Successful Microwave Packaging Design

"Rules of Thumb"

(Non-exclusive!)

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Packaging, Materials

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1. Find (estimate, measure, or look up) dielectric constants of microwaved products (components) as a function of temperature and calculate microwave penetration depth as a function of temperature for each of them.
2. Find (estimate or look up) specific heats and thermal conductivities of the food components.
3. Make sure that the water activity in the products is above 0.9 and identify water content in each of them. Heating time to achieve necessary temperature in the amount of water equivalent to the water content of the product is a very good first approximation for the necessary heating time of the whole product. Avoid using components with low water content and activity.
4. Defrosting of high water content and activity product at -20^{o}C takes approximately the same time that is necessary for heating the defrosted (or simply refrigerated) product to approximately +70…75^{o}C (required by food regulations). By other words, defrost takes 50% of the whole microwaving time.
5. Design your packaging and product so that:
   a) dimensions of the packed product(s) exceed one and a half of an average penetration depth of the food composition at +1^{o}C…+5^{o}C, but doesn't go above the triple penetration depth;
   b) component(s) with shortest penetration depth do not shield the component(s) with longer penetration depth;
   c) avoid packing products that have dielectric and thermal properties close to the properties of water (e.g. egg) together with bread;
   d) in general, for multicomponent products, adjust (match) specific heats of the components before matching their dielectric constants since heating rate is inversely proportional to the specific heat;
   e) thermal and dielectrics properties of frozen foods are similar;
   f) frozen foods are sensitive to thermal runaway and may focus microwaves due to large penetration depth; this means that frozen products should preferably be shielded in a few directions (both reflectors and susceptors can be used), and low power (~ 30% of max. available) operation is a good idea too;

6. Products shaped (frozen) as slabs and blocks should be shielded alongside the vertical surfaces. Not only reflectors, but also susceptors can be used for this purpose, especially if a product has to be browned or roasted.
7. Microwave transmitting patterns, both resonant gaps and sub-wavelength windows, must have overall total length of openings in all directions greater than approximately 6.2 cm. The overall total length of reflective interspaces in all directions must remain less than 6.2 mm.
8. In order to retain specific/dual textures (crispy crust and softer interior) of backed, fried, and roasted products (bread, meat, fish, poultry), when re-heating them in a microwave oven, corresponding packaging must contain at least two components: a susceptor cage (box) with water-vapor and microwave transmitting patterns, as the inner packaging, and a heat insulating outer packaging, e.g. a paper or cardboard box, or a bag.
9. Avoid mechanical contacts between frozen foods and susceptors.
10. Perforation patterns and corners in both susceptor and reflector packaging sheets must be chamfered in order to avoid local amplifications of electric field.
11. All electro conductive elements in one packaging unit must be short-circuited (i.e. galvanically connected to each other) in order to avoid the air breakdowns.
12. Packaging units containing conductive (i.e. reflective) elements and the internal walls of the ovens should have at least 2 cm separation the inner walls of a microwave appliance.

Packaging for microwaveable food =
Habitual food packaging +
Thermal insulation +
Microwave-reflective elements +
Microwave-susceptive elements