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Selected environmental aspects of the introduction into the polish market of exotic wood species on the example of caviuna (*Machaerium scleroxylon* Tul.)

Andrzej Krauss[1], Hanna Krauss[2], Bogusława Waliszewska[1], Jacek Piątek[2,3]

[1] *Poznan University of Life Sciences, Faculty of Wood Technology, Poznań, Poland*
[2] *Poznan University of Medical Sciences, Faculty of Medicine I, Poznań, Poland*
[3] *Institute of Rural Health, Lublin, Poland*

Abstract

The chemical and elemental composition of caviuna wood was determined. The elemental composition of the examined wood was similar to the elemental composition of the deciduous tree species of the temperate zone except that it did not contain sulphur. The examined wood was found to comprise a very high content of extractive substances which could contain toxic substances, as well as a considerably higher proportion than in other palisander species mineral compounds determining tool dulling. Numerous cases of diseases were recorded among people who came into contact with the examined wood. An elevated level of eosinophils was found in these people. It was confirmed that Caviuna wood, following its introduction into the trade turnover of exotic wood species, posed many threats in the working environment.

Key words

exotic wood, toxic properties, chemical propertied, chemical composition, caviuna

INTRODUCTION

During the last decade, a significant increase has been recorded of the import into Poland of wood species derived from overseas plant species. Although on the one hand, numerous functional advantages as well as exceptional properties of many exotic wood species are widely known, nevertheless, on the other hand, the sensitivity of this wood to mechanical processing in domestic conditions is less recognised and very little is known about the toxic properties of many imported wood species.

The first reports in European literature concerning the harmful impact of wood on the human organism date from the 16th century [1]. It was Ramazzani [2] who first indicated the occupational risk, mainly to saw operators, by describing irritations of nose and eyes frequently occurring among them. Numerous descriptions of cases of the toxic influence of wood date from the beginning of the 20th century [3-5], while in later years, studies were conducted to identify wood toxic properties.

Toxic properties of exotic wood

At the present time, toxic properties of the majority of exotic wood are recognised and described in world literature [6-9], although still only slightly recognised in the production practice of domestic enterprises. Identification of these species by timber importers and later in production enterprises encounters many difficulties frequently resulting from objective causes. One of them is the fact that in the case of many exotic wood species, there are several accepted Latin botanical names, and usually even more local and commercial names. Since recently in the European Union the names of exotic wood species are listed in the EN 13556:2003 standard [10]. Timber importers frequently apply commercial names, sometimes using different names for one species or the same name for different wood species [11,12]. Proper identification of wood species and professional knowledge regarding its possible harmful properties to health constitutes the basis which makes it possible to ensure work safety and hygiene in the course of its processing, as well as the subsequent contact with finished articles.

Exotic wood is characterised by exceptionally wide, in comparison with other materials, variability of traits and properties affecting its versatile application. A parameter which well characterises the physical and mechanical properties of the wood is its density. Exotic wood species of economical significance are characterised by an extremely wide range of densities extending from about 100 kg/m^3 in the case of balsa wood to approximately 1.300 kg/m^3 in the case of Lignum vitae. Among exotic wood species it is possible to find species of exceptional resistance to the action of biotic or abiotic factors (e.g. resistant to insect attack, including termites, or to corrosion in sea water) as well as species characterised by other unique properties, e.g. self-lubricating wood of persimmon, dimensionally stable wood of Maracaibo boxwood, or Massaranduba wood resistant to the action of caustic substances [8,11].

The possibilities of processing and utilisation of exotic wood are sometimes restricted by its considerable content of non-structural substances referred to as 'extractives' which are responsible, among other things, for the toxic action of wood. The above-substances can be found primarily in parenchymal

Address for correspondence: Andrzej Krauss, Poznań University of Life Sciences, Faculty of Wood Technology, Wojska Polskiego 28, 60-637 Poznań, Poland, Phone/Fax +48 61 8487485
E-mail: akrauss@up.poznan.pl

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cells; they also permeate cell walls and fill intercellular spaces as well as the resin and latex tubes [6,13,14].

