UNIVERSITY OF EDUCATION, WINNEBA

COLLEGE OF TECHNOLOGY EDUCATION – KUMASI CAMPUS

CONVINIENCE FOOD AND ITS PACKAGING EFFECT ON HUMAN HEALTH: A CASE STUDY OF BANTAMA MARKET

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A Dissertation in the DEPARTMENT OF HOSPITALITY AND TOURISM EDUCATION, Faculty of VOCATIONAL EDUCATION submitted to the School of Graduate Studies, University of Education, Winneba, in partial fulfillment of the requirements for the award of the Master of Technology (Catering and Hospitality) degree

JANUARY, 2022

DECLARATION

Candidate's Declaration

I, Tetteh Hannah, hereby declare that, this declaration is the result of my own original work and that no part of it has been presented for another degree in the University or elsewhere.

Candidate Signature: ……………………………… Date: …………………………..

Tetteh Hannah

Supervisor's Declaration

I hereby declare that preparation and presentation of this research work were supervised in accordance with the guidelines on supervision of research work laid down by the University of Education, Winneba.

Supervisor Signature: …………………………… Date: …………………………..

Dr. Mrs. Ellen Olu Fagbemi

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DEDICATION

This research work is dedicated to my parents Mr. and Mrs. Tetteh for their unconditional love, financial support and prayers in making my dreams a reality.

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LIST OF ABBREVIATIONS

IP	Intelligent Packaging
FPM	Food Packaging Material
MPA	Modified Packaging in Atmosphere
NIH	National Institutes of Health
SSB	Sugar-Sweetened Beverage
WHO	World Health Organisation

ABSTRACT

Packaging is an important material that protects the food put into it from external factors, keeps it fresh, allows the food to reach the consumer in a healthy and reliable way, and enables proper transportation and storage. Food packaging, which has widespread uses for reasons such as facilitation of everyday life, is one of the more recent hot topics regarding food due to issues such as consumers' health, food costs and environmental factors. Glass and plastic are the most common packaging materials encountered by consumers. All glass and plastic materials that come into contact with foods and beverages such as so drinks bottles, baby bottles, foam containers, jars, and demijohns are under the scope of food packaging.

In recent years, sensitivities regarding food security, human health and the environment have increased in food & beverage packaging. Glass packaging has advantages such as being healthier, being able to maintain food for longer durations and having 100% recyclability, whereas plastic packaging has advantages such as being less costly, being resistant to breaking and causing less air pollution.

Over the past four decades, demand for foods that save households time in meal preparation and clean up (i.e., "convenience foods") has grown in Ghana and around the world. This has implications for dietary quality and health. But little is known about the drivers behind the growth in demand for such foods. One driver might be that Ghanaians and for that matter the world at large is purchasing more processed foods because of those foods' declining market prices relative to their less processed counterparts. Another driver might be that the most advertised foods are those that are the most convenient or that Ghanaian households have little time for meal preparation because of labour market participation. How declining incomes affect the demand for convenience may also be a driver. Between 1999 and 2010, changes in prices and total food expenditure drove most food-purchasing patterns. Meals and snacks at fast-food

restaurants were also responsive to changes in advertising expenditures, while hours worked had little effect on demand for any foods.

In the 21st century increasing world population, rising food prices and other socioeconomic impacts are expected to generate a great threat to agriculture and food security worldwide. Food is one of the basic needs of the human being. It is required for the normal functioning of the body parts and for a healthy growth. Consumer interest in ready-to-eat (RTE) snack and ready-to-serve (RTS) food is growing due to their convenience, value, attractive appearance, taste and texture. Most of the foods packed in plastic material. But longer use of plastic-coated material is slow poison for human health.

CHAPTER ONE

INTRODUCTION

1.0 Background of Study

Food, substance consisting essentially of protein, carbohydrate, fat, and other nutrients used in the body of an organism to sustain growth and vital processes and to furnish energy. The absorption and utilization of food by the body is fundamental to nutrition and is facilitated by digestion. (Britannica, 2020). Hunting and gathering, horticulture, pastoralism, and the development of agriculture are the primary means by which humans have adapted to their environments to feed themselves. Food has long served as a carrier of culture in human societies and has been a driving force for globalization. This was especially the case during the early phases of European trade and colonial expansion, when foods such as the hot red pepper, corn (maize), and sweet potatoes spread throughout Europe to Africa and Asia. (Britannica, 2020).

Food serves multiple functions in most living organisms. For example, it provides materials that are metabolized to supply the energy required for the absorption and translocation of nutrients, for the synthesis of cell materials, for movement and locomotion, for excretion of waste products, and for all other activities of the organism. Food also provides materials from which all the structural and catalytic components of the living cell can be assembled. (Kenneth & Snell, 2020).

Processed food is food that is altered from its natural state, such as freezing; drying; milling; canning; mixing; or adding salt, sugar, fat, or other additives. Here we define ultra-processed foods as multi-ingredient, industrially formulated mixtures. Ultra Processed Foods are formulated mixtures highly processed to the extent that they are no longer recognizable as their original plant or animal sources. Most are manufactured to be ready to eat or ready to heat, requiring no preparation before quick, easy consumption. (Barry, 2020).

Again, Food is one of the basic needs of the human being. It is required for the normal functioning of the body parts and for a healthy growth. The processed, semi processed and ready to eat food are called convenience foods. Technological development of food processing equipment, process and packaging material, have got revolution in the development of convenience food sector as for the necessity of taste, nutritional requirements of consumers. Food processors like MTR foods, ITC foods, Priya foods, ADF foods and many others are developing newer and newer products to meet the demand of Indian palate. Consumer interest in ready-to-eat (RTE) snack foods is growing due to their convenience, value, attractive appearance, taste and texture. Today a greater number of women are working than before and hence looking for products convenient to cook fast. The ready-to-eat (RTE) market in India, currently estimated at Rs. 128 crore (2006) is expected to expand to reach Rs. 2,900 crores by 2015, according to an analysis done by Tata Strategic Management Group (TSMG). In its analysis, TSMG said that the factors contributing to the growth would be changes like cold chain development, disintermediation, streamlining of taxation, economies of scale on the supply side, coupled with increasing disposable incomes, diminishing culinary skills and the need for convenience on the demand side (Vijaybhaskar and Sundaram, 2012).

The increase in consumption of foods that require less time to prepare has received recent attention because these foods are associated with being less healthful. First, the growth in consumption of restaurant foods has been blamed for Americans' poor diet quality and increasing body weight. As Americans began to purchase more food away from home (FAFH), they also increased their away-from-home share of caloric intake from 17.7 percent in 1977-78 to 31.6 percent in 2005-08, mainly from sit-down and fast-food restaurants (Lin and Guthrie, 2012). One additional meal eaten away from home increased daily intake by about 134 calories and lowered diet quality by about 2 points on the Healthy Eating Index-2005, enough to shift the average adult's diet quality from a classification of fair to poor (Todd et al., 2010). In addition, increased FAFH consumption resulted in higher intakes of sugar, saturated fat, and sodium as well as lower intakes of fiber and calcium (Nguyen and Powell, 2014; Lin and Guthrie, 2012). The poor diet quality of FAFH products may also be linked to increased obesity in the United States (Currie et al., 2010; Chen et al., 2013). The relationship between substitution of meal preparation and consumption of convenience foods and overall healthfulness of purchases becomes even more apparent during economic downturns, as previous research shows that body weight is inversely related to economic conditions. Ruhm (2000, 2005) argued that declining work hours during a weakening economy may provide one reason why individuals engage in healthier behaviour, possibly due to the increased nonmarket time available for lifestyle investments. During the most recent economic recession (December 2007–June 2009), Americans increased meal preparation and clean up time, with 10-11 percent of forgone market work hours reallocated to core home production (cooking, cleaning, and shopping) (Hamrick and Okrent, 2014; Aguiar et al., 2013). During the same period, evidence suggests that Americans purchased more healthful foods for at-home consumption and fewer foods for away-from-home consumption (Kuhns and Volpe, 2014; Todd, 2014). Hence, the change in labour force participation may be related to the recent decline in body weight and, subsequently, the declining rate of obesity among some Americans (Flegal et al., 2012). However, others have found little evidence that the most recent economic downturn has had any impact on healthfulness of consumption (Dave and Kelly, 2012). Some have even argued that the downward trend in the caloric content of food purchases for at-home consumption may be a long-term trend that started before December 2007 (Ng et al., 2014).

It is not just household time constraints that may drive changes in demand for convenience foods. An important determinant of the demand for all food is market price. Over the last decade, the price of basic and complex ingredients grew at a faster rate than RTC and RTE meals and snacks. While price growth of fast foods kept pace with basic ingredients, the growth in the price of meals and snacks at sit-down restaurants began to slow in 2005. This uneven price growth may be symptomatic of supply-side factors that have made processed foods cheaper over time compared to less processed foods. For instance, food manufacturers that produce many more-processed foods have experienced multifactor productivity gains between 0.23 and 0.75 per year, whereas producers of many basic and complex ingredients have had very little or even negative productivity gains (Bureau of Labour Statistics, 2013). In addition, Moss (2013) argues that more-processed foods tend to use ingredients that are cheaper than their less-processed counterparts (sugar, fats and oils, and sodium). In any case, it is likely that the differential price growth between convenience foods and less convenient counterparts has caused some substitution away from the less-processed FAH products to more-processed FAH products.

1.1 Statement of Problem

The increase in demand of civilization has torched every corner of humane settlement. Though shifting to a healthier dietary pattern can indeed prevent disease, it's critical to understand that food cannot and should not replace pharmaceutical drugs. Medicine was developed to save lives and treat diseases. (Kubala, 2019). But today because of the need to work in offices outside our traditional homes, there is the need to find a way of eating. Due to technology people now package food and move them to their convenient place to eat. To preserve the food from spoiling and wasting, they intent to add preservatives that will preserve the food. Historically, chemicals exceeding maximum allowable exposure levels have been disastrous to underdeveloped countries like Ghana because managing the excess is always a challenge. Many of these synthetic chemicals involved in packaging and storing the food we eat as captured in literature has long term effects on our health. Although most of these chemicals are regulated by the technical known how firms or organizations like FDA and Standard Board etc., the number of players involve in the food market is numerous. Most of them are trying all add ups to get costumers. Now, are the end users (consumers) aware of the health effect of these preservatives? Are the players (convenience food joint owners) aware of the health implications? as well as the regulators, are they aware? These so call "convenience foods" are everywhere across the world that is been patronized by thousands of people and their health effects should not be undermined. The burden of foodborne diseases to public health and welfare and to economies has often been underestimated due to underreporting and difficulty to establish causal relationships between food contamination and resulting illness or death. (WHO, 2020).

The 2015 WHO report on the estimates of the global burden of foodborne diseases presented the first-ever estimates of disease burden caused by 31 foodborne agents (bacteria, viruses, parasites, toxins and chemicals) at global and regional level. (WHO, 2020).

The 2018 World Bank report on the economic burden of the foodborne diseases indicated that the total productivity loss associated with foodborne disease in low- and middle-income countries was estimated to cost US$ 95.2 billion per year, and the annual cost of treating foodborne illnesses is estimated at US$ 15 billion. (WHO, 2020).

1.2 Main Objective

The main objective of the study is to assess and evaluate convenience foods and its packaging effects on human health; a case study of Bantama Market in the Kumasi Metropolis of the Ashanti Region of Ghana.

1.2.1 Specific Objective

1. To assess the prevalence of fast-food joints/services in and around the Bantama market
2. To determine customer's behavioral patterns with convenience foods in Bantama market
3. To examine the relationship between the impact of convenience food packaging and human health in Bantama market.

1.3 Research Questions

In order to dig out the root of the reason why girl child does not have interest in Technical Education in Ghana, it is necessary for the researcher to formulate some hypothesis to focus her attention and direction on them.

a. What are the reasons for the prevalence of convenient food joints/services in and around the Bantama Market?
b. What are the customers behavioural patterns with convenience foods in Bantama market?
c. What is the relationship between the impact of convenience food packaging and human health in Bantama market?

1.4 Significance of the Study

Food is one of the basic needs of the human being. It is required for the normal functioning of the body parts and for a healthy growth. The processed, semi processed and ready to eat food are called convenience foods. Technological development of food processing equipment, process and packaging material, have got revolution in the development of convenience

food sector as for the necessity of taste, nutritional requirements of consumers. (Pardeshi, 2014). The issue of assessment of health risks of food packaging materials represents an ongoing challenge. This is due to the fact that food packaging materials have the potential for release and subsequent transfer of components into the food. (Schrenk, 2014). This transfer then can lead to an exposure of the consumer to those components and/or their reaction products. Food is packed into a large variety of containers made from a number of different materials and combinations thereof. These have to fulfill several criteria mainly in order to preserve the food, extend it shelve-life and maintain its quality with respect to freshness, taste, flavour, colour etc. (Schrenk, 2014). Consumer interest in ready-to-eat (RTE) snack foods is growing due to their convenience, value, attractive appearance, taste and texture. Today a greater number of women are working than before and hence looking for products convenient to cook fast. (Schrenk, 2014).

1.5 Organisation of Study

Chapter One: This chapter entails background to the study, statement of the problem, purpose of the study, objectives, significance of the study, limitation and delimitation and organization of research.

Chapter Two: This chapter deals with the review of literature on the studies that have been done on the area under study.

Chapter Three: This chapter presents the methodology of the research. It describes the research design that was used, the independent and dependent variables, location of the study and the target population. The sample, sampling techniques, research instruments, data collection methods and data analysis methods have also been discussed.

Chapter Four: This chapter presents findings which have been discussed under the thematic areas and sub-sections in line with the study objectives.

Chapter Five: This chapter presents the summary of the study based on the analysis of findings the research objectives. The specific objectives of the study are:

i. To assess the prevalence of fast-food joints/services in and around the Bantama market
ii. To determine customer's behavioral patterns with convenience foods in Bantama market
iii. To examine the relationship between the impact of convenience food packaging and human health in Bantama market

1.6 Limitation of Study

A limitation is that which hinders a research or test from being achieved. Due to the inadequate financial support experienced, the researcher found some difficulty in collecting data from sellers and buyers within the community. The researcher could not cover all respondents intended for the research work. Also, most of the respondents were not educated. This slowed the interview process since at some point in time an interpreter was required.

1.7 Delimitation of Study

The study will be carried out Bantama Market in Kumasi Metropolitan Assembly in the Ashanti region of Ghana. Bantama is a suburb of Kumasi. Kumasi is the regional capital of the Ashanti Region of Ghana. Bantama is both a residential and commercial area in the Kumasi Metropolitan Assembly. It is in the centre of the regional capital. Bantama geographical coordinates are 6° 42' 0" North, 1° 38' 0" West and its original name (with diacritics) is Bantama.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

Food is one of the basic needs of the human being. It is required for the normal functioning of the body parts and for a healthy growth. The processed, semi processed and ready to eat food are called convenience foods. Technological development of food processing equipment, process and packaging material, have got revolution in the development of convenience food sector as for the necessity of taste, nutritional requirements of consumers. Food processors like MTR foods, ITC foods, Priya foods, ADF foods and many others are developing newer and newer products to meet the demand of Indian palate. Consumer interest in ready-to-eat (RTE) snack foods is growing due to their convenience, value, attractive appearance, taste and texture. Today a greater number of women are working than before and hence looking for products convenient to cook fast. (Schrenk, 2014).

