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Exposure to Allergens and Microorganisms in Cultivating and Handling of Crops - A Review on Health Hazards and Some Aspects on Exposure Assessment and Exposure Control**Dan Norbäck and Gunilla Wieslander**

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Introduction

Exposure to vegetable dust from cereals, or other types of crops, may result in both allergic and non-allergic diseases. Grain dust lung is one of the oldest occupational diseases described in the literature¹. Some crops contain allergens that may cause various types of allergic manifestations in sensitized workers²⁻⁹. Another hazardous exposure related to crop cultivation and handling is microbial exposure from mouldy crops and plant materials². Exposure to allergens and microorganisms may occur during harvest, but occupational exposure occurs also during post harvest treatment, e.g. during storage, refining or preparing of agricultural products. This paper reviews some literature on occupational health hazard from crops, and discuss aspects on exposure assessment and exposure control.

Health hazards related to allergen exposure

Plant dust known to cause allergy includes grain (e.g. wheat, rye, oats, barley), buckwheat, soybeans, coffee beans, tea leaves, herbal tea, cork, cotton, flax, hemp, jute, tobacco, castor bean (*Ricinus Communis*), rue (*Ruta graveolens*), plant proteases (papain, bromelain), and dust from "Maiko" (roots from devil's tongue ; *Amorphophalus konjak*)²⁻⁹. These allergic reactions may include both rhinitis, eye symptoms, and specific allergic asthma. Non-specific airway obstruction, e.g. decrement in forced expiratory volume in one second (FEV₁) during the workday, may also occur at organic dust exposure³. Such non-allergic airway obstruction may occur among farm workers, miller, and grain handler exposure to grain dust, or among processors, cutters, blenders, and packers handling various types of dusty plant materials³.

Occupational asthma

The types of cultivated plants differ between different climate zones, and so do the causes of occupational asthma. Coffee workers may suffer from asthma caused by dust from green coffee beans⁶. Workers exposed to castor-beans, commonly cultivated in Brazil and India, may also

develop allergic asthma^{6, 8}. Cereal dust is another cause of asthma among grain handlers⁶, and bakers asthma was described already by Ramazzini¹. Besides allergy to the flour itself, various contaminants in flour may play a role in baker's asthma, including fungi and arthropod contaminants (e.g. mite *Tyroglyphus farinae* or *Glycyphagus destructor*, and the grain weevil (*Sitophilus granarius*)⁹. In Japan, Maiko, a dust from the tuberous root of devil's tongue has been reported to cause occupational asthma^{6, 7}. Wheat flour asthma is reported to be rare in Japan⁷, but occupational asthma from buckwheat has been described from both Japan, and other countries^{7, 10, 11}. Occupational exposure to plant pollen has also been described as causes of occupational asthma, e.g. strawberry pollen at indoor cultivation of strawberry⁷, pollen from sugar beet⁷, pollen from pyrethrum (*Chrysanthemum cinerariaefolium*)⁷, and *lycopodium* species⁷. Spore exposure from cultivation of edible mushrooms may also cause occupational asthma, e.g. from *Shiitake mushrooms*⁷.

Dermal disorders

Skin disease account for a large proportion of all occupational illness within agriculturally related industries¹². Contact urticaria is most frequently caused by skin contact to various citrus fruits, nuts, spices and grains, containing allergens and vasoactive substances, and food handlers and gardeners are at particular risk. Certain plants contain compounds causing phytophototoxic dermatitis, e.g. Umbelliferace family (celery, parsley, carrots, and coriander, Moraceae family (figs), and Rutaceae family (lime). Phototoxic eczema from celery may occur among farmers who harvest it, or among grocery store workers. Bartender may also develop phytophototoxic eczema on the first and second finger during summertime, when they squeeze limes outdoors while making cocktails. Exposure to citrus fruit may also occur in various occupations, and may cause allergic reactions to terpens (d-limonene, geraniol, and citral)¹².

Health hazards related to microbial exposure

Microbial growth may occur in various crops and food, particularly during damp and humid conditions. Exposure to microorganisms may represent a potential health hazard, with respect to allergic reactions, asthma, toxicosis, and airway inflammation¹³⁻²⁰. Microorganisms produce a variety of compounds, including volatile organic compounds²¹⁻²⁴, cell-wall toxins such as endotoxines and 1-3-beta-glucanes¹³⁻¹⁴, allergens, and specific mycotoxines. Endotoxines and 1-3-beta-glucanes may cause airway inflammation at low exposure levels, and may contribute to the development of bronchial hyperresponsiveness and asthma¹³⁻¹⁴. Mycotoxines are potent biological agents, and reports on mycotoxicosis (e.g. ergotism) dates back to 1000 A.D.¹⁵. Recently, aflatoxines were classified as human carcinogens by the International Agency for Research on Cancer (IARC)¹⁶. Most studies on mycotoxines deals with oral exposure through

contaminated food, and there are only few publications on occupational airborne exposure to mycotoxins in airborne spores. Toxines from *Stachybotrys sp.*, and aflatoxines from *Aspergillus flavus* have been shown to cause various types of health impairments in humans, including immunosuppression, dermatitis, conjunctivitis, upper and lower airway symptoms, fatigue, and headache¹⁵.

Inhalation fever (Organic dust toxic syndrome)

Inhalation fever, or organic dust toxic syndrome (ODTS), are terms describing a noninfectious, febrile illness associated with chills, malaise, myalgia, a dry cough, dyspnea, headache and nausea that occurs after heavy organic dust exposure¹⁷⁻¹⁹. This syndrome is thought to be an acute febrile reaction to organic dust exposure distinct from allergic alveolitis. In the Nordic countries, pulmonary reactions to inhalation of dust from mouldy hay occasionally occurs among farmers¹⁹. Among farmers, ODTS is reported to be much more common than allergic alveolitis¹⁹, the incidence being 10-190 cases / 10000 farmers²⁰.

