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Simmondsia chinensis (Jojoba): A Comprehensive Pharmacognostic Study

Mohamed L. Ashour [1*], Nahla A. Ayoub [1], Abdel Nasser B. Singab [1] and Mohamed M. Al Azizi [1]

1. Department of Pharmacognosy, Faculty of Pharmacy, Ain Shams University, Abbassia, 11566 Cairo, Egypt [E-mail: mohamed_ashour@pharm.asu.edu.eg; Tel: +20224051120]

Simmondsia chinensis (Link) C. Schneider or simply Jojoba belongs to family Simmondsiaceae is a woody, evergreen, perennial shrub native to Southern Arizona, Sonora and Baja California. The seeds produce a liquid wax, which is very similar to spermaceti and has wide applications in cosmetics and pharmaceutical industry. In addition, different extracts from jojoba plant are widely used in many folk medicinal uses. The aim of the present work was to make an in-depth pharmacognostic study (both macro- and micro-morphological) in order to help in the identification and standardization of *S. chinensis* waxes and extracts. All the microscopical measurements of different elements and the numerical values of the leaves are listed.

Keyword: *Simmondsia chinensis*, jojoba, macro-morphological, micro-morphological, botanical.

1. Introduction

Plants and plants derived materials represent the basis of many traditional medicine systems as Ayurvedic, Kampo, and many others that have been used successfully for healing ailments over millennia. Nowadays, it is very interesting to emphasize that despite of the vast increase in manufacturing synthetic and/or semi-synthetic therapeutic agents to face the global demand for new drugs, approximately 80% of the world's inhabitants rely mainly on traditional herbal medicines for their health care[1,2].

Simmondsia chinensis (Link) C. Schneider. (Syn. *Buxus chinensis* Link; *Simmondsia californica* Nutt.) or simply Jojoba belongs to family Simmondsiaceae is mostly a woody, evergreen, perennial shrub that produce small seeds, which contains waxy liquid very similar to spermaceti[3,4]. The plant is native to Southern Arizona, Sonora and Baja California. Now, it is cultivated in different parts of the world including Egypt due to its high economic value[5].

Thorough phytochemical investigation of different jojoba extracts in addition to the wax obtained from its seeds lead to identification and characterization of different components belonging to different classes of secondary metabolites. Most of the wax content are esters of high molecular weight monounsaturated fatty acids and alcohol in addition to many sterols and vitamins[6]. However, few flavonoids were isolated and biologically evaluated for their hepatoprotective and antioxidant activity from the methanol extract of Jojoba pericarp. These flavonoids include quercetin 3,3'-dimethyl ether, isokaempferide and quercetin 3-methylether[7].

Jojoba has a rich ethnobotanical history for its uses for a number of skin and scalp disorders. Other early-mentioned medical uses, such as curing the suppression of the urine, helping in

weight loss, improvement of liver functions, elevating body immunity, remedy for cancer and promotion of growth of hair are also reported[8].
Most of these uses were extensively studied and the plant wax and extracts showed promising activity as skin emollient[9,10], anti-acne, antipsoriasis[11], anti-inflammatory[12] and anti-hypercholesterolemia[13].
Most of the previous botanical work was carried only on the seeds, fruits and the leaves of this medicinally important plant. However, lack of comprehensive botanical study on different plant organs encouraged the authors to complete the botanical picture of the plant and to find out the main diagnostic features of the aforementioned organs that might help in identification of the plant either in the entire form or in its powder form leading to improvement in their use in folk medicine.

2. Material and methods

2.1 Plant material:

Samples of *Simmondsia chinensis* (Link) Schneider including the underground part and both male and female flowers were collected from the farms of The Egyptian Natural Oil Company, Ismailia Desert Road, Egypt. The plant was kindly identified and authenticated morphologically by Prof. Dr. Mahmoud M. El-Serafy, Department of Horticulture, Faculty of Agriculture, Al-Azhar University, Nasr City, Cairo, Egypt. Fresh plant materials of different organs were fixed in ethyl alcohol (70%) containing glycerin 5% soon after collection. Histological sections were cut using a manual microtome (American Optical Co.) model 900 and stained using Safranin and Malachite green. For isolated elements and powder examination each individual organ was, separately, air-dried according to the standard herbarium technique and reduced to powder No. 36. Voucher specimens of the authenticated plant have been deposited at the Department of Pharmacognosy, Faculty of Pharmacy, Ain Shams University (P-MA-1). The figures were taken using the Carl Zeiss optical microscope (Berlin, Germany) fitted with camera lucida.

3. Results and Discussion

I- Macromorphology:

Simmondsia chinensis (Link) Schneider family Simmondsiaceae is a perennial much woody branched, dioecious shrub (Fig. 1). It has strong tap-rooted system, divergent erect branches that carries opposite decussate leaves, leathery ovoid capsular fruits and black shiny seeds. The plant flowers in February to April, the fruits appears in July to August, and the full maturation of the seeds occurs in October.

The roots have dark brown colored surface showing fine longitudinal striations. It is composed of several tap roots developed by repeated forking below the crown with maximum depth of about 15 m and about 15 cm in diameter and carries numerous, hairy secondary adventitious roots and rootlets. Dried roots break with short fibrous fracture, odorless and has astringent taste (Fig. 1 B).

The old stem: are monopodially branched, hard, erect, and cylindrical in shape with brown color and slightly rough surface with small longitudinal fissures. While, young stems are green, hairy and flexible. The old stems measure 2–4 m in height and 1–5 cm in diameter. While, the young stems are 15–75 cm height and 2–7 mm in diameter. It breaks with short fibrous fracture and has astringent taste and no characteristic odor.

The leaves are green to grey in color, cauline, opposite decussate, exstipulate, and short petiolate. The lamina is simple, oblong-ovate in shape, 2–6 cm long and 1–2.5 cm width with entire margin, acute apex and symmetric base. It has pinnate reticulation. Both upper and lower surfaces have the same color and hairy. The leaves have coriaceous texture, astringent taste and almost odorless (Fig. 1C).

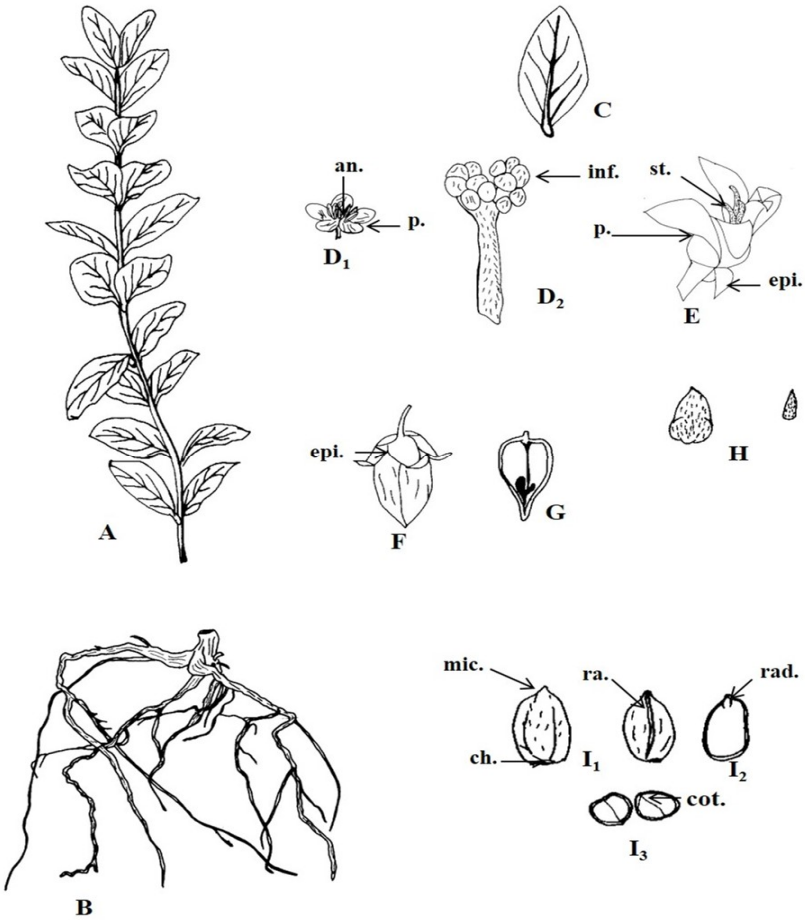

Fig. (1): Macro-morphology of *Simmondsia chinensis* (link) Schneider family Simmondsiaceae.

A. Sketch of young aerial branch (2 years) **(X 0.8)**
B. Sketch of young root. (2 years) **(X 0.3)**
C. Sketch of the leaf. **(X 0.8)**
D. Sketch of the male flower.
   D_1: open solitary flower **(X 2.5)**
   D_2: male inflorescence **(X 2.5)**
E. Sketch of the female flower. **(X 4.0)**
F. Sketch of the fruit. **(X 0.5)**
G. Longitudinal section in the fruit.
H. Persistent calyx and epicalyx. **(X 1.0)**
I. Sketch of the seed. **(X 1.0)**
   I_1: The entire seed from both sides.
   I_2: Longitudinal section of the seed.
   I_3: Transverse section of the seed.

an., anther; cot., cotyledon; epi., epicalyx; inf., inflorescence; mic., micropyle; p., perianth; per., persistent calyx; ra., raphé; rad., radical; st., style.

The flowers are regular, actinomorphic, unisexual, dioecious and pedicellate with flat receptacle and the inflorescence is spike or raceme. The flower varies in its size according to sex; it may attain 2–5 mm across. Flowers are composed of imbricated calyx in two whorls

enveloping the sexual organs (male or female) (Fig. 1 D_1, D_2, E & H). The pedicel is cylindrical, hairy, erect and green in color.

