

A typology of fruits

The following is based on one of the talks given by KOEN CAMELBEKE* during the Trompenburg study days (see pp.184-186).

Summary

A schematic, simplified and pragmatic classification of fruits is presented. This arrangement is principally based on external morphological characters. All fruit types are clarified by a few examples.

Introduction

During my position as assistant at the Ghent University in Belgium I made notes for the biology students dealing with several morphological and systematical topics, one of them being fruit morphology and typology. This text was improved with experiences and comments during two talks on the same subject; one for the Belgian Dendrological Society in 2005 and one on an IDS study day at Arboretum Trompenburg last year. I also made use of the publications by Stoffers (1982) and Spjut (1994). This last work is unique because of its elaborateness and detail, and is one of the only publications that deal with this subject exclusively. Spjut unfortunately makes use of aberrant definitions and terminology, making his paper accessible only to specialists

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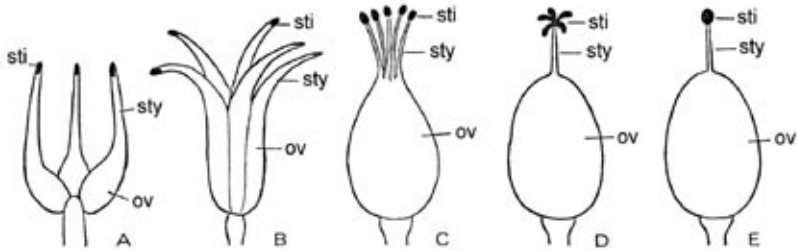
Euonymus americana has a capsule composed of more than one carpel with valves that split open.

and therefore generally not followed by the botanical community.

The proposed schematic classification of fruits types is mainly based on externally visible morphological characteristics and is therefore not phylogenetic. Of course some taxa are defined or recognized by a specific fruit type such as the caryopsis of the grass family or the legume of the Leguminosae (exceptions ignored, as always). But in many other taxa a multitude of fruit types will occur. A good example being the Ranunculaceae (buttercup family) with a follicle in *Caltha* (marsh marigold) a berry in *Actaea* (bugbane or baneberry) and an achene in *Ranunculus* (buttercup).

Definitions

A fruit (fructus) is the ripened ovary of the flower after fertilization containing the seed(s).



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Fig. 1
Gynoecium. **A**: with free carpels; **B**: with partly fused carpels; **C-E**: carpels fused, with free styles and stigmas (**C**), with 1 style and free stigmas (**D**), with 1 style and 1 stigma (**E**).—sti: stigma; sty: style; ov: ovary.

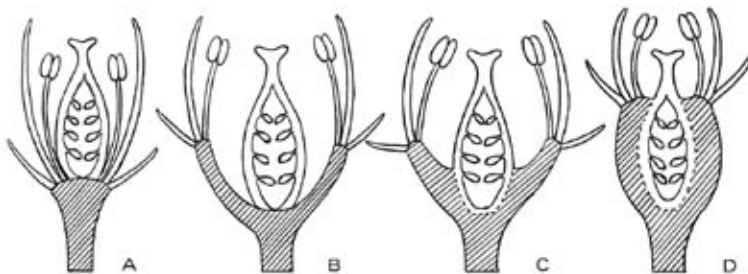


Fig. 2
Ovary (longitudinal section). **A-B**: superior ovary; **C**: half-inferior ovary; **D**: inferior ovary.

Reminder: a flower generally consists of a flower stalk (pedicellus) and a receptacle (receptaculum). Inserted on this receptacle are the calyx, corolla, stamens and one or more pistils. The pistil has the following parts: the stigma, style and ovary. In the ovary one can find one to many ovules, which will

become the seed(s) after fertilization. The pistil can be made up of one or many carpel(s). The above definition of a fruit inevitably leads to the fact that the female cones of gymnosperms (= "naked seeds") are NOT fruits in the strict sense. As we all know, it can be very tempting to address these cones of e.g. firs or spruces as fruits but the use of the term female cone (conus -> conifers) is botanically more appropriate and correct.