"Packaged food is very convenient. It is nice to have good food that you can grab and go," says Claudia DeMegret, director of education at the City Parks Foundation in New York. (Claudio, 2012). "You try to be conscientious—buy fresh food and recycle. But you also have to wonder about how all this packaging affects the food we feed our kids and . . . how much of it ends up in landfills." Food packaging does much more than simply hold a product. It keeps food safe and fresh, tells us how to safely store and prepare it, displays barcodes that facilitate purchasing, provides nutritional information, and protects products during transport, delivery, and storage. On the other hand, packaging also fills trash containers and landfills, lasting far longer than the products it was made to contain. It consumes natural resources. And it can also transfer chemicals into our food, with unknown health effects. Our relationship with packaging—you could say it's complicated. (Claudio, 2012). It is well known that chemical components from packaging can migrate into foods, but questions of how much migration occurs and what the potential health effects may be are gaining more attention from researchers and regulators. (Muncke, 2011). However, few studies to date have looked at adverse human health effects of these exposures. (Muncke, 2011). Plastics are indispensable and persistent materials used in daily life that can be fragmented into micro- or nanoplastics. They are long polymer chains mixed with additives that can be toxic when in contact with distinct species. The toxicity can result from polymer matrix, additives, degradation products and adsorbed contaminants.

Although plastics can help protect our food and prevent contamination from bacteria and chemicals, when it comes to waste, a staggering amount of it comes from plastics used for food packaging. With single use plastic straws and bags recently banned in places around the U.S. and internationally, and the detrimental impacts to humans and environmental ecosystems, it's important to think about how we can individually reduce our use of these materials. (Behrmann, 2019). According to the U.S. Environmental Protection Agency, containers and packaging alone contribute over 23 percent of the material reaching landfills in the U.S. and much of that is from food packaging. This waste is reaching our landfills and polluting our beaches, ending up in the ocean where it harms wildlife and causes navigational hazards for boats — which creates losses in fisheries, tourism and other important economic resources. (Behrmann, 2019). With the increased consumption of convenience foods, snack foods, frozen foods and microwave meals, the demand for single use packaging is massive. It is also important to reduce the consumption of these items given they consume limited natural resources and use significant amounts of energy to produce and ship. Plastic threatens human health in terms of leaching harmful chemicals into our food, water supply and ambient environment that can negatively impact reproductive function and overall health. (Behrmann, 2019).

Packaging of foods has been an age-old practice; for example, early man wrapped food items with leaves and goats' skin. (Ihekoronye & Ngoddy, 1985). In the present day, however, food items are packaged in plastics, metals, tins/cans, bottles, paper and wooden cartons, thus justifying food packaging relevance. However, convenient (packaged) foods are easier to prepare, save time, easy to store, reduce wastage and make the task of food preparation by housewives, workers and students easier. For example, in urban homes, women simply do not have the time to spend in shop queues or cooking time for breakfast meals in particular. (Palling, 1980). This arises from the morning rush of urban families to report early to work, school and so on. Therefore, the pre-packaged, pre-priced goods available even in supermarket shops are a tremendous time saving device; thus, providing convenience to the household. (Palling, 1980). These attributes of convenience foods have necessitated the investigation of packaged foods consumption pattern and impact of these on the Zaria environment.

Protective and functional packaging, nutritional information, ingredient listing and easy to-open package were the attributes mostly influencing consumer's choice of packaged food products to patronize. (Odunze, Mohammed, Ike, Onuigbo, & Shaibu-Imodagbe, 2008). However, selecting an appropriate package is not the only factor that guarantees the product's shelf-life. In fact, besides selecting the proper material for packaging, which is crucial, the conditions under which the food is stored are equally important. (Souza, Moura, & Silva, 2017). The package is the face of a product and is often the only experience consumers have before making a purchase (Marsh & Bugusu, 2007). Thus, it is essential that the package presents good aesthetics (Souza, Moura, & Silva, 2017) to convince the consumers to buy the product. In this way, packaging can drive sales in a competitive market, as packaging can be designed to enhance the image or differentiate one product from others (Farmer, Emblem, & Emblem, 2012). In addition, packages bring essential information about the product, such as a list of ingredients, nutritional composition, preparation instructions, brand identification, and prices (Marsh & Bugusu, 2007). Modern packaging can encompass more than one type of material to explore and combine the functional or aesthetic properties of each one (Marsh & Bugusu, 2007). The kind of packaging applied varies according to the product characteristics, the level of protection required, the intended shelf-life, the target market, the distribution and the sales circuit (Souza, Moura, & Silva, 2017). Packaging production translates into a globalized industry characterized by its internal diversity, while on the other hand, each of its sectors individually influences the market (Wyrwa & Barska , 2017). The use of plastic bags to carry groceries and goods goes back to the 1970s (Jalil, Mian, & Rahman, 2013), but plastic materials have been increasingly used for food since then. In the latest decades, the relative share of plastic on food packaging systems has been way too high due to the many advantages associated with the use of plastics for food packaging: they are fluid and mouldable, offering considerable design flexibility; they are inexpensive and lightweight; and they have a wide range of physical and optical properties. (Marsh & Bugusu, 2007). However, they also have disadvantages, the most important ones being their permeability to light, gases, vapours, and low-weight molecules (Marsh & Bugusu, 2007). Plastics can be divided into two groups: thermoplastics and thermosets. Thermoplastics do not suffer chemical changes in their production so that they can be recycled. Contrarily, thermosets suffer chemical changes in their production, which preclude a new merge; therefore, they are not recyclable (Muncke, 2011). Most plastics are produced from petroleum and are discarded in the environment where they are not degradable, creating considerable environmental problems. The in-correct disposal of plastic bags, and other forms of plastics, has created a problem, since they have found a way to be everywhere, including the oceans, posing a threat to aquatic life, agricultural lands, and the environment in general (Bashir, 2013). Thus, alternatives to plastic bags are necessary, but these alternatives should be less harmful to the environment or have no impact at all (Jalil, Mian, & Rahman, 2013). The majority of plastics are of single-use; thus, a significant proportion of this material is lost each year. The immense production, combined with low levels of recycling or reuse, and insufficient sustainable policies to support the circular plastic economy, result in a large contribution of waste to the environment. The United States

Environmental Protection Agency (EPA) estimated that 14.5 million tons of plastic containers and packaging were generated in 2018, corresponding approximately to 5% of municipal solid waste generation (in this analysis, the "plastic packaging" as a category excluded single-service plates and cups, as well as trash bags, which are classified as nondurable goods). In 2019, plastic packaging generated around 54% of the global anthropogenic waste (Behrmann, 2019). According to EPA, the recycling rate of PET bottles and jars was 29.1 percent in 2018 (910,000 tons). There are two ways to reduce the primary production of packaging, reuse, and recycling. In the reuse, the product is returned and reused in its original form. Another way to reuse is replacement; that is, containers which allow refilling. Examples of reuse are beverage packaging, such as returnable glass bottles, plastic packaging for personal care products, and cleaning products that would enable the use of refills, as well as refillable water bottles. Recycling involves converting the materials, involving reprocessing into new products. (Marsh & Bugusu, 2007). Thus, to make recycling economically viable, the materials need to have a market. Recycling effectiveness is linked to several factors, such as the correct disposal of the material, the type of material, and its conditions after use. Materials such as paper and cardboard, metals, and glass have a more consolidated recycling market, unlike plastics, which have, however, gained more attention recently. Plastic is not biochemically inert; thus, it can interact with the human body and the environment, causing negative impacts (Rodrigues, et al., 2019). However, investment in truly sustainable innovations is still scarce. Industries that opt for sustainable packaging generally turn to the use of recycled materials, not considering the production of packaging which uses sustainable raw materials with a low degradation time (Rodrigues, et al., 2019). Reducing the amount of pack aging in food products represents an opportunity, as well as a challenge, for the food and beverage industry, as the main concern is related to food safety. Thus, finding ways to reduce its quantity and subsequent waste is a very challenging task (Farmer, Emblem, & Emblem, 2012). The requirements for packaging and articles which remain in contact with food are becoming systematically stricter (Wyrwa & Barska , 2017), as they can affect the health of consumers and the environment. Nevertheless, the criteria for packaging to produce the lowest environmental impact are difficult to define (Souza, Moura, & Silva, 2017). Recycled metal and glass materials are considered safe for use in packaging that remain in contact with food, as the heat used to melt and form the material is sufficient to kill microorganisms and pyrolyze organic contaminants. However, in the case of plastics, reprocessing uses enough heat to destroy microorganisms, but it is not enough to pyrolyze all organic contaminants. Thus, post-consumer recycled plastics are hardly used for food packaging (Marsh & Bugusu, 2007). In general, the smaller the number of polymeric components and complexity of plastic packaging, the greater is the recycling value, due to the reduction of steps and technological resources applied in the process (Wyrwa & Barska , 2017). The profitability of the package recycling market shows its attractive aspects for business initiatives in the sector. Still, the success of recycling is directly related to cultural, political, and socioeconomic factors, such as the implementation of recycling companies, the existence of selective collection, and the continuous availability of recyclable waste, incentive programs for recycling projects, encouraging the sale of recycled products, as well as actions in the production–use-consumption chain of packaging (Klemperer, 2019). Understanding the profile of people who buy plastic is vital for planning future plastic reduction interventions, legislation, and campaigns (Ellis, 2014). The role of consumers is of most importance in order to help decision-making bodies and governmental regulators to successfully implement measures in order to reduce the use of plastic, and particularly those of single use, which have a high impact on the environment, as well as on human health, as final elements of the possible contamination chains. The study by Adam et al. (Ellis, 2014) explored consumer's attitudes towards the single-use plastics in Ghana considering their effect on marine pollution. They found that while some consumers avoid the consumption of single-use plastics, others consume them without any restrictions. Nevertheless, there was a third group that, although also conscientious about the implications of single-use plastics, still sometimes use them. A study conducted with Canadian consumers (Souza, Moura, & Silva, 2017) revealed that practically all of the participants (around 94%) felt motivated to reduce the consumption of foods packed using single-use plastic. In this study, the authors also said that environmental concerns were more critical than food safety from the point of view of consumers. On this point, it was an undeniable fact that the Covid-19 pandemic brought to light new challenges concerning food safety, and therefore the work by Kitz et al. investigated the consumer perception of food packaging with single-use plastics during the Covid-19 period. They found that the motivation to reduce plastics was not so strong as before the pandemic, but this decline was not so pronounced among women as it was among men. Although there is vast information in the literature about the negative impact of plastics on human health, as well as for the environment at the global scale, the information about the consumer's perceptions and knowledge and to what extent this shapes their behaviour and food choices is scarcer. To the best of our knowledge, this has not yet been accomplished for Portuguese consumers. This work is part of a project studying plastic food packaging, including Portuguese citizens' practices, knowledge, and concerns, from different perspectives, namely the impact on human health and the environment. This particular work has focused on the aspects related to sustainability, including recycling practices and knowledge about the impact of plastics on the ecosystems on a global scale.

2.1 Plastics as Contaminants

Contaminants that can affect the quality and usefulness of water and others are chemical, physical or biological. Primary contaminants affect the health of humans or the health of aquatic life, e.g., fisheries, aquatic plants and insects. Secondary contaminants affect the taste, smell, color, and comfort of water, for example. Primary contaminants do pose a threat to health. Therefore, we must be aware of the degree of toxicity of them (dose-response relationship). The length of exposure and the concentration of the contaminant may result in either acute or chronic toxicity to the organism. Industrial practices in plastic manufacture can lead to polluting effluents and the use of toxic intermediates, the exposure to which can be hazardous.

Most plastics are relatively inert biologically, and they have been employed in medical devices, such as prosthetics, artery replacements, and "soft" and interocular lenses. Problems with their use largely result from the presence of trace amounts of non-plastic components, e.g., monomersand plasticizers. This has led to restrictions onthe use of some plastics for food applications. For example, the use of polyacrylonitrile for beverage bottles was banned, because the traces of its monomer, acrylonitrile, were a possible carcinogen. There has been concern about endocrine disruption (ED) from phthalate- containing plasticizers used for plastics, e.g.,PVC. When exposed to high temperatures, some plastics decompose or oxidize and produce low molecular weight products that may be toxic.

Trillions of plastic bags have been produced since their introduction over 30 years ago. The production of plastic bags depletes our earth's non-renewable resources (viz. chemicals, energy, and petroleum-based products). The U.S. aloneuses over 100 billion bags annually. This is equivalent to throwing away over 12 million barrels of oil /yr. Over 85 billion bags are thrown away each year in the U. S. alone. South Africauses 8 billion plastic bags a year. Once a plastic bag is disposed of, it takes over 1,000 years to degrade. They do not biodegrade, instead they photo degrade. The sun breaks down the plastic into smaller and smaller toxic particles. The degradation releases toxic waste into the environment, polluting land, air, and water. Hundreds of thousands of these bags are inhaled or eaten by animals each year. Cows, sheep, goats, sea turtles, fish, sharks, whales,birds, and other animals fall victim to plastic bags each year. Over 100,000 animals were killed by entanglement over a 3-year period.

In countries such as South Africa, discarded plastic bags are a major eyesore. Often carried from landfills by the wind, discarded plastic bags are often seen hanging in bushes, floatingin lakes and rivers, flapping from fences, spoiling landscapes and choking innocent animals. Plastic They are mockingly referred to as the “national flower”. Uganda, and South Africa, have banned “single use” plastic shopping bags. Africa now “charge” for the use of plastic bags. Othercountries, e.g., Kenya, are considering a bag taxor plastic bag ban. Plastic bags collect around the city, choking drains, threatening small animals, damaging the soil and polluting beaches. Plastic waste has hada terrible impact on tourism (e.g., the beaches east of Accra), give tourists the impression that Ghana is a filthy country.

Plastics that act as pollutants are categorized by size into micro-, meso-, or macro debris. (Hammer, Kraak, & Parsons, 2012). Plastics are inexpensive and durable making them very adaptable for different uses; as a result, manufacturers choose to use plastic over other materials. (Hester & Harrison, 2011). However, the chemical structure of most plastics renders them resistant to many natural processes of degradation and as a result they are slow to degrade. Together, these two factors allow large volumes of plastic to enter the environment as mismanaged waste and for it to persist in the ecosystem.

Of all the plastic we use, 40% is used just once. Every year we use several billion items such as bags, bottles, trays, and food packaging. Supermarkets are full of it. Some people are careless with packaging and leave it behind as litter. But there are also places where people can’t do otherwise because there is no waste collection system. It is without a doubt that even if most people do their best, much of that single-use plastic enters the environment, being one of the biggest causes of plastic pollution. (Foundation, n.d.). Plastic materials are everywhere. We use plastic bags, straws and plastic bottles for such a short time and then we dispose of it. Yet, they remain forever - toxic till the end. (TheWorldCounts, 2022).

When plastic is produced, it's made from toxic materials such as benzene and vinyl hydrochloride. It is destined to be toxic from birth to forever. These chemicals are known to cause cancer, and the manufacturing by-products contaminate our air and soil. The type of plastic that is the major source of dioxin is PVC. (TheWorldCounts, 2022).

Phthalates are another toxic chemical added to plastics to make them softer and more pliable. It is known to affect our fertility, disrupt our endocrine glands, birth defects and other health problems. The problem with phthalate is that they are not chemically bound to the products, so they're easily evaporated into the air.

2.2 The Problem of Plastic Pollution: The Downside

Most plastic has an indefinite life span and will probably still be mixed in the soil of thisplanet thousands of years from now. Ships at sea toss garbage bags and plastic products overboard. Garbage scows carrying refuse from major cities also are disposing of their loads in the world'soceans.

Recent studies have shown about 3,500 particles of plastic /km^2 in the sea off thesouthern African coast. In fact, surveys of 50 South African beaches from the Eastern Cape to Cape Town show an increase in plastic pollutionof 190% between 1985 and 1989. "Even remote and apparently pristine layers of sand and mud are now composed partly of this microscopic rubbish, broken down from discarded waste," the report in the journal Science said.

