
# KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI

## COLLEGE OF ENGINEERING

## DEPARTMENT OF CHEMICAL ENGINEERING

## CENG 291 ENGNEERING IN SOCIETY

# THE SHORT SHELF LIFE OF PERISHABLE FOODS AVAILABLE IN MADINA

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# CHAPTER ONE: INTRODUCTION

## 1.1 COURSE BACKGROUND

"Engineering in society" as a course in the college of engineering, KNUST represents a step in the direction of inculcating professionalism and the practical 'know- how' in the graduates it produces each year.

Students undertake projects geared towards identifying and generating solutions to problems confronting their respective communities using knowledge gained in their field of engineering.

Over the years, the course has stood the test of time as an initiative to tackle the concerns of the nation as a whole pertaining to the credibility and the solution oriented nature of students graduating from the university as engineers and is still working to prove the college "supply" system of top notch engineers is very functional and dynamic in response to societal demands.

## 1.2 COURSE OBJECTIVE

The course generally aims at imbibing into students the notion that the essence of engineering is to solve problems in our society.

The course also seeks to act as a driving force to propel students to be innovative and apply their field of engineering to the development of the nation. At the end of the course, the students should have had a deepened interest in their discipline of engineering and come to appreciate the extent to which their field of engineering can contribute to the various areas of their life.

## 1.3 ABSTRACT

The purpose of this study is to identify a major challenge confronting the La Nkwantanang-Madina community and deduce realistic solutions to solve the problem. Two approaches were adopted. Firstly, questionnaire surveys, interviews, and field investigation supported by quantitative analysis were employed to identify the short shelf life of perishable foods as one of the most alarming concern of the 20 586 households (according to the 2010 Population House Census data) living in the community. The second approach, based on the estimated data, sought to ascertain the current measures the indigenes as well as local industries in the community were using to manage the problem at hand and possible ways by which it could be improved. The result of the in-depth analysis of the problem provided the necessary information required to design a

production process. The anticipated outcome of this production process is to appreciably extend the shelf life of most perishable foods commonly available in the community.

# CHAPTER TWO: METHODOLOGY

## 2.1 PROBLEM IDENTIFICATION

Surveys of several forms were carried out in the rural and urban parts of Madina community to assess the needs and problems facing the community. 10 Study samples each were randomly taken from four selected localities in the community namely; 'Madina Zongo', 'Madina market area', 'Madina estate' and 'Madina old road' respectively to perform the exercise. A number of factors were considered in selecting the localities stated above:

- Accessibility to the locality,
- The diverse cultural, ethnic, and religious ideas, beliefs, thoughts and practice of the area
- The scope of their boundary.

Some of the study samples taken from the rural areas of the community like Madina Zongo were not literate so they had to go through one-on-one interviews to ascertain their problems in the

community. Most of the study samples from the urban areas had limited time to spare due to their work demands. Hence the questionnaire survey model was adopted for this set of people. The overall data collected spot on problems facing the society such as **poor drainage system, little or no job opportunity, the short shelf life of perishable foods available in the community, poor hygienic conditions, and the increased cost of living in the society.**

Among these problems, 30% of the study samples from both the rural and urban areas shared common concern for the **short shelf life of perishable foods** made available in the society as a major challenge confronting them either as producers, traders or consumers.

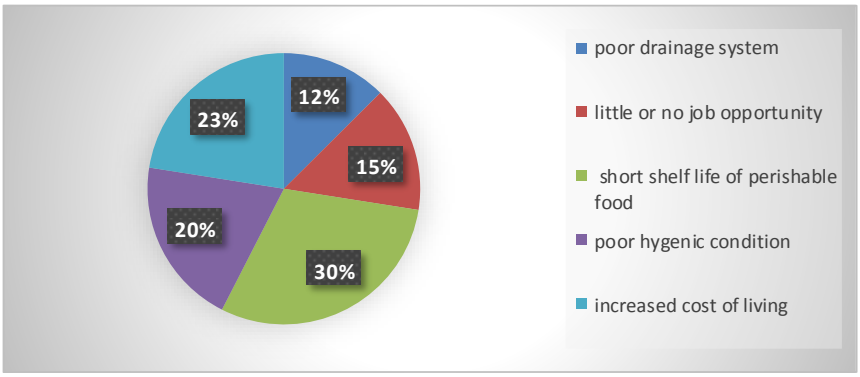


*Figure 1: Distribution showing major problems facing the Madina community*

Upon further field investigations, visits were once made again but to specific targets; the small scale farmers (producers), traders and consumers in the community. This was to discuss the extent to which the short shelf life of available perishable foods in the community was affecting them and current measures they were taking to manage the situation.

