Safety of Food in Vending Machines

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Glossary

Ambient temperature foods Foods that are stable at room temperature.
Food safety management plan Also referred to as the HACCP plan—a plan written to show how a company plans to manage and control food safety hazards within its business.
HACCP A system that identifies, evaluates, and controls hazards that are significant for food safety. The acronym stands for hazard analysis, critical control points.
Micromarkets Small, unattended convenience stores in workplaces and other closed locations.
Smart fridge A chilled cabinet fitted with a door lock, payment system and sensors to detect which product(s) has been taken.
Vending operator The person who cleans and fills a vending machine.
Work instructions Written instructions for vending operators to ensure they carry out their tasks in a manner designed to protect food safety.

Abstract

Vending businesses buy foodstuffs, store them, and distribute them to machines that are regularly cleaned and refilled. Except for chilled- or frozen-food vending this is usually a straightforward process with the only hazard to food safety being physical or chemical contamination. Chilled and frozen food must be kept under refrigeration throughout its entire shelf life and particular care must be taken with these types of foodstuffs. The water contact parts of hot drink machines need to be cleaned regularly with hot water and detergent and particular care needs to be taken with machines that use liquid milk.

Introduction

Since its inception at the end of the 19th century the vending industry has developed as technologies have been introduced and customer expectations have risen (Segrave, 2015). The first machines dispensed chocolate bars and cigarettes through simple coin operated mechanisms. Hot drinks machines were introduced in the 1940s using powdered coffee and milk (Higuchi, 2007). As technology has progressed and new ingredients have become available, the range and quality of the offering has improved immeasurably (Sibanda et al., 2020). Now the industry product range includes packaged food and drink at both chilled and ambient temperatures, coffee and tea made directly from ground coffee beans or leaf tea together with fresh milk as well as a range of drinks made from powders.

Machines used in food and drink vending are of two types, those for wrapped or packaged foods and those which prepare and dispense hot or cold drinks. The former can store and dispense a very wide range of foodstuffs and drinks including products that are

fresh, chilled, frozen or have a long shelf life at room temperature. These include ice cream, plated meals, sandwiches, fresh fruit, baked goods, dairy products, confectionery, and snacks. In general, products are vended for immediate consumption, but some require heating before consumption. In these cases, the vended product is put through a heating process either in the machine or close by. There are no machines currently in use in which products are stored at temperatures above ambient for reasons of food safety.

The floor standing vending machine is still the backbone of the industry, but it is now joined by smart fridges and micromarkets. Smart fridges are similar to refrigerators in retail stores, where the consumer opens the door to take the product. They have sensors to detect the product(s) removed and the payment point calculates the cost of the purchase(s). Micromarkets comprise several machines, fridges and shelves which can include both packaged food product and drinks machines to provide the equivalent of an unattended convenience store. The machines are located within business premises and are fitted with less sensor technology than a smart fridge, but the honesty of the customer is encouraged using security cameras. In both cases, the temperature of a unit displaying chilled food is controlled to a preset maximum level, usually 5 °C, and the door is locked if the temperature rises above this set-point. Both systems have continuous contact with the operator company and only the operator company can unlock the door. The machines are cleaned and refilled by the operator company.

The Vending Market

In most countries with a significant vending presence (e.g., US, Japan, and Australia), the market is dominated by can, bottle, and snack machines, whereas in Europe more than 60% of the vending machines serve hot drinks. In the past, coffee was prepared from powder but more recently machine technology has allowed the use of ground coffee beans and liquid milk.

Machines need to be checked, replenished, cleaned, and maintained and generally this is done by the vending operator company. A small proportion of vending machines are owned by individual institutions and cleaned and restocked by them. Some others are operated by catering companies, but the great majority are cleaned, maintained, and filled by an operating company of which there are 10,000 in Europe alone. While a few of these companies are multinational organizations employing thousands of people, most are small- and medium-size enterprises (SMEs) or family businesses operating between a few hundred and a few thousand machines. Vending machines are sited in the workplace, in leisure facilities, educational establishments and occasionally, public sites; in Europe 80% of all machines are sited in the workplace. Few vending machines are manufactured to a sufficient standard that they can be placed in the open without protection where they could be exposed to the elements.