Dust which is produced in the course of wood mechanical processing can cause mechanical and chemical irritation as well as allergies. Some wood species may cause an immediate (after 20-30 minutes) allergic reaction, e.g. limba and obeche wood. A delayed allergic reaction which occurs usually from 8 - 48 hours after contact, e.g. skin contact allergy caused by numerous exotic wood species, as a rule, occurs in the same person following another contact with the allergen. However, other compounds found in exotic wood possess medicinal properties, e.g. "ipein" from ipe wood used as a component for strengthening infusions or "guaiacin" from Lignum vitae wood used as an anti-cough agent.

The harmful effect of substances occurring in woody plants involves, mainly, the development of allergic reactions and poisoning. The occurrence of toxic constituents in many wood species is a family feature. The most important groups of allergens include: benzo- and naphthoquinones, and the most frequent causes of poisoning are glycosides and alkaloids. Approximately 400 tree species are known which can exert a harmful effect on human health which, apart from the above-mentioned illnesses, can lead to many other ailments, such as: dizziness, headaches, nausea, stomach aches, pareses, sight disorders, or even deaths [6,9]. The above-mentioned ailments are caused by natural constituents found in these species, e.g. alkaloids, quinones, phenols, terpenes, flavones, stilbenes and coumarins. Other substances occurring in wood and serving as its natural impregnators or dyes can also be harmful to human health. They affect mainly persons who come into direct contact with them during processing. Numerous cases of dermatoses are also known in persons wearing jewellery or ornaments manufactured from exotic wood species, although no cases of a harmful influence of furniture made from such wood have been observed.

Rosewood

The term 'palisander' is a trade name given to wood derived from the deciduous trees of the *Dalbergia* genus occurring in equatorial forests in America, Asia, Africa and Australia, and which is also applied to the wood of *Machaerium* genus which can be found, primarily, in central and southern America, mainly in Bolivia and Brazil [8]. These two genera, which belong to the *Fabaceae* family, comprise many species whose appearance and properties are very similar, and it is frequently difficult to distinguish them. Palisander wood is characterised by dark coloured and richly colourfully striped heartwood and narrow, light coloured sapwood. Palisander is used, primarily, to manufacture exclusive furniture and fancy articles, veneers, parquets as well as musical instruments [8,15,16]. With respect to some physical and mechanical properties as well as applications, palisander wood can be compared with the *Quercus sp.* species from the temperate climatic zone. Wood of *Dalbergia nigra* (Vell.) Fr. All. and *Dalbergia stevensonii* Standl. species - commercial names Brazilian rosewood and Honduras Palisander - is highly valued, although its excessive harvesting caused this wood to be replaced by a different species with similar properties and appearance known on the timber market under the commercial names Caviuna and Santos rosewood (*Machaerium scleroxylon* Tul.).

New wood species on domestic market

The increasing volume of exotic wood processed in Poland has resulted in increased incidences of illnesses of persons exposed to direct contact with toxic wood species. One of the examples of health hazards can be the increased incidence of health problems observed in one of the largest enterprises processing wood of exotic species among workers during their contacts with wood of *Machaerium scleroxylon* Tul. [17]. Wood of this species can be encountered under numerous commercial names of which the most frequent ones include: Santos rosewood, Santos Palisander, Pau Ferro, Caviuna, Morado. It occurs naturally in Bolivia, and was introduced into the market to replace the *Dalbergia nigra* Fr.All. species occurring mainly in Brazil and Argentina under such commercial names as Brazilian rosewood Rio Palisander, Rio Jacaranda and Caviuna.

