

## DEFINITION

Bread has been baked or pasteurised by microwaves and radio waves for over 60 years. In 1944 scientists experimented with 'electronic heat' and two years later a patent was approved for baking with radio waves. In the 1940–50s at least four patents related to heating food with microwaves were granted. The earliest bakery related application for microwaves was pasteurisation of bread in 1960–70s, with bread baking using microwaves first referred to in published literature in 1966.

## HOW DO MICROWAVE OVENS WORK?

Microwave energy is made up of electromagnetic waves that vibrate at billions of times per second. Polar molecules, e.g. molecules of water, that contain areas of both positive and negative charge, will rotate to align themselves with an applied electromagnetic field, just as a compass would. When microwaves are applied to food these polar molecules attempt to rotate, and since the field vibrates so rapidly they are in constant motion. These molecular movements cause heat, just like when you rub your hands together to warm them. Therefore, microwave energy is an efficient form of heating for foods which contain a high percentage of water. Heat is generated inside the food product and moves toward the surface. The internal steam pressure also forces moisture towards the surface, which is the opposite of how conventional heating works. Materials with no electrical charge, like glass, are unaffected by microwaves and do not heat.

## ADVANTAGES

- Use less energy than conventional ovens and due to instantaneous heat can bake much faster, reducing time for cooking, drying and tempering foods.
- When combined with conventional heating, microwaves may increase efficiently by 100–300%. For example, microwaves can be used to push moisture to a food product's surface where it can be evaporated more efficiently by a hot air system.
- Installation and maintenance costs for microwave equipment is less than conventional ovens, they use less space, and they are easier to clean and maintain.

## DISADVANTAGES

- Foods containing moisture content of 50% or more may instantaneously boil or cook when exposed to microwaves as microwaves work best with a moisture content under 25%.
- Due to internal pressure microwave heating may cause delicate products to puff.
- Results in lack of crust in microwave-baked bread. Crust is required for flavour and texture, to prevent collapse of the freshly baked bread loaf, and prevent premature microbial spoilage. This problem could be solved by combination cooking, where microwave baking is followed by conventional oven crust formation, although this adds another complicated step to processing.
- Toughening of protein foods, including bread, following microwave processing. Loaf skin tends to be rubbery, tough and difficult to tear, while the crumb can be firm and difficult to chew. These problems may be solved by reformulating the product to suit microwave cooking.

## CONVERSION OF BAKERY PRODUCTS TO MICROWAVING

Although development of products suitable for the microwave is based on trial and error there are some guidelines to follow. You must consider the food properties of the conventional product and the desired end product qualities before changing to microwave baking.

Start with considering how easy it will be to convert the traditional recipe. Recipes that are easy to adapt usually call for the same ingredients, but cookware and cooking time are adjusted. These types of recipes include moist cooking, which includes steaming or cooking in high moisture sauces. Bakery products are more difficult to adapt as they contain lower moisture and hence may exhibit a tough dry texture or a very fragile structure. Additional shortening and/or eggs are often required if these issues are to be overcome.

Bakery products which are usually characterised by a crisp crust or dry surface are difficult to replicate, for example, pizza crust toughens, fruit pies will become soggy and angel food cakes are basically impossible to microwave as they require dry heat for leavening.

## PRODUCT

## POINTS TO CONSIDER

BREAD	Select whole grains or products finished with a topping or icing as microwaving does not brown the bread crust. Microwave yeast breads at 50% power and rotate at least once. Reduce baking powder by at least one fourth in coffee cakes. Use extra shortening in yeast and quick bread to prevent toughness and dryness – 1/4 cup shortening per 2 1/2–3 cups flour in yeast bread and 1–2 Tablespoons of shortening for every cup of flour in muffins and coffee cakes. Decrease liquid in dense quick bread batters or very liquid batters. Additional egg can be used as a binder in very liquid batters. Bread must be heated uncovered to avoid sogginess.
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## > INFORMATION SHEET

CAKES	<p>The best cakes for conversion are rich whole egg products. Oil cakes, other than chiffon, are also good choices. White, angel and sponge cakes are not good options for the microwave as they toughen and they require dry heat for leavening. Reformulating is essential.</p> <p>To make microwave cakes less fragile, an extra egg should be added and the amount of liquid reduced by approximately 2 tablespoons for each egg added. Cakes with three or more eggs can be adapted by further reducing the liquid – either by 1/3 for cakes baked in layers or 1/4 if cooked in a ring shape. If the cake is not too rich, add 2 tablespoons of shortening.</p> <p>Cook in a round or ring-shaped pan.</p>
PIES	<p>Double crusted pies cannot be made in the microwave as the bottom crust becomes soggy and the top does not brown. Microwaved pies need to be prepared in a precooked shell and topped with a crumb rather than a crust.</p>
BISCUITS	<p>Stiff crumbly batters with more flour in proportion to shortening are the best for microwave cooking. If biscuits contain a high level of shortening, it will melt over the batter, leading to uneven cooking. These types of biscuits are not suitable for the microwave.</p> <p>Moulded biscuits which are not suppose to brown are also suitable.</p>

## INDUSTRIAL MICROWAVE APPLICATIONS

In industry the main use for microwaves is tempering products, e.g. fruit or fish. Microwaving reduces the time taken for tempering from weeks or days to minutes. It takes up minimal Plant space and bacteriological or production degradation issues are irrelevant. Tempering may be done by using a continuous microwave tunnel which is set to the desired processing criteria.

Microwaves are also used for the following:

- Defrosting finished baked goods, such as bread, pastry and muffins. A total defrost microwave oven is available which enables controlled defrosting of a product as it moves through changes of state without hot spots.
- Drying as microwaves selectively heat moisture while only slightly heating most solids, meaning drying is more uniform throughout the product.
- Proofing yeast-leavened doughnuts, reducing time taken from 40 to 4 minutes.
- Frying chemically leavened cake doughnuts, reducing fat absorption by 25% and frying time by 20%.
- Proof and bake oven which incorporates microwave energy, steam injection and forced convection air. First step is microwave defrosting, followed by proof cycle involving humidity and microwave energy and a final cycle of hot air and microwaves. This oven reduces the proof and bake cycle of baked rolls from more than an hour to less than 30 minutes.

## OTHER NON-CONVENTIONAL OVENS

- Electric Resistance Ovens heat the product internally and in theory produce a uniform heat. The heat is generated by using the food as a conductor between electrodes that carry an alternating current. Dough is heated by high electrical resistance and bread is produced with an elongated crumb structure. Baking bread in ERO retards staling in the final product.
- Radio waves are also electromagnetic waves, which vibrate at a lower frequency than microwaves. They are particularly useful for heating foods that contain low levels of water, e.g. post-baking cookies and crackers. However, bread baked using this method has been unsuccessful due to lack of flavour and crust.

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