From Wood to Food: Will Bio-Economy Change Sectors?

T. Stern[1]

***Abstract* - The concept of bio-refining, equivalent to petrochemical refining, is a basic concept of bio-economic innovation. The so called wood-, forest-based or ligno-cellulosic biorefinery is one of the basic biorefinery concepts which frequently bases on existing pulp and paper processes. Three dilemmas for innovation and adoption in context of the increasing multi-functionality of renewable raw materials are defined in literature: competing goals, incumbent vs. new entrant competition and the change of industry boundaries. This review presents how forest biorefineries and the food sector are connected as a consequence of these dilemmas and how they may change sectorial boundaries in the future.**

Introduction

Bio-economy and associated terms (e.g. bio-based economy, circular economy, post-carbon economy) have been increasingly used and discussed (Staffas et al., 2013). Forestry, as well as agriculture, are both frequently mentioned as important sectors to be included in a vision of a future bio-economy (Langeveld et al., 2010). According to OECD (2006) the concept of bio-economy can be defined as "transforming life science knowledge into new, sustainable, eco-efficient and competitive products". Therefore innovation plays a crucial role when realizing the vision of a bio-economy. The concept of bio-refining, equivalent to petrochemical refining is a basic concept bio-economic innovation (Langeveld et al., 2010). The so called forest-based (van Heiningen, 2006) or ligno-cellulosic biorefinery is one of the basic biorefinery concepts which frequently bases on existing pulp and paper processes (Chambost et al., 2007; Ragauskas et al., 2006).

Dilemmas for Innovation

Boehlje and Bröring (2011) described three dilemmas for innovation and adoption in context of the increasing multi-functionality of renewable raw materials:

(1) the competing goals dilemma,
(2) the new entrant competition dilemma and
(3) the industry boundaries dilemma.

The competing goals dilemma refers to the three dimensions (economic, social and environmental) of sustainability which are equally considered in bio-economic vision. It basically questions the potential trade-offs between those three dimensions and how they can be practically implemented. The food-fuel debate for example is one outcome of this dilemma. Concerning wood the intensive discussions regarding the use for materials or energy can be allocated to this dilemma.

The incumbent versus new entrant competition dilemma is based on the fact that the vision of a new bio-economy offers the opportunity for new entrants to successfully enter the biomass markets and replace the incumbents who have been the dominant players in the industry. Agricultural raw materials for example are becoming increasingly important to e.g. health/pharmaceutical or chemical industries. In case of the forest sector this dilemma is so far strictly related to new participants from the bio-energy market (Schwarzbauer and Stern, 2010).

Finally the third dilemma is connected to the consequential redefinition of industry boundaries. The vision of a bio-economy is very likely to include a process of convergence that leads to "new competitive landscapes" (Bettis and Hitt, 1995) in which actors from different formerly distinct industries could become competitors or partners.

Hence, this work aims at using the presented dilemmas as a theoretic framework for a detailed analysis of the potential interactions between the forest-based sector and the food industry.

A Review of Market Surveys

The results presented in table 1 are based on four business to business surveys, a consumer survey and additional secondary data research. In total the surveys refer to about 200 interviews with relevant companies.

Wood constituents and extractives are already used in the food industry, for example cellulose as a thickener agent or vanillin, which is obtained from lignin (Goldstein 1981) as a flavour.

Famous examples for wood-based products in functional foods are phytosterols, which are used in margarines because of their ability to reduce the human cholesterol level. Phytosterols could be obtained from cereals like soy or corn but also from tall oil, a by-product from pulp production (Heasmen and Mellentin, 2001).

Wood extractives used in the context of food applications are for example polyphenols or triterpenic acids. Their health effects, such as antioxidant potential, active agent against osteoporosis, positive cardiovascular effects and weight loss effect seem to be very interesting for the application in the dietary supplement and functional food industries.

[1] Tobias Stern tätig bei Kompetenzzentrum Holz GmbH, Market Analysis and Innovation Research Team, Austria (t.stern@kplus-wood.at).

Table 1. Potential applications, barriers, incentives and market potential of new wood based materials in Central Europe based on Stary (2011), Koppensteiner (2012), Hayden (2012), Stern (2009).

Materials	Application	Barriers	Incentives	pot. Volume [t/a]	pot. Value [€/t]
Hemicelluloses	Food packaging films current technology	limited applicability	rising oil price	4,000	1,000
	Food packaging films future technology	technical feasibility	rising oil price	300,000	1,000
	Microencapsulation niche strategy	registration & approval	good properties	500	8,000
	Microencapsulation mass strategy	registration & approval	-	5,000	3,000
	Food additive niche strategy	registration & approval	good properties	3,000	5,000
	Food additive mass strategy	registration & approval	good properties	20,000	2,000
Extractives	Polyphenols as bioactive substances in dietary supplements and functional food	registration & approval, other raw materials, consumers	high quality/purity	100	500,000
	Triterpenic acids as bioactive substances in dietary supplements and functional food	registration & approval, other raw materials, consumers	good properties	100	130,000

Hemicelluloses are carbohydrates which could be refined to monosaccharide, disaccharides, oligosaccharides or polysaccharides. Due to their closeness to other (poly-) saccharides (e.g. starch, cellulose, inulin, etc.) it is not surprising that these intermediates share some of their potential applications.

Conclusion

The implementation of biorefineries based on agricultural raw materials will most likely question the sectorial boundaries between agriculture, food and chemical (fuel) industries. In contrast, first forest biorefineries (e.g. Lenzing AG, Austria) indicate that pulp-based companies may find it appropriate to select first niche applications (e.g. Xylitol) that promise higher added value and better competitive conditions than commodities (e.g. packaging films, fuels). The results of market studies presented in table 1 provide an indication of the economic considerations of such a decision process. Therefore it can be expected that quite a few forest-based biorefineries will aim at serving the food value chain in the near future.

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