Most samples contain a range of plastics or polymers that include nylon, polyester and acrylic. Creatures that feed on contaminated plankton have plastics inside their bodies. Thus, humans who eat sea life are also consuming these plastic particles. Turtles are particularly affected by plastic pollution; many have been found dead with plastic bags in their stomachs. (Bashir, 2013).

Marine bird species are found to be eatingand dying from consuming plastic particles. A study of blue petrel chicks at South Africa's remote Marion Island found that 90% of them had plastic in their stomachs. The plastic wasapparently fed to them accidentally by their parents. Seabirds ingest belly-fuls of plastic pollution. Environmental exposure to a widespreadcompound used to make common plastic food containers and baby bottles and to line tin cans interferes with cell division in the eggs of female mice. If cell division is disturbed, it can resultin aneuploidy, or an abnormal number of chromosomes in the eggs. This condition is the leading cause of mental retardation and birth defects in humans, including Down syndrome. Even extremely low levels of BPA, produced genetic abnormalities. BPA exhibits hormone-like properties and imitates the effects of naturally- occurring estrogens. In mice 20 ppb daily for 5 to7 days was enough to produce effects. Mice and humans have a very similar cell division program for eggs. Moreover, exposing animals in the womb to levels of BPA similar to those found in the environment disrupts their sperm count, prostate and testicular development. It is worth mentioning that BPA was invented in the 1930s during the search for synthetic "estrogens". (Bashir, 2013).

2.3 Plastic as Poisons and Pollutes

Plastic is made from oil and coal, materials that are both unsustainable and non-renewable. Mining, transport, energy production and petrochemical processes all damage the environment. In this way, plastic production contributes to problems such as oil spills, toxic emissions, and global warming through the release of greenhouse gases (GHG). If you decide to burn plastic to try to get rid of it, there arealso problems. Dioxins and furans are two highly toxic chemicals created unintentionally during plastic incineration. Open burning of plastics isa common practice in Africa. Most of the African countries do not have proper incinerators. Moreover, plastic bags in the villages and towns are used to ignite the charcoal for cooking. Therefore, most of the inhabitants and their neighbors are forced to inhale the smoke and the highlydamaging vapors. (Bashir, 2013).

2.4 Paper and Cardboard

Paper and cardboard used as FPMs usually are coated with plastic polymers since they have weak barrier functions in order to avoid the transfer of chemical compounds between the food and the outside world. Therefore, many paper/cardboard-containing FPMs bear the same problems as the plastic polymers (Gärtner et al., 2009). Similar conclusions can be drawn for adhesives used for gluing of paper/cardboard. The latter also contain plastic polymer-like materials in addition to solvents, many of them being of organic nature. Furthermore, polyfluorinated acids and related compounds are used for coating of paper to provide resistance to oil and moisture (Zafeiraki et al., 2014).

Recently, the increasing use of recycled paper/cardboard as the only or partial constituent of food packaging materials has led to special concerns. This is due to the contamination of recycled paper with a variety of chemicals, mostly derived from printing inks. Likewise, mineral oils are frequently present in recycled paper/cardboard and, due to their lipophilicity and persistence, are easily found in the food items (Lorenzini et al., 2013). Even in the absence of a direct contact between the food and the FPM, transfer from the recycled cardboard via the gas phase into the food may occur, making the use as a FPM more problematic. Printing ink on paper/cardboard can also be as source of food contamination when non-recycled material is used for manufacturing of FPM. This is due to a variety of constituents such as the photo-initiator ITX (2- isopropylthioxanthone; Rothenbacher et al., 2007).

Paper and board are versatile materials used to package foods. Paper packaging can e.g., be made of parchment paper or have the shape of bags to package loose foods. Cartonboard is commonly used for e.g., liquid and dry foods, frozen foods and fast food. Corrugated board finds broad application in direct contact with food (e.g., pizza boxes) and as secondary packaging.

Paper and board are made of natural fibers of bleached or unbleached cellulose or are, alternatively, recycled from recovered materials. Chemical additives are needed in the manufacture of paper and boards to achieve different technical functionalities. They are either added to the pulp during production or coated onto the surface afterwards. Additives can be mainly categorized into functional additives and processing aids (Ottenio et al. 2004). The first group of additives is used to modify the properties of the paper. They typically remain in the paper and include sizing agents, wet and dry strength resins, softeners, dyes, and pigments. Processing aids are used to improve the paper making processes and are not, or only in traces, transferred into the final product. Common processing aids are defoamers, biocides, felt cleaners, and deposit control agents.

Paper and carton are permeable barriers. Especially low molecular weight and volatile additives, but also non-volatile compounds and external contaminants can migrate from and through the packaging into the food. Well-known migrants from paper and board include mineral oils, photoinitiators, phthalates, and per- and polyfluorinated substances (Biedermann and Grob 2010; Bradley et al. 2012; Trier et al. 2011; Fierens et al. 2012).

Recycled paper and board often contain mineral oils and many other substances which may migrate into foods at levels exceeding safe thresholds (Biedermann-Brem et al. 2016). The source of these contaminants is usually the "raw" material, i.e., the recovered paper and board treated with various chemicals, many of which are not intended to come into contact with food, or which exceed acceptable levels. Although recycling of paper and board is essential for a society aiming at the circular economy, the safe use of paper and board for FCMs remains a challenge: The identification and toxicological assessment of the migrants from recycled paper and board was judged to be unrealistic. Additionally, each manufacturer may produce a new cocktail of migrants with each new batch of recycled paper and board. After this topic was brought to public awareness in 2011, many food companies stopped using recycled paper and board and switched to materials made from virgin fibers. Alternatively, functional barriers can be used to reduce the migration from recycled paper and board into food. Such barriers can either be integrated into an internal plastic bag or coated onto the internal surface of the paperboard box.

In Europe, food contact materials are generally regulated under the EU Framework Regulation EC 1935/2004 on materials and articles intended to come into contact with food, which allows for further regulation being made on paper and board materials. Up to this date no specific regulation on paper and board food contact materials has been enacted under European Community law. In 2002, Resolution ResAP (2002) on paper and board materials and article intended to come into contact with foodstuffs was adopted by the Council of Europe (CoE). However, the Report of the EFSA Scientific Cooperation (ESCO) Working Group on non-plastic Food Contact Materials includes an inventory list of substances used in non-plastic food contact materials, including paper and board. While this report may be used to inform other panels within EFSA, it does not aim to produce a Scientific Opinion, which could inform action by the European Commission. In 2012, a voluntary Industry Guideline for the Compliance of Paper and Board Materials and Articles for Food Contact was published by the Confederation of European Paper Industries (CEPI) and the International Confederation of Paper and Board

Converters in Europe (CITPA). In 2015, the German Federal Institute for Risk Assessment (BfR) released a recommendation on paper and board in contact with food.

In the U.S., paper and paperboard components are regulated as indirect food additives under the Code of Federal Regulation (21 CFR 176). Alternatively, food contact substances used in paper and board may also be acknowledged by an effective Food Contact Substance Notification (FCN). Substances that have been affirmed as Generally Recognized as Safe (GRAS) for use in food packaging, subject of the Threshold of Regulation (ToR), or sanctioned prior to 1958 are exempted from regulation.

2.5 Metals

The use of a variety of relatively toxic metals such as lead or zinc as/in FPMs has been banned for food containers. Currently, iron/steel-based cans are mostly coated with plastic polymers to avoid corrosion of the metal by food constituents or transfer of metal ions into the food. The latter may affect flavour, colour and other quality features of the food in a dramatic way and thus have to be avoided. Aluminium is widely used for the manufacturing of cans for beverages. The relatively reactive nature of aluminium makes it necessary to coat the metal with plastic polymer films, also to avoid corrosion/reaction with the food. Thus, the problems eventually occurring from migration of constituents of plastic polymers into food also fully apply to steel and aluminium cans (Cooper et al., 2011). Food packaging is not only half (by weight) of the total packaging material sales but also accounts for 67% (by volume) of the total packaging waste out of which 10% is metal packaging waste. In 2016, in the European Union alone, 170 kg of packaging waste was generated per inhabitant which varied between 55 kg (Croatia) and 221 kg (Germany) per inhabitant among the member countries. Paper and cardboard (41%), plastic (19%), glass (19%), wood (16%) and metal (5%) are the most common types of packaging waste (EUROSTAT 2019). According to the United States Environmental

Protection Agency, 1.8 million tons of aluminium was generated as packaging waste in 2015, which represented about 0.8% of the municipal solid waste and out of which 670 thousand tons of aluminium beverage cans was recycled (USEPA 2019a). On an average 2% of the world's energy is utilized for producing aluminium (The World Counts 2019) and packaging industry of the USA alone utilizes approximately 27% of the total aluminium consumed. Recently, aluminium cans with thinner gauge material had resulted in 26% weight reduction which directly permits production of 34 cans as compared to 27 cans from a pound of aluminium. Furthermore, steel can weight had reduced by 40% since 1970. Recycling of aluminium can is swinging between 50 and 52% because of better collection, segregation and recycling (Marsh and Bugusu 2007). An attempt has been made in this article to review the metal packaging materials used in food industry and Indian Standard specifications, their safety and recyclability aspects.

2.5.1 Materials for Metal Packaging

- **Coated steel**

Several alloys of iron are called as steels, with all of them having carbon content ranging between 0.2 and 2% which binds the iron atoms in rigid lattice and contributes to mechanical properties of steels, especially exceptional tensile strength. The alloys of iron used for food packaging applications can be categorized as 'carbon steel' with carbon content not exceeding 1% (Lee et al. 2008). Tin plate, tin free steel and polymer coated steels are the three majorly used coated steel for food packaging applications.

- **Tin plate**

Tin plate is the most important coated steel used in food packaging applications. Tin plate usually refers to steel (base steel) coated with tin on each side. Historically, dipping was used for coating and it was known as hot-dipped tin plate, but now electroplating is most commonly used (known as electrolytic tin plate) because of its ability to have coatings of different thickness on both sides. The process of tin plate production (Fig. 1) involves: tinning which involves covering of steel base plate with thin layer of tin; flow melting comprising thermal treatment above tin's melting point (260–270 °C) and rapid quenching in water leading to formation of tin iron compound (FeSn2); chemical passivation in a sodium dichromate electrolyte generating tin and chromium oxides on the surface thus providing more stability and resistance to atmosphere; coatings with oily lubricant such as dioctyl sebacate and acetyl tributyl citrate for resistance against scratch, environmental corrosion and finally passage of tin plate sheets through container forming machines (Barnes et al. 2006). Tin plate is cheaper and heavier than aluminium, recyclable, has magnetic property which helps in its easy segregation, easy to decorate, impermeable to moisture and gases, and also withstands high temperature of product processing which makes it suitable for sterile products including beverages for longer storage. However, it requires surface coatings as it may react with food and its containers generally requires an opener to access product (Catala et al. 2005). According to the Bureau of Indian Standards (IS: 9396 1987), the tin plate for food and drink cans should have tin plate of 0.15–0.49 mm thickness and coated on both sides either by dipping or electro-deposition. As per IS:5818 (1988), permitted thickness and properties of tin coatings on metal plate had been reported in Table 3. For thermally and non-thermally processed food products, MR type (medium residual) baseplate may be used and type *L* (low metalloid) baseplate is recommended for highly aggressive products and special applications as copper toxicity (i.e., copperiedus) occurs in contact with acidic food products.

- **Tin free steel (TFS)**

Tin free steel or electrolytically chromium/chromium oxide coated steel (ECCS) is similar to tin plate except non-involvement of flow melting and chemical passivation during its production. The production process involves dual electroplating of chromium and chromium sesquioxide and finally coating with an oil such as butyl stearate oil. ECCS is slightly less expensive as compared to tin plate and more susceptible to corrosion in acidic environment because of absence of sacrificial tin layer and therefore usually coated. Conversely, it is more acceptable for protective enamel coatings than tin plate because of low melting point (232 °C). The use of TFS is less as compared to tin plate and mainly utilized for food can ends, crown caps, and vacuum closures for glass containers (Li et al. 2011). Removal of coatings as a prerequisite for welding of TFS hinders its extensive usage for single use containers and recyclability. Moreover, its low cost over tinplate makes it the best choice for drums used in bulk storing and transportation of finished products.

- **Polymer coated steel**

Various efforts for the passivation of steel against corrosion has led to the utilization of conducting polymers like polyaniline, polythiopen and polypyrrole for coating steel cans. A bilayered polypyrrole coating prevented corrosion of steel in 3.5% sodium chloride solution for 200 h (Ohtsuka 2012). Similarly, thermally sprayed coatings of synthetic fluoropolymer like polyvinylidene fluoride (PVDF), ethylene chlorotrifluoroethylene (ECTFE), perfluoroalkoxy alkane (PFA) and fluorinated perfluoroethylenepropylene (FEP) had been successfully tested for avoidance of corrosion using optical microscope, liquid immersion and salt spray tests (Leivo et al. 2004). Studies on utilization of polyethylene terephthalate (PET) and polypropylene (PP) as coatings on deep drawn cans had indicated good effectiveness as well as no solvent emission during process (Boelen et al. 2004). Polymer coated steels are highly abrasion and corrosion resistant with outstanding appearance and moisture barrier properties.

- **Stainless steel**

Stainless steel is the iron alloy which possess extensive corrosion resistance and chemical inertness property due to chromium content (normally above 11%). Although, chromium is highly active metal but in contact with atmospheric oxygen, it forms an inert layer of chromium oxide (Cr_2O_3) on steel surface leading to its auto-passivation against corrosion. Stainless steel, owing to its corrosion resistance and inertness, is used in food industry as a packaging material and for development of food processing and storage equipment. Austenitic, ferritic and martensitic are the three major types of stainless steel based on their crystalline structure. Austenitic types are considered as food grade and most commonly used for packaging applications. Stainless steel is costly as compared to aluminium and tin therefore it is mainly used for returnable containers in food packaging (kegs for beer, wine and soft drinks). However, for large storage or transport containers, stainless steel is the leading material. Food and dairy processing industries mainly utilizes austenitic 304 grade (18% chromium and 8% nickel) for mild treatment applications and austenitic 316 grades (16% chromium and 10% nickel) for excessive corrosion resistant surfaces due to presence of 2% molybdenum in the latter (Cvetkovski 2012).

- **Aluminium**

Aluminium, with 8.8% of earth's crust, is the most abundant metallic constituent. Aluminium production process involves the conversion of alumina to aluminium hydroxide ($Al(OH)_3$) in a solution of sodium hydroxide at 175 °C. The insoluble are filtered off and soluble $Al(OH)_3$ precipitated as white fluffy solid. The cost of aluminium is higher as compared to almost all coated steels and mostly preferred for seamless containers because of its incompetency to get welded. Aluminium is mainly used as light weight packaging material in its pure form for sea foods, soft-drink cans, pet foods etc. while addition of manganese enhances its strength (Morris 2011). It is also used for making foil, cans, laminated and metallized packaging material in combination with paper and plastics. Aluminium is used for food packaging application in different forms like collapsible tubes, bottles, caps, closures, retort pouches, laminated and metallized films, which are discussed in subsequent sections. Aluminium is considered to be the best material for recyclability because of its easy conversion to new products but foils from recycled aluminium usually contain pinholes and its non-magnetic property creates segregation glitches.

