Production of Quality Biomass Feedstock for the Biorefineries in the Mediterranean region

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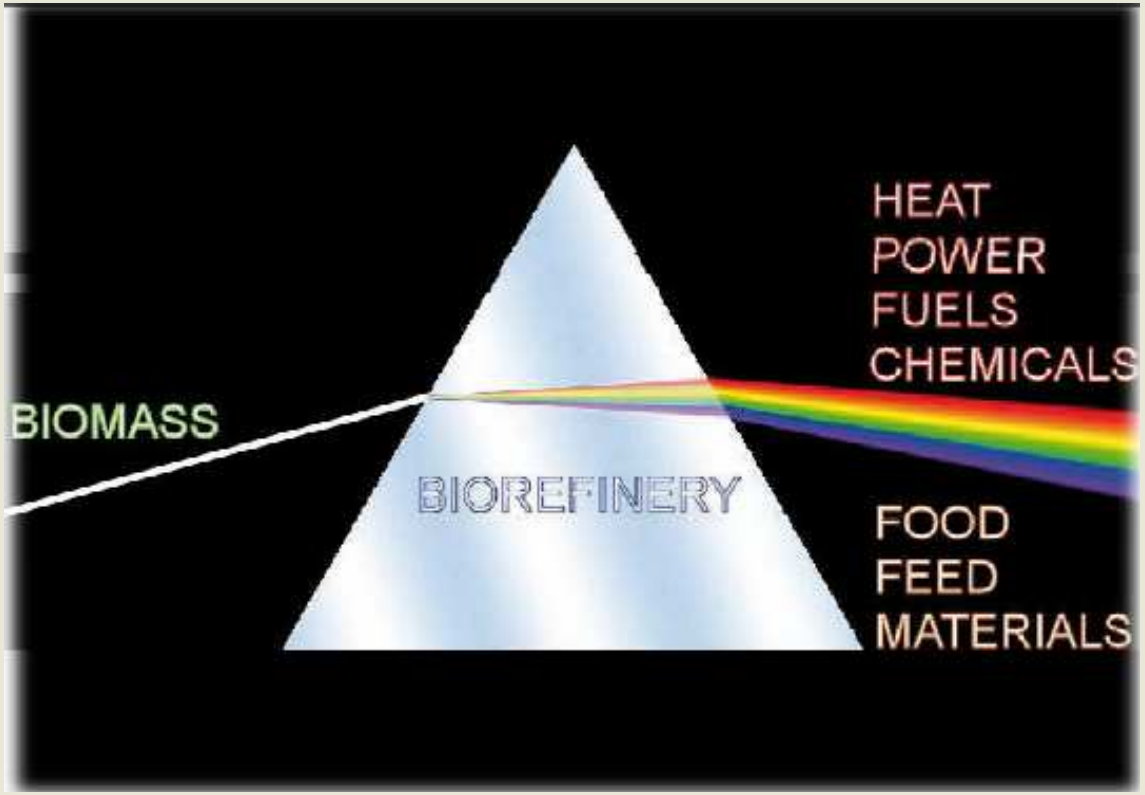
The members of IEA Bioenergy Task 42 have agreed on the following definition for biorefinery: **"Biorefinery is the sustainable processing of biomass into a spectrum of marketable products (food, feed, materials, chemicals) and energy (fuels, power, heat)"**



According to IEA Bioenergy 42 there are two types of Biorefinery

The "Energy-driven" Biorefinery

The main target is the production of biofuels and bioenergy. The biorefinery aspect adds value to co-products.

The "Product-driven" Biorefinery

The main target is production of food/feed/chemicals/materials, in general by biorefinery processes. Often side-products are used for the production of secondary energy carriers (power/heat) both for in-house applications as well as for distribution into the market.

IEA Bioenergy 42 developed a classification scheme with four features to describe different Biorefineries

1. Platforms
2. Products
3. Feedstocks
4. Processes

The **platforms** (e.g., C5/C6 sugars, syngas, and biogas) are intermediates connecting different biorefinery systems and their processes.

The **two biorefinery product groups are energy** (e.g. bioethanol, biodiesel, and synthetic biofuels) **and products** (e.g. chemicals, materials, food and feed).

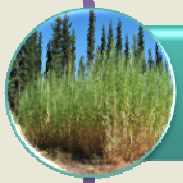
The t**wo main feedstocks** are “energy crops” from agriculture, forestry, trade and industry (e.g. straw, crops, short rotation forestry) and “biomass residues” from agriculture, forestry, trade and industry.

The four conversion **technologies** are: biochemical (e.g. fermentation, enzymatic conversion), thermochemical (e.g. gasification, pyrolysis), chemical (e.g. hydrolysis, esterification) and mechanical processes (e.g. fractionation, pressing, size reduction)

Energy crops as feedstocks for the biorefineries:

Oil crops (sunflower, rapeseed, castor, crambe, camelina, etc.)

Fibre crops (kenaf, flax, hemp, nettle, etc.)



