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SELF-HEATING PACKAGING - AN ACTIVE PACKAGING TECHNOLOGY: A REVIEW

[1]Anusha V, [2]Rita Narayanan

[1]PhD Scholar, [2]Professor and Head
[1]Department of Food Processing Technology
[1]College of Food and Dairy Technology, Tamilnadu Veterinary and Animal Sciences University, Chennai, Tamilnadu, India

***Abstract*:** Active food packaging is based on a deliberate interaction of the packaging with the food and/or its direct environment. It aims at extending shelf life or improving safety while maintaining quality. Self-heating packaging is a system of active packaging which has the ability to heat the food content without external heat source. This is an emerging technology and has gained market expansion due to the demand for convenient foods and changes in life-style of consumers. The heating of contents is achieved by the exothermic reaction between quicklime and water which heats the product to around 40°C within 3 minutes. The global self-heating food packaging market size is projected to hit around USD 89.10 billion by 2030.

***Key words*:** Active packaging, Self-heating, Convenient foods, Exothermic.

1. INTRODUCTION

Labuza and Breene (1989) described the concept of active packaging and used effectively for increasing the shelf life of processed foods and meet consumer demands by providing high-quality products in fresh and safe condition. The active packaging system changes and maintains the conditions of the packaging throughout the storage period to extend shelf-life as well as improve safety or sensory properties by maintaining packaged food quality the quality (Ozdemir and Floros, 2004; Dainelli *et al*., 2008). It is an innovative concept in which the package, the product and the environment interact with each other and particularly used for fresh and extended shelf-life foods.

Active packaging techniques for preservation and improving quality and safety of foods can be divided into three categories; absorbers (scavengers), releasing systems and other systems (Raija, 2003). Scavenging systems eliminate unwanted compounds like oxygen, ethylene, carbon dioxide, taints, excessive water etc, while releasing systems add or release active compounds into the head-space or to the packaged food like carbon dioxide, preservatives, antioxidants etc. Other systems may have miscellaneous tasks such as temperature control, modifiers for microwave heating, temperature sensitive films etc. (Hurme *et al*., 2002).

Temperature control active packaging comprises (Day, 2003). For getting added convenience, self-heating and cooling packs for food and beverages allow the consumer to drink or eat during working or travelling. For example, special insulating materials have been developed to protect against excessive temperature abuse during storage and distribution of chilled foods. Thinsulate is a special nonwoven plastic with many air pore spaces used for protecting chilled foods.

2. SELF-HEATING PACKAGING

Self-heating food packaging is an active packaging having the ability to heat the food content without external heat source or power. These types of packages are useful for military operations, during natural disasters, mountaineers, field engineers and whenever conventional cooking is not available. The packages are often used to prepare main courses such as meat dishes, which are more palatable when hot. The first self-heating can was invented in 1897 by Russian engineer Yevgeny Fedorov.

Self-heating functions of beverage packages have been defined by Katsura (1989). Complaints ranging from the product being too hot or not heating at all is the major problem that has to be faced during development of this type of containers. Some unique features of these packages are safe food, no liquids to spill, no flame, smoke and fumes, heat without access to microwave oven or stove, no refrigeration needed, easy to use and surface of the package not reaches 54°C. The main difficulties associated with self-heating cans include more expensive than conventional type, undergo uneven heating of contents and take more space.

Self-heating packs have been used for beverages such as tea, coffee, hot chocolate etc., noodles, ready-to-eat meals, soups, meat products etc.

2.1 Principle

The basic principle with self-heating packs is that bottom of the can/pouch is pushed releasing a small amount of water that when mixed with a salt (calcium or magnesium oxide) causes an exothermic reaction which develops heat in the product. These exothermic reactions transfer energy to the surroundings (Day and Potter, 2011). The energy generated is transferred as heat energy, which upsurge the temperature of the reaction mixture and its surroundings. Almost half of the volume within the package is occupied by the heating device. Most commonly using self-heating mechanism is quicklime/water but calcium chloride/water, potassium permanganate/ glycerol and super corroding alloys/salt water can also be used (Anon, 2006c).

2.2 Technology

The exothermic reaction is the source of heat for the self-heated can that initiates by pressing on the bottom of the can by user (Day, 2003). Heat is generated by one of the exothermic solutes (Calcium or Magnesium oxide) and the water. Heat liberated from this reaction is 62.3 KJ/mol. It generates heat within 3 min and remains hot for 20min.

The can is manufactured as three containers. The product container surrounds heating agent container separated from water container by a thin breakable membrane. While pushing on the bottom of the can, piercing of membrane caused by a rod allowing the water and heating agent to mix properly. The resulting reaction releases heat thus warms the product surrounding it.