2.5.2 Application of Metals in Food Packaging

- **Dairy products**

  The main role of packaging is to prevent deteriorating factors such as light, moisture, oxygen and microorganisms from affecting the shelf-life of milk products. Pasteurized milk for retail sale is generally packed in polyethylene pouches. The premium milk variants like ultra-heat-treated flavoured milk, condensed milk and evaporated milk are packed in metal-based containers in the form of cans or multilayered packages such as retort pouches and aseptic containers. Ultra-high temperature treated milk is packed in multilayer packages which consists aluminium foil as an internal barrier layer. Evaporated and condensed milk packed in metal cans with lacquer coatings remains shelf-stable for 6 months to 1 year. Fat rich dairy products like butter, butter oil and cream require protection against fat oxidation due to light and oxygen. Butter wrapped in parchment paper develops an objectionable oxidised flavour while butter cubes wrapped in aluminium foil are acceptable even after 48 days of storage. Light transmittance of metallized paper is less than 10% and negligible for foil which makes it an appropriate packaging material for butter to prevent oxidative degradation. Fermented products like *dahi*, yoghurt, kefir, kumiss, etc. are mainly packed in high impact polystyrene (HIPS) and polypropylene containers for retail purpose and short-shelf life (Raju and Singh 2016). However, aluminium foil and plastic or paperboard and foil laminate are highly preferred as lids for yoghurt and *dahi*. Metallized films of PET are used for fresh cheese varieties like cottage, mozzarella, cream, feta, etc. while cheese slices or spreads are widely wrapped in printed or plain aluminium foil across the globe.

Ethnic Indian milk-based confections such as *khoa*, *rasogolla*, *gulabjamun*, *rasomalai*, *paneer*, *chhana* and *ghee* are packaged in tin containers for extending their shelf-life and promoting exports. Lacquered tin containers with capacities varying between 1 and 15 L are widely used for packaging of *ghee* (Sabikhi et al. 2018). Sachets and stand-alone cartons having multilayered laminated structures of polyvinyliedene chloride/aluminium foil/polypropylene are also used for packaging of *ghee* in small sizes intended for better aroma protection and longer storage life. *Burfi* stored in tin cans at 30 °C possessed a shelf-life of 150 days. *Gulabjamun* is hot filled in tin cans for extending its shelf-life to 6 months at room temperature (Vasava et al. 2018). *Chhana* and *paneer* stored in tin cans offers maximum shelf-life with lowest chemical deterioration. The shelf-life of *rasogolla* stored in tin cans with permissible preservatives like sodium benzoate possess a shelf-life of 6 months. *Sandesh*, another traditional sweet of eastern India, when stored in tin cans at 30 °C remains acceptable for 45 days. *Chennapoda* prepared with different amount of semolina, sugar and cottage cheese remained acceptable in three layered retort pouches [12 μm polyethylene terephthalate/9 μm aluminium foil/62.5 μm copolymer of nylon and cast polypropylene (CPP)] for 30 days at refrigerated storage (Pal et al. 2019).

Ice-cream is predominantly packaged in reusable plastics with very little use of steel cans. Reusable ice-cream cans are lead soldered cylindrical tin cans having 'slip-on-lids' with rounded corners. In order to have better presentation at scooping shop, ice-cream (especially 'Gelato') is often packed in reusable stainless-steel containers (Goff and Hartel 2013). Powdered products of milk including whole milk powder (WMP), skim milk powder, butter milk powder, ice-cream powder, casein, caseinate, infant milk powder, whey powder, lactose powder, cream powder and cheese powder are packed in metal or tin cans having easy opening closures. Fat containing powder like WMP, butter milk powder, cream powder is packed in tin cans with nitrogen gas flushing to achieve very low oxygen concentration (approximately less than 4%) in the headspace in order to prevent deteriorative reactions related to fat oxidation.

- **Beverages**

Soft drinks usually contain sugar dissolved in treated water with additional ingredients while carbonated drinks also contain carbon dioxide. Therefore, carbonated soft drinks require containers which can hold internal pressure of CO_2 and being corrosion resistant at the same time, which is provided by enamelled two-piece cans. Two-piece cans overcome the problem of flavour deterioration related to iron pick from side seams of three-piece cans as the former lacks side seams (Bernardo et al. 2005). The first three-piece beer can was introduced in 1935 by Krueger Brewing firm in the United States (Barak 2018). Till 1950s, tin plate was majorly used for beer cans, but iron pick up from the seamed end led to objectionable metal-based turbidity in the product. Aluminium cans with easy opening ends called as "stay on tab" provided the best barrier properties to deteriorating factors of beer i.e., oxygen and light, which had created monopoly of aluminium beer cans in the present market. However, aluminium cans had never been accepted as packaging of wine because of sulphur based foul smell. Oxygen scavenging by immobilized yeast, self-cooling beer cans and temperature indicator based on thermochromic ink for beer cans are some of the recent advances in beer packaging (Ramos et al. 2015).

- **Fruits and vegetables**

The selection of metal-based packaging material and protective coatings for canning of fruits and vegetables depends on its type, processing (majorly thermal treatment) and storage conditions. The inherent mildness or aggressiveness activity is dependent on the natural components and treatments given to fruits and vegetables. Very high concentration of nitrates in vegetables like spinach, lettuce, radish and green beans, anthocyanins in raspberries and red fruits, and sulphur dioxide added as preservative in fruit juices reacts with metallic containers and corrodes it. Sulphur rich vegetables like garlic, onion and asparagus reacts with metal and form black spots of metallic sulphides accompanied with the release of hydrogen sulphide gas. Zinc oxide based or type II coatings are used to avoid the black staining of cans. Interestingly, pineapple canned in plain tin plate cans without any coating endorsed reaction between tinplate and ingredients of pineapple, creating an attractive yellow colour of product (Robertson 2013). However, this could be unsafe to consume but no such incidents and reports are available.

- **Fish, meat, poultry and sea foods**

  Several other ready to eat products like crab, shrimp curry and prawn products are widely canned for longer storage and distribution. Various fish products like mackerel in brine and oil, mussel in oil and brine, fish curry, tuna in oil and prawns in brine were canned in polymer coated tin free steel (TFS) which resulted in a shelf-life of more than 24 months at a temperature of 28 ± 2 °C (Mallick et al. 2006a). Tuna (*Euthynnus affinis*) fish canned in open top sanitary (OTS) cans with sulphur resistant lacquer and ECCS containers with clear PET coating possessed a shelf-life of more than 5 months at room temperature (Maheswara et al. 2011). Similarly, rohu (*Labeo rohita*) fish curry canned in polyester coated TFS in 60:40 ratio of fish and curry remained acceptable in terms of chemical, texture and sensory attributes up to 6 months at 37 °C (Mallick et al. 2006b). Seer fish (*Scomberomorus guttatus*) curry and mackerel fish curry packaged in three layered flexible retort pouches (12µ polyester/15µ aluminium foil/75µ polypropylene) remained acceptable for 24 and 12 months, respectively (Gopal et al. 2001). Four layered retort pouches (12µ polyester/12µ aluminium foil/75µ cast polypropylene/biaxially oriented nylon 15µ) were found suitable for heat treatment and 12 months ambient temperature storage of *Rogan josh*, a traditional meat curry of Kashmir (Shah et al. 2017). Ready-to-eat black clam (*Villorita cyprinoides*) remained acceptable in three layered retort pouches (12.5µ polyester/12.5µ aluminium foil/80µ cast polypropylene) for 1 year at ambient temperature (Bindu et al. 2007). Heating or storage of food in aluminium foil had been reported to increase the aluminium concentration of stored food commodity irrespective of the side i.e., shiny/dull surface (Ertl and Goessler 2018).

- **Bakery and confectionary products**

  Historically, unsealed aluminium foil of 0.009 mm thickness was used to wrap chocolate blocks but presently, heat sealable laminates (aluminium foil and LDPE) are most commonly used. Premium quality chocolates and other bakery products like biscuits, cookies and crackers are packed in metal boxes as gift packs. Nitrogen gas flushing in metal cans is also used for packaging superior quality fried snack products while use of metallized films is widespread in confectionary and bakery products (Mexis et al. 2011). Aluminium foil with varying thickness is also used for biscuit overwraps.

- **Coffee and tea**

  Tinplate cans were the first commercialized container for packaging of roasted and milled coffee which provides barrier to loss of volatiles and holds the pressure created by CO_2 emission during their storage. Flexible laminated packages having aluminium as the middle layer (approximately 12 µm thickness) are most widely used for packaging of roasted and powdered coffee. Initially, instant coffee was packed in metal cans for retail sale but flexible packaging material having aluminium foil layer between PET and LDPE (PET-Al foil-LDPE) had replaced it because of 1 year shelf-life at lower cost by latter one. Paperboard cartons with aluminium foil liner are used for packaging loose tea while premium tea products are packed in metal containers with snap-on lids. Aluminium foil is used for bulk packaging of tea in the form of tea chest liner. Metallized multilayer plastic films provide the best aroma and moisture barrier properties for longer storage of tea. Ready to drink tea is also packed in retort pouches (Kim et al. 2011).

2.5.3 Food Safety Issues of Metal Packaging

The adverse health effects of metal containers for food packaging are mainly related to two major processes: *migration* and interaction. *Migration* refers to the transfer of packaging components to food product or vice versa during their storage or processing. The common migrants from metal packaging includes tin, bisphenol A (BPA), lead, aluminium, chromium, coatings and contaminants from metal. Overall migration for metal packaging is usually carried out using plastic's protocol with distilled water, 3% acetic acid, 10% ethanol, 50% ethanol and *n*-heptane as food simulants. However, no use of acetic acid had been suggested for coatings on metal surface by the Commission of the European Communities (CEC) (Peter and Ulrich 2007). *Interaction* is the physical, chemical or microbiological reaction at food–package interface or compatibility of food products with metal containers depending on their chemical composition, pH, processing treatments, container's material, coatings on the package, storage temperature and humidity. Interaction of metal and food results in corrosion, pitting, perforation, loss of coating and product deterioration and discolouration. Some of the common catalyst for enhancing the reaction between food and metal include nitrates, phosphates, plant pigments, synthetic colours, copper and sulphur compounds.

Bisphenol A (BPA), chemically known as 2,2-(4,4-dihydroxydiphenyl) propane is used as a monomer in the production of polycarbonate and epoxy-resins (lacquer), as antioxidants in some plasticizers and as an inhibitor of polymerization of vinyl chloride in the production of plasticized PVC. It represents major migrant from tin cans into food products which is an endocrine-disrupting chemical and causes failure of reproductive system and also possess carcinogenic activity. A study revealed higher level of BPA migration from heat processed tuna fish cans (121 °C for 90 min) as compared to non-heated cans coated with organasol and epoxy phenolic coatings. Commercially heated and organosol resin coated cans filled with food simulants was reported to contain 646.5 µg/kg of BPA, which is much above the safe limit (Munguia-Lopez et al. 2005). A positive relationship was reported in migration level of BPA from coffee cans with caffeine content. Different levels of caffeine (0.05, 0.1, 0.5 and 1.0 mg/mL) in canned coffee had 21.5, 23.8, 58.9 and 79.7 ng/mL of BPA, respectively (Kang and Kondo 2002). The partitioning tendency of BPA in solid portion of canned foods as compared to liquid portion was investigated using liquid chromatography mass spectrometry method (Noonan et al. 2011). Canned food items (fruits, vegetables, soups, fish and meat) in Belgian market contained 40.3 ng/g of BPA on an average, which was also found to be dependent on the type of can and sterilization treatment given (Geens et al. 2010). The chlorohydrins of bisphenol A diglycidyl ether (BADGE) and of bisphenol F diglycidyl ether (BFDGE), used as starting materials for epoxy-resins, were detected in canned vegetables and coffee samples in Japan market. However, the migration was within the safe limit (< 600 µg/kg of food) defined by European Union, but concerns related to formation of more toxic products of BADGE and BFDGE still remains unanswered (Uematsu et al. 2001). An exposure assessment study of BPA in New Zealand indicated 7% contribution of BPA to oestrogenicity whose impact remains unclear. Contrarily, water stored in uncoated stainless steel and aluminium lined with epoxy resin showed no detectable BPA contamination representing their aptness for use as 'BPA free' container (Cooper et al. 2011). However, considering the adverse effect of bisphenol-based coating materials, use and presence of its derivative BFDGE and novolac glycidyl ethers (NOGE) had been prohibited in the manufacture of food contact surface during 2005 itself by European Union (Peter and Ulrich 2007).

Studies had revealed presence of aluminium in food samples (pastries and ready to eat meals) contained in aluminium trays. Animal experiments in past had showed connection between aluminium and Alzheimer's disease, owing to which aluminium weekly uptake safe limit was reduced from 7 to 1 mg/kg body weight by FAO/WHO Joint Committee on Food Additives

(Stahl et al. 2011). Three different tomato sauce samples packed in aluminium foil containers showed aluminium leaching which increased with decrease in pH and increase in temperature which is alarming for consumers and regulatory bodies as Al foil is extensively used in such products (Joshi et al. 2003). Tin at higher concentrations can cause gastrointestinal perturbations like nausea, vomiting, diarrhoea, abdominal cramps, bloating, fever and headache owing to which the maximum permissible levels of tin in solid foods is 250 mg/kg and 150 mg/kg in beverages as per Food and Agriculture Organization (FAO). Tin content in canned fruits (pineapple, lichies, pear, mushrooms, apricot, guava, fruit cocktail and mango) was evaluated and for canned papaya and apricots it was 269.8 and 153.4 mg/L. Acidic juices may corrode the tin plate which results into substantial level of tin in food. Higher concentrations are generally observed in canned vegetables and fruits (Morte et al. 2009). Various other contaminants from metal packaging may include chromium, used for tin plate treatment, which causes carcinogenic and mutagenic toxicity; fatty acid and esters used as lubricant leads to stale, rancid or woody flavour in canned beverages, and lead used for soldering is highly toxic to bones and brains of infants (Arvanitoyannis and Kotsanopoulos 2014). More studies are needed for detection of tin and aluminium in food items contained in metal-based containers

2.6 Glass

Glass is a food packaging material entirely made from natural raw materials, which are toxicologically inert. The major constituents, i.e., sodium/potassium silicates are non-toxic and chemically highly inert. The transfer of silicates and cations into food is marginal and even if it occurs, is toxicologically irrelevant, since the cations usually present are non-toxic. Virtually no traces of problematic migrants originating from the glass are found in glass-bottled food products (Hayashi et al., 2011).

Cases of concern related to migration of chemicals such as 2-ethylhexanoic acid into food have been associated to glass-made food packaging materials only, if these were combined with other materials, i.e., in metal lids. The problems of polymers/adhesives used in lids have been solved, however, by the use of alternative processes in their production (Elss et al., 2004).

Glass is extensively preferred as a packaging material due to its properties like recycling reuse and neutral reacting nature. It preserves food and beverages for a long term and avoids contamination. For example, beer is stored in dark glass bottles to avoid spoilage. In addition, this packaging is used in chemicals as glass has a neutral nature and does not react. Glass packaging uses interactive design as a major aspect to attract consumers. (Media, 2016).

Glass jars, lids, containers and bottles are made of various shapes, size and colour according to requirements. Glass is widely used in packaging of food, beverages, chemicals, pharmaceuticals, cosmetics and other materials. Products segment the global glass packaging market by glass ampoules, glass bottles and glass lids and stoppers. The applications market is segmented as food packaging, alcoholic beverage packaging, non-alcoholic beverage packaging, pharmaceutical packaging, personal care packaging and others. (Media, 2016).

Alcoholic beverage packaging is the major application in the global glass packaging market. Increasing use of glass packaging in food and pharmaceutical packaging is a significant factor driving this market. Properties of glass packaging like long-term preservation, recycling and reuse are remarkable factors anticipated to drive the glass packaging market for the forecast period. Innovative design and use of advanced technology are key aspects of glass packaging. High cost and use of plastic over glass packaging is a major factor restraining the global glass packaging market.

Europe and Asia Pacific are the leading geographies for the global glass packaging market, with players Amcor Ltd., Bormioli Rocco SpA, Ardagh Group, Hindustan National Glass & Industries Ltd., Gerresheimer AG, Koa Glass Co. Ltd., Nihon Yamamura Glass Co. Ltd., Owens-Illinois Inc., Saint- Gobain S.A., Piramal Glass Limited, Vetropack Holding AG, Stolzle-Oberglas GmbH, Wiegand Glas and Vidrala SA. (Media, 2016).

