TECHNOLOGY ASSESSMENT:

TECHNOLOGY VIABLE TO KEEP "TAKE-HOME" FOOD WARM FOR 30 MINUTES

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ABSTRACT

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Various technologies are reviewed for appropriateness of packaging technology to retain heat within a take-home package. Technologies explored include insulation materials, Phase Change Materials (PCM), induction heating, non-chemical heat sources, and exothermic reactions. Journals, patents, and numerous material science laboratories/researchers were contacted to obtain the current state of the industry.

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CHAPTER ONE: TEMPERATURE RETENTION

6.2 Introduction

The purpose of a take-home container is to preserve the warm or cool nature of the food until it is ready for consumption. During the time from production to consumption, hot and crispy foods vent latent heat and cool down. Cold food items warm to room temperature causing a decline in their flavor profile. Until recently, packaging solutions have been expanded polystyrene, corrugated, and paperboard containers. However, more effective means of retaining temperature conditions are transferable to the packaging arena. Technology now exists to meet the consumer need of keeping food warm or cold more consistently, and for extended periods of time.

The solution to this problem would seem to be the development of new technologies or the application of existing insulative technologies. These consist of some cover, or enclosure based package that is 'passive' in nature – that is, not introducing an alternate heat source to the packaging system. Such containers simply do their best to preserve the latent heat of the contained food. In the past, these containers have been made of expanded polystyrene, fiberglass, metallic or polymeric materials that are suitable for applications where a relatively short amount of time elapses prior to consumption.

'Active' packaging may be a more desirable alternative to achieving an adiabatic package. Active containers have been used in hospital food service applications since the 1980's. Metallic masses, (combinations of metal and wax), have been embedded in heat-retentive containers to act as capacitors, actively absorbing and storing heat prior to being exposed to a food product. These containers have the advantage of being able to keep food warm for extended periods. This material can be a relatively simple metallic structure, (as would be the case with electromagnetic inductive heat), or a phase change material (PCM).

Containers may also be heated by means of radiant electricity, as would be the case with ‘cigarette lighter’ heated pizza delivery cases. Similar results can also be obtained through the use of an active exothermic reactive element in the container, as has been demonstrated in the arrival of self-heating military MREs.

This document constitutes an investigation into temperature retentive developments after 1998. However, some technologies (developed prior to 1998), are also examined. Further exploration is warranted since research has not been done to clearly assess their technological appropriateness to food packaging. Additionally, several technologies were abandoned early in this century due to their cost prohibitive nature. Technological advances in manufacturing and materials science have made them viable options today.

Specific areas addressed are: insulative materials, heat retention by chemical, non-chemical and other means. An overview of each technology is presented at the beginning of each section. Relevant journal articles are then summarized followed by patents. In some cases, authors and laboratories were contacted for clarification and more recent information.

CHAPTER TWO: THERMAL INSULATION TECHNOLOGIES

2.1 Overview of technology

The flow of heat through any medium of transmission is proportional to the difference in thermal potential or, in this case, temperature across the medium and inversely proportional to the resistance of the insulative medium. This relationship demonstrates that as long as a temperature difference exists between two bodies, heat will flow. Therefore, insulative resistance cannot halt the heat flow; it can only retard the flow. Conductivity, then, describes the transfer of heat through insulation. This heat is transferred through the medium as radiant heat from the warm side of each gas cell to the cool side, and convected from the warm side to the cool side. Thus, to minimize radiative and convective heat transfer, cells containing gas of low thermal conductivity should be small and numerous within the medium.

In the past, four principal means of insulation have been accepted by the packaging industry; fibers, foams, reflectors and loose-fills. Most fibrous insulations have very low densities – they rely on their mass to slow radiative heat transfer. The fibers are held together by means of organic binders that give fibrous insulation what limited structural properties it has. Foams are either open or closed-cell structures. Closed cell foam often entraps gasses that are significantly heavier than air to reduce the conduction portion of heat transfer. The cell structure also reduces radiant transfer. Open-cell foam uses similar air pockets, and retards heat transfer by means of creating a tortuous path. Air conduction is still less than fibrous insulation due to the nature of the cell structure. Reflective surfaces have low emittance and block a large portion of radiant heat flow. When used in vacuum systems, foil reflectors are often layered between thin fibrous materials. Systems designed for use in air are less energy efficient, and can cost much more than other insulative means. Loose fill insulation generally consists of a mass of unstructured fibers composed of rock slag, glass or alumina-silica, which are packed, into cavities. Powders, such as perlite, silica aerogel, and adiatomaceous earth can also be used.

