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(54) Title: PREPARED MEAL PRODUCT FOR MICROWAVE OVEN

(57) Abstract: The present invention relates to a prepared meal product for being heated in a microwave oven and a method for heating said prepared meal product in a solid state microwave oven, wherein the prepared meal comprises a tray with separate areas and food items, characterized in that at least one area of the tray is more thermally insulated than at least one other area of said tray.

Title: Prepared meal product for microwave oven

The present invention relates to a prepared meal product for being heated in a microwave oven and a method for heating said prepared meal product in a solid state microwave oven.

Household microwave ovens are very common appliances with more than 90% household penetration in the US and comparable numbers in other industrialized countries. Besides the re-heating of leftovers, the preparation of frozen meals and snacks is considered to be the most important use of microwave ovens in the US. The main benefit of microwave ovens is their speed, which is a result of the penetration of the electro-magnetic waves into the food products. Although this heating mechanism is sometimes called 'volumetric heating', it is important to know that the heating pattern is not very even throughout the volume of the food. In fact, there are several aspects of today's household microwave ovens and their interaction with food that can lead to unsatisfactory results: The vast majority of household microwave ovens have a magnetron as microwave source, because this device is inexpensive and delivers enough power for quick heating. However, the frequency of microwaves from magnetrons is not controlled precisely and may vary between 2.4 and 2.5 GHz (for most household ovens). Consequently, the pattern of high and low intensity areas in the oven cavity is generally unknown and may even vary during the heating process.

Solid State Microwave Technology is a new technology and offers several advantages over magnetron-based technology. The main difference lies in the precise control of the frequency, which is a result of a semiconductor-type frequency generator in combination with a solid state amplifier. The frequency is directly related to the heating pattern in the cavity, so a precise frequency control leads to a well-defined heating pattern. In addition, the architecture of a solid state system makes it relatively easy to measure the percentage of microwaves that are being reflected back to the launchers. This feature is useful for scanning the cavity with a frequency sweep and determining which frequency, i.e. pattern, leads to more absorption by the food and which is less absorbed. Multi-channel solid state systems offer additional flexibility in that the various sources can be operated at the same frequency, with the option of user-defined phase angles, or at different frequencies. The solid state microwave technology is further described for example in: P. Korpas et al., Application study of new solid-state high-power microwave sources for efficient improvement of commercial domestic ovens, IMPI's 47 Microwave Power Symposium; and in R. Wesson, NXP RF Solid State cooking White Paper, NXP Semiconductors N.V., No. 9397 750 17647 (2015). Examples of such solid state microwave ovens are described in US2012/0097667(A1) and in US2013/0056460(A1).

Prepared meal products often come in multi-compartment trays. The food components or items in the various compartments are usually very different in nature and therefore have different requirements of heating. A common problem is that the amount of energy supplied to each of the compartments does not meet the culinary requirements of the food therein. For instance, the meat component of a meal typically requires more energy than the vegetable component. Since all components need to reach a safe temperature, the vegetable portion is often overcooked.

A further complication arises when the prepared meal product is initially frozen when being placed in a microwave oven for being defrosted first in the oven at a lower energy level and then being heated in a continuous subsequent manner at a higher energy level to the desired temperatures for each compartment.

This means that there is a need for targeted microwave heating. The problem is that the heating effect by microwaves is difficult to control in general. Even solid state microwave technology, with its precise frequency control, does not solve the problem per se. The knowledge of which frequency causes heating in which part of the product is difficult to obtain. Existing solutions use microwave active packaging materials, such as susceptors or shielding. For example, WO2017/092913A1 discloses a packaged food product for being heated in a solid state microwave oven, where the tray of the packaged food product comprises a susceptor. WO2017/114605A1 discloses vessels for targeted heating in a solid state microwave oven, where the vessel comprises a susceptor. However, susceptor and shielding materials are expensive and hence for commercial prepared meal products not necessarily the preferred solution.

There is still a clear and persisting need to provide a solution for a more targeted defrosting and/or heating of different food items of a prepared meal product, where those food items are presented and heated in a food tray in a microwave oven, such as for example a magnetron powered or a solid state powered microwave oven.

Summary of the invention

The object of the present invention is to improve the state of the art and to provide an improved solution to defrost and/or heat food items in a food tray in a microwave oven, such as e.g. a magnetron or solid state powered microwave oven, to overcome at least some of the inconveniences described above.

Particularly, the object of the present invention is to provide a prepared meal product designed for being defrosted and/or heated in a microwave oven, where at least two different food items can be defrosted and/or heated simultaneously.

A further object of the present invention is to provide a prepared meal product where individual food items can be defrosted and/or heated, respectively cooked, more regularly and in a controlled way, for example to different final temperatures for each individual food item.

A still further object of the present invention is to provide a solution where two or more different food items can be defrosted and/or heated simultaneously in one dish to achieve optimal cooking of each different food item at the same time at the end of the same heating period. Particularly, the object is to provide a solution where a meat product, such as a beef, chicken, lamb or pork product, can be heated or cooked to perfection in a microwave oven at the same time as a vegetable product and/or a pasta, noodle, rice or potato product present in a same dish at the same time, when starting the heating/cooking process from a frozen prepared meal product.

The object of the present invention is achieved by the subject matter of the independent claims. The dependent claims further develop the idea of the present invention.

Accordingly, the present invention provides in a first aspect a prepared meal product for being heated in a microwave oven, the prepared meal product comprising a microwavable tray and food items, wherein the microwavable tray has at least 2 separate areas, each area comprising at least one food item; characterized in that at least one area of the microwavable tray is more thermally insulated than at least one other area of said microwavable tray.

In a second aspect, the invention relates to a method for heating a prepared meal product according to claim 1 in a solid state microwave oven, the method comprising the steps of:

a) placing the prepared meal product into a cavity of a solid state microwave oven;
b) performing two or more radio frequency scans between a predetermined minimal and maximal frequency;
c) determining one or several radio frequencies having a higher energy return loss when compared from one radio frequency scan to a previous radio frequency scan;
d) heating the prepared meal product at a radio frequency determined in step c).

It has now been surprisingly found by the inventors that when they insulated one compartment of a two compartment tray in a model system and used this to heat up the same amount of a frozen compound such as for example water (as model) or mashed potatoes in each compartment in a microwave oven, it was possible to target the microwave energy preferentially to the non-insulated compartment in such a way as to increase and amplify an initially very small difference in temperature between the compartments to a substantial heating difference over time. This finding now allows to design prepared meal products, i.e. food items provided in a specifically designed tray, in such a way that some of the food items are heated to a higher temperature than other food items placed on the same tray and heated in the microwave oven under the very same conditions for the same time period.

This now allows to design novel prepared meal products comprising different food items in one dish or tray, where the different food items require for example different amounts of energy for being heated or cooked appropriately. The present invention now allows designing such novel prepared meal dishes which can be heated in a microwave oven, such as a magnetron based or a solid state microwave oven, and where by the design of the tray and its material individual different food items can be cooked all at the same time in a same oven optimally and to perfection.