Chemical diffusion from within the glass is thought to be hindered due to glass' structure. This also applies to compounds from the outside (e.g., printing inks, adhesives). Glass' inertness is assumed due to its chemical structure, an amorphous non-crystal solid with pore sizes that are too small to allow molecules or single atoms to pass through. (Wagner, 2014).

2.7 Active Packaging System

Active packaging is a solution, in which the packaging, the product, and the environment interact. These are the systems, which (as a result of the chemical, physical, and biological activities) actively change conditions of the packed food, cause an extension of its sustainability and thus its shelf life, and guarantee or significantly improve the microbiological safety and/or sensory properties, while maintaining its quality. In contrast to the traditional packaging materials, active packaging causes extending the shelf life of food and preserving its higher quality during reactions with the internal atmosphere and the product. (Ozdemir & Floros, 2010).

Therefore, active packaging systems should be considered an innovative way in the field of food packaging. They interact with the packed product, change the conditions of the packed food, and control its quality at the same time. (Ozdemir & Floros, 2010).

Active packaging represents a large and diverse group in terms of both its purpose and solutions applied. The use of proper active packing extends the shelf life of products through its impact on processes emerging in food:

- physiological processes, e.g., breathing of fresh fruit and vegetables;
- chemical processes, e.g., oxidation of fats;
- physical processes in the case of bread staling;

- microbiological changes due to the impact of microorganisms;
- infections caused by insects.

The atmosphere inside packaging can be actively controlled by substances which absorb (scavengers) or release (emitters) gases or steam.

Scavengers are designed to remove undesired components from the environment inside packaging. There is no direct migration between a scavenger and a product but only improvement of the conditions inside packaging, which prolongs a shelf life of the product. Depending on the application, it may be associated with the absorption of oxygen, moisture, ethylene, or carbon dioxide. It is in order to achieve specific effects that such substances as zeolite, cellulose, activated carbon, silica gel, iron ions, ascorbic acid, potassium permanganate, and calcium hydroxide are applied. (Yildirim & Röcker, 2018).

The second group of packaging consists of emitters. The principle of operation of emitters is based on releasing desired substances that have a positive impact on food into the packaging environment. Such packaging contains and produces compounds capable to get inside the packaging and inhibit adverse processes. They are intended to guarantee stable conditions during storage and should ensure extension of the shelf life. It is by means of emitters that humidity inside packaging (vegetable packaging) can be controlled, the growth of harmful microorganisms (emitters of CO_2, SO_2, and ethanol) can be inhibited, and bacterial spoilage can be prevented (antibacterial). Emitters can be fragrant substances, food additives, food ingredients, humidity regulators, and biological active substances, which prevent growth of microorganisms. The most commonly used antimicrobial substances are ethanol, sulphur dioxide, and carbon dioxide. (Yildirim & Röcker, 2018).

The following active packaging systems are used in the food industry:

- oxygen, carbon dioxide, and ethylene scavengers;
- carbon dioxide emitters;

- odour emitters and absorbers;
- relative humidity regulators (water content in the packaging atmosphere);
- antibacterial substances;
- antioxidants.
- To guarantee sustainability of food packaged with the use of innovative technologies, it is highly desirable to maintain the least amount of gas in the free space of packaging. It is in order to ensure a long-term storage and freshness that minimization of the oxygen presence is essential, which may react with the content of packaging. Through the use of oxygen scavengers, it is possible to control residual oxygen inside packaging, which prevents further deterioration of the quality of the packed products. Scavengers remove oxygen from the atmosphere, in which the product is kept, and/or absorb oxygen diffusing through the packaging material during storage. Easily oxidizable compounds (powdered iron, ascorbic acid, unsaturated fatty acids, and unsaturated hydrocarbons), enzymes (glucose oxidase and alcohol oxidase) or photosensitive dyes are used as oxygen scavengers. Their application may be very useful, especially if vacuum packaging (VP) or packaging in modified atmosphere (MPA) is not possible or proves not to be effective. (Yildirim & Röcker, 2018).
- The response of the most popular oxygen scavengers is based on oxidation of iron compounds. The substances absorbing oxygen based on iron compounds are placed in sachets permeable to oxygen most often. The largest sachets absorbing oxygen available in the market contain approximately 7 g of ferric oxides. Due to the high sorption capacity of iron compounds, the oxygen scavengers based on them are the most effective absorbers in the market. Depending on size of a sachet, the iron compounds can absorb from 20 to 2000 cm^3 of oxygen. Attempts are being made to embed iron compounds absorbing oxygen in different types of polymers, so that the materials

obtained in this way may be in the form of labels glued inside packaging, seals of bottle caps, or be an integral part of packaging. In addition, introduction of iron compounds to a polymer matrix ensures that they do not have direct contact with packed food product, which guarantees safety of a consumer. These are oxygen scavengers, in which the substance absorbing oxygen is ascorbic acid and/or its derivatives that are equally popular besides absorbers based on iron compounds. The action of ascorbic acid may be supported by alkaline compounds, salts of aluminium and iron, as well as siliceous iron.

- The first iron absorber, called Ageless®, was brought to Japanese market by Mitsubishi Gas Chemical Company at the end of the seventies of the last century. Absorbers of this type are currently produced also by other companies under different names, e.g., FreshPax™, FreshMax™ produced by Multisorb Technologies Inc. It is in these absorbers that zeolites are covered with iron oxide (II) with addition of sodium chloride. Under the influence of oxygen and moisture present in packaged products, iron oxide (II) is oxidized to iron oxide (III). Newer, more efficient iron oxygen scavengers are based on metallic iron obtained as a result of electrolytic reduction.
- Oxygen scavengers using iron nanoparticles, which react with oxygen even in a moisture-free environment, are a novelty among absorbents based on iron.
- It is in food industry that ethylene and carbon dioxide absorbers are used beside oxygen scavengers.
- The ethylene level control during food storage plays a key role in extending its shelf life. Ethylene is a phytohormone, which initiates and accelerates ripping processes, causes degradation of chlorophyll, and inevitably leads to a deterioration of the visual and organoleptic quality if fresh or minimally processed fruit and vegetables. Ethylene absorbers are supposed to protect fruit and vegetables sensitive to the hormone. The

most commonly used ethylene absorber is potassium permanganate embedded in silica gel. Potassium permanganate changes colour after ethylene oxidation from purple to brown. Silica gel with an absorber is packaged in sealed sachets permeable to ethylene, excluding the possibility of contact with the product in packaging. Another system for elimination of ethylene is impregnation of zeolite clay with an ethylene absorber with suitable additives to enable absorption of other aromatic hydrocarbons. Zeolite clay with an ethylene absorber can be embedded in a packaging film increasing emission of ethylene and carbon dioxide into the outside atmosphere. A disadvantage of this solution is reduction of the transparency of the packaging. A very efficient ethylene absorbent is activated carbon with palladium chloride as a catalyst. This absorbent significantly reduces softening of minimally processed bananas and kiwi fruit as well as counteracts chlorophyll degradation in spinach.

2.7.1 Packaging health risks: synthetic chemicals and consumer health

A recent report conducted by scientists in the Journal of Epidemiology and Community Health, part of the British Medical Journal group, warned that synthetic chemicals found in packaging could have a detrimental effect on consumer health in the long term.

One of the report's authors, Dr Jane Muncke, from the charitable Food Packaging Forum Foundation, writes: "Chemicals diffuse from food packaging into foods in small amounts, and in the past, this was considered low risk. (Phillips, 2015).

"But based on recent scientific understanding we now are concerned about even low levels of hormone active chemicals, and far too little is known about the mixture effects and especially about our exposure to such chemicals at critical points in human development, such as in the womb and during early childhood."

This concern for the potential danger of packaging can also be seen in the views of the UK population as a recent survey found that 81% of UK consumers had some concern about food being contaminated by packaging. The survey also found that 72% of people in the UK believe that certain materials in food and drink packaging can be harmful to health. The glass industry states that glass is the safest packaging material to use as it has a proven history with no negative impact. (Phillips, 2015).

"There is clearly some concern in the UK about the issue of food contamination from certain types of packaging sources but when we look to many other European countries, they have even greater worries about this," says Cocking. (Phillips, 2015).

"The reasons why it's a greater concern in Europe are not entirely understood. Whatever it is, one thing that is clear is that there is a universal message across all of these countries and the UK and that is that consumers prefer glass, which is inert, as the healthiest material for food and drink.

"It's time for us to look beyond the label that tells us what's in our food and drink and also think about what our food and drink is packaged in."

2.8 Intelligent Packaging

Intelligent food packaging is becoming more popular because of the growing usage of active packaging, that requires monitoring the performance of active components and the overall packaging conditions, and because of intelligent systems enabling reliable and rapid product differentiation, traceability, and other interactive features. In this chapter three main intelligent packaging (IP) systems are presented: two-dimensional barcodes and radiofrequency identification systems, intended mainly for storage, distribution, and traceability purposes; indicators, which provide immediate qualitative information about measured quantity in the food environment; sensors for quantification of the analytes to evaluate the food quality and the package integrity. The aim is to provide an overview of currently available commercial applications of IP systems and latest research trends and innovations. (Gregor-Svetec, Cerqueira, Lagaron , & Pastrana Castro, 2018).

Printed electronics is one of emerging technologies for production of IP systems. Recent developments and key challenges are briefly described. The role of printing inks in food packaging is changed with the use of functional inks. Functional inks have electrochemical, thermal, optical, or chemical properties that react to the change of substrate, packed food, or environment. In the review of conductive inks for printed electronics and chromogenic links, applications on the market and research trends are presented. (Gregor-Svetec, Cerqueira, Lagaron , & Pastrana Castro, 2018). However, the intelligent packaging systems can be classified into three categories; sensors, indicators and radiofrequency identification (RFID) systems.

2.8.1 Sensors

A sensor is a device that can be used in the detection, location and measurement of energy or matter. It responds by giving a continuous output signal which can be interpreted to measure the physical or chemical stimuli to which it responds. Most sensors consist of two basic components; a receptor and a transducer. Sensors may be of several types depending on their response stimuli:

Biosensors: These can detect record and convey information relevant to biological systems. The receptors, known as bioreceptors in this case, recognize the target analyte and transducers convert these biochemical signals into measurable electrical signals. The bioreceptors may be organic or biological, like antigens, enzymes, nucleic acids, etc. The transducers used can be of optical, acoustic or electrochemical nature. Most of the commercial biosensors are a combination of antibody-based receptor and optical transducer. Sire Technologies Inc.

developed an antibody-based biosensor with the trade name Food Sentinel System® where a membrane with immobilized antibodies is used as a part of barcode which acts as the sensor. The pathogens interact with the antibodies and a localized dark bar is formed which renders the barcode unreadable. ToxinGuard® developed by Toxin Alert, Canada, is another such system where antibodies are printed on polyethylene based plastic packaging material. The interaction between pathogen and the antibodies results in production of a fluorescent signal which indicates pathogenic attack.

Gas sensors: Gas sensors are employed for the detection of gaseous analytes like oxygen, water vapor, carbon dioxide, ethylene, etc. inside the package. Other than oxygen, carbon dioxide and water vapor sensors, the most commonly used gas sensors are ethanol sensors, piezoelectric crystal sensors, semiconductor field effect transistors, and organic conducting polymers [5,6]. Papkowsky et al. described optical oxygen sensors which were based on the principle of quenching or luminescence upon gaseous analyte contact. The use of pH sensitive dyes like methyl red and curcumin for the detection of basic volatile amine released from rotten meat and fish have been reported.

Chemical sensors: Chemical selective coatings which can adsorb a particular chemical on the surface and detect its presence, composition, activity or concentration have been employed as chemical sensors. Since carbon-based nanomaterials like graphene, carbon nanotubes and carbon nanofibers have excellent electrical and mechanical properties as well as exceptional surface area, they have been widely applied as chemical sensors. These nano-based sensors are used for the detection of chemical contaminants, pathogens and spoilage, as well as for the tracking of products or ingredients through the processing chain.

Electronic Nose: Instruments have been designed to identify and classify the mixture of aromas in an odour on a repeatable basis – a function similar to that of the mammalian olfactory system. The instrument is composed of an array of sensors, either chemical sensors or biosensors, which show partial specificity to each kind of odor. The statistical methods are used to recognize simple and complex odor and produce a unique response towards each one. Successful testing of electronic nose system has been carried out in response to the odor released by fresh yellowfin tuna, vacuum packed beef, fruits and vegetables, and broiler chicken.

2.8.2 Indicators

These are defined as the substances which can determine the presence or concentration of other substance, or the reaction between two or more substances, by giving characteristic optical changes like change in colour.

Freshness Indicators: These indicators provide information about the product quality by determining the chemical changes resulting from the microbial growth within the product. The microbial growth metabolites react with the indicators integrated inside the food package to give visual information regarding the product quality. Colorimetric indicator labels by the trade name FreshTag® were launched by COX Technologies, USA, which indicated the production of volatile amines by the stored fish and seafood products by means of change in colour. Yoshida et al. developed a chitosan based colorimetric pH indicator which was used to determine the presence of metabolites resulting from microbial growth such as n-butyrate, lactic acid, and acetic acid. Indicators for the determination of carbon dioxide produced during spoilage of meat products were also developed. Aqueous solutions of chitosan or whey protein isolates were used which changed transparency in response to the presence of carbon dioxide. However, a major disadvantage of colorimetric freshness indicators is that the colour change can occur even in the absence of contaminants and significant deterioration of the product.

Time temperature indicators (TTIs): Temperature is the most important environmental factor which determines the spoilage kinetics of food products. The temperature over which the food product tends to spoil is known as threshold temperature. Time temperature indicators are responsible for indicating whether the ambient temperature of the stored food exceeded the threshold temperature and also the minimum time which the food product spent over threshold temperature. TTIs are labels that provide visual indication of the temperature abuse of temperature dependent perishable products, like frozen foods, during distribution and storage from the point of production to the point of consumption. There are three basic types of TTI available in market: critical temperature indicators, partial history indicators and full history indicators. Several commercial TTIs are available which can be diffusion, enzymatic or polymer-based systems. 3M Company, USA has commercialized diffusion based TTIs by the trade name 3M Monitor Mark® and Freshness Check®. An example of commercial enzymatic TTI is VITSAB® which is based on color change resulting from a pH drop due to controlled enzymatic hydrolysis of a lipid substrate. Temperature dependent polymerization reaction form the basis of polymer system based TTI commercialized by Lifelines Technology Inc., USA, by the trade name Lifelines Freshness Monitor®. FreshCode (Varcode Ltd.) and Tempix (Tempix AB) are based on barcodes printed with fading inks that disappear due to temperature abuse.

Integrity Indicators: Leakage prevention is an important aspect to be considered throughout the production and distribution chain of packaged food. Integrity indicators function to ensure their integrity. Visual oxygen indicators are composed of redox sensitive dyes which change color with change in oxygen concentration in MAP foods. Mitsubishi Gas Chemical Company developed is oxygen indicator tablets by trade name Ageless Eye® which turn pink when oxygen concentration is less than 0.01% and turns blue when it goes beyond 0.5%. The presence of oxygen will be indicated in five minutes or less, while the change from blue to pink may take three hours or more.

2.8.3 Radiofrequency identification (RFID) systems

RFID is a tag or reader based automatic identifications system used for item identification and data accumulation without human intervention. RFID tags have some identification number stored in their databases and are able to accordingly act upon it by retrieving the information about that number from the database. RFID tags are categorized into active and passive. Active tags run on the power supplied by an in-built battery which makes the microchip circuitry functional and sends the signal to the reader. On the other hand, Passive RFID tag's function depending on the power supplied by the reader. These tags consist of a coiled antenna which, when comes in contact with the radio waves emitted from the reader, produces a magnetic field and hence generates power to transmit information to the reader.