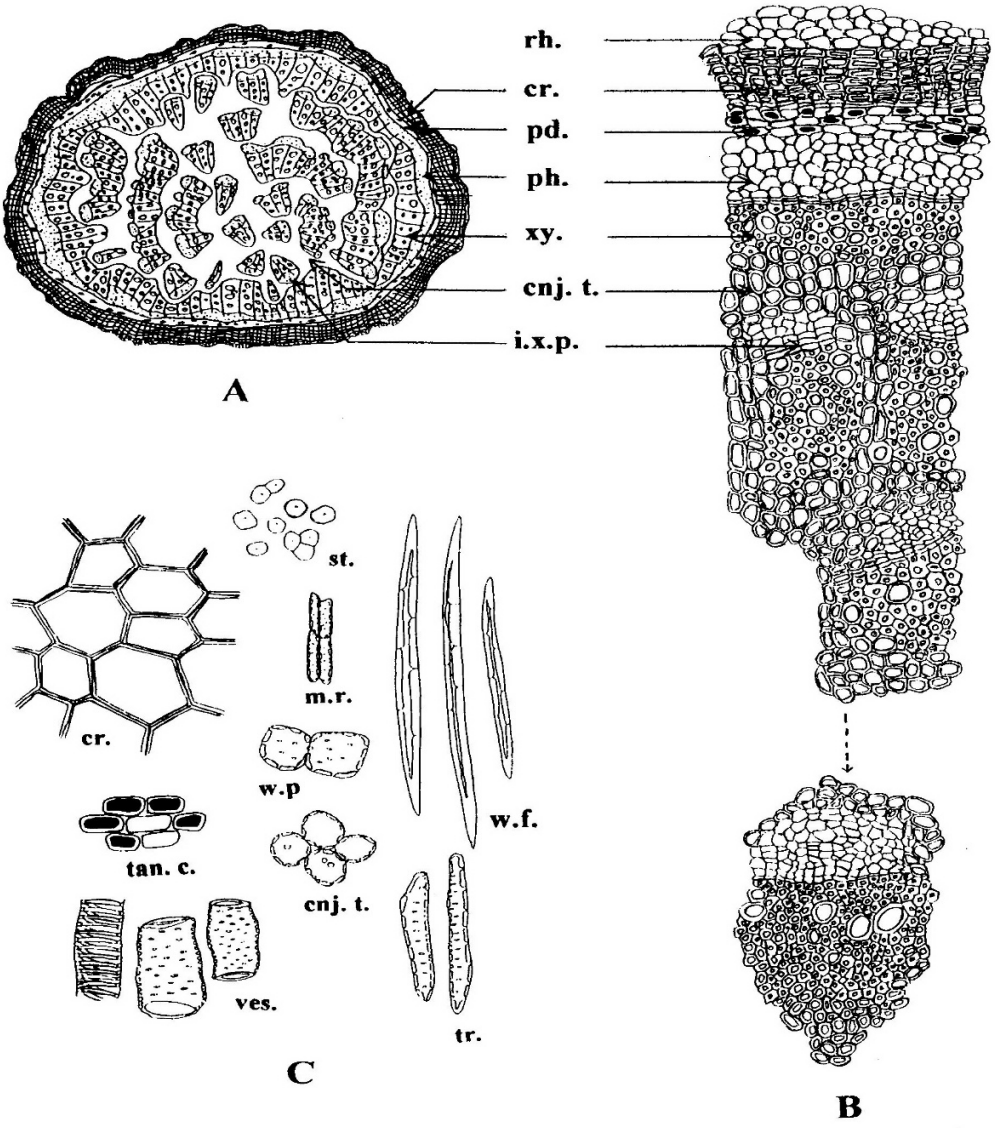

Fig. (2): Micromorphology of the 2 years old root of *Simmondsia chinensis* (link) Schneider

A.	Diagrammatic transverse section of the root.	**(X 20)**
B.	Detailed transverse section of the root.	**(X 112)**
C.	Isolated elements of the root.	**(X 190)**

cnj.t., conjunctive tissue; cr., cork; i.x.p., interxylary phloem; m.r. medullary ray; pd., phelloderm; ph., phloem; rh., rhytidoma; st., starch (X=285); tan.c., tannin cell; tr., tracheids; ves., vessel; w.f., wood fiber; w.p, wood parenchyma; xy., xylem.

It measure 0.7–1 cm long, 0.2–0.4 cm in diameter. The calyx (Fig. 1 H) is consisted of five lanceolate to triangular sepals. It measures 0.8–1.5 cm in length and 0.4–0.6 cm in width with entire margin, acuminate apex, smooth surface and indistinct midribs. Epicalyx presents in the

form of three or four segments. The male flower (Fig. 1 D_1& D_2) is small, clusterous and pale yellow in color. The androecium is composed of numerous stamens directly attached to the flat receptacle. Each stamen composed of large anther with very short innate (basifixed) filament. The female flower (Fig. 1 E) is relatively much larger, usually solitary with pale green in color and odorless. The gynaecium is composed of three syncarpous, superior, ovate ovaries with three locules separated by thin septa. The pistillate flower measures 0.5–0.7 cm in diameter. Styles are long, erect, slender, fused at the base measuring 1.5–2.0 cm in length. Stigmas are papillosed. Placentation is axile with one pendulous and anatropous ovule (Fig. 1 G).

The fruits are loculicidal, thick leathery capsules with small greenish stalk. Fruits are ovoid in shape with 2–4 cm long and 1–1.7 cm diameter (Fig. 1F). It has a smooth shiny, green appearance when it is unripe while it gets a longitudinally wrinkled dark brown appearance upon ripening. It has two scars; one of them due to the attachment with the receptacle and the other for the style. Each capsule dehisces along its ventral sutures dispersing mostly one and rarely three shiny brown or black seeds. The fruits have astringent taste and no odor.

The seeds are ovate in shape, peanut-sized, 1.2–1.5 cm long and 0.7–1.0 cm in diameter. It has straight embryo consists of thick two cotyledons with no endosperm and straight radical (Fig. 1I). The testa is thick, leathery, with dark brown color. As a typical anatropous ovule, the hilum is present in the narrow end near the micropyle while chalaza found in the opposite wide flattened end, covered with dense mat of trichomes. The dorsal longitudinal raphé is characteristic for family Simmondsiaceae. It has oily taste and no characteristic odor.

II- Micromorphology:

a. The root:

A transverse section in the old root (Fig. 2) is circular in outline, showing an outer layer of periderm consisting of several rows of cork cells and narrow phelloderm surrounding a complete ring of wide stele. The stele consists of alternating concentric bands of xylem and conjunctive tissue that encloses randomly distributed strands of phloem. The center of the root consists of four vascular bundles arranged in a cross shape. The periderm (Fig. 2 B & C) is the outermost layer of the root and it consists of cork layers and phelloderm. The cork is formed of 8–12 radially arranged rows of brownish polygonal or isodiametric rarely tangentially elongated cells with suberized straight anticlinal walls covered with dark brown rhytidoma. The phelloderm consists of 2–4 rows of small, dense, elongated parenchymatous cells with small intercellular spaces and slightly thickened cellulosic walls. These cells are frequently filled with tannins deposits and have no calcium oxalate crystals. The endodermis and pericycle are indistinct.

The vascular tissue of the root is composed of phloem, cambium, conjunctive tissue and xylem which are arranged in actinostele shape. The phloem is well marked outermost zone of the stele, consists of thin walled cellulosic sieve tubes, companion cells and phloem parenchyma containing starch granules with no phloem fibers. The cambium is formed of two rows of small, rectangular or roughly brick-shaped meristematic cells with thin cellulosic walls. The xylem is wide and contributing about 75% the diameter of the root. It is formed of compact, lignified pitted elements composed mainly of wood fibers, wood parenchyma, tracheids and xylem vessels. The wood fibers are strongly lignified thick walled pitted cells with acute apices and narrow lumen. Wood parenchyma is subrectanguler, axially elongated cells with moderately thick, pitted and lignified walls. Tracheids are pitted with thick lignified walls and wide lumen. Vessels are abundant lignified with pitted or spiral thickenings. The medullary rays are uni- or biseriate which transverse the vascular tissue, composed of radially elongated cells with moderately thick lignified walls. Numerous starch granules are mostly simple with few compound of three, polygonal with centric hilum and very faint striation.

The conjunctive tissue is present as alternative rings with the xylem elements and composed of lignified thick walled parenchymatous cells and

containing numerous starch granules. The interxylary phloem is present as randomly scattered concentric patches of phloem inside the inner boundary of each band of conjunctive tissue. It is composed of the same elements present in the normal phloem.

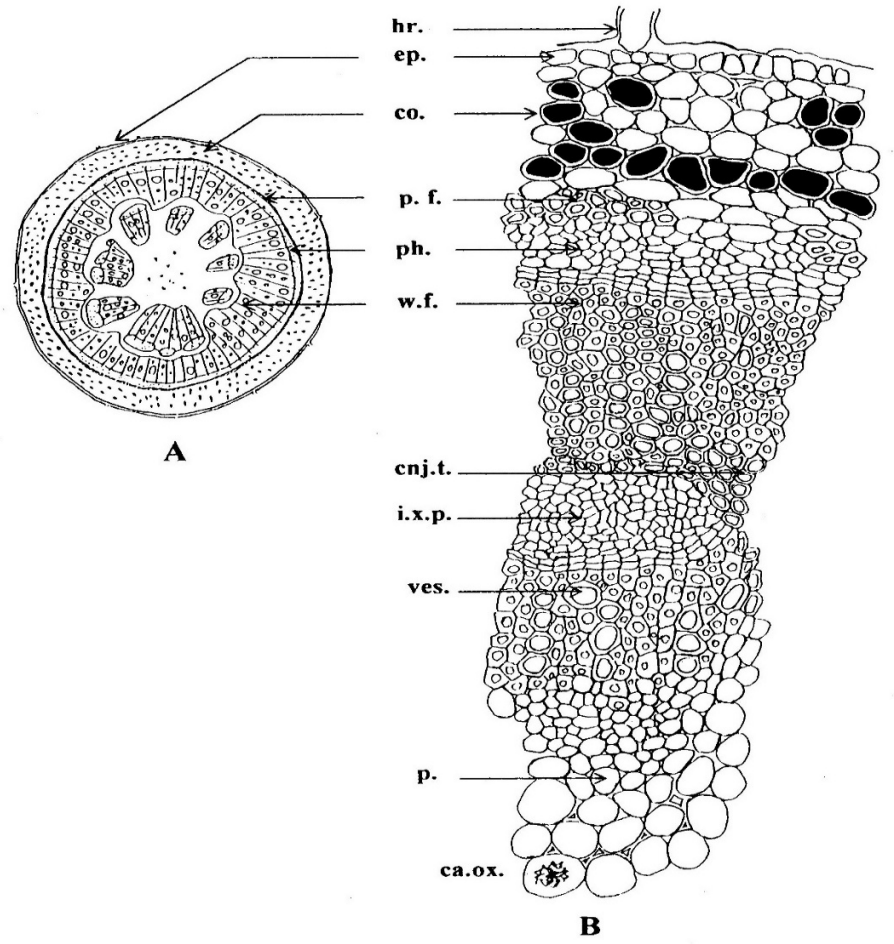

Fig. (3): Micromorphology of the young stem of *Simmondsia chinensis* (link) Schneider

A. Diagrammatic transverse section of young stem. **(X 40)**
B. Detailed transverse section of young stem. **(X 295)**

ca.ox., cluster crystals of calcium oxalate; cnj.t., conjunctive tissue; co., cortex; ep., epidermis; hr., hair; i.x.p., interxylary phloem; p., pith; p.f., pericycle fiber; ph., phloem; ves., vessel; w.f., wood fiber .

b. The stem:

A transverse section in the young stem of *S. chinensis* (Fig. 3) is circular in outline. It shows an outer epidermis enclosing a narrow parenchymatous cortex followed by a complete lignified zone of pericyclic fibers surrounding the stele. The vascular tissue is composed of collateral vascular bundles in the form of continuous layer of phloem separated from the xylem by a cambium layer. The xylem elements are separated from each other by a conjunctive tissue, which contains an interxylary phloem patches in the form of alternating layers with the xylem and the core of the section is occupied by parenchymatous pith.