Brief Description of the Drawings

Figure 1: Positions of temperature readings in the trays used for Example 1-3 (Figure 1a), and for Example 4 (Figure 1b).

Figure 2: Results of Example 1 with 2% salt solution in cold oven. Horizontal axis shows heating time in minutes; Vertical axis shows the measured temperatures in °C.
The figure legend is as follows:
△ Tray-1 minimal temperature determined;
▲ Tray-1 average temperature determined;
○ Tray-2 minimal temperature determined;
● Tray-2 average temperature determined;

Figure 3: Results of Example 2 with mashed potatoes in pre-heated oven. Horizontal axis shows heating time in minutes;

Vertical axis shows the measured temperatures in °C. The legend is identical to Figure 2.

Figure 4: Results of Example 3 with mashed potatoes in cold oven. Horizontal axis shows heating time in minutes; Vertical axis shows the measured temperatures in °C. The legend is identical to Figure 2.

Figure 5: Results of Example 4 with mashed potatoes in cold oven in small cups. Horizontal axis shows heating time in minutes; Vertical axis shows the measured temperatures in °C. The legend is identical to Figure 2, with Tray-1 meaning Cup-1, and Tray-2 meaning Cup-2.

Figure 6: Results of Example 5 with mashed potatoes in a cold standard magnetron based microwave oven in small cups. Horizontal axis shows heating time in minutes; Vertical axis shows the measured temperatures in °C. The legend is identical to Figure 2, with Tray-1 meaning Cup-1, and Tray-2 meaning Cup-2.

Detailed Description of the invention

The present invention pertains in a first aspect to a prepared meal product for being heated in a microwave oven, the prepared meal product comprising a microwavable tray and food items, wherein the microwavable tray has at least 2 separate areas, each area comprising at least one food item; characterized in that at least one area of the microwavable tray is more thermally insulated than at least one other area of said microwavable tray.

A "prepared meal product" is a food product which has been prepared by a food manufacturer and which is sold, typically frozen, to be prepared by a consumer for example by heating in a microwave oven and be consumed at home or out of home.

A “solid state microwave oven” is a microwave oven delivering solid state electromagnetic energy. The production of such solid state energy is transistor-based and not magnetron produced.

A “magnetron based microwave oven” is the standard microwave oven typically used today practically worldwide as kitchen appliance and where the microwaves are generated by a magnetron.

A “tray” is a shallow platform for carrying or holding things such as food items. For example trays are typically used for holding food items in the area of prepared dishes and frozen meals. Trays usually have a more or less flat bottom part which allows to stably place the tray onto a surface e.g. for heating it in an oven or for putting it onto a table for ease of consumption.

“Thermally insulated” means that the heat transfer between two objects of different temperatures which are in thermal contact or in range of thermal radiative influence is reduced.

In one embodiment of the present invention the microwavable tray of the prepared meal product comprises a thermal insulation material in such a way as to provide more thermal insulation to at least one area of the microwavable tray than to at least one other area of said same microwavable tray.

In another embodiment of the present invention the microwavable tray of the prepared meal product consists of a thermally insulating material in such a way as to provide more thermal insulation to at least one area of the microwavable tray than to at least one other area of said same microwavable tray.

In a preferred embodiment, the thermally insulating material which provides more thermal insulation to the at least one area of the microwavable tray has a heat conductivity h=k/x of not more than half of the heat conductivity of the at least one other area of said same microwavable tray. Thereby, h is the overall heat transfer coefficient of the material. Factor h is measured in [W/(m^2K)], wherein K stands for Kelvin and W for Watt. Factor k is the thermal conductivity of the insulating material measured in [W/(mK)], and x stands for the thickness of the insulating material.

Table I provides some k-values for materials typically used for making packaging trays useful for the present invention.

Table I:

Material	**k=W/mK at ca. 25°C**
Aluminum	205
Cellulose	0.23
Celluloid	0.12 - 0.21
Cork board	0.043
Crystallized PET (CPET)	0.15 - 0.4
Fiberglass	0.04
Nylon	0.25
Paper	0.05
Polycarbonate	0.19
Polyester	0.05
Polyethylene	0.33 - 0.51
Polypropylene (PP)	0.1 - 0.22

Polytetrafluorethylene (PTFE)	0.25
Polyvinylchloride (PVC)	0.19
Vinyl ester	0.25

In a preferred embodiment, the insulating material of the prepared meal product of the present invention which provides more thermal insulation to the at least one area of the microwavable tray has a heat conductivity h=k/x of not more than 25%, preferably not more than 10%, of the heat conductivity of the at least one other area of said same microwavable tray.

In another embodiment, the thermally insulating material of the prepared meal product according to the present invention providing more thermal insulation to the at least one area of the microwavable tray has a thermal resistance value R of at least 0.01 m^2K/W, preferably of at least 0.03 m^2K/W, more preferably of at least 0.05 m^2K/W, even more preferably of at least 0.1 m^2K/W. R stands for thermal resistance value R. R is measured in m^2K/W, wherein K stands for Kelvin and W for Watt. Thermal conductivity (k-value) is the ability of a material to conduct heat and it is measured in W/mK. Consequently, the value R is determined by assessing the k-value of an insulating material and measuring its thickness x as follows: R=x/k. Typical k values are provided in Table I above.

In an embodiment, the thermally insulation material of the prepared meal product of the present invention is in the form of one or several insulation layers. The thermal insulation material is preferably selected from the group consisting of cellulose, cork board, fiberglass, paper material, polycarbonate, polyester, polyethylene, polypropylene (PP), polystyrene (PS), polytetrafluorethylene (PTFE), polyvinylchloride (PVC), vinyl ester and combinations thereof.

The thermal insulation material can also be provided by a layer of plastic material, paper material, paperboard, or a combination thereof. Thereby the plastic material can be selected for example from PP (polypropylene) or Polyethylene terephthalate (PET), or particularly from crystallized Polyethylene terephthalate (CPET), and combinations therefrom with paper material such as for example PET laminated paperboard.

Preferably, the layer of plastic material, paper material, paperboard or a combination thereof, is at least 0.20mm thick, preferably at least 0.30mm thick, more preferably at least 0.50mm, at least 1.0mm or at least 2.0mm thick. These are preferred minimal thicknesses to assure an adequate thermal insulation and stability of the tray.

In an embodiment, the tray of the prepared meal product of the present invention is not thicker than 10mm, preferably not thicker than 7mm, more preferably not thicker than 5mm or 3mm. The tray is preferably designed for a single use application. Therefore, the tray should be thick enough to support the amount and weight of the food items to be placed therein, and to support a certain handling of the tray by the consumer such as placing it into a microwave oven, carrying it around and using it as a tray for directly eating from the package. Furthermore, the tray should not be too thick as to be not too heavy by itself, and not to require more packaging material as absolutely necessary in order to reduce production costs and environmental impact, particularly when the tray is used only once and discarded thereafter.

In a preferred embodiment of the present invention, the separate areas of the prepared meal product are separate compartments in the tray.