Lignocellulosic crops (giant reed, switchgrass, miscanthus, cardoon, reed canary grass, etc.)

Short rotation forestry (eucalyptus, poplar, willow, etc.)

Sugar crops (sweet sorghum, sugar beets, etc.)

Energy Crops should have:

- High yields (biomass yields, oil yields, sugar yields)
- Low production cost (low inputs for water and fertilizers, etc.)
- Environmental friendly way of cultivation
- The ability to be cultivated in low fertility agricultural areas and/or marginal land with satisfactory yields in order to avoid the competition with food

Which are the *main driving forces* for the cultivation of *energy crops*?

- The growing need for **starch** and **sugar** plant species as source for **bioethanol production**
- The growing need for **biodiesel**, **aviation biofuels** and **biochemicals** from **oil crops**
- The growing need for **solid biomass** to obtain **heat and electricity**, either directly through combustion or indirectly through conversion for use as fuels. **Lignocellulosic-rich raw materials** can used to produce fuel like **methanol**, **biodiesel**, **synthetic gas**, and **hydrogen** (using thermal and thermochemical processes by direct or indirect liquefaction or gasification) and **ethanol** (through hydrolysis and subsequent fermentation)
- To produce **biogas** from energy/biomass crops

Biorefineries

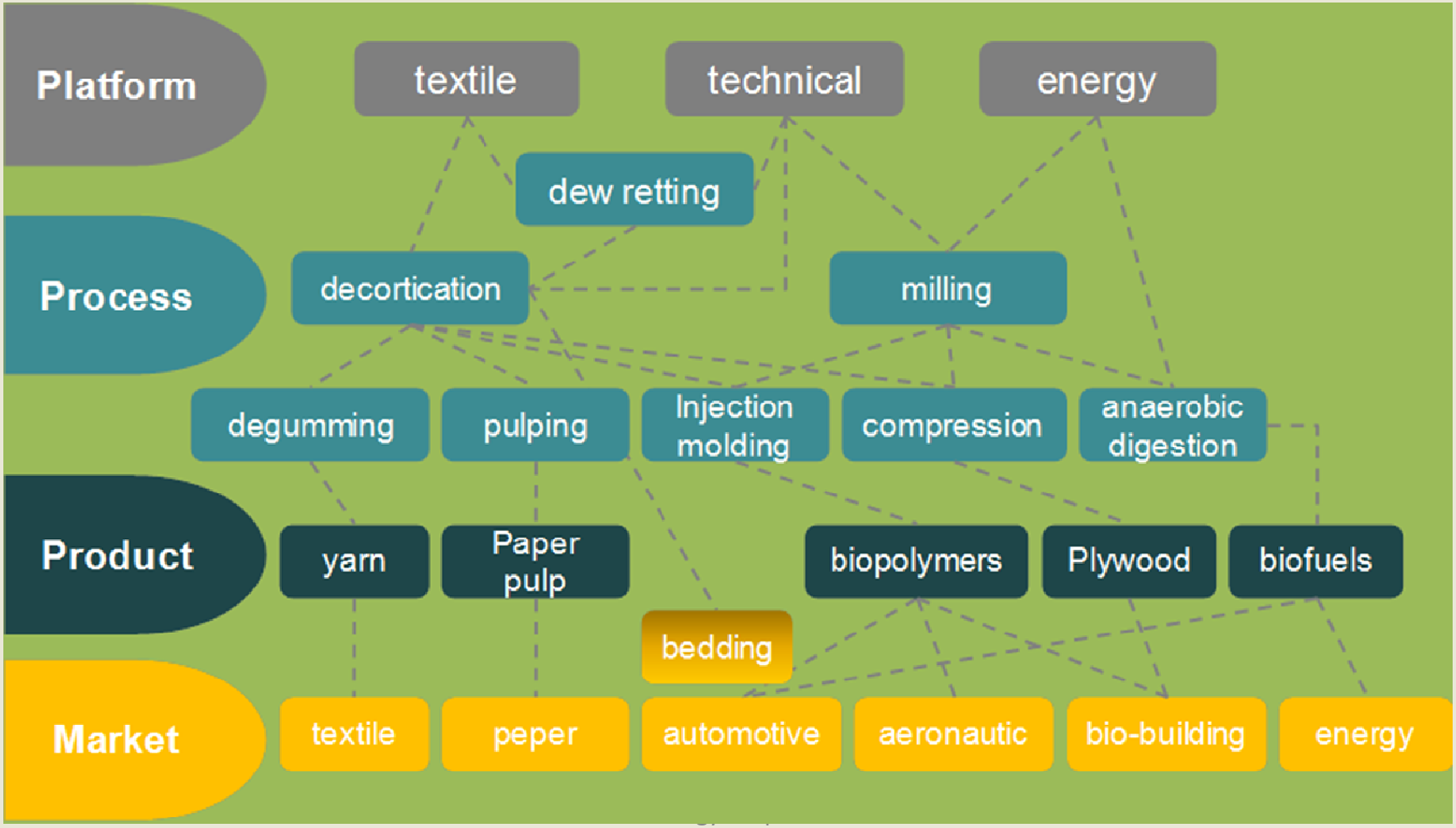
The development of **biorefinery processes** (the sustainable processing of biomass to a spectrum of marketable products and energy) is an **absolute necessity** and it is **the key to meet** this **vision towards bio-based economy** that includes the:

- the use the available biomass as efficiently as possible and with the lowest environmental impact,
- energy consumption,
- manufacturing costs and CO_2 footprint,
- the redefinition of the transformation routes,
- and the change in products specifications according to the new processes performances and limitations.

