

Literature Study:

Microwaveability of Aluminium Foil Packages

for

European Aluminium Foil Association

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by

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1 Background and Goal

According to consumer perception and also to many operating guidelines for microwave ovens, the use of metal in microwave ovens is prohibited. This restricts the use of food packages containing aluminium foil like

- aluminium foil trays
- plastic trays with aluminium foil lids
- dishes or bowls covered with aluminium wrap foil

from being used as convenience cookware in microwave ovens

From a physical standpoint however, a well-controlled use of metal in microwave ovens is feasible. Public perception and guidelines may therefore wrongfully exclude aluminium foil from application in microwaveable food packages.

Goal of the literature study is to re-assess feasibility, safety and performance of microwave heating foods in packages containing aluminium foil by a literature survey.

This report presents the survey and a critical summary.

2 Critical Summary

Based on physical insight and on empirical findings, all evaluated studies agree that there is no reason to NOT use aluminium foil packages for heating food in the microwave oven – as long as some design rules and heating guidelines are followed. It is safe, similarly efficient and may be even more uniform than microwave heating of food in microwave transparent packages. Instructions are not more complicated than for microwave transparent trays and oven damage or degradation is practically no issue.

Still, the actual situation in the market and in public perception is quite different.

- Public microwave oven safety instructions declare use of metal (and implicitly aluminium foil packages) in the microwave oven as unsafe.
- Microwave oven manuals do not mention aluminium foil packages and lack appropriate instruction. They also prohibit the use of metal in the oven. On the other hand, oven manuals recommend use of aluminium foil to shield delicate parts of the food.

- Packaging manufacturers do not sell aluminium foil packages and foil trays as microwaveable. Instead, they developed plastic trays for use in the microwave oven.
- Producers of food for reheating do not use aluminium foil packages or trays very often (own observation in German super market). And if so, they recommend with few exceptions transferring food on to "microwave safe" i.e. non-metallic dishes before reheating in the microwave.

Conclusion:

It seems that there are either

- negative experience with aluminium foil packages in microwave ovens that is not reflected in the published studies;
- other (non-microwave) problems with food and aluminium foil like corrosion or discoloration;
- communication problems between foil manufacturers on one side and consumers, food producers, packagers, and oven manufacturers on the other side;
- further considerations (not directly linked to microwave heating) by food marketing, handling, convenience in favour of plastic trays.

In order to clarify and remedy the situation I would recommend the following measures:

- + A survey by interviews to find out if food and packaging producers and oven manufacturers have been confronted with negative experience in microwave heating of aluminium foil packages by their customers – in particular to find out, what is actually the basis for concern or reserve against aluminium foil packages.
- + Well documented microwave heating tests with meals in aluminium foil packages from the actual assortment found in super markets. (Such items are however rare in German supermarkets. And if food is offered in aluminium foil packages for heating, the packages are not optimised for the microwave oven. Possibly, new meals in aluminium foil packages have to be developed for the tests.)
- + Public demonstration of successful use of aluminium foil packages in microwave ovens, demonstrations in TV-shows or sale shows.

3 Physics of microwave oven

The kitchen microwave oven is a device to rapidly heat foods by application of electromagnetic fields of a frequency of 2.45 GHz. The heating mechanism is based on two interactions between food and microwave field:

- the dipolar interaction of water dipoles in the food with the fast alternating electric field;
- the ionic interaction of ions present in the food with the electric field.

Both mechanisms generate heat throughout the volume of the food.

Heat generation in the food is however not uniform. It is influenced by oven construction and geometry, which in turn influences field distribution or standing wave pattern in the oven cavity.

Heating is also influenced by the food shape and electric properties, which in turn influence coupling of the external electric field into the food and the excitation of internal standing waves inside the food. And of course, heat generation is influenced by the food container, which in case of the aluminium foil tray will reflect the incident microwave energy and allow coupling of the electric field into the packed food only from the open top side. Therefore a completely closed aluminium foil package will shield the food from the microwave field completely and no food heating will occur at all. For the oven this situation is equivalent to operation without an absorbing load and is not recommended. Examples for completely closed aluminium foil packages are aluminium foil trays with closed aluminium lid, food items wrapped into aluminium foil, or a food in a closed pouch of aluminised film.

All the mentioned influence factors are acting together and in mutual dependence to create a specific heating pattern in the food and they also determine rapidity, efficiency, and evenness of heating. In the end, these factors decide on the quality of the heated food.

Metal inside the microwave cavity has a strong influence on field intensity pattern and on coupling of the field into the food. Therefore careful analysis of the heating situation with metal food containers is important and requires theoretical as well as experimental work. But the same applies to oven construction and design as well as to proper food formulation and design of microwave transparent packages for best microwave heating results.