The opinions of the people listed above were used to substantially identify the short shelf life of perishable food as a major problem facing the people living in Madina.

## 2.2 PREPARATION OF MAP.

A digital format of the map of the Madina community was procured using an application software called 'Google Earth'. The layout of the community was acquired for the use of this report under the service of Google Earth.

## 2.3 DATA COLLECTION

The primary source of data used to support this report was mainly obtained through qualitative means. Questionnaires, interviews and observation were the key forms of survey used during the field investigation to collate data. The survey was structured in two forms to solicit as much needed information as possible from its respondents.

During the first survey, the study samples were given the opportunity to identify **two** major problems that were confronting them in their locality. These data were used to draw a table showing the problems facing the community at large. This was relevant in bringing out the short shelf life of perishable goods as a prevailing problem in the community.

The second survey was drawn out in the forms of questionnaire and interview to produce data on how they were managing the problem and ways they wished the problem could be solved.

Three main sections of people in the community were identified for the administration of the second form of survey are namely: the farmers, the traders and the consumers.

| **Problems facing the community** | **LOCALITY** | | | | **Total (20)** | **Total (100%)** |
|---|---|---|---|---|---|---|
| | **Madina Zongo** | **Market area** | **Madina Estate** | **Madina old road** | | |
| Poor drainage system | 2 | 2 | 3 | 3 | 10 | 12.5 |
| Unemployment | 6 | 0 | 4 | 2 | 12 | 15 |
| Short shelf life of perishable foods | 5 | 8 | 6 | 5 | 24 | 30 |
| Poor hygienic conditions | 6 | 5 | 2 | 3 | 16 | 20 |
| Increased cost of living | 1 | 5 | 5 | 7 | 18 | 22.5 |

*Table 1: various problems facing the Madina community and their corresponding level of concern*

Secondary data were obtained from; the La Nkwantanang-Madina district analytical report provided by Ghana statistical service and other government publications, electronic format of published journals, articles and books.

Several visits were made to Nkulenu Industry cited in the community where I was engaged in a six-week internship program. Vital information was acquired concerning how they were processing perishable foods (fruits and vegetables), primarily adding value on Ghanaian food products hence tackling the short shelf life of the commodities they process for export.

