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INQUIRY IN BEECH WOOD PROCESSING INDUSTRY CONCERNING RED HEARTWOOD

Christian Hansmann
Wood K plus, Competence Centre for Wood Composites and Wood Chemistry
Linz, Austria

Robert Stingl, Alfred Teischinger
Institute of Wood Science and Technology
Department of Material Sciences and Process Engineering
BOKU - University of Natural Resources and Applied Life Sciences,
Vienna, Austria

ABSTRACT

An inquiry into the beech wood processing industry has provided a survey of the existing knowledge, technologies and products relevant to beech containing red heartwood from the practical point of view. A lower price and a lower recovery factor are rated as most important consequences of red heartwood. Regarding products the necessity for developing new products and for supra-regional activities for marketing of red heartwood can be recognized. Most of the grading is performed manually. Steaming is thought to be suitable in order to reduce colour differences between red and light-coloured heartwood. Other possible methods for homogenisation and stabilisation of the wood colour are not well known. Thermal treatment is thought to be most suitable. Beech red heartwood is still thought to be best suited for pallets, packaging or hidden furniture parts. The greatest chances in alternative products are seen in design furniture or design interior accessories as well as flooring.

KEY WORDS: *Fagus sylvatica* L., red heartwood, inquiry, wood processing, products, wood colour

INTRODUCTION

Beech (*Fagus sylvatica* L.) is the most abundant broadleaf species in Central Europe and is one of the most valuable wood species in Europe used for furniture. Unfortunately, for the European beech wood resource the inhomogeneous discolouration of red heartwood (red core) is very common. Red heartwood is a facultative coloured heartwood formation starting in the centre of the stem. The beech red heartwood can be found in the following basic forms (Sachsse 1991): classical red heartwood (Fig. 1a), spattering red heartwood (Fig. 1b), wounded red heartwood and abnormal red heartwood (Fig. 1c). This study is dealing with the classical red heartwood showing a reddish-brownish colour and a cloudy formation which does not follow the year rings (Zycha 1948).

Fig. 1: (a) classical red heartwood, (b) spattering red heartwood, (c) abnormal red heartwood (Pictures: Trenciansky in Trenciansky and Hansmann 2007)

Primarily, the discolouration leading to the classical red heartwood is initiated by the penetration of oxygen leading to oxidation of soluble carbohydrates and starch to phenolic compounds and its polymers (Dietrichs 1964, Rieder 1997, Koch et al. 2000). These compounds of high molecular weight do not penetrate the cell wall and therefore the red heartwood does not show any increased durability. As summarised by Koch et al. (2000), the formation and shape of the red heartwood is influenced by individual characteristics of the tree such as age, diameter, amount of dead branches, crown shape and by site factors (Racz et al. 1961).

From the technological point of view, the classical red heartwood possesses physical and mechanical properties similar to the non-discoloured heartwood (Molnár et al. 2001). So far, the timber market has not fully accepted the red heartwood which is mainly due to the aesthetic aspect. Another reason is the fact that tylosis formation in vessels makes the impregnation of heartwood with wood preservatives impossible and it influences sorption and drying abilities in an inappropriate way (Sachsse 1991). However, some of the timber processors started looking for classical red heartwood timber in order to use its decorative characteristics.

In the last decade emphasis was placed on several active marketing concepts for red heartwood of beech. According to the actual style trends, beech containing red heartwood was marketed e.g. as "natural beech" or "eco-beech" giving hope to the forest industry for a higher valuation of beech containing red heartwood. While at first beech with red heartwood was mainly used for high quality furniture made of solid wood, products with red heartwood can now be found in big furniture stores, too. In general increased demand could be observed in the last years for coloured heartwood, also for other species such as ash (Wagemann 2006). Several initiatives and presentations at exhibitions, especially in Germany, assisted that development. Nowadays, furniture made of beech red heartwood is already well-established, and can be found in the individual production by carpenters as well as in the industrial production of kitchens, living- and bedrooms. Finally, beech red heartwood has found its way into public or commercial buildings.

