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Microwave ovens

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Microwave ovens work with powerful high-frequency radiation (microwave radiation). This radiation is absorbed by food and transformed into heat. Food heated by microwave ovens does not actually contain any microwaves and therefore does not give off radiation. The metal case of a microwave oven and a metal-wire screen in its door ensure that most of the radiation stays inside the appliance. A small proportion leaks out. High radiation intensities can develop close to the surface of the housing (0-5 cm), but these fall to more than ten times below the permitted level at a distance of just 30 cm. However, leakage radiation may be greater if the door seals are defective or dirty.

As far as is currently known, leakage radiation from an intact microwave oven that is used correctly poses no threat to health. Overheated food or incompletely inactivated germs in the food may constitute a danger. As with conventional cooking methods, burns also represent the major risk associated with microwave ovens. Hot water or hot foodss are very dangerous if it are spilled or spurts onto the body.

Food can be heated safely in a microwave oven as long as the appliance is used correctly. The following tips will help you to get the best results:

- Familiarise yourself with the instructions for use and the safety precautions contained in them. If unsure, ask for clarification from the place of purchase or from the manufacturer.
- Use microwave ovens solely for heating foodstuffs.
- Keep the microwave oven out of the reach of children or use the child-proof lock built into the appliance so as to avoid the machine being inadvertantly switched on or opened by a child.
- Keep the door frame and seal and the inside of the oven clean and check that the door catch, the seal and the housing of the appliance are intact. Under no circumstances should you use an appliance with visible damage such as a defective or deformed door. Have the repairs carried out by the manufacturer of the appliance.
- Prevent liquids from overheating and ‘exploding' by placing a glass rod or a heat-resistant plastic spoon in the cooking vessel.
- In general, cook eggs on the hob, as eggs heated in the microwave oven can explode.
- Food with a skin or shell (e.g. fruit, potatoes, tomatoes) must be pierced before cooking or cooked using a different method.
- Both the inside and the outside of food should be heated for 10 minutes to at least 70 °C in the microwave oven to make sure that it is cooked through and that micro-organisms are killed. Stir the food from time to time so that it is evenly heated.

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Schwarzenburgstrasse 157, CH-3003 Bern

– In order to avoid burns use conventional methods to heat baby food. Take particular care if you do use a microwave oven to heat baby food. Warm the bottle without the teat in place. The above tip prevents explosive evaporation of liquids. Shake the bottle before you give it to the baby and check the temperature of the baby food to make sure that no part of it is too hot. Do not hold the baby in your arms when operating the microwave oven.

1 Technical Data

Typical frequencies:

- 0 Hz from the permanent magnets used to power the magnetron (static magnetic field)
- 50 Hz from the power supply (low-frequency magnetic field)
- 2,45 GHz from the microwave radiation (high-frequency electromagnetic field)

Output

500 – 2000 Watt (Haushaltsgeräte)

1.1 Principle

Materials which are weak conductors of electricity, e.g. water and many other components of food, absorb microwave energy. Absorption takes place when energy is transferred to electrically charged particles (ions) and dipoles. Dipoles are particles which have one positively and one negatively charged end, which means that their electrical charge is unevenly distributed. The dipoles most commonly found in food are water molecules.

All the dipoles and ions in a food product are in constant motion. If a food is additionally exposed to an electrical field, the dipoles attempt to align themselves with this field according to their charge.

The electrical field (radiation) of a microwave oven changes direction extremely rapidly (five billion times per second). The ions and dipoles attempt to align themselves with this alternating field. This intensifies their movements even further, leading to a rise in the temperature of the food.

This type of heating is the absolute opposite of the conventional way of heating food, in which heat energy is applied to the surface of the food and transferred to the inside of the product by conduction.