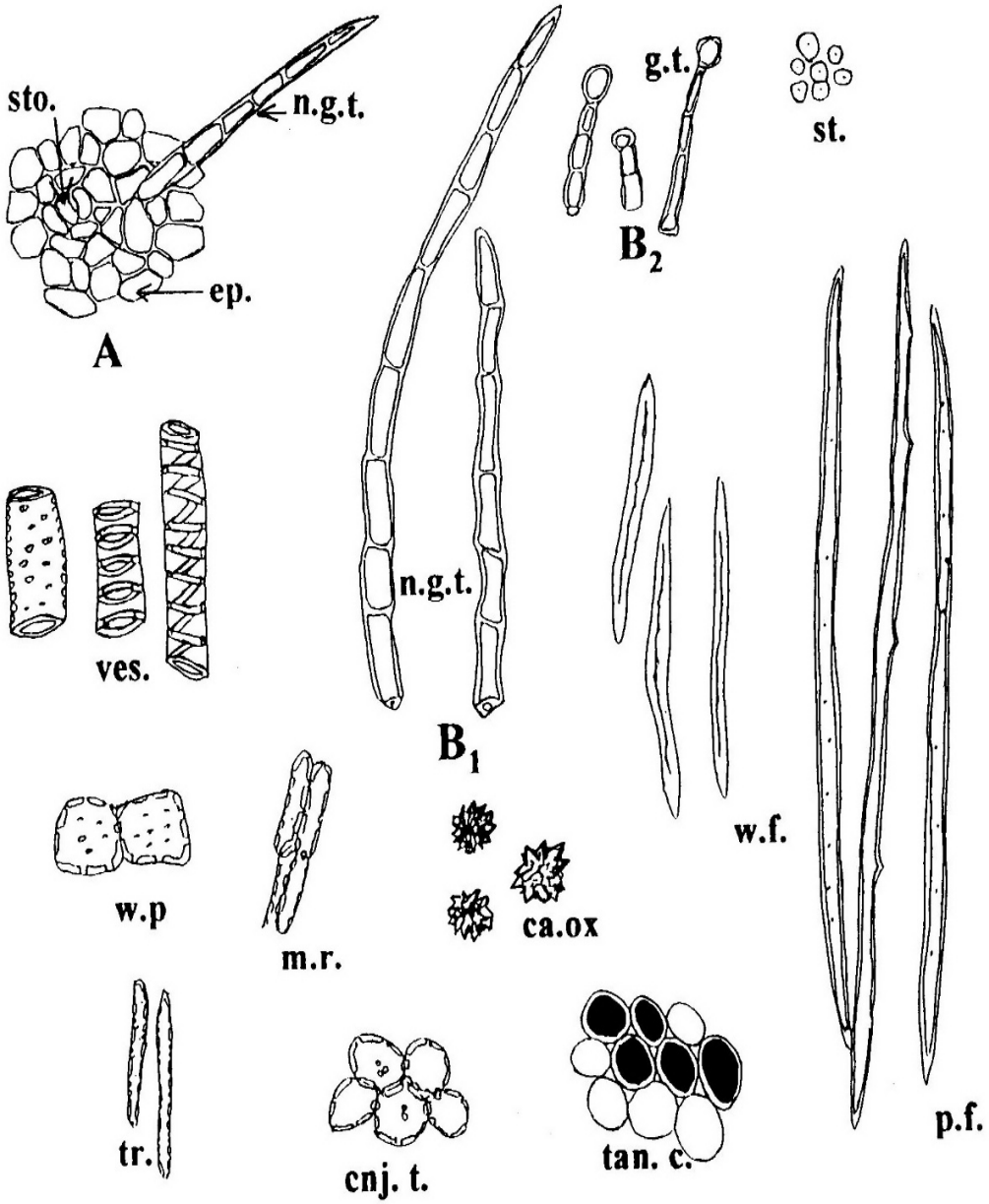

Fig. (4): Isolated elements in young stem of *Simmondsia chinensis* (link) Schneider (X=285, starch, X=340)

A. Surface preparation in the young stem.
B_1. Non-glandular trichomes of young stem.
B_2. Glandular trichomes of young stem.

ca.ox.., cluster crystals of calcium oxalate; cnj.t.., conjunctive tissue; ep., epidermis; g.t., glandular trichomes; m.r., medullary rays; n.g.t., non-glandular trichomes; p.f., pericycle fiber; st., starch; sto., stomata; tan.c., tannin cell; tr., tracheids; ves., vessel; w.f., wood fiber; w.p., wood parenchyma.

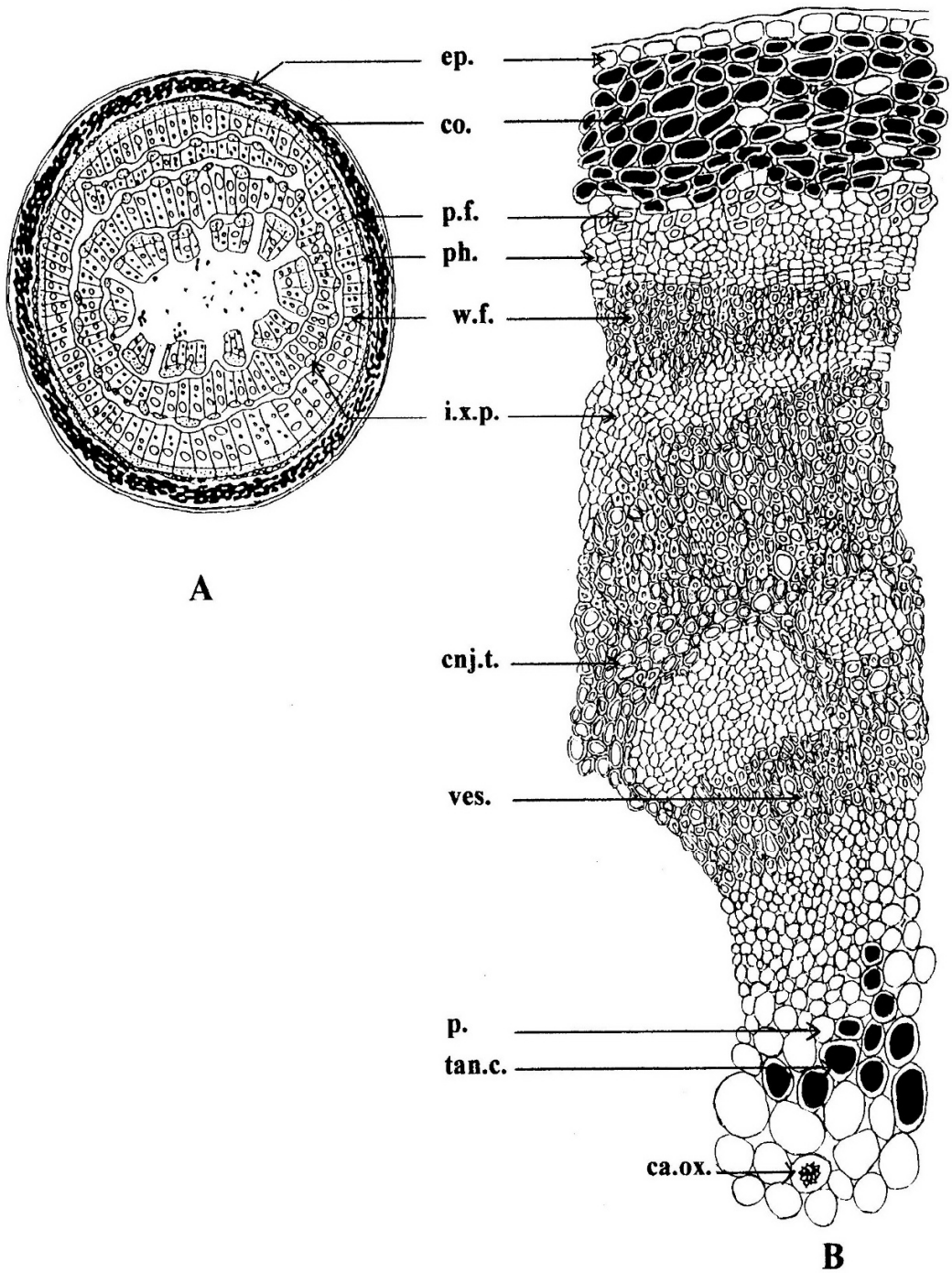

Fig. (5): Micromorphology of the old stem of *Simmondsia chinensis* (link) Schneider

A. Diagrammatic transverse section of young stem. **(X 23)**
B. Detailed transverse section of young stem. **(X 120)**

ca.ox.., cluster crystals of calcium oxalate; cnj.t.., conjunctive tissue; co., cortex; ep., epidermis; i.x.p., interxylary phloem; p., pith; p.f., pericycle fiber; ph., phloem; tan.c., tannin cell; ves., vessel; w.f., wood fiber.

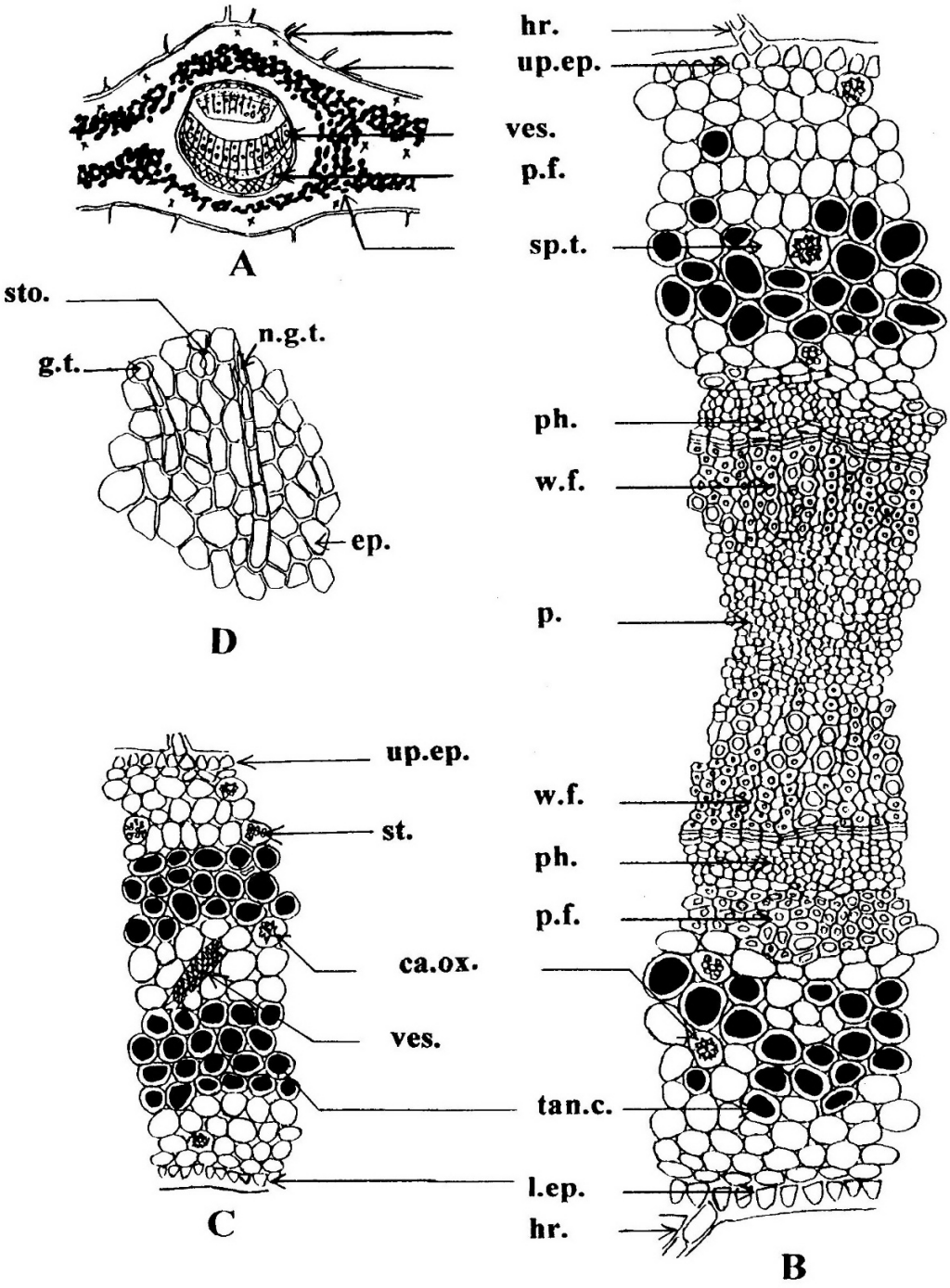

Fig. (6): Micromorphology of the leaf of *Simmondsia chinensis* (link) Schneid

A. Diagrammatic transverse section of the leaf. **(X 23)**
B. Detailed transverse section in lamina region. **(X 75)**
C. Detailed transverse section in midrib region. **(X 145)**
D. Surface preparation in the epidermis. **(X 285)**

ca.ox., calcium oxalate cluster crystals; g.t., glandular trichome; hr., hair; l.ep., lower epidermis; p., pith; p.f., pericycle fiber; ph., phloem; sp.t., spongy tissue; st., starch; sto., stomata; tan.c., tannin cell; up. ep., upper epidermis; ves., vessel; w.f., wood fiber.