In one embodiment of the present invention, the tray of the prepared meal product is a two-compartment tray or a multi-compartment tray. A multi-compartment tray may have three, four, five or even more compartments in one tray. One of the advantages to using a two- or multi-compartment tray is that it allows to easily separate individual different food items from each other. In this way and in combination with the use of the thermal insulation material, the bundled energy of a microwave application can be very clearly and local specifically targeted to the appropriate food item(s) to be heated. Consequently, the prepared meal product of the present invention preferably comprises a tray which has two, three or more separate compartments.

In one embodiment, at least one of the compartments of the tray is shielded from microwaves in a microwave oven. This allows to further optimize the targeted application of microwave energy for the different heating of the different food items. This would for example allow to include a food item into a multi-food item dish which will not be heated in the microwave application. This food item may be for example a salad, a pastry, or a dessert.

Preferably, the prepared meal product according to the present invention comprises a food, which comprises one, two, three or even more food items. Thereby, for example, one food item may be a meat product, preferably selected from beef, pork, chicken, lamb or fish, or a meat analogue product. A second food item may be a carbohydrate based food product, preferably selected from potato, pasta, noodle or a cereal product, including rice. A third food item may be a vegetable product, a salad, a dessert or a bakery product.

In one embodiment of the present invention, the prepared meal product comprising the tray with the food items is packaged in a plastic bag, a carton box and/or wrapped with a shrink film.

In one embodiment of the present invention, the prepared meal product is frozen or chilled.

In a second aspect, the invention relates to a method for a method for heating a prepared meal product according to claim 1 in a solid state microwave oven, the method comprising the steps of:

a) placing the prepared meal product into a cavity of a solid state microwave oven;
b) performing two or more radio frequency scans between a predetermined minimal and maximal frequency;
c) determining one or several radio frequencies having a higher energy return loss when compared from one radio frequency scan to a previous radio frequency scan;
d) heating the prepared meal product at a radio frequency determined in step c).

In one embodiment, the solid state microwave oven used in the method of the present invention comprises an air fan circulating air in the cavity, such as hot or cold air. Preferably, the air fan blows warm or hot air into the cavity.

In an embodiment of the present invention, the method further comprises a step of heating the inside of the cavity of the solid state microwave oven with a heating source other than solid state microwaves. The heating source other than solid state microwaves can be selected from an infrared emitter, a hot air inlet, and a heating plate.

The heating source alone or in combination with the circulation of air in the cavity, for example by an air fan, or vice versa, i.e. circulating air in the cavity alone or in combination with a heating source, has the advantage of initiating defrosting of the food item(s) which are placed in the less insulated area of the tray. It is this very initial very small difference in defrosting which is then amplified by the method of the present invention and which then allows to differently heat or cook the different food items placed in the differently insulated areas of the tray.

In a preferred embodiment of the method of the present invention, there is a time period between at least two radio frequency scans of step b), during which an initial difference in defrosting of the food items can be achieved. Preferably, the time period is at least 5 seconds, 10 seconds, 15 seconds, 20 seconds, 30 seconds or 1 minute.

In a preferred embodiment of the method of the present invention, the radio frequency scan is from 900 to 2500 MHz, but preferably from 902 to 928 MHz, or from 2400 to 2500 MHz.

Preferably, the heating in step d) in the method of the present invention is for at least 30 seconds, preferably for at least 45 seconds, more preferably for at least 60 seconds. Thereby, the heating time needed between the scans will typically depend on several factors, namely the intensity of the heat transfer, the difference in thermal insulation, the dielectric changes of the food material as a result of the heat flux and the sensitivity of the electronics involved in the scan.

Those skilled in the art will understand that they can freely combine all features of the present invention disclosed herein. In particular, features described for the product of the present invention may be combined with the method of the present invention and vice versa. Further, features described for different embodiments of the present invention may be combined.

Further advantages and features of the present invention are apparent from the figures and examples.

Example 1: Model sodium chloride solution

Two identical trays (Tray-1 and Tray-2) (CPET with 0.2mm minimum wall thickness and dimensions: 138mm x 110mm x 46mm) were each filled with 200 g of an aqueous 2% sodium chloride solution, sealed with a polyester film and frozen overnight at -18°C. On the following day, one of the trays (Tray-1) was put into a further identical empty tray with a sheet of kitchen paper in between the trays to provide additional thermal insulation. Thereby, the heat conductivity of Tray-1 was reduced as the value x for the tray doubled, and a further layer of an insulation material (kitchen paper) with a thickness of between 1-3mm was added. The R value of the non-insulated Tray-2 was calculated as 0.00133 m^2K/W, whereas the insulated Tray-1 had an R value of about 0.04 m^2K/W. Hence, the value h of Tray-1 was about 30 times smaller than the value h of Tray-2.

The polyester film on both trays was removed, and the trays were then placed in the experimental Solid State microwave oven, side by side without a gap and adjusted to a same height. The insulated tray was on the left side, the non-insulated one (Tray-2) was on the right side.

The oven cavity was then scanned from 2400 to 2500 MHz at a power of 20 Watt per channel, using all channels of an Ampleon four-channel amplifier in coherent mode. The resulting curve of the compound return loss was saved for later comparison. Three minutes later, while the trays were left unchanged in the experimental oven cavity comprising a cold air fan but no conventional heating facilities, a second scan with the same parameters as the first one was performed and the compound return loss determined again as before.

The two scans were compared, identifying a frequency where the power return loss (absorbed power expressed in Watts) was highest for the second scan compared to the first one. This frequency was 2450 MHz. A first heating phase was then conducted at this frequency with using all channels in coherent mode at a power of 100 Watts per channel for 8 min.

After this heating step, both trays were probed with a thin thermocouple at medium height (in the positions indicated in Figure 1a) to determine the local temperature. If ice was present, the thermocouple could not penetrate, and the temperature was noted as 0°C. The minimum and average temperatures for each tray were determined in this way and shown in Figure 2.

Subsequent heating steps were then conducted in intervals of 2 min at a power of 200 Watts per channel. Again, the frequency was 2450 MHz, but the mode of operation was 'Random Cook', a method in which the phase angles between the channels are varied every 100 ms in order to create a variety of different electro-magnetic fields, i.e. a non-targeted heating pattern. After every interval, the local temperatures in the trays were determined again in the same way as indicated above. A floating piece of ice was assigned to the central probing point, which was invariably the last area where ice remained. The total number of these 2 min intervals was 5. The results are shown in Figure 2.

The results as shown in Figure 2 can be summarized as follows: The chosen frequency of 2,450 MHz was related to an electro-magnetic field in the cavity that caused preferred heating of Tray-2. After 8 minutes of heating at that frequency in coherent mode and with no changes of the phase angle, the ice in Tray-2 started to melt. The melting caused the dielectric losses in Tray-2 to rise substantially compared to Tray-1, which was still frozen. Between 8 and 14 minutes of heating time, Tray-2 continued to heat faster than Tray-1, although the mode of heating was not targeted any longer. Towards the end of the process, Tray-1 started to catch up with Tray-2, because the latter started to lose heat in the form of evaporated water.