Assessing Food Safety Risks in Vending

Hazard analysis, critical control points (HACCP) is a management tool that gives a structured approach to the identification and control of hazards (Pierson, 2012). It requires the journey that any foodstuff follows from farm to fork to be divided into steps, the hazards present at each step to be identified and appropriate measures to be put in place to ensure that the food always remains safe.

All vending products, whether sold from a vending machine, smart fridge or micromarket, follow the same general pathway from supplier to consumer. The vending company purchases foodstuffs that are delivered to a warehouse, distributed from there to locations where machines are sited and used to stock the machines. However, in some cases chilled foods are provided by a company that makes them and delivers them direct to the machine. In the past, drinks machines would have been received from manufacturers, connected to a source of potable water, and filled with powdered ingredients. However, an increasing number of modern drinks machines use ground coffee beans, leaf tea and fresh milk, which bring their own particular requirements.

In preparing their HACCP-based food safety management plan, companies would break this pathway down into a series of steps and assess the food safety risks at each step. This same technique will be used in this chapter to provide an overall understanding of the management of the safety of food and drinks in vending (Hunter, 1992).

Types of Vended Food

From a food safety point of view, food and drink sold from vending machines falls into three general categories; food that can be stored at ambient temperature, drinks made from powders or syrups, and food that must be kept chilled or frozen for food safety reasons.

Most of the food and drink sold from vending machines is microbiologically stable at ambient temperature and humidity. This includes confectionery (chocolate, cereal, and fruit bars), bagged snacks (nuts, crisps, baked, and extruded snacks), and drinks in cans, bottles, and cartons (long-shelf-life milk drinks, fruit drinks, carbonated drinks, and water). It also includes the ground coffee, leaf tea and powders for hot and cold drinks and the syrups used for post-mix (that is drinks made by mixing syrup and water in the cup) still and carbonated drinks vended by machines.

Some foods however, need to be stored at lower temperatures in order to inhibit microbiological growth. Foods such as sandwiches and salads must be kept chilled throughout their shelf life to ensure their safety.

Other foods are stored frozen and either vended frozen for eating cold, for example ice cream, or vended to be heated before eating, like ready meals. A further group of machines heat the chilled or frozen products within the machine before vending.

Steps in the Vending Business

All vending businesses have the same basic process for all foodstuffs, whether kept at ambient, chilled or frozen temperatures, which comprises the following steps.

- Purchase of products from manufacturers or wholesalers.
- Transport of the products to the vending company.
- Storage by the vending company.
- Transport of products by the vending company to the machine.
- Filling and cleaning of the vending machine.
- Storage within the machine and dispensing of the product.

None of these steps provide a means whereby unsafe food can be treated to make it safe, so the safety of food in vending depends on safe food being purchased by the company and that food being kept safe throughout its shelf life.

Each step in the vending process will be considered separately.

Purchase of Products From Manufacturers

The first step in the process is the purchase of products. The production of foodstuffs should always be carried out under a food safety management plan that minimizes the risks of contamination by bacteria or physical or chemical hazards. Large food companies have quality assurance departments that can audit suppliers and provide confidence that all necessary actions have been taken to minimize risks. Vending companies, with few exceptions, do not have such teams within their businesses and, as a consequence, must rely on other means to assure the safety of the products.

If the vending companies are buying from one of the major brands then they can rely on the manufacturer having extensive quality assurance procedures in place to maintain the reputation of the brand. However, if they are buying a product with a less well-known brand then they would have to depend on other indicators, for example, whether the supplier had been audited by a large company. It is not sufficient to rely on the supplier having ISO 9001. This certification is not a measure of the quality or safety of the foodstuffs, but of the paperwork trail within the company. It would be possible to rely on ISO 22000 or the British Retail Consortium (BRC) global standard but unfortunately it is precisely the smaller manufacturing companies who are less likely to have these standards. Less bureaucratic standards for smaller companies, such as Safe and Local Supplier Approval (SALSA) in the UK, have been developed but uptake has been limited and slow.

The situation is exacerbated when purchasing chilled foods such as sandwiches and plated salads. Companies who make these products are often small companies that provide products within the local area. They may be audited by the local authority but rarely by a commercial organization with skills in auditing food manufacturing processes. It is important to ensure that the company has the facilities to rapidly chill the foods so that they are below the safe storage temperature before leaving the premises because chillers in vending machines are sized to keep food at a safe temperature rather than to cool it down.

