

OCCUPATIONAL ASTHMA CAUSED BY SAMBA (*TRIPLOCHITON SCLEROXYLON*) WOOD DUST IN A PROFESSIONAL MAKER OF WOODEN MODELS OF AIRPLANES: A CASE STUDY

PATRYCJA KRAWCZYK-SZULC¹, MARTA WISZNIEWSKA¹, CEZARY PAŁCZYŃSKI²,
EWA NOWAKOWSKA-ŚWIRTA², ANNA KOZAK¹, and JOLANTA WALUSIAK-SKORUPA¹

¹Nofer Institute of Occupational Medicine, Łódź, Poland

Department of Occupational Diseases and Clinical Toxicology

²Nofer Institute of Occupational Medicine, Łódź, Poland

Department of Allergology and Environmental Health

Abstract

Objectives: Wood dust is a known occupational allergen that may induce, in exposed workers, respiratory diseases including asthma and allergic rhinitis. Samba (obeche, *Triplochiton scleroxylon*) is a tropical tree, which grows in West Africa, therefore, Polish workers are rarely exposed to it. This paper describes a case of occupational asthma caused by samba wood dust. **Material and Methods:** The patient with suspicion of occupational asthma due to wood dust was examined at the Department of Occupational Diseases and Clinical Toxicology in the Nofer Institute of Occupational Medicine. Clinical evaluation included: analysis of occupational history, skin prick tests (SPT) to common and occupational allergens, determination of serum specific IgE to occupational allergens, serial spirometry measurements, metacholine challenge test and specific inhalation challenge test with samba dust. **Results:** SPT and specific serum IgE assessment revealed sensitization to common and occupational allergens including samba. Spirometry measurements showed mild obstruction. Metacholine challenge test revealed a high level of bronchial hyperactivity. Specific inhalation challenge test was positive and cellular changes in nasal lavage and induced sputum confirmed allergic reaction to samba. **Conclusions:** IgE mediated allergy to samba wood dust was confirmed. This case report presents the first documented occupational asthma and rhinitis due to samba wood dust in wooden airplanes model maker in Poland.

Key words:

Occupational asthma, Wood dusts, Samba, *Triplochiton scleroxylon*, Specific inhalation challenge test

OBJECTIVES

In Europe, over 3 million people work in wood industry in exposure to wood dust [1]. Bronchial asthma is one of the most frequent health problems in this population – its prevalence is twice as high as it is in the non-exposed one [2]. In this population also a higher risk of developing bronchitis and impaired spirometry can be observed [3].

Asthma may be induced by wood dust of various tree species such as: red cedar tree, beech, oak, samba, iroko (kambala) [4–7]. It is estimated that about 6–15% of woodworkers suffer from bronchial asthma [8].

In Poland, exotic species of trees are used in the industry and in the model making more and more frequently. The example of such a material is samba (*Triplochiton*

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Corresponding author: P. Krawczyk-Szulc, Department of Occupational Diseases and Clinical Toxicology, Nofer Institute of Occupational Medicine, św. Teresy 8, 91-348 Łódź, Poland (e-mail: patunia@imp.lodz.pl).

scleroxylon) from West Africa, also known as an African maple. Wood of the samba tree is soft, with a great resistance, and it is frequently used for the production of wooden frames, boxes and saunas. Samba may be also useful in model making. Wood dust particles belong to the low molecular weight (LMW) allergens and like other allergens from this group cause mainly IgE-independent reactions [9]. However, there are data confirming that allergens of samba wood – as one of the exceptions – may also cause IgE-dependent reactions [10,11].

A patient with suspicion of occupational asthma due to wood dust was admitted to the Department of Occupational Diseases and Clinical Toxicology in the Nofer Institute of Occupational Medicine. That was a 48-year-old patient who had been working in the factory producing airplanes, at first as a turner and then for the next 7 years as a former, among others in the production of forms of airplanes' models. At work he was exposed to wood dust, including samba, lime and pine tree, but also to polyester epoxy resins, polystyrene, paints and varnishes. The patient had a 35 pack-years history of smoking. He quit smoking 9 months before being admitted to the Clinic. Family history of allergy was negative. According to the history, the first respiratory symptoms were shortness of breath, periodical dry cough, sneezing, rhinorrhea, which started after 27 years of work. At the beginning, the symptoms occurred only at work and were becoming less intensive at home. In the patient's opinion, the symptoms were related to exposure to epoxy resins and paints present in the workplace. The symptoms improved at the weekends and during holidays.