A fruit consists of the following parts:

- The fruit wall (pericarp) which itself is mostly made up of three layers. The outermost layer is called the exocarp; mesocarp is the botanical term for the middle layer of the fruit wall; the inside layer is called the endocarp. These three layers are best discernible in fleshy fruits.
- locules (cavities, cells) and septa
- placenta(e)
- seed(s)

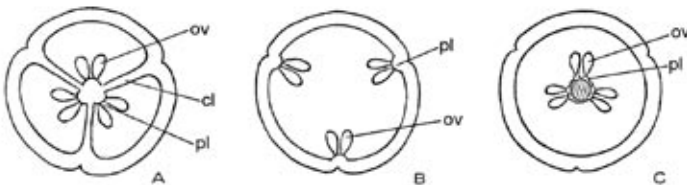


Fig. 3

Placentation. **A:** axil placentation; **B:** parietal placentation; **C:** central placentation. – ov: ovule ; cl: septum ; pl: placenta.

Furthermore a division is made between:

- Real fruit: only the ovary contributes towards the formation of the fruit.
- Covered fruit: inferior ovary results in covered fruit (the ovary is covered by and fused to the cup-shaped receptacle, the hypanthium)
- False fruit: also other parts (of the flower or inflorescence) contribute towards the formation of the "fruit".

A simplified, schematic classification of the fruit types (typology)

1. Real fruit

1.1. Fruit dry at maturity (versus fleshy fruit)

1.1.1. Indehiscent

1.1.1.1. Not opening

This category of fruits by definition contains only one seed. As soon as a dry fruit contains more than one seed it will either be opening or break up in parts to ensure the spreading of



Top, the fruit of *Cercidiphyllum japonicum* var. *sinense* (female plant) are follicle. **Left**, the schizocarp diachenium (in two parts) of *Acer negundo* var. *violaceum*, is typical of the genus. **Below**, the covered fruit of *Crataegus macracantha* are called pomes in which the endocarp has formed a leathery case around the seed.



the seeds. Within this category of real, dry, indehiscent, not-opening fruits four types can be recognized:

- a) **Achene** (achenium): the fruit consists of only one carpel and has one single seed, e.g. *Ranunculus*.
- b) **Nutlet** (nux): the fruit consists of several fused carpels but with a single seed, e.g. *Tilia* (note that the diaspore of *Tilia* is not the fruit but a so-called pseudosamara consisting of several nutlets and a bract). Not many botanists use this distinction between achene and nutlet.
- c) **Samara**: winged nutlet, e.g. *Fraxinus*, *Ulmus*, *Eucommia*.
- d) **Grain** (caryopsis): the single seed is inseparably fused to the fruit wall and in ripe condition often enclosed in chaff. The



Left, the fruit of *Ilex* 'Emily Brunner' (*cornuta* x *latifolia*) are drupes in which the seed is surrounded by a stony endocarp. There are four-seeded or tetrapyrrena. **Right**, *Fraxinus sieboldiana* has winged nutlets or samara for fruit.

typical fruit of grasses (Poaceae, Graminae).

1.1.1.2. Opening

As explained above, this category contains more than one seed per fruit. Here also, four types can be recognized:

- a) **Capsule** (capsula): this fruit type is composed of more than one carpel. This very common type is for convenience subdivided in accordance with the way the fruit opens.
 - Valves (valvae): splitting open from top to base and remaining fused at the base.
E.g. *Iris*, *Hyacinthoides*, *Rhododendron*, *Stewartia*, *Agave*, *Buddleja*, *Euonymus*, etc. Further division of this type is possible depending on whether the opening of the fruit occurs opposite a septum or opposite a cell.
 - Teeth (dentes): fruit opens at the top in short portions.
E.g. *Silene*, *Dioscorea*, *Lythrum*, *Cyclamen*.
 - Longitudinal lines (rimae): the valves of the capsule remain fused at top and basis.
E.g. *Staphylea*, *Cuphea*, Orchids.
 - Pores (pori): capsule open with small holes at top or basis of the fruit.
E.g. *Papaver*. The fruits of *Garya elliptica* probably belong

to this category but I have never seen female specimens.
Can anyone confirm?

–Lid (operculum):

E.g. *Jeffersonia*, *Eucalyptus*, *Anagallis*, *Hyoscyamus*.

