Occupational exposure and respiratory health problems among nutmeg production workers in Grenada, the Caribbean

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ABSTRACT

Background: The nutmeg industry is a major contributor to the Grenadian economy. However, workers in the industry face many environmental and occupational health risks.

Objectives: The goal of this study was to investigate respiratory health problems and possible related occupational exposures among nutmeg production workers.

Methods: A questionnaire, spirometry and allergen skin-prick test was given to 92 nutmeg workers. Samples for measurement of airborne dust, mold, and phosphine were also collected from work environments.

Results: Approximately half of the workers with lower respiratory symptoms such as dry cough (49.4%) and shortness of breath (42.9%) reported that their symptoms were work related. Spirometry results showed that 18.8% of workers had obstruction. Area geometric mean (GM) inhalable dust concentrations, GM personal concentrations, and total mold spores during work activities were found to be high.

Conclusions: High prevalence of respiratory symptoms among workers in this facility was consistent with measured levels of dust and mold, and was widespread over all work areas.

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Introduction

Nutmeg has become Grenada's most economically important exported agricultural product since it was first introduced by Frank Gurney who brought it from Indonesian Banda Islands in 1843 [1]. The Grenada flag has a symbol of the nutmeg, which represents Grenada as the "Isle of Spice." The nutmeg (*Myristica fragrans*) tree is important for two spices that can be derived from the fruit. The red outer coat is called a mace and its inner seed is called a nutmeg. Nutmeg has been used traditionally as spice and also possesses carminative, astringent, hypolipidemic, antithrombotic, antiplatelet aggregation, antifungal, aphrodisiac, anxiogenic, antidiarrheal, and antiinflammatory properties [2]. Nutmeg oil is prominently used in the pharmaceutical industry and mace is mostly used in the cosmetic industry [3].

The nutmeg industry is one of the most significant contributors toward Grenada's local economy, serving directly and indirectly as a source of employment and support for a significant portion of the local population on the small Caribbean island. However after Hurricane Ivan on September 7 2004, Grenada lost 90% of the nutmeg trees [3]. Before Ivan, nutmeg accounted for 80% of Grenada's agricultural export. Linked to the devastation of Hurricane Ivan in 2004, only one nutmeg production

plant in Gouyave remained active. The nutmeg processing mainly includes sorting, cracking, grading, storage, fumigation, packing, and shipping (Figure 1). The processing plant uses an old and ineffective technology that limits the economic benefits and increases the environmental and occupational health risks for workers.

It is important to address potential environmental and occupational health risks for the nutmeg workers because many studies have begun to identify negative occupational health outcomes resulting from working in the spice industry. Schol & Jensen-Jarolim found that inhalation of spice dust can cause asthma, allergic alveolitis, contact dermatitis, and rhinoconjunctivitis. These respiratory allergies are a result of increased sensitization to different respiratory sensitizers [4,5]. Another study found that spice workers associated with onion and garlic power dusts developed occupational rhinoconjunctivitis prior to developing occupational asthma [6]. In addition, cinnamon spice workers [7] and fennel seed workers [8], both showed a high prevalence of occupational asthma.

Besides respiratory allergies, upper and lower irritation has also been associated with spice workers involved with chili pepper, cloves, and spice grinding [5,9,10]. Impaired lung function resulting from exposure to spice

Figure 1. Nutmeg and mace processes at the nutmeg plant.

dust was also shown in three spice processing factories in Selangor [11]. The main goal of this study was to determine respiratory health problems and possible related occupational exposures among nutmeg production workers in Grenada.

Method

We invited all workers ($n = 92$) to participate in a cross-sectional study, which was approved by the Institutional Review Board of St. George's University, Grenada. Eighty-six workers completed the questionnaire, and 85 took part in spirometry and skin-prick testing.

Questionnaire

Trained personnel collected information using a standardized questionnaire. In addition to demographic, occupational, and health information, the questionnaire included sections on exposure history, upper and lower airways symptoms, physician-diagnosed chronic diseases, smoking status, and home environment. Survey questions were developed based on existing validated standard questionnaires including ATSDR, Occupational and Environmental Exposure History Questionnaire,

ATS, Respiratory Diseases Questionnaire, NHANES III, and Respiratory Health and Disease Questionnaire [12]. To be able to collect accurate information on environmental factors and respiratory health problems, the survey included questions from a validated standard questionnaire that has been used in our previous NIOSH studies [13–15].