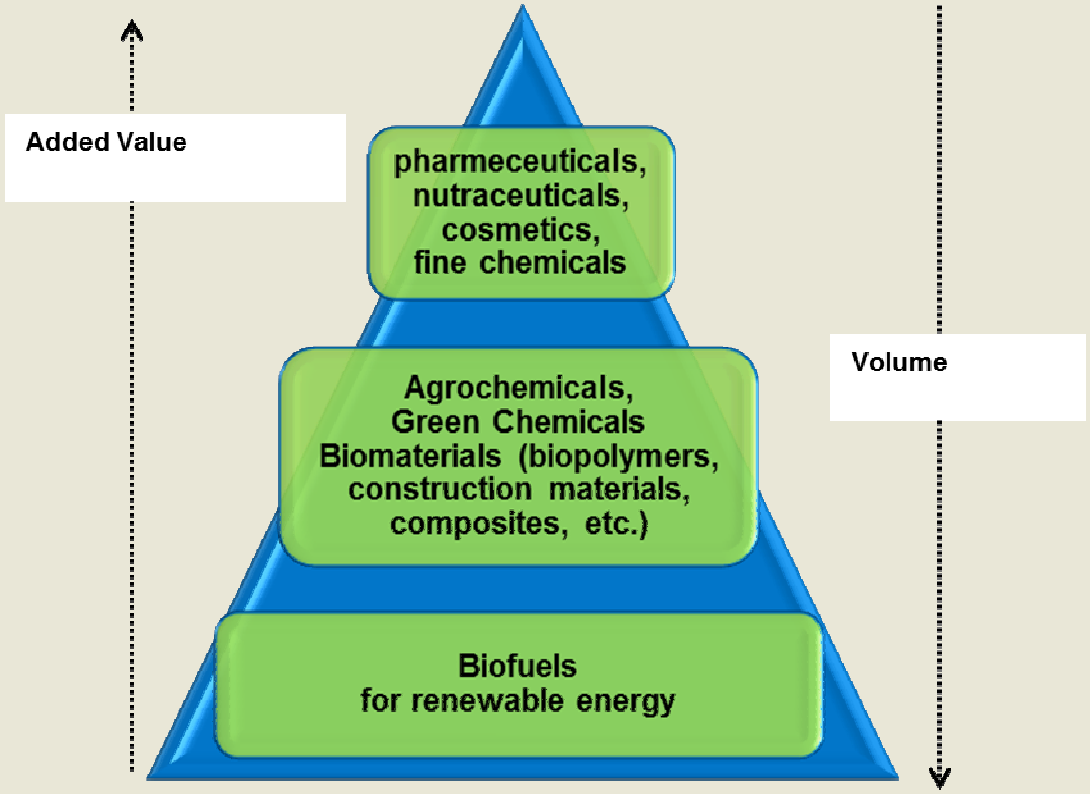
Biorefineries

- **Biorefineries** can use **various combinations of feedstock** and **conversion technologies** to produce **a variety of products**.
- **Most of the existing biorefinery concepts use limited feedstocks and technologies**, solely produce **ethanol** or **biodiesel** and further generally focus on producing **biofuels**, with the consequence of substantially **reducing the added value of the biomass chain**.
- A **relatively small fraction** is used for **chemistry** and **chemical products** that have a **higher added value**.
- **Economical** and **production advantages** increase with the overall **level of integration in the biorefinery**.
- The **benefits** of an **integrated biorefinery** are mostly based in the **diversification in feedstocks** and **marketable final products**.

The main platforms, process, products and markets in a biorefinery concept of fibre crops



Pyramid value of the added economic value of the biomass uses



The added value is the highest at the top of the pyramid and the lowest at the bottom. On the contrary, the volume of biomass needed for the applications is the lowest at the top of the pyramid and the highest at the bottom of the pyramid (www.bio-basedeconomy.nl).

Energy crops for the Mediterranean region for future biorefineries

Oil crops

Sunflower

Safflower

Cuphea

Castor

Fibre Crops

Kenaf

Flax

Hemp

Cotton

Nettle

Lignocellulosic crops

Giant reed

Cardoon

Elephant grass

Phalaris sp.

Sugar Crops

Sweet sorghum

Sugar beets

Classification of the fibre crops

According to www.fibrecrops.nl a botanic classification can be made for fibres based on the part of the plant from which they can be obtained.

The major groups of fibre crops with technical or economic importance are: ***bast fibres, grass fibres, leaf fibres, seed hairs, palm fibres and woody fibre***.

