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ADEL BOUAKLINÉ, CLAIRE LACROIX, NICOLE ROUX, JEAN PIERRE GANNEUX, AND FRANCIS DEROUIN

Laboratoire de Parasitologie-Mycologie and Service de Diététique, Hôpital Saint-Louis, Paris, France

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The prevalence of thermotolerant fungi on non-heat-sterilizable food was determined. Aspergillus spp. were noted in 100% of pepper and regular tea samples, 12 to 66% of fruits, 27% of herbal teas, and 20% of freeze-dried soup samples. All soft cheese samples were contaminated by Geotrichum and yeast (Candida norvegensis) but Candida albicans was never identified.

Invasive aspergillosis is usually acquired by inhalation of conidia, and prevention consists mainly of the use of laminar-airflow rooms for patients at high risk (1, 8, 11). However, Aspergillus spp. are frequently present on food and thus can be an indirect source of airway or digestive tract colonization (10). One typical example is pepper, which has been found to be massively contaminated by Aspergillus flavus, Aspergillus fumigatus, and Aspergillus niger (2, 3, 12). Microbial contamination of food given to neutropenic patients can be eradicated by heating at 210°C, irradiation, or treatment in a microwave oven. However, the efficiency of the last two procedures is not proven (5), and heating cannot be applied to some types of foods, such as fruits, fruit juices, bread, and cheese. The aim of this study was to determine the prevalent thermotolerant fungi in non-heat-sterilizable food served to neutropenic patients in hematology wards.

Several types of foods were selected from those served in three hematology wards of St. Louis Hospital, Paris, France. At least 15 individual samples of each food were taken at random from the kitchens of the wards, the central kitchen, or the hospital pharmacy, where foods were usually stored. Food included regular tea (bags), herbal tea (bags), chocolate (powder), freeze-dried coffee, chicory, freeze-dried soup (bags), salt (bags), ground pepper (bags), caster sugar (bags), fresh bread, sandwich loaves, rusks, ketchup, mustard, vinegar sauce, cereals, potato crisps, aperitif biscuits, sweet biscuits, sponge cakes, cheeses (soft cheeses [Saint Nectaire and Cantal], processed cheese, and cream cheese), fruits (apple, apricot, banana, kiwi, lemon, melon, orange, and peach), and fruit juices (apple, cocktail, grape, and pineapple). Apart from fruits, all foods were individually wrapped. Foods without hermetic packaging were kept in sterile bags until analysis. Solid and semiliquid food (500 mg) was homogenized in a Potter homogenizer with 0.5% NaCl solution under sterile conditions. In the case of fruit, only the peel was collected. For liquid food (500 mg) was poured into two petri dishes. Liquefied (45°C) MC agar (15 ml) was poured into the petri dishes and allowed to solidify at room temperature. After 24 h of incubation at 37°C, 1 ml of each SC broth was subcultured onto fresh MC agar plates, and the remainder was kept at 37°C. Subculture plates were incubated for another 3 days at 37°C and examined daily. Molds were identified by their macroscopic and microscopic appearance according to the type of food (Tables 1 and 2). The heaviest and most frequent fungal contamination varied a lot according to the type of food (Tables 1 and 2). The heaviest and most frequent fungal contamination occurred in pepper and tea. Herbal teas were less frequently contaminated than regular tea and did not contain Aspergillus species. Three of 15 samples of freeze-dried soup contained spores of Aspergillus and Mucorales. At least one sample of all fruit types, except melons, was contaminated by molds. The rate of contamination of fruits with a downy skin, such as apricots, kiwis, and...
peaches, was >50%, compared with 12.5 to 33.3% for smooth-skinned fruits, such as apples, bananas, lemons, and oranges. *A. fumigatus* was also found in two samples of heat-sterilized grapefruit juice. Processed cheese and cream cheese were free of fungal contamination, whereas 100% of soft cheese samples were massively contaminated by *C. norvegensis*.

Our results confirm the severe contamination of pepper. As pepper is usually sprinkled on food just before eating, there is a major risk of producing an aerosol of *Aspergillus* spores and exposing the patient to an airborne contamination. Regular tea was also consistently contaminated by molds, as were most herbal teas (4, 6, 7). The risk associated with tea bags is probably lower than that associated with pepper, as the tea is usually prepared in the kitchen by the addition of boiling water, which likely kills the spores, although this has not been clearly demonstrated. Similar uncertainty applies to freeze-dried soups, which may also contain spores of *Aspergillus* and *Mucorales*. Fruits with a downy skin may also pose a risk of contamination if they are directly handled by the patient.

Contamination by yeasts was far less frequent. *Candida albicans* was not found. However, several samples of soft cheese were massively contaminated by *C. norvegensis*, a yeast frequently isolated from dairy and cheeses which may cause invasive infections (9).

On the basis of these results, we recommend several measures designed to reduce the risk of fungal contamination of food and thereby patient exposure to *Aspergillus* spores. First, we recommend that all foods for which there is no appropriate sterilization process should no longer be served to neutropenic patients. This is the case for pepper, even when it is presented in sachets (2). Heat decontamination of pepper bags at 210°C would probably be effective but results in a great loss of flavor. Other sterilization processes, such as microwave treatment or gamma irradiation, may not fully inactivate spores. Similarly, soft cheeses should not be given to patients, as they are highly contaminated by yeasts and cannot be sterilized. Banning tea may be unacceptable for those patients who are confined to their rooms for long periods, but we believe that teas, as well as other dried foods, such as soups, should be prepared with boiling water in the ward’s kitchen and not by the patient. Second, if food cannot be sterilized by heat or other means, it should be disinfected. Any washable individual wrapping should be disinfected with soap and water followed by application of an ethanol solution (70%) to eliminate fungal contamination. This process was performed on some fruits and on an in vitro model, with excellent results (data not shown). As effective surface disinfection is not possible with some fruits, especially those with downy skin (apricots, kiwis, and peaches), we recommend that these fruits be prohibited. Finally, food should be stored in a protected environment and measures should be taken to prevent fungal contamination of the food during preparation of meals.

In conclusion, this study shows that food is a potential source of fungal exposure for neutropenic patients. We propose that the catering process in hematology wards should include sterilization of foods and dishes, listing of banned foods, compliance with procedures for disinfection of individual packaging, and regular mycological testing of storage sites and kitchens. High-quality and varied meals are important for the patient’s well-being, but this should be balanced against the accompanying risk of fungal infection.

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### REFERENCES