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COOKING FOODS IN MICROWAVE OVENS

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During cooking, heat is transferred into and within food. With a conventional range, the heat comes from a flame or an electric heating element; in some cases, it may be a surface heated by an enclosed element.[1] A microwave oven has no flame or element (unless it contains a conventional browning element); instead heat is created directly in foods and liquids. Energy from invisible microwaves causes rapid movement of fat and water molecules; the movement produces heat.

The four methods of transferring heat into and within food are: conduction, convection, radiation, and by microwaves. Most cooking produces combinations of these methods. The heating time of food items for any of the methods of heat transfer will vary with the amount of heat available, the amount of food and its shape, the starting temperature of the food, and the composition of the food.

Conduction. Slow heating in which heat moves from hot to cold areas through the product. This transfer takes place between adjacent molecules usually progressing from the surface to the interior of the product.

Convection. More rapid heating than conduction. It occurs in a liquid or moving air medium. Heat transfer occurs as convection currents rapidly equalize the temperature of the food item by giving off heat to the cooler areas. In a microwave oven, the top surface of foods and liquids absorbs energy resulting in rapid heat build-up which will cause boil-overs. Stirring liquids occasionally will reduce this hazard and allow the convection currents to work most efficiently.

Radiation. Rapid heating of the surface of food. The heat transfer takes place from a reflected heat source, such as a broiler. The interior of the food item is heated by conduction or convection.

Microwaves. Rapid heating within food. The fat and water molecules in food absorb energy and become hot. Microwaves penetrate into the food item. The penetration depth is about two inches; however, the amount of energy absorbed is greatest near the surface. The interior of larger food items and dense food items that is beyond penetration depth, is heated by conduction and convection of the heat created near the surface. Heating time varies greatly with food amounts. Food in flat thin shapes has more surface area exposed to microwaves and will heat faster than food in a chunky shape.

During cooking, heat affects the appearance, texture, and flavor of the food. Some of these changes are controlled by adjusting time of cooking and/or amount of heat when a conventional heat source is used. In a microwave oven, these changes are controlled by adjusting time and/or power.

In conventional oven cooking, a selected temperature is maintained by a control sensing the temperature of the

[1]Current flowing through coils located beneath the ceramic surface, generates a magnetic field in the cooking utensil causing the utensil to become hot.

Using lower power in later stages of cooking a sirloin tip roast will result in more even heating and uniformity of doneness.

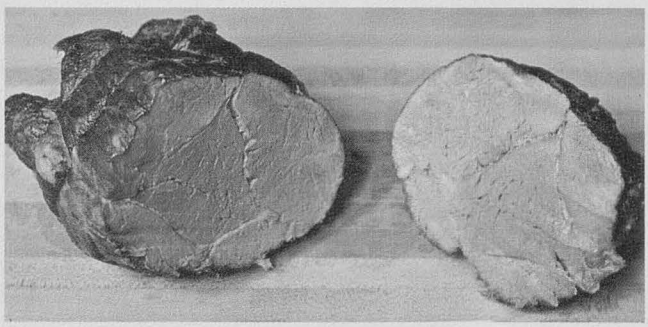

Figure A: 2/3 power to 130°F (54°C). 1/3 power to 140°F (60°C).

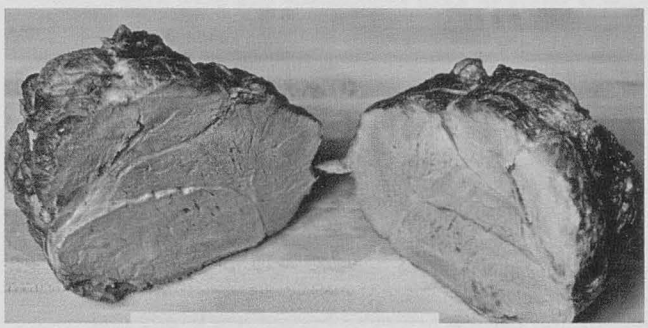

Figure B: 2/3 power to 140°F (60°C).

air in the oven. In top-of-the-range cooking when temperature controls are available, a selected cooking temperature is maintained by a control sensing the temperature of the pan. In microwave ovens when temperature controls are available, the temperature of the food around the probe is sensed and the power is either shut off or cycles to maintain a selected temperature.

APPEARANCE

This refers to overall color and shape of the cooked product. Proteins, amino acids, and certain sugars react at high surface temperatures and in a dry environment to produce brown-colored components, which are associated with the "expected" or conventional appearance of baked products and browned meats.[2] This type of browning takes place only when the surface of the food becomes very hot, as in the dry condition of a conventional oven or broiler. Other reactions which contribute to the brown color of baked products (carmelization of sugars and dextrinization of starches) also occur in hot and dry conditions.

Moist conditions on the surface of food during cooking in a microwave oven prevent many foods from browning. Cake batters and lean meats contain mainly water and the temperature of the surface does not reach the point at which the browning reactions take place. Foods containing a high amount of fat, such as bacon, or large quantities of food with fatty surfaces, such as roast chicken, will reach temperatures at which browning will occur.