Research laboratories and patents provide an informed view of recent technologies.

6.2 EXAMINATION OF RECENT INSULATION TECHNOLOGIES

These articles are representative of current insulative technological advances, and were selected based upon their merit to address the needs of the take-home market.

2.2.1 Traditional Foams

In 1999, Burgess conducted an examination of several insulative methods. Various configurations of expanded polystyrene, corrugated, and liner-in-box systems were compared using ice-melt thermal testing. The insulative systems R-values were then determined, and related to the variations in the package configuration. These included: thickness, aluminum lamination, the amount of aluminum lamination, and the number of layers of insulation. The experimental results can be used to determine the refrigeration requirements for various shipping environments (Burgess, 1999).

Studies have also been conducted on various means of improving insulative packaging. In 1998, one such case study examined potential improvements for a pharmaceutical company's insulated foam shipper. The package physically consists of a foam insert in a corrugated liner box, and is used for the transportation of temperature sensitive diabetic supplies. The temperature-retentive properties of the package were enhanced by means of a foil liner (Foil liner…, 1998).

Developments were also made in 1999 by two Japanese materials scientists. Their prototype design for a hybrid corrugated/foamed polystyrene box is designed to be used for low temperature shipping scenarios, such as flowers or fresh fish. The desirable cost characteristics of corrugate make it an ideal candidate for structural combination with insulative packaging materials (Kato, Sasaki, 1999).

Optimal take-home packaging is largely a function of the particular food that is attempting to be preserved. Fava, Pagliarini and Piergiovanni conducted an examination of the unique challenges of pizza delivery packaging. Comparison was made between traditional corrugated containers and expanded polystyrene containers. Results showed a marked improvement in delivered quality with the new foam insulated package (Fava, Pagliarini, Piergiovanni, 1999).

2.2.2 Thermal Barrier Coatings

Dinwiddie and Wang conducted experimental comparisons of various thermal barrier coatings for insulative packaging applications in 2001. Their discussion focused on the relationship between thermal conductivity and diffusivity and the micro structural characteristics of certain thermal barriers. Also included is an overview of thermal barrier classification by thermo-physical properties (Dinwiddie, Wang, 2001).

2.2.3 Aerogels

Hrubesh and Pekala attempted to quantify various means of thermal exchange through porous materials. This includes radiative, solid and gaseous, as well as how the molecular structure of an aerogel allows it to reduce thermal conductivity. Their experimental results showed favorable insulative improvements when aerogels were used with small pore size and low solid conductivity (Hrubesh, Pekala, 1994).

In 1999, a group of materials scientists examined the conductive properties of extremely low density aerogels. In particular, their physical properties were studied with a micro indentation technique. Results showed two variations in mechanical properties; elasticity in low density aerogels, and elastoplasticity in higher density aerogels (Esteve, Martinez, Molins, Moner-Girona, Roig, 1999). These properties are explained further by Pajonk and Pierre by refrencing the differences between carbon, organic and silica polymers in aerogel processing (Pajonk, Pierre, 2002).

6.2 EXAMINATION OF RECENT INSULATION TECHNOLOGIES: PATENTS

Of the patents examined, the following were selected due to their technological appropriateness. They represent the insulative technologies most applicable to the take-home food problem. Additional patents surveyed are listed in the patents section

US6010027: Thermally insulated synthetic resin container and thermally insulated synthetic resin lid.

This patent is representative of current advances in re-useable temperature retentive containers. The container is molded from synthetic resin, preferably using polymers such as polyester with desirable gas barrier properties. Other potential polymers include ethylene vinylalcohol, polybutylene terephthalate, and polyvinylidene chloride. The resin layers are laminated to reflective barriers such as copper, silver or aluminum foil as a means of retarding radiant temperature loss.

Unique to this design is the addition of barrier gasses with heat conductivity less than that of air. The inventors suggest xenon, krypton or argon, pumped into the container's cavities at room temperature. (Fujii; Takafumi, Furuyama; Kensuke, Kamachi; Hidefumi, Tanaka; Atsuhiko, Yamada; Masashi, 2000)

US6147337: Microwaveable heat retentive receptacle.