The harmful to health, long-term effect of palisander wood dust produced during processing of species from the *Dalbergia* genus has been known since the beginning of the last century. Wood dust of palisander timber is highly irritating and allergenic. Allergy develops as a result of direct contact or by inhaling dust. Inhaling reactions may include: e.g. paroxysmal or chronic dyspnoea, inflammation of nose mucous membrane, hay fever, whereas skin and eye reactions can include contact dermatoses, eye irritation, conjunctival inflammation and lacrimation [6,9]. The allergic compound is benzoquinone included in the so-called 'neoflavonoids' and given the species name of '*dalbergione*'. From among six *dalbergione* compounds identified so far, the strongest effect was found to occur in the case of R-3,4-dimethoxy-dalbergion which is considered to be a strong allergen responsible for contact allergies also caused by the *Machaerium scelroxylon* Tul. species [6,18]. All *dalbergione* benzoquinones exhibit cross-reactions between one another; therefore, a person who becomes allergic by contact with wood of one kind (e.g. *Dalbergia*) can also develop allergy to wood of another kind (e.g. *Machaerium*) even though there had not been any earlier contact with it.

First reports about *Machaerium scleroxylon* Tul. genus as a strongly irritating substitute of the *Dalbergia nigra* (Vell.) Fr. All. genus derive from the beginning of the 20th century, and more detailed data about allergic reactions to Santos Palisander wood date from 1968. Morgan [19] described a case of an 'outbreak' of dermatoses in a furniture factory in which Rio Palisander wood was accidentally replaced by that of Santos Palisander. As the use of Santos Palisander wood became more widespread, cases of ailments associated with it also became more frequent. Wood of this species has also been processed in Poland recently and has caused problems mainly of a health nature. The properties of this species are described only superficially, especially in European literature, providing information connected only with its aesthetic and functional value and basic data about physico-chemical properties, while data associated with its chemical composition and ease of processing of this wood species is rare.

The aim of the presented study was to determine the chemical and elemental composition of a wood species new to the Polish market - *Machaerium scleroxylon* Tul. - and to supplement the description of this species with special attention paid to its effect on the human organism as an example of an environmental hazard associated with the implementation of new natural raw materials onto domestic market.

MATERIAL AND METHODS

The experimental material was wood of the Santos Palisander (*Machaerium scleroxylon* Tul.) species imported from Bolivia in the form of 0.6 mm thick veneer in 20-40 cm wide and 250-300 cm long sheets. The average density of heartwood 850 kg/m^3 and of sapwood 770 kg/m^3.

Chemical analyses were carried out on coloured heartwood, i.e. the part of wood applied in the wood industry and containing in its composition considerable quantities of non-structural substances. The heartwood exhibited distinctly varied colours, from brown-pink with few brown streaks to grown-violet with numerous violet-black streaks. Because the very narrow, light-coloured sapwood has no application in the timber industry, no chemical analyses were conducted on this part of the wood. Heartwood samples were first comminuted with the assistance of a laboratory mill Pulverisette 15 from Fritsch Company, and then separated using appropriate sieves to obtain an analytical fraction of 0.5 to 1.00 mm. Analyses of the chemical composition were carried out in accordance with the methodology recommended by Prosiński [14], determining the contents of cellulose by the Seifert method, lignin by the Tappi method, pentosans by the Tollens method, holocellulose using sodium chlorite, mineral substances and substances soluble in cold and hot water, in alcohol a benzene mixture (1:1) and in a 1% NaOH solution. In addition, the elemental wood composition, i.e. content of carbon, hydrogen, nitrogen and sulphur, was determined. Additionally, in persons in whom the appearance of allergic reactions was observed, the concentration of total IgE by the immunochem iluminescence method was determined. Levels of eosinophils were estimated under light microscope.

RESULTS AND DISCUSSION

Table 1 collates the quantities of individual constituents in the heartwood of the caviuna species. The content of cellulose, the primary wood constituent in the examined palisander species, amounted to 41.83% and was identical with the comparable wood of *Quercus robur* L. from the temperate zone in which 41.98% cellulose was determined [20]. High temperatures of the tropical regions exert a favourable influence on lignin production in wood, as confirmed by its high concentration in the examined wood amounting to nearly 32%, i.e. by 6% higher than in oakwood. This species of palisander, according to the classification applied in the Philippines regarding wood utilisation for cellulose production, can be found in the group of high – over 30% – lignin content. Wood of the caviuna species is also characterised by high (70%) holocellulose content which should be taken into considerations during its chemical processing. The content of sugars as a lower degree of polymerisation, i.e. hemicelluloses containing, primarily, pentosans and hexosans, can be calculated from the difference in the amount of holocellulose and cellulose. Their quantity in caviuna wood was higher than 28%. The amount of pentosans, acting in wood as skeletal substances, reached 16.25% which means that the amount of nutritive substances, i.e. hexosans, exceeded 11%. The comparable wood of oak contains 23.3% hemicellulose of which 23.0% are pentosans, whereas hexosans constitute a very small proportion [14].