In ***FIBRA*** we focus on ***fibre crops with common interest in EU and China***, which are:

- ***Bast fibres*** (flax, hemp, kenaf, jute, nettle, and ramie),
- ***Grass fibres*** (miscanthus, switchgrass, giant reed and bamboo),

flax

hemp

kenaf

jute

nettle

ramie

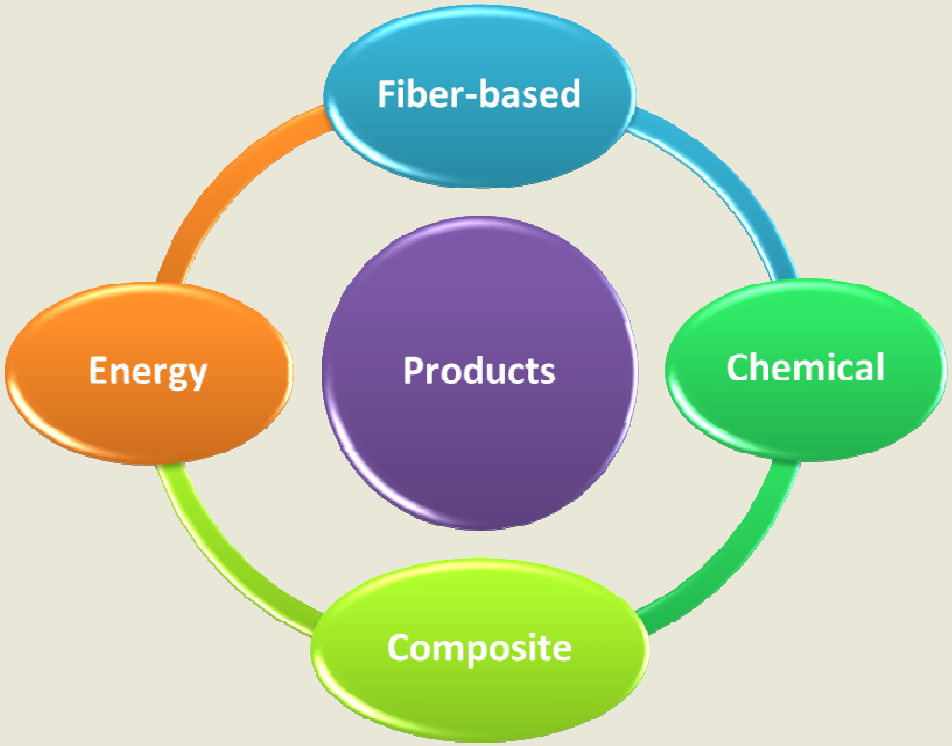

miscanthus


Giant reed


switchgrass


bamboo

Products from fiber crops



The issues that addressed in FIBRA are:

- ***State-of-the-art for the Main products and the Secondary products***
- ***Anticipated development in short term***
- ***Anticipated development in long term***

Fiber crops for the Mediterranean region

Flax is an annual winter or spring crop that its origin should be from Iran or Kurdistan that can be cultivated in some areas in the Mediterranean region. It is cultivated either for its fibrous stems or for its linseed or both. It is considered as multipurpose crop. The fibre flax is more resistant to drought and high temperatures compared to linseed.

Hemp is originated from central Asia and it can be cultivated in the Mediterranean region. Hemp belongs to the oldest group of plants used by humans. In Europe the area of its cultivation is 15,000 ha. Its seeds contain 35% oil and 46-70 % of the oil content is the linoleic acid. The whole plant give 8-16 t/ha dry matter yields (fibre yields 2-4 t/ha).

Kenaf is an annual spring crop endemic to Africa. It can be grown in the Mediterranean region and is very cold sensitive. The optimum temperature is 15 to 29^{0}C. Kenaf is one of the fibre allied to jute and shows similar characteristics. There are several uses for the core and the bark, while the whole crop has high protein. Its seed oil is edible and has high concentrations of omega antioxidants.