After the last heating cycle, the coldest reading point found anywhere in one of the two trays was 72°C. The weight loss due to evaporation of water from Tray-1 was 4.5 %, the weight loss from Tray-2 was 10.4 %.

Example 2: Mashed potato in pre-heated oven

The same experiment as in Example 1 was conducted with the following alterations: The trays were filled with 200 g of mashed potato instead of a sodium chloride solution, and the experimental Solid State oven cavity was pre-heated to 210°C with hot air convection. The trays and their thermal insulation were identical as in Example 1.

The heating method of the two trays filled with mashed potatoes was identical as described in Example 1 with the following differences: the waiting time between the first and second scan (also from 2400 to 2500 MHz) conducted at a power of 50 Watt per channel was 30 seconds, and the frequency with the highest power return loss was identified as 2414 MHz. The first heating phase was then conducted at this frequency using all channels in coherent mode at a power of 100 Watts per channel for 8 min. Local temperature readings were then taken in the same way as in Example 1. Subsequent heating steps were then conducted in intervals of 2 min at a power of 250 Watts per channel and at a frequency of 2450 MHz. Like in example 1, the mode was now 'Random Cook', where the phase angle is varied every 100 ms in order to provide a non-targeted heating performance. Local temperatures were measured as described above. The total number of 2 min cycles was 6.

The results are summarized in Figure 3 and show that Tray-2 already had an average temperature of 63 °C after the targeted part of the cooking cycle, compared to 18 °C for Tray-1. This means that it also had a much higher dielectric loss than Tray-1. This led to further accelerated heating of Tray-2, even though the heating method was now non-targeted. Since Tray-2 reached the boiling point, its preferred power absorption was now converted to weight loss by evaporation, while Tray-2 continued to catch up. After the last heating cycle, the coldest reading found anywhere in the two trays was 74 °C. The weight loss of Tray 1 was 10.4 %, the weight loss of Tray 2 was 31.3 %.

Example 3: Mashed potato in cold oven

The same experiment as in Example 2 was conducted with the difference that the experimental Solid State oven cavity was not pre-heated but was at room temperature (22°C) when the experiment started.

The first scan was conducted immediately after placing the two trays in the cold oven. Now a fan was used to circulate cold air in the cavity for 3 minutes. Then another scan was conducted. Like before, the scans were compared, and the frequency with the biggest difference in return loss (in decibel) was determined. In this experiment, the frequency was 2,425 MHz. Subsequent heating was carried out with 250 Watts in 'Random Cook' mode, as explained before. The results are shown in Figure 4.

Like in Example 2, the mashed potato in Tray-2 was already partially defrosted after 8 min. The following non-targeted heating phase still led to preferred absorption by Tray-2, which reached the boiling point after approx. 18 min of total cook time.

After the last heating cycle, the coldest reading found anywhere in the two trays was 78 °C.

The weight loss of Tray-1 was 10.4 %, the weight loss of Tray-2 was 31.1 %.

Example 4: Mashed potato in cold oven (in small cups instead of trays)

The same experiment as in Example 3 was conducted with the following alterations: A different set of containers was used, cylindrical cups instead of trays. Each tray was filled with 140 g of mashed potato. The cups were made of polypropylene (PP) with an average wall thickness of 0.6mm. Dimensions of the cups were: 94mm diameter at the opening end and 62mm in height. Cup-1 was further insulated in the same way as Cup-1 in Example 1, namely a first tray with the frozen content was put into a further identical empty cup with a sheet of kitchen paper in between the cups to provide additional thermal insulation. Thereby, the heat conductivity of Cup-1 was reduced as the value x for the tray was doubled and a further layer of an insulation material (kitchen paper) with a thickness of about 2mm was added. The R value for the non-insulated Cup-2 was calculated as 0.006 m^2K/W, while the insulated Cup-1 had an R value of about 0.04 m^2K/W. Hence, Cup-1 was about 7 times better insulated than Cup-2.

After placing the cups in the cold cavity, the cavity was scanned from 2400 to 2500 MHz at a power of 25 Watt per channel and proceeded in the same way as in Example 3. The frequency determined for the heating step was 2410 MHz, and the first phase of microwave heating was executed at 200 W per channel for 4 minutes. Six subsequent heating steps were then conducted in intervals of 2 min at a power of 200 Watts per channel, using the ‘Random Cook’ mode. The results were collected and are shown in Figure 5.

Like in the other examples, Cup-2 heated up earlier. In this case, due to the lower mass, it was already completely defrosted after just 4 minutes. Again, the following non-targeted heating made Cup-2 reach the boiling point and lose much more weight than Cup-1.
After the last heating cycle, the coldest reading found anywhere in the two cups was 84 °C.
The weight loss of Cup 1 was 7.2 %, the weight loss of Cup 2 was 34.5 %.

Example 5: Mashed potato in cold magnetron based Sharp Carousel oven (in small cups instead of trays)

The same experiment was conducted as in Example 4, but instead of placing Cup-1 and Cup-2 into the cavity of an experimental solid state microwave oven for the defrosting and heating experiment, they were placed into a standard 1100 Watt Sharp Carousel microwave oven. This microwave oven was a standard microwave oven, powered by a magnetron. The oven was equipped with an air fan blowing cold air into the cavity.

Three minutes after having placed the two cups into the oven cavity, a first heating phase was conducted, using the 30% power setting of the oven for 4 minutes.

After this, both cups were probed with a thin thermocouple at medium height in the positions indicated in Figure 1b. If ice was present, the thermocouple could not penetrate enough for a good reading. The temperature was therefore noted as 0°C. The minimum and average temperatures for each cup were determined and plotted in Figure 6.

The following heating steps of each 2 minutes were all conducted at the 80% power setting of the microwave oven. After every interval of 2 min, the temperature in the cups was probed again in the same way as indicated above.

The total number of these 2 min intervals was 6. After the last heating cycle, the coldest reading found anywhere in the two cups was 97°C. The results are shown in Figure 6. Like in the example 4, Cup-2 heated up earlier. The weight loss of Cup-1 was 7.2%, the weight loss of Cup-2 was 34.5%.

Claims

1. A prepared meal product for being heated in a microwave oven, the prepared meal product comprising a microwavable tray and food items, wherein the microwavable tray has at least 2 separate areas, each area comprising at least one food item; characterized in that at least one area of the microwavable tray is more thermally insulated than at least one other area of said microwavable tray.

2. The prepared meal product according to claim 1, wherein the microwavable tray comprises a thermal insulation material in such a way as to providing more thermal insulation to at least one area of the microwavable tray than to at least one other area of said same microwavable tray.

3. The prepared meal product according to claim 1, wherein the microwavable tray consists of a thermally insulating material in such a way as to provide more thermal insulation to at least one area of the microwavable tray than to at least one other area of said same microwavable tray.

4. The prepared meal product according to claim 2 or 3, wherein the thermally insulating material providing more thermal insulation to the at least one area of the microwavable tray has a heat conductivity h=k/x of not more than half of the heat conductivity of the at least one other area of said same microwavable tray.