Table 1. Chemical composition of *Machaerium scleroxylon* Tul. wood

Percentage content of major constituents				Percentage content of mineral substances
cellulose	lignin	pentosans	holocellulose	
41.83	31.89	16.25	70.05	3.89

Mechanical wood processing is strongly affected by the presence of mineral substances. Wood of caviuna contains 3.89% ash, i.e. over 10 times more than its mean content in species of deciduous trees from the temperate zone. This extremely high content of mineral substances indicates that the examined wood can cause strong dulling of tools since, for example, strongly tool-dulling wood of Rio Palisander contains only 1% ash [8]. According to Grosser [15], caviuna wood can contain local deposits of minerals causing strong dulling of tools.

The performed chemical analyses also determined the elemental composition of caviuna heartwood. The wood was found to contain 50.96% carbon, nearly 6.5% hydrogen, and small quantities of nitrogen – 0.32%; it therefore can be said that this wood species was characterised by an elemental composition similar to that of deciduous tree species from the temperate zone [14]. No presence of sulphur was determined in the examined wood species.

The content of soluble substances present in heartwood of *Machaerium scleroxylon* Tul. species is shown in Table 2. The concentrations of these substances in the wood of deciduous tree species can vary widely and range from about 0.5%, e.g. in the wood of aningeria (*Aningeria robusta* Aubrév. Et Pellegr.) to approximately 40%, e.g. in quebracho (*Schinopsis balansae* Engel.) wood [8] and depends primarily on the species, age, and tree growing conditions. In domestic wood species, the content of extractive substances is lower and usually does not exceed 8-10% [14]. The content of these substances in wood is well characterised by their solubility in water and alcohol. In the case of the examined exotic wood species (*Machaerium skleroxylon* Tull.), quantities that passed through cold and hot water amounted to 6.09% and 10.17%, respectively, and were twice as high in comparison with appropriate values of *Quercus robur* L. wood growing in the temperate zone [20]. The amount of substances soluble in 1% NaOH contained in the wood of caviuna was also high, which is associated with significant quantities of hemicelluloses.

Table 2. Content in the wood of *Machaerium skleroxylon* Tull. of substances soluble in different solvents

Percentage proportion of soluble substances			
Cold water	Hot water	alcohol – benzene(1:1)	1% NaOH
6.09	10.17	15.55	24.31

Machaerium skleroxylon Tull. wood, together with four other species of palisander, are to be found on a list of main wood species causing contact allergies [21]. In this context, a very high content of substances soluble in the alcohol-benzene mixture (1:1), reaching 15.55%, i.e. five times higher than in the wood of *Quercus robur* L., deserves attention. The extractive substances, apart from the fact that they sometimes give individual wood species specific properties, can also be of a toxic nature.

Numerous cases of ailments of workers having contact with caviuna wood were recorded in a wood processing enterprise situated in Piła district (Wielkopolska Voivodeship). This enterprise is involved in importing natural veneers, as well as their further processing (cutting, gluing, formatting, and using them to finish various kinds of boards). The processing involves various wood species, including exotic wood. In the course of the long-term operation of this enterprise, there were no cases of diseases caused by contact with processed wood. It should be mentioned that the performed veneer processing involved, basically, their cutting with the assistance of cutters ('guillotines'), i.e. devices using knives, while processing by sawing occurs only sporadically, hence the produced quantities of dust are incomparable with those found in sawmills, woodworking shops, furniture or parquet factories. Health problems among workers began to appear when the first delivery of the new species of veneer (*Machaerium skleroxylon* Tull.) arrived. Earlier, it had never been applied in this enterprise. The observed cases of allergic reactions are presented in Table 3.

