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Homeohydrous (Recalcitrant) Seeds: Dehydration, the State of Water and Viability Characteristics in *Landolphia kirkii*

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ABSTRACT

Differential scanning calorimetry was used to study the relationships among drying rate, desiccation sensitivity, and the properties of water in homeohydrous (recalcitrant) seeds of *Landolphia kirkii*. Slow drying of intact seeds to axis moisture contents of approximately 0.9 to 0.7 gram/gram caused lethal damage, whereas very rapid (flash) drying of excised embryonic axes permitted removal of water to approximately 0.3 gram/gram. The amount of nonfreezable water in embryonic axes (0.28 gram H_2O/gram dry mass) did not change with drying rate and was similar to that of desiccation-tolerant seeds. These results suggest that the amount of nonfreezable water *per se* is not an important factor in desiccation sensitivity. However, flash drying that removed all freezable water damaged embryonic axes. Differences between desiccation-sensitive and -tolerant seeds occur at two levels: (a) tolerant seeds naturally lose freezable water, and sensitive seeds can lose this water without obvious damage only if it is removed very rapidly; (b) tolerant seeds can withstand the loss of a substantial proportion of nonfreezable water, whereas sensitive seeds are damaged if nonfreezable water is removed.

Desiccation tolerance of organisms involves, *inter alia*, the ability to withstand loss of water sorbed to macromolecular structures, particularly the surfaces of membranes, without irreversible denaturation (3, 4). A current theory, the "water replacement hypothesis," suggests that, in desiccation-tolerant tissues, water closely associated with macromolecular surfaces can be replaced by polyhydroxyl compounds that stabilize the macromolecules as water is withdrawn (3, 4). This hypothesis implies that such water replacement does not occur in desiccation-sensitive tissue.

Recalcitrant, or "homeohydric" (1), seeds are shed when the water content is high and when they are desiccation intolerant. A model describing homeohydric seed behavior suggests that the more rapid the rate of dehydration, the lower the water content the seeds can tolerate (6). Both experimental (5) and observational (8) evidence support this. Most homeohydric seeds are too large to be dried quickly, but if embryonic axes are excised, they can be dried rapidly. Isolated axes subjected to this "flash" drying retain viability to a much lower water content than axes in intact seeds dried more slowly over silica gels (1).

In this paper, we address (a) to what extent drying rate can affect the minimum moisture content that homeohydric tissues can survive, (b) whether the rate of water removal affects the thermal properties of water remaining in the tissues, and (c) whether there is a correlation between the thermal properties of water and expression of desiccation sensitivity. If desiccation tolerance is related to the ability of tissue to lose "bound" water without the denaturation of macromolecules, there may be differences in the thermal characteristics of water in axes of homeohydrous seeds flash dried and those dried more slowly. The relationships among dehydration rate, desiccation tolerance, and the state of water were studied using embryonic axes of the homeohydric seeds of *Landolphia kirkii* Dyer. This species is a viny shrub native to Mozambique and the inland region of northeastern South Africa. Its large (approximately 1.5 g) endospermic seeds are typical of many other seeds from tropical species in that they are intolerant to chilling and desiccation, the embryonic axis is fully developed when it sheds, and there are no tendencies toward dormancy. If maintained at their original water content, the seed will lose viability in approximately 1 month.

MATERIALS AND METHODS

Seed Collection and Transport

The details of collection and transport of recalcitrant seeds for experimental use may materially affect results (2). For these experiments, intact mature fruits of *Landolphia kirkii* were hand harvested in the field and transported, within 48 h of collection, in plastic bags by road to Durban, South Africa. The fruits are hard coated and contain 15 to 30 seeds to which the sticky fruit pulp adheres. The seeds lose virtually no water in the intact fruit. On receipt, seeds were removed from the fruit, cleaned by rubbing with paper towels, briefly surface sterilized with 10% bleach, dusted with a fungicidal powder, and sealed in plastic bags. They were then immediately air freighted in the temperature/pressure-controlled hold to the laboratory in Fort Collins, CO, where they were stored in the plastic bags at 25°C. The time lag between removal of the seeds from the fruits and receipt in Fort Collins was 5 to 7 d and between receipt and initiation of experiments never more than 7 d.