RFID tags provide the ability to identify, control and manage the goods through supply chain and have been successfully applied for this purpose. These are more advanced, reliable and efficient than the conventional barcode tags for food traceability. RFID tags for monitoring temperature, relative humidity, pressure, pH, and light exposure of the products are already available in the market which aid in enhancing food quality and safety. (Negi, Priyadarshi, & Kulshreshta, 2019).

The recent years have witnessed development in various intelligent packaging systems. These technologies, when integrated with the food packages can prove to be useful not only for the extension of food shelf life while improving quality, but also can provide useful information regarding the product. More intensive research is still required in the area of intelligent packaging material to develop more economical systems while offering convenience to the consumer.

2.9 Previous Consumer Perceptions of Food Packaging Studies

Previous studies have been conducted to assess consumer perceptions of sustainability in food packaging. It has been shown that food packaged sustainably can increase the consumer's perception of quality (Magnier, Schoormans, & Mugge, 2016). Packaging that appears sustainable has been found to make consumers perceive the quality of that food product to be higher than those in conventional packaging, even when there is not a label present (Magnier et al., 2016). Trends in consumer preferences have shown that consumers are spending less time grocery shopping and preparing food, but prefer foods with fewer preservatives, that are convenient, fresh, and taste good (Han et al., 2018). This evolution of consumer attitudes paired with an expanded distribution of foods has driven a demand for high-quality and safe foods with longer shelf-lives and a reduced environmental toll from food packaging (Han et al., 2018).

There is a general lack of understanding of food packaging that can be most efficiently used to minimize environmental effects. Consumers may believe that they are making sustainable purchases based on the material and marketing of the packaging, instead of the sustainability of the production of the food product (Lindh, Olsson, & Williams, 2015). This lack of consumer education can be attributed to multiple barriers of purchasing sustainably packaged food (Grunert, 2011). Currently, the COVID-19 pandemic has shifted consumer behaviours to a greater emphasis on hygiene while grocery shopping (Shamim et al., 2021). A study conducted in 1984 concluded that consumers' greatest concern with packaging-free food products was sanitation (Johnson). Beyond the aforementioned article, there is a lack of research in consumer perceptions of plastic-free food packaging.

2.10 The Purchase of Food Packaging

In terms of the environmental impact of waste, food that is lost due to spoilage or damage is considered a greater waste than packaging going to a landfill (Licciardello, 2017). The main function of packaging is to prevent food waste before reaching the consumer, while being attractive enough for the consumer to want to purchase it (Licciardello, 2017). In some cases, it 8 is more efficient to package the food more heavily due to the high environmental costs that went into making the food product (Williams & Wikström, 2010). Foods like cheese and meat need to have more packaging in order to prevent food waste, but lower impact foods could be modified to contain less packaging. Reducing food packaging would reduce greenhouse gas production by decreasing manufacturing, distribution, and disposal of packaging (Reducing Wasted Food & Packaging, n.d.). Optimizing packaging to be effective in preventing food waste would help to reduce the amount of material needed to package food products as well as the space needed to ship them. If the material could not be modified due to safety or spoilage reasons, decreasing any material found to be in excess would bring down the amount of packaging entering landfills.

2.11 Degradation of Plastic

Plastic breaks down into microscopic pieces as it degrades, dispersing into the water and soil that it contacts. In 2017, the United States produced 14.5 million tons of plastic packaging and containers (Containers and Packaging, 2019). Of that 14.5 million tons of plastic produced in the U.S., 10.1 million tons were sent to landfills (Containers and Packaging, 2019). Of the plastic sent to the landfills, an estimated 32% leached into the soil and oceans (Guillard et al., 2018).

Whether thrown away, recycled, combusted for energy recovery, or littered, plastic finds its way into the soil or water that every person on Earth relies on for food (Jambeck et al., 2015).

Plastic has made its way to the floor of every one of the world's oceans, accumulating from the surface down (Toxicological Threats of Plastic, 2017). It is estimated that plastic makes up 60-80% of the litter polluting the oceans (Derraik, 2002). Chemicals known as persistent, bioaccumulative, and toxic bind to plastic particles (Toxicological Threats of Plastic, 2017). These particles are toxic to humans and wildlife, and they are magnified as they move up food chains to be ingested by humans (Toxicological Threats of Plastic, 2017).

2.12 Ultra-Processed Foods in the Global Diet

A substantial factor affecting overweight/obesity has been a major shift in the types of ready-to-eat, ready-to-heat, processed, and packaged foods and beverages available for consumption (Poti et al., 2015). This has been particularly important in Latin America and the Caribbean, where Popkin and Reardon have documented regional food system changes related to overweight/obesity (Popkin, 2018). The last 60 years have seen a revolution in food science and manufacturing of highly processed foods, resulting in an increase of ultra-processed foods availability. The proportion of calories obtained from these foods which include additives that enhance flavours and scents and are high in added saturated fat, added sugar, and added salt-saw explosive growth first in high-income countries in 1970–2000, then in Latin America in the 1990s with modern retailing, and now across all remaining low- and middle-income countries (Canella et al., 2014; Cediel et al., 2017; Monteiro et al., 2011; Monteiro et al., 2013; Moubarac et al., 2014; Martínez Steele et al., 2016). Over the last 25 years, the availability and sales of these ultra-processed foods have increased rapidly across low- and middle-income countries and all regions of the world, and a growing set of studies is measuring this shift (Canella et al., 2014; Cediel et al., 2017; Monteiro, et al., 2017; Monteiro et al., 2013; Moubarac et al., 2014; Martínez Steele, et al., 2017). More profoundly, research is establishing a solid link between the move from real foods which are unprocessed or minimally processed to ultra-processed foods and overweight/obesity and many nutrition related noncommunicable diseases (NCDs).

2.13 Ultra-Processed Foods' Impacts on Dietary Intake, Obesity, and NCDs

The rapid growth in sales of ultra-processed foods in low- and middle-income countries greatly threatens to increase overweight/obesity and undernutrition, because infants are increasingly fed these products. In addition, studies are beginning to associate ultra-processed foods with reduced length-for-age (Pries et al., 2019). The Pries et al. 2019 study is the only one linking infant consumption of any ultra-processed food aside from infant formula, which fits into a different category but is also ultra-processed. We need longitudinal studies on cohorts with more recent full dietary intake data to reflect the shift in diets toward ultra-processed foods, which infants globally are consuming increasingly (Feeley et al., 2016; Pries, Filteau and Ferguson, 2019; Pries, et al., 2016; Pries, et al., 2016; Pries et al., 2019; Vitta et al., 2016).

A team of US National Institutes of Health (NIH) researchers in 2019 conducted a random controlled trial with a crossover design, so each person was his or her own control. They fed normal-weight adults a diet of real food for two weeks and a diet of ultra-processed foods for two weeks. When fed the real food the adults lost 0.9 kilograms, but when fed the ultra-processed food they gained the same 0.9 kilograms. Each group started with one diet regimen and then shifted to the other (Hall, 2019). This NIH trial is important as up to this period all the studies discussed below were observational and therefore had focused on subsequent health risks for people according the amount of ultra-processed foods in their diet. Although these studies were controlled for a large list of potential confounders, such as physical activity and smoking, residual confounding never can be discarded. The NIH study put all subjects in a controlled food environment for a month. The researchers provided the two groups' foods with the same distribution of fibre, protein, carbohydrates, fat, and total energy. However, while ultra-processed beverages can lower energy density and total energy, all ultra-processed foods are higher in energy density than real food. The two groups were allowed to eat ad libitum or the amount they wanted. As a result, the same individuals consumed 500 kilocalories more when they were in the ultra-processed food group than when they were in the real food group, which is important. Whether the mechanism involved is hyper palatability or energy density or both requires further study. This NIH work was amplified by several papers that came out two weeks later in the British Medical Journal that looked at two large European cohorts and showed a strong positive relation between ultra-processed foods and cardiovascular disease and all-cause mortality (Fiolet et al., 2018; Lawrence and Baker, 2019; Rico-Campà et al., 2019; Srour et al., 2019). A large number of studies published earlier reported longitudinal data from children and adults that associated ultra-processed food intake with increased NCD risk (Adjibade et al., 2019; Costa et al., 2019; Cunha et al., 2018; Fiolet et al., 2018; Gómez-Donoso et al., 2019; Kim, Hu and Rebholz, 2019; Mendonça et al., 2017; Mendonça et al., 2016; Rauber et al., 2015; Rauber et al., 2018; Rico-Campà et al., 2019; Rohatgi et al., 2017; Sandoval-Insausti et al., 2019; Schnabel et al., 2019; Srour et al., 2019; Vandevijvere et al., 2019).

2.14 Impacts of Regulations on Ultra-Processed Food Consumption

Globally most regulations focus on either fiscal policies or front-of-the-package labels (FOPLs).

Nevertheless, some countries have focused on healthier eating in schools, and several have started to address marketing of ultra-processed foods directed toward children (Popkin, 2018; Shekar, 2019). These policies are discussed below in the context of reducing consumption of ultra-pro-

cessed foods high in added sugar, added saturated fat, or added sodium or ultra-processed foods with high energy levels per 100 grams, since these elements have the strongest scientific basis.

To date the most widespread fiscal policies have put taxes on sugar-sweetened beverages (SSBs), and at this point, over 42 countries have this type of taxes. In the Americas these taxes have been based on volume (Figure 1: Sugary drinks taxes in Americas). For example, Mexico's tax, approximately 10% (one Mexican peso per liter on any nonalcoholic drink with added sugar) (Colchero, et al., 2016; Colchero, et al., 2017). Chile raised the tax on SSBs with more than 15 grams of sugar per 240 millilitres from 13% to 18% (Caro et al., 2018). Several Caribbean islands have implemented similar small, incomplete taxes (Alvarado et al., 2019). Globally only the United Kingdom (UK) and South Africa have instituted taxes that include a tier that is not taxed. The United Kingdom has three tiers in addition to no tax on low-sugar products, and South Africa taxes products per gram of sugar. Most of these taxes exclude dairy products and 100% fruit juice, but the latter is increasingly considered for taxation, as the health impact of 100% fruit juice is comparable to that of SSBs. Increasingly countries are now including taxes on milk products with added sugar. Only a few countries tax nonessential foods. Hungary and Mexico are the two most prominent, both countries tax a subset of foods that the government denoted as unhealthy. The Mexican government taxes energy-dense foods with more than 275 calories per 100 grams at 8% of the price, and evaluations show that this tax has had an impact on nonessential food purchases equivalent to the tax level (Batis et al., 2016; Taillie et al., 2017). Similarly, the Hungarian tax adopted in 2012 applies to the sugar, caffeine, and salt contents of various categories of ready-to-eat foods and drinks, including energy drinks, which youths widely consumed. One econometric analysis using broad food and beverage categories from household expenditure data in Hungary found a 3.4% decrease in purchases of taxed processed food and a 1.1% increase in unprocessed food purchases (Bíró, 2015). Other initial reports suggest a much larger 27% decline in sales of taxed foods and extensive reformulation of ultra-processed food (WHO Regional Office for Europe (Nutrition Physical Activity and Obesity Programme), 2015).

2.15 Fast Foods and Its Effect

Fast food refers to food that can be served ready to eat. The terms fast food and junk food are often used interchangeably. Most of the junk foods are fast foods as they are prepared and served fast, but not all fast foods are junk foods, especially when they are prepared with nutritious contents. Consumption pattern of snacks have a role to play in the development of not only obesity but chronic diseases also like diabetes, hypertension and cardiac diseases and thus snacking needs to be considered in obesity treatment, prevention and general dietary recommendations (Dhruv et al., 2011).

India has rich heritage of foods and recipes. Popular north Indian fast foods include aloo tikki, bhel puri, chaat, pakora, chole bhature, pav bhaji, dhokla,samosa and pani puri. Calorie and fat content in Indian fast food depends on the cooking method. Most of Indian fast foods are prepared by deep frying in fats especially trans-fat and saturated fats. Foods which are baked, roasted or cooked in tandoor have lower fat content. Hydrogenated oil used in Indian cooking is rich in trans-fats and have been replaced in many restaurants by refined vegetable oil. Consumption of diet high in sugar, saturated fat, salt and calorie content in childhood can lead to early development of obesity and cardiovascular diseases.

2.16 Plastic Packaging of Food

India packaged food industry has expanded at an unparalleled growth rate over the last few years. The market for packaged food in India was valued at USD15 billion in the Financial Year 2013. Growing at a compound annual growth rate (CAGR) of about 15 to 20 per cent annually, the Indian packaged food industry is likely to touch $30 billion by 2015 (ASSOCHAM). Plastic packaging plays a significant role in the shelf life and ease of storage and cooking for many foods. Plastic packaging, containers and cling films often have instructions on how to use them safely to keep the chemical migration to a minimum. However, some people have expressed health concerns regarding chemicals migrating from the plastic packaging or cling film into food in contact with it. The portion size in pre-packaged, ready-to-eat and restaurant foods is increasing in the US and elsewhere, building on the consumers' desire for 'value for money'. In recent years the number of restaurants offering 'supersize' options on their menu has rapidly risen, and other food items, especially snack foods, have increased package weight (French, 2001). The information below outlines different types of plastics and their uses around food, and packaging, and how to reduce the risk of chemicals from plastic migrating into food. More than 30 types of plastics have been used as packaging materials including polyethylene, polypropylene, polycarbonates and polyvinyl chlorides1. Polyethylene and polypropylene are the most common.

2.16.1 Polyethylene

Polyethylene plastic comes in high or low density. High-density polyethylene is stiff and strong and used for milk bottles, water and juice bottles, cereal box liners, margarine tubs, grocery, rubbish and retail bags but is not heat stable (i.e., it melts at a relatively low temperature). Low-density polyethylene is relatively transparent and used to make films of various sorts (including domestic/household cling film), and bread bags, freezer bags, flexible lids and squeezable food bottles.

2.16.2 Polyethylene Terephthalate (PET or PETE)

PET or PETE is polyester. It is commonly used in soft drink bottles, jars and tubs, thermoformed trays and bags and snack wrappers because it is strong, heat resistant and resistant to gases and acidic foods. It can be transparent or opaque.

2.16.3 Polypropylene

Polypropylene is more heat resistant, harder, denser and more transparent than polyethylene so is used for heat-resistant microwavable packaging and sauce or salad dressing bottles.

2.16.4 Polycarbonate

Polycarbonate is clear, heat resistant and durable and often used as a replacement for glass in items such as refillable water bottles and sterilisable baby bottles. It is also sometimes used in epoxy-based lacquers on the inside of food and drink cans to prevent the contents reacting with the metal of the can.

2.16.5 Polyvinyl chloride (PVC)

PVC is heavy, stiff and transparent and often used with added plasticizers such as phthalates or adipates. Common uses of PVC with plasticizers include commercial-grade cling films for over-wrap of trays in supermarkets and filled rolls at delicatessens.

2.17 Migration of Chemicals from Food

From plastic bottles and some cans lined with polycarbonate – tiny amounts of bisphenol A are formed when polycarbonate bottles are washed with harsh detergents or bleach (eg, sodium hypochlorite). Some food or drink cans may be lined with a lacquer to stop the food interacting with the tin. This may also release tiny amounts of bisphenol A. At high levels of exposure, bisphenol A (BPA) is potentially hazardous because it mimics the female hormone estrogen. From commercial cling films made from PVC –DEHA: diethylhexyl adipate is a food-compatible phthalate plasticiser and tiny amounts may migrate into fatty food (such as meat or cheese), especially with heating. DEHP (diethylhexyl phthalate) is another plasticiser that has been of concern because it can migrate, and for that reason it is not used in food-related products in USA. It has been used as jar or bottle seals and lid inserts of bottles, spreads and juices and may be in printing ink for labels.