Medical field tests

Spirometry testing was conducted according to American Thoracic Society guidelines using the EasyOne Model 2001 (nidd Medical Technologies, Andover, MA) diagnostic spirometer. Test results were interpreted using reference values generated from the Third National Health and Nutrition Examination Survey. Skin-prick allergy testing was performed with prepared nutmeg extracts plus positive (histamine) and negative (glycerin in water) controls using the GreerPIK system (Greer Laboratories, Lenoir, NC).

Exposure assessment

Potential exposures were assessed for inhalable dust using Institute of Occupational Medicine air samplers (SKC Inc., Eighty Four, PA) with 25-mm diameter, 0.8- μ m pore size polyvinyl chloride filters ($n =$ six personal and nine area samples); (1 $\rightarrow$ 3)- β -D-glucan and endotoxin using two-piece, closed-face cassettes with 37-mm diameter, 0.8- μ m pore size polycarbonate filters ($n = 9$ area samples each); mold spores using spore traps (Air-O-Cell®, Zefon International Inc., Ocala, FL) ($n = 17$ task samples); culturable mold (3 settled dust samples); and phosphine using colorimetric detector tubes (Dräger Safety Inc., Pittsburgh, PA) ($n = 4$ samples during fumigation). All measurements were analyzed by comparing the measured values to U.S. Occupational Safety and Health Administration Permissible Exposure Level (PEL) and NIOSH Recommended Exposure Limit.

An analysis of the data was performed using SPSS statistical software package version 21.0.

Results

Workers were mostly female (74.0%) and non-smokers (79.1%) with a mean age of 48.3 ± 8.1 years. The most common self-reported lower respiratory symptoms were dry cough (49.4%) and shortness of breath (42.9%) (Table 1). The most common self-reported upper respiratory symptoms were sneezing (66.3%) and stuffy nose (47.1%). Prevalence of physician-diagnosed asthma and sinusitis were 9.3 and 25.6%, respectively. Skin-prick test results indicated that 16.5% of workers had nutmeg allergy, and spirometric results showed that 18.8% workers had obstruction. Smokers and non-smokers had similar prevalence of symptoms. Questionnaire analyses showed similar symptom prevalence across work areas.

Table 1. Prevalence of self-reported symptoms, physician-diagnosed diseases, and medical test results.

Symptoms	Overall <i>n</i> (%)	Work-related <i>n</i> (%)
<i>Lower airways symptoms</i>		
Wheezing	18 (20.9)	8 (44.4)
Dry cough	42 (49.4)	20 (36.6)
Shortness of breath	36 (42.9)	17 (47.2)
<i>Upper airways symptoms</i>		
Sneezing	57 (66.3)	33 (60.0)
Stuffy nose	40 (47.1)	18 (46.2)
Runny nose	19 (22.1)	10 (52.6)
<i>Physician-Diagnosed</i>		
Asthma	8 (9.3)	
Sinusitis	22 (25.6)	
<i>Medical test results</i>		
Obstructive spirometry	16 (18.8)	
Nutmeg allergy positive	14 (16.5)

Figure 2. Geometric mean (GM) inhalable dust concentrations of personal and area air samples by work area at the nutmeg processing facility.

