones.

100 flax seeds (Karg et al. 2018) and 20 capsules were measured and photographed.

Context of finding: Gaston Maspero was active in the area of Sheikh Abd el-Qurna (Western Thebes, modern Luxor) in 1886. His excavation reports have never been published.

Assasif, S.Schw. Nr. 164 dated to 1188 - 525 BC


Content: approx. 60 uncharred capsules. 10 capsules were measured and photographed.

Original box: „39 Linum us. L. in Gräbern beim Assasif zu Theben, XX-XXVI Dyn. 1885 gefunden von Prof. Schiaparelli.“

39 Linum us. L. in graves at Assasif in Theben, 20th-26th dynasty 1885 discovered by Prof. Schiaparelli.

Content: approx. 70 flax capsules. 10 capsules were photographed (top and side view) through the glass lid of the sealed box.

Context of finding: Ernesto Schiaparelli was director of the Museo Archeologico Nazionale di Firenze from 1881 to 1893. His first two expeditions to Egypt date into that period, one in 1884-1885 and one in 1891-1892, where he mainly acquired items from dealers. The label on the box points to some graves located in the Assasif (Western Thebes, modern Luxor).

Abusir el-Meleq, S.Schw. Nr. 167 dated to the 2nd century AD

Original box: „Linum us. L. als Totenbeigabe in Gräbern des 2. ten Jahrh. nach Chr. bei Abusir-el-malak 1903. Ausgrabungen von Dr. Rubensohn.“

Flax as grave goods in burials dated to the 2nd century AD at Abusir-el-malak 1903. Excavations by Dr. Rubensohn.

Content: 33 flax capsules (one half). 20 were measured and photographed.

Context of findings: Otto Rubensohn excavated a necropolis in Abusir el-Meleq during four archaeological campaigns between 1902 and 1905. He discovered graves from the pre-dynastic to the Islamic period in
Egypt, with finds from the third intermediate period until the Greco-Roman epoch (Rubensohn and Knatz 1904).

**The measurements on the archaeological flax samples**

Flax capsules were measured with an Olympus SZX16 DP72 stereo microscope and by using an image analysis program. In Table 1 the ID, the dating of the Egyptian desiccated capsules, the number of measured capsules and the means of the measurements are listed.

**The measurements on the genebank accessions**

The data on genebank accessions was provided by Plant Gene Resources of Canada (PGRC). The flax collection at PGRC is a world collection and covers the entire range of diversity in the species and includes many ancient landraces. The characterization data was generated during field trials planted from 1998 to 2008 at Saskatoon (Diederichsen et al. 2013). Based on comprehensive characterization, the classification into fibre flax, linseed flax and intermediate flax according to Kulpa and Danert (1962) was conducted for all accessions (Diederichsen 2009). For assessing the degree of dehiscence of the mature flax capsule a rating scale was applied on ten capsules and the modal value was recorded. Data on dehiscence was collected from 2931 accessions. For measuring the width of the mature capsules, the measurements were done by passing the mature capsules through holes of defined diameter in a metal plate to determine in which of nine classes ranging from 5.6 mm to 9.1 mm the capsules fall. Ten capsules were assessed for each accession and the modal value was recorded. Capsule width was assessed for 2926 accessions.

It is possible to distinguish modern flax capsules from the different usage groups for oil and for fibre, as they differ in size (Diederichsen and Richards 2003, 25). The degree of the spontaneous opening of the mature capsules (dehiscence) allow to categorize the accessions into various groups (Table 2).

**Results**

Table 2 shows that fibre flax accessions at PGRC have relatively more capsules rated as being notably to slightly dehiscent than indehiscent. In the typical linseed the capsules tend to be for the most only very slightly dehiscent. The intermediate flax tends to have mostly slightly dehiscent capsules. Table 3 shows the width measurements of the flax capsules of the accessions at PGRC. A clear distinction is that fibre flax has narrower capsules than linseed flax. However, the intermediate types have also for the most narrower capsules. In Figure 3 the capsule width distributions for fibre flax and linseed are extracted from Table 3 to allow for better comparison of the two extreme groups when it comes to capsule width.