2.18 Bisphenol A

Bisphenol A is used primarily to make plastics, and products using bisphenol A-based plastics have been in commercial use since 1957 (Zheng et al., 2007). Polycarbonate plastic, which is clear and nearly shatter-proof, is used to make a variety of common products including baby and water bottles, sports equipment, medical and dental devices, dental fillings sealants, CDs and DVDs, household electronics, eyeglass lenses, foundry castings, and the lining of water pipes. BPA is also used in the synthesis of poly-salons and polyether ketones, as an antioxidant in some plasticizers, and as a polymerization inhibitor in PVC. Epoxy resins containing bisphenol-A are used as coatings on the inside of almost all food and beverage cans. However, due to BPA health concerns, in Japan epoxy coating was mostly replaced by PET film. Bisphenol A is also a precursor to the flame retardant tetrabromo-bisphenol A, and formerly was used as a fungicide.

2.19 Human Exposure Sources

The major human exposure route to BPA is diet, including ingestion of contaminated food and water. Bisphenol A is leached from the lining of food and beverage cans where it is used as an ingredient in the plastic used to protect the food from direct contact with the can. It is especially likely to leach from plastics when they are cleaned with harsh detergents or when they contain acidic or high-temperature liquids. BPA is used to form epoxy resin coating of water pipes; in older buildings, such resin coatings are used to avoid replacement of deteriorating pipes. There is limited evidence on inhalation exposure but the body of research on dermal absorption continues to grow. There are many uses of BPA for which related potential exposures have not been fully assessed including digital media, electrical and electronic equipment, automobiles, sports' safety equipment, electrical laminates for printed circuit boards, composites, paints, and adhesives. In November 2009, the Consumer Reports magazine published an analysis of BPA content in some canned foods and beverages, where in specific cases the content of a single can of food could exceed the FDA "Cumulative Exposure Daily Intake" limit. Consumer groups recommend that people wishing to lower their exposure to bisphenol A avoid canned food and polycarbonate plastic containers (which shares resin identification code 7 with many other plastics) unless the packaging indicates the plastic is bisphenol A-free. To avoid the possibility of BPA leaching into food or drink, the National Toxicology Panel recommends avoiding microwaving food in plastic containers, putting plastics in the dishwasher, or using harsh detergents.

2.20 Health Effects

The largest exposure humans have to BPA is by mouth from such sources as food packaging, the epoxy lining of metal food and beverage cans and plastic bottles.

- Obesity: Bisphenol A may increase the risk for obesity. Endocrine disruptors, like bisphenol A (a monomer of polycarbonate plastic), can distress neural circuits that regulate feeding behaviour, which has been proposed to increase the risk of obesity (John and Mike, 2012).
- Neurological Effects: BPA altered long-term potentiating the hippocampus and even nanomolar (10^{-9} mol) dosage could induce significant effects on memory processes (Nadal, 2013).
- Disruption of the Dopaminergic System: A 2008 review concluded that BPA mimics estrogenic activity and affects various dopaminergic processes to enhance

mesolimbic dopamine activity resulting in hyperactivity, attention deficits, and a heightened sensitivity to drugs of abuse (Wolstenholme et al., 2012).

- Thyroid Function: BPA is a thyroid-disrupting chemical, (Tanida et al., 2009) that may especially affect pregnant women, neonates and small children (Zoeller, 2007).
- Cancer Research: Bisphenol A may increase breast cancer risk (Recchia et al., 2004).
- Neuroblastoma: BPA promotes the growth, invasiveness and metastasis of cells from a laboratory neuroblastoma cancer cell line (LaPensee et al., 2010; Zhu et al., 2009; Zhu et al., 2010).
- Brain Tumors: A Chinese human study linked BPA to noncancerous brain tumors. Those with higher urine BPA levels were about 1.6 times more likely to have meningioma compared to those with lower concentrations (Zheng et al., 2007).
- Reproductive System and Sexual Behaviour: A 2009 study had shown exposure to BPA in the workplace was associated with self-reported adult male sexual dysfunction (Prins et al., 2008).

2.21 Diethylhexyl Adipate or DEHA

Diethylhexyl adipate or DEHA is a plasticizer. DEHA is an ester of 2-ethylhexanol and adipic acid. Its chemical formula is C22H42O4. DEHA is used as a plasticizer which is used primarily in food-contact wrapping. Occupational exposure to DEHA during manufacture is minimized through the use of good industrial hygiene practices which include personal protective equipment such as gloves and dust mask as appropriate. The World Health Organization has established an international drinking water guideline for di (2 ethylhexyl) adipate of 80 μg/L. The United States Environmental Protection Agency (1998) has set a maximum contaminant level (MCL) for di (2-ethylhexyl) adipate in drinking water of 0.4 mg/L.

DEHA can migrate from cling film wrappings to food. In general, higher levels of DEHA are found in food with high fat content (Harrison, 1988). Decreasing the storage temperature to 5°C inhibits the migration by 22%, and decreasing the temperature to -18°C inhibits the migration by up to 75%. Conversely, increasing the temperature to 50°C enhances the migration up to 400%. Microwave cooking of foods can also enhance migration. The extent to which high temperature enhances migration of DEHA into foods is dependent on the area in contact and the fat content of the food. Estimates of total DEHA consumption are low with the MAFF reporting an estimated total consumption of 8.2 mg/person/day (117 µg/kg/day for a 70 kg person). Studies in humans indicate that this value may be an upper limit with a median exposure of 2.7 mg/person/day determined from a limited sampling (Loftus et al., 1994).

2.21.1 Effects on Human Health

- Acute Toxicity

  The effects of acute exposure to DEHA are summarized in the SIDS Profile. Oral treatment of rats with DEHA has not resulted in mortality or clinical signs of toxicity except at dose levels greater than the current 2000 mg/kg limit dose level (Smyth et al., 1951; Anonymous, 1976a). Data for acute inhalation exposure are limited, but available information shows no mortality to rats exposed to air saturated with DEHA for 8 hours (Smyth et al., 1951). Dermal exposure does not result in lethality or clinical signs of toxicity even at dose levels in excess of the current limit dose level of 2 000 mg/kg (Smyth et al., 1951). Dermal irritation following prolonged exposure (24 hours) was slight, but a shorter exposure period did not result in any signs of irritation (Smyth et al., 1951).

- Repeated Dose Toxicity

DEHA has been evaluated for systemic toxicity in 14-, 21-, and 90-day oral feeding studies of rats and mice. Although none of the studies were conducted according to current testing guidelines, the information available suggests that repeated exposure of animals to DEHA (up to 90 days) resulted in reduced body weight gain for rats at dose levels of 6300 ppm in feed and higher, and for mice 3100 ppm in feed and higher (Anonymous, 1976b; Anonymous, 1980).

- Mutagenicity

Geno-toxicity studies in vitro have been negative for mutations, unscheduled DNA synthesis, and DNA interaction. In addition, there was no evidence of mammalian cell mutation in mouse lymphoma assays conducted with and without metabolic activation. No chromatic exchange was observed in an SCE assay using Chinese hamster ovary cells with or without activation (Galloway et al., 1987), and there was no induction of unscheduled DNA synthesis in primary rat hepatocytes incubated with DEHA. In vivo studies for genotoxicity have also been negative for micronucleus and dominant-lethal assays. Two independent mouse micronucleus assays were conducted without evidence of interaction with DNA even at a dose level of 5 000 mg/kg (Shelby et al., 1993). In a dominant-lethal study using mice, DEHA did not demonstrate decreases in litter size that might suggest adverse effects on spermatogenesis (Singh et al., 1975).

CHAPTER THREE

METHODOLOGY

3.0 Research Design

Research design is overall plan for obtaining answers to the research questions. It is the procedural out line for the conduct of any investigation. The researcher design selected for this research is case study.

Case study is one of the research designs which is used for collecting data. It is an investigation of an individual groups, institution or other social unit. Furthermore, case study can be used to survey a family group, a class, a school, a community and event or even an entire culture.

Case study is a purposeful tool for examining variables, phenomena, process and relationship that have not been thoroughly researched. It provides a short, interesting information about phenomena under study. Also, case study probes deeply and analyses interaction between the factors that explain present status or that influence change or growth. There are several types of case study but one that suitable for the research is observation case study. This study focuses on a classroom, group, teachers and students. In this case the researcher or applied variety of observation and interview methods as the major tools.

To make everything easier and possible the researcher adopts multiple sources of studying. These are observation, questionnaire and interview for the data collection. This case study was considered because it is suitable and convenient to measure the effects of convenience foods on human health.

3.1 Population

Study population is a subset of the target population from which the sample is actually selected. (Hu, 2014). The study population will consist of both male and female adult who are into the commercial activities.

3.2 Sampling Techniques and Sample Size

Obtaining information on the whole population mentioned may not be an easy one, it will be very expensive and will take longer time to produce the end results.

For that matter data collection has to be based on a sample to represent the whole targeted population to draw a final conclusion in data collection, purposive sampling was used to select the respondents. The researcher hand pick individuals in the population to draw his conclusion because everybody can supply equals answers to the questions.

To minimize expenditure and produce effective results, the researcher chooses Bantama Market in Kumasi Metropolitan Assembly in the Ashanti region of Ghana for the study.

Present study sample will be obtained based on the sample size calculation using the Cochran's formula:

$$n = \frac{z^2pq}{e^2}$$

Where;

n= sample size

z = confidence level 95% (1.96)

p = estimated population proportion in Bantama market (15%)

q = predefined (1-p)

e = margin of error at 5%

Now $n = \frac{(1.96)^2(0.15)x(1-0.15)}{(0.05)^2} = 195.92.$

However, an estimated total sample of 200 will be recruited for the study including 10% of missing and incomplete data.

3.3 Sources of Data

The researcher will obtain used data from primary and secondary sources respectively. Indeed, the primary data will come from information of participants (Data gathered from commercial activities).

The researcher, further made extensive use of information through searching the World-Wide Web (www) for significant and relevant information to enrich the study.

3.4 Research Instrument

Research instrument is a tool for research work in data collection. The tools used for any data collection should be properly structured and suitable for what it's supposed to measure.

The instruments used for this data collection were, questionnaire, interview and observation. These instruments are capable of measuring and it gives accurate result it is easy to prepare and distribute to individuals for data collection.

3.5 Eligibility Criteria

***Inclusion criteria* –** The study will include participants of all age groups who are into the commercial market activities and are willing to participate.

***Exclusion criteria* –** The present study will exclude people who are non-regular customers in the commercial market activities and are not ready to participate.

3.6 Data Collection and Measurements

A standardized questionnaire prepared in English language would be used for data collection. Patrons within the Bantama Market will be randomly selected for sample recruitment. Data will be collected on socio-demographic characteristics, socio-economic status, hospitality satisfaction experiences etc.

3.7 Statistical Analysis

Data will be analyzed using statistical package for Social Sciences (SPSS) version 20 and presented as mean standard deviation or percentages. Continuous data would be analyzed using unpaired t-tests, whilst categorical data will be analyzed using Fisher's exact test. Logistic regression would be performing as well. All statistical analysis will be considered significant at $p<0.05$.

3.8 Ethical Consideration

Ethical clearance would be taken from the university's ethical clearance committee in order to undertake this study. Permission will be taken from the Metropolis's Directorate before the study will take place within the district. Informed consent of the study participants will be taken into consideration. Major issues regarding cultural, religious and human rights will be considered. All responses given by the participants will be treated with confidentiality.

CHAPTER FOUR

RESULTS OF THE STUDY

4.1 Introduction

To identify a more realistic approach to find out possible techniques involved in food packaging and its effects on consumer health, research was conducted. This was to support the literature review, personal interview and person observation. With a small population area, the research data was gathered in and around the Bantama Market, in the Kumasi Metropolis.

4.2 Background of Data Analysis

Questionnaires and Interviews were applied and conducted to three categories of respondents; consumers, retailers, shop owners. The table below shows the distribution of questionnaire and its retrievals.

Table 1: Questionnaires Distribution and Retrieval

Category	Number of Questionnaires		Percentage
	Distributed	**Retrieved**	
Consumers	110	105	95%
Retailers	60	53	88%
Shop Owners	30	30	100%

Source: Field Survey, 2022

From the table, table 4.2.1 above, out of 110 respondents that were given questionnaires, 105 were retrieved successfully representing 95% success rate. Also, 60 retailers and or hawkers that were issued questionnaires, 53 were retrieved representing 88% success rate. Moreover, 30 shop owners where issued questionnaire and 30 were retrieved successfully representing 100% success rate.

4.3 Socio-Demographic Characteristics of Respondents

Demographic information gives the background information of the respondents in a study. Below is the demographic information of the various respondents sought, namely;

a. Gender of retailers, consumers and shop owners.

b. Age of respondents

The results are discussed in tables 4.2 and table 4.3 below.

4.3.1 Gender

The gender distribution of consumers, retailers and shop owners is presented according to sex. The result in the table 4.2 below shows the findings.

Table 2: Gender

Respondents	**Frequency**		**Percentage**		**Total**
	Male	**Female**	**Male**	**Female**	
Consumers	55	55	50%	50%	110
Retailers/Sellers	25	35	42%	58%	60
Shop Owners	10	20	33%	67%	30

Source: Field Survey, 2022.

4.3.2 Age of Respondents

The table 4.3 below shows age distribution of respondents (consumers, retailers and shop owners) of the study. The results were analyzed and the findings are as shown below.

Table 3: Age Distribution of Consumers, Retailers and Shop Owners

Age Bracket	Consumers		Retailers/Sellers		Shop Owners	
	Freq	**%**	**Freq**	**%**	**Freq**	**%**
20 – 30 years	50	45	25	42	5	16
31 – 40 years	35	32	25	42	18	60
41years and above	25	23	10	16	7	23
TOTAL	110	100	60	100	30	100

Source: Field Survey, 2022.

From table 4.3 above, 50 consumer respondents were within the ages of 20 – 30 years representing 45%. 35 respondents, representing 32 respondents were within the ages of 31 to 40 years. 25 consumers were within the above the age of 41 years, representing 23% out of a total of 110 respondents for that category. This clearly shows that, most of the respondents during the survey were in their youthful age.

Also, 25 respondents representing 42% of retailers/sellers were within the age bracket of 20 – 30 years. With the ages of 31 to 40 years, 25 respondents representing 42% was recorded. Moreover, 10 respondents representing 16% were above the age of 41 as retailers/sellers. Moreover, 5 respondents representing 16%, 18 respondents representing 60% and 7 respondents representing 23% were recorded for shop owners respectively.

The data represented above clearly shows that, majority of the respondents were within the ages of 20-30years across all categories.

4.3.3 Income levels of Respondents

The table 4.4 below shows the daily income levels distribution of respondents (consumers, retailers and shop owners) of the study. The results were analyzed and the findings are as shown below.

Table 4: Income levels of respondents

Income Levels (GH¢)	Consumers		Retailers/Sellers		Shop Owners	
	Freq	%	Freq	%	Freq	%
Below 1,000.00	60	54	30	50	5	16
1,000.00 – 3,000.00	30	32	20	34	18	60
Above 3,000.00	20	23	10	16	7	23
TOTAL	110	100	60	100	30	100

Source: Field Survey, 2022

From table 4.4 above, 60 consumer respondents representing 54% had their daily income levels below GH¢ 1,000.00. Also, 30 respondents representing 32% earned between GH¢ 1000 – GH¢ 3,000.00 daily. Above GH¢ 3,000.00, 20 respondents representing 23% of consumer respondents had their daily income exceeding GH¢ 3,000.00.