- b) **Legume** (legumen). A legume is composed of only one single carpel and opens along two sutures. Typical for the Leguminosae (Caesalpiniaceae, Fabaceae, Mimosaceae).
- c) **Follicle** (folliculus). Resembling a legume in only one carpel but opens with a single suture, e.g. *Cercidiphyllum*, *Delphinium*, *Caltha*, *Sedum*, *Illicium*, *Magnolia*, *Paeonia*, *Trochodendron*.
- d) **Silicle/silique** (silicula/silqua): The fruit type typical for Brassicaceae (Cruciferae). It consists of two fused carpels that separate when ripe, leaving a persistent partition (the replum). This replum is easily observed in *Lunaria* (honesty) as a silver membrane. When the length of the fruit is more than three times the width the term silicula is used (*versus* silqua). This is an artificial subdivision not used in other fruit types.

1.1.2. Dehiscent (in one-seeded parts)

As discussed above, fruits containing more than one seed will exhibit a strategy to disperse these seeds. This is a way of preventing many seeds arriving in one spot and having been dispersed inefficiently and end up competing with each other. The first (see 1.1.1.2.) way is by opening. Another possibility is to fall apart in one-seeded structures. Two types are recognized within this last category.

- a) **Schizocarp** (schizocarpium): when mature the fruit splits up into one-seeded parts (mericarps) which themselves remain closed. A further subdivision is possible depending on the numbers of mericarps:
 - diachenium (2 parts) : Apiaceae p.p., *Acer*
 - tetrachenium (4 parts): Lamiaceae p.p.
 - polyachenium (many parts): Malvaceae p.p.
- b) **Regma** (rhegma): as above but mericarps dehiscent. A similar subdivision as in schizocarps is possible:
 - dicoccus (2 parts): *Mercurialis*
 - tricoccus (3 parts) : *Euphorbia*
 - pentacoccus (5 parts) : *Geranium*

1.2 Fruit fleshy at maturity

Fleshy fruits are often conspicuously coloured and can have a sweet taste. This makes them more attractive to animals who guarantee an efficient dispersal of the seeds. A (partial) digestion can be necessary to weaken the seed coat (or at least promote germination) and make germination of seed possible.

- 1.2.1. **Berry** (bacca): many seeds embedded in a (solid) fleshy mass. Well known examples are: kiwifruit (*Actinidia*), *Berberis*, tomato (*Solanum*), and citrus fruit.
- 1.2.2. **Drupe** (drupa): the seeds are surrounded by a stony endocarp. As a rule a drupe contains only 1 to 5 *stones* while a berry typically will contain many more seeds. Depending on the number of *stones* this type can be further subdivided in:
- one-seeded drupe (drupa monopyrena): e.g. *Prunus* (cherry, almond, peach, etc.)
 - multi-seeded drupe (drupa polypyrena):
 - drupa dipyrena : e.g. coffee, *Cornus*
 - drupa tripyrena : e.g. *Sambucus*
 - drupa tetrapyrena : e.g. *Ilex*
 - drupa pentapyrena : e.g. *Vitis*

2. Covered fruit

Typical example: the pome (pomum): The endocarp forms a leathery case around the seeds (the core). All members of Rosaceae subfamily Maloideae exhibit this fruit type (a.o. *Amelanchier*, *Chaenomeles*, *Crataegus*, *Malus*, *Pyrus*, *Sorbus*). Note that the distinction between a real and a covered fruit is seldom made. Almost all “fruits” of species with flowers with inferior ovaries are classified within the real fruit categories.

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3. False fruit

Not only the (covered) ovary but also other parts of flower and/or inflorescence take part in the formation of the “fruit”. Some examples as illustration:

- Strawberry (*Fragaria*): fleshy developed receptacle with many achenes.
- Pineapple (*Ananas*): fleshy growth of complete inflorescence (flowers, axis, bracts, etc.)
- Rose hip (*Rosa*): cup-shaped receptacle with many achenes within.
- Mulberry (*Morus*): inflorescence with fleshy developed perianth around the achenes.

Acknowledgements

I would like to thank the following for their help, advice or support: Philippe de Spoelberch (Arboretum Wespelaar), Prof. Paul Goetghebeur and Dr Marie-Stéphanie Samain (Ghent University) and the direction of the National Botanic Garden of Belgium (Meise) for giving permission to reproduce the plates from the *Nouvelle flore de la Belgique, du G.-D. de Luxembourg, du Nord de la France et des Régions voisines* (i.c. Fig.10 p.1025; Fig.11 & 12 p.1027), 5th edition.

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