From product to product the heating agent and responsible reaction varies. However, calcium oxide is mostly used (Uzma *et al*., 2018).

The reaction is:

$$CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(s)$$

In some cases, copper sulphate and powdered zinc can also be used, but this process is less efficient.

$$CuSO_4(s) + Zn(s) \rightarrow ZnSO_4(s) + Cu(s)$$

Anhydrous calcium chloride is often used as well. In this case, no chemical reaction occurs, instead the heat of solution is generated (Uzma *et al*., 2018).

2.3 Heating Method

According to Uzma *et al*. (2018) for heating the contents in the packages, two methods are used viz. Type (i) and Type (ii). In Type (i) method the inner chamber holds the food or drink and the outer chamber houses chemicals that undergo an exothermic reaction when combined. By pulling the ring on the can the barrier that keeps apart the chemicals in the outer chamber from water breaks causing exothermic reaction which further helps in the heating of the food contents.

Figure 1: HotCans: Self-heating canned food (Source: Techcrunch, 2009)

In Type (ii) method the chemicals present in the inner chamber and the beverage in the outer chamber. By pushing on the bottom of the can the barrier separating the chemical from the water breaks and heat the contents of the can. The main advantages of this design include more efficiency (less heat is lost to the surrounding air) and reduced excessive heating of exterior of the product.

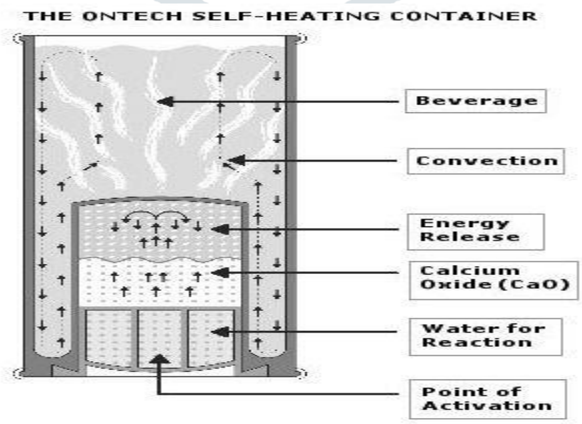

Figure 2: Self-heating technology (Source: Future of food, 2008)

3. TYPES OF PACKAGES

Different types of self-heating packages include cans, bottles, pouches, bags and containers.

Figure 4: Different types of self-heating packages (Source: Tempra Technology)

According to Islam (2022) the can is made of a double-walled, vacuum insulated stainless steel. Aluminium heat exchanger present in the can transfers the heat from the liquid to the outside wall of the can that keeps the food or drink at a constant temperature for hours. Cans with different sizes, shapes, handles and straws are widely available in the market. Many types of drinks and foods such as coffee, tea, soup, hot chocolate mix etc., that are available in self-heating cans.

Housing system of a self-heating bottle consist of an exothermic phase change material and one or more fluid channels extending from one end of the housing to the other. During thermal communication with the exothermic phase change material, fluid passing through the fluid channels is heated by the exothermic phase change material. The self-heating connector is particularly suited for use with a fluid container and a fluid delivery port such as a baby's bottle and feeding teat (Jim *et al*., 2006).

Self-heating pouches contain food grade calcium oxide, calcium hydroxide, iron, magnesium chloride and aluminium. The pouch system comprises a contents-containing section, a temperature-controlling section and a bag for liquid reactant (which may be water). By manually rupturing the seal between the latter two sections, liquid reactant exothermically reacts with the temperature control agent (Rick, 2014). Polyethylene, polypropylene and polyester can be used as fil substrates. It may be in the form of stand-up pouch or reportable pouch and allowance for a transparent window in the film. Generally, these pouches are made for single use only.

Self-heating containers are the sophisticated form self-heating pouch technology. By pressing a button outside the bowl, exothermic reaction is activated. It will heat the food in 5-10 minutes.

4. COMMERCIAL PRODUCTS

Self-heating packs have been used for a number of products such as tea, milk, coffee, noodles, hot chocolate, vegetable chili, beans with balls, sausages, soup and creamy rice pudding. For decades, the commercial availability of self-heating cans and containers have been reported and mainly popular in Japan (Day, 2003; Anon, 2002; 2005b; 2006c).

The joint venture between Crown Cork, Thermotic Developments and Nestlé launched the most successful self-heating containers. During 2001 in the UK, Nestlé introduced 210 ml Nescafé coffees in self-heating insulated cans, heated with an occasional shake to around 40°C within 3 minutes ("Hot When You Want") that used quicklime and water for exothermic reaction. These self-heating cans were manufactured by Thermotic Developments (UK) but were withdrawn from the market in 2004 because the coffee didn't get hot enough during the winter months.