# CHAPTER THREE: DISCUSSION OF RESULTS

## 3.1 OVERVIEW OF THE MADINA COMMUNITY

### 3.1.1 THE SETTING OF MADINA

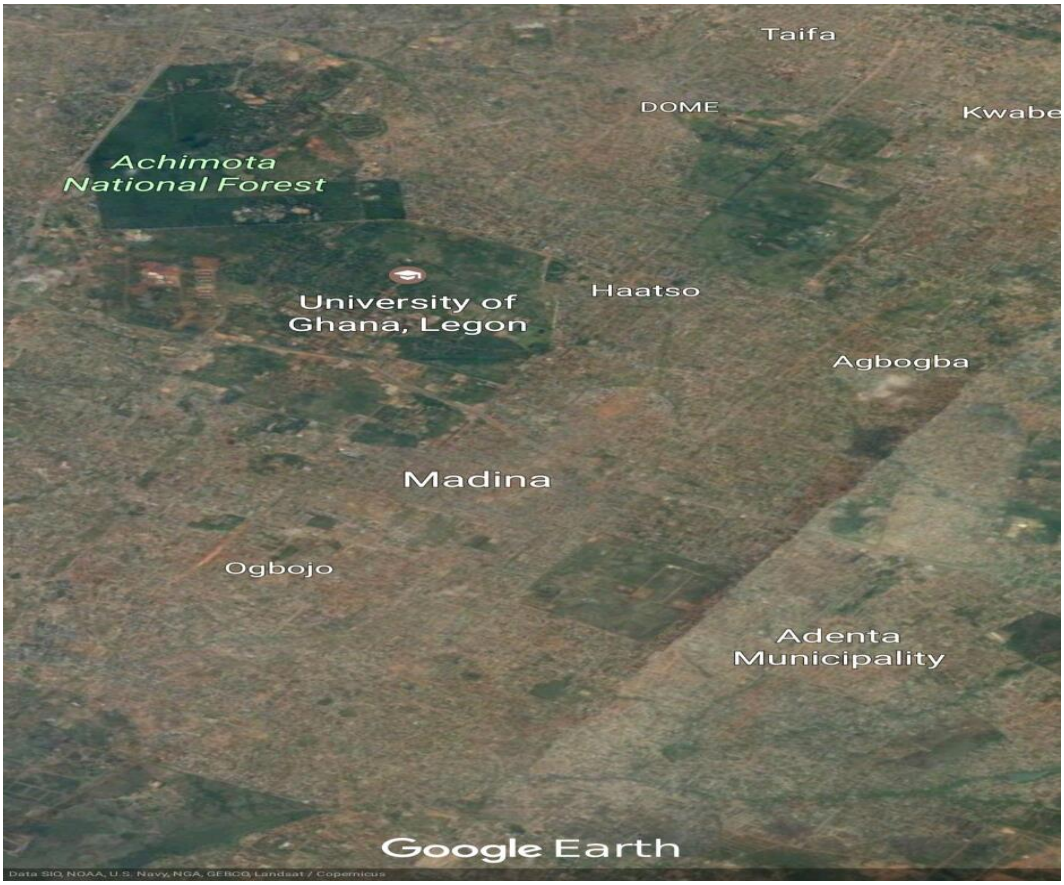


*Figure 2: The map of Madina and its neighboring communities*

The La Nkwantanang-Madina municipal is located in the Greater Accra Region. It is one of the 16 Metropolitan, Municipal and District Assemblies in the region and was created in 2012 as part of the newly created Assemblies aimed at deepening decentralization and bringing development to the door step of citizens. La Nkwantanang Madina Municipal was established bative Instrument (L.I.) 2131 and inaugurated in June 2012. It was carved out of the Ga East Municipality. Madina is located at the northern part of the Greater Accra Region. It covers a total land surface area of 70.887 square kilometers. It is bordered on the West by the Ga East Municipal, on the East by the Adentan Municipal, the South by Accra Metropolitan Area and the North by the Akwapim South District. Madina is generally urban (84percent).

### 3.1.2 CULTURE AND SOCIAL STRUCTURE

The indigenous people of the Madina community are Ga Dangmes and the main language spoken is Ga-Adangbe. There are two main Traditional Areas; namely the La Traditional Area and the Teshie Traditional Area. In addition to these major traditional divisions, there are other areas in the community whose historical allegiance is to other groups. All these are part of the indigenous Ga-Dangme people who settled in the area in the 16$^{th}$ and 17th Centuries covering a large area from the coast to the southern edge of the Akwapim – Togo Range. It is mainly a patrilineal society. Their livelihoods traditionally are farming and trading. There are large groups of settler communities who have evolved their own systems of organization heavily influenced by their cultural heritage. The settler communities comprise of 4 settlers who were settled in the area in the late 1950s and come from the Gonja, Dagomba, Wala, Frafra, and Hausa stock. These communities have evolved to become almost indigenous by establishing firm roots in the area. Other ethnic groups in Madina are Akans, Ewes, Nzemas and Guans among others. The indigenes are the La people and they celebrate the Homowo festival. However, due to the cosmopolitan nature of the community many other ethnic minority tribes also celebrate their own festivals.

### 3.1.3 ECONOMY

The main economic activities in the Madina community are commerce, agriculture, services and manufacturing. Trading is one of the main economic activities in the community with the Madina market as the main trading centre. It generates employment and revenue to the people in the community. There are many manufacturing industries in the community. They include the Nkulenu Industry, Mechanical Lloyd, Royal Aluminum Company, Special Ice Water Company, and Voltic Water Bottling among others. The items produced include food processing, packaging and fabrication. The services sector covers areas such as financial institutions, hospitality, personal care and beauty, telecommunications, graphic design, food services and professional services among others. This sector employs large numbers of skilled people and it is one of the rapidly growing sectors of the community economy. There is also a constructional industry in the community engaged in businesses such as block factories, stone quarrying and the sale of building materials in addition to the provision of skills such as masonry, carpentry, tiling and many other associated skilled jobs in the industry.

The major agricultural activities are farming and livestock rearing. The crops include cereals, tubers and vegetables. Livestock and poultry farmers can be found at Teiman, Ayimensa, Pantang and Oyarifa.