This patent again addresses the issue of re-usable food service containers, but approaches the problem differently. Besser suggests using an interior layer of polymeric nylon, ester, ether, acetate (or copolymers containing similar materials), because they can absorb microwave heat to a melting point in excess of 400°F. Polymeric materials are superior to metals because they will not reflect microwaves back into the emitter, causing damaging arcing. This package combines good insulative designs with an active heat retaining element; key to successful temperature retention. (Besser; John. November, 2000)

US6149005: Container for transporting foods.

Rusconi's design is interesting because it deals with temperature retention as well as ease of use. The container is designed to retain heat in multiple portioned segments – ideal for transporting a days worth of meals (breakfast, lunch and dinner), or multiple meals for multiple consumers. Rusconi also incorporated enclosures for silverware and a beverage. A shoulder strap is optional for easy transportation. (Rusconi; Danilo, 2000)

US6196448: Heat-retaining food carton.

It is important to remember that plastic is not the only viable option for heat retention. It is also important to consider the properties of the food that you desire to preserve via your package. Correll addresses both of these points in his design of a folding carton specifically for crispy side items, (fried foods, breadsticks, chicken wings). Correll's design minimizes the transfer of internal package heat (to keep the food warm), prevents moisture condensation on the container walls (to preserve the crispy nature of the contained food product), and accomplishes both in a cost sensitive manner. (Correll; John. 2001)

US6248981: Sealed food container and method of ensuring delivery of the container in a heated state.

Robert's design also possesses characteristics that are desirable in the take-home food container market. The invention incorporates a heated tray that is evacuated of air and sealed with a barrier film. The vacuum aides in the retention of the content's heat, and the seal is tamper evident, so the packaging is particularly useful in the medical realm. However, the design could cause flavor damage to its contents if condensation became an issue. (Check; Robert, 2001)

CHAPTER THREE: PHASE CHANGE MATERIAL TECHNOLOGIES

3.1 Overview of Technology

The molecules of a substance in a liquid or solid state possess both kinetic and potential energy. The potential energy is due to electro-static attraction between the particles. To change the physical state of the material requires the addition (from solid to liquid), or removal of (from liquid to solid), energy. When energy is supplied to a solid at its specific melting point, the energy will cause the solid to melt without changing its temperature. During a phase change, the energy supplied goes into increasing the potential energy stored between the molecules. Latent heat is the term used to describe energy that causes a change of state without a corresponding change in temperature.

Phase Change Materials (PCM's), take advantage of latent heat. PCM's are designed to maintain the midpoint of a narrow temperature range. This temperature range is determined by the hydrocarbon molecule length of the phase change material. Different lengths suit the material to different temperature ranges. When a PCM is exposed to heat, some of its phase change particles absorb the heat and melt. As the ambient temperature in the container decreases, the phase change particles return to a solid state, releasing their stored heat. PCM's can move through these cycles indefinitely, making them ideal candidates for reusable containers.

Research laboratories and patents provide an informed view of recent technologies.

6.2 EXAMINATION OF RECENT PHASE CHANGE MATERIAL TECHNOLOGIES

These articles are representative of current phase change technological advances, and were selected based upon their merit to address the needs of the take-home market.

3.2.1 PCM Developments

PCM technology is being developed for a large variety of applications. Unfortunately, published materials have become limited in the last five years. The field is currently dominated by patents.

Cuevas-Diarte, Espeau, Haget, and Mondieig proposed a double wall PCM container in 1997. Their solution was a commercially available prototype for cooling liquid food items. An examination of the container showed it to be a viable solution (Cuevas-Diarte, Espeau, Haget, Mondieig, 1997).

PCM's can also be applied to packages as barrier coatings, an idea investigated by Nordwall. In the study, tiny, metal-coated ceramic speres produced by Spectral Dynamics Systems (SDS), were added to standard paint. Single or multiple coatings of this substance were found to have a dynamic effect on the conductive properties of the painted object (Nordwall, 1999).

An excellent summation of the history of PCM's was written in 2003. This includes specific materials, applications and principles of heat transfer. More than 150 materials are listed, including 45 phase change materials presently in production (Cabeza, Marin, Mehling, Zalba, 2003).

3.3 EXAMINATION OF RECENT PHASE CHANGE MATERIAL TECHNOLOGIES: PATENTS

Of the patents examined, the following were selected due to their technological appropriateness. They represent the phase change technologies most applicable to the take-home food problem. Additional patents surveyed are listed in the patents section

US6108489: Food warning device containing a rechargeable phase change material.