Self-heating coffee, tea and chocolate products produced by Nuova Bit S.R.L. distributed under the brand name CaldoCaldo (Potter *et al*., 2008). It is an Italian development that uses anhydrous calcium chloride and water for the exothermic reaction. The substances are mixed by shaking the container for 40 seconds which swirls the hot solution around the aluminium cup containing 40 ml of beverage and the temperature rises around 23°C.

Ontech™ introduced the self-heating formula to the USA market in the name of Hillside Beverages and 10-ounce (295 ml) Wolfgang Puck gourmet lattes in self-heating cans. Exothermic reaction between quicklime and water within portable plastic container fitted into a cup holder which heated the coffee to around 60°C (145°F) in six minutes and kept it hot for 30 minutes. Unfortunately, it was technically not a success and Hillside Beverages (OnTech) went out of business in 2008 (Best in Packaging – Part 1, 2012).

In April 2005, Spain launched 200 ml 2GO Self-Heating Can of Fast Drinks. The welded tinplate can consist of a number of readily-available components such as three-piece welded and expanded tinplate can bodies and a full-aperture easy-open end to reveal press-button that starts the heating process. The three compartments in the system include packaged beverage, calcium hydroxide and water. Dissolution of calcium hydroxide in water generates large amount of heat (up to 40°C, 104°F) in 3 minutes, which heats the beverage located in the first compartment of the can and allows for it to remain hot for up to 20 minutes (Best in Packaging – Part 1, 2012).

Heat Genie launched high efficiency solid fuel technology for self-heating packages. It uses a simple button press activation. Hence the button is a thermo-mechanical device. The heating process stops by spending the fuel. Heat Genie heat ups the product for 145°F within 2 min and stays warm around 30 min (Best in Packaging – Part 2, 2012). In 2020, La Coulombe, a Philadelphia based company partnered with heat genie.

42 Degree Company produced self-heating can which increases the temperature of the content in just 3 min with a heating temperature of 42°C. The company launched self-heating can for beverages like Cappuccino Caramel, Coffee Arabica Without Sugar, Coffee Arabica With Sugar, Chocolate Drink With Milk, Chai Latte Masala and Caffe Latte (Jenny, 2018).

Malasia introduced double chambered aluminium can in the brand name Hot-Can which contains the beverage in the outer chamber and holds water and calcium oxide separately in the inner chamber. By pressing button at the bottom of the can exothermic reaction starts between water and quicklime that heats the contents of the outer chamber to 50-55°C in less the 3 minutes (Best in Packaging – Part 1, 2012).

Flexible twist innovative self-heating (quicklime) for liquid food and beverages was launched ScaldoPacks. The product consists out of a "pouch-in-a-pouch-concept" where inner pouch serves as the reaction chamber while the consumable product carried by outer pouch. Pressing of the reaction chamber causes heating of the consumable product. By doing so, the exothermic reaction is activated, adding 35°C in about 5 minutes to a 200ml consumable product (Best in Packaging – Part 2, 2012).

5. MARKET ANALYSIS

In the recent years self-heating food packaging global market has witnessed significant growth owing to increase in convenient food products demand and living standard among customers across the globe. In the year 2021, the global self-heating food packaging market size was valued at USD 60.4 billion and in 2030 it is expected to hit around USD 89.10 billion over the forecast period 2022 to 2030 (Precedence Research, 2022). The market for self-heating food packaging is still in its infancy, rising consumer awareness of its functionality and advantages is anticipated to lead to considerable demand over the forecast period. The primary element accelerating the self-heating food packaging market expansion is the rise in convenient food items demand and the level of life among consumers throughout the world.

Major factors that driven the market for self-heating food packaging include expansion of global food and beverage industry, rise in the wholesome on-the-go food demand, increase in the demand for ready-to-eat foods, confectionary foods and beverages like soups, tea, coffee etc., rising food and beverage consumption and changing consumer lifestyles. New growth prospects due to increased technical breakthroughs, modernization of packaging processes and growth in demand from emerging nations. The main factors limiting market growth are the increased usage of chemical heat sources and strict government environmental pollution regulations and thus causing difficulty in the expansion of the economy for self-heating food packaging (Precedence Research, 2022).

6. CONCLUSION

Changes in consumer preferences have led to innovations and developments in new packaging technologies. Demand for quality food has driven packaging innovation. These developments led to improvement in food processing and packaging technologies. Packaging provides for convenience with products that can be heated in the package and products that can be purchased as single-serve items. Active packaging is an emerging area of food packaging. In active packaging, self-heating packaging system is gaining significant growth in the recent years. The primary element accelerating the self-heating food packaging market expansion is the rise in demand for convenient food items and the life-style changes of consumers throughout the world. More growth prospects will result due to increased technical breakthroughs, modernization of packaging processes and growth in demand from emerging nations.

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