

# Effect of microwaving on different foods and biological systems

■ UPASANA, PARVEEN SHAISTA AND ARCHANA CHAKRAVARTY

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■ **ABSTRACT** : The use of microwave cooking is tremendously increasing day by day as it is convenient, fast and economical. But, various evidences shows that microwaves destroy the nutrients of food, may create carcinogens in food, and unnecessary exposure to radiation can create several health issues. On the other hand, several studies reveal that if the consumer follows safety instructions carefully then microwave cooking may result in food with nutrient quality similar to those cooked by other cooking methods. Food safety is an important health issue, thus, there is a need to deal with the various aspects of microwaving. In this context, this review paper focuses on the effect of microwave cooking on different food items and biological systems.

■ **KEY WORDS**: Microwave cooking, Food safety, Health issue

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See end of the paper for authors' affiliations

## UPASANA

Department of Home Science  
(Food and Nutrition), Banaras  
Hindu University, VARANASI (U.P.)  
INDIA

Email: upasana87@gmail.com

## What are microwaves? :

Electromagnetic waves are waves of electrical and magnetic energy together through space. Electromagnetic waves can be characterized by their wavelength, frequency or energy (Fig. 1). The frequency of an electromagnetic wave is simply the number of oscillations which passes a fixed point per unit of time. The wavelength is defined as the distance travel in one complete oscillation. The shorter the wavelength, the higher the frequency. An electromagnetic wave consists of very small packets of energy called photon. The energy in each packet or photon is directly proportional to the frequency of the wave. The higher the frequency, the larger the amount of energy in each photon (WHO Fact sheet, 1998). In electromagnetic spectrum, energy types are graded on the basis of the amount of energy they produce. Microwaves are high frequency electromagnetic waves that alternate in both positive and negative direction (Lassen and Ovesen, 1995). The frequency range of microwaves is 300 to 300,000MHz. Microwaves are reflected, transmitted or absorbed by materials in their path in a similar manner to light. Metallic materials totally reflect microwaves while non-metallic materials such as glass and some plastics are mostly transparent to microwaves.

## Microwave oven: structure and function :

Basically, microwave oven consists of a magnetron, waveguide, stirrer, turntable, cooking cavity, door and choke (Fig. 2). Through the power supply, microwaves are generated in the magnetron, a vacuum (tube that converts electrical energy into oscillating electromagnetic field) and feeds into waveguide, a rectangular metal tube that directs generated microwave into the cooking cavity from magnetron. Stirrer distributes the microwave from waveguide into the cooking cavity for uniform cooking of food. The accessibility of food in cooking cavity is possible through the door. Door and choke in oven prevent microwave leakage through the gap between the doors as they are specially engineered for this purpose.

## Microwave cooking: The heating process :

During cooking, the microwave energy is absorbed by the food and would lead to excitation, rotation/collision of polar molecules and ions inside the food. The molecular friction would generate heat and subsequently lead to temperature rise. The microwave can heat the food in two different ways:

### Dipolar interaction :

Microwave energy is absorbed by polar molecules such as water molecules inside the food and will rotate according