However, while recent inquiries (Becker et al. 2000) suggested that potential end-users find red heartwood of attractive appearance and/or feel convinced by its ecological benefits, red heartwood still significantly restricts the log quality of beech stems and end products and therefore leads to severe economic losses. Thus an EU co-funded project was launched in 2005, convening eight project partners from four countries (A, D, HU, E) ranging from universities and research institutes to forest products industries. The objectives of the EU-project "Innovative solutions for improved processing of beech (*Fagus sylvatica* L.) with red heartwood" (INNOBEECH*) were to optimise the processing of beech logs containing red heartwood, to develop grading devices for red heartwood timber, to align and stabilise the wood colour by means of adequate steaming and drying schedules and UV-treatment and to develop high-value products of red heartwood.

As a first step, an inquiry into the beech wood processing industry and related sectors

should provide a survey of the existing knowledge, technologies and products relevant to the topic. It was of interest to find out which way the beech wood processing industry estimates and evaluates the red heartwood when purchasing beech and the importance of the red heartwood for grading. Advanced knowledge of national and international sawn timber grading rules regarding their transferability to red heartwood and of the latest developments in timber grading technology should be obtained. Furthermore, an overview of approaches on high-value uses for red heartwood, of indoor and outdoor as well as of structural use of beech wood and the corresponding production processes should be obtained. Finally, the survey should identify open questions and unsolved problems in processing beech red heartwood and ideally highlight new enhancements in industry.

METHODS

The questionnaires were sent out to three different groups of the forest products industry:

- Group A: Stem and Wood (manufacturers of "low" processing depth: lumber and veneer)
- Group B: Processes (manufacturers of "medium" processing depth: production of half-finished goods, e.g. gluelam, plywood, TMT, …)
- Group C: End-fabrication (manufacturers of "high" processing depth: production of parquet, window, furniture, …)

The complete questionnaire design was developed according to the "Total Design Method" (TDM) (Dillmann 1978, 1983) in order to achieve a high response rate. High rates of return using the TDM during a mail survey in the forest- and wood industry sector in Germany were already reported (Voss and Becker 1987). The questionnaire mainly consisted of direct closed (multichotomous/fixed-alternative) questions (if possible).

In Austria the mail survey was additionally accompanied by sending out a press report which was published in three national wood-industry related magazines (one of them online). In the text the whole project was shortly presented while the importance of the mail survey was pointed out separately in order to achieve higher return rates (Dillman 1978, 1983).

In question topic (1), respondents were asked to rate characteristics of round timber indicative for the occurrence of red heartwood. In question topic (2) respondents rated the consequences of using red heartwood at round timber level, at sawn timber level and at products level. Question topic (3) concerned grading (measuring and classification) of sawn timber. Question topic (4) regarded steaming and drying with special consideration of wood colour. In question topic (5) respondents rated the suitability of different methods to homogenise and stabilise the colour of wood. Question topic (6) concerned the suitability of beech with red heartwood for different applications. At last, question set (7) asked respondents to provide sociodemographic information. The sociodemographic questions were mainly open-ended questions. That included the position of the respondent, the number of employees in their business, as well as the main products. Further, they responded in regard to important regions, where the wood comes from, whether they processed it in their own business, the amounts being produced or processed, and the distribution of diameter classes. Respondents had the opportunity to add "general comments" at the very end of the questionnaire.

A five-point Likert type scale was used for the direct closed questions ranging from 1 to 5 (Fig. 2), for the first set from e.g. „not indicative" (1) to „very indicative" (5). Only the end-points were labelled. Numbers only were used for the intervening points. Multiple responses were not desired. A „don't know" option was also provided for respondents, who hesitated to express an

opinion. That option was to increase the response rate, however, the „don't know" option was not chosen very often. Besides, three blank lines were added at the end of each set of questions. Thus, respondents could name and rate items not provided in the lists given. This option was not chosen very often either. Such comments are referred to as question specific comments in this text.