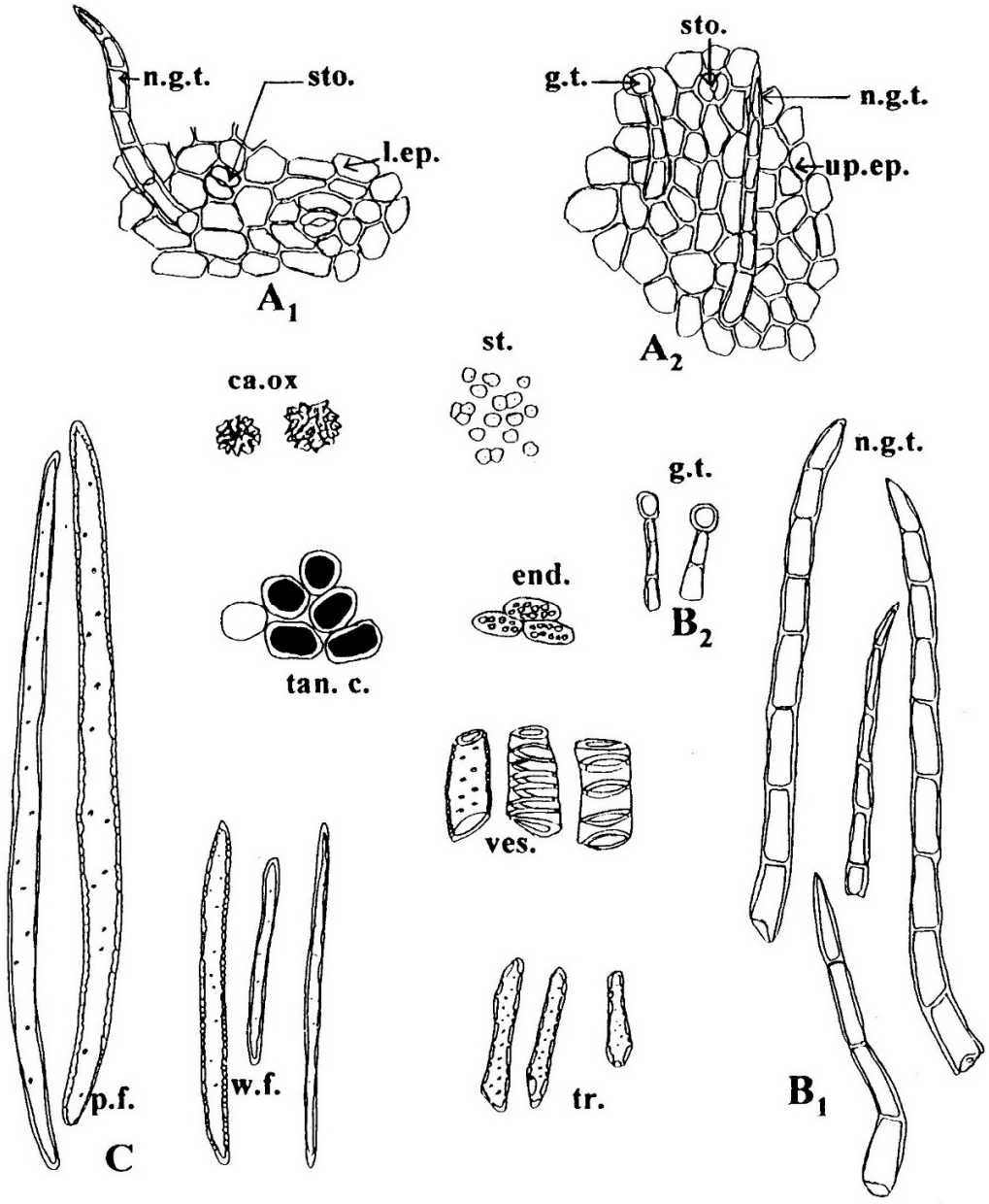

Fig. (7): Isolated elements of the leaf of *Simmondsia chinensis* (link) Schneider (X=265, starch, X=420)

A_1. Surface preparation in the upper epidermis.
A_2. Surface preparation in the lower epidermis.
B_1. Non-glandular trichomes of young stem.
B_2. Glandular trichomes of young stem.
C. Fibers

ca.ox.., calcium oxalate cluster crystals ; end., endodermis; g.t., glandular trichomes; l.ep., lower epidermis; n.g.t., non-glandular trichomes; p.f., pericycle fiber; st., starch; sto., stomata; tan.c., tannin cell; tr., tracheids; up.ep., upper epidermis; ves., vessel; w.f., wood fiber.

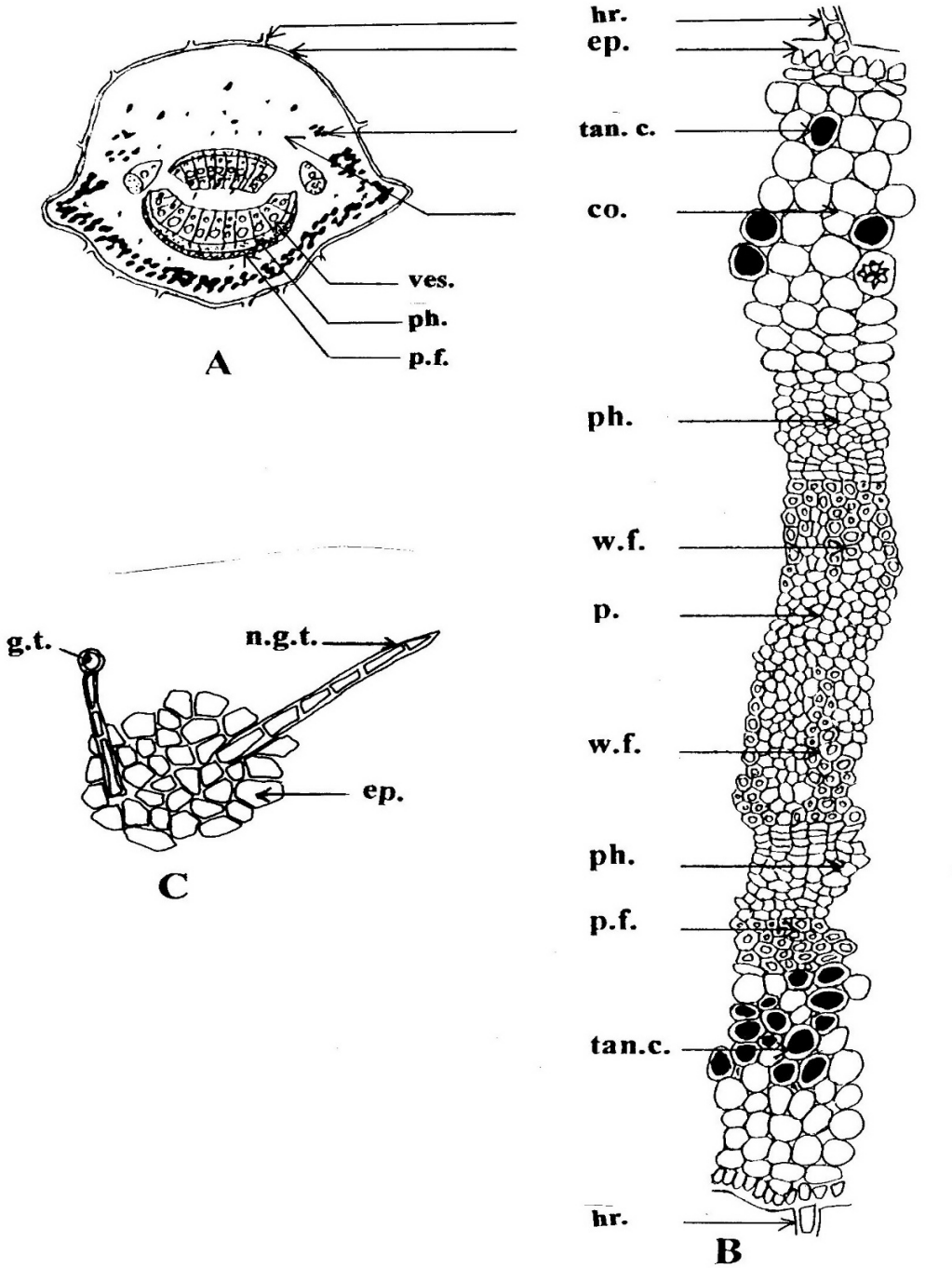

Fig. (8): Micromorphology of the petiole of *Simmondsia chinensis* (link) Schneider

A. Diagrammatic transverse section in the petiole. **(X 23)**
B. Detailed transverse section in the petiole. **(X 185)**
C. Surface preparation in the epidermis of the petiole. **(X 265)**

ca.ox., calcium oxalate cluster crystals; co., cortex; ep., epidermis; g.t., glandular trichome; hr., hair; n.g.t., non glandular trichome; p., pith; p.f., pericycle fiber; ph., phloem; tan.c., tannin cell; ves., vessel; w.f., wood fiber; xy., xylem.

The powder of young stem (Fig. 4) is light green in color with no characteristic odor and astringent taste. The epidermis consists of a single layer of polygonal, axially elongated subrectanguler cells with straight anticlinal walls and covered with thick smooth cuticle, measuring 10-16-25 µ in length, 9-12-14 µ in width and 10-15-19 µ in height. Stomata are occasional, of anomocytic type, slightly sunken below the stem surface, measuring 16-24-30 µ in length and 10-14-16 µ in width. Trichomes are abundant of both kind glandular and non-glandular types. The covering hairs are uniseriate multicellular of 5 to 11 cells and covered with smooth cuticle, measuring 172-245-383 µ in length and 11-14-17 µ in width. The glandular hairs are short and less frequent with multicellular uniseriate stalk 2-4 cells and unicellular head also covered with smooth cuticle, measuring 31-43-66 µ in length and 6-9-10 µ in width.

The cortex is comparatively narrow and formed of 5-6 rows of thin-walled rounded to isodiametric parenchymatous cells. Some cells contain dark tanniferous deposits and few starch granules, resembling those of the root but much smaller, being simple, with faint striation and point hilum. It measures 2–3.5 µ in diameter. Endodermis is indistinct. Few calcium oxalate clusters are present, measuring 21-24-29 µ in diameter.

The pericycle consists of one- to three-layered sheath of undulate thick-walled, lignified fibers with simple or bordered pits and acute apices. It appears polygonal in cross sections with wide lumen, measuring 439-489-543 µ in length and 7-12-17 µ in width. The stele is represented by complete ring of open vascular tissue. The phloem is relatively narrow layer encircling wide xylem with cambium in-between. Numerous patches of interxylary phloem are present scattered in the conjunctive tissue that alternating with xylem elements. The phloem consists of thin walled cellulosic sieve tubes, companion cells and phloem parenchyma with no bast fibers. The cambium is formed of 2–4 rows of small, tabular tangentially elongated meristematic cells with thin cellulosic walls. The xylem is wide, lignified pitted formed of thick-walled elements consisting of wood fibers, wood parenchyma, tracheids and xylem vessels. The fibers are numerous; fusiform strongly lignified thick-walled pitted cells with acute apices and narrow lumen, measuring 155-184-291 µ length and 9-11-16 µ width. Wood parenchyma is subrectanguler, axially elongated cells, measuring 50-68-88 µ in length and 20-24-37 µ in width. Tracheids are long pitted with thick lignified walls and wide lumen, measuring 83-96-118 µ in length and 8-10-13 in µ width. Numerous single xylem vessels are found. It is lignified, pitted, annular or spiral thickenings measuring 28-33-47 µ in diameter. The medullary rays are uniseriate and transversing the xylem and the phloem, composed of radially elongated cells with moderately thick lignified walls, measuring 13-17-25 µ in length and 9-12-15 µ in width. It contains numerous starch granules similar to those found in the cortex. Interxylary phloem and the conjunctive tissues are similar to that of the root. The pith consists of 11–18 rows of polygonal to rounded parenchymatous cells with slightly thick walls. The cells in the center of the pith are larger than those adjacent to the xylem elements. The cells contain scattered starch, clusters of calcium oxalate, and tannin.