Allergic alveolitis (hypersensitivity pneumonitis)

This disease has been described mainly among farmers that have been exposed to high concentrations of mouldy organic dust ("farmers lung")¹⁷⁻¹⁹. It is characterized by acute recurrent pneumonia with fever, cough, chest tightness, and lung infiltrates. There are diagnostic criteria to be fulfilled for the diagnosis of extrinsic allergic alveolitis²⁵. Allergic alveolitis is a rare disease, among farmers the incidence rate is estimated to be 2-30 cases / 10000 farmers²⁰. In Japan, the most prevalent form of allergic alveolitis is reported to be summer-type hypersensitivity pneumonitis, caused by indoor moulds during summer²⁶.

Exposure assessment

Allergen measurements

One of the major problems in occupational epidemiology is the estimation of the exposure. Exposure measurements are needed to identify sources of exposure, to evaluate the effect of environmental improvements, and to be able to compare the exposure in different types of occupations, or in different countries. For allergens, it is not obvious that there is a dose-response relationship. Another problem in studies on immunodepression and antibody formation is the control for other factors (e.g. viral infections, tobacco smoking, exposure to irritants) modifying the effect of the allergen exposure²⁷. Exposure measurements of airborne allergens have not been applied until recently, mainly because of a lack of analytical methods capable of detecting low levels of airborne allergens. Quantitative and specific allergen measurements in settled dust have been applied in some studies on indoor animal allergens, e.g.

monoclonal antibodies from cats, dogs and house dust mites²⁸⁻²⁹. It is, however, unclear to what extent allergen contents in settled dust reflects the relevant airborne exposure to allergens.

Dust measurements

Because of the difficulties in quantifying airborne allergens, personal exposure measurements of airborne total dust, respirable dust, or organic dust have been applied, by conventional hygienic methods⁵. Total dust can be sampled on cellulose acetate filter, and determined by gravimetric analysis^{5, 30}. If both inorganic dust and organic dust is present in the air, organic dust concentration can be determined as the weight difference before and after low-temperature ashing of the total dust samples collected on the filters³⁰. Respirable dust can also be determined by direct reading instruments (e.g. SIBATA PH5), based on the measurement of Rayleigh light scattering by a laser diode³¹. Such direct reading instruments may have a lower accuracy than gravimetric methods for dust measurements. They are, however, particularly useful as a tool to identify emission sources, and to evaluate the effects of measures aiming to reduce the dust exposure.

Measurements of microorganisms and microbial exposures

There are various types of exposures related to microbial growth. By tradition, microbiologists have measured only viable spores in air samples, by cultivation and identification of mould species. In many types of occupational environments, however, only a small proportion of the airborne microorganisms are viable. Biological effects of nonpathogenic microorganisms are similar for viable and non-viable organisms. In addition, there are cases when bacteria, and not only moulds, should be included in the exposure assessment. One method capable of detecting both viable and non-viable moulds and bacteria is the CAMNEA method. This method utilizes pumped air sampling on polycarbonate filters (Nucleopore, Pleasanton, California, USA), followed by acridine orange staining, and counting of microorganisms by epifluorescence microscopy³². The CAMNEA method has been demonstrated to be a simple and accurate mean to measure microbial exposure in highly contaminated occupational environments³³.

There are also chemical and biological methods available to quantify specific compounds related to microbial exposure. Endotoxins are toxic constituents to the cellwall of gram negative bacteria, and (1-3)-beta-glucans are constituents of the cellwall of microfungi. Both endotoxins and (1-3)-beta-glucans can be detected by the Limulus assay, a biological method^{34, 35}. Because of possible interaction between these toxins, and the nonspecificity of the Limulus system, there is a need to develop new sensitive and specific analytical methods for these cell-wall toxins, e.g. by means of gas chromatography and mass-spectrometry.

Microorganisms may also emit volatile organic compounds (VOC). Some of these VOC's are specific compounds produced exclusively by microorganisms (e.g. geosmin or 1-octen-3-

ol)²¹⁻²⁴. It has recently been shown in Sweden that measurements of MVOC can be used also as a rapid and economical indicator of mould growth in stored cereals²⁴. The most commonly occurring metabolites from grain-deteriorating *Aspergillus sp.* and *Penicillium sp.* were found to be 3-methylfuran, 2-methyl-1-propanol, and 3-methyl-1-butanol. It was therefore concluded that these are the best indicators of mould growth in stored cereals. One particular advantage of MVOC analysis, as compared to cultivation of mould spores, is possibility to get a representative air sample from the whole batch of cereals in the store, and the possibility to get the analytic results within one day.

Conclusions and recommendations

Exposure to organic vegetable dust from cereals, or other types of crops may cause various allergic and non-allergic health disturbances, including asthma, dermal disorders, fever reactions, and airway obstruction and inflammation. In occupations where dust exposure to vegetable dust occurs, it is important to minimize the exposure to the workers. This is particularly important if the work process generates a large proportion of respirable dust, and if the dust is contaminated by moulds or bacteria, or contains known allergens.

Exposure control could be done by encapsulation of the process, use of local exhaust ventilation, or by use of personal airway protection devices, e.g. disposable dust filters. Mould growth in the crop should be avoided, and special precaution is needed when mouldy plant material is handled. The measurement of microbial volatile organic compounds (MVOC) as a rapid and economical indicator of microbial growth in stored crops should be further evaluated. If possible, the exposure to potential occupational biohazards should be quantified by exposure measurements. It is also important to evaluate the effects of measures taken aiming to reduce the dust exposure, by repeated exposure measurements.

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