Some baked products, such as cakes, require even heating for a properly-shaped product. Cakes microwaved often have an irregular top surface. In a microwave oven, the size and shape of products affects the evenness of heating. In an item such as a round cake, the outer areas are heated by microwaves entering from the top, sides, and bottom; the center of the cake is heated only by microwaves entering the top and bottom because the center is beyond the penetration depth of microwaves entering from the sides of the cake. More even heating will occur in a doughnut-shaped pan or if available energy is reduced by selecting a low-power setting during the early stages of cooking.

TEXTURE

This refers to properties described as rough or smooth, coarse or fine, moist or dry, compact or porous, tough or tender, hard or soft. Tenderness, grain, crispness, and flakiness are affected by heat as follows:

Tenderness qualities vary depending on the food. In meat it refers to ease of chewing and with pastry and baked products, to the ease of breaking. Conditions which would lead to the development of toughness should be avoided. This is especially important in meat and protein cookery. A slow rate of heat penetration will:

—Minimize the toughening of protein.[3]
—Help break down the connective tissue in less tender cuts of meat.[4]

In conventional cooking, a slower rate of heat penetration is achieved by using a low temperature or heat setting. In microwave ovens, a slow rate of heat penetration can be achieved by using a low power setting. This lower power will result in more even heating and uniformity of doneness of the meat and lower cooking losses.[5] Even heating within the meat item, like a roast, is aided by turning the product over midway through the cooking process and by using low power.

Initial studies on microwave cooking of certain cuts of beef conducted in 1978 at the University of Minnesota produced new methods of microwaving chuck arm and sirloin tip beef roasts. The new instructions are in the following chart under roasts. The roasts prepared following the new instructions were tender at the medium degree of doneness.

It was also observed in the recent study, that manufacturers suggested cooking times for roasts are only rough estimates of cooking time. A meat thermometer or temperature probe sensor is a much more reliable guide to the degree of doneness of roasts.

Grain refers to the fineness or coarseness of the cell structure of the product. The rate of water evaporation and carbon dioxide production by baking powder or yeast in batters and doughs greatly affects the grain. Some batters and doughs are porous and coarse when microwaved; this is due to the rapid vaporization of water and rapid production of carbon dioxide. Commercial batter mixes contain stabilizers to better preserve the fine cell structure.

Crispness refers to the dryness or brittleness of food. The desired crispness of certain products, such as cookies and pastry, is related to the drying out of the product in a conventional oven. The lack of a dry, hot condition in the microwave oven prevents most products from developing a crispness.

Flakiness refers to a thin layer of baked dough separated by open spaces. This will occur in either conventional or microwave cooking. Some people will associate a crispness with flakiness and this will not occur in the microwave oven.

FLAVOR

Trace amounts of many compounds are responsible for the expected flavor of cooked food products. Certain foods cooked in the microwave oven may not taste quite the same as when cooked by conventional methods. Some flavor compounds are formed slowly, such as in soups and stews, and may never be formed during fast heating. Fast heating does prevent the warmed-over flavor from reheating leftovers.

USES OF MICROWAVE OVENS

A microwave oven can be used to thaw, heat, reheat or completely cook foods. Uses for food preservation are discussed below.

Thawing is accomplished by using a low power setting or by manually alternating cooking and standing times. During the standing time the heat from the thawed area moves toward the frozen area.

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[2]This reaction is known as the Maillard Reaction.

[3]When protein is cooked, it goes through a series of changes called denaturation. These changes bring about a toughening of the protein and a loss of water. If these changes proceed slowly, the degree of toughening can be controlled.

[4]The conversion of connective tissue protein, collagen, to gelatin is a slow, moist heat process. There is more collagen in less tender cuts of meat than in tender cuts of meat.

[5]Results of studies conducted by the National Livestock and Meat Board and reported by Starrak, "Meat Cookery in Microwave," *The Microwave Energy Application Newsletter,* Volume 12, Number 4, 1979.

Heating and reheating involve bringing thawed and refrigerated foods, canned and bottled cooked foods, and fully baked products to a serving temperature. The following chart refers mainly to complete cooking of food. Check microwave cookbooks for specific directions for food items.

Do not use the microwave oven for canning. At the present time, there is no published research to support recommendations for home canning in microwave ovens. Attempts to can low acid foods such as vegetables, meat, fish and poultry can result in botulism food poisoning.

Directions for microwave blanching of vegetables prior to freezing are now published by a number of microwave oven manufacturers. These directions include a range of times for heating a given amount of vegetable for example "microwave until the vegetable has a bright color throughout—from 2 to 4 minutes." These time ranges were developed by making judgments on the palatability of frozen products after a short period of storage. While there is no hazard to health connected with microwave blanching of vegetables, there is no assurance that these blanching times are sufficient to destroy enzymes which will cause nutritional and sensory deterioration of the vegetable. These timetables for microwave blanching are not the result of research conducted to determine the length of microwave exposure needed to inactivate enzymes.

