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Short Communication

Thermal Inactivation of *Cochliobolus miyabeanus* and *Gibberella fujikuroi* related to Temperature, Humidity, and Specific Enthalpy of Moist Air

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Abstract : Thermal death studies in moist heat inactivation of *Cochliobolus miyabeanus* and *Gibberella fujikuroi* were conducted. The fungi cultured on rice straws at 72°C for two weeks were dried at room temperature and then heated in moist air at constant temperature and humidity. For both species, logarithmic thermal death time curves depending on the relative humidity ranging 30 to 95% were obtained in the temperature ranging 65 to 85°C at five-degree intervals. It was also shown that the thermal death time depended logarithmically on an increment of the specific enthalpy of moist air. This dependence facilitates to evaluate and predict the lethal effect of moist heat on fungi.

Key words : rice disease, thermal death, moist heat, relative humidity, specific enthalpy

Introduction

It is well known that sevaral strains of fungi and bacteria are extremely tolerant against hot water or dry heat (RAHN, 1945 ; TOGASHI, 1949). TANABE *et al.* (1989) demonstrated that dry heat inactivation at 120°C of *Cochiliobolus miyabeanus* NIAES5425 and *Gibberella fujikuroi* NIAES 5133 needed 156 and 44 minutes of exposure time, respectively.

Thermal death of microorganisms in dry heat is influenced by humidity as an environmetal factor. BRANNEN and GARST (1972) showed that dry heat sterilization at 105°C on *Bacillus subtilis* var. *niger* spores was enhanced in the relative humidity range 0.03 to 0.2%. SHULL and ERNST (1962) reported high efficiency of saturated and superheated steam in killing dried spores of *B. stearothermophilus*. These facts suggest that inactivation of microorganisms by heated moist air is effective as a short-term treatment. However, littel information is available on the time of exposure necessary to eradicate fungi by moist heat treatment at lower temperature than 100°C.

This paper deals with thermal death of *C. miyabeanus* and *G. fujikuroi* exposed to moist air in temepratures ranging 65 to 85°C.

Materials and Methods

Cochliobolus miyabeanus (S. ITO et KURIBAYASHI) DRECHSLER ex DASTUR, NIAES 5425 and *Gibberella fujikuroi* (SAWADA) S. ITO NIAES 5133 were offered by National Institute of Agro-Environmental Sicences, Ministry of Agriculture, Forestry and Fisheries. After an inoculation of each fungus into the rice straw medium containing 5 g of cutted rice straws in 10 ml distilled water in a petri dish, samples were dried according to the methods described in our previous paper (TANABE *et al.*, 1989). Water content of dried samples was about 5%.

Twenty rice straw samples in an aluminum foil cup of 15 μm thickness were exposed to heated moist air for an appropriate period at the intervals of 10 minutes in a thermostatic and humidistatic chamber (500×600×400 mm in dimentions, Kusumoto Kasei Co. Ltd. model FX-2050 (P)). The temperature of moist heat treatment ranged 65 to 85°C at five-degree intervals and the relative humidity ranged 30 to 95%. After the treatment samples were incubated on the potato dextrose agar medium at 27°C for 3 to 4 days.

Lethal effect of moist heat was evaluated based on relations between the thermal death time and the relative humidity or an increment of specific enthalpy. Thermal death time is the shortest time necessary to kill all microorganisms at given temperature (RAHN, 1945). In the present study, the thermal death time was determined from quantal (all-or-none) responses of fungi on the medium after the heat treatment (TANABE *et al*, 1989).

The temperature and the humidity in the chamber were measured with dry and wet bulbs of thermocouples. The pressure of water vapor at a given temperature is

$$e = e_s - 0.0080P(t - t') \qquad \text{(Pa)} \qquad (1)$$

where e_s is the pressure of saturated water vapor at the dry bulb temperature, P is the atmospheric pressure, t is the dry bulb temperature and t' is the wet bulb tempareture.

The standard formula for relative humidity is

$$RH = \frac{e}{e_s} \times 100 \qquad (\%) \qquad (2)$$

The moisture content is

$$x = 0.622 \times \frac{e}{P - e} \qquad \text{(kg/kg dry air)} \qquad (3)$$

If the enthalpy at 0°C equals zero, then a specific enthalpy of moist air at a given temperature h is approximately given by

$$h = C_{pa}\, t + x(L_{vo} + C_{pv}\, t) \qquad \text{(kJ/kg dry air)} \qquad (4)$$

where C_{pa} is the heat capacity of air at constant pressure, C_{pv} is the heat capacity of water vapor at constant pressure, and L_{vo} is the evaporation heat of water at 0°C. Since the parameters C_{ps}, C_{pv} and L_{vo} are given 1.005, 1.846 and 2500 respectively, then the equation (4) is