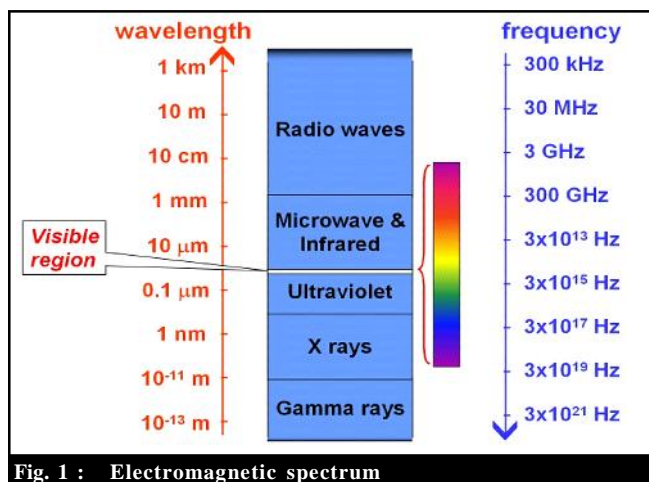


Fig. 1 : Electromagnetic spectrum

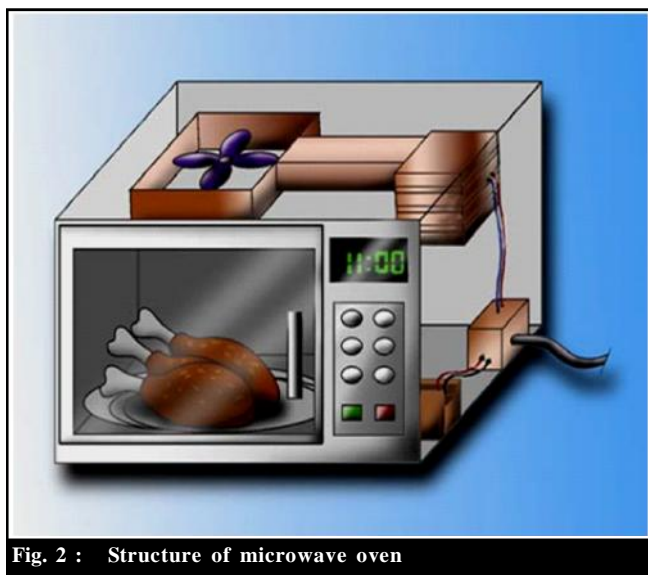


Fig. 2 : Structure of microwave oven

to alternating electromagnetic field. The water molecule is a dipole with one positive charged end and one negative charged end. These dipoles will orient to themselves when they are subjected to electromagnetic field. The rotation of water molecules would generate heat for cooking (Buffler, 1993; Ohlsson, 1993; Hill, 1998).

#### Ionic interaction :

By the electromagnetic field, ionic compounds (*i.e.* dissolved salt) in food can also be accelerated and collide with other molecules to produce heat. This generated heat will help in cooking food. The constituent of food being cooked will determine the efficiency of microwave cooking. The rate of interaction of different food component with microwave varies. Because of dipolar interaction, food with higher moisture content will be heated up faster. With the increase in concentration of ions (dissolved salts), the rate of heating

also increases due to the ionic interaction with microwave.

#### Risk associated with microwave cooking :

The risk associated with microwave cooking is briefly described under following headings *i.e.* chemical and microbiological risk.

#### Chemical risk associated with microwave cooking :

Cooking processes especially at high temperature *i.e.* grilling, baking etc induce the production of potential carcinogens. Microwave cooking may also increase the production of carcinogens or mutagens in foods. In a study that examined mutagen production in cooked lamb and beef found no such evidence of mutagenicity in microwave cooked lamb chops, sirloin steak, leg of lamb or rolled beef loaf (Barrington *et al.*, 1990). Another study also showed no adverse effect of microwaves on the cooked diet with those cooked conventionally when fed to rats (Jonker and Till, 1995).

Several studies have been conducted to compare the effect of microwave cooking with other conventional methods on the formation of heterocyclic amines (HCAs), polyaromatic hydrocarbons (PAHs) and nitrosamines chemicals and their findings are as follows:

#### Heterocyclic amines (HCAs) :

HCAs are a group of compounds present in cooked muscle meat after high temperature cooking such as grilling / barbecuing, broiling and pan frying. When meats are cooked at or below  $100^{\circ}\text{C}$  with shorter cooking time, negligible amounts of HCAs are found (National Cancer Institute, 1996). One study showed that the formation of some types of HCAs in chicken legs can be reduced by microwave cooking as compared with frying (Chiu *et al.*, 1998).