During the last 5 months before admission to the Department, the patient observed a significant exacerbation of respiratory symptoms. The cough and dyspnea developed immediately after entering the workplace, where processes of laminating were held. At the Regional Centre of Occupational Medicine the patient was examined by a pulmonologist and atopic asthma was recognized. However, further diagnostics was needed due

to occupational exposure to epoxy resins. Therefore, the patient was referred to our Department. On admission, the patient reported: shortness of breath, chest pain, periodical dry cough, sneezing, rhinorrhoea and watering of eyes. Auscultation revealed only sharpening of the vesicular rustle and single whirring.

MATERIAL AND METHODS

Skin prick tests

Skin prick tests (SPT) to common allergens (dust mites, feathers, grass/weed/tree pollens, moulds) were performed with application of extracts produced by Allergopharma. SPT to wood dust (pine, spruce, oak, beech, samba) were performed by the use of Allergopharma extracts and standardized extracts prepared by the Laboratory of the Institute of Immunology and Allergology (Institut für Prävention und Arbeitsmedizin der Deutschen Gesetzlichen Unfallversicherung Institut der Ruhr-Universität Bochum (IPA)) in Bochum, Germany.

The negative control was the allergen diluent and the positive control – 1 mg/ml metacholine dihydrochloride solution. The largest wheal diameter was assessed after 15 min. A wheal diameter of ≥ 3 mm and equal to or greater than half of that formed by histamine was defined as positive, indicating sensitization.

Spirometry measurements were carried out on the Viatest equipment (Mijnhardt, Holland) immediately before specific inhalation challenge test (SICT) and after 5 min as well as in the 1st, 2nd, 4th, 5th, 24th h after. Simultaneously, the variability of peak expiratory flow (PEF) was monitored before and after SICT, every hour during 24-h observation.

Bronchial reversibility was assessed by administration of short-acting β_2 agonist (bronchodilator) – 400 mg of salbutamol. Improvements in forced expiratory volume in the 1st s (FEV_1) $> 12\%$ and > 200 ml after 15 min was recorded as a positive result [12].

Serum IgE level

Total serum immunoglobulin E (IgE) and specific serum IgE (sIgE) for pine, oak, samba allergens, dust mites, synthetic fibers and formaldehyde were determined (Immucap, Phadia, Sweden).

Metacholine challenge test

Metacholine challenge test by Cockcroft for the evaluation of bronchial hyperresponsiveness (BHR) was performed [13]. Metacholine hydrochloride (Sigma Chemical Company, USA) solved in saline solutions was inhaled with growing concentrations of 0.03; 0.06; 0.125; 0.250; 0.5; 1.0; 2.0; 4.0; 8.0 and 16 mg/ml using the DeVilbiss 646 inhaler (USA). The test was interrupted if decrease of forced expiratory volume in the 1st second (FEV_1) was at least 20%. The threshold value of reaction to metacholine was estimated from the logarithmic curve dose-reply, appointing the metacholine concentration causing the 20% decrease of FEV_1 (PC20H).

Specific inhalation challenge test (SICT)

Standardized extract of wood dust was not available so the SICT was conducted by simulating the patient's workplace conditions [14]. It was performed in a workplace simulation setting (room space 6 m² with temperature 22–25°C) with the patient's own samples. The patient was polishing samba wood pieces from his workplace for 30 min, using the abrasive paper. The SICT was held under the surveillance of a physician, who noted all respiratory symptoms appearing during the test. On a day preceding conducting the specific inhalation challenge test, a provocation with placebo – potato flour was performed in the same conditions and at the same time. Before, 4 h and 24 h after the provocation a morphological evaluation of nasal lavage fluid was carried out. Moreover, before and 24 h after the SICT morphological changes of induced sputum were also assessed. The test was evaluated as positive, if FEV_1 fell by $\geq 20\%$ of the baseline value in the

absence of any change in response to a control challenge or 3-fold increase in BHR level was observed.

Morphological evaluation of nasal lavage fluid and induced sputum

All the procedures were performed as in the 'nasal pool' method. Nasal lavage fluid was whirled for 10 min with rotational speed of 1000/min. Then cellular precipitate was washed in a buffered saline solution (PBS, Sigma, USA), and finally it was put in 1 ml of farm RPMI base (Sigma USA). The cells were dyed using May-Grünwald-Giemsa method and toluidine blue and then they were counted in the Fuchs-Rosenthal's Chamber. A total number of leukocytes was indicated, as well as the amount of eosinophilic and basophilic white cells. The precipitate was whirled again for 10 min with rotational speed of 600/min and it was dyed using Giemsa method. Proportional composition of cells was evaluated by estimation of 200 cells and indication of the epithelium, neutrophilic, eosinophilic, basophilic cells, monocytes and lymphocytes.

RESULTS

Skin prick tests to common aeroallergens were positive with various species of dust mites, grass and trees pollens, cat's fur and with the samba wood dust, while SPT results to wood dusts of spruce, oak, pine, fir and beech were negative. Total serum immunoglobulin E (IgE) level was 135.42 kU/l. Increased specific serum IgE to occupational allergens was also found (Table 1).