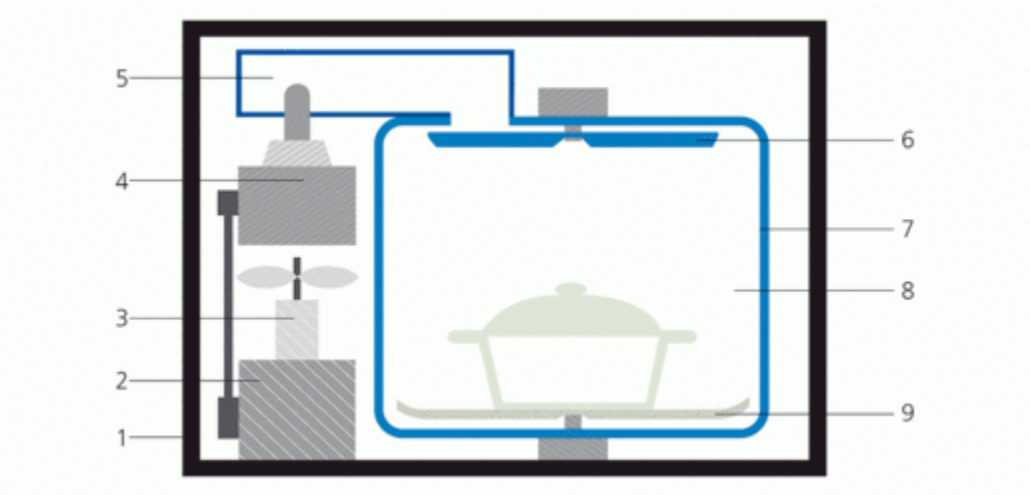
1.2 How it works

In a microwave oven, the microwave radiation is produced by a high-frequency generator known as a magnetron. A transformer generates the high voltage needed to power the magnetron. The magnetron is switched on and off 50 times a second, producing pulses of microwave radiation. A pulse typically lasts 10 milliseconds. The radiation is introduced into the cooking area of the oven by the magnetron.

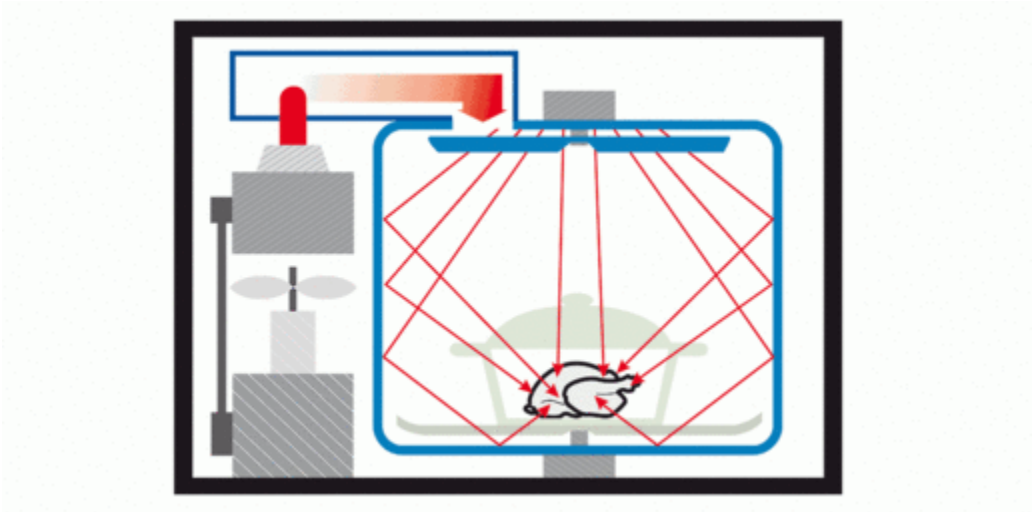
The metal walls of the case and metal-wire screen in the door ensure that the radiation is reflected and stays inside the oven. Opening the door switches off the radiation source immediately, and the oven becomes radiation-free within 10 µs (microseconds).

Some of the microwaves reflected from the walls are superimposed on each other, producing a

greater or lower intensity of radiation in certain places. This phenomenon, known as interference effects, means that food will cook faster in some parts of the oven than in others. A stirrer can distribute the radiation more equally or a turntable in the oven can ensure that food is heated more evenly in spite of the irregular distribution of the radiation (figure 1)



1 Gehäuse
2 Transformator
3 Kühlgebläse
4 Magnetron
5 Hohlleiter
6 Reflektorflügel
7 Reflektorblech
8 Garraum
9 Drehteller



1.3 Operation

The transformer generates a high voltage for the magnetron, which produces electromagnetic waves. These microwaves are focussed by a metal tube, and fed into the cooking chamber by the waveguide. The waves are distributed through the cooking chamber by a rotating reflector and reach the food on the turntable directly or by reflection from all sides.

1.4 Suitable and unsuitable cooking vessels

Electrical isolators such as glass and porcelain are almost completely permeable to microwaves and therefore make good materials for microwave cooking vessels. Porcelain decorated with gold should not be used as the decoration will be destroyed.

