

Physics Recreations: Microwave Oven Cooking

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1 Introduction

Heating food in a microwave oven presents a challenge not encountered in cooking with a conventional oven: not all microwave ovens operate with the same power. For example, suppose you find a recipe that calls for heating a dish in a microwave oven, and the directions are written for an 1100-watt microwave oven. But your microwave oven is rated at 750 watts. What do you do?

2 The Physics

A microwave oven works by bombarding the food with microwaves whose frequency matches the resonant frequency of water molecules in the food. In effect, the microwave oven “shakes” the water molecules to heat the food.

The solution to adjusting the cooking time is that you require the same amount of *total energy* to be applied to the food. The microwave’s power rating tells the rate at which energy is produced by the oven. We know power and energy are related by

$$P = \frac{E}{t} \tag{1}$$

where P is power, E is energy, and t is time. Suppose microwave #1 has power rating P_1 and requires cooking time t_1 , and suppose microwave #2 has power rating P_2 and requires cooking time t_2 . If the total energy produced by both microwaves is to be the same, then

$$E = P_1 t_1 = P_2 t_2 \tag{2}$$

and so the cooking time for the second microwave is

$$t_2 = \frac{P_1}{P_2} t_1 \tag{3}$$

In other words, *adjust the cooking time according to the ratio of the oven powers.*

3 Example: Corn on the Cob

As an example, a simple way to prepare corn on the cob is to heat the corn in the microwave, heating one or two ears *in the husk* for 3 minutes (assuming an 1100-watt microwave oven). If your microwave oven is rated at 750 watts, then how long should the cooking time be?

Solution. Multiply the original cooking time by the ratio of the oven powers. Since your microwave is *lower* power, you will have to *increase* the cooking time by multiplying by a ratio greater than 1, so that you get a cooking time greater than 3 minutes:

$$3 \text{ min} \times \frac{1100 \text{ W}}{750 \text{ W}} = 4.40 \text{ min} = 4 \text{ min } 24 \text{ sec} \quad (4)$$

After cooking for 4:24 in your 750-W microwave oven, husk the corn and add butter and salt to taste.

4 Important Note

This analysis applies only to a microwave oven—not to temperatures on a conventional oven. Baking in a conventional oven involves more complex chemical processes, and baking times cannot be adjusted in the same way.

For example, if a pizza recipe says to bake the pizza for 20 minutes at 400°F, it does *not* follow that you will get the same results by baking it for 1 minute at 8000°F!