Spirometry measurements revealed FVC – 4.51 l (91% of predicted values), FEV_1 – 2.85 (70%), Tiffeneau index – 63%. The patient exhibited bronchodilator reversibility by 15% FEV_1 increase compared to the baseline. The non-specific inhalation challenge test with metacholine revealed a severe bronchial hyperreactivity – $PC_{20} = 0.2$ mg/ml. During the specific inhalation challenge test with wood dust the patient reported shortness

Table 1. Specific IgE levels determined by the immunoenzyme assay

Allergen	Concentration (kU/l) / class
Dust mites	0.65/1.8
Formaldehyde	< 0.35/0
Synthetic fibres	0.77/2.0
Wood dust	
pine	1.20/2.2
oak	1.51/2.3
obeche	0.97/2.1

Reference values: < 0.35 kU/l – negative result (class 0); 0.35–0.7 kU/l – low concentration (class 1); 0.7–3.5 kU/l – moderate concentration (class 2); 3.5–17.5 kU/l – high concentration (class 3); > 17.5 kU/l – very high concentration (class 4).

of breath, which was the most severe during the first 2 h after the challenge. Dyspnea, reported by the patient, developed already during the specific inhalation challenge test with the greatest intensity right after the test. Auscultation revealed numerous whistles 5 min after starting SICT, 2 h and 4 h after the challenge. The daily change in FEV₁ and PEF values after the challenge with placebo and with samba wood dust are presented in Figure 1.

The greatest declines in FEV₁ i.e. of 18% compared to the baseline was observed in the 2nd and the 5th h after the challenge test with wood dust. Decrease in PEF was

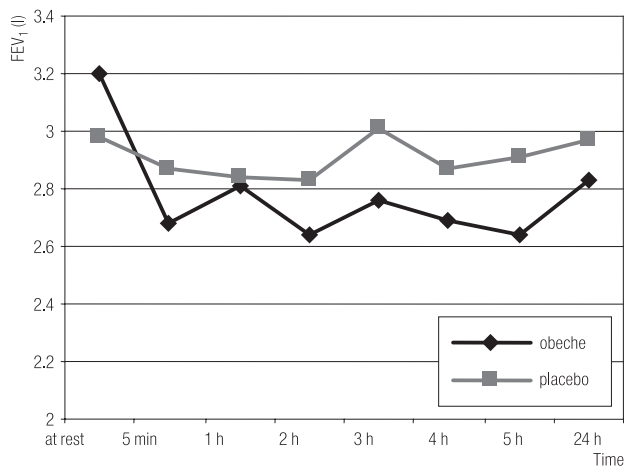


Fig. 1. Changes in FEV₁ across 24-hours after specific challenge test with obeche wood dust and placebo

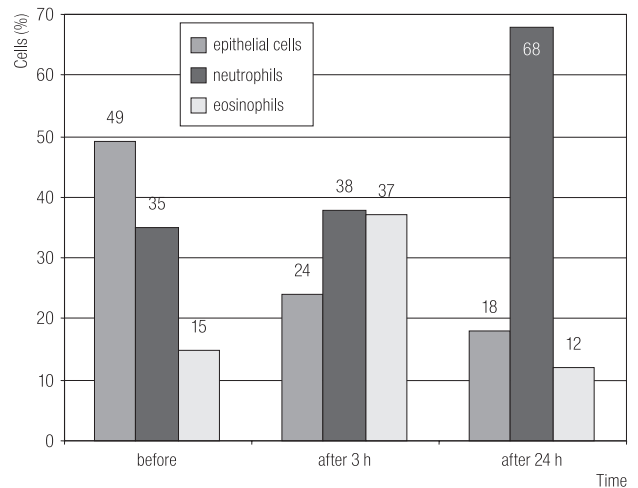


Fig. 2. Morphological changes in nasal lavage fluid before and after specific challenge test

also the highest 2 h after the specific challenge test and it amounted to 24% compared to PEF prior to the challenge. Morphological evaluation of nasal lavage fluid after the inhalation challenge test with samba wood dust revealed the inflow of neutrophils, eosinophils and a slight increase in the percentage of basophils. An increased percentage of eosinophils 4 h after the challenge test, neutrophils 24 h after the challenge test, and basophils, 4 h and 24 h after the specific challenge test was observed, while a number of epithelial cells was reduced (Figure 2).

Two-fold increase in the percentage of eosinophils in the induced sputum was observed 24 h after the SICT (Table 2).

DISCUSSION

Samba (*Triplochiton scleroxylon*) is a tropical tree, which grows mostly at transition zone between wet evergreen forests and tress which partially shed leaves. The samba wood is usually light-straw, yellow-brown or creamy-white in color. Data on the frequency of exposure to exotic wood dust in Poland are lacking, but it seems that the increasing use of these materials may result in health problems in the exposed workers.