Table 3. Number of allergic reactions recorded on work stations

Work station	Number of allergic reactions / number of workers employed on a given post during the time of exposure to allergens	Type of reaction
Sorting division	1/16	Nettle rash and palm itch
Mechanical cutting of wood	4/6	Intense nettle rash of upper limbs and neck, conjunctivitis, laryngitis
Veneering finishing	6/12	Weakness, fainting, conjunctivitis, nettle rash

In the majority of persons in whom the appearance of allergic reactions was observed, the level of eosinophils was elevated (Tab.4) in contrast to correct concentration values of total IgE.

Table 4. Level of eosinophils and concentration of total IgE in persons working on workstations where allergic reaction as a result of contact with caviuna wood occurred

Work station	Eosinophils level	Total IgE concentration
Sorting division	0.76 ± 0.08 x 109/l.	84 ± 13 U/ml.
Mechanical cutting of wood	0.99 ± 0.11 x 109/l.	65 ± 24 U/ml.
Veneering finishing	0.71± 0.06 x 109/l.	78 ± 14 U/ml.

The technological process to which the palisander veneer is subjected is not complicated. Packages of veneer arrive at the factory in sealed foil wrappings and are taken out of them on arrival and stored in a warehouse. Once they reach the production section they are sorted and cut into required lengths and breadths. When making veneer panels/sheets, it is necessary to perform many manual operations such as: sorting, arranging, replacing, preparing for gluing. After gluing and formatting the sheets, they are manually sorted again and those that need repair due to some defects are examined at quality control stands, filling wood losses with appropriate filler, and when dry, the veneer is sanded manually again to fine-finish the surface. It was among workers employed in performing the above-mentioned tasks that a negative allergic effect of this wood species was observed. In the group of six persons employed to cut the raw material, four were found to suffer from strong irritation of the skin on hands, forearms and neck, as well as conjunctivitis, and one worker required specialist treatment due to laryngitis. Numerous cases of allergic reactions were recorded in particular at posts involved in operations connected with the finishing of veneers, i.e. in places where the workers remained in relatively long contact with the raw material (no protective gloves were used), and were exposed to dust produced during manual sanding of repaired veneer. Symptoms of allergy assumed the form of skin irritation and conjunctivitis, sometimes manifesting as blisters on the neck and facial skin. In isolated cases, short-term weaknesses or fainting occurred.

It is worth emphasising that in the described case, allergic reactions were observed not only in workers exposed to wood dust, but also in employees who had contact with solid wood, which confirms a particularly toxic character of the *Machaerium skleroxylon* Tull. wood. The presented case clearly indicates possible environmental hazards which can result from the introduction of new, not fully recognised materials of plant origin. It is therefore essential to obtain special detailed knowledge about the structure and properties of the applied materials because plant materials, even very similar with respect to their physico-mechanical and even basic chemical and elemental composition, can frequently contain specific secondary substances which, in contact with the human organism in the work environment, may lead to serious disturbances in its functioning.

CONCLUSIONS

1. Due to growing imports of wood of exotic species, serious environmental threats occur which, until recently, were only of secondary significance. Toxic wood properties can pose a serious problem for the manufacturers of wooden articles. This issue requires monitoring as well as prophylactic actions from the medical services in agreement with employers.
2. Possibilities of preventing negative effects of the influence of toxic wood species on persons employed in wood processing using various technical means are limited. Therefore, only persons without allergic anamnesis in the past should be allowed access to this kind of work which requires constant medical supervision.
3. Health effects of the contact with caviuna wood are connected mainly with the skin, although other reactions are also possible. Allergic reactions occur primarily in persons who have direct contact with processed material.
4. Heartwood of the caviuna wood is characterised by a cellulose content of 41.83%, increased lignin content - 31.89%, typical for deciduous species, as well as a high content of mineral substances (3.89%) which can cause problems in the mechanical processing of the wood of this species.
5. Heartwood of the caviuna wood contains up to 15.55% extractive substances (soluble in alcohol-benzene mixture). They can determine some physical wood properties (e.g. density, colour) and contain compounds harmful for health.

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