Topic 1:
The following CHARACTERISTICS of round timber are visible cortically.
Which characteristics are indicative for red heartwood?

	Indication					
	Not indicative				Very indicative	Don't know
Stem curvature	1	2	3	4	5	
Large stem length	1	2	3	4	5	
Spiral grain	1	2	3	4	5	
Chinese beards	1	2	3	4	5	
Sound branch	1	2	3	4	5	
Dead branch	1	2	3	4	5	
Very smooth bark	1	2	3	4	5	
Buttressing	1	2	3	4	5	
Large root collars	1	2	3	4	5	
Insect outbreak	1	2	3	4	5	

Fig. 2: Five-point Likert type rating scale. Example shows abbreviated topic 1.

RESULTS AND DISCUSSION

The overall return rate across the four participating countries was 21.3 %, which presents the usual value for such surveys. Finally 106 questionnaires could be analysed. 34 % of the respondents assigned their company to the first production stage (Group A "Stem and Wood"), only 8 % to Group B ("Processes") and 23 % assigned to "end-fabrication" (Group C). 18 % of the respondents assigned to more than one group because they have more than one production stage in their company. 17 % provided no information at all. Most of the companies (78 %) employed fewer than 100 employees, which reflects the structure of the hardwood manufacturing industry very well. Small businesses dominated the sample for both roundwood and sawn wood. 38 % of the respondents process 1000 to 5000 solid cubic metres beech roundwood per annum. Also with 38 % the group of companies who process 1000 to 5000 cubic metres beech sawn wood per annum is the strongest group. Neither for roundwood not for sawn wood could any significant differences be revealed by means of a one way ANOVA among the participating countries regarding the volume of processed beech wood per annum. Companies processing more than 30000 solid cubic metres of roundwood occurred only in

Austria and Germany within this study. Regarding sawn wood, only one Austrian company which processes more than 30000 cubic metres participated in the survey.

When the respondents were asked to name up to three core products made of beech in their company, the producers of construction lumber, unedged boards, veneer, plywood, parquet and furniture, as well as wood traders were addressed so as to name most of the possible uses of beech wood. The aim was to reach all those who produce or process beech wood. This kind of sampling is called purposive sampling, where the respondents are chosen carefully in order to serve the research purpose (Churchill 1995). The majority of businesses returning their questionnaires belonged to the "Stem and Wood" sector. These businesses mainly sell sawn wood or produce veneers.

One fourth of the respondents are dealing with a red heartwood amount of 11 to 20 percent (Fig. 3). Together with the two adjacent groups (1 to 10 percent and 21 to 30 percent), more than 50 % are in between those three groups. On the other hand, also more than 50 % of the respondents have a red heartwood amount of more than 20 %, which automatically results in a distinct lower recovery factor on today's market situation.