Personal geometric mean (GM) inhalable dust concentrations ranged from 2.3 mg/m³ in cracking to 7.3 mg/m³ in first-stage sorting (Figure 2). Area GM inhalable dust concentrations were lower than personal dust concentrations and ranged from 0.43 in cracking to 1.8 mg/m³ in first-stage sorting. Area GM glucan (a mold cell-wall component) and endotoxin (a gram negative bacteria cell-wall component) concentrations ranged from 90 to 11 ng/m³, respectively, in final sorting to 395 and 83 ng/m³, respectively, in first-stage sorting (Figure 3). Results for one set of short-duration area samples (dust, glucan, endotoxin) were not shown. Analysis of mold in bulk dust showed 8.4×10^4 , 2.0×10^6 , and 4.4×10^7 colony forming units per gram from the mace dust removal, first-stage sorting, and first-stage drying areas, respectively. Total mold spores during work activities ranged from 3.3×10^3 (mace dust removal area) to 9.8×10^5 spores/m³ (first-stage drying area). *Penicillium* and *Aspergillus* were the predominant mold genera in these samples. Concentrations of dust, glucan, and endotoxin were highest in first-stage sorting. In contrast, culturable mold from settled dust and mold spore levels (during turning of nutmegs) were highest in first-stage drying. Phosphine levels at the beginning and end of fumigation were ≤ 0.1 ppm.

Figure 3. Geometric mean (GM) glucan and endotoxin concentrations by work area at the nutmeg processing facility (1 ng = 8 endotoxin units).

Discussion

Spice grinding, in general, has been associated with dust, skin, and hearing problems. However, there is still a lack of literature on the health of nutmeg workers, specifically. Symptoms of skin and respiratory tract irritation were the main findings reported among chili pepper, paprika, coriander, cinnamon, ginger, curry process workers [9,16–18]. In addition, a recent case study regarding occupational health and safety of spice workers in Grenada revealed that workers still had hazardous work related exposure to pesticides and there is still a lack of awareness regarding health and safety despite the passage of some occupational health and safety regulations [19].

Since 79.1% of workers were non-smokers, the results of the survey suggest that most respiratory symptoms might come from an occupational exposure. In addition, workers from the nutmeg industry also experienced upper respiratory symptoms such as asthma, sinusitis and lung function impairment which is consistent with prior studies [9,11,16–18]. Another interesting finding was that the Skin-prick test results indicated that nearly a quarter of workers had nutmeg allergy and obstruction which is significant because this increases their chances of developing chronic respiratory illnesses with prolonged exposure to nutmeg dust [19].

Area air samples for inhalable dust mainly include particulates from the mace and nutmeg process. These particulates can cause irritation and respiratory allergies at concentrations below the permissible exposure limits set by the US Occupational Safety and Health Administration of 15 mg/m³. The most common self-reported symptoms due to the occupational exposure were sneezing and a stuffy nose. Additionally, the nutmeg processing plant has inefficient natural ventilation, which causes room temperature to rise beyond 35 °C. These risk factors and conditions are consistent with dehydration and limitations in the mucosal membranes of the upper respiratory track and increased vulnerability to inflammatory processes and contact allergic symptoms

of sneezing and stuffy nose. Therefore, nutmeg workers may still be at risk for respiratory illness despite the real-time measurements showing moderate concentrations of airborne inhalable dust in first-stage drying.

Sampling results from settled dusts and air in the nutmeg facility revealed that there were high concentrations of endotoxin and mold found in the first-stage drying area, on the outer shells of nutmeg on drying racks and during the turning of nutmeg in the first-stage drying. This high concentration of endotoxin and mold was associated with negative respiratory health effects reported by workers on the questionnaire. Additionally, area phosphine levels were found to not exceed exposure limits. However, previous case study shows that personal pesticide exposure may still be a health hazard among nutmeg workers [19].

A limitation of a cross-sectional study design for this type of research is that risk factors for developing disease cannot be accurately measured. The causal relationship between exposure and occupational factors and health effect can only be hypothesized in this study. Another limitation in this study is the method of data collection. Questionnaires are self-administered and there is the possibility of information bias, therefore creating some uncertainty regarding the commitment of the participants to answer all the relevant questions completely. This can lead to missing and incomplete data and affect the final analysis. The need for participants to provide accurate data will be more strongly emphasized to participants in future studies.

Upper and lower airways symptoms were remarkably high among nutmeg process workers. High prevalence of respiratory symptoms among workers in this facility was consistent with measured levels of dust, mold, glucan, and endotoxin, and were widespread over all work areas. Our findings are among the first to describe occupational health issues in this industry and are also consistent with prior published reports on respiratory health of spice workers. Future studies should consider planning a population-based case control study to investigate environmental and occupational risk factors and health outcomes.

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Disclosure statement

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