For a more detailed description see [BUFFLER] and [RISMAN]

Metal parts as aluminium foil packages heat only marginally in the microwave field, since electrically well conducting metal reflects and does not absorb the impinging microwave field. The metal may however assume an electric potential that is much different from other metal parts in the vicinity such as the oven walls. If the potential difference is high enough and the distance between neighbouring metal parts small enough, a voltage arc may occur. Arcing is promoted by sharp protruding edges. Therefore, smoothing the corners and edges of aluminium foil containers is recommended to keep risk of arcing as low as possible.

Arcing is one of the “dangers” usually linked to use of aluminium foil packages and other metal items in the microwave. But arcing can also occur between food and the oven wall and is not a singular risk with metal parts or aluminium foil packages. The risk of producing an arc unintended is however very low (see studies) The effect of an arc is usually negligible; in the worst case it is a small mark in the paint of the oven wall. It does not pose a safety threat to the oven operator or a damage risk to the oven and the magnetron.

4 Studies on Aluminium Foil Packages in Microwave Ovens

A number of experimental studies with aluminium foil packages in microwave ovens have been carried out since the late 1970ies. A good overview on studies up to 1988 is found in NICHOLL. All studies focus on foil trays, other forms of foil packages have obviously not been investigated.

The main cited sources are the study of Decareau, 1978 (DECAREAU) and Alusuisse, 1987 (ALUSUISSE). Further studies were carried out 1989/1990 by Campden Food and Drink Research Association (cited in FC1) and 1990/1991 by the Finland Technical Research Centre (AHVENAINEN1 and 2).

All studies agree, that:

- + use of aluminium foil trays for heating food in the microwave oven is perfectly possible, if a few guidelines are followed: Trays must not touch oven wall, trays should be shallow with a deepness of less than 3 cm, food should cover most or all of tray bottom;
- + safety of microwave oven operation is not affected by heating food in aluminium foil trays, if instructions are followed. If arcing occurs, it will not damage oven or start a fire but may cause minor aesthetic defects in the oven wall;

- + heating uniformity is in many cases better compared to heating in plastic or microwave transparent trays;
- + sensory quality of heated foods is also better with aluminium foil trays in many cases (AHVENAINEN1);
- + heating speed and efficiency is only little affected by use of aluminium foil trays. Decareau quantifies 0 % to 33 % slower heating of food in aluminium foil containers at the same oven power setting depending on food. Others mention influence of tray form (AHVENAINEN1, FC1) and oven construction (AHVENAINEN, RISMAN) on heating efficiency.

A somewhat less optimistic position is taken by Risman (RISMAN), based on theoretical considerations and experimental measurements of heating efficiency. He states a higher efficiency drop for aluminium foil trays (up to 50 %) and a problematic performance for frozen foods (“there will be almost no heating at all for the lowest 10 mm [at the bottom of an aluminium tray]”). The pessimistic view on heating frozen foods is not supported by the other studies.

Alusuisse performed a long-term test to detect negative influence of aluminium foil trays on magnetron operation lifetime. No negative or destructive influence on magnetron operation was detected after a test time equivalent to 32 years average household service life (ALUSUISSE).

A few general rules for microwave heating performance of aluminium trays can be derived from the studies-

- + food in round aluminium foil trays heats more rapidly (effectively) than in rectangular trays;
- + since food in aluminium foil trays heats only from above, deep trays are not recommended;
- + ovens with microwave coupling into oven cavity from below have a quite high drop in heating efficiency with aluminium trays – though heating of food in foil trays is perfectly possible.
(This oven construction is rarely found with home kitchen ovens but may be found in food service ovens.)
- + most studies mention a more uniform heating of food in aluminium foil trays, in particular with frozen food.
- + most studies point to the necessity to optimise food formulation, food lay out, and package design in order to achieve best heating results in the microwave oven.

Clear conclusion: according to the studies, there is no real obstacle against the use of aluminium foil trays in the microwave oven.

5 General Discussion on Microwaveable Aluminium Foil Packages

Possibly as a consequence of the positive outcome of the studies in the 1980ies and the early 1990ies, a number of publications appear in the early 1990ies, which positively discuss and promote use of aluminium foil trays in the microwave oven (see ADAMS, GEORGE, KENDAL, MORRIS, MURPHY, PERKIN, PIDGEON, SCHIFFMAN, SCHULZ, WIRTH). Some foil containers explicitly designed for microwave or dual oven use appear on the market (PN, VR). Perkin reports positive results of discussions with oven manufacturers that resulted in the endorsement of microwave use of foil containers by 10 oven manufacturers (PERKIN).

Only few restrictions are voiced. SCHULZ points out that uneven tray trims with protruding spikes may lead to arcing. "Verpackungs-Rundschau" mentions positive studies and existence of specific instructions but also expresses concern: "Since the observance of the instructions is not always guaranteed, the actual use of foil containers is not recommended" (VR).