There are quite a number of agro-processing establishments in the Municipality. These include The Nkulenu Industries located in Madina, which process vegetables and fruits on a large scale. Gari processing is predominant at Teiman. Alternative livelihood activities include mushroom and snail production and the rearing of grass cutters and rabbits.

The community is linked by road to other parts of Accra and the rest of the country.

Commercial transportation by vehicles, taxis and others provide employment for drivers and mechanics. There are a number of business associations in Madina, which include market women's associations, drivers' associations, farmer groups, dressmakers and beautician's associations.

### 3.1.4 VEGETATION

The community is dominated by two closely related vegetation types, namely; shrub lands and grassland. The grassland covers the low lying parts of the community graduating into shrubs and wood thickets towards the northern part close to the Akwapim –Togo Range.

### 3.1.5 CLIMATE

The community lies within the dry equatorial climatic zone. It experiences double maxima rainfall of 700mm in the first rainy season and 770mm in the second rainy season. The Akwapim –Togo Range heavily influences the rainfall pattern of the community. The northern side of the Range, which is on the leeward side, receives a lot more rainfall and moisture (in the form of dew) than other parts of the community thus creating a somewhat distinct ecological zone. The average annual temperature ranges between 25.1° C in August and 28.4°C in February and March. February and March are normally the hottest months (Dickson and Benneh, 2001).

## 3.2 NATURE AND CHARACTERISTIC OF THE PROBLEM

### 3.2.1 INTRODUCTION

Shelf life is the duration of time that a commodity may be stored without becoming unfit for use, consumption, or sale. In the context of perishable foods, it can also be referred to as the length of time that food can be kept before it is too old or unsafe to be sold or eaten. Perishable foods available in Madina include from fresh vegetables, meat, fresh fish, dairy products and ripe fruits.

*Figure 3: Image of assorted leaf and fruit vegetables (top left), cocoyam leaves (top right), red pepper (bottom left), Mangoes (bottom right)*

These products are liable to deteriorate, perish or spoil rapidly and become inedible because of decay, various forms of fermentation. The listed factors are few among many which contribute to shortening the already- short life span of the perishable foods available in the community.

| Product | Shelf life (days) |
|---|---|
| **Fresh vegetables (tomato, cabbage etc.)** | 5-7days |
| **Fresh herbs** | 2-3 days |
| **Fresh meat** | 2 days |
| **Fresh fish** | 2 days |
| **Lettuce** | 3 days |
| **Milk** | 5-7 days |
| **Fresh fruits (mango, banana, avocado pear etc.)** | 3-7 days |

*Table 2: Types of perishable commodities and their relative shelf lives*

The shelf life of the commodities stated in the table above is usually affected by the:

- Length of time and the temperature at which it was held before purchase.
- Temperature of the food storage area
- Humidity level of the food storage area
- Packaging nature
- Characteristics of the food item (chemical properties and reactions)

One of the food security problems in most developing countries worldwide is largely due to the short shelf life of perishable foods and their inability to preserve food surpluses.

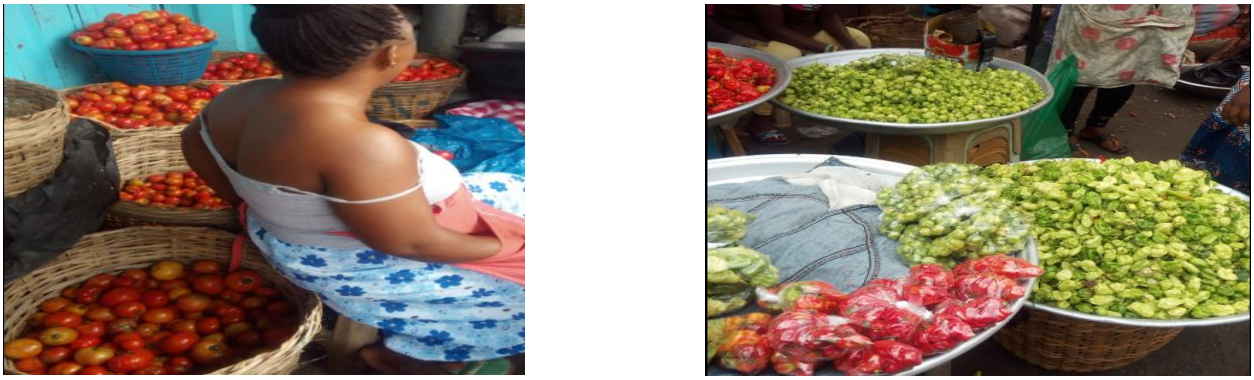

*Figure 4: Image of a trader with her stock of ripened tomatoes, red and green pepper*