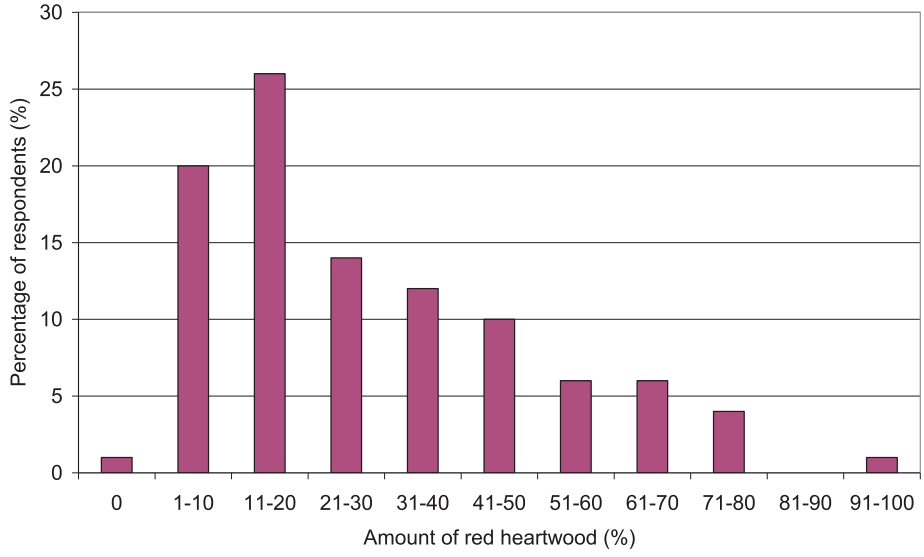

Fig. 3: Estimated amount of red heartwood in the respondents´ companies

In Austria 65 % of the roundwood is purchased on the home market, while in Germany 82 % and in Hungary even 100 % of the respondents acquire their beech roundwood on the national market. In Austria the most important national regions are Styria and Upper Austria. In Germany, most of the nationally purchased beech roundwood comes from North Rhine-Westphalia, Baden Wuerttemberg and Hesse closely followed by Bavaria and Lower Saxony. In Hungary the Southwest and the West are the most important proveniences of beech roundwood. As expected the situation is different for Spain, where all respondents import their beech roundwood. Here the most important region is Central-East-Europe. Hungary, Bosnia and South-Europe in general were stated as the most important import markets for beech roundwood in Austria. In Germany the respondents specified Bosnia, Austria, Poland and Romania as their

most important international proveniences for beech roundwood. While respondents in Hungary purchase their beech roundwood only on domestic markets, the respondents in Spain import their beech roundwood mainly from Central-West Europe. As there were no explicit instructions for answering this question, the answers differ in their geographic accurateness. Austrian and German respondents mainly defined their purchasing regions by the name of the state or federal state, while in Hungary and Spain the region where the beech roundwood is purchased was described more extensively. However, it is evident that in the participating countries (except for Spain) the domestic market is the most important one. Internationally, Central- and South-East-Europe are the most important markets for beech roundwood.

Respondents were asked to provide the distribution of diameter classes for roundwood processed in their business (Fig. 4). A majority (50 %) of roundwood fell into class three (40-59 cm). The situation in Austria and Germany was quite similar. In Hungary, the situation differed slightly, where class two (20-39 cm) is a little bit stronger regarding the mean values. But no significant differences could be revealed between the three countries by means of a one way ANOVA. For Spain, an analysis was not possible due to a lack of answers in this category.

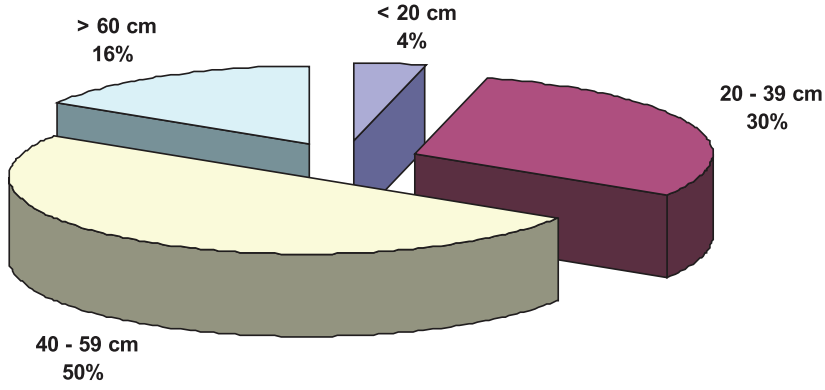

Fig. 4: Distribution of diameter classes

Regarding indicative characteristics of logs for red heartwood, the enterprises answered that "high tree age" and "large diameter" ought to be best and second best suited characteristics of round timber in order to recognize red heartwood (Fig. 5). "Dead branch" and "insect outbreak" are rated as third and fourth most important characteristics in order to indicate the risk of red heartwood in a stem. These ratings conform well to published literature (Knoke 2003). "Stem curvature", "smooth bark" and "spiral grain" are rated to be the three least indicative characteristics of round timber that provide an indication of red heartwood.