A transverse section in the old stem (Fig.5) is more or less similar in the anatomical features to the young stem except that the epidermal cells are less hairy and the cortex is filled with tannins. Several layers of conjunctive tissue containing interxylary phloem alternating with the secondary xylem that appears as secondary growth rings are noticed. Pith is narrower and contains much tannin.

c. The leaf:

A. The lamina and the midrib regions.

A transverse section in the lamina of *S. chinensis* (Fig. 6 A, B& C) shows a biconvex outline at the midrib region, more prominent on the upper side. It shows an upper and lower hairy epidermises enclosing the spongy tissue. The vascular tissue is composed of a large collateral arc to crescent-shaped vascular bundle. Small inverted vascular bundles are present. The pericycle consists of

continuous patch of fibers over the vascular bundles. Calcium oxalate clusters crystals, starch granules and tanniferous deposits are widely scattered. Pith is narrow in the form of slightly lignified parenchymatous cells.

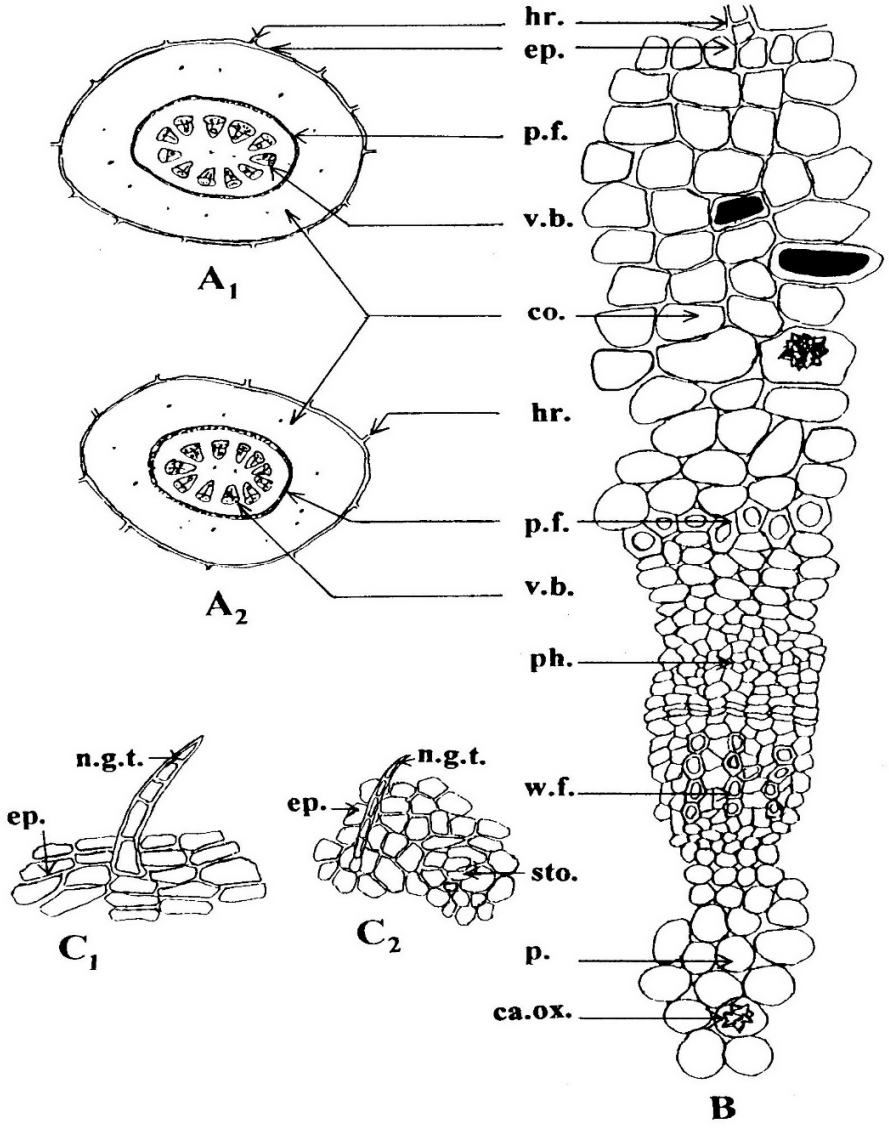

Fig. (9): Micromorphology of the flower stalk of *Simmondsia chinensis* (link) Schneider

A_1. Diagrammatic transverse section in female flower stalk.	**(X 32)**
A_2. Diagrammatic transverse section in male flower stalk.	**(X 32)**
B. Detailed transverse section in the flower stalk.	**(X 185)**
C_1. Surface preparation in the female flower stalk.	**(X 225)**
C_2. Surface preparation in the male flower stalk.	**(X 225)**

ca.ox., calcium oxalate cluster crystals; co., cortex; ep., epidermis; hr., hair; n.g.t., non-glandular trichome; p., pith; p.f., pericycle fiber; ph., phloem; sto., stomata; v.b., vascular bundle; w.f., wood fiber.

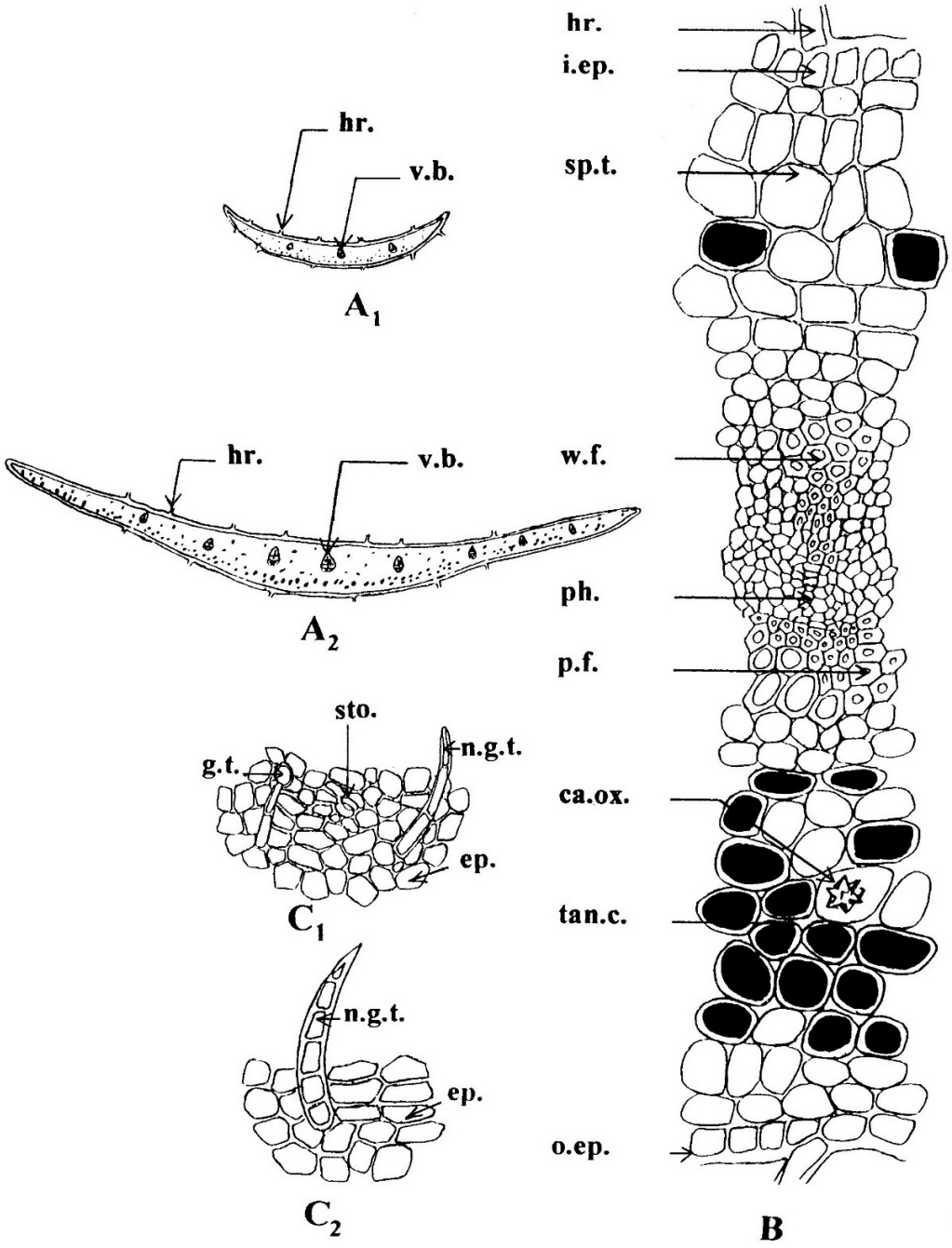

Fig. (10): Micromorphology of the perianth of *Simmondsia chinensis* (link) Schneider

A_1. Diagrammatic transverse section in the male perianth.	**(X 32)**
A_2. Diagrammatic transverse section in the female perianth.	**(X 32)**
B. Detailed transverse section in the perianth.	**(X 228)**
C_1. Surface preparation in the male perianth.	**(X 228)**
C_2. Surface preparation in the female perianth.	**(X 228)**

ca.ox., calcium oxalate cluster crystals; hr., hair; i.ep., inner epidermis; o.ep., outer epidermis; p.f., pericycle fiber; ph., phloem; sp.t., spongy tissue; sto., stomata; tan.c., tannin cell; v.b., vascular bundle; ves., vessel; w.f., wood fiber.