Lignocellulosic crops for the Mediterranean region

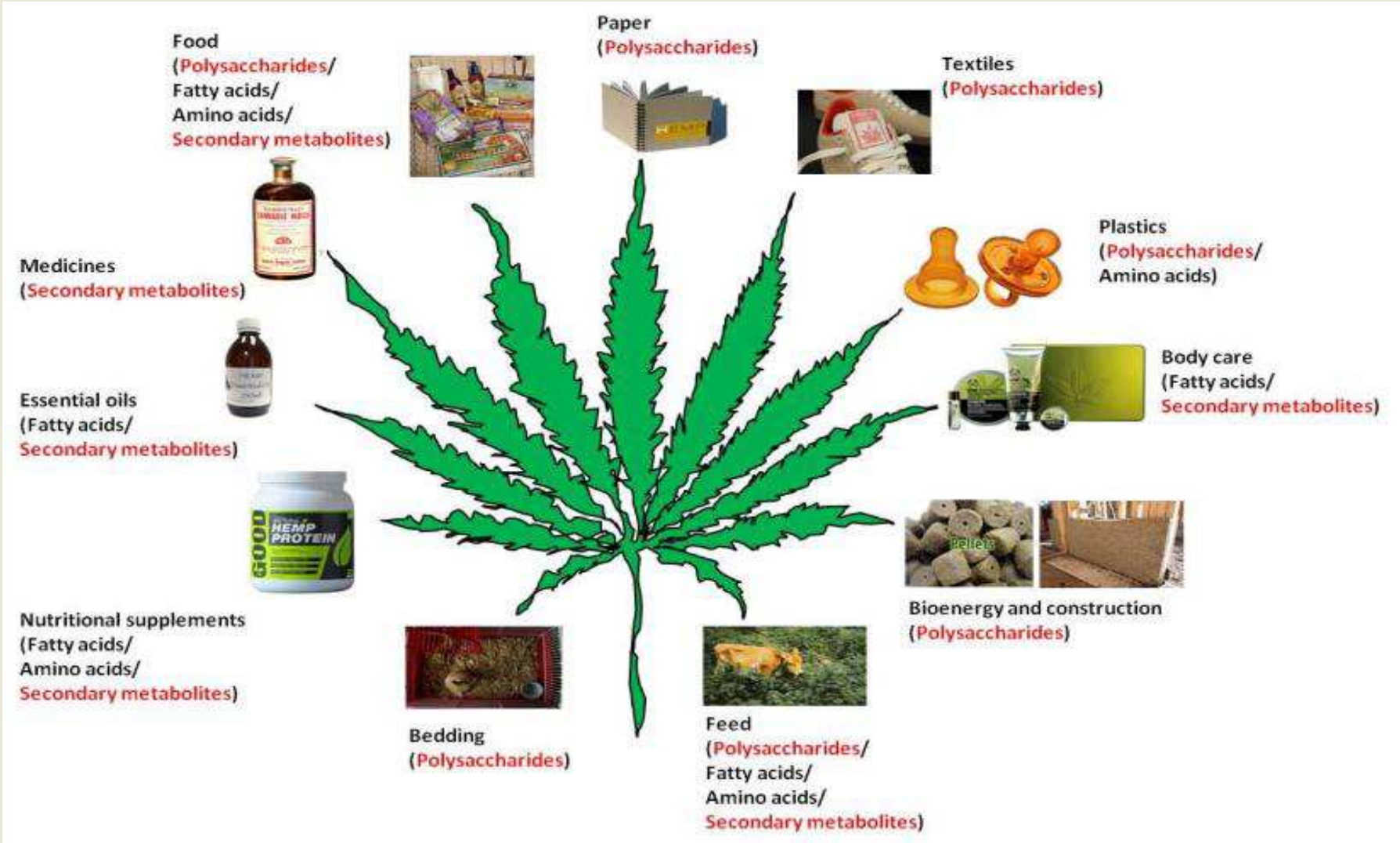
Giant reed grows wild in the Mediterranean region (south of Europe and north of Africa) and it is considered the champion of the biomass crops due to its high biomass yields (up to 40 t/ha dry matter yields) and the fact that can be cultivated with satisfactory yields in marginal lands with a life time 15 to 20 years.

Cardoon is originated from the Mediterranean region and it was known by the ancient Egyptians, Greeks and Romans. It is not irrigation since its vegetative phase take places from October to May and dry yields of 12 t/ha can be anticipated in medium fertility fields. In fields with high depth its lifetime could be 10 years.