A GUIDE FOR USING CONVENTIONAL HEAT SOURCES AND MICROWAVES (2450 MHz) WITH SELECTED FOOD ITEMS

Food item	Requirements when using conventional heat sources	Suggestions when using microwaves
FRUITS AND VEGETABLES	most are cooked in own moisture, liquid is added to aid in heating or to prevent scorching	exceptional quality; very little water is added; most vegetables and fruits have plenty of moisture to heat by microwaves and steam will aid in even heating; scorching is not a problem
STARCH-THICKENED FOODS	slow rate of heating and frequent stirring to prevent lumpiness and scorching	exceptional quality; after initial blending, less stirring is needed to prevent lumpiness; scorching is not a problem
FISH	moderate or high temperature	excellent results because it is tender, high moisture product, often cooked in sauces which creates excellent results; good way to prepare lutefisk
MEAT AND POULTRY		
Roasting tender cuts—such as rib, leg of lamb, pork loin, young poultry	moderate temperature uncovered	use low to medium power.[1] Place on rack uncovered; add no liquid. (Boneless roasts are preferred. Bone affects the transmission of microwaves and results in uneven heating.)
Roasting choice grade—such as sirloin tip and chuck arm	low temperature uncovered	use low to medium power or the following directions: Sirloin tip— medium high or 2/3 power to 130°F (54°C) followed by low or 1/3 power to 140°F (60°C). Chuck arm— medium high or 2/3 power to 140°F (60°C) followed by low or 1/3 power to 150°F (66°C).
Braising less tender cuts—such as chuck, heel or round roasts	low temperature covered and small amount of liquid for moist roasting	use low power[1] to simmer
Braising less tender cuts—such as round and chuck steak, blade chops	direct heat source to brown surface, a long slow cooking at simmer temperature covered	to brown, use browning utensils,[2] browning element,[3] combination cooking,[4] or coloring product;[5] or sauce; use low power[1] to simmer
Stewing less tender cuts—such as stew beef and stewing hens	long, slow cooking at simmer temperature	use low power[1] to simmer
Broiling and Frying tender cuts—such as loin or rib steaks and chops, ground beef and sausage, chicken, fish , bacon	direct heat source and high temperature to brown surface	to brown, use browning utensils,[2] browning element,[3] combination cooking,[4] or coloring product;[5] bacon will brown because of high fat content; products that are breaded will not be as crisp because of the moist surface of foods

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Food item	Requirements when using conventional heat sources	Suggestions when using microwaves
Baking tender cuts—such as meat loaf, ham	moderate temperature	use medium high power; using low power[1] in the late stages of cooking is preferable to full power for the entire time
Deep Fat Frying	capability to adjust heat in order to keep fat at a set temperature	NOT RECOMMENDED: very difficult to regulate fat temperature; could be dangerous if fat were to reach too high a temperature
EGGS		
Fried	hot surface under egg, low temperature	microwave with close attention; use browning utensil;[2] may create hot surface by heating fat in dish then adding the egg—cover and microwave; the high fat content of the yolk will cook faster than the white
Cooked in shell	quantity of simmering water	NOT RECOMMENDED: egg may explode
Scrambled	low temperature	cover container so some cooking is done by steam
Poached	quantity of simmering water	use small amount of simmering water; cover and microwave
Souffle and Puffy Omelet	medium, hot dry oven	NOT RECOMMENDED; cannot duplicate the dry condition of oven
Custard	low, even heat	use low power:[1] and watch carefully so custard does not boil and cause curdling; may heat milk before mixing with other ingredients
BAKED PRODUCTS		
Cakes	moderate temperature, even heating	using lower power[1] in the early stages of cooking may help prevent irregular-shaped top; unable to cook angel food, chiffon cakes
Cookies	hot surface when browning is necessary; hot and dry if crispiness is necessary	select cookies such as bars, that need no browning and are soft
Pies	hot oven for crust, adjust temperature depending on filling	browning element or combination cooking[4] will brown and also dry crust so it becomes crisp

[1]Low power settings—are usually achieved by cycling full power off and on. Cycling power off and on may be done manually if low power settings are not available. Low, 1/3 power; Medium, 1/2 power; Medium High, 2/3 power; High, full power.

[2]Browning utensil—special utensil designed to absorb microwave energy which causes the utensil to become very hot. The empty utensil is preheated in the microwave oven until the grill surface is hot enough to brown the food placed directly on it. This utensil comes with some models or may be purchased separately.

[3]Browning element—unit is available in some microwave ovens. In portable ovens it cannot be used simultaneously with the microwave cooking operation. Also, the wattage of the element limits the speed at which browning will occur.

[4]Combination cooking—in a few models the microwave energy heat source is combined with conventional heat sources in a single cavity oven. The microwave oven can be used with other heat sources, such as the range top, oven, or broiler or outdoor grill; foods may be started or finished in the microwave. The microwave-conventional oven combines microwaves with electric heating elements located within the same oven cavity; the oven is not available with gas. The microwave-convection oven combines microwaves and moving air heated by either a gas burner or an electric heating element. The burners or elements for baking or boiling may be used separately or at the same time as the microwaves.

[5]Coloring product—gravy mixes or special browning products.

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