*Figure 5: Image of fresh fish (left), sliced fresh meat (right)*

### 3.2.2 THE SHORT SHELF LIFE OF PERISHABLE GOODS AS A PROBLEM IN MADINA

The shelf life of perishable goods is an essential indicator of the economic viability in the section of the private informal sector which involves in the commerce of these perishable goods. It is therefore an alarming issue since the private informal sector is the largest employer in the community, employing 69.7 percent of the entire population of the community.

Also, 75.5 percent of the agricultural activity in Madina is crop farming, followed by livestock rearing (29%). Therefore, there is a large number of the employed sector of the community that depend on the extent to which commodities like tomatoes, cocoyam leaves, mango, banana, fresh meat and fish, pine apple, water melon, cabbage, avocado pear etc. can last without spoilage or deterioration in order to make profits

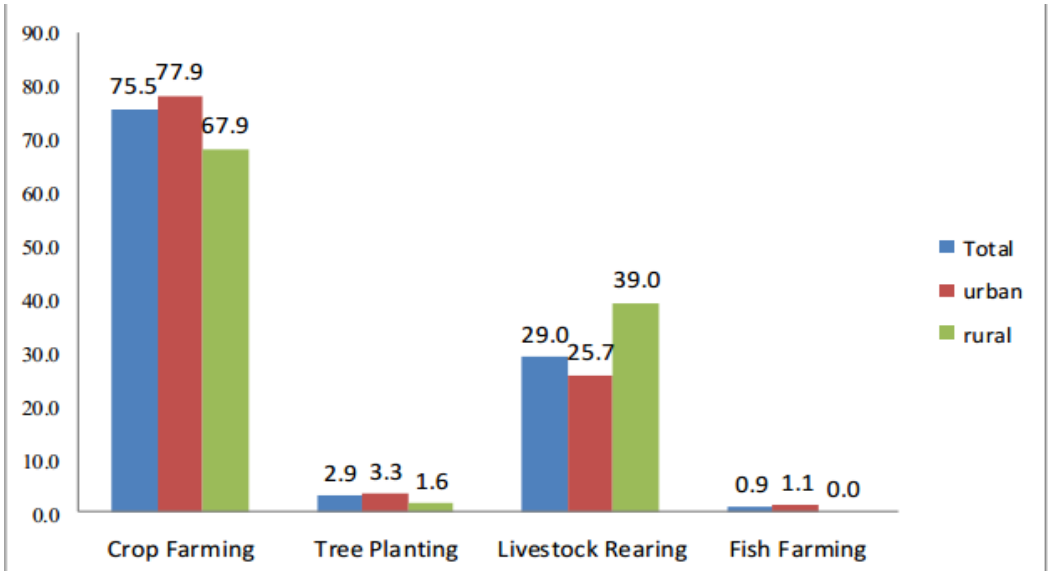


*Figure 6: Household Agricultural activities in Madina Locality*

A survey was taken in the community. 50% of the examined study samples purchase fruits and vegetables anytime they visited the market. 32% chose fish and meat and 18% preferred dairy products. From the data collected, it was concluded that perishables such as fruits and vegetables are in high demand in the community. They are available in large quantities in the community during certain months of the year. Madina has a very large market where the excess quantities of these perishables which cannot be consumed from the areas they were grown are brought to be sold. This is to prevent the farmer from losing money and the food from going waste. Due to the short shelf life of these perishable foods, farmers and traders are forced to sell them as quick as they can before they go bad and incur loss upon themselves. When the food stuff begin to show signs of spoilage and decomposition, they are sold at very cheap price compared to what they actually cost. Profit made is barely enough to cover for expenses made in the transportation of the goods, the materials (fertilizers, pesticides etc.) bought to grow the crops, preserve and store them. This common practice in Madina does not help sustain the economic sector in any way.