#### Polyaromatic hydrocarbons (PAHs) :

PAHs referred to a large group of organic compounds containing two or more fused aromatic rings made up of carbon and hydrogen atoms. It is considered that incomplete combustion lead to the formation of PAHs. Cooking steps such as roasting, grilling, barbecuing and smoking produce PAHs and increase the level of PAHs in the food being cooked (SCF, 2002). A study concluded that significant amount of PAHs was found when beef cooked in corn oil by conventional frying and reheating whereas, negligible amount of PAHs was found when cooked by microwave cooking and reheating (Hill, 1998).

#### Nitrosamines :

Nitrosamines are formed by a reaction between a nitrosating agent (*e.g.* nitrites) and a secondary or tertiary amine. This reaction may take place in several foods as a result of curing, drying or cooking (Scanlan, 1993). According to International Agency for Research on Cancer (IARC), the

most common and studied nitrosamine, N-nitrosodimethyl amine (NDMA) has been classified as a probable human carcinogen (IARC, 1978).

#### **Microbiological risk associated with microwave cooking:**

As effective as conventional methods, microwave cooking can kill the food borne pathogens since it generally requires shorter time and may sometimes result in lower temperatures at the food surface. Various studies concluded that the effectiveness of microwave cooking is comparable with conventional methods in killing microorganism and spores, provided that appropriate temperature and time are reached (Welt *et al.*, 1994; Hill, 1998; Celandroni *et al.*, 2004). It is suggested that in both the cooking methods *i.e.* conventional and microwave cooking, raw animal food should be heated to a temperature of 75°C for atleast 15 seconds to kill any food borne pathogens that may be present in the food. Various studies indicated that covering of food during microwave cooking could avoid uneven heating of food that may contribute to microbiological risk (Decareau, 1992).

#### **Effect of microwaving on different food :**

On the basis of various researches it was found that microwaves altered food both chemically and molecularly, lost its nutrients and created harmful compounds in foods. Under being unacceptable conditions, the following effects have been observed when foods are subjected to microwave:

##### *Milk, meat and pulses :*

These are the major source of protein for our body. In 1989, Dr. Lita Lee noted in the December issue of the British medical journal Lancet that microwaved milk not only depletes the vitamin content but converts certain amino acids into related substances that are biologically inactive. These altered amino acids are known poisons to both the nervous system and the kidneys (Kopp, 1996). In 1992, Journal of Pediatrics reported that researchers at the Stanford University Medical Centre discovered that the changes in human breast milk that was microwaved just enough to warm, it included the destruction of 98 per cent of its immunoglobulin-A antibodies and 96 per cent of its lysozyme activity, which inhibits bacterial infections (Kopp, 1996).

Heating of prepared meats sufficiently to ensure sanitary ingestion creates d-nitrosodietha nolamine, that is a well known cancer causing agent (Kopp, 1996). The active-protein and biomolecular compounds destabilized by microwave. The rate of protein degradation depends on the heating time and temperature.

##### *Cereals, sugars and oils :*

These all provide energy to our body. During microwave cooking, cancer causing agent *i.e.* protein-hydrolysate

compounds are created in cereal grains. Microwave unnaturally altered molecular composition of natural sugar and oil (Kopp, 1996).

##### *Vegetables and fruits :*

Brief exposures of microwave to raw, cooked or frozen vegetables and fruits enhance the production of alkaloids (such as caffeine, morphine and strychnine) that are harmful for the human body. The Spanish scientific research council, CEBAS-CSIC, found that microwaved broccoli lost 97 per cent, 74 per cent and 87 per cent of three cancer protecting antioxidants (flavonoids, sinapics and caffeoyl-quinic derivatives). The availability of vitamin complexes A, B, C and E; and essential minerals are vastly reduced. Microwaving lowers the metabolic behaviour and digestibility of fruits and vegetables (Bialic, 2006).