This invention is not a means of containing food for transport, but the favorable aspects of the design are easily transferable. The basic premise is the same as that of any PCM – a core of material (in this case consisting of alkyl crystalline alkyl hydrocarbons, alkyl hydrocarbon waxes, crystalline fatty acids, linear crystalline primary alcohols, ethylene copolymers, polyethylene, polyethylene glycol, polyethylene oxide, and acetamide), gives off its latent heat as it cools. However, this particular design can be heated by many different means; microwave, steam or convection. It could be easily incorporated into an existing insulative package design to actively heat the contents. (Frohlich; Sigurd, Koellner; Hans Jochen, Salyer; Ival, 2000)

US6400896: Phase change material heat exchanger with heat energy transfer elements extending through the phase change material.

This invention comprises a cylindrical shape surrounded by PCM. There are energy exchangers (coils), that pass through the PCM. This allows the container to efficiently heat or cool the interior contents depending upon their particular requirements. This kind of versatility makes it an ideal candidate for food service applications where both hot and cold items are served. (Longardner; Robert, 2002)

US6402982: Phase change composition containing a nucleating agent.

This patent pertains to a particular mixture of water and sodium chloride (with a 1% nucleating agent), which has PCM characteristics making it ideal for packaging applications. Salyer's material is able to absorb and release significantly greater levels of energy per unit weight as it approaches its freezing point. Additionally, the material is primarily water and salt, making it a very cost sensitive packaging solution. (Salyer; Ival, 2002)

US6501057: Residually heated food carrier.

This patent is a temperature retentive PCM container for use in institutional food service. It incorporates elements of traditional insulative containers, as well as being adaptable to induction heating. The PCM chosen is Bareco's Petrolite P 20, a synthetic microcrystalline wax having ideal temperature characteristics. While Jarvis' design is meant for re-useable containers, the PCM is economic enough to have potential in the take-home packaging market. (Jarvis; Charles, 2002)

CHAPTER FOUR: INDUCTIVE HEATING TECHNOLOGIES

4.1 Overview of Technology

Electromagnetic induction is the creation of an electromotive force in a conductor as the result of a changing electromagnetic field around the conductor. This involves raising the temperature of an electrically conductive material by subjecting it to an alternating electromagnetic field. The conductor and the electromagnetic field generator do not need to be in contact for induction to occur – the electric currents induced in the conductor bring about dissipation of power in the form of heat. This allows a conductive material to be heated without removing it from its insulative container.

Research laboratories and patents provide an informed view of recent technologies.

6.2 EXAMINATION OF RECENT INDUCTION HEATING TECHNOLOGIES: PATENTS

Of the patents examined, the following were selected due to their technological appropriateness. They represent the inductive technologies most applicable to the take-home food problem. Additional patents surveyed are listed in the patents section

US6097014: Apparatus and process for delivery of prepared foods.

This design is representative of traditional reusable inductively heated food containers for institutional food service applications (hospitals). It consists of an insulated container with magnetic materials in both the bottom and the upper portions. These plates are heated by means of an inductor located on the serving tray. While this design is not specifically applicable in its current form to the take-home food market, there is great potential for inductively heated food containers. (Kirsch; Norbert, 2000)

US6188053: Heat retentive server.

Sanitizing inductively heated containers can be difficult. The plastic that is molded around the magnetic discs begins to degrade when it is exposed to dishwashing chemicals. Eventually, the inductive discs crack apart, allowing water to damage the inductive unit. This patent addresses this problem through a specially designed polypropylene sleeve. The container also has many desirable insulative properties, but has been specifically designed for repeated use. The costs associated with this may make it impossible to apply to the take-home problem. (Wyatt; Burk, 2001)

US6191401: Heat maintaining food delivery container.

The Salernos improve on other inductively heated containers by altering the shape of the magnetic absorbers. While other patents use heavy, stiff heat retainers positioned at the bottom of the package, their design uses flexible heat retainers to keep the active heating component as close as possible to the food. They also claim an optimized means of inductive heating which requires substantially less pre-heat time. (Salerno; Mark, Salerno; Roberta, 2001)

US6232585: Temperature self-regulating food delivery system.

This invention is for use in applications where the container must maintain a constant temperature for longer than one and a half hours. The design consists of an insulated container with an inductively heated plate at the bottom. This container is placed in an inductive cradle, which periodically receives temperature feedback, and adjusts the amount of energy released accordingly. While this method is ideal for extremely temperature sensitive items, the additional cost of the cradle limits its applicability. (Ablah; Amil, Clothier; Brian, 2001)

US6279470: Portable and self-contained system for maintaining prepared
foods in a cool state and reheating them.