Negative voices, dangerous incidences or other adverse experiences have not been found in the literature search.

However it seems, the discussion on use of aluminium foil packages in the microwave oven died out in the second half of the 1990ies. No more citations are found and the foil trays also seem to have disappeared from oven manuals and safety instructions. Even packaging manufacturers do not promote use of foil trays in microwaves.

A search on packaging-technology.com (PT) for the key words "microwave" and "microwaveable" delivered five hits – all of them concerning plastic packages. The online catalogue of Plus-Pak Company (PP) offers only plastic trays for microwave use. The same company offers smooth walled aluminium foil trays but without mentioning the possible use in microwave. In the material selection table of the catalogue however, the microwave use of aluminium is answered with "yes". Another packaging web-site, Packaging Automation Inc., gives a restricted recommendation for aluminium in its "Tray Materials and Applications"-selection table:

"Aluminium foil – crinkle wall: not recommended for microwave;
Aluminium foil – smooth wall: "Suitable for use in the oven and most microwaves" (PAI).

Own observations in a German super market support the general picture. There are only a few products packed in aluminium foil packages that are intended for heating. A large vendor of frozen meals, IGLO-Unilever, has a range of products in aluminium foil trays like "Schlemmerfilet", a frozen fish fillet with

topping that needs heating in the baking oven. The instruction for microwave heating is essentially:

- Take out the fillet from the aluminium tray,
- put it on a microwave safe dish,
- heat.

Only one food line in aluminium foil packages with recommendation for microwave heating was found: BUSS, a vendor of sterilised meals in aluminium foil trays gives the following instruction:

- remove cover lid from tray,
- put aluminium tray into microwave oven,
- cover with plastic dome,
- heat.

6 Public Information and Safety Guidelines on Microwave Ovens

Several information leaflets and presentations address the public in order to promote use of foil containers in the microwave oven and give a safe operating instruction: (AFCMA, Foil Container Bureau, ALUSUISSE). RAYTHEON presents a leaflet with consumer information on metal cookware designed for use in the microwave oven. The information presented seems correct and the user instructions adequate.

Some sites on the Internet (BHC, FDA, USDA) give safety instructions for use of microwave ovens. US Food and Drug Administration as well as US Department of Agriculture warn from use of metal in the microwave. "Generally, metal pans or aluminium foil should not be used in a microwave oven" (FDA). "Never use aluminium foil in the microwave oven" (USDA). Better Health Channel warns from using metal containers but concedes: "it's possible to use aluminium foil" (BHC).

7 Oven Manuals

Five oven manuals have been examined (BOSCH, LG, PANASONIC, SAMSUNG, SHARP).

There is a large reservation against the use of metal items in the microwave like: "Never use metal or metal trimmed utensils when using the microwave

function.” and “Metal objects in the oven may arc, which can cause serious damage.” (LG). “Do not use metal pans and bake-ware” (SHARP). “Metal utensils not recommended – these can damage your oven. Remove all metal before cooking.” (Samsung).

Surprisingly, ALL manuals recommend the use of aluminium foil sheets to shield delicate food parts from overheating!

NONE of the manuals even mentions the use of aluminium foil packages for heating food in the microwave oven - not to speak of detailed instructions for use of aluminium packages in the oven!

8 Possible Risks of Microwave Ovens

There are of course risks in operating a microwave oven - with and without aluminium foil packages. Aluminium foil packages and other metal items in the microwave oven may cause arcing if they are near each other or near the oven walls. Experiments with arcing and plasma balls are presented at different websites like BEATY and WEMAN. One site demonstrates metal melting in the microwave oven (REID).

The risk of producing an arc unintended is however very low (see studies) and not restricted to metal or aluminium foil packages as arcs have been observed between foods and between food and oven wall (RISMAN). The effect of an arc is usually negligible; in the worst case it is a small mark in the paint of the oven wall. It does not pose a safety threat to the oven operator or a damage risk to the oven and the magnetron.

Other risky situations are in my opinion much more severe:

- + Operation of empty microwave oven or oven with very small absorbing load will lead to high field intensities and increase risk of arcing and plasma forming. It may also increase reflection back into magnetron and shorten magnetron life.
- + Heating of food with full power until it is dried out and will char and catch fire (BUFFLER, “potato fire”, RISMAN).

The use of aluminium foil sheets to shield delicate parts of the food, as recommended by microwave oven manuals, seems more “dangerous” than use of aluminium foil packages. Foil sheets torn off from a roll usually have an irregular shape with protruding corners. These corners and tips are much more prone to arcing than regularly shaped and smoothed aluminium foil packages. Arcing with irregular shaped aluminium wrapping foil has been observed even when foil did not touch oven wall (AHVENAINEN2).