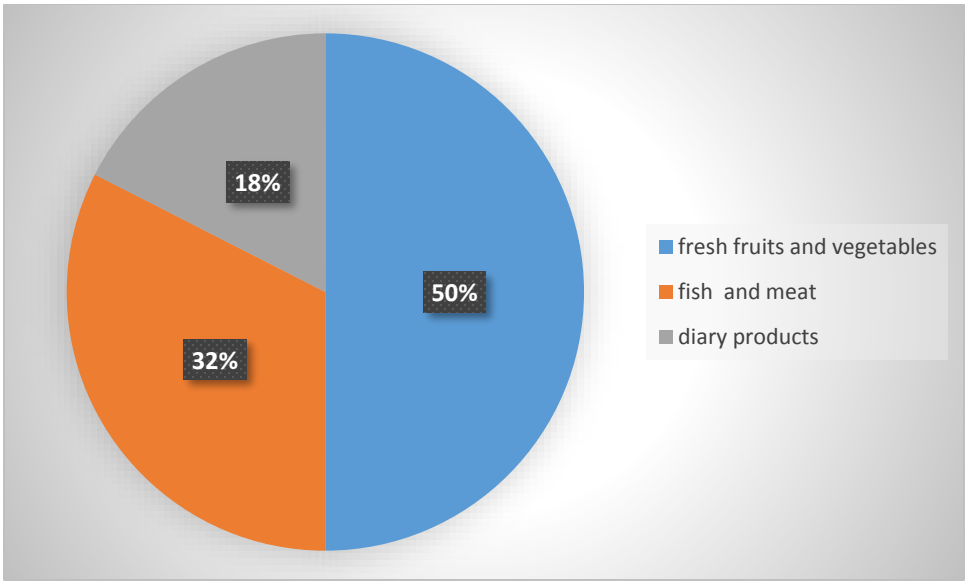


*Figure 7: Distribution demand of perishables in Madina*

### 3.2.3 CAUSES OF THE SHORT SHELF LIFE OF PERISHABLE FOODS

Perishable foods have the tendency to decay over a short period of shelf life. No rational and consistent regime for reducing this decay of perishable foods can be devised without knowledge of the causes at work to bring about the decay. Some of the causes are;

- Presence of microorganism:

  Micro-organisms are small organisms which cannot be easily seen. Like all living beings, micro-organisms require air, moisture, right temperature and food to grow and multiply. The micro-organisms responsible for food spoilage are moulds, yeast and bacteria.

*Figure 8: Decayed orange (left), and lettuce (right)*

1. Moulds: are in the form of threads developed on perishable foods and are easily visible to the eye. They contain spores which can spread through the air and start new mould plants. When these moulds find a favorable environment, they germinate and produce a fluffy growth, often white or grey but sometimes bluish-green, red, orange, or some other colour, depending upon the variety of the mould. A relatively small portion of the moulds, found on foods are capable of producing toxic materials known as mycotoxins of which aflatoxins is an example.

2. Yeasts: yeasts are tiny organisms which are not visible to the naked eye, but which can be seen through the microscope. They multiply very fast and cause fermentation by acting on certain components of the perishable foods like fruit juices, syrups etc. During the yeast fermentation, the sugars present in the food are broken up to form alcohol and carbon dioxide. Foods liable to be spoiled by yeasts are fruit juices, syrups, molasses, honey, jams and jellies.

3. Bacteria: are unicellular organisms and are much smaller in size than either yeasts or moulds. They occur in different sizes and shapes and are classified as coccus (spheroidal), bacilli (cylindrical) or spirillae (spirilar) on the basis of their shape as seen under the microscope. They also vary in their requirement for food, moisture, acidity, temperature and oxygen. Bacteria can grow rapidly between 20°C and 53°C. bacteria are classified according to the temperature range they need for growth.

(i) A higher temperature than 45C are known as thermophile, (e.g. in canning industry and milk processing plants)

(ii) Temperatures between 20-25C are called mesophiles.

(iii) Temperature less than 20C are called psychrophites (e.g. in refrigerators and in cold storages)

- Ethylene:

Ethylene is a plant hormone that plays a key role in the ripening and senescence of fruits and vegetables (Reid, 1992). All plant cells produce low levels of ethylene; however, anything that causes stress to the plant tissues will stimulate ethylene synthesis. Stressors may include excessive

water loss, physical damage or pathogenic attack. Climacteric fruits produce high levels of ethylene during initiation of ripening and the hormone is believed to stimulate and coordinate the physiological and biochemical changes which occur during ripening. Exposure to exogenous ethylene can lead to an acceleration of maturation and senescence, for example, green vegetables lose their chlorophyll more rapidly, thickened fibres can develop in asparagus, premature ripening can occur in unripe fruits and cabbages and cauliflowers can lose their leaves through accelerated through accelerated leaf abscission.