This invention consists of various insulated containers placed on an inductively heated tray. The containers keep the food cold until it is ready for consumption, at which time a rechargeable power source inductively heats their containers. The tray is divided into 'hot' and 'cold' sections, allowing for some of the containers to be heated while others remain cold. (Laligant; Pascal, Le Blevennec; Pierre, Simeray; Janick, 2001)

US6350972: Induction-based heated delivery container system.

This invention utilizes a flexible magnetic induction receptacle, similar to the Salerno design. The temperature of the delivery container is regulated by using metal with a Curie point of 275°F, that is, the material loses its magnetic properties (and thus its susceptibility to induction heating), at a temperature of 275°F. This allows for more rapid container pre-heating, while acting as a fail safe for container overheating. (LaFevor; Jack, Wright; David, 2002)

US6512211: Storage pouch for use with an induction heater.

This patent represents the most current incarnation of the inductively heated pizza delivery bag. The materials used have excellent insulative properties, the bag is capable of being heated in a relatively short period of time, and a special pouch has been devised for keeping the inductive plates in proximity to the pizza. (Lockhart; Edward, Moyer; Joseph, 2003)

CHAPTER FIVE: NON-CHEMICAL HEAT SOURCE TECHNOLOGIES

5.1 Overview of Technology

The most traditional means of keeping something warm is to place it near a source of radiant heat. This is traditionally the result of heat via electrical resistance, and has been applied to pizza delivery in the form of 'cigarette lighter' heated pizza delivery containers. Patents dominate recent research.

5.2 EXAMINATION OF RECENT A NON-CHEMICAL HEAT SOURCE TECHNOLOGIES

5.2.1 Heat Via Electrical Resistance

One of the principle means of keeping an insulated delivery container warm is by an internal electrical heater. Kroskey conducted an examination of technological advances in pizza delivery bag construction pertaining particularly to heating by means of electrical resistance. Humidity, temperature and different means of heat retention were discussed, as well as the specific challenges associated with keeping a pizza warm and crisp in a cold and humid environment (Kroskey, 2001).

5.3 EXAMINATION OF RECENT A NON-CHEMICAL HEAT SOURCE TECHNOLOGIES: PATENTS

Of the patents examined, the following were selected due to their technological appropriateness. They represent the non-chemical heat source technologies most applicable to the take-home food problem. Additional patents surveyed are listed in the patents section

US6120819: Method for institutional distribution of meals.

This invention is intended for use in an institutional food service environment. It is very similar in design to inductively heated food service applications, except that no special equipment is necessary for the heating to take place. The temperature of the food is maintained by actively heating the interior of a well insulated tray. (Ferbus; Jean, Violi; Jean, Violi; Raymond. 2000)

US6222160: Food transport container with integral heater.

This design incorporates some elements of insulated pizza delivery systems. It uses plastic fiber and foil layers to help maintain internal temperature while at the same time actively heating the packaging system with electrical resistance. The container was designed to be efficient enough to be powered by a standard automotive battery, making it ideal for food delivery. (Dahlke-Baumann; Jeanne, Remke; Matthew, 2001)

US6267045: Cooking device with energy storage and extraction system.

This design represents a high cost solution to temperature retention problems. The container is designed with heat and air circulation in a manner that allows the interior contents to actually be cooked while in transit. This would allow restaurants to provide customers with food that would cook itself on t he ride home. The system is also equipped to cool or even freeze its contents if necessary. (Kohlstrung; Peter, Wiedemann; Peter, 2001)

US6300599: Wrap heater and method for heating food product.

This container is a series of sleeves heated with electrical resistance. The outer sleeve has a heavily insulated layer to protect the internal temperature of the entire system. The internal sleeve can be configured to insulate in one or more directions, allowing different sides of the food product to be exposed to different levels of heat. This would be ideal for open faced sandwiches or pizza. (Bostic; William, Mericle; Robert, Owens; Byron, 2001)

US6486443: Apparatus and method for heated food delivery.

This invention is designed for pizza delivery. It consists of a fiberglass outer housing, and a woven, foil and plastic inner container. The primary source of heat is an electrical resistance heater providing more than 2.5 watts of energy per square inch. The container is also equipped with an external panel that provides the delivery driver with information such as the location of the delivery, the time since departure, or the temperature of the contents.