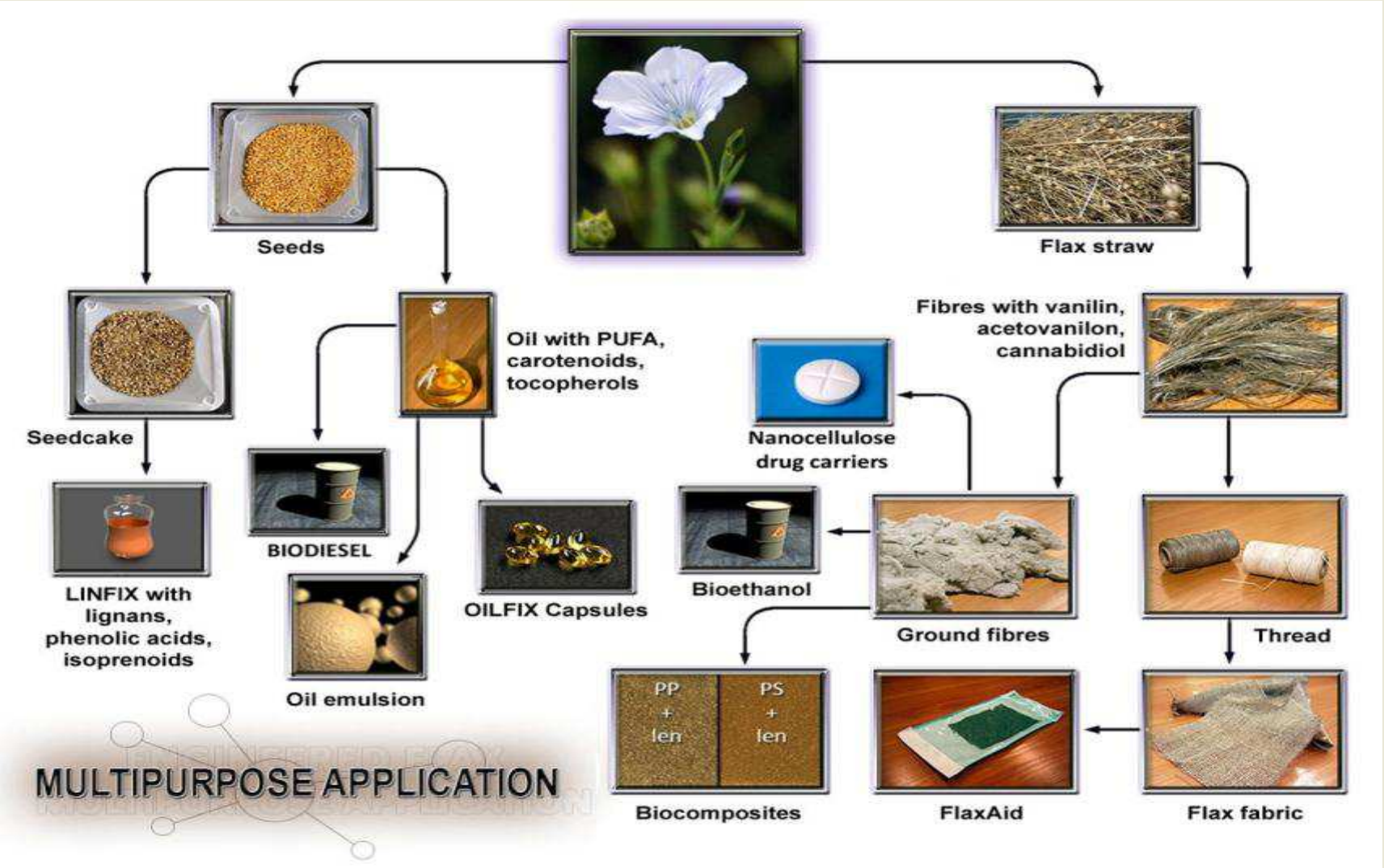
Elephant grass can be cultivated in the Mediterranean region but does not tolerate much frost. It can tolerate precipitation from 200 to 4000 mm and annual temperatures of 13.6 to 27.3 ^{0}C. The reported yields varied a lot from 14t/ha to 84 t/ha.

Phalaris aquatica is to the Mediterranean region, it has been dispersed throughout the world by agronomists and farmers for its value as forage in pastures. It is reported dry matter yields around 10 t/ha. One of its important characteristic its low lignin content.

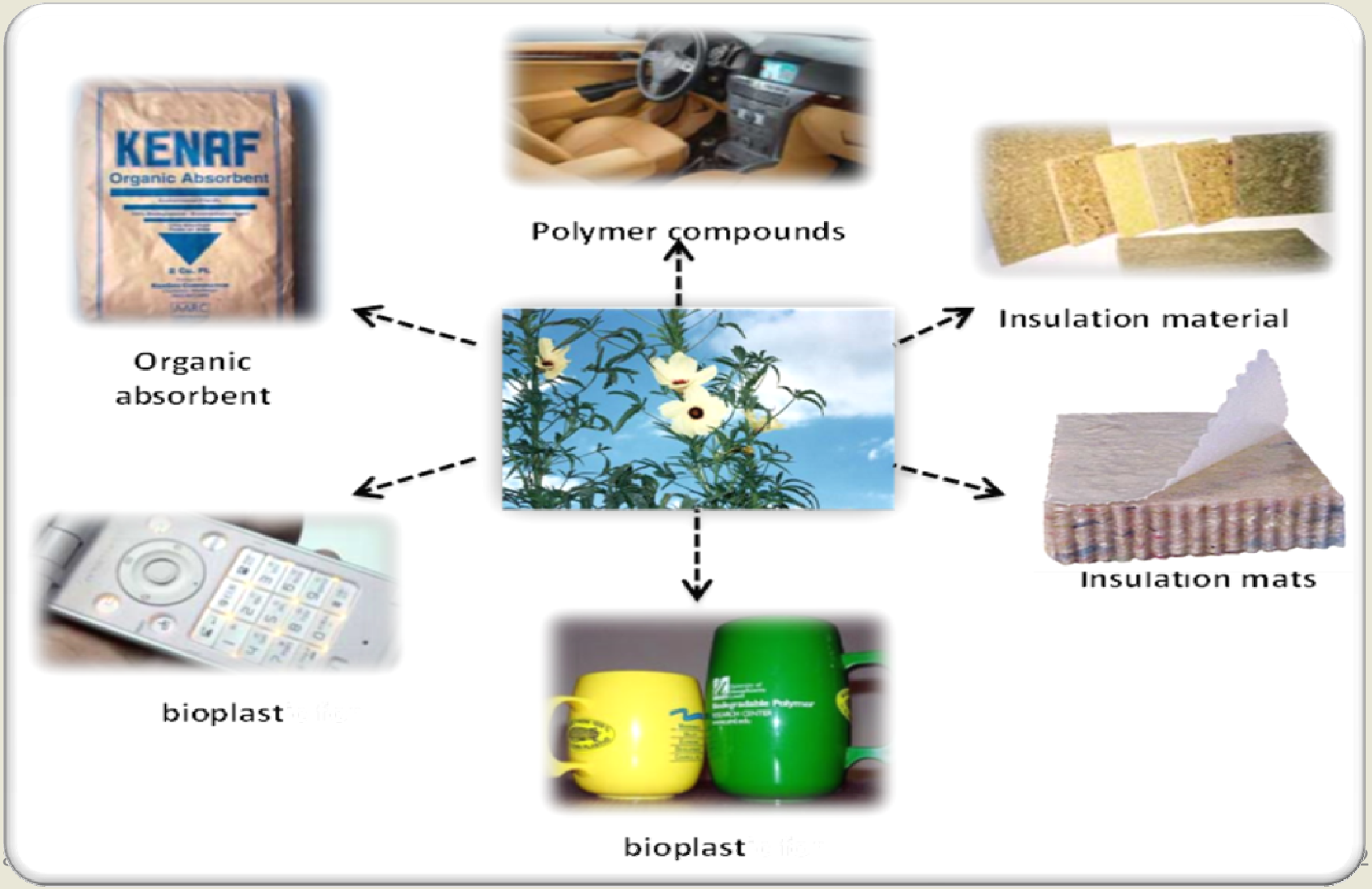
Hemp products (modified from Small and Marcus, 2002)