5. The prepared meal product according to claim 4, wherein the thermal insulating material providing more thermal

insulation to the at least one area of the microwavable tray has a heat conductivity h=k/x of not more than 25%, preferably not more than 10%, of the heat conductivity of the at least one other area of said same microwavable tray.

6. The prepared meal product according to one of the claims 2 to 5, wherein the thermally insulating material providing more thermal insulation to the at least one area of the microwavable tray has a thermal resistance value R of at least 0.01 m^2K/W, preferably of at least 0.03 m^2K/W, more preferably of at least 0.05 m^2K/W, even more preferably of at least 0.1 m^2K/W.

7. The prepared meal product according to one of the claims 2 to 6, wherein the thermal insulation material is in the form of one or several insulation layers.

8. The prepared meal product according to one of the claims 2 to 7, wherein the thermal insulation material is selected from the group consisting of cellulose, cork board, fiberglass, paper material, polycarbonate, polyester, polyethylene, polypropylene (PP), polystyrene (PS), polytetrafluorethylene (PTFE), polyvinylchloride (PVC), vinyl ester and combinations thereof.

9. The prepared meal product according to claim 1, wherein the separate areas are separate compartments in the tray.

10. The prepared meal product according to claim 9, wherein the tray has three or more separate compartments.

11. The prepared meal product according to one of the claims 9 to 10, wherein at least one of the compartments of the tray is shielded from microwaves in a microwave oven.

12. The prepared meal product according to any one of the claims 1 to 11, wherein the food item is selected from the group consisting of meat, fish, vegetable, salad, potato, rice, pasta, sauces, gravies, desserts and a bakery product.

13. The prepared meal product according to one of the claims 1 to 12, wherein the tray comprising the food items is packaged in a plastic bag, a carton box and/or wrapped with a shrink film.

14. The prepared meal product according to one of the claims 1 to 13, wherein the prepared meal product is frozen or chilled.

15. A method for heating a prepared meal product according to claim 1 in a solid state microwave oven, the method comprising the steps of:
   a) placing the prepared meal product into a cavity of a solid state microwave oven;
   b) performing two or more radio frequency scans between a predetermined minimal and maximal frequency;
   c) determining one or several radio frequencies having a higher power return loss when compared from one radio frequency scan to a previous radio frequency scan;
   d) heating the prepared meal product at a radio frequency determined in step c).

16. The method according to claim 15, wherein the solid state microwave oven comprises an air fan circulating air in the cavity.

17. The method according to claim 15 or 16, further comprising a step of heating the inside of the cavity of the solid state microwave oven with a heating source other than solid state microwaves.

18. The method according to claim 17, wherein the heating source other than solid state microwaves is selected from an infrared emitter, a hot air inlet, a heating plate, and an electric grill.

19. The method according to claim 15, wherein the radio frequency scan is from 902 to 928 MHz, or from 2400 to 2500 MHz.

20. The method according to claim 15, wherein the heating in step d) is for at least 30 seconds, preferably for at least 45 seconds.

Figure 1a:

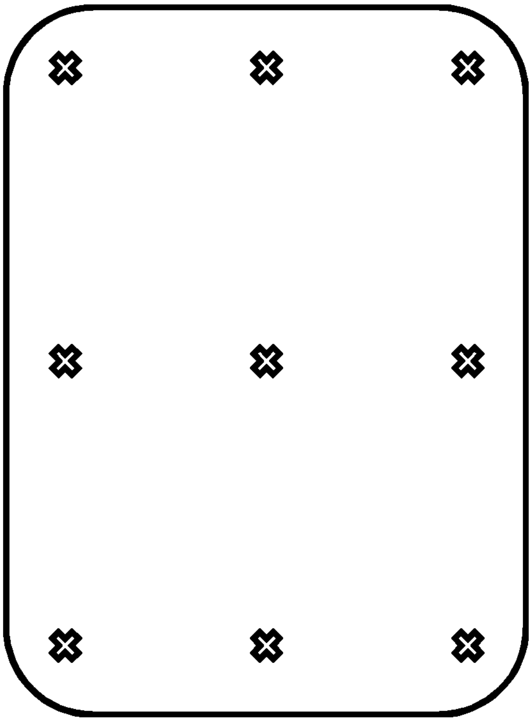


Figure 1b:

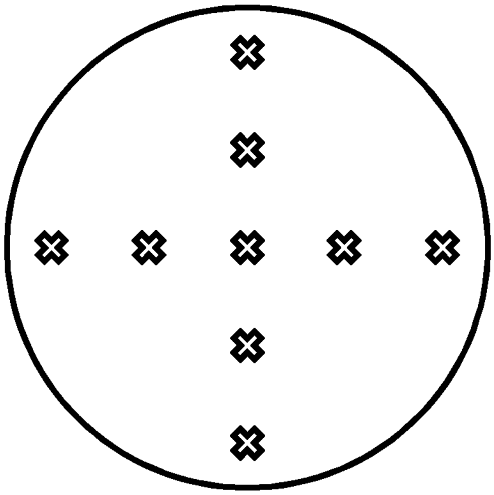


Figure 2:

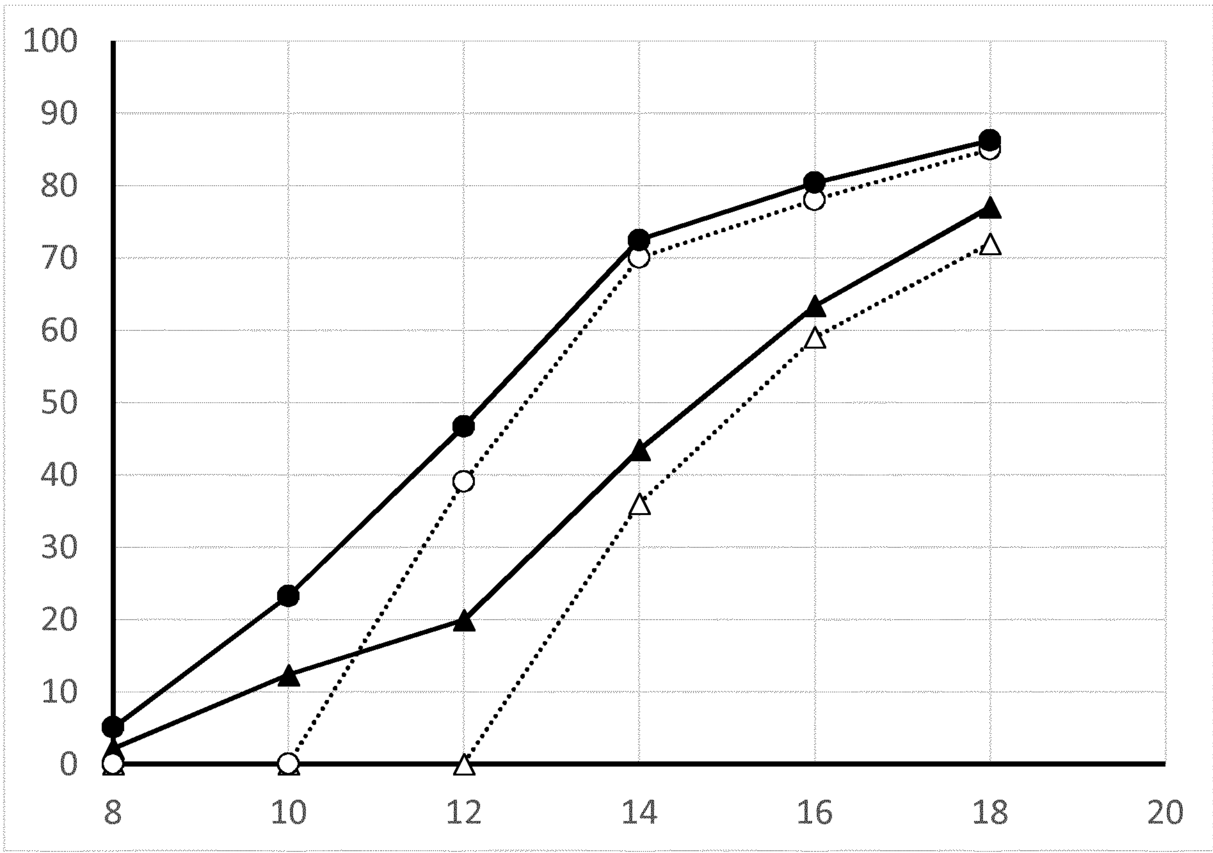


Figure 3:

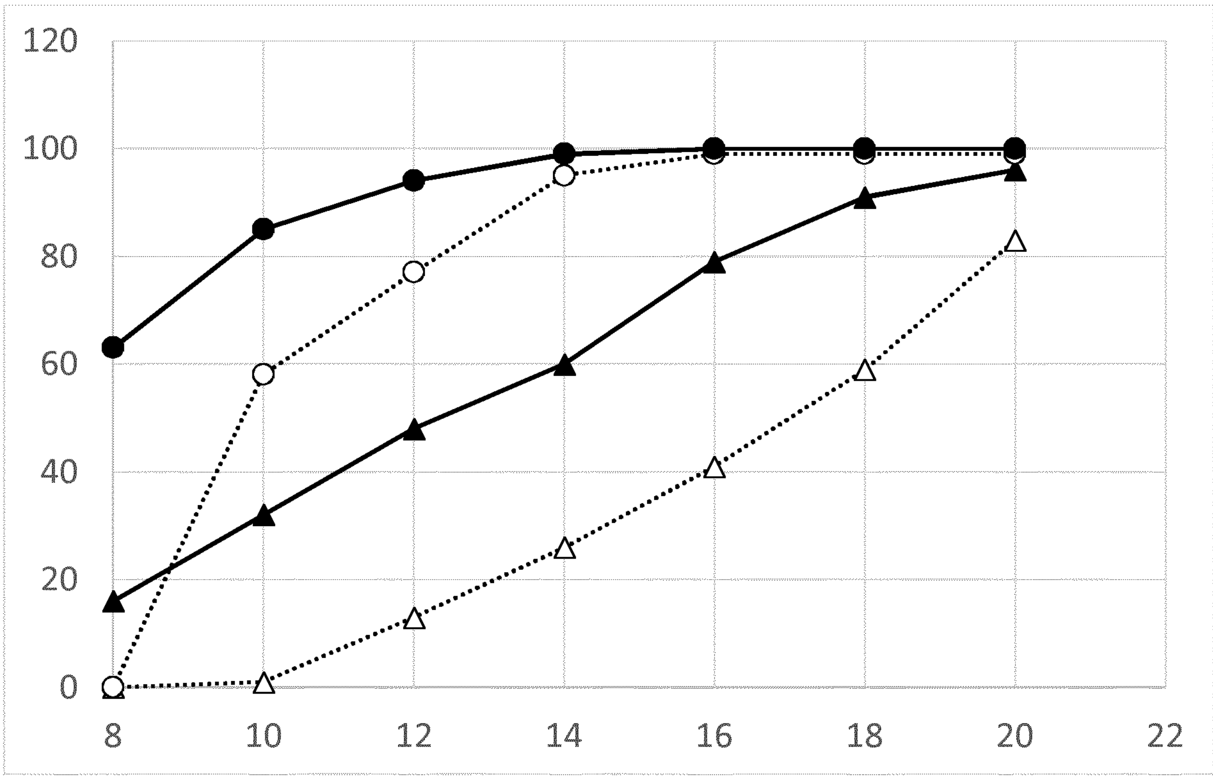


Figure 4:

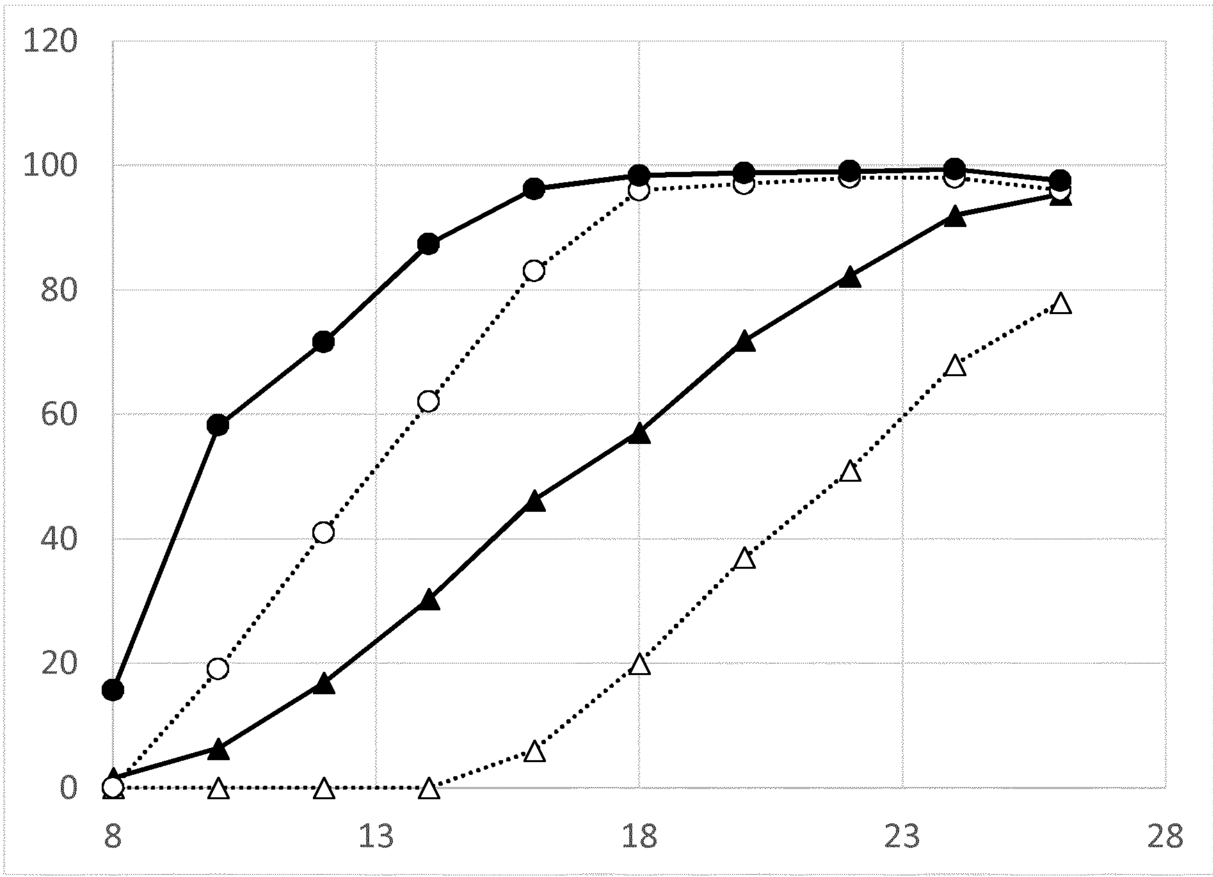


Figure 5:

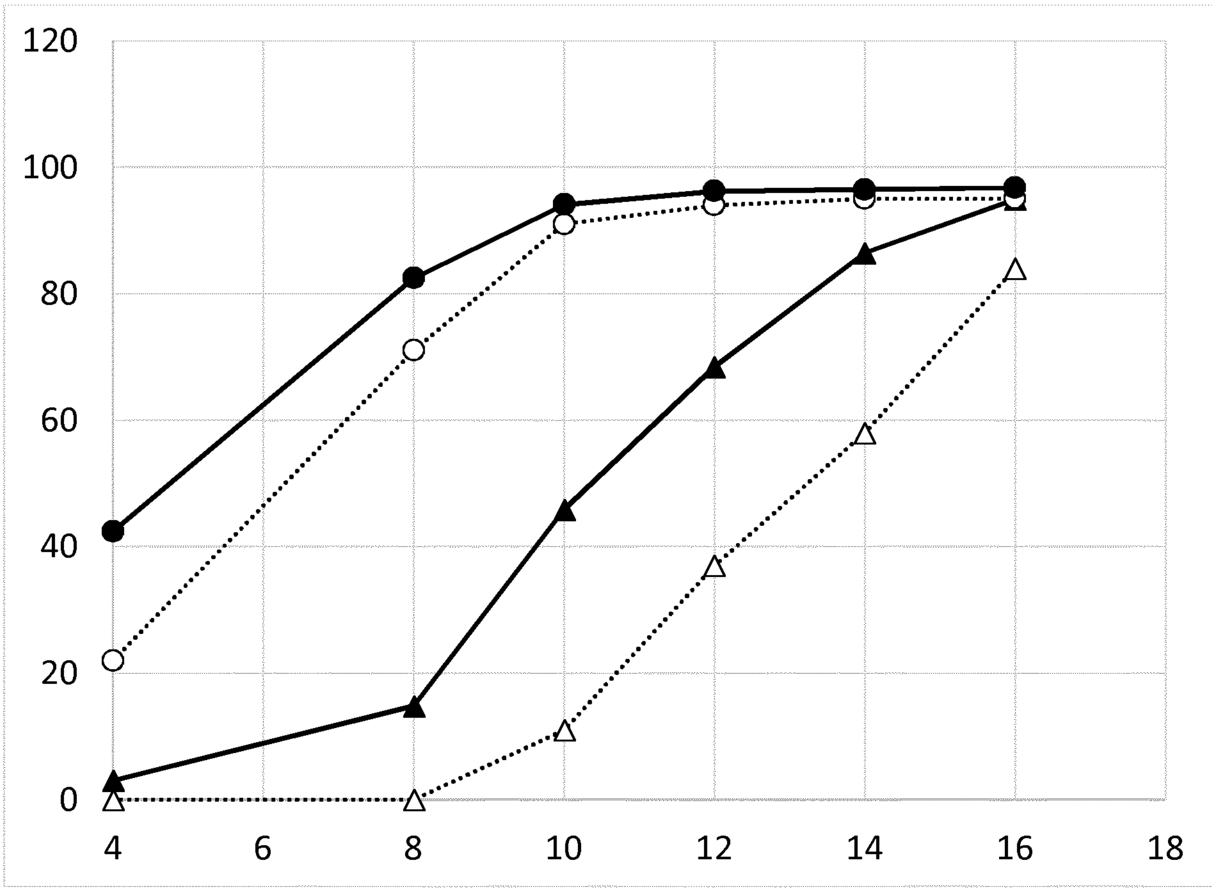
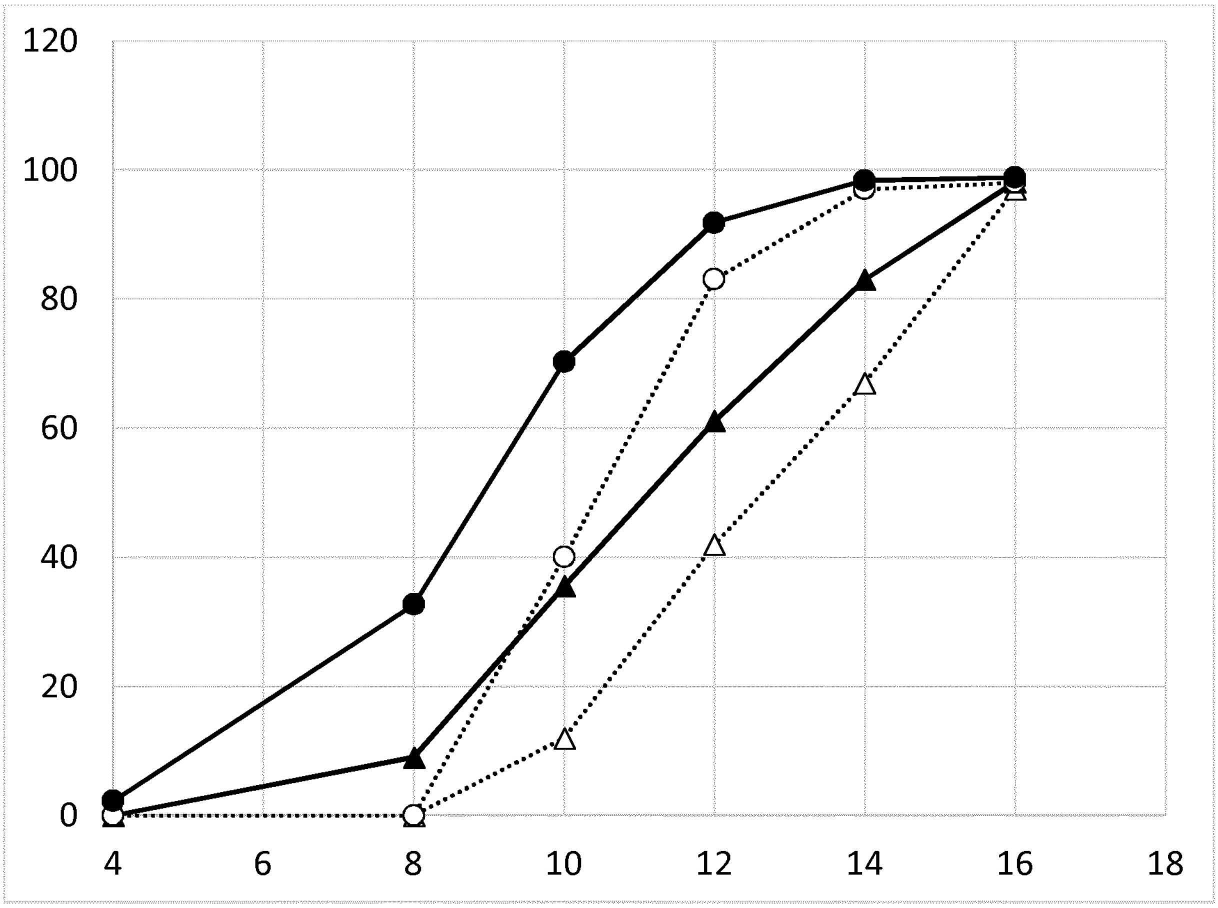