The consequences of red heartwood for logs have been rated by the respondents. A lower price for the red heartwood containing beech logs due to sorting into lower grades was stated clearly. Additionally, a lower recovery factor was seen as a consequence of the occurrence of red heartwood. Approximately 50 % of the respondents indicated no losses due to trim and declared no additional processing necessary due to specific steaming in case of red heartwood occurrence. However, the economic consequences are quite evident. Regarding sawn timber the situation is similar. It is logical that the necessity of specific cutting and a lower recovery factor in general, finally lead to lower prices, as clearly stated by respondents (Fig. 6). On the other hand, specific steaming or

drying processes were more likely to be seen as an unnecessary consequence due to the usage of red heartwood. Problems during processing such as planing, warping, gluing or loss of surface quality are of smaller importance according to the respondents opinions, which agrees with published findings (Pöhler et al. 2004). The majority of respondents saw necessities of supra-regional activities for marketing of red-heartwood, followed by the necessity for developing new products. This opinion matches the willingness to establish or operate a new assortment, as stated by the respondents. There is still a big problem of lost shares of the market by using red heartwood due to missing customer acceptability. As a logical consequence of these facts, raised prices by appealing surface of the red heartwood products could only be achieved by some of the respondents. This was reflected by the fact that several respondents are of the opinion that the marketing opportunities for red heartwood products are good if the marketing is good. Others do not see any demand on the market for red heartwood products.

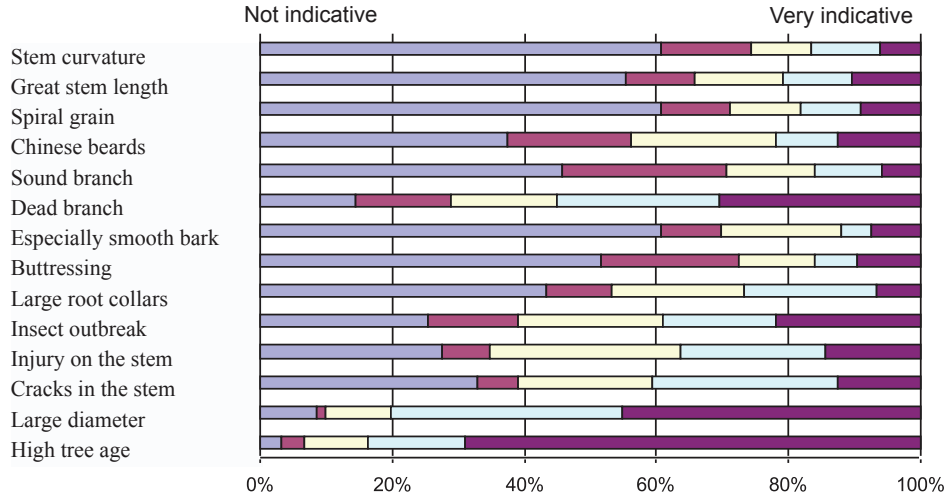

Fig. 5: Characteristics of logs indicative for red heartwood (frequencies)

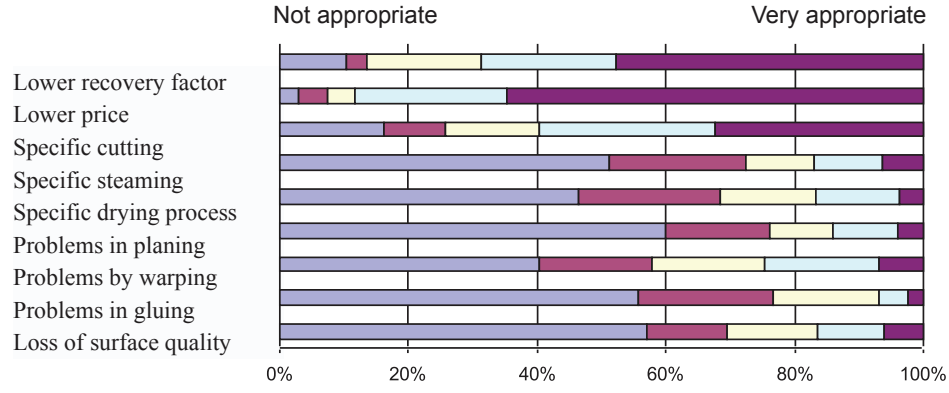

Fig. 6: Consequences of usage of red heartwood for sawn wood (frequencies)

