

## **Development of management technique in manufacturing dehydrated food using the dielectric property**

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The primary purpose of food drying are to enhance the storage, transportation qualities and sensory properties of the sample, because dried foods have the ability to resist microbial and enzymatic degeneration.

To control the drying process, it is essential to accurately measure changes in the moisture content in the material. Determining the end point of drying is also important to ensure the quality of the dried food. However, most conventional dryers are operated by measuring the temperature at a few selected points, from which the overall drying conditions are extrapolated. Thus, in many cases, the end point of the drying process has to be determined empirically from limited information. This can result in over or uneven drying with a resultant energy loss or serious determination in the quality of the final product.

It is difficult to accurately measure the change in weight in the drying chamber. Therefore, methods to accurately and continuously measure weight and moisture content during the drying process have been researched.

The capacitance of a material, which is a function of permittivity(dielectric constant), can be measured easily without contact with or destruction of the material. Water has an intrinsic dielectric property corresponding to the state, and the permittivity of food largely depends on its moisture content. Therefore, if the change in moisture content during the drying process could be measured by application of the capacitance measurement technique, a non-destructive and continuous evaluation of the drying rate as well as the end point of the drying process would be possible.

### **1. Measurement of Change in Moisture Content during Drying Process Using the Dielectric Property of Foods**

A continuous and non-destructive method for measuring the moisture content of foods during the drying process is proposed. Changes in the dielectric property, weight and temperature of samples of agar gel, vegetables and meats during the air-drying process were measured automatically. The results showed significant correlation between the capacitance of each sample and moisture content. This technique will enable us to control drying conditions automatically without sampling the material during the drying process.

### **2. A Relationship Between Weight and Capacitance Changes during Freeze-drying Process of Food**

The development of a non-destructive method was attempted for the measurement of food weight change in a freeze-dryer. An aqueous solution of 10% dextrin was used as a food sample. Changes in both weight and temperature of the sample were simultaneously measured during a freeze-drying process. The capacitance of sample was also measured using two stainless steel

heating shelf boards as a pair of electrode plates.

Sample temperature histories varied with the sample position in the dryer. Sample temperature did not precisely indicate the freeze-drying state of the sample. Determining the endpoint of freeze-drying based solely on the results of sample temperature measurements remained practical problems. The capacitance change showed a good correlation with the weight change. Thus, it is feasible to monitor the weight of a sample during freeze-drying by measuring its capacitance.

### **3. Control of ice fraction by capacitance measurement for prevention of collapse during freeze drying of food**

We evaluated a non-destructive determination for preventing collapse (foaming and shrinking phenomena through evaporation to dryness) in freeze-dried food products. Three different types of miso (soy-bean paste) soup prepared with different contents on a dry solid basis were used as the food product model. Differential Scanning Calorimetry (DSC) determination was used to evaluate the freezing ratio of the miso soup. The soup was freeze-dried to evaluate the relationship between the incident of collapse and the freezing ratio. We found that collapse was completely prevented when the freezing ratio was about 95% or greater. At any solid content of the soup collapse was also prevented when the freezing ratio was 95% or greater. Freeze-dried temperature of the miso soup was changed to determine the capacitance variation, and its relationship with the incidences of collapse was evaluated. The result revealed that the incident of collapse was about 50% at a temperature where capacitance was maximal. Additionally, capacitance of the soup was graphically differentiated, and we found that the incidence of collapse was 0% at freezing temperature lower than the inflection point where the soup exhibited a freezing ratio of 95%. These results suggested that in preparing freeze-dried food products, collapse during freeze-drying could be prevented by continuously monitoring the capacitance of food products during freezing process, and by freezing them to a temperature at which collapse can be suppressed.

**Key words:** Dielectric Property, Capacitance, Drying Process, Moisture Content, Freeze-drying Process, Collapse