Unfortunately, it is the chilled foods that carry most risk of contamination with pathogens such as *Listeria monocytogenes* and, in general, the purchase of novel or local food items requires considerable diligence by the vending operator to ensure that the manufacturer understands their process well enough to guarantee the safety of the food. Certain foodstuffs, such as soft cheese made from unpasteurized milk, carry the greatest risk and these should not be offered for sale from vending machines.

Transport to the Company

Products may either be delivered by the supplier to the vending company's warehouse or collected by the vending operator company. Many vending companies collect some smaller batches and have larger volumes delivered by the supplier or wholesaler. The only risks to product safety during this step, for foods that are stable at ambient temperature, are those caused by physical or chemical contamination in the vehicle. These may include broken glass or shards of metal or chemicals such as disinfectant or oil from damaged bottles picked up from the vehicle. This is an unlikely event, but it has occurred, and it would be good practice for those checking in the delivery to give a quick look around the inside of the vehicle before unloading. Companies have greater control over their own vehicles, and it is important that vending companies have working practices and training in place to ensure that all vehicles operated by the company are clean and tidy and pose no threat to food safety.

Chilled or frozen food must be kept under temperature control throughout its shelf life. It is important that the delivery vehicle has a refrigeration system that can keep the food at the appropriate temperature under all weather conditions. The company's food safety management plan would require the temperature to be monitored and there are several ways in which this can be achieved depending on the technology in the vehicle. Many modern vehicles have systems that allow continuous monitoring of temperature, and technology now allows this information to be continuously transmitted to both the supplier and customer in real time. Older vehicles may only have a thermometer and here, as a minimum, the temperature should be recorded on arrival. Because the vehicle

thermometer will measure air temperature, the vending operator should also measure the temperature between two packs of product to ensure that the temperature of the product itself is within national standards. Further reassurance would be provided by occasional use of a data logger to accompany product to show the temperature experience of the product throughout the journey.

Storage

Once the product has been received and passed into the vending company warehouse, care must be taken that the foodstuffs are not contaminated. Vending companies, being small companies, tend to have limited space within their premises that are often an industrial unit on a trading estate. Within these premises they will store machines, machine parts and foodstuffs, prepare machines for sale, and repair defective machines. Some companies divide the available space with partitions whereas others operate an open plan system. While it is possible to control the risks of physical and chemical contamination in an open plan arrangement it does need careful management. One of the problems with limited space is effective pest control. It is important that the normal practices of pest control, for example, storage off the floor and away from walls, are followed together with securing the services of a reputable pest control company. Good pest control consists of more than just putting down bait boxes. It involves good hygiene management of the store and regular monitoring and review by the pest control contractor to ensure that the earliest signs of a possible infestation are recognized and acted upon.

It is also important that the practices of good warehouse management are followed including good control of stock rotation. This approach not only ensures that the consumer gets a quality product but also assists in managing traceability.

The situation with chilled and frozen food requires yet more care. These foods must be kept at safe temperatures at all stages along the cold chain, from manufacturer to consumer. Some vending companies receive chilled food into a temperature-controlled store whereas others contract with the supplier of the chilled food to distribute directly to the vending machines. The latter approach removes the need for the vending company to have temperature-controlled storage but takes the process out of their control. However, they still need to check that their contractor's procedures are sufficiently robust to ensure that the temperature of the food is properly controlled throughout its shelf life.

When the vending company stores the food themselves, they must manage the temperature carefully to ensure that it complies with national regulations so that there is no risk to food safety. Temperature control is not harmonized across the world. Within the EU each Member State has its own national regulations with, in some cases, different temperatures for different types of foodstuffs.

To some extent the situation with frozen food is simpler. The product must be kept frozen, with the maximum temperature being specified by the manufacturer. Generally specific storage and delivery systems must be established for frozen product to maintain product quality.

Transport to the Vending Machine

Products are transported to machine sites by van. These vans will carry both food products and cleaning materials and it is essential that they are kept clean, tidy, and well organized so that there is no possibility of contamination of food products by cleaning or other materials. In major cities it is frequently impossible for vans to park close to sites and products must be loaded onto trolleys for transport to the machine. It is important that staff are properly trained in loading and transporting so that fragile products are not damaged or contaminated during this phase of the process.

