Executive Summary of Final Report

Study on Microwaveability of Aluminium Foil Packages
Phase II: Experimental Study

for:
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1 Summary

Goal and Scope

After a first literature study on microwaveability of food packages containing aluminium foil and household foil, an experimental study on the subject was performed. The experimental study assesses feasibility, safety and performance of microwave heating foods in packages containing aluminium foil and household foil. Results of heating experiments will provide sound information on performance and proper use of these packages in microwave heating applications.

About 190 aluminium foil trays have been heated in four different kitchen microwave ovens. Test products have been tap water, egg batter, frozen lasagne, and minced meat. In addition, 10 plastic beakers and 10 trays with lids made from aluminium foil or aluminium laminate were tested. In these cases, the food products were a noodle soup and a children menu. Finally, microwave heating of food on a porcelain dish covered with household foil was tested. The test food in this case was a loaf of minced meat. Heating efficiency, heating uniformity, and possible hazardous conditions have been investigated.

Safety

Not a single case of hazardous condition has been observed in any of four microwave ovens during more than 200 heating procedures with packages containing aluminium foil at maximum microwave power setting. No damages or changes to ovens could be noticed. Severe abuse situations had to be constructed in order to provoke electric sparks with aluminium foil trays.

The abuse situations were:

+ empty aluminium foil tray inside oven, touching the oven wall at full microwave power;
+ two empty aluminium foil trays inside microwave oven, touching each other.

Both abuse situations are clear violations of heating instructions and should not occur in normal household use of microwave ovens. Therefore they seem not to be of practical relevance.

Twelve tests with household foil wrapped over dishes were also performed. Only one single electric spark without any relevance to safety occurred during these twelve tests. The spark formed for a fraction of a second at a large fold of the foil and burnt a hole of about 1 cm diameter into the foil. The incident had no consequence to safety or aesthetic of oven and did not alter quality of heated food.

Heating Time and Heating Efficiency

Heating efficiency is in general lower with aluminium foil trays. Heating times to achieve the same heating effect are longer than in plastic trays and the consumed electric energy is higher by the same proportion.

The extension of heating time for aluminium foil trays over heating time for plastic trays varied between 20% and 70%, depending on food and tray geometry. Also a large influence of oven design on heating performance of food in aluminium foil trays was observed with a preference for ovens with a horizontal magnetron antenna in the microwave feeding window.

Generally, the heating efficiency was smaller for small trays with a lower ratio of open surface dimensions to microwave wavelength. Also the ratio of open surface area to food volume may play a role. The dependence of the efficiency from food properties is not as clear. Efficiency was at the low end for tap water and at the high end for egg batter. Frozen lasagne and meat ball mass were in between.

For plastic containers with foil lid as tested with a children meal in a plastic tray and a noodle soup in a plastic beaker, the effect of the lid on heating efficiency is very small. The needed heating time extension to achieve the same heating effect as without lid was estimated to about 10%.

Heating Patterns and Heating Uniformity

Food heating patterns are quite different in aluminium foil trays and in plastic trays. In plastic trays, the microwave energy heats preferably the edges and corners of the food filling. The centre usually heats slower. In aluminium foil trays, microwave energy heats preferably the upper layers of the centre region of the filling. Corners and in particular the bottom edges are heated least. In trays of both materials, very uneven heating can be observed. It depends on the tray geometry and the food material, how uniform the heating will be.

In experiments with egg batter, the heating patterns were different between aluminium foil trays and plastic trays but similar with respect to amount of non-uniformity or to maximum temperature difference. The experiments did not indicate a clear advantage nor a disadvantage for aluminium foil trays with respect to heating patterns. In experiments with microwave heating of frozen lasagne portions and meat ball mass, rather satisfying and appealing heating patterns have been achieved in aluminium foil trays. Also heating seemed to be more uniform.

Visual appearance of lasagne and meat ball mass heated in foil trays was better because a nice brown crust was formed on the surface.

Conclusion

No hazardous situation or oven damages have been observed during heating more than 200 food portions in packages containing aluminium foil and household foil in four different microwave ovens at full microwave power.

Microwave heating patterns in aluminium foil trays are different from patterns in plastic trays and similarly uneven. In same cases, uniformity is better in aluminium foil trays. Satisfying heating results can be achieved in both tray forms.

Heating efficiency is lower in aluminium foil trays than in equivalent plastic trays. The actual difference in heating efficiency depends on food properties, tray geometry, and oven design.

Microwave heating of food packed in aluminium foil trays or in plastic containers with aluminium foil or aluminium laminate lids is perfectly viable. Use of aluminium household foil to cover foods during microwave heating is considered safe but may lead to sparking and should not be promoted.

2 Guidelines

Microwave heating of food in packages containing aluminium foil like foil trays or plastic containers with foil lids is uncritical. Only very few additional rules have to be followed compared to packaging or containers without foil. More or less the guidelines issued many years ago by the American Aluminium Foil Container Manufacturers Association (AFCMA) still apply:

1) Remove metal lid or wrap from container

2) Make sure the container is not much bigger than the food it holds

3) Loosely cover the container with plastic wrap

4) Place foil container directly on plate or glass dish

5) Position the foil container in the centre of the microwave oven – at least 2.5 cm away from the side walls - and ensure that the container is not touching other metal or foil

6) Cook or heat food to desired temperature

Modern microwave ovens have turn tables made from glass or a ceramic material with a rim. These support positioning of food trays in order to avoid any touch to the wall (rule 4 and 5). The consumer has to be made aware, that a foil tray must not be put directly onto the metal floor of the cooking chamber, on a metal browning plate or a metal grill delivered with many microwave ovens. Also it is important to remind, that aluminium foil lids on foil trays or other foil wraps that prevent entrance of microwave energy to the food have to be removed prior to heating.