9 Literature Resources with Extracts

General Information on Microwave Oven

[BUFFLER]

Buffler C.R.: Microwave Cooking and Processing; Engineering Fundamentals for the Food Scientist,
New York, 1993

#

Microwave packaging materials are usually desired to be transparent to microwaves impinging to them.

Foil is usually used as shielding material in package design and is especially useful for multi-component meals where different portions need different heating rates.

Metal foil in the form of strips and patches may be used to modify and intensify the microwave electric field.

Metal foil, in general, is not recommended for use on a microwaveable package.

Fires: Desiccated foods heat rapidly to their burning point of 233 °C if left in the microwave oven.

Engineering improvements have essentially eliminated the technical problems with aluminium containers in modern microwave ovens.

Food products in metal trays may be defrosted or heated with no associated problems.

Microwave accessories for heating, browning and grilling have been developed from metal.

The use of foil to prevent overcooking of sensitive parts of food products has been recommended for 20 years. The use of large foil pieces is however not recommended.

Products with high salt content may arc when placed adjacent to each other or to the oven wall.

Experimental Studies

[AHVENAINEN1]

Ahvenainen R.; Heiniö R.-L.: Factors Affecting the Suitability of Aluminium-foil Trays for Microwave Oven Heating: Comparison with Plastic Trays
Packaging Technology and Science 5, 1992

#

Results of a study carried out at Finland Technical Research Centre in 1990-1991.

Comparison between aluminium and CPET trays with three different casserole type dishes in differently shaped trays. The initial condition was frozen and chilled.

Heating time in round aluminium trays shorter than in round plastic trays

Heating time in rectangular aluminium trays longer than in plastic trays

(exception: combination oven with hot air)

Heating was more uniform in aluminium trays: larger temperature difference inside a tray develop in plastic trays, in particular with frozen food.

Sensory judgement of heated food was in all cases in favour of aluminium trays, difference was very significant for frozen food. In plastic trays, dried out and burned spots in corners were observed.

Appearance of aluminium trays after heating was in all cases better than plastic trays where food sticking to the wall was observed.

Arcing has been observed in some cases, when trays touched walls or two trays touched each other. The likelihood of arcing depends also on oven construction.

Situation is more complicated with multi-component meals. Proper choice of component geometry and lay out is more important than choice of packaging material.

Resume: aluminium trays are very promising packages for chilled and frozen food products intended for microwave heating. Provisions have to be taken to avoid arcing.

[AHVENAINEN2]

Ahvenainen R.; Sipiäinen-Malm T. et al.: Packaging Materials in Microwave Ovens
Packaging Technology and Science 5, 1992

#

Results of a study carried out at Finland Technical Research Centre in 1990-1991.

When correctly used, aluminium trays are suitable for heating both refrigerated and frozen foods in a microwave oven.

Quality of pizza and casserole after heating is better in aluminium trays than in plastic trays.

Aluminium trays should not touch oven walls.

Aluminium wrap foils used to cover food sparked, even when they did not touch the wall!

[ALUSUISSE]

Aluminium Foil Containers in Microwave Ovens

1987

#

Report on experiments at Alusuisse Research Institute in Neuhausen, Switzerland

The output power of a magnetron is higher with higher food load (and lower reflection into magnetron)

No oven damage with partly filled aluminium trays was observed in a long term test equivalent to 32 years of service.

No arcing has been observed in all tests. In practice, the subject is hardly of importance.

Energy consumption with the use of aluminium foil containers is comparable with that of other materials. For small containers, slight advantage for plastic container. With large containers, slight advantage for aluminium. For frozen food, always slight advantage for aluminium.

Heating in aluminium containers is more uniform with chilled and with frozen products due to suppression of edge overheating. Heating speed with aluminium containers is not significantly different from heating in plastic containers.

[BLACKMORE]

Blackmore M.A.; Staddon M.: Aluminium Foil Containers in Microwave Cookers
Aluminium Foil Container Manufacturers Association, 1986

#

Two different meals in aluminium containers and earthenware were reheated from frozen to 90 °C in a 700 W microwave at different power settings.

Heating of the food in aluminium containers was successful and gave acceptable sensory results. Heating in earthenware was faster.

[BOLLINGER]

Bollinger M.: Was geschieht im Mikrowellenofen? Das Verhalten von Aluminiumschalen

Schweizer-Aluminium-Rundschau, 1989

#

Cites results of Alusuisse study and additional studies at the Swiss Material Test Laboratory in St. Gallen.

Article promotes use of foil containers in microwave. More uniform heating of chilled and frozen food in foil single compartment trays than in plastic trays. In foil multi-compartment trays more uniform temperatures between compartments and temperature equilibration due to thermal conductivity of aluminium foil.

Also positive performance in dual-ovens with microwave and infrared heating. With foil containers, lower temperature of packaging material. With PET container, packaging material temperatures reach critical values.