Moreover, half the number of consumers as retailers and sellers had their daily income levels below GH¢ 1,000.00. This represented 50% of retailers. Twenty (20) respondents representing 34% of retailers/sellers had their daily income levels between GH¢ 1,000 – 3,000. Ten (10) respondents, which is 16% of a total of 60 total respondents had their daily income levels above GH¢ 3,000.00.

More so, 5 respondents who were shop owners had their daily income levels below GH¢ 1,000.00, representing 16%. Eighteen (18) respondents representing 60% had their daily income levels between GH¢ 1,000.00 – 3,000.00.

4.3.4 Do you prefer packed food products to loosen items for the following product categories?

The researcher in seeking to understanding the effects of convenience foods packaging on the health of humans, respondents' choices were sought on the above question. Table 4.3.4 below represents the summary of 200 respondent choices.

Table 5: Respondents' preference of packed foods to loosen items

Category	Responses				
	Always	**Often**	**Sometimes**	**Rarely**	**Never**
Fast food	178		22		
Grocery		130		70	
Cooking oils	195		5		
Medicines	145	15	40		
Dairy products	200				
Health drinks	110		60	30	

Source: Field Survey, 2022

From the table 4.3.4 above, 178 respondents representing 89% were of the view that, they always preferred packed fast food to loosen ones. Also, 22 respondents representing 11% were of the view that, they sometimes preferred packed fast food to loosen items. Also, out of the total of 200 respondents, 130 respondents representing 65% were of the view that, they preferred packed groceries as against 70 respondents, representing 35% who rarely liked packed groceries.

With preference of cooking oils, 195 respondents representing 97% said they preferred packed cooking oils to loosen items. 5 respondents representing 3% preferred packed cooking oils to loosen items. However, 145 respondents representing 72% preferred packed medicines as against 15 respondents representing 7% who often preferred packed medicines to loosen items. Forty (40) respondents, representing 20% preferred packed medicines to loosen items sometimes. Surprisingly, all respondents preferred packed dairy products to loosen items. One hundred and ten (110) respondents representing 55% always preferred packed health drinks as against 60 who sometimes and 30 who rarely.

4.3.5 Why do you buy packed food for the following product categories?

Table 6: Respondents reasons for buying packed food

Category	Responses		
	Better Quality	Hygiene	Reliable Producer
Fast food	70	60	70
Grocery	75	45	80
Cooking oils	80	50	70
Dairy products	150	30	20
Health drinks	160	30	10

Source: Field Survey, 2022

From table 4.3.5 above, seventy (70) respondents representing 35% said they preferred buying fast food because of its better quality. Sixty (60) respondents representing 30% said they buy fast food because of Hygiene as well as 70 respondents saying they purchase fast food because of the availability of a reliable producer. Seventy-five (75) respondents representing 37% buy packed or convenience foods because of better quality. Forty-five (45) respondents were of the view that they buy packaged foods because of the hygienic conditions surrounding its preparation and processing. Eighty (80) respondents alluded to the fact that they buy or go in for packaged foods due to the availability of a reliable producer. Similarly, eighty (80) respondents were of the view that, they buy cooking oils based on the quality of it. Health drinks recorded a score of 160 respondents who said they patronized such items on the premise of better quality. Thirty (30) respondents scored hygiene as the main reason for patronizing convenient foods as against ten (10) respondents who patronized convenience foods based on a reliable producer premise.

4.3.6 What type of packaging do you prefer most for the following product categories?

Table 7: What type of packaging do you prefer most for the following product categories

Category	**Responses**		
	Poly packs	**Paper Bag**	**Pouches**
Fast food	70	60	70
Grocery	75	45	80
Cooking oils	80	50	70
Dairy products	150	30	20
Health drinks	160	30	10

Source: Field Survey, 2022

From table 4.3.6 above, seventy (70) respondents representing 35% said they preferred buying fast food because packaged in poly packs. Sixty (60) respondents representing 30% said they buy fast packaged in paper bag as well as 70 respondents saying they purchase fast food packaged in pouches. Seventy-five (75) respondents representing 37% buy packed in poly packs. Forty-five (45) respondents were of the view that they buy packaged foods in paper bags. Eighty (80) respondents alluded to the fact that they buy or go in for packaged foods wrapped in pouches. Similarly, health drinks recorded a score of 160 respondents who said they patronized such items packaged in poly packs. Thirty (30) respondents scored paper bags as the main reason for patronizing convenient foods as against ten (10) respondents who patronized convenience foods based its packaging in pouches.

4.3.7 Are you aware of the health hazards in patronizing convenience foods?

Table 8: Are you aware of the health hazards in patronizing convenience foods?

Categories	Frequency	Percentage
Very Sure	100	50.00
Sure	60	30.00
Neutral	20	10.00
Not Very Sure	0	0.00
Not Sure	20	10.00
Total	**200**	**10.00**

Source: Field Survey, 2022

From table 4.3.7 above, 100 respondents representing 50% were of the view during the administration of the questionnaire that, they are very sure of the health hazards in patronizing convenience foods. Sixty (60) respondents representing 30% said they were very sure of the health hazards in patronizing convenience foods. Also, 20 respondents representing 10% were not sure about the health hazards in patronizing convenience foods.

4.3.8 Are you aware packaging toxins contaminate food items?

Table 9: Are you aware packaging toxins contaminate food items?

Categories	Frequency	Percentage
Very Sure	40	50.00
Sure	40	30.00
Neutral	75	10.00
Not Very Sure	25	0.00
Not Sure	20	10.00
Total	**200**	**10.00**

Source: Field Survey, 2022

4.3.9 Health Effects

The largest exposure humans have to BPA is by mouth from such sources as food packaging, the epoxy lining of metal food and beverage cans and plastic bottles.

4.3.9.1 Obesity

Bisphenol A may increase the risk for obesity. Endocrine disruptors, like bisphenol A (a monomer of polycarbonate plastic), can distress neural circuits that

regulate feeding behaviour, which has been proposed to increase the risk of obesity (John and Mike, 2012).

4.3.9.2 Neurological Effects

BPA altered long-term potentiating the hippocampus and even nanomolar (10−9mol) dosage could induce significant effects on memory processes (Nadal, 2013).

4.3.9.3 Disruption of the Dopaminergic System

A 2008 review concluded that BPA mimics estrogenic activity and affects various dopaminergic processes to enhance mesolimbic dopamine activity resulting in hyperactivity, attention deficits, and a heightened sensitivity to drugs of abuse, (Wolstenholme et al., 2012).

4.3.9.4 Thyroid Function

BPA is a thyroid-disrupting chemical, (Tanida et al., 2009) that may especially affect pregnant women, neonates and small children (Zoeller, 2007).

4.3.9.5 Neuroblastoma

BPA promotes the growth, invasiveness and metastasis of cells from a laboratory neuroblastoma cancer cell line (LaPensee et al., 2010; Zhu et al., 2009; Zhu et al., 2010).

4.4 Factors Impacting Decisions to Purchase Foods Packaged in Plastic or Without Plastic

The variables *Unimportant to me, slightly important to me, somewhat important to me,* and *very important* to me were coded, 1-4, respectively in order to determine the mean response to each factor. By mean, the participants ranked the following factors impacting the decision to purchase foods packaged with or without plastic packaging: sanitation/safety (mean=3.24), availability (mean=3.12), cost (mean=3.08), shelf-life (mean=2.85), and convenience (mean=2.76).

4.4.1 Sanitation/Safety

The mean response for sanitation/safety was Somewhat important to me (mean=3.24) (std dev=0.88). Sanitation/safety was reported as Unimportant to me (3.3%), Slightly important to me (19.6%), Somewhat important to me (26.6%), and Very important to me (50.5%).

4.4.2 Cost

The mean answer for cost was Somewhat important to me (mean=3.08) (std dev=0.93). Participants rated cost as Unimportant to me (7.1%), Slightly important to me (18.0%), Somewhat important to me (35.0%), and Very important to me (39.9%).

4.4.3 Convenience

The mean for convenience was Slightly important to me (mean=2.76) (std dev=0.86). Convenience was ranked as Unimportant to me (8.2%), Slightly important to me (27.7%), Somewhat important to me (44.6%), and Very important to me (19.6%).

4.4.4 Shelf-life

The mean response for shelf-life was Slightly important to me (mean=2.85) (std dev=0.86). Shelf-life was ranked Unimportant to me (6.0%), Slightly important to me (27.3%), Somewhat important to me (42.1%), and Very important to me (24.6%).

4.4.5 Availability

The mean answer for availability was Somewhat important to me (mean=3.12) (std dev=0.85). Availability of food packaged with or without plastic was valued as Unimportant to me (4.9%), Slightly important to me (16.3%), Somewhat important to me (40.8%), and Very important to me (38.0%).

4.5.6 Budget

Budget was considered Somewhat (37.3%), Quite a bit (34.1%), A little (23.8%), or Not at all (4.9%). The mean answer was Somewhat (mean=3.01) (standard deviation=0.88).

4.6 Packaging Material

The answers to Question 10, How likely are you to purchase foods wrapped in each of the following materials? were coded in order to be analyzed. Extremely unlikely was assigned a value of 1, Somewhat unlikely was 2, Neither likely nor unlikely was 3, Somewhat likely was 4, and Extremely likely was 5. The participants ranked their likelihood of purchasing the following materials as cardboard (mean= 3.90), plastic (mean= 3.75), glass (mean=3.74), paper (mean=3.72), aluminium/steel (mean=3.13), then styrofoam (2.32). For the no packaging section, the answers to Question 11, How likely are you to purchase foods without any packaging? the answers were coded the same. Not at all likely was assigned a value of 1, Somewhat unlikely was 2, Neither likely nor unlikely was 3, Somewhat likely was 4, and Very likely was 5.

4.6.1 Styrofoam

Participants rated their likelihood of purchasing styrofoam as Extremely unlikely (31.9%), Somewhat unlikely (28.1%), Neither likely nor unlikely (20.0%), Somewhat likely (16.2%), and Extremely likely (3.8%) (mean=2.32, std dev=1.19).

4.6.2 Aluminium/Steel

The values for aluminium/steel packaging were Extremely unlikely (10.3%), Somewhat unlikely (21.1%), Neither likely nor unlikely (27.0%), Somewhat likely (28.6%), and Extremely likely (13.0%) (mean=3.13, std dev=1.19).

4.6.3 Glass

For glass, respondents were Extremely unlikely (4.9%), Somewhat unlikely (10.8%), Neither likely nor unlikely (18.9%), Somewhat likely (36.2%), and Extremely likely (29.2%) (mean=3.74, std dev=1.13).

4.6.4 Plastic

Plastic was Extremely unlikely (2.7%), Somewhat unlikely (11.9%), Neither likely nor unlikely (18.9%), Somewhat likely (40.5%), and Extremely likely (25.9%) (mean=3.75, std dev=1.05).

4.6.5 Paper

Participants declared their likelihood of purchasing paper food packaging as Extremely unlikely (2.7%), Somewhat unlikely (8.6%), Neither likely nor unlikely (23.8%), Somewhat likely (43.8%), and Extremely likely (21.1%) (mean=3.72, std dev=0.98).

4.6.6 Cardboard

Finally, cardboard was Extremely unlikely (1.6%), Somewhat unlikely (6.5%), Neither likely nor unlikely (20.7%), Somewhat likely (42.9%), and Extremely likely (28.3%) (mean=3.90, std dev=0.94).

4.6.7 No Packaging

The participants rated their likelihood of purchasing foods without any packaging as Not at all likely (7.6%), Somewhat unlikely (17.3%), Neither likely nor unlikely (16.8%), Somewhat likely (33.0%), and Very likely (25.4%) (mean=3.51, std dev=1.25).

CHAPTER FIVE

FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

The goal of this research was to assess consumer perceptions of convenience foods and its packaging effects on human health via a survey developed for this purpose. A survey was used to be able to quantify consumer perceptions. This study indicated that the order of factors affecting the decision to purchase food with or without plastic packaging were sanitation/safety, availability, cost, shelf-life, and convenience, respectively. It found that participants were, in order from most to least, likely to purchase cardboard, plastic, glass, paper, aluminium/steel, then styrofoam. On average, the participants were neither likely nor unlikely to purchase foods without any packaging. These ranking are significant for the production, manufacturing, distribution, and marketing of food products.

5.2 Summary of the Findings

The participants ranked the factors affecting their decisions to purchase foods packaged with or without plastic packaging, from most to least important as: sanitation/safety, availability, cost, shelf-life, convenience. This aligns with Johnson's 1984 study that found that consumers were most concerned with sanitation for foods without packaging. This ranking could also be affected by the global pandemic and the rise in safety precautions taken while grocery shopping (Shamim et al., 2021). The participants ranking availability as the second highest factor is related to Grunert's barriers of purchasing sustainable foods; consumers may not have the knowledge of what makes food packaging sustainable to be able to discern which foods at their grocery stores are packaged more sustainably (2011). It is interesting that the participants ranked cost below sanitation and availability, because foods that appear to be packaged sustainably are perceived by consumers as higher quality and/or more expensive (Magnier et al., 2016). This result differs from the assumption that, based on those previous studies, cost would greatly affect the likelihood of consumers purchasing foods in plastic-free food packaging.

The participants ranked their likelihood of purchasing the following materials, from most to least likely, as: cardboard, plastic, glass, paper, aluminum/steel, then styrofoam. There is a lack of scholarly research available comparing the overall sustainability of food packaging materials from production to end-of-life (life cycle assessment); including factors such as biodegradability, CO2 production, natural resource consumption, etc. This is another example of a barrier to consumers purchasing sustainably packaged foods, because there is not literature widely available for consumers to educate themselves with (Grunert, 2011). Materials such as aluminum, steel, and glass can be recycled indefinitely without reducing the quality of the material, and materials such as paper and cardboard can be recycled into a multitude of paper products (Maine Department of Environmental Protection, n.d.). Meanwhile, plastic can only be recycled with plastic of the same type and process, if it is able to be recycled at all (Maine Department of Environmental Protection, n.d.). This data is important because consumer behaviours drive the market; if consumers buy more foods packaged sustainably, producers will package more foods sustainably (Grunert, 2011). Due to the study using a census sampling method, correlations cannot be drawn because the participants selected this ranking of purchasing factors and food packaging materials. The reliability of these data is impacted by its population only being people trading at the Bantama Market in the Kumasi Metropolis of the Ashanti Region of Ghana. The sample size of n=20 represents less than 1% of the total population of traders and buyers at the market. There are approximately 3000 people in and around the market area.

5.3 Conclusion

While the consumption of convenience foods can certainly be viewed as an effect of time pressures and increased daily travel it may also influence and exacerbate these trends. As breakfast and lunch become more flexible other activities can be included in the morning routine, such as going to the gym before work, which might increase the numbers of trips taken or miles travelled. Similarly, flexible food practices mean that more time is freed for existing activities, like travelling to work. And while decoupling food from specific places like the home might seem at first glance to reduce mobility by eliminating the need to make a trip home for lunch, it may also, over time, encourage people to live further from work. Crucially, though, packaging makes possible the convenience food system and the practices that surround it. Indeed, food packaging is an important enabling component of changes in patterns of everyday mobility which have led to growing transport-related CO2 emissions. In drawing attention to the complex links between packaging and everyday mobility we are invited to reconsider the idea that packaging is an environmentally benign technology just because we have managed the waste and recovery problem.

5.4 Recommendations

To better understand the implications of these results, future studies could address consumer perceptions and attitudes toward specific sustainable food packaging materials with a larger population representing those independent variables. Future studies could use this survey with an expanded section on perceptions of plastic food packaging. For example, the participants could be asked to self-report their knowledge of the sustainability of the materials in the survey. Pictures of various food packaging could be used for the participants to rate which they are most likely to purchase. This survey could also be used in additional markets and trading centres and beyond to be able to generalize and draw correlations from the results of the study.

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