The measurements of the ancient flax capsules from Egypt are shown in Table 1. We measured 88 capsules from the Schweinfurth collection and categorized them after the scheme for capsule dehiscence in Diederichsen and Richard (2003, fig. 2.4). The oldest capsules date to the 3rd millennium BC and derive from the site of Abusir el-Meleq located in Northern Egypt (S.Schw. Nr. 169). These four capsules are
slightly dehiscent (a bit open) and rather small in size (figures 4a and 4b). We interpret them as belonging to a fibre flax variety. Likewise dated to the 3rd millennium BC flax capsules were available from the sample of the site Abusir (S.Schw. Nr. 388). The capsules are fragmented and could not be measured. Interestingly the fragments clearly show that the capsules had 10 lodicules which indicate that each capsule originally contained up to 10 seeds. Most capsules that date to the 2nd millennium BC look indehiscent (closed) and the size is in all sites bigger than those capsules from Abusir el-Meleq (S.Schw. Nr. 169). We therefore interpret these capsules as counted among an oil flax (linseed) type. From the site of Sheikh Abd el-Qurna (S.Schw. Nr. 166) 88 randomly selected capsules were categorized according to Diederichsen and Richards (2003, 25): 55 into the groups “notably/slightly dehiscent” and 12 capsules into the groups “very slightly/non-dehiscent” (figures 5a and 5b). In other words, this flax could have been an intermediate type. The measurements of 20 capsules from this site do not point to a fibre flax either. Both observations also apply to the capsules from the site of Assasif dated to the 2nd-1st millennium BC (S.Schw. Nr. 164): the capsules are quite big and slightly open, again most probably an intermediate flax type that was used for both purposes: oil and fibre production. The most recent flax capsules from the site Abusir el-Meleq (S.Schw. Nr. 167), dated to the 2nd century AD, are big and show closed capsules, definitely a seed usage type of the flax plant.

Discussion and conclusions

For the first time desiccated flax capsules from ancient Egyptian sites were studied and compared with measurements and morphological features of modern genebank material. The comparisons show that the oldest flax finds, dated to the 3rd millennium BC, were probably fibre flax types, whereas in all later periods from which we could study material, an intermediate flax and/or oil type was in use. An earlier study on Egyptian flax seeds showed similar results (Karg et al. 2018).

Most of the flax findings originate from the Theban region, which is not the most suited region for cultivating fibre flax, compared to the Delta areas where there are better soils and there is much more water available. The change in cultivating different flax types throughout the millennia might be attributed to different reasons that need to be investigated in the future, such as the following: did local production of fibre flax diminish because the raw material for textile production or even the textiles themselves were imported from other regions? Did climatic change during the second millennium BC trigger better conditions for the cultivation of an oil flax type? Was linseed oil more demanded as food or for the embalming process of the dead and was this variety therefore more often used as grave goods?

With this multidisciplinary study we want to show that it is possible to come closer of finding answers to the question whether ancient cultures consciously selected crop varieties and cultivated those for special needs and purposes. We want to appeal that characterization data of genebank accessions should more often be used in the future in order to enlighten the long-term history and evolution of cultivated plants. In addition, archaeological plant material should more often be studied by applying advanced methods,
such as entangling their ancient genetic make-up as this might also set focus to prevent the shrinking biodiversity of important crops and give an impetus for their protection.

**Declarations**

**Acknowledgements**

A grant given by the EU (Synthesys Programme) enabled the first author to study ancient Egyptian flax seeds and capsules from the Schweinfurth collection kept at the Botanical Museum of the Free University of Berlin in Germany. The stay in Berlin was additionally financed by a grant of the Centre for Textile Research and the Saxo Institute, both associated at the University of Copenhagen, Denmark. We want to thank all three Institutions, as well as the host for their support and Renate Germer who made contact to the Botanical Museum.

**Conflict of interest**

The authors declare that they have no known competing financial interests or personal relationship that could have appeared to influence the work reported in this paper.

**References**


2. Cassuto D, Orendi A, Shai I (2022) Food for thought or threads for weaving: can we identify the uses for ancient flax seeds discovered in the Southern Levant? In: Ulanowska A, Grömer K, Vandenbergh I, Öhrman M (eds.) Ancient Textile Production from an Interdisciplinary Perspective - Humanities and Natural Sciences Interwoven for our Understanding of Textiles. Springer, Cham, pp 197-219


zu Berlin - Preußischer Kulturbesitz


22. Rubensohn O, Knatz F (1904) Bericht über die Ausgrabungen bei Abusir el Mälaq im Jahre 1903. ZÄS (Zeitschrift für ägyptische Sprache und Altertumskunde) 41, 1–21


   https://www.journals.uchicago.edu/doi/10.1086/658367

**Tables**

Tables 1 to 3 are available in the Supplementary Files section.

**Figures**
Figure 1

Map with the Egyptian sites described in the text.
Figure 2

Nicely decorated show box with flax capsules from collection Schweinfurth (S.Schw. Nr. 166) with label handwritten by Schweinfurth.
Figure 3

Capsule width distribution in fibre flax (n=394) and linseed (n=172) from modern genebank accessions
Figure 4

a and b 4 flax capsules from the ancient site of Abusir el-Meleq, S.Schw. Nr. 169
Figure 5

a and b 10 flax capsules from the ancient site of Abd el-Quarna, S.Schw. Nr. 166

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.
- KargetalTable1.xlsx
- KargetalTable2.xlsx
- KargetalTable3.xlsx