Table 2. Morphological changes in induced sputum after specific inhalation challenge test (SICT)

Time of sputum collection	Cells in induced sputum (%)				
	epithelial cells	neutrophils	eosinophils	basophils	monocytes
Before SICT	24	47	3	1	0
24 h after SICT	13	56	6	2	0

Sensitization to samba wood allergens is an interesting allergological problem, as the IgE-dependent allergic reactions, which are not typical for wood dusts allergens [15,16] were observed. For example, in the case of allergy to red cedar dust in approximately 30% of exposed population SPT to plicatic acid (PA) are positive or the specific IgE antibodies for PA are detected [17]. Therefore, the diagnosis and confirmation of occupational respiratory allergy to wood dust cannot be based only on the results of skin prick tests or the presence of specific serum IgE. SICT is considered as a 'gold standard' or 'reference standard' but fall in FEV₁ value may be due to irritating effect of wood dust. To differentiate this and confirm allergic reaction the other objective method i.e. morphological changes in induced sputum could be helpful.

The majority of data on asthma due to samba wood dust is based on case reports, therefore, it is difficult to determine the incidence of sensitization to these allergens. Cases of IgE-dependent allergic reactions to plicatic acid from red cedar, as well as single cases of allergy to pine and spruce were also reported [18]. In our wood dust allergens panel used for the SPT we included species that typically grow in our country and, for the described patient, samba allergens were additionally used. The patient suffered from symptoms typical for bronchial asthma. In the case of asthma due to samba wood dust symptoms are the same as in the asthma caused by other antigens. However, a characteristic feature of asthma caused by wood dust is the occurrence of first symptoms after work, often at night – a few hours after allergen exposure. Later on, the symptoms begin to occur immediately after contact with wood dust, which is associated with late acute asthmatic reaction

to the allergen at the beginning followed by development of a 2-phase reaction [19–21].

The patient reported typical asthma symptoms occurring quite immediately after entering the workplace. Positive SPTs with common aeroallergens and occupational allergens, also with samba tree allergens, were found. However, sensitization to common allergens does not exclude recognition of occupational respiratory disease, and positive SPTs results are not conclusive of the necessity of developing symptoms of allergic disease like allergic rhinitis or asthma. Sensitization to common allergens and an elevated total serum IgE level in the described patient confirmed the presence of atopy. Atopy increases the risk of development of occupational asthma due to sensitization to the high molecular weight allergens [22–25]. It was observed in bakers and farmers exposed to flowers and animals allergens [26–28]. There is no sufficiently proved relationship between atopy and occupational sensitization in the case of allergy to wood dust allergens, which are classified as the low molecular weight allergens. It is considered that atopy does not predispose to wood dust induced asthma, although some studies have suggested that it is an important modifying factor. According to Sjostedt et al. asthma occurs more often in atopic workers exposed to wood dust than in atopic population not exposed to such allergens [29].

Spirometry measurements, carried out when the patient was not exposed to occupational allergens, showed a mild airway obstruction that could suggest COPD due to 35 pack-years history of smoking. However, bronchial reversibility and significant bronchial hyperresponsiveness, which are an integral part of a clinical course of asthma, supported

asthma diagnosis. SICT with workplace allergens is the gold standard in diagnosis of occupational asthma [30].

When asthma due to wood dust is suspected, apart from spirometry measurements monitoring, the cellular changes in induced sputum should be evaluated to exclude irritation by the dust itself. SICT is generally considered positive when fall in FEV₁ of at least 15% from pre-challenge value is recorded at the time of an immediate reaction (ERS consensus not published yet). In our case 18% fall in FEV₁ was recorded in the 2nd and the 5th h after the SOCT. It is suggested by some evidence that in the case of a delayed reaction, FEV₁ fall \geq 15% may be considered as positive SICT [31–35]. In the presented case occupational history of asthma symptoms, type of exposure, positive results of SPT to occupational allergens, the high level of bronchial hyperresponsiveness as well as significant decrease in FEV₁ and clinical symptoms with bronchial obstruction induced by the specific challenge test confirmed a positive reaction to the occupational allergen. Additionally, evaluation of cellular changes in nasal lavage fluid and induced sputum in the patient revealed a significant, more than 2-fold, increase in eosinophil proportion. Due to those findings occupational asthma and allergic rhinitis were recognized.

This case of allergy to exotic *Triplochiton scleroxylon* wood is the first one described in Poland. Samba wood, apart from model making, is also used in the industry, which makes it a potential occupational allergen. Therefore, special attention should be paid to the workers involved in mechanical wood processing as a population at risk of occupational allergy.

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