Figure 6:



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2019/051958

A. CLASSIFICATION OF SUBJECT MATTER
INV. B65D1/36 B65D81/34
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B65D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, BIOSIS, EMBASE, FSTA, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	WO 2005/068321 A2 (SHIELTRONICS B V [NL]; VAN DE WEIJER FRANCISCUS JOHAN [NL]; DRIESSEN M) 28 July 2005 (2005-07-28) abstract figures 1,2,6,7,8 pages 17-28 claims 1-38 -----	1-3,7-11 4,5
X Y	US 2015/096976 A1 (FRANCE DAVID WILLIAM [US]) 9 April 2015 (2015-04-09) abstract paragraphs [0031], [0032], [0037] figures 1,5 claims 1-20 -----	1-3, 7-12,14 4,5
	-/--	

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
7 March 2019	21/05/2019

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1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP2019/051958

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-14

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	WO 2007/141140 A2 (NESTEC SA [CH]; SHARMA RICHA [US]; KNUDSEN KAJ F [IT]) 13 December 2007 (2007-12-13) abstract figures 1-3 paragraphs [0004] - [0014] claims 1-26 -----	1-3, 7-12,14 4,5
X Y	WO 2011/090470 A2 (HEINZ CO H J [US]; JACKSON DANIEL C [US]; ROWOTH CHRISTOPHER P [US]; R) 28 July 2011 (2011-07-28) abstract figures 1,14-18,8, 10, 21, 22 paragraphs [0064] - [0069], [0078] - [0081], [0092] claims 1-37 -----	1-3, 7-12,14 4,5
X Y	WO 2017/092913 A1 (NESTEC SA [CH]) 8 June 2017 (2017-06-08) cited in the application abstract table 1 examples 1-3 claims 1-20 figures 1-3 -----	1-3,6-9, 12-14 4,5
X Y	WO 2017/114605 A1 (NESTEC SA [CH]) 6 July 2017 (2017-07-06) cited in the application abstract tables 1,3 example 3 figures 1, 3, 7, 8, 10 -----	1-3,6-9, 12-14 4,5
X Y	WO 2006/128156 A2 (GRAPHIC PACKAGING INT INC [US]) 30 November 2006 (2006-11-30) abstract pages 24-30 examples 1-2 table 2 claims 1-42 figures 5-8, 10, 13 -----	1,2,7-9, 11,12,14 4,5
X	WO 2010/104849 A1 (HODSON JAY DANIEL [US]; DOUGLAS BRIAN [US]; KLITTICH MENA [US]; CVANCA) 16 September 2010 (2010-09-16) abstract claims 20-22 figures 1-9 -----	1,2,7-9, 11,12,14

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2019/051958

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2005068321 A2	28-07-2005	AU 2005205677 A1	28-07-2005
		CA 2552668 A1	28-07-2005
		CA 2762970 A1	28-07-2005
		CN 1910092 A	07-02-2007
		EP 1706334 A2	04-10-2006
		EP 2599738 A2	05-06-2013
		ES 2420954 T3	28-08-2013
		JP 4640341 B2	02-03-2011
		JP 2007518641 A	12-07-2007
		NL 1025282 C2	20-07-2005
		NZ 548468 A	25-06-2010
		US 2008230176 A1	25-09-2008
		WO 2005068321 A2	28-07-2005
US 2015096976 A1	09-04-2015	US 2015096976 A1	09-04-2015
		WO 2015054187 A1	16-04-2015
WO 2007141140 A2	13-12-2007	AU 2007255524 A1	13-12-2007
		CA 2654333 A1	13-12-2007
		EP 2029443 A2	04-03-2009
		NZ 573440 A	25-05-2012
		US 2009208614 A1	20-08-2009
		WO 2007141140 A2	13-12-2007
WO 2011090470 A2	28-07-2011	AR 079819 A1	22-02-2012
		AU 2010343358 A1	12-07-2012
		CA 2785965 A1	28-08-2011
		CN 102695922 A	26-09-2012
		CR 20120379 A	09-01-2013
		EP 2519779 A2	07-11-2012
		HK 1171498 A1	17-07-2015
		JP 2013516216 A	13-05-2013
		KR 20120112688 A	11-10-2012
		NZ 600646 A	27-09-2013
		RU 2012132455 A	10-02-2014
		SG 181852 A1	30-07-2012
		US 2011256284 A1	20-10-2011
		WO 2011090470 A2	28-07-2011
		ZA 201204768 B	24-04-2013
WO 2017092913 A1	08-06-2017	CA 3003604 A1	08-06-2017
		EP 3383764 A1	10-10-2018
		WO 2017092913 A1	08-06-2017
WO 2017114605 A1	06-07-2017	CA 3009465 A1	06-07-2017
		EP 3398403 A1	07-11-2018
		WO 2017114605 A1	06-07-2017
WO 2006128156 A2	30-11-2006	AT 499314 T	15-03-2011
		CA 2607402 A1	30-11-2006
		EP 1904383 A2	02-04-2008
		EP 2284099 A1	16-02-2011
		ES 2388717 T3	17-10-2012
		JP 4856176 B2	18-01-2012
		JP 2008545589 A	18-12-2008
		US 2006289522 A1	28-12-2006
		US 2009084781 A1	02-04-2009
		WO 2006128156 A2	30-11-2006

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2010104849 A1	16-09-2010	US 2010230403 A1	16-09-2010
		WO 2010104849 A1	16-09-2010

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-14

   a prepared meal product for being heated in a microwave oven, the prepared meal product comprising a microwavable tray and food items, wherein the microwavable tray has at least 2 separate areas, each area comprising at least one food item; characterized in that at least one area of the microwavable tray is more thermally insulated than at least one other area of said microwavable tray

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2. claims: 15-20

   a method for heating a prepared meal product of claim 1 in a solid state microwave oven, the method comprising the steps of:a) placing the prepared meal product into a cavity of a solid state microwave oven;b) performing two or more radio frequency scans between a predetermined minimal and maximal frequency;c) determining one or several radio frequencies having a higher power return loss when compared from one radio frequency scan to a previous radio frequency scan;d) heating the prepared meal product at a radio frequency determined in step c).