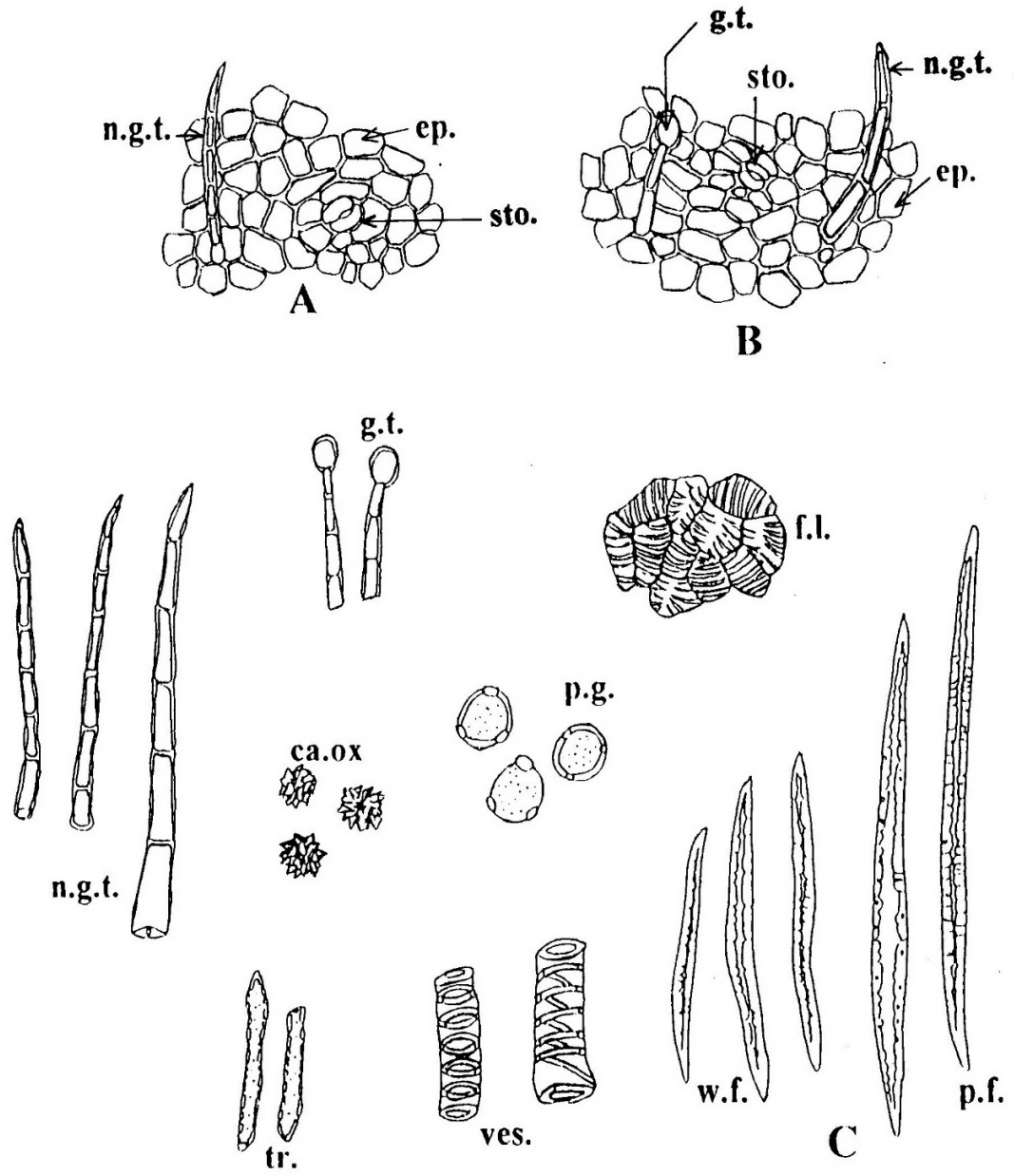

Fig. (11): Isolated elements of the male flower of *Simmondsia chinensis* (link) Schneider (X=228)

A_1. Surface preparation in the male flower stalk.
A_2. Surface preparation in the male sepal.
C. Fibers

ca.ox.., cluster crystals of calcium oxalate; ep., epidermis; f.l., fiberous layer of anther; g.t., glandular trichomes; n.g.t., non-glandular trichomes; p.g., pollen grain; p.f., pericycle fiber; sto., stomata; tr., tracheids; ves., vessel; w.f., wood fiber.

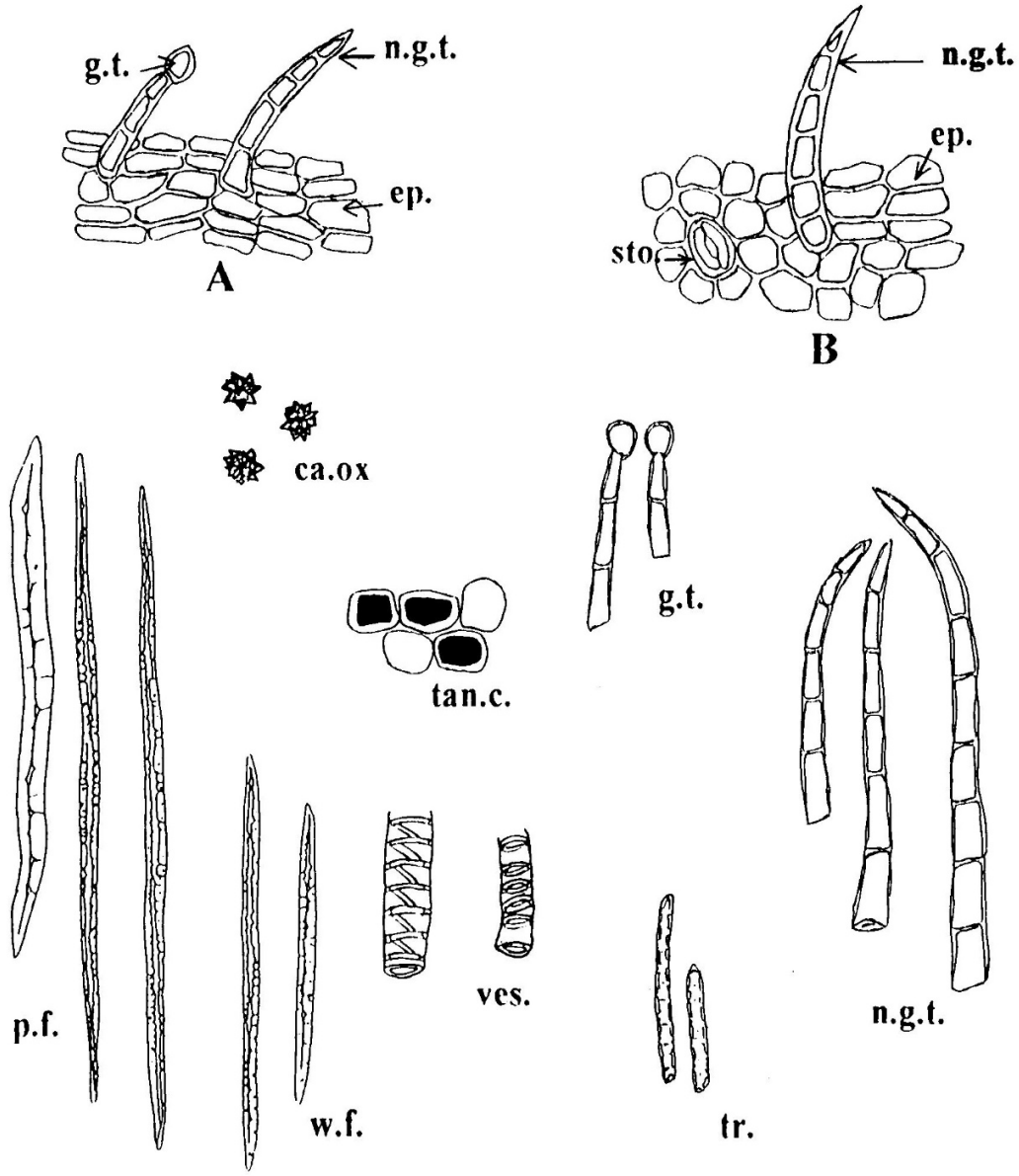

Fig. (12): Isolated elements of the female flower of *Simmondsia chinensis* (link) Schneider (X=228)

A_1. Surface preparation in the female flower stalk.
A_2. Surface preparation in the female sepal.
C. Fibers

ca.ox.., cluster crystals of calcium oxalate; ep., epidermis; g.t., glandular trichomes; n.g.t., non-glandular trichomes; p.f., pericycle fiber; sto., stomata; tan.c., tannin cell; tr., tracheids; ves., vessel; w.f., wood fiber.

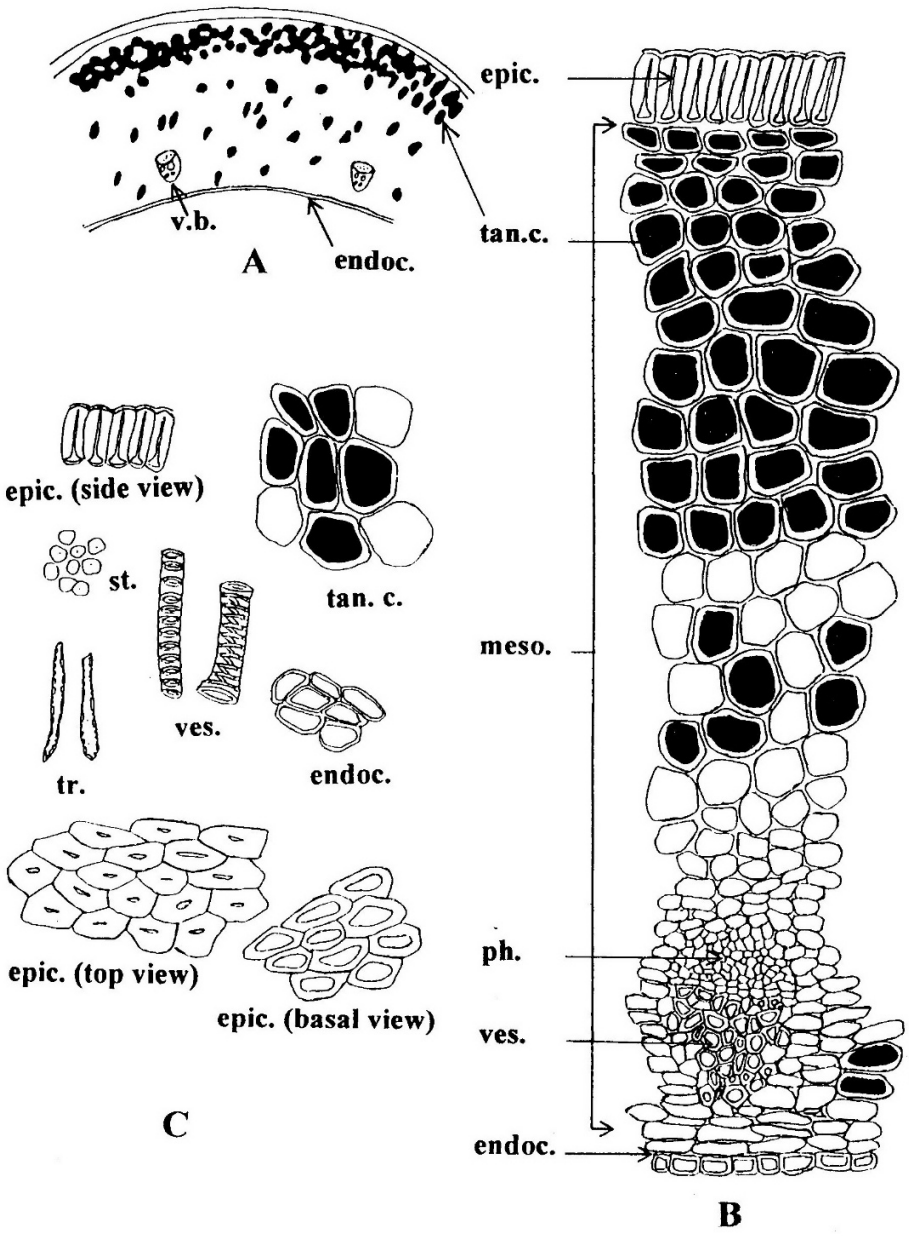

Fig. (13): Micromorphology of the pericarp of *Simmondsia chinensis* (link) Schneider

A. Diagrammatic transverse section in the pericarp. **(X 40)**
B. Detailed transverse section in the pericarp. **(X 165)**
C. Isolated elements of the pericarp. **(X 212)**

epic., epicarp; meso., mesocarp; endoc., endocarp; ph., phloem; st., starch; tan.c., tannin cell; tr., trachides; v.b., vascular bundle; ves., vessel.