#### **Effect of microwaving on biological system :**

Both microwaved food and exposure to the microwave producing equipment can harm the important biological system. Some of them are:

##### *Digestive system :*

Digestive system consists of organs that collectively perform the function of digestion *i.e.* the breakdown of larger biomolecules into smaller molecules enough to enter the cell. Mouth, esophagus, stomach, small intestine, large intestine, digestive glands such as pancreas, gall bladder and liver comprises the digestive system. Disorders occur in digestive system due to elemental alteration during microwaving of food and its unstable metabolism.

##### *Lymphatic system :*

This system consists of a fluid, lymph which is circulating within the lymph vessels in the body structure containing lymphatic tissue and bone marrow. This system carries out immune responses. Due to chemical alterations within food substances, dysfunction occurs in the lymphatic system, causing a degeneration of the body's ability to protect itself against certain forms of neoplasm (cancerous growths).

##### *Endocrine system :*

Endocrine system secretes hormone that is known as messenger molecule, in the blood stream which deliver it to all body cells. Due to microwave exposure, both in male and female hormones production and their maintenance may be imbalanced and interrupted.

##### *Loss of vital energies :*

Humans, animals and plants located within a 500 metre radius of the equipment in operation suffer a long term, cumulative loss of vital energies.

**Microwave and food safety :**

In the microwave cooking, the rate of heating depends on the power of the equipment *i.e.* microwave oven, on the water content, density and amount of food being heated. Microwave energy does not penetrate well in thicker pieces of food, and may produce uneven cooking. If parts of the food are not heated sufficiently to kill potentially dangerous micro-organisms, this can lead to a health risk.

**Safety suggestion for microwaving :**

Some points which must be considered while handling microwave oven. These are as follows:

**General rules :**

- Microwave should be purchased from reputable manufacturers.
- The manual of the oven should be read carefully for cleaning methods and recommended handling techniques.
- If the oven is not working properly then don't operate it.
- Microwave oven should be kept always clean.

**Cookware and wraps :**

- Always use microwave safe cookware and plastic wraps for microwave cooking.
- For microwave cooking, don't use containers with metallic decoration, plastic storage bags, plastic grocery bags, foam trays or aluminium foil.

**Cooking :**

- Always wash your hand before and after the food handling.
- Don't cover the food completely with microwave safe lid / plastic wrap so that the steam can easily escape. During cooking, the food should not be in contact with plastic wrap.
- To avoid overcooking of the outer portion of the meat, the large pieces of the meat should be cook at the medium power for longer time.
- For uniform cooking,
- Food should be cut into smaller pieces and if meat pieces are large then debone them;
- Food items should be put evenly in the plate;
- Always place thicker/ larger portion of food in the plate towards the outside;
- During cooking stir / rotate the food several times;
- After cooking let the food stand for few minutes.
- Liquid / water may be superheated without appearing to boil. So, don't overheat it.
- To avoid bursting of the egg shell, cook the egg without shell as the steam built up inside the shell.

**Defrosting :**

- For defrosting, the packet of the food should be removed and placed it on microwave safe cookware. Always rearrange and rotate food while defrosting.

**Reheating :**

- For uniform and safe heating, always cover the food with the microwave safe lid / plastic wrap.
- Check the presence of vent at a corner of cooking dish which helps to escape steam during reheating.
- For heating high fat or high sugar content, food always leave an inch of air space in plastic wrap to avoid the melting.
- Reheat pre-cooked food and leftovers to serve hot.

**Conclusion :**

Since, the microwave technology has spread around the world. But, some studies on the possible harmful effect of microwave, that are enumerated above indicated that it may be advisable not to use microwave oven for daily cooking purposes and might be use for heating and defrosting food items with the mentioned safety guidelines.

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**Authors' affiliations:**

**PARVEEN SHAISTA AND ARCHANA CHAKRAVARTY**, Department of Home Science (Food and Nutrition), Banaras Hindu University, VARANASI (U.P.) INDIA

Email: [parveen87shaista@gmail.com](mailto:parveen87shaista@gmail.com); [archana.nutrition@gmail.com](mailto:archana.nutrition@gmail.com)

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