Microwaves are reflected almost completely by electrically conductive materials such as metals, so food in metal containers will not be heated. Another reason for not using metal cooking vessels is that they disrupt the optimum distribution of the microwaves in the oven's cooking space. Sparking may occur if metal parts are placed too close to the wall of the oven cavity.

2 Meauring exposure

2.1 High-frequency radiation

Leakage radiation from microwave ovens

The high-frequency radiation that escapes from a microwave oven while it is in use is called leakage radiation. It must not exceed 5 mW/cm2 at a distance of 5 cm (this is equivalent to an electrical field strength of 137 V/m). Three different studies have investigated the leakage radiation from new and used microwave ovens in households and restaurants (Table 1).

Table 1. Mean leakage radiation from microwave ovens measured at a distance5 cm from the appliance

Study		Average leakage radiation (mW/cm2)	Number of appliances measured	Age of appliances (years)
Study [2]: used appliances		0,41	106	0,1 – 14
Study [3]	new appliances	0,08	60	0
	used appliances	0,17	103	1 - 23
Study [4]: used appliances		< 0.062 for 50% of the appliances, max. 0.086	130	0,5 – 18

The three studies conclude that leakage radiation is most likely to occur if the door seals are worn or dirty, or if the door or catch is worn. The maximum permitted level of leakage radiation was exceeded in only one case.

Specific absorption rate (SAR)

The best way to describe exposure of humans to high-frequency radiation is in terms of the SAR (specific absorption rate). The SAR (in W/kg) shows how much energy (W) is absorbed by the human body (kg).

A study was carried out to determine the SAR caused by leakage radiation from a microwave oven[5]. The microwave oven was prepared in such a way that it emitted the maximum permitted leakage radiation. At distances of 30 cm (equivalent to whole-body exposure) and 5 cm (equivalent, for example, to exposure of the head while looking at the cooking food) the measured SAR values were well below the recommended thresholds (Table 2); the recommended threshold is exceeded only when the body is in direct contact with the microwave oven [6, 7].

Table 2: SAR values of a microwave oven with maximum permitted leakage radiation (5 mW/cm2 at a distance of 5 cm) compared with the recommended threshold for various types of exposure

Distance (cm)	Levels measured with microwave oven SAR (W/kg)	Recommended limit	
		SAR (W/kg)	exposed parts of body
< 0.1	7.95	4	limbs
5	0.256	2	head, trunk
30	0.0056	0.08	whole body

2.2 Low-frequency magnetic fields

Low-frequency magnetic fields are created by the transformer, the motor that rotates the turntable and the powerful transformer in the magnetron. The low-frequency magnetic fields of 34 microwave ovens were determined and the mean was calculated (Table 3) [8]. The measured values were all below the recommended threshold of 100 µT (microtesla). The magnetic fields decreased greatly with increasing distance from the appliance.

Table 3: 50 Hz magnetic fields of 34 measured microwave ovens, mean ± standard deviation

Distance (cm)	Magnetic field (µT)
5	27,3 ± 16,7
50	1,66 ± 0,63
100	0,37 ± 0,14

3 Effects on health

3.1 The effects of electromagnetic fields

High-frequency radiation

The possible effects of the radiation emitted by microwave ovens on the eyes have been investigated. The lenses in the eyes do not have an extensive blood supply, making it difficult for heat generated in them to be dissipated. This means that the lenses in the eyes are sensitive to high temperatures, which can lead to permanent damage (cataracts). When a person looks at cooking food through the window in a microwave oven, the eyes are brought very close to the appliance and to within the range where leakage radiation is present. However, studies have shown that the radiation exposure is too low when the door is closed to produce any significant increase in the temperature in the eyes [9].

Overall, there is no evidence that microwave ovens have any impact on health by increasing the body temperature.

Low-frequency magnetic fields

Microwaves are among the household appliances that tend to produce powerful low-frequency magnetic fields. However, the burden of the magnetic fields caused by such appliances is relatively low since they are only ever operated for a short time. The studies carried out to date have not produced reliable evidence that microwave ovens have any effect on health [10-13].

3.2 Hazards associated with incorrect use of appliances

Heating foods and objects

Microwaves typically heat food rapidly, leading to excess pressure inside items of food that are not too large (not thicker than 3-4 cm). Foods such as eggs, tomatoes, potatoes and sausages, which are surrounded by an external shell or skin, can burst or explode in a microwave oven or after they have been removed from it. Eggs For this reason, foods enclosed in a skin or shell must be pierced or peeled before they are heated; it is better to boil eggs conventionally in water. heated in a microwave oven are particularly dangerous, as they can cause mild to severe burns [14] and injure the eyes.

