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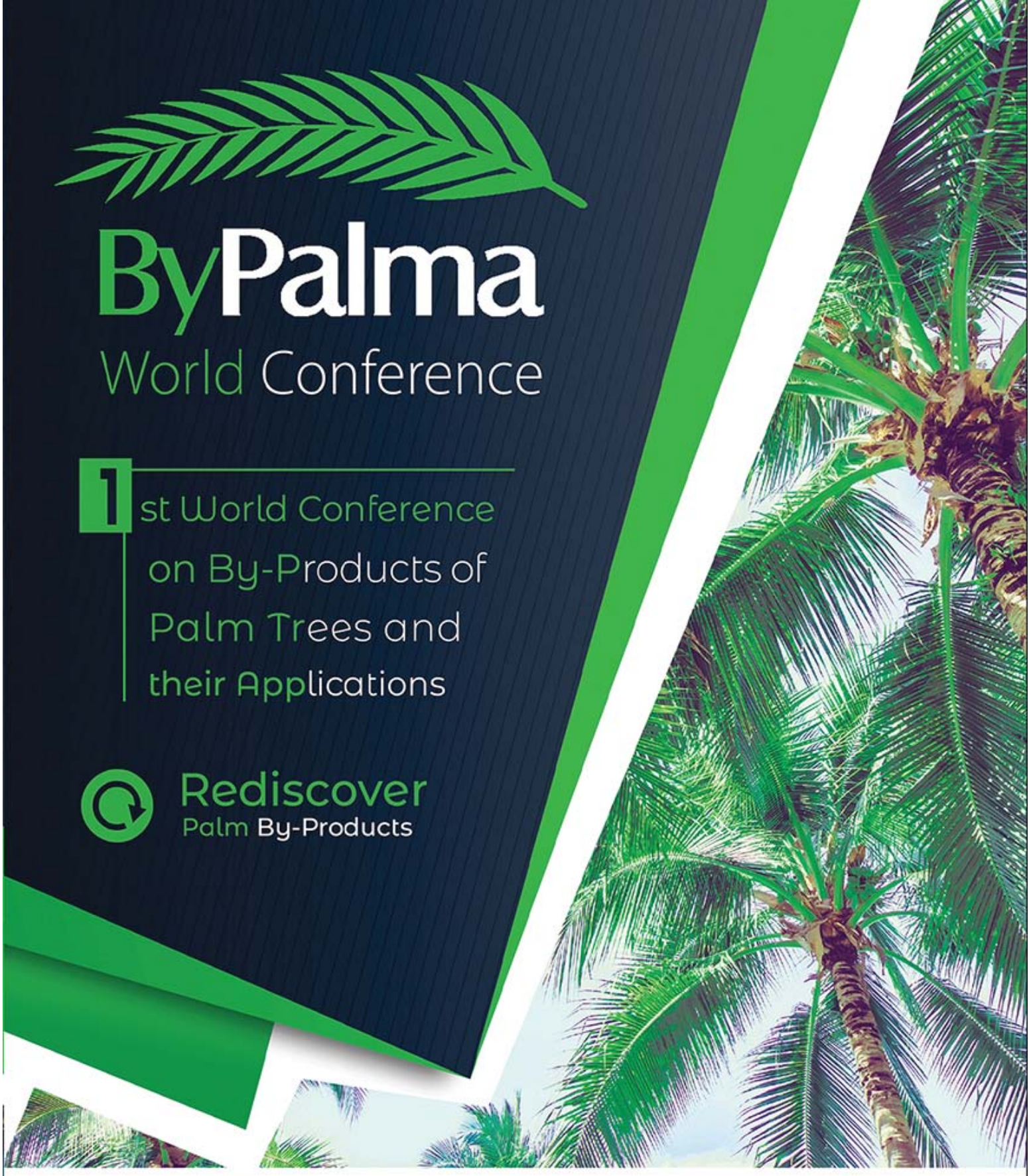

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By-Products of Palm Trees and Their Applications

1st World Conference on By-Products of Palm Trees and Their Applications (ByPalma), Aswan, Egypt, 15-17 December, 2018.

Hamed El-Mously[1], Mohamad Midani[2] and Mohamed Wagih[1]

[1] Faculty of Engineering, Ain Shams University, Egypt

[2] Faculty of Engineering and Materials Science, German University in Cairo, Egypt

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Wood, Bamboo and Palm Wood - Similarities and Differences in Research and Technology Development

Johannes Welling[1,a*], Walter Liese[2,b]

[1]Thünen-Institut of Wood Research, Leuschnerstr. 91c, 21031, Hamburg, Germany
[2]Institute of Wood Science, University Hamburg, Leuschnerstr. 91d, 21031 Hamburg, Germany

[a]johannes.welling@thuenen.de, [b]wliese@aol.de

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Abstract. Wood science has a history of several hundred years, bamboo research started in the of the last century and palm wood research is even younger. Consequently, there are differences not only in depth and width of knowledge, but also in the state of the art of conversion technologies and utilization options. There are considerable wood resources all over the world, but bamboo and palm resources are restricted to certain regions. Similarities and differences in research and technology development related to the three raw materials will be examined and expected future developments will be discussed. Technological progress needs time for a) development based on fundamental knowledge and practical experience, b) diffusion of knowledge into industry, and last but not least c) consumer acceptance and commercial breakthrough. Policy interaction may accelerate development and diffusion of knowledge, however in some cases may also impede or hinder the utilization of a specific raw material resource. While wood science and wood technology have reached a mature stage, research on bamboo and bamboo utilization is progressing rapidly; however, research on palm wood and, especially, the processing of palm wood and the utilization of palm products is still at an early stage. Existing knowledge and expertise around wood/bamboo science and technology should be used for speeding-up the development and realization of palm wood utilization options.