[DECAREAU]

Decareau R.V.: The Effect of Aluminium Packaging Materials on Microwave Oven Performance; Final Report, 1978

#

No concern by oven manufacturers on using aluminium containers.

No load operation more likely to be a potential source of magnetron damage than use of aluminium containers.

Frozen foods in aluminium containers can be heated successfully.

Quality of heated food equal or better than of food heated in plastic containers.

Difference in heating time in aluminium compared to plastic container is 0 to 33 % (depends on food product).

Arcing only occurs if the container is allowed to touch oven wall.

No evidence of adverse effects on magnetron tube.

[FC1]

Foil Container Bureau: Foil Containers in Microwave Ovens – Background Notes On Tests by Campden Food and Drink Research Association, 1990

#

All tested aluminium containers may be used safely in the microwave oven.

Even in induced abuse conditions, arcing occurs infrequently.

No physical damage to the oven was recorded.

[NICHOLL]

Nicholl Food Packaging Limited: Archive UK AFCMW. Microwave Information 1988

#

Very good survey which summarizes 10 years of studies and experience with aluminium containers in microwave oven.

All reports and articles endorse use of aluminium foil containers in microwave ovens. No detrimental effects are observed, if instructions are followed properly.

Arcing: only observed under no-load conditions with container touching wall

Magnetron: no degradation and overheating observed, no frequency detuning

Cooking performance: Equivalent to other packaging materials. Heating uniformity is improved in many cases.

Efficiency: may be insignificantly lower than with plastic containers.

[RISMAN]

Risman P.O.: Metal in the Microwave Oven Microwave World 13(1), pp 28-32, 1992

#

Theoretical and experimental study on microwave heating with metal and plastic containers.

In general, the oven efficiency or the fraction of the magnetron generated MW-power that goes into heating the food item is lower with metal containers. Details depend on oven construction, container geometry and position, electric properties of food. The efficiency drop is most pronounced with ovens with bottom feed. Efficiency drop is less with frozen foods.

Lower efficiency means also higher electric field in the oven cavity, which may lead to higher risk of arcing, and more reflection back to the magnetron, which may shorten operation lifetime.

Fast degradation of magnetron operation by metal containers is no issue with modern microwave ovens.

Reasonably good thawing will be achieved in a metal container, if thickness of food is lower than two to three times penetration depth. But almost no thawing will occur in the lowest 10 mm and in the bottom corners of a rectangular tray.

Ignition of a potato or other items, which have been heated for abnormally long times so that they dry and charring begins, is by current arcs in the electrically conductive carbon.

[SEVERUS]

Does Foil Packaging have a Microwave Future? Aluminium Foil Containers in Microwave Ovens

Dr. H. Severus, ALUSUISSE

#

long term operation test of 3700 operating hours, corresponds to 32 year service life with 15 min operation per day. Test with plastic and aluminium trays filled with a water hose. Power degradation of 15 % at end of operation test was measured.

Aluminium container depth should not exceed 30 mm.

A few millimetres distance of container edge from oven wall prevent arcing.

Smoothly rolled rims and plastic or lacquer coatings further reduce possibility of arcing.

With small containers, heating efficiency is better for plastic than aluminium containers; with large containers ($D > 21$ cm) efficiency is better with aluminium containers.

Efficiency lower with aluminium containers, if MW-feed into oven is from below; but heating still possible.

Heating uniformity in test with lasagne better in aluminium tray. This is most pronounced at start of heating (= edge overheating in plastic tray)

Advantage for aluminium in combination ovens (MW+grill+hot air) with high temperatures > 200 °C.

Ready meals in aluminium containers already on the market.

[WIRTH]

Wirth O.E.: Mikrowellengerechte Verpackungen aus Aluminium
Verpackungsrundschau 11, 1991

#

Results of Alusuisse study are reported.

General Contributions and Discussion

[ADAMS]

Adams B.; Hayter J.: Foil and the microwave oven
Microwave packaging - the Pira biennial update, 1991

#

Aluminium foil containers can be safely and advantageously used in the microwave. Heating uniformity may be improved.

New developed microwave active packaging (Micro Match system): foil tray with plastic or cardboard lid which is equipped with a foil pattern to improve heating uniformity.

[FLOWER]

Flower P.J.; Jones C.I.: Microwave Receptor Developments in Cartons and Flexible Packaging
Packaging Technology and Science 4, 1991

#

Microwave susceptors/receptors by adding metal patterns to packing material.

[GEORGE]

George R.M.: Recent progress in product, package and process design for microwaveable foods

Trends in Food Science & Technology 4, 1993

#

Aluminium foil packaging materials can be used to reduce edge overheating and improve heating uniformity.

Active packaging with susceptor films for crisping and browning.