A lot of different standards or guidelines for measuring sawn hardwood (particularly beech wood) are used throughout the group of respondents. While national or even regional standards or guidelines are very common (48 %), only 7 % of the respondents use European standards. Beyond that, there was another big group of 45 % who was using factory guidelines (21 %) or customer preferences (24 %). A huge majority of 97 % of the respondents measure their sawn timber manually. Only 3 % do both, manual and automatic measuring. Only one of the respondents relies on automatic systems only. The knowledge of automatic systems is not disseminated very strongly as only 20 % know automatic measuring systems. As one consequence the application of automatic systems by competitors is overestimated. Most of the interviewees estimate that they give around 5 % more wood to the customer because of tolerant measuring when using manual measuring systems, compared to only 2 % when using automatic systems. Thus, a distinct advantage of automatic systems is recognised by the respondents. 37 % of the enterprises would like to measure more accurately, while 25 % seem to be content with the accuracy. Almost 50 % of the respondents would be content with measuring rates up to 20 $m.min^{-1}$. Another quarter of the interviewees desire a measuring rate of 21 $m.min^{-1}$ to 30 $m.min^{-1}$.

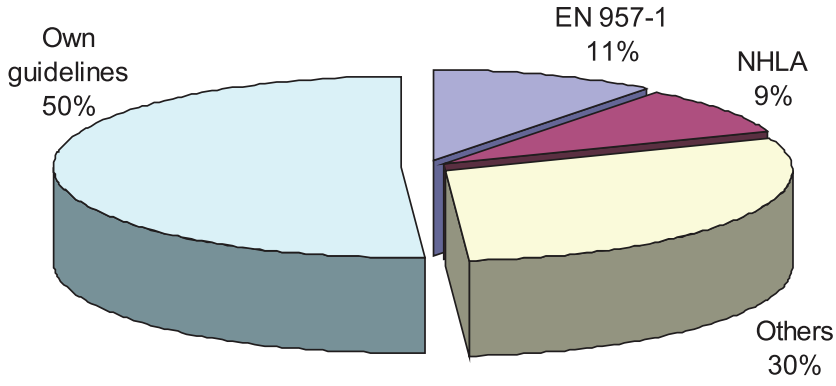

Fig. 7: Standards or guidelines for classification of sawn hardwood

As shown in Fig. 7, different standards or guidelines are used by the companies for classifying their sawn hardwood, comparable to the multiplicity of different standards or guidelines used for measuring. Their own guidelines are mainly based on form, size, position and frequency of wood defects. Additionally, other criteria such as colour of the heartwood, stem curvature, branches, large diameter and insect outbreak are used. The "other" guidelines can be divided into national or regional standards or guidelines. DIN, MSZ, "Tegernseer Gebräuche", ÖHHU, customer preferences and factory guidelines are mentioned. A huge majority of 98 % of the respondents classify their sawn timber manually. Only 2 % use automatic classification. Again, (as it was with automatic measuring systems) the application of automatic systems by competitors is overestimated. Most of the interviewees estimate that they deliver 5 % more wood to the customer because of tolerant classification, closely followed by 2 %, when using manual measuring systems. Again an advantage of automatic systems can be recognised by the respondents, but the distribution of answers also shows that the interviewees are not informed well. 37 % of the respondents would like to classify more accurately, while 25 % seem to be content with their accuracy. This reflects the results regarding measuring. More than 50 % of the respondents would be content with classification rates up to 20 $m.min^{-1}$. 19 % of the interviewees desire a classification rate of 21 to 30 $m.min^{-1}$.