The powdered leaf (Fig. 7) is light green in color with no characteristic odor and astringent taste. Microscopically, the epidermises are uniseriate formed of compactly arranged polygonal, isodiametric or axially elongated cells with straight cellulosic anticlinal walls covered with thick smooth cuticle, measuring 18-27-33 µ in length, 11-17-22 µ in width and 8-11-15 µ in height. Anomocytic stomata are sunken, more frequent in the lower side, measuring 16-19-23 µ in length and 10-12-14 µ in width. Glandular and non-glandular trichomes are present. The non-glandular trichomes are numerous uniseriate multicellular of 7-12 cells and covered with smooth cuticle, measuring 211-268-340 µ in length and 11-14-16 µ in width. Multicellular uniseriate stalk of 3-5 cells and unicellular head glandular trichomes are present, measuring 35-47-66 µ in length and 6-11 µ in width.

The mesophyll is undifferentiated into palisade and spongy tissue. It composed of 14-19 rows of thin-walled nearly rounded isodiametric to elongated parenchymatous cells with no intercellular spaces. Clusters of calcium oxalate crystals are widely scattered especially in the first layer of the cortical tissue, measuring 27-32-37 µ in diameter. Tannin deposits are widely distributed around the vascular tissue. Simple starch granules are present, measuring 6-8-10 µ in diameter. The endodermis is distinct as an axially elongated parenchyma cells containing starch granules over the vascular bundles.

The pericycle is composed of lignified thick-walled patches of fusiform fibers with wide lumens and blunt apices surmounting the vascular bundles, measuring 400-423-450 µ in length and 8-13-19 µ in width. The vascular tissue is composed of discontinuous ring of collateral vascular bundles. The main lower is crescent-shaped while the smaller are inverted and composed of 2-4 collateral vascular bundles. The phloem is composed of delicate, thin-walled cellulosic sieve tubes, companion cells and phloem parenchyma while phloem fibers are absent. The xylem is composed of thick-walled lignified narrow vessels with spiral, pitted and annular thickening, measuring 23-27-31 µ in diameter, septate lignified fibers with wide lumen and blunt apices, measuring 135-163-218 µ in length and 10-12-15 µ in width. Long pitted or reticulate tracheids measuring 78-86-108 µ in length and 8-11-12 µ in width and xylem parenchyma are present. The medullary rays are uniseriate longitudinally elongated thick walled non-lignified parenchymatous cells. Starch granules are present and it is similar to that present in the cortex. The pith is narrow lignified, thick-walled parenchymatous cells. The microscopical numerical values of the leaf including stomatal number, stomatal index and vein-islet number are listed in Table 2.

B. The petiole

The transverse section of the jojoba petiole (Fig. 8 A& B) is almost rounded in outline, showing epidermal layer followed by a wide cortex containing clusters of calcium oxalate crystals. The vascular tissue is composed of main large crescent-shape collateral vascular bundle accompanied by one inverted and two small lateral vascular bundles. Pith is narrow and parenchymatous.

The epidermis is composed of polygonal isodiametric cells with straight anticlinal walls, measuring 17-21-27 µ in length, 7-11-13 µ in width and 8-10-13 µ in height covered with thick evenly distributed cuticle. Non glandular trichomes are numerous, uniseriate, multicellular of 4 to 7 cells covered with smooth cuticle, measuring 135-179-224 µ in length and 11-13-15 µ in width. Stomata are absent.

The cortex is wide and composed of 10 – 13 rows of thin-walled rounded to polygonal parenchymatous cells with straight anticlinal walls. Some cells contain dark tanniferous content especially in the lower side and others contain cluster of calcium oxalate crystals measure 20-22-26 µ in diameter or simple starch granules with faint striation and point hilum measuring 4-7 µ in diameter. Endodermis is indistinct.

The pericycle is lignified thick-walled patches of fusiform fibers over the main crescent-shape vascular bundle, with wide lumen and blunt

Table (1): Microscopical Measucrements of Different Elements of *Simmondsia chinensis* plant. (in Microns)

Item	Measurements		Item	Measurements	
Cork cells			**Stomata**		
Root	L:	87-92-103	Flower		
	W:	47-60-71	Male stalk	L:	20-24-28
	H:	7-10-19		W:	10-15-19
Epidermal cells			Male perianth	L:	19-22-25
Flower				W:	10-12-15
Male stalk	L:	13-17-25	Female stalk	L:	22-26-30
	W:	9-11-17		W:	11-17-19
	H:	7-10-12	Female perianth	L:	21-25-31
Male perianth				W:	11-15-19
Outer	L:	16-19-27	**Multicellular**		
	W:	11-15-20	**Non-glandular hair**		
	H:	8-10-12	Flower		
Inner	L:	22-28-35	Male stalk	L:	167-203-252
	W:	9-11-15		W:	10-13-14
	H:	7-9-12	Male perianth	L:	141-159-183
Female stalk	L:	21-26-35		W:	8-11-13
	W:	15-19-23	Female stalk	L:	173-225-261
	H:	8-12-15		W:	11-13-15
Female perianth			Female perianth	L:	145-167-191
Outer	L:	20-27-31		W:	9-11-15
	W:	14-22-25	**Multicellular**		
	H:	8-11-15	**Non-glandular hair**		
Inner	L:	27-32-39	Flower		
	W:	12-15-21	Male stalk	L:	53-59-65
	H:	7-11-15		W:	9-10-12
Fiber			Male perianth	L:	58-61-71
Root	L:	180-200-260		W:	8-11-13
	W:	9-12-15	Female stalk	L:	57-61-72
Flower				W:	10-11-15
Male stalk			Female perianth	L:	58-63-71
Pericycle	L:	380-403-420		W:	9-11-15
	W:	7-9-11	**Vessel**		
Wood	L:	144-151-173	Root	D:	45-60-72
	W:	8-10-11	Flower		
Male perianth			Male stalk	D:	12-15-19
Wood	L:	127-138-157	Male perianth	D:	23-27-31
	W:	11-14-16	Female stalk	D:	15-16-20
Female stalk			Female perianth	D:	23-28-34
Pericycle	L:	391-423-435			
	W:	8-11-13	**Starch**		
Wood	L:	151-161-180	Root	D:	3.5-5-6
	W:	9-10-13	Flower Stalk	D:	6-8-9
Female perianth			Fruit Pericarp	D:	2.5-3-5
Wood	L:	137-146-160			
	W:	10-12-16			

D: Diameter **H: Height** **L: Length** **W: Width**

apices, measuring 430-466-470 µ in length and 7-9-12 µ in width. The collateral vascular bundle is crescent-shaped, accompanied by two small lateral vascular bundles and one inverted basal one. The xylem is composed of lignified thick-walled elements mainly narrow spiral and annular vessels, measuring 17-19-23 µ in diameter, septate lignified fibers with wide lumen and blunt apices, measuring 156-176-191 µ in length and 10-12-15 µ in width. Long pitted or reticulate tracheids measuring 90-111-123 µ in length and 8-10-12 µ in width and lignified thick-walled xylem parenchyma are also present. The phloem, medullary rays and the pith are similar to that present in leaf.

d. The flowers:

1- The stalk

A transverse section in the stalk of the male flower (Fig. 9 A_2) is circular in outline. It shows outer epidermis layer followed by a relatively wide cortex that contains few tannin deposits and calcium oxalate cluster crystals. Endodermis is indistinct. The stele is composed of a complete ring of pericycle fibers followed by phloem and xylem. Pith is present with calcium oxalate cluster crystals.

The epidermis is composed of one layer of polygonal cells covered by smooth cuticle and carrying numerous non-glandular multicellular (3-6 cells), uniseriate hairs. The cortex is composed of 9-11 rows of elongated polygonal parenchymatous cells with thin walls and narrow intercellular spaces. Few calcium oxalate cluster crystals and tannin deposits are present. Simple starch granules are present with faint point hilum and indistinct striation. Endodermis is indistinct.

The pericycle is composed of complete ring of lignified thick-walled fibers with acute apices and narrow lumens. The vascular tissues are composed of continuous ring of separated collateral vascular bundles. The phloem is anatomically similar to that present in all other organs, but phloem parenchyma is much abundant with many simple starch granules with indistinct hilum and no bast fibers are present.

The xylem is composed of lignified thick-walled xylem vessels with pitted, spiral or annular thickening, wood fibers are strongly lignified with acute apices and narrow lumens. Tracheids are present with pitted thick-walled thickening. The medullary rays are uniseriate, of radially elongated cells with non-lignified thick-walls. Starch granules are present. The pith is polygonal, thin-walled parenchymatous cells which contain starch granules and clusters of calcium oxalate crystals. The female flower stalk is anatomically similar to that of the male flower.

2- The Perianth:

A transverse section in the sepals (Fig. 10) shows a typical leaf structures, it is crescent in shape. It shows outer and inner epidermises enclosing the spongy tissue which contain large tannin deposits and calcium oxalate clusters. Many scattered collateral vascular bundles.

The outer epidermis is formed of one layer of polygonal cells covered by thick smooth cuticle. Non-glandular hairs are present, being multicellular (3-6) uniseriate. Anomocytic stomata is present. Few glandular trichomes with uniseriate multicellular stalk (2-3 cells) and unicellular head are present.

The mesophyll is composed of undifferentiated parenchymatous cells with straight thin-walls and narrow intercellular spaces. Tannin deposits are abundant especially beneath the outer epidermis. Numerous scattered vascular bundles are present near the lower epidermis. It is composed of a patch of pericycle fibers with thick lignified wall, blunt apices and nearly wide lumen followed by phloem and xylem vessels with spiral or annular thickening. Wood fibers with acute apices and narrow lumen are also present. The inner epidermis is similar to outer epidermis but with much anomocytic stomata.

A transverse section in the stalk of the female flower is anatomically similar to that of the male flower, however the female perianth can be distinguished from the male by the presence of larger vascular bundles and hence the increase overall size of the transverse section. The female flower perianth is similar to the male flower

sepals with few differences. The transverse section is much larger (approximately triple length) and the vascular bundles are much larger.

The powders of both male flowers (Fig. 11) and female flowers (Fig. 12) are yellowish green in color, odorless with astringent taste and most of the characteristic elements are listed in Table 1.

Table (2): Microscopical numerical values of the leaf of *Simmondsia chinensis* (Link) Schneider. (Simmondsiaceae)

The item	Recorded value
Stomatal number for upper epidermis.	10-12-14
Stomatal number for lower epidermis.	14-16-18
Stomatal index for upper epidermis.	5.2 – 5.7
Stomatal index for lower epidermis.	5.5 – 5.9
Vein-islet number	11 – 15
Veinlet termination number	16 – 21

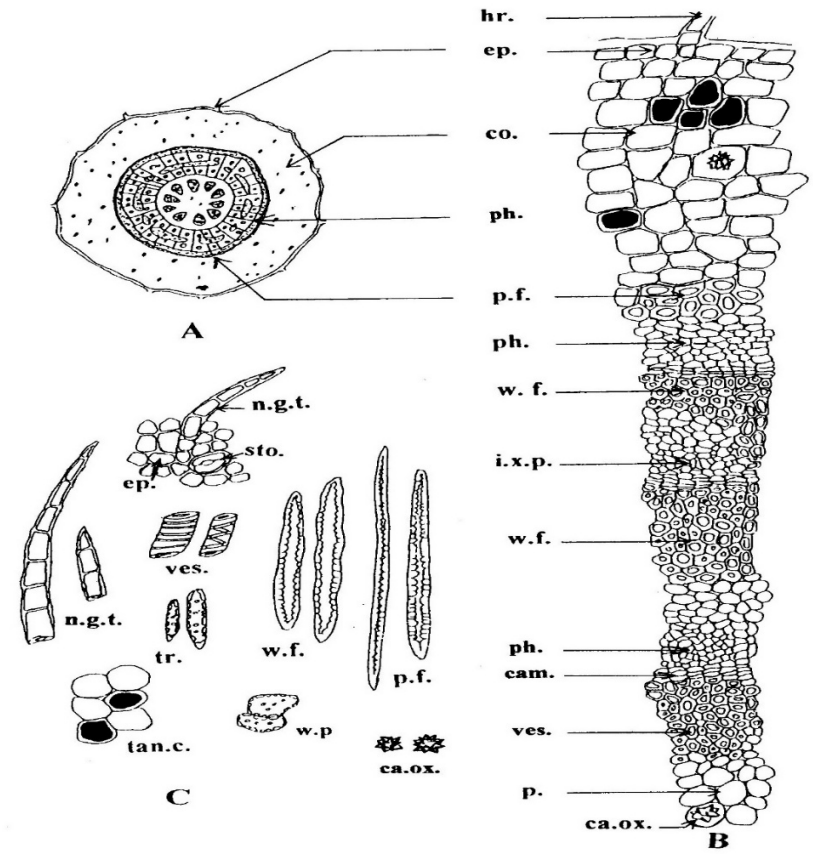

Fig. (14): Micromorphology of the fruit stalk of *Simmondsia chinensis* (link) Schneider

A. Diagrammatic transverse section in the fruit stalk. **(X 32)**
B. Detailed transverse section in the fruit stalk. **(X 150)**
C. Isolated elements of the flower stalk. **(X 212)**

cam., cambium; co., cortex; cr., cluster crystals of calcium oxalate; ep., epidermis; hr., hair; i.x.p., interxylary phloem; n.g.t., non-glandular trichome; p., pith; p.f., pericycle fiber; ph., phloem; sto., stomata; tan.c., tannin cell; tr., trachides; ves., vessel; w.f., wood fiber; w.p., wood parenchyma.