Metal film patterns printed on package to direct microwave energy to defined parts of the food (artificial dielectrics) and promote uniform heating.

[KENDAL]

Kendal N.: Foil in the Microwave – Due Diligence and the Environment.

The Microwave Association, 6th annual conference 1991

#

Cites a number of studies of safety and quality use of aluminium foil containers in microwave ovens.

Impact on better recycling of aluminium foil compared to high temperature plastic. Examples of microwave oven instructions with reference to aluminium foil containers from Samsung, Ariston, Electrolux.

[LEVINSON]

Levinson S.: You Can Use Metal in a Microwave Oven
Microwave World 13(1), pp 24-27, 1992

#

Article promotes development and use of metal cookware for microwave ovens. Ovenware manufacturers should label their product "Microwave Safe", similar to plastic, glass, and ceramic ovenware.

[MORRIS]

Morris C.: Microwave method for aluminium food-trays
Food engineering, 1981

#

Citation of Decareau study and ACFMA illustrated six-step procedure for microwave use of aluminium trays.

A frozen food manufacturer, Amana Refrigeration Co., does not approve method because of slower heating and uneven heating in multi-component meals.

[MURPHY]

Murphy M.; Hunt J.: Bright future for foil in the microwave
Packaging Week 10(17), pp 14-15, 1994

#

Introduction of new frozen meal for microwave heating in specially designed aluminium tray (Microfoil). The tray has an oval cut out in the bottom to let microwave energy enter from below. The tray has a carton over-pack and is heated in the overpack.

[MW]

The Foil Issue is Alive and Well
Microwave world 1/1, 1980

#

Summary of controversial presentations at a conference. A large packaging producer and manufacturer of aluminium foil trays (E-Z por) questions findings of Decareau and strongly recommends cardboard packaging.

[PERKIN]

Perkin J.: The Allure of Aluminium
Food processing, 1993

#

Ten microwave oven manufacturers endorse use of aluminium foil trays in their ovens.

Results of experiments at Campden Research are cited.

[PIDGEON]

Pidgeon R.: Microwaveable foil tray get go-ahead
Packaging week 8/19, 1992

[PN]

Foil cleared for microwaves as ovenable board makes UK debut
Packaging news, 1979

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Citation of the Decareau study

[SCHIFFMAN]

Schiffmann R.F.: Verwendung von Aluminiumfolien-Verpackungen in
Mikrowellenöfen
Neue Verpackung, 1987

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According to own investigation for Alcoa 1985, no damage to magnetron by
aluminium trays in magnetron. Arcing may occur but in rare instances and is
very unlikely to start a fire.

Evenness of heating may be a problem (hot spots in tray). Deep trays are not
recommended.

[SCHULZ]

Schulz E.: Mikrowellengeeignete Verpackungen von Convenience-Produkten für
Endverbraucher
Lebensmitteltechnik 4, 1991

#

Aluminium trays can be used in microwave ovens, trays are dual-ovenable.

Tray geometry has to be optimised for heating uniformity

Uneven tray rims with protruding spikes may lead to sparking/arcng.

[VR]

Verpackungsmaterial und Spezialfolien für die Mikrowellentechnik
Verpackungs-Rundschau, 1991

#

New developments in microwaveable and dual-ovenable packaging materials:
plastics, cardboard, multilayer films. Foil containers in microwave oven are used
to some extent in the US, based on studies and specific instructions. Since the
observance of the instructions is not always guaranteed, the actual usage of foil
containers is not recommended.

[WIRTH]

Wirth O.E.: Aluminium Foil Containers for Microwave Ovens: Exploding the
Myth with Hard Facts
Journal of Packaging Technology 2/2, 1988

Results of Alusuisse study are reported.

[RMI]
Ready Meals Info: New ready meal packaging concepts thanks to aluminium foil containers
<http://www.readymealsinfo.com/articles/aluminium.htm>

... there is still a curious reluctance on the part of food companies to educate their customers about the advantages and complete safety of using foil containers in microwave ovens.
In the case of the Danish 'MenuSystem', the foil-packed meals are supplied expressly for re-heating in microwave ovens. The only measure required to stop arcing is to place any aluminium dish on a ceramic plate or turntable and no to allow metal items to touch.

[PAI]
Packaging Automation Inc.: Tray Materials and Applications
<http://www.pal.co.uk/materials.php>

Aluminium foil – crinkle wall: not recommended for microwave
Aluminium foil – smooth wall: "Suitable for use in the oven and most microwaves"

[PP]
Plus Pak: Online Catalog, New Products, Ready-to-cook smooth wall aluminium containers.

<http://www.pluspack.dk/side.php?side=66>

Microwaveable packages: PP-trays are offered
Aluminium trays: Microwave heating is not mentioned in product description!
But in material guide for microwave use: aluminium – yes!