CHAPTER SIX: EXOTHERMIC HEAT SOURCE TECHNOLOGIES

6.1 Overview of Technology

An exothermic reaction is a chemical occurrence characterized by the transfer of heat to the system's surroundings. For food heating applications, this is typically created by the combination of two or more chemically reactive agents. The resulting reaction creates a single use, high temperature heat source.

6.2 EXAMINATION OF RECENT EXOTHERMIC TECHNOLOGIES

These articles are representative of current technological advances in exothermic packaging, and were selected based upon their merit to address the needs of the take-home market. Patents dominate research.

6.21 Self-Heating Containers

According to Brody, exothermic packaging has been resisted by industry due to the costs typically associated with it. He examines current and past international packaging technologies used to heat and cool food containers, as well as specific uses of calcium oxide as a chemical reactant (Brody, 2002).

A specific example of self-heating, exothermic beverage packaging technology was presented by the Poway corporation in 1998. Their container is a blow molded, six layer polypropylene structure that is completely recyclable, simple and relatively inexpensive (Self heating…, 1998).

6.3 EXAMINATION OF RECENT EXOTHERMIC TECHNOLOGIES: PATENTS

Of the patents examined, the following were selected due to their technological appropriateness. They represent the exothermic packaging technologies most applicable to the take-home food problem. Additional patents surveyed are listed in the patents section

US6178963: Heat pack.

This patent provides the most typical example of a chemically activated heat source. Two reactive elements are packaged separated, and then combined by means of a flexible trigger. The resulting reaction is used to heat a beverage or food item. This design is somewhat flawed in that its manufacture requires the addition of a spring-like trigger, which adds additional costs. (Baik; Chang, 2001)

US6248257: Portable heat source.

This invention consists of a mixture of acidic salt with a basic anhydride. The mixture reacts when a trigger is activated, creating a high temperature heat source without the need for any modern facilities. This invention provides the consumer with the ability to warm (or potentially cook), their food at their own convenience. (Bell; William, Copeland; Robert, Dippo; James, Yu; Jianhan, 2001)

US6289889: Self-heating flexible package.

This heater has been designed to provide an exothermic reaction from the combination of calcium oxide with ordinary water. Central to its improvements on other packages is the lack of any kind of reaction inducing trigger. The design allows for activation simply through agitation with the hands. Further, the device is produced with nothing but standard flexible packaging materials with known and proven barrier properties, making it ideal for food packaging applicatons. (Bell; William, Dippo; James, 2001)

US6309598: Electrochemical heater and method for sterilizing.

This invention takes a novel approach to the reactionary process by integrating it into a corrugated design. A dry mixture of magnesium, iron, and calcium nitrate is deposited within the valleys of a single-wall corrugated medium, and covered with a porous sheet of polypropylene. This would allow many existing corrugated container designs to be directly translated into new technology. (Tully; Thomas, 2001)

US6318359: Heat pack using super-cooled aqueous salt solution.

In this instance, the reacting agent is a super-cooled salt liquid. The salt is heated to a very high temperature and then cooled to a temperature that is cooler than its normal crystallization point. When the exothermic reaction is desired, the reaction is initiated, and the solution begins to crystallize, giving off energy. Unfortunately, this invention is intended for use as a heat pack in hospital situations, so the temperature of the reaction isn't extremely hot. (Schmidt; George, Whitely; Jeffrey, 2001)

US6502407: Self-heating or self-cooling containers.

This invention approaches the task of heating a container indirectly; that is, it does not use direct contact with the reactive elements to warm the food. Instead, the reaction occurs at a temperature which is able to produce steam. This would be an ideal means of heating non-moisture sensitive foods, such as vegetables or pasta. (Richardson; Robert, Searle; Matthew, 2003)

CHAPTER SEVEN: CONCLUSION

7.1 Temperature Retention in a Take-Home Container

The solution to maintaining the flavor profile of a take-home meal must are as varied as the potential food items to be contained. Each solution must be individually suited to unique problems of the food product.

'Active' packages are suitable to a large variety of packaging applications, whether heating or cooling is concerned. The particular means chosen, (electrical or induction heating), depends upon the cost constraints of the food service scenario. A cost-sensitive solution may be the combination of inductive particles in a less expensive PCM material – for instance, metal particles in sand.

The 'active' heating component should be combined with the latest means of insulative technologies. This may be a reusable container comprising several high cost technological components, or a simple re-design of existing corrugated or polystyrene containers.

It is clear that the technology exists today for exciting new technologies to be applied to the realm of take-home foods.

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