$$h = 1.005\, t + x(2500 + 1.846\, t) \qquad \text{(kJ/kg dry air)} \qquad (5)$$

when an atmospheric air in the laboratory is 23°C and 70% R.H., an initial specific enthalpy of the air is 54.5 kJ/kg dry air. Therefore, at a given temperature and humidity, an increment of specific enthalpy of heated moist air is given by

$$\Delta h = h - 54.4 \qquad \text{(kJ/kg dry air)} \qquad (6)$$

Results and Discussion

Figure 1 shows the moist heat inactivation of *G. fujikuroi* and *C. miyabeanus* as a function of relative humidity and temperature. A relationship between the thermal death time and relative humidity was significant logarithmic at five levels of temperature. Regression coefficients of these lines were between −0.780 and −0.996. Although both strains survived after dry heat treatment below 90°C (TANABE *et al.*, 1989), they were inactivated within 30 minutes of the exposure time by moist heat at 65°C and 70% R.H.

Figure 2 shows the thermal death time of these strains as a function of the increment of the specific enthalpy. Regression lines were obtained using all of plots in Figure 1. The thermal death time decreased logarithmically with the specific enthalpy. Regression coefficients of the lines for *C. miyabeanus* and *G. fujikuroi* were −0.716 and −0.881, respectively. For example, when an atmospheric air is heated and humidified up to 70°C and 60% R.H. or 80°C and 40% R.H., about 400 kJ/kg dry air of the increment of the specific enthalpy is obtained in either cases. Consequently, *G. fujikroi* treated under these two different conditions was inactivated about 180 minutes (Figure 2.A).

Thus an application of the spcific enthalpy to a graphical procedure allows the prediction of lethal effect of heated moist air on microorganisms.

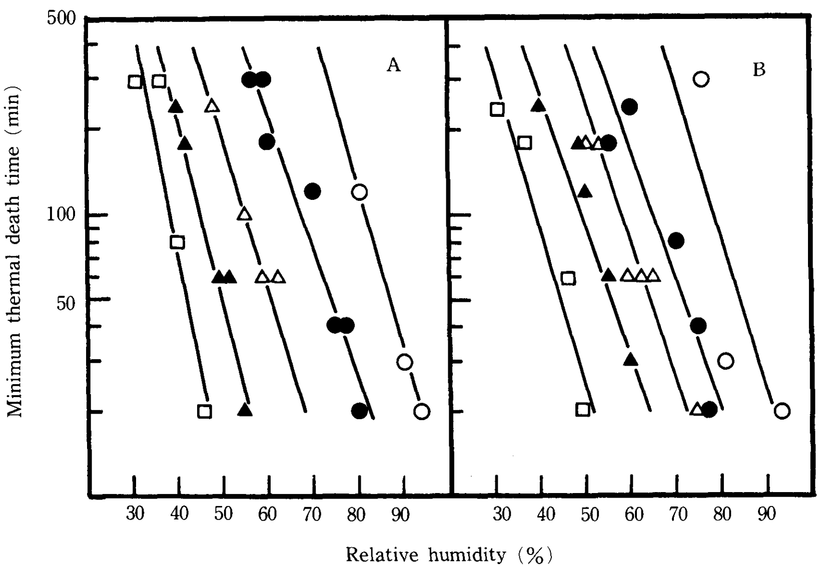

Fig. 1. Inactivation of *G. fujikuroi* and *C. miyabeanus* as a function of relative humidity and temperature.
A, *G. fujikuroi* : B, *C. miyabeanus*
○, 65°C : ●, 70°C : △, 75°C : ▲, 80°C ; □, 85°C

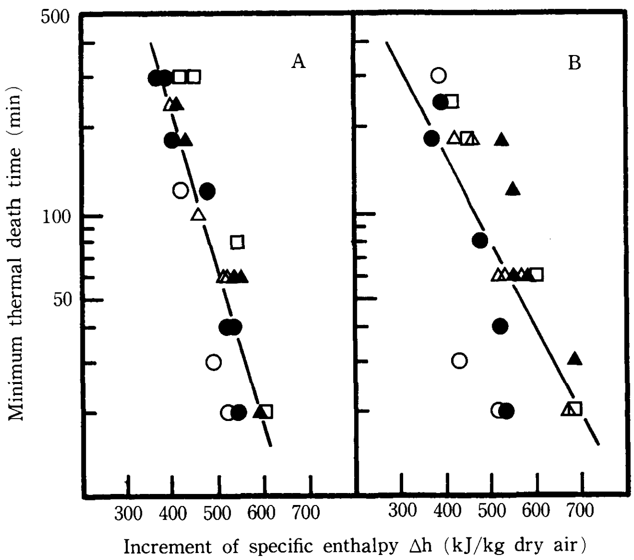

Fig. 2. Relationship between the thermal death time and increment of specific enthalpy at various temperature.
A, *G. fujikuroi* : B, *C. miyabeauns*
○, 65°C : ●, 70°C ; △, 75°C ; ▲, 80°C ; □, 85°C

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