[PT]
[packaging-technology.com](http://www.packaging-technology.com)
<http://www.packaging-technology.com/search.asp>

Search for "microwave" or "microwaveable": 5 hits, none with aluminium.

Public Information, Guidelines, and Consumer Instruction on Use of Aluminium Foil Packages in Microwave Ovens

[AFCMA1]
AFCMA: Aluminium Foil Containers are the Smart Choice for both the Environment and the Microwave

#

Statement on positive role of aluminium trays in package recycling.

[AFCMA2]

Microwave cooking with Aluminium Containers
Aluminium Foil Container Manufacturers Association

#

Step by step cooking instruction for food in aluminium trays in microwave ovens.

Aluminium trays should have rather full compartments. More food than aluminium should be exposed to the microwave.

[ALUSUISSE]

Alusuisse: Aluminium Foil Containers in the Microwave Oven
Public Information

#

Results of the Alusuisse Study are presented.

[FC2]

Foil Container Bureau: Foil Containers in Microwave Ovens – Guidelines for Food Processors on Packaging Development, 1990

#

formulated after tests by Campden Food and Drink Research Association
Packages have to be tested for each individual product in order to identify optimum container construction and shape.

According to guidelines on microbiological safety, a minimum temperature of 72 °C should be reached throughout the food during microwave heating.

Recommendation for shallow containers with 30 mm depth or less.

Foil or foil-board lids have to be removed.

Stirring is recommended for more uniform heating.

Place tray in the centre of the oven and not closer than 6 mm to a metal surface. Heat containers one by one in the microwave oven. Containers must be at least two thirds full.

[FC3]

Foil Container Bureau: Better Cooked Results from Your Microwave Oven Using Shallow Aluminium Foil Containers, 1995

#

Consumer Microwave Information Leaflet

Benefits of aluminium trays: more protection of delicate food, more even heating, food can be browned under the grill.

Use shallow trays, around 3 cm deep. The foil shields the sides and base of the food from overheating. Make sure that container does not touch any other metal such as oven walls. Cover with a plate or cling film. Increase cooking time by 10 %.

Over twenty oven microwave manufacturers have approved the use of foil containers.

Aluminium foil has long been recommended for shielding chicken wing tips from overcooking. There is therefore nothing intrinsically wrong with using metal in the microwave oven.

[RAYTHEON]

Raytheon Micro 21 - Use of Metalware in Microwave Ovens.

Consumer Information on microwave cookware with metal parts from Raytheon Company

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There is no hazard in placing utensils that have been designed for microwave cooking into microwave ovens, even if they contain metal structures or elements..... The use of metal allows the microwave energy to be directed into more efficient operation and cooking process.

The precautions against empty oven operation must still be observed – with or without the cooking utensils.

[EAFA]

EAFA: Alufoil File

2004

#

Consumer information on alufoil containers. Contains a brief guideline on using alufoil containers in microwave ovens.

Public Safety Instructions on Microwave Ovens

[BHC]

Better Health Channel: Microwave Ovens Safety Issues

http://www.betterhealth.vic.gov.au/bhcv2/bhcarticles.nsf/pages/Microwave_ovens_safety_issues?open

#

“Don't use metal containers or containers with metal trims.

It's possible to use aluminium foil. Check with your instruction manual, but generally speaking, you can use small amounts of aluminium foil (for example, to shield chicken wings from overcooking) as long as the foil doesn't touch the sides of the oven.”

[FDA]

U.S. Food and Drug Administration (FDA) – Center for Devices and Radiological Health: Microwave Oven Radiation

<http://www.fda.gov/cdrh/consumer/microwave.html>

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“Generally, metal pans or aluminum foil should also not be used in a microwave oven, as the microwaves are reflected off these materials causing the food to cook unevenly and possibly damaging the oven.”

[LEMF]

LessEMF.com: Microwave Oven Radiations Hazards & Standards

<http://www.lessemf.com/mw-stnds.html>

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"It is very important that food containers which have been designed to package frozen or chilled foods such as ice cream or margarine, are not exposed to high temperatures in a microwave oven. The low melt temperatures of these plastics may result in migration of undesirable contaminants into the food or in physical disintegration of the containers themselves.

As migration is more likely to occur into hot fatty foods, glass containers are preferred to plastic for heating them.

[USDA]

USDA Food safety and inspection service: Cooking safely in the microwave oven

<http://www.fsis.usda.gov/Frame/FrameRedirect.asp?main=/oa/pubs/microwav.pdf>, 2000

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" Never use thin plastic storage bags, brown paper or plastic grocery bags, newspapers, or aluminium foil in the microwave oven."

[SPRAGUE]

Sprague D.: A better approach to microwave oven safety.