If these rules are followed, microwave heating of foods in packages with foil is perfectly safe and adequate.

Food manufacturers however have to consider some additional and more complicated questions. To answer these questions, microwave heating experts may be consulted.

With plastic containers with foil lids, not much difficulties will arise. Heating is safe and heating times to achieve a desired heating effect are only slightly longer with foil lid than without or with plastic film cover. Also heating patterns will not be significantly affected, if the gap between food surface and lid is large.

If the manufacturer intends to market food in foil trays intended for microwave heating, some technical questions have to be resolved. In particular the food composition and arrangement and the tray geometry have to be optimised in order to support efficient and uniform heating. The general rules concerning tray geometry are:

1) Filling height in the tray should not exceed 25 mm.

2) The food should fill the tray from wall to wall without air gaps at the walls, since these would promote intensive energy coupling into the food near the gap.

3) The corners and edges of the tray should be rounded to avoid spots with very low field intensity and poor heating.

4) Larger trays have better heating efficiency than small trays.

5) The manufacturer also has to keep in mind, that heating patterns in foil trays are completely different from heating patterns in plastic trays and may therefore lead to different sensory results. This is in particular of importance for solid foods that cannot be stirred to create a uniform mixing temperature.

An additional concern is the proper heating instruction for the consumer. Usually the heating times necessary to achieve a desired heating effect are longer for food in aluminium foil trays than for food in plastic trays. The actually needed increase in heating time depend on the food, the tray geometry, and the oven design. Extensive testing is needed during product development to achieve good heating results in most microwave ovens.

If these questions can be positively resolved, the resulting food product in packages with aluminium foil can be heated in a microwave oven rapidly, with good efficiency, and to a sensory quality that is not different from food in plastic trays.

3 Conclusions

Heating safety

Not a single case of hazardous condition has been observed in any of four microwave ovens during more than 200 heating procedures with packages containing aluminium foil at maximum microwave power setting. No damages or changes to ovens could be noticed. Severe abuse situations had to be constructed in order to provoke electric sparks with aluminium foil trays.

The abuse situations were:

+ empty aluminium foil tray inside oven, touching the oven wall at full microwave power;
+ two empty aluminium foil trays inside microwave oven, touching each other.

Both abuse situations are clear violations of heating instructions and should not occur in normal household use of microwave ovens. Therefore they seem not to be of practical relevance.

One spark without any relevance to safety occurred during 12 tests with household foil wrapped over dishes. The spark formed for a fraction of a second at a large fold of the foil and burnt a hole of about 1 cm diameter into the foil. The incident had no consequence to safety or aesthetic of oven and did not alter quality of heated food.

Microwave heating of food in foil trays or in plastic containers with foil lid is safe if a few guidelines are followed. The basic rule is, that contact from the foil of the package to oven walls oven floor or to other metal parts must be avoided. Even if such a situation occurs by error or incident, it is very unlikely, that a dangerous situation will develop. The occurrence of sparks can be spectacular and may alarm and worry the user but is not a dangerous situation and will not damage the oven.

Quality of heating

Heating patterns differ considerably between aluminium foil and plastic trays. In many cases they are complementary. In some applications (frozen lasagne, meat ball mass) the microwave heating seems to be more uniform in aluminium foil trays than in plastic trays. This is of no importance, if the food is liquid and can be stirred after heating to achieve a uniform mixing temperature.

In some cases also the visual appearance of heated food was better in aluminium foil trays by surface browning and crust forming than in plastic trays, where the surface remained wet and soft.

In practically all heating trials, it was possible to achieve satisfying heating results with aluminium foil trays and with plastic trays without optimising the heating regime. The trials always used maximum oven power

and heating times that resulted from a schematic calculation. Further improvements of heating results in aluminium foil trays seem possible, if heating regime is optimised and adapted to the specific food.

Heating efficiency

Heating efficiency is in general lower with aluminium foil trays. Heating times to achieve the same heating effect are longer than in plastic trays and the consumed electric energy is higher by the same proportion.

The extension of heating time for aluminium foil trays over heating time for plastic trays varied between 20% and 70%, depending on food and tray geometry. Also a large influence of oven design on heating performance of food in aluminium foil trays was observed with a preference for ovens with a horizontal magnetron antenna in the microwave feeding window.

Generally, the heating efficiency was smaller for small trays with a lower ratio of open surface dimensions to microwave wavelength. Also the ratio of open surface area to food volume may play a role. The dependence of the efficiency from food properties is not as clear. Efficiency was at the low end for tap water and at the high end for egg batter. Frozen lasagne and meat ball mass were in between.

For plastic containers with foil lid as tested with a children meal in a plastic tray and a noodle soup in a plastic beaker, the effect of the lid on heating efficiency is very small. The needed heating time extension to achieve the same heating effect as without lid is estimated to about 10%.

With a porcelain dish wrapped by household foil, the heating efficiency was not much decreased by the foil, despite the fact that only a rather small area at the bottom of the dish was open for microwave entrance to the covered food. In a trial with water as a food load, the heating time extension compared to heating time without lid was estimated to 20%, with meat ball mass it was estimated to 40%.