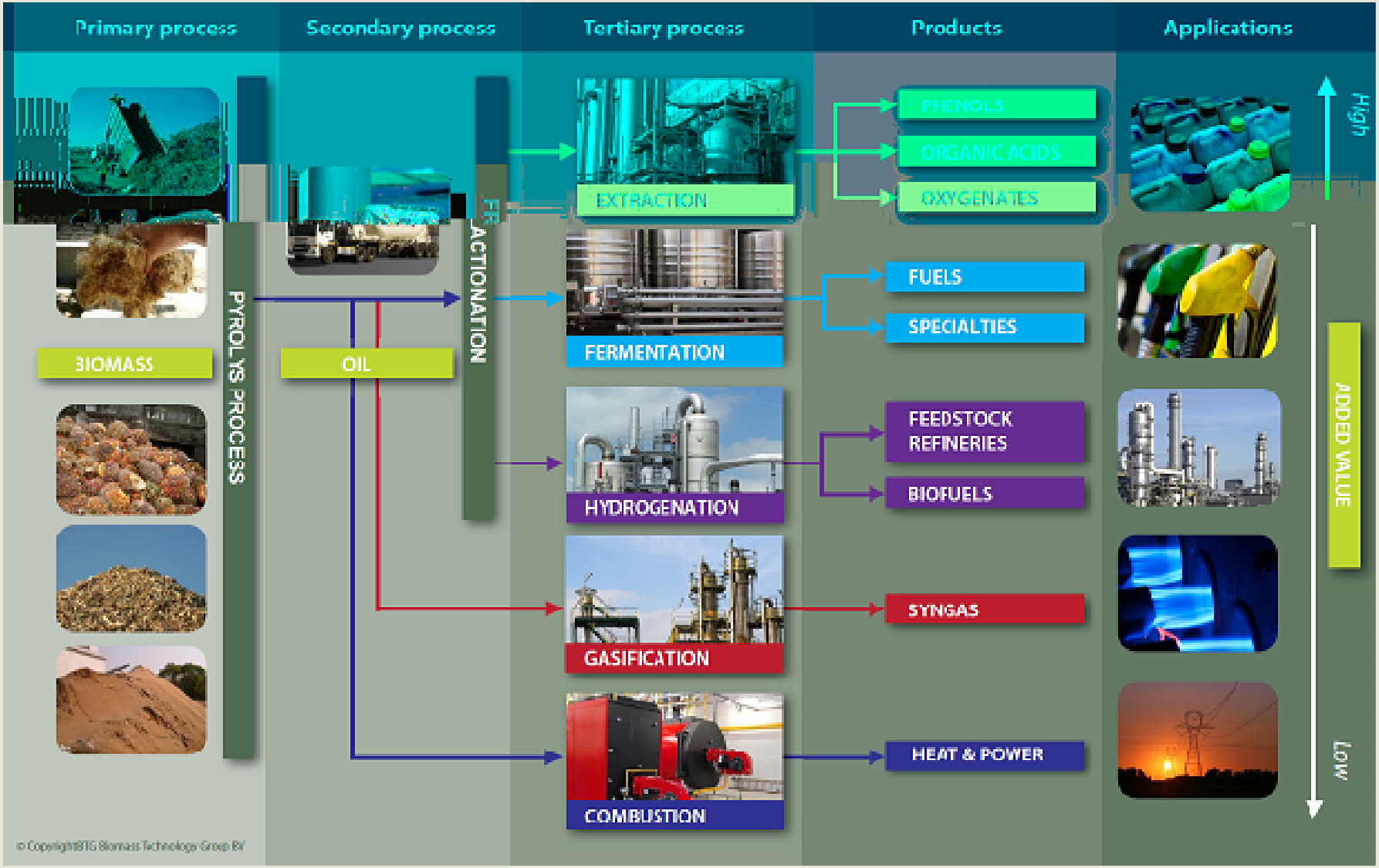
Flax products (source: Prof. Jan Szopa, University of Wroclaw)