Regarding grading in general, the interviewees would prefer a more objective process, would like to introduce a faster process and would like to measure more accurately. A documentation of results is seen as an important point. Rather more negative than positive is the respondents´ opinion on having more classification criteria, especially regarding a grading according to colouring or hue. This opinion rather differs from the general opinion of the respondents on the necessity for developing new products and from the stated willingness to establish or operate a new assortmentRespondents were asked to rate given methods with regard to their suitability for processing beech roundwood and beech sawn wood in order to reduce colour differences between red and white heartwood. "Steaming of sawn timber" in general and "longer steaming period" were selected most frequently. "Cooking of roundwood" and "steaming of roundwood" were also considered well suited, as well as a "higher steaming temperature" in general. Different drying methods are believed to be more or less unsuited to reduce colour differences. Additionally, several respondents query the colour homogenisation between white and red heartwood. They point out the importance of the colour difference and mentioned again the importance of creating a market for red heartwood products. The steaming scheme is chosen depending on the desired wood colour by approximately two-thirds of the respondents who have a steaming plant in their company. The rest steams according to a standard scheme without any special adjustment to wood colour. As shown in Fig. 8, the amount of red heartwood does not play a decisive role for selecting the steaming- or drying-process. In any case, there are no efforts made by the majority of respondents to homogenise the colour by the chosen steaming- or drying-schemes. However, some are concerned about the amount of red heartwood, presumably because of other quality reasons than wood colour.

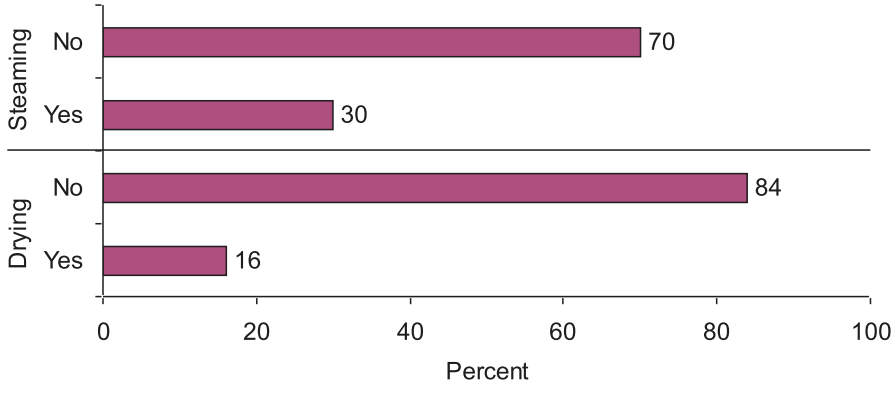

Fig. 8: Considering the red heartwood amount for steaming or drying

Without any cover treatment the colour of red heartwood will turn grey as it is not stable in UV-light. Respondents are not sure about the suitability of the different methods to homogenise or stabilise the wood colour – the frequencies of answers in the five-point Likert type rating scale were about evenly distributed. This could also reflect a low level of knowledge about the given possibilities. Only for thermal treatment respondents see a clear possibility for colour homogenisation.

Beech red heartwood could be used for different types of products. Respondents were asked to rate the suitability of beech with red heartwood for different applications. According to the

interviewees, red heartwood is still suited better for applications with low requirements such as pallets, packaging and hidden furniture parts (Fig. 9). A certain chance is also seen for design furniture and for flooring, in contrast to applications in mass production or veneer production.