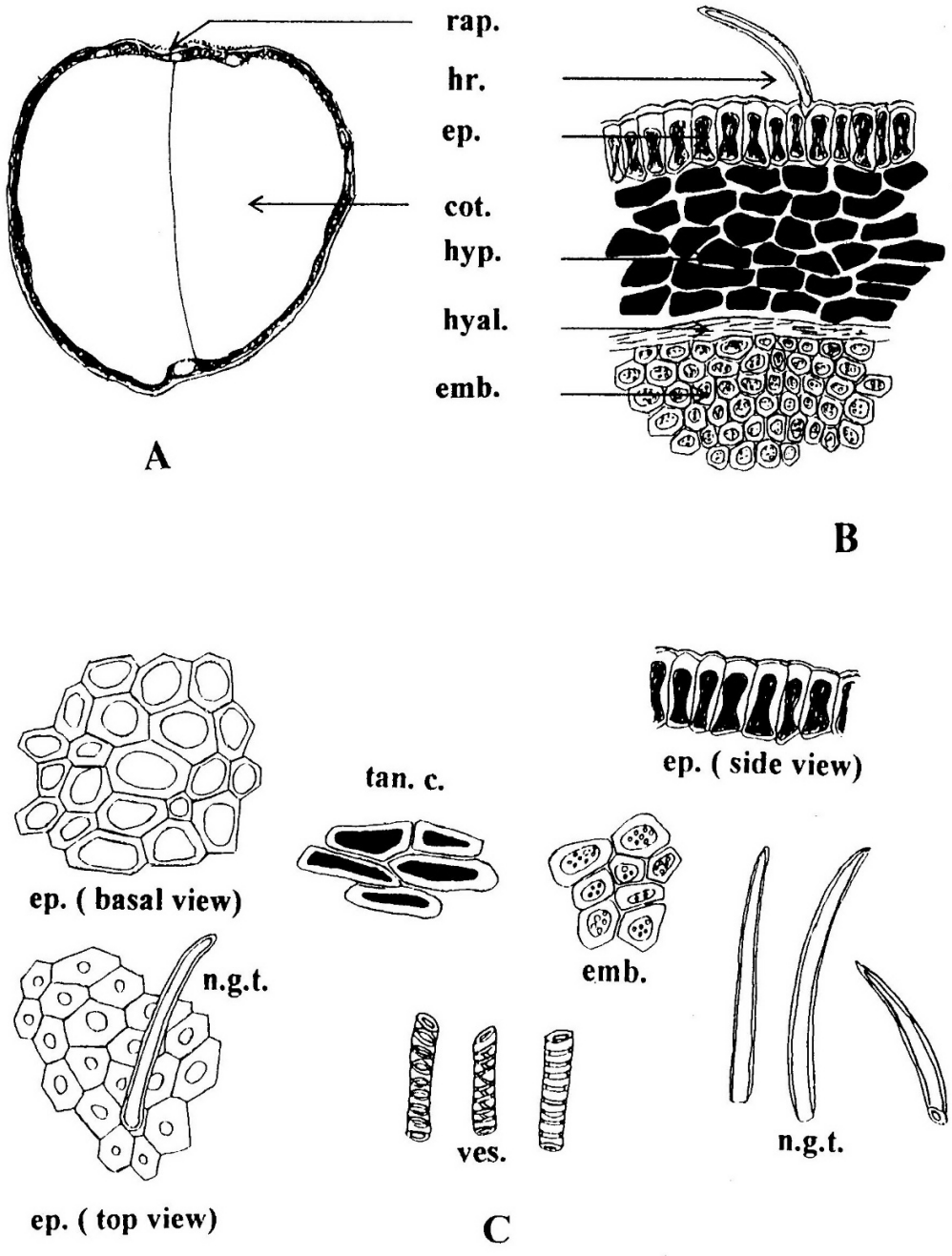

Fig. (15): Micromorphology of the seed of *Simmondsia chinensis* (link) Schneider

A.	Diagrammatic transverse section in the seed.	**(X 11)**
B.	Detailed transverse section in the seed.	**(X 145)**
C.	Isolated elements of the seed.	**(X 230)**

cot., cotyledons; ep., epidermis; emb., embryo; hr., hair; hyal., hyaline layer; hyp., hypodermis; n.g.t., non-glandular trichomes; tan.c., tannin cell.

e. The fruit:

A transverse section in the pericarp of *S. chinensis* (Fig. 13 A& B) shows a narrow layer of epicarp and endocarp that enclosing a wide mesocarpic layer which is transversed by numerous scattered vascular bundles and contains high deposits of tannins and starch granules.

The epicarp is formed of one layer of radially elongated cells with strong lignified thickening in the outer tangential and radial walls (inverted funnel-shape structure) which is covered with smooth cuticle and have no trichomes. The mesocarp is composed of several layers of parenchymatous cells (30-38 rows). The parenchymatous cells are polygonal to rounded with narrow intercellular spaces and contain a lot of tannin deposits near the epicarp, while it is rare near the endocarp but rather filled with many starch granules. Starch granules are oval, measuring 2.5-5 µ in diameter mostly simple with faint point hilum and striation. Many scattered collateral vascular bundles, which are composed of non-lignified phloem elements, lignified spiral or annular vessels, and pitted tracheids. The endocarp is composed of one layer of rectangular to barrel shape cells with thin cellulosic walls. The transverse section in the pedicel of jojoba fruit is similar to that of the young stem (Fig. 14 A& B).

f. The seed:

A transverse section (Fig. 15) in the seed is circular to triangular in outline, showing a narrow outer layer of seed coat (testa) surrounding the kernel. The seed is an exalbuminous.

The testa is composed of layer of epidermal cells, hypodermis, vascular bundles and hyaline layer. The epidermis is composed of one layer of radially elongated cells with inverted cup-shaped non-lignified thickening measuring 28-32-40 µ in length, 14-16-20 µ in width and 30-42-62 µ in height that covered sparsely with long unicellular trichomes that become dense at the region of the chalaza and measure 40-56-68 µ in length and 5-7-8 µ in width. The hypodermis is composed of several rows (5-8 rows) of elongated to spherical parenchymatous cells that mostly filled with tanniferous material and transversed by few vascular bundles. The hyaline layer is composed of one to two layers of thin walled collapsed cells. The kernel is composed of two cotyledons that constitute the embryo. It occupies the main part of the transverse section and it is composed mainly of polygonal to rounded parenchymatous cells containing oil droplets and irregular protein masses with thick cellulosic walls.

4. Conclusion

Although *Simmondsia chinensis* liquid wax and extracts are widely used all over the world for treatment of many ailments. In addition, Jojoba products have wide applications in both cosmetics and pharmaceutical industry. In this work, we provide an in-depth study on the botanical characterization of different *S. chinensis* organs in order to assist in the identification and standardization of the plant. This study can also help in prevention of adulteration of a high economic crop that widely distributed in arid lands of the world. However, a thorough taxonomical study is required for better understanding of the plant.

5. References

1. Cordell, G.A., Natural products in drug discovery – Creating a new vision. Phytochem Rev, 2002. 1: 261-273.
2. Farnsworth, N.R., Akerele, O., Bingel, A. S., Soejarto, D. D., and Guo, Z., Medicinal plants in therapy. Bull World Health Organ, 1985. 63(6): 965-81.
3. Kubitzki, K. and C. Bayer, Flowering plants, Dicotyledons : Malvales, Capparales, and non-betalain Caryophyllales. The Families and genera of vascular plants. 2003, Berlin ; New York: Springer.
4. Van Wyk, B.-E. and M. Wink, Medicinal plants of the world : an illustrated scientific guide to important medicinal plants and their uses. 1st ed. 2004, Portland, Or.: Timber Press.
5. Khan, I.A. and E.A. Abourashed, Leung's encyclopedia of common natural ingredients : used in food, drugs, and cosmetics. 3rd ed. 2010, Hoboken, N.J.: John Wiley & Sons, Inc.
6. Miwa, T.K., Structural determination and uses of jojoba oil. J Am Oil Chem Soc, 1984. 61(2): 407-410.
7. El-Shamy, A.M., Shehata, A. H., Sanad, O. A., El-Halawany, A. M. and Abd El-Latif, H. A., Biologically active flavonoids from Simmondsia chinensis (Link)

Schneider growing in Egypt. Bull Fac Pharm Cairo Uni, 2001. 39(2): 55-63.
8. Yaron, A., Metabolism and physiological effects of Jojoba oil, in The chemistry and technology of jojoba oil, J. Wisniak, Editor. 1987, American Oil Chemists' Society: Champaign, Ill. p. 251-265.
9. Taguchi, M., Test results on safety of Jobacohol (Jojoba alcohol) for cosmetic uses, in Proceedings of the 6th international conference on Jojoba oil and its uses, J. Wisniak and J. Zabicky, Editors. 1985, Ben Gurion University: The Negev, Beer Sheva, Israel. p. 371-391.
10. Brown, J., J. Arqette, and J. Reinhardt, Jojoba esters; A new family of cosmetic emollients, in Proceedings of 9th international conference on Jojoba oil and its uses and of the 3rd international conference on new crops and products, L.H. Princen and C. Rossi, Editors. 1994, AThe association for the advancement of industrial crops: Catamarca, Argentina. p. 100-103.
11. Mosovich, B., Treatment of acne and psoriasis, in Proceedings of the 6th international conference on Jojoba oil and its uses, J. Wisniak and J. Zabicky, Editors. 1985, Ben Gurion University: The Negev, Beer Sheva, Israel. p. 393-397.
12. Habashy, R.R., Abdel-Naim, A. B., Khalifa, A. E. and Al-Azizi, M. M., Anti-inflammatory effects of jojoba liquid wax in experimental models. Pharmacol Res, 2005. 51(2): 95-105.
13. Farag, R.S., M.M. Farag, and R.F.M. Ali, Use of sunflower oil mixed with jojoba and paraffin oils in deep-fat frying process. Int J Food Sci Technol, 2008. 43(7): 1306-1315.