Chilled or frozen product should be transported in insulated bags with cold packs to maintain the temperature at safe levels. The company procedure needs to be tested to ensure that product is still at a safe temperature before it is loaded into the vending machine.

Vending companies provide services to a wide range of clients, from large customers with many machines, to small customers with just one machine. The servicing of these sites depends both on the number of machines on a site and on the proximity of the site to a company depot. Sites with many machines will have operators on site all day, whereas smaller sites will be serviced by operators who have a route that may have several sites, each with one or more machines. Some of these operators will be based away from the depot and will receive deliveries of stock to their van. Working practices must be written to ensure that however the stock is delivered, it is always safe from risk of contamination.

Filling and Cleaning of the Vending Machine

The frequency of cleaning and filling machines is determined to a large extent by the use of the machine. It is not uncommon for very busy machines to be replenished twice a day, but for infrequently used machines to be visited only weekly. The frequency of visiting chilled food machines will be dictated by the shelf life of the product, which is often 3 days.

The only risk to food safety during filling and cleaning a machine selling ambient temperature foods is that of contamination with the cleaning chemicals. This risk can be mitigated by training and work instructions that ensure that chemicals are never near the foodstuffs.

There are two additional concerns with chilled food. The first is that the chilled food vending machines are designed only to maintain chilled food at a safe temperature, not to chill the food down from room temperature. The temperature of food does slowly decrease within a chilled vending machine but too slowly to comply with any national temperature control regulations so chilled food must be at the correct temperature when it is delivered to the machine. This situation creates a problem for

companies that would like to buy their sandwiches from a local shop. The shop must have chilling facilities that will chill the food sufficiently quickly to comply with national temperature control regulations and must devise a method of safely delivering the food to the vending machine without an unacceptable rise in temperature. It is also important that the machine is open for as short a time as possible so that the food inside does not warm up to an unsafe temperature. It has been shown that the temperature of the air in the machine rises even during efficient refilling and that it takes around an hour for it to fall back to the previous level but that the temperature of the product is scarcely affected. Work instructions and training should focus on the need for planning and good organization in refilling a chilled vending machine.

Frozen food also must be at the correct temperature before being loaded into the machine. This situation requires greater thought and planning to ensure that the temperature does not rise during transport through a warm building or while the product is being loaded into the machine.

The great majority of chilled and frozen food vending machines display the temperature inside the machine but do not have facilities to provide records of temperature over time. As a check on the performance of the machine it is good practice to record the displayed temperature when a machine is filled.

Hot drinks machines will need regular cleaning to control bacterial growth in the mixing bowls and dispensing area (Hunter, 1992). There are two common ways of cleaning the drink contact parts of the vending machine. Once the parts have been removed, they are either cleaned in a bucket on site or bagged up and replaced by a clean set brought from the vending company premises. Provided that the procedure is carried out carefully there is no difference in the effectiveness of these two methods. It has been demonstrated that disinfectant is not needed for cleaning on site, brushing with detergent and hot water followed by rinsing is quite sufficient to keep bacterial loads below a safe level (Hall et al., 2007). It is worth noting that there is only one report in the literature of a food poisoning incident being caused by inadequate cleaning of a hot drinks vending machine (Nelms et al., 1997).

It is important that the person doing the cleaning does not themselves contaminate the machine and that they wash their hands appropriately. As a minimum this should be on arrival at the premises, after using the toilet and before putting on gloves, if these are worn. It is important to train staff to wash their hands correctly. It is also important to be aware that bacteria can be carried on gloves and transferred from place to place, so it would be good practice to change gloves frequently.

It is sometimes forgotten that the cloths and brushes used in cleaning the machine can be a source of contamination and the work instructions should identify the best approach to keeping them clean between machine visits.

Storage and Dispensing

Vending machines are placed in a very wide range of locations. Those in office environments are generally free from risk of pest infestation or chemical contamination but these issues should be considered when placing machines in industrial or public sites. For example, machines have been placed in stables, where they have been infested with flies, in print shops and in bus depots where the surfaces of the cups have become contaminated with solvents and diesel fumes. Sites like these should be avoided and machines should be placed in a clean, well-lit area, out of direct sunlight and away from doors to the outside that could provide access for ants and other insects. In addition, machines should not be placed under stairways where dust and contaminants could be dropped from above and they should not be sited where they may attract pests such as cockroaches.