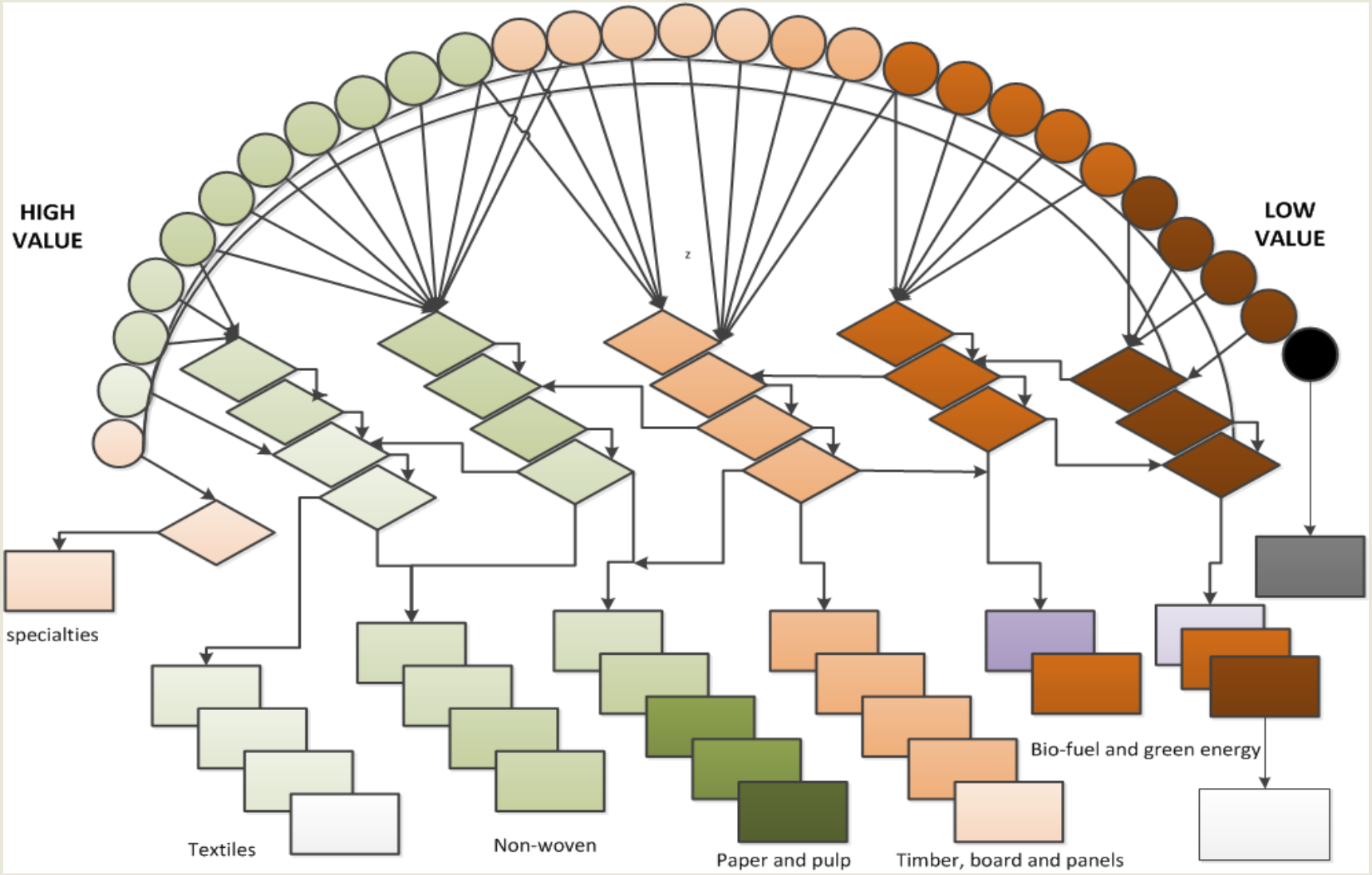
Kenaf products



Perennial grasses products and applications



Markets (Cellulose Matrix)



International Conference on "Industrial Crops and Products", Athens 15-18/9/14

www.aaic.org

Thank you very much for your attention

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