Health Physics Society,

<http://hps.org/hpspublications/articles/microwaveoven.html>

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Food and Drug Administration/Center for Devices and Radiological Health (FDA/CDRH) performance requirements in Title 21, CFR, Part 1030.10. This requirement states that new ovens may not leak microwave radiation in excess of 1 mW cm⁻² at 5 cm from the oven surface. It also states that ovens, once placed into service, may not leak microwave radiation in excess of 5 mW cm⁻² at 5 cm from the oven surface.

Oven Manuals

[BOSCH]

Instruction for use: HMT 9626 / EU, HMT 9659 / EU

Bosch GmbH

#

Safety information for microwave operation. Risk of scalding: When heating up liquids, always place a teaspoon in the container to prevent delayed boiling.

Ovenware: Ovenware made of metal can block the microwaves which means that the food closed in metal containers remains cold.

Make sure that there is a gap of at least 2 cm between metal items such as

spoons and the walls or the inside of the door.

Defrosting: Delicate parts such as legs and wings of chicken or fatter outer layers of roasts can be covered with small pieces of aluminium foil. This prevents the food from cooking too quickly. The foil must not come into contact with the oven walls.

Heating food: when heating liquids, always place a teaspoon into the container to stop the liquid from boiling over.

NO mentioning of aluminium foil trays!

[LG]

Microwave oven operation manual: Model MP-9482S

Lucky Goldstar Electronics Inc.:

#

Shielding: Strips of aluminium foil (which block microwaves) can be placed over the corners or edges of square and rectangular foods to prevent those portions from overcooking. Never use too much foil and make sure the foil is secured to the dish or it may cause 'arcing' in the oven.

If necessary, shield small areas of meat or poultry with flat pieces of aluminum foil. This will prevent thin areas becoming warm during defrosting. Ensure the foil does not touch the oven walls.

"Metal objects in the oven may arc, which can cause serious damage."

"Never use metal or metal trimmed utensils in using microwave function!

Microwaves cannot penetrate metal. They will bounce off any metal object in the oven and cause arcing, an alarming phenomenon that resembles lightning."

The oven is equipped with a round metal tray to put food containers on it (for defrosting)!

NO mentioning of aluminium foil trays!

[PANASONIC]

Operating Instructions Over The Range Microwave Oven: Models NN-H264/S254

Panasonic Inc.

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Use of aluminium foil in the microwave oven: for shielding only;

Comments: Small strips of foil can be moulded around thin parts of meat or poultry to prevent overcooking. Arcing can occur if foil is too close to oven wall or door and damage to your oven will result.

When using foil in the oven, allow at least 1-inch (2.5 cm) of space between foil and interior oven walls or door.

Metal bakeware: not recommended.

NO mentioning of aluminium foil trays!

[SAMSUNG]

Microwave Oven Owners Manual: MD800WC/SC

Samsung Corp.

#

Cooking Utensils:

Limited use: Aluminium foil – use narrow strips of foil to prevent overcooking of exposed areas. Using too much foil can damage your oven, so be careful.

Not recommended: metal utensil – These can damage your oven. Remove all metal before cooking.

NO mentioning of aluminium trays!

[SHARP]

MICROWAVE OVEN OPERATION MANUAL: MODEL R-409HK

Sharp Corp.

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DO NOT USE metal pans and bake-ware.

How to use aluminium foil in your microwave oven: Small flat pieces of aluminium foil placed smoothly on the food can be used to shield areas that are either defrosting or cooking too quickly. Foil should not come closer than one inch to any surface of the oven.

Shield with small flat pieces of aluminium foil any thin areas of meat or poultry to prevent overcooking before dense, thick areas are cooked thoroughly.

Defrosting: shield already thawed parts of the food item with aluminium foil.

NO mentioning of aluminium foil containers.

Miscellaneous

What's new in Microwave Modelling

35th Annual Microwave Symposium

Microwave World 21/1, 2000

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No contributions on aluminium foil containers

[STR]

Strahlenschutzkommission: Elektromagnetische Felder neuer Technologien

Statusbericht 2003

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Microwave ovens are mentioned but not treated.

Microwave Experiments under Abuse Conditions

[BEATY]

Beaty W.J.: Unwise Microwave Oven Experiments

<http://www.amasci.com/weird/microexp.html>

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Two adjacent aluminium foil sheets can produce an arc, which evaporates pieces from the foil sheets.

If flames form in the microwave oven, they will absorb microwave energy and form a plasma ball floating to the oven ceiling.

[WEMAN]

We-man: We-man's funny things to do with your microwave oven

<http://margo.student.utwente.nl/el/microwave/>

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Aluminium layer of CD will burn away under arcing in a microwave oven.

[REID]

Reid D.: Melting metals in a domestic microwave

<http://home.c2i.net/metaphor/mvpage.html>

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Metal is melted in the oven for small size hobby metal casting