Snack or can vending machines are essentially boxes in which the products are held. However, there are standards for their design and manufacture, which should be followed. In essence, the machines should be designed and manufactured to be easy to clean with no dark areas in which pests could hide. The materials of construction should be robust and smooth, and corners should be of sufficient radius to be easily cleanable. Food or water contact parts do not have to be made of stainless steel but should always be made of materials, such as polycarbonate, that comply with national or international regulations. The tubing in hot drinks vending machines must be made of materials approved for use with drinking water. Water inlet hoses are usually multilayer extrusions to allow them to cope with the pressure of the supplied water and to have minimal migration of chemicals from the tubing into the water. Tubing within the machine is generally either taint-free plastic or silicone.

Chilled food machines, whether vending machines, smart fridges, or fridges in a micromarket, must keep their foodstuffs at a safe temperature. While there is no worldwide agreement on the temperature, generally these machines have thermostats set to around 5 °C by the manufacturer. These thermostats are controlled by the temperature of the air returning to the chiller. The chillers have sufficient cooling capacity to maintain temperature in an airconditioned building out of direct sunlight and to slowly reduce the temperature rise caused by opening the door. They have a time switch and an upper temperature limit so that if the air temperature rises for too long or by too much the machine will not vend or the door will lock. Because chilled food items have a short shelf life in the machine it is important that they are removed before their expiry date. Color-coded labels can be useful for highlighting on which day of the week product should be removed. Product removed from the machine must be taken from the site and disposed of correctly.

Hot drinks vending machines must be connected to a source of potable water, preferably from the public supply, in order to guarantee the safety of the water and drinks made from it. There are machines using bottled water, but it is not recommended to use water direct from a borehole without having it tested regularly. Where the public supply is of high quality, heterotrophic bacteria are often used as an indicator of quality and levels of these in the water arriving at a building may be less than 100 cells/mL. Some growth, into the thousands, can be expected in water as it passes through the pipework in a building and through a vending machine or water dispenser, but it has been recognized that such limited growth poses no threat to human health (Bartram et al., 2003).

Machines must be connected through a check valve to ensure that water cannot, under any circumstances, pass back into the public mains water system. In the case of machines dispensing carbonated drinks the valve should be a double check valve since carbonated water can dissolve copper. Machines can remain on site for many years, and it would be good practice to change the double check valve after 10 years. Because both soft drinks and carbonated water are acidic, it is very important that the pipework in soft drinks dispensing or vending systems is made of a material that will not corrode under acidic conditions. Acute illnesses have occurred in the past from copper leaching from piping and tubing downstream of a check valve should be either plastic or stainless steel. Water is often passed through a filter before entering the machine. This can have three parts, a particulate filter, an activated carbon filter and an ion-exchange unit. These filters serve to remove any particulates such as chalk that have arisen during the passage of the water through the building, to remove taints such as those from chlorination and to reduce the hardness of the water to improve the taste and color of the coffee and tea. It is important that the water is tested for hardness before fitting the ion-exchange unit as reducing the level of calcium too far can lead to the water being plumbosolvent—that is, able to dissolve lead out of any brass components. It can also mean that the water might not conduct electricity sufficiently to allow level sensors to function correctly. Some coffee machines have brass fittings in contact with water and it is important that the brass is specified to contain very low levels of lead.

Traceability

It is good practice for the vending company to keep records of those from whom they purchase foodstuffs, and this is generally a legal requirement. In the European Union (EU), for example, it is part of Regulation EC 178/2002. It is not necessary to keep records of batch codes or lot numbers of deliveries as, in the unlikely event of a product recall, all product of the relevant brand can be removed from all machines. Once product is back at the company warehouse then it can be checked for date codes or lot numbers as necessary. This procedure will be much less time consuming and bureaucratic than keeping records of every delivery.

Conclusions

Vending, in all its forms, is an efficient way of providing food and drink with little risk. However, it is essential that those operating vending machines carry out a HACCP study and develop appropriate work instructions and training to keep customers safe.

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