Reconstitution

Microwave systems permit rapid reconstitution without loss in quality

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□ THE ULTIMATE GOAL in food heating is to be able to raise the temperature of the food material to serving temperature, as needed, in the shortest possible time, with no deterioration in quality. This is more difficult to accomplish from initial temperatures below freezing, less difficult from a tempered or refrigerated condition, and least difficult from room temperature.

Traditional heat sources are limited by the thermal conductivity of the food material and cannot begin to approach the theoretical minimum energy required to do the job. Infrared and steam under pressure come the closest. Methods in which heat is generated within the food mass would appear to offer the best opportunity of approaching the ultimate goal. Such methods include direct ohmic heating, dielectric heating, and microwave heating.

• **Direct Ohmic Heating** is accomplished by using the food material as part of an electrical circuit. Ordinary 60-Hz current is passed through the food from an electrode in contact with the top surface of the food to the container which serves as the opposite elec-

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trode. From an efficiency point of view, this method ranks very high. The only heat losses are to the surroundings, and those can be minimized by proper insulation. Heating cycles of 20 min or less have been obtained for heating 2-in-thick food masses from −10°F to 160°F (−23.3°C to 71.1°C).

• **Dielectric Heating** can accomplish the same results as ohmic heating in the same time frame; however, the efficiency is considerably poorer, as there are losses in converting 60-Hz power to high-frequency power in the 13-40 MHz range. Equipment cost is also expected to be higher because of the need for more sophisticated componentry. An advantage of dielectric over ohmic heating is that contact between food and electrodes is not required.

• **Microwave Heating** can also accomplish the same results, though at still lower efficiencies, typically 50%. Microwave equipment costs, until recently, were substantially higher than for dielectric equipment. Today, the differences are less dramatic, as a result of the very-active development of the microwave oven market these past few years.

Of these three methods, only microwave energy is being used commercially and in the home for heating foods.

MICROWAVE APPLICATIONS

Some innovative application and developmental efforts involving microwave energy are worthy of comment:

• **Total Tray System** (Chemetron Corp., Louisville, Ky.). This is a relatively-recent innovation in hospital food service, covered by U.S. patents 3,854,021 and 3,854,-022 (Moore, 1974; Moore and Leyers, 1974). The system involves a special food tray and a special microwave oven.

The rationale behind this development is that in removing a plate of food from a tray to heat it in a microwave oven carries the risk that the plate may be inadvertently returned to another patient's tray. This could cause a problem if the patient were on a special diet.

In the Chemetron system, the complete tray is placed in the microwave oven, but the oven design permits only the plate of food to be heated. A metal cover built into the oven cavity drops down over all meal components except those to be heated, thereby shielding them from microwave energy. The tray has a built-in sensing element and will fit in the oven in only one orientation, directly over a detector that is below the floor of the oven. Closing the oven door automatically turns on the microwave power.

The sensor in the tray is made of a ferromagnetic material of such composition that it heats at a rate close to that of the food material. When the sensor reaches a certain preselected temperature approximating the serving temperature of the food, it loses its magnetic properties; this causes a magnetic switch in the detector below the oven floor to open, thereby turning off the microwave power. If the tray is not removed from the oven, the sensor will cool, regain its magnetic properties, and cause the circuit to close and the microwave power generator to again become energized. The oven will continue in this way to cycle on and off to keep the food warm until a logic circuit built into the controls turns the oven off after a predetermined number of cycles.

This system has been installed in a number of hospitals but in view of its newness should still be considered experimental. A possible drawback of this system is its limitation to non-frozen food items. Because it does not take into account the extra energy required to effect a change of state, the sensor would shut off before frozen food materials were completely thawed.

• **Differential Heating Container System** (Teckton, Inc., Waltham, Mass.). The Differential Heating Container System is another experimental system being used in a limited way for hospital food service. This system, described in U.S. Patents 3,547,661 and 3,615,713 (Stevenson, 1970, 1971), is able to handle meals from the frozen state.

The differential heating container (DHC) is a metal holder with various-sized apertures to permit the passage of microwave energy. The plated frozen or refrigerated meal is placed in the container in a specific orientation. The openings in the container above and below each of the components of the meal are sized to permit microwave energy to enter the components in quantities appropriate to the temperature to which each of the components must be raised. If good portion control is maintained in the fabrication of frozen meals and placement of the components is reasonably consistent, a single DHC design can be used for a number of different meals.

• **Hot-Food Vending System.** A large number of food service operations use refrigerated vending machines in conjunction with separate microwave ovens to provide hot foods to customers. There are even a few simple units which have microwave heating means built into the unit, but these have involved heating only single items such as hot dogs. A vending system for heating a complete three-component meal is not commercially available. A prototype of such a concept is, however, being fabricated under contract to the U.S. Army Natick Research and Development Command.

The system has been designed so that the individual components of a meal could be heated separately in parallel microwave ovens within the vending machine. Before selection, the items are maintained at −10°F (−23.3°C) in a mechanically-refrigerated storage area. The customer may select one item from each of three sections, each section having four choices and each choice being in a separate stack. The selected items are automatically transferred to a microwave heating chamber in front of each section. Each item is then heated at a predetermined rate controlled by a solid-state programmer (the 5TI Programmable Control System, Texas Instruments, Inc., Attleboro, Mass.); the average heating period for the complete meal is 2-3 min. Although some items will be ready before others, all are delivered to the consumer at the same time.

A unique feature of this system is the combination of microwave heating and directed hot air to heat and crisp certain highly-popular items such as French fried potatoes and fried chicken. The directed hot-air technique, described in U.S. patent No. 3,884,213 (Smith, 1975), has been applied commercially for the continuous baking of frozen pizza. More than 1,000 pizzas/hr are being processed through a pair of units at the Texas A&M University student cafeteria.

Basically, the system works as follows: Air heated to 400°F is directed through multiple 7/16-in apertures at velocities of 1,200 ft/min. The banks of apertures are located above and below a wire mesh conveyor belt and spaced at regular intervals along the belt. The hot-air jets create discrete areas of high heat transfer which accomplish crisping, browning, or searing when they impinge against food surfaces. The effect is spread evenly over the product by virtue of product movement on the belt.

The technique can also be applied to the progressive heating of prepared frozen or tempered foods in bulk containers such as the half- and full-size steam table pans common to the food service industry. For example, half-size steam table pans containing 5 lb of beef stew have been heated from 38°F to 160°F in 16-18 min.

MORE PROGRAMMED CONTROL

The above examples represent only a few of the possibilities for innovation in food reconstitution equipment. The future will see improvements in control techniques with increased emphasis on programmed control of cooking processes. Such control will result in more efficient use of energy as well as higher yields and improved quality.

REFERENCES

Moore, D.G. 1974. Electromagnetic oven system for automatically heating variable numbers and sizes of food items or the like. U.S. patent 3,854,022.

Moore, D.G. and Leyers, W.E. 1974. Electromagnetic heating system which includes an automatic shielding mechanism and method for its operation. U.S. patent 3,854,021.

Smith, D.P. 1975. Cooking apparatus. U.S. patent 3,884,213.

Stevenson, P.N. 1970. Container and food heating method. U.S. patent 3,547,661.

Stevenson, P.N. 1971. Selective cooking apparatus. U.S. patent 3,615,713.

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