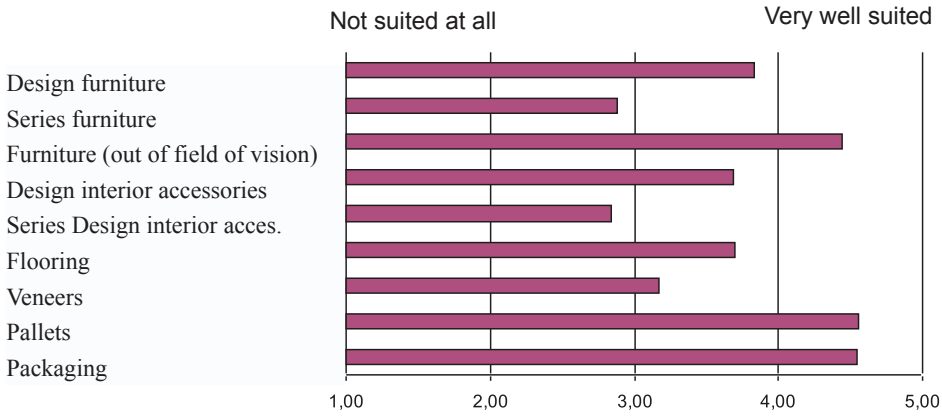

Fig. 9: Suitability of beech with red heartwood for different applications

CONCLUSIONS

The results of the inquiry into beech wood processing industry and related sectors about existing knowledge, technologies and products to process beech containing red heartwood show that a lower price and a lower recovery factor are still the most important consequences of using beech wood containing red heartwood. Beech logs are priced according to their potential yield of bright wood. Consequently, red heartwood significantly restricts the log quality of beech stems and end products and therefore leads to severe economic losses.

Regarding the products, the necessity for developing new products and for supra-regional activities for marketing of red-heartwood can be recognized. In the last decade emphasis was already placed on several active marketing concepts for red heartwood of beech. Nowadays, furniture made of beech red heartwood is already established. In general, increased demand for coloured heartwood could be observed in the last years.

The companies which process beech wood containing red heartwood use cortically observable characteristics of round timber in order to estimate the occurrence and the amount of red heartwood in beech logs. As the three most important ones, large tree age, large diameter and the occurrence of dead branches are named most often. This approach is consistent with the actual standard of knowledge and is already well-established.

Almost all of the grading is done manually, the companies' own guidelines are prevailing. The knowledge of automatic systems is not disseminated very strongly, however, more accurate grading is desired strongly. In fact, company-internal grading guidelines would allow reacting rapidly on product- or market developments which could be well supported by efficient automatic grading systems.

Highest ratings of the suitability of methods for processing of beech roundwood and beech sawn wood in order to reduce colour differences between red- and light-coloured wood are given to steaming of sawn timber together with a longer steaming period followed by steaming and cooking of roundwood. One can see that alternative drying techniques such as high temperature drying or high frequency vacuum drying are not very well known. The importance of wood colour is reflected by the fact that a great number of enterprises uses a special steaming scheme depending on the desired colour or hue. It has turned out that different methods for homogenisation and stabilisation of the wood colour are not very well known. Thermal treatment is thought to be most suitable. In general, the idea of colour homogenisation between red and bright heartwood is queried several times. Consequently, the importance of the colour difference and the importance of creating a market for red heartwood products are pointed out. However, according to the opinion of the interviewees beech red-heartwood is still suited best for pallets, packaging or hidden furniture parts. Highest chances in alternative products are seen in design furniture or design interior accessories as well as flooring. These inconsistencies reveal a general problem of any small structured branch of business and show the necessity for further developing colour-optimised grading and processing of beech wood containing red heartwood.

* INNOBEECH: Innovative solutions for improved processing of Beech (*Fagus sylvatica* L.) with red heartwood. Proj. No.: COOP-CT 2004-508137. Proj. Leader: Institute of Forest Utilization and Work Science, Albert-Ludwigs-University Freiburg, Germany.

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Christian Hansmann
Wood K plus
Competence Centre for Wood Composites and Wood Chemistry
St.-Peter-Strasse 25
4021 Linz
Austria

Robert Stingl
BOKU - University of Natural Resources and Applied Life Sciences, Vienna
Institute of Wood Science and Technology
Department of Material Sciences and Process Engineering
Peter-Jordan-Strasse 82
1190 Vienna
Austria

Alfred Teischinger
BOKU - University of Natural Resources and Applied Life Sciences, Vienna
Institute of Wood Science and Technology
Department of Material Sciences and Process Engineering
Peter-Jordan-Strasse 82
1190 Vienna
Austria