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Production of fibre boards from agricultural raw materials and residues

Wood prices are increasing and wood is short of supply. Therefore non wood resources e.g. from agricultural production are coming into consideration as alternatives or as replenishment. If agriculture wants to become a future supplier for raw materials for the fibre board industry, several general requirements such as fibre quality, perennial and regional raw material availability at competitive prices and stable quality of end products have to be fulfilled. At present, the main focus is especially on hemp shives, rapeseed straw, fermentation fibres from biogas plants and wood from short rotation coppice.

Keywords
Derived timber product, fibreboard, fibre, hemp, shives, rape, fermentation fibre, poplar, wood

Abstract
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With the increasingly extensive use of all available, renewable raw materials and the intensified discussion about the climate change, wood as an important natural resource could globally become a rare resource in the future. Since recently, wood has not only been used in its genuine physical form, but also as energy source in form of wood chips, briquettes, and pellets. The growing competition on the procurement markets has been leading to a rise in wood prices and a shortage of certain woods. The fibre board industry, the second largest consumer of rough timber behind the sawmilling industry, has gradually been coming under distress due to the strong promotion of renewable resources as a fuel source [1]. With growing demand in smallwood and prices strongwood hence going up, the fibre board industry is getting increasingly dependent on alternative material resources for the manufacture of composite materials. A contingent source for raw materials could be found in fibre containing raw materials and remnant materials in agriculture. This present research focuses on the question of the extent to which agriculture can supplement as a producer of raw materials for the composite material industry, with regard to sufficient supply and reasonable prices of raw materials in the long term.

Moreover, for detailed investigation of processing lines, the Leibniz Institute for Agricultural Engineering Potsdam-Bornim e.V. (ATB) has developed a new technology for the supply and processing of natural fibre, and built a pilot plant for the production of fibre board materials (**figure 1**) [2; 3; 4]. This new technology features particularly high flexibility regarding the raw materials used and reduces the demand of energy for the generation of fibre materials. The focus of the experimental research lies on the processing of natural fibre plants like hemp and flax, but also in the generation of fibre materials from hemp shives, rape straw, Miscanthus, and fast growing woods from short rotation coppice.

Agricultural fibre resources

General provisions for the use of agriculture based fibre resources are their sufficient regional availability, competitive prices compared to wood, and the compliance with material standards and parameters. With the currently usual processing plant capacities of raw materials for derived timber products of 10 to 40 t/h it appears rather reasonable, not only with concern to material properties, to just partly substitute the use of wood. A substitution of 50 % of wood by hemp shives in particle board production at a plant capacity of 20 t/h would require more than 20,000 ha of crop land (**figure 2**). Even if such extension of hemp crop – based on currently approx. 1,500 ha in Germany – were possible, the development of suitable sales markets for the fibre produced in hemp decortication (ca. 36,000 t) would have to be considered. Although the price of hemp shives of approx. 180 €/t is above the price of wood chip, the use of hemp shives could already be economically efficient due to several advantages in the overall processing. These are particularly the reduced demand for raw material, energy, and transport as well as the weight reduction of the finished products. The use of straw

Fig. 1

Pilot plant for the production of fibre materials. Photo: ATB

from flax (rsp. oilseed flax) or rape may also be considered, since substantially more favourable prices for raw material could be expected, particularly for rape straw as a side product of seed production. With a cultivation area of 1.4 million ha, rape straw would sufficiently be available for extensive substitution of wood [5]. However, its use in wood materials may cause unfavourable effects in material properties according to the present state of knowledge.

Experimental research in a pilot plant

In the ATB pilot plant, different raw materials were processed to fibre materials, using a combination of twin-screw extruder and disk mill [6]. Utilizing image analysis (Fibreshape 5.0), the produced fibre qualities were evaluated regarding their fibre geometry, and compared to wood fibre (**figure 3**).

The thickness ratio [s], defining the length-to-width ratio of the fibres, can be utilized as parameter for the quality of the fibre material produced. Higher thickness ratios provide a greater strength of the produced fibre boards [7; 8]. In the tests, highest thickness ratios were achieved for pine wood with s = 27.6, closely followed by fibre from wet-preserved hemp (s = 23.3). Rape straw fibre achieved a clearly inferior thickness ratio at s = 9.5, which was reflected in reduced strength of the fibre boards produced thereof.

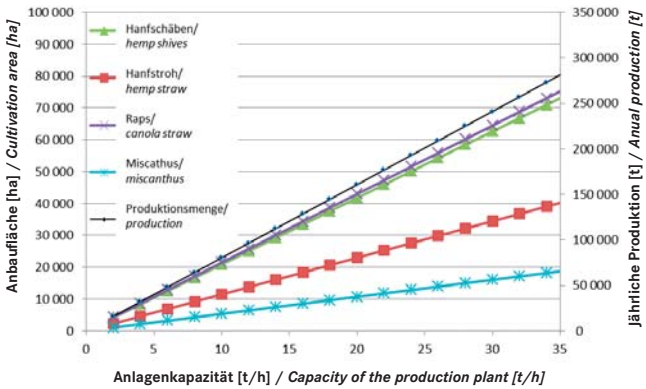
Additionally, for some raw materials, the suitability for the production of fibreboards was established in two density grades (medium density fibre boards (MDF) and high density fibre boards (HDF)), using a PF-resin as binder [9]. Besides wood fibres, only fibres from hemp shives and bamboo meet the minimal requirements on bending strength for HDF according to DIN EN 622-2 [10] for general use (**figure 4**). Fermentation fibres from biogas production are also available in substantial quantities and at very reasonable cost, but are only suitable for the use in low strength applications, e.g. as filler in mud-brick building, due to their low material properties.