Introduction

In the evolution process Mother Nature designed dicotyledon plants with a lignified cellulose matrix some hundred million years ago. This was the time when the success story of trees started. At that time, the monocotyledon ferns, grasses and palms did already exist for quite a long period for time. Mankind occurred only some millions of years ago. Considering the age of our planet, the evolution of science happened during the very recent few seconds of our planets history.

Wood is one of the oldest raw and building materials used by mankind. But most probably, early men have used also bamboo and palm wood wherever this was available. Looking back in the history of science, it becomes obvious that the early researchers concentrated on investigating the structure, function and behavior of wood, and not that of bamboo or palms. The success of wood as the basic material for construction was initially based on experience and tradition gained in regions where natural materials with high natural durability existed, which could stay in service for long periods of time. Only later, wood science explained why and how this could occur. Nowadays, wood science has reached a mature stage, but bamboo and palm wood science are still at an early stage.

Key developments for progress in wood science and bamboo / palm wood research

Wood has been used by mankind since thousands of years and for many different purposes. Selection of wood species for specific fields of application were mainly based on experience. The development of the microscope in the 16th/17th century by the Dutch lens maker Zacharias Janssen firstly allowed an insight view into the microstructure of bio-based materials [1]. This invention led to a better understanding of why certain wood species have better properties and how it comes that some species are more suitable for certain applications than other species. A variety of test methods had to be developed in order to describe and compare the properties and behavior of wooden materials in an objective manner. As a result of the abundance of wood all over the world, highly sophisticated wood processing techniques were developed and introduced worldwide. Due to its regional distribution, bamboo and palm wood utilization naturally occurred only in certain regions.

Sustainable forestry was firstly introduced by Carlowitz in 1713 [2]. This led to man-made managed forests not only in Germany but in many other countries worldwide. At that time and for long after, bamboo was considered a natural resource, which did not need management by men. Palms were cultivated mainly because of its fruits. Bamboo was used as building material and its sprouts as foodstuff. The palm fruits (e.g. dates, coconut and many others), in addition to its regional importance, were important articles of trade because they could be transported over wide distances without deterioration.

Wood research has been focusing from the very beginning on the woody tissue. Since several hundred years wood scientists have been deepening and widening the knowledge on wood, its formation, properties, processing, and its application in form of a large variety of wood products.

Research on bamboo started in the 20th century in India and in China. In the Western world Walter Liese in the early 50ies of the last century tested the suitability of bamboo species for substituting wooden poles in German coal mines to overcome the serious raw material shortage after World War II. At that time some science-based knowledge on bamboo did already exist, but it was widely unknown to the Western research community. Research on palm wood only started some decades ago when it became obvious that millions of palm trees in large coco, date and oil palm plantations had to be replaced. Solutions for elimination of the palm trunks (worst case) or for its transformation into usable products (best case) had to be found. This shows that the drivers for development of research on wood, bamboo and palm wood are quite different.

Comparison of the utilization pathways of trees, bamboo and palms

The tables 1, 2, and 3 provide an insight view into the various utilization pathways of trees, bamboo and palms. Some of these pathways had considerable relevance in the past, but nowadays hardly do exist anymore. Other utilization pathways had disastrous consequences. Huge amounts of wood were burnt for potash production, a chemical needed for the glass manufacturing, and for energy needed by the glass and porcelain manufacturing industries. In Germany this led to an almost complete depletion of the wood resources of the Black Forest and the Bavarian Forest. The wood demand for ship building activities led to deforestation and karstformation in many Mediterranean countries. Oil palm plantations in the tropics are nowadays one of the major reasons for destruction of rain forests.

However, some pathways show a great potential for future development. For wood a growing demand is foreseen for the construction of prefabricated houses in Central Europe. Many experts also see wood as an important feedstock for future bio-refinery. Pulp and paper industry are still relying on wood as its main resource. In this sector, bamboo will play an important role in the future. The rising demand for wood and bamboo as a resource for textile fibers will lead to the

substitution of cotton fibers. A possible consequence will be a reduce of the area of agricultural land needed for cotton production, which then can be used for other crops.

Palm plantations normally are established for the utilization of the palm fruits (dates, coconut, oil palm nut). Millions of hectares of coconut plantations exist since many decades. The area for oil palm production is increasing rapidly. But only recently the older coco nut and oil palm plantations have reached an age where replacement of the palms has become necessary. Currently the trunks must be burnt or disposed to avoid pests that might also infest the palms of the plantation. Here an integrated utilization concept for the palm trunks is urgently needed. This concept should focus on the unique properties of the palm trunks. The Palmwood R+D Net is working in this field.