Airtight containers which are tightly closed, e.g. bottles, glass jars of baby food, vacuum-packed food, must be opened before they are heated in a microwave oven. Teats must be removed from babies' bottles since exploding bottles can cause extremely serious burns [15].

Heating liquids and food

There is a danger that liquids may be heated beyond their boiling point in a microwave oven without evaporating or forming bubbles. In superheated liquids (beverages, inhaled medications etc.) even the slightest movement can cause large bubbles which explode from the container, taking liquid with them and causing burns. This danger can be avoided by standing a glass rod or plastic spoon in the liquid. A teaspoon can also be used, provided that it is made of a single material, e.g. stainless steel. Silver-plated spoons should not be used.

Microwaves tend to heat the interior of liquids, foods and gel-like substances (e.g. hot/cold gel packs) faster than the surface, so the container or food does not necessarily feel hot when it is taken out of the microwave oven. There is a danger that babies, in particular, may burn their throats. For this reason, liquids, food and other objects should always be stirred and checked to see that they are not too hot.

Microwave ovens should be placed out of reach of children in order to avoid accidents. Even children below 2 years old are able to open microwave ovens and remove food [16]. In addition, children represent the age group that is in most danger from injuries from microwave ovens [17].

Hygienic food preparation

Food may heat up unevenly in a microwave oven.

- Because of the way microwave ovens are designed, parts of the cooking area may be very hot why some are cooler.
- The different components of food (water, fat, protein, carbohydrates) heat up at different rates, leading to the formation of hot spots and cold spots.
- Very salty foods tend to overheat on the surface.

If food cooks unevenly, the micro-organisms contained in it may not be destroyed completely. The following tips will help to ensure that food prepared in a microwave oven is safe to eat:

- Extended heating times and standing time after heating allow heat to spread and help to equilibrate the temperature between hot and cold spots. This process can be accelerated by stirring. Food must be heated both inside and on the outside to at least 70°C for 10 minutes.
- Large quantities and thicker items (thicker than 3-4 cm) may not be cooked through properly; in such cases a different cooking method should be used.

Changes in the chemical composition of food

Whenever food is heated, it undergoes chemical changes, new chemical substances are formed and existing substances are partly destroyed. These changes are dependent on the cooking time and temperature. The changes that take place in food heated in a microwave oven are roughly the same as those that occur during conventional cooking. The nutritional value, digestibility of proteins, composition of amino acids and stability of fat-soluble vitamins (A and E) are similar with both methods. Micro-

wave cooking has less negative impact on the stability of water-soluble vitamins (C and B) than conventional cooking methods. Less oxidation of fats occurs, so no highly reactive toxic substances (radicals) are formed. When food is heated in a microwave oven, fewer undesirable substances such as polycyclic aromatic hydrocarbons and heterocyclic aromatic amines are generally formed than when food is fried in a pan. However, microwave cooking does not brown food.

Extensive toxicological studies have investigated food heated in a microwave oven for the presence of novel toxic substances [16]. It was shown that there are no differences between food heated in a microwave and conventionally cooked food. Microbiological and biochemical studies have not demonstrated any toxic effect of food cooked in a microwave oven on genetic material.

4 Regulation in law

Microwave ovens are low-voltage appliances which are governed in Switzerland by the Regulation concerning electrical low-voltage appliances [19]. This regulation requires low-voltage appliances not to endanger either persons or objects when used correctly, where possible when used in a foreseeable incorrect manner, and when foreseeable faults occur. It also states that low-voltage appliances may only be marketed if they comply with the essential health and safety requirements of the European Low Voltage Directive.

Manufacturers of low-voltage appliances must obtain a Declaration of Conformity for a product before it can be brought onto the market; this declaration states that the product complies with the essential requirements. The essential requirements for individual products are specified in technical standards; the requirements that the electromagnetic fields created by microwave ovens have to meet are specified in EN 62233 [20] for the low-frequency range and EN 60335-2-25 [21] for the high-frequency range. The corresponding conformity criteria are identical to those stated in the threshold recommendations of the EU [6].

Manufacturers are responsible for ensuring that their appliances comply with the conformity criteria; there is no comprehensive oversight of the market in Switzerland. The Swiss Inspectorate for High Current Installations (www.esti.admin.ch) checks compliance with the regulations by inspecting random samples of products on the market

5 References

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Specialist staff

Federal Office of Public Health FOPH
emf@bag.admin.ch