Boards made from fibres from pinewood chips and a mix of hemp shives and pinewood chips (70 : 30) meet the strength requirements according to DIN EN 622-5 [10] for MDF for load bearing use (**figure 5**). Fibre materials made from hemp straw, wet-preserved hemp, or poplar from short rotation coppice could be used in applications with lower board density (< 300 kg/m³), e.g. insulation materials, greening materials and for erosion protection.

Conclusions

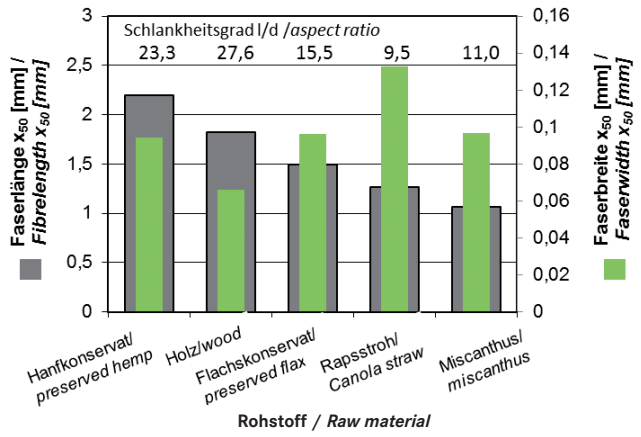
Agriculture is already capable of providing fibre resources for the fibre board industry (e.g. hemp and rape straw) in required quantities and at competitive prices, particularly on the background of continuously increasing wood prices (year 2010: > 75 €/t). However, in lower density fibre boards, the substitution of wood fibre contributes to potential reduction in strength parameters of the finished products. Such adverse effects could probably be compensated by adapting optimized processing technologies for the production of derived timber products to the specific properties of agricultural raw materials.

Fig. 2



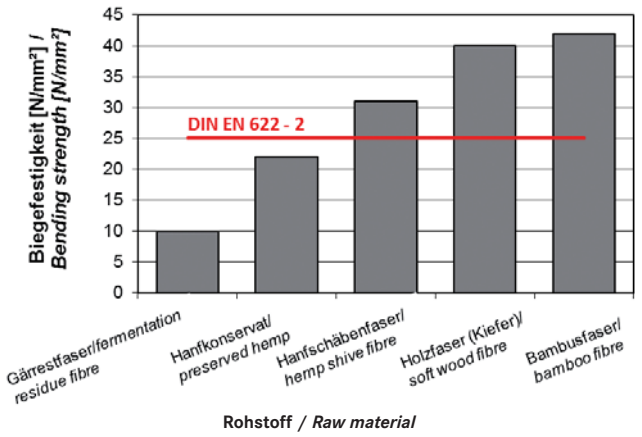
Required cultivation area for different fibre resources in dependence on the capacity of a fibre board production line

Fig. 3



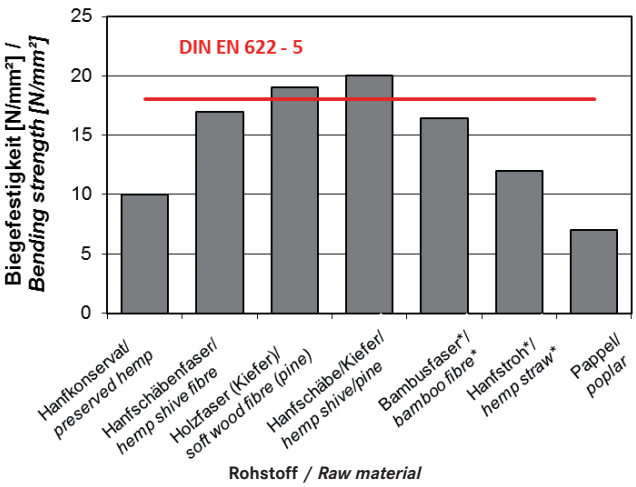
Fibre length and width for fibres produced from different raw materials

Fig. 4



Bending strength of high density fibre boards produced from different raw material (density 800 kg/m³)

Fig. 5



*Bending strength of medium density fibre boards produced from different raw material (*density 550 kg/m³, all other densities 600 kg/m³)*

Currently, a potentially interesting opportunity of application is the use of hemp shives in particle boards for the reduction of board density. Further opportunities for the use of agricultural fibre resources could lie in the substitution of pinewood in board materials by rape straw, hemp, or poplar as well as the use of fibres generated from these materials in insulation material or materials for greening.

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