Palm fronds are used locally, the fibers originating from oil palm fruit bunches and the coco mesocarp fibers have found many applications (ropes, floor mats and carpets, filling material). Due to its high starch content certain palm species are used for alimentation (sago starch).

Table 1 Tree utilization pathways

	Currently established	Options with high potential
Fruits, seeds	Alimentation; chemicals; handicraft, ornaments	
Wood	Energy; ashes (mainly potassium carbonate); building material; underground engineering material; pile foundation; ship building; interior design; source for fibers; barrels; handicraft; weapons, resource for engineered products; resource for textile fibers	Energy; building material; interior design; resource for engineered products; resource for biorefinery; resource for textile fibers
Bark	Energy; chemicals; medicine; cork stopper; mulching; soil improvement	Medicine
Sap, resin	Alimentation; chemicals, medicine	
Leaves	Humus formation	

Table 2 Bamboo utilization pathways

	Currently established	Options with high potential
Fruits, sprouts	Alimentation; chemicals; handicraft; ornaments	
Culm	Building material; interior design; handicraft; resource for textile fibers, charcoal, medical application	Resource for fibers; resource for engineered products; resource for biorefinery; resource for textile fibers
Sap	Beverage	
Leaves	Shelter; animal fodder	

Table 3 Palm utilization pathways

	Currently established	Options with high potential
Fruits, seeds	Alimentation; pharmaceutical industry; handicraft; ornaments; energy	Pharmaceutical industry
Culm	Handicraft	Building material; interior design; resource for engineered products; resource for biorefinery
Sap	Beverage; starch (sago)	
Leaves, fronds	Shelter; material for braiding; animal fodder	

Reasons for different industrial developments in the wood, bamboo and palm sector

Wood from forests is available all over the year. It can be harvested in the forest which represents a standing stock for the woody resource. Once harvested, many wood species can be stored in form of round wood either in the forests, at the forest road or in the factory. In the past wood harvesting was seasonal in many regions, but nowadays wood for large scale industrial application is harvested all over the year. This kind of raw material availability was the reason for the development of huge factories and integrated industrial sites, where sawmilling, wood-based panel production, glulam production and energy generation can be combined. This allows a very effective use of all parts of a tree, which leads to high added value.

Annual agricultural crops, which are also considered a valuable fiber resource, normally are harvested during a very short period of the year. For industrial processing of agricultural fibers this means that the raw material has to be stored to ensure a continuous production all over the year. Up to now this has been a major obstacle for industrial utilization of e.g. cotton stalks, bagasse, oil palm fruit bunches and coco mesocarp. Not only the missing disposability, but also the often-found high sugar or starch, content hinder the storage bagasse, bamboo, and palm biomass. While growing in tropical and subtropical regions bamboo and palm biomass deteriorates easily due to fungal and insect attack. Only when solutions for storage and preservation of palm biomass are found, an industrial utilization of palm biomass will become feasible. Managing the felling of the palm stems in a plantation in such a way that allows a continuous supply of raw material all year long, would be an important factor for establishing a palm wood industry. Another important factor for industrial investors is the quantity of material available within a certain transport distance. In addition, a good infrastructure and roads usable during all seasons are needed to supply a palm wood-based industry with sufficient raw material.

In case of wood and bamboo the lignocellulose biomass is considered the main renewable raw material and all the other parts are by-products. This is different in cultivation of palms. Here the fruit is the main product and all other plant parts, including the stem and fronds, have to be considered as by-products. The main product always comes first while by-products often stay behind. This changes only when the profits made with the by-products start exceeding the profit made with the main-product.

An extensive source of literature is available in wood science. Handbooks summarizing the knowledge collected over decades do exist and are in use [3] [4] [5]. In bamboo research the publications of INBAR comprise a huge source of knowledge and information [6] [7], but in the palm sector only some examples [8] of such literature exist.

How can we accelerate progress in palm utilization?

The rapid progress achieved in wood science has been and still is based to a great extent on knowledge exchange between scientists, which are organized in associations and networks. Very well-known are organizations such as IUFRO and InnovaWood (both having institutional members), and IAWS (personal members). In the bamboo world INBAR plays a key role. In the palm wood sector scientists, consultants, entrepreneurs, industry representatives, and developers have just recently started to organize themselves by establishing Palmwood R+D net.

Even though the three raw materials (wood, bamboo culm and palmwood) are different, palm researchers can use the knowledge and consider many of the ideas developed in the wood or bamboo sector. Especially when it comes to processing palm-based woody matter many techniques and processes are already available, which can be used after minor modification and adaptation for converting palm stems and palm fronds into valuable products.

Obstacles which have led to disappointment or financial flops in the past with wood, bamboo, sugarcane, cotton stalks or other agricultural lignocellulose crops should be considered and analyzed carefully in order to avoid repeating mistakes and unprofitable investments.

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