- Spoilage by enzymes:

Enzymes are organic catalyst present in living cells. The life of every living cell depends upon the chemical reactions activated by these enzymes. Hence, they cause food spoilage due to the chemical reactions as in cutting apples; it becomes brown while tomato cause develops a black scum. A raw green mango after a few days becomes sweet in taste and yellow in colour due to enzyme action. A few more days, it becomes soft, develops black spots and start smelling bad. This is the continued action of enzymes. Enzymes are sensitive to heat and are easily destroyed by heat. They can act from 0C to 60C; their optimum temperature of reaction is 37C. All enzymes are inactivated by temperatures above 80C. When the skin of fruits is not cut or damaged and it gets spoilt. This is due to the enzyme action.

*Figure 9: Image of enzymatic action on perishables e.g: apple, banana (left), leafy vegetables and tomatoes (right)*

- Spoilage by insects:

Worms, bugs, weevils, fruit flies, moths cause extensive damage to food and reduce its nutritional value and make it unfit for human consumption

- Senescence:

Senescence is the natural ageing of the plant tissues and is stimulated by the presence of ethylene and anything else that speeds up respiration rates as described above. Senescence ultimately affects all aspects of quality, ending in the death of the product. Some senescence changes can specifically affect certain types of fresh produce processing, for example, changes to the chemical and physical structure of the cell wall (Jimenez et al.,1997). Although in fresh produce, texture is highly dependent on cell turgor, the integrity of the cell wall is important to the texture of some processed products (Femenia et al., 1998). In some fruits and vegetables (e.g. apples and tomatoes), the breakdown of intercellular adhesion between cells leads to a condition known as mealiness which is generally perceived as a loss in textural quality. (Van der Valk and Donkers, 1994). In potatoes, so-called senescence sweetening is where, over time, storage starch is gradually converted to sugars. Concentrations of reducing sugars of greater than 0.1% into potato tissues being processed into chips and crisps can lead to browning or blackening of the product during the cooking process (Van der Plas, 1987).

*Figure 10: Senescence of lemons (left), tomatoes (right)*

### 3.2.4 EFFECTS OF THE SHORT SHELF LIFE OF PERISHABLES TO CONSUMERS

The short shelf life of perishable foods is not only a huge concern to those who make a living from selling them. It is also a problem affecting the 20 586 households in the community. In homes, perishable foods are mostly for immediate consumption needs, resulting in wastage of food surpluses during the short harvest periods and scarcity during postharvest periods. Even though most houses implore the use of fridges and freezers for storage of perishables once purchased from the market or mall, it does not indefinitely store the perishables till the time of need. It simply slows down the growth of bacteria and the food's shelf life is extended a little longer. Inevitably, the food gets spoilt. Some people prefer cooking their perishables like vegetables, meat and fish immediately after purchase. It is true that this method, cooking, has been approved scientifically to be a good mode of controlling heat, moisture and pH in the perishable. Hence, inhibiting spoilage by preventing microbial growth and slowing down the food's natural breakdown process. But what most people are in the dark about is the fact that this process permanently eliminates the action of enzymes only. Although, bacteria and fungi are killed during the cooking process, they re-infect the cooked food when measures are not taken to prevent their return. It is evident that the current extent of this problem has totally outpaced the capacity and measures of the people to manage the situation.

| S/No. | Community Name | Total | Sex | | House holds | Houses |
|---|---|---|---|---|---|---|
| | | | Male | Female | | |
| 1 | Madina | 79,832 | 38,515 | 41,317 | 20,586 | 8,486 |
| 2 | Adenta West | 12,495 | 6,074 | 6,421 | 3,289 | 2,313 |
| 3 | Oyarifa | 4,283 | 2,052 | 2,231 | 1,109 | 553 |
| 4 | Amanfrokoo | 2,073 | 1,027 | 1,046 | 547 | 342 |
| 5 | Pantang Hospital | 1,714 | 872 | 842 | 398 | 60 |
| 6 | Pantang Village | 1,478 | 741 | 737 | 390 | 182 |
| 7 | Oshiyie | 1,441 | 715 | 726 | 363 | 220 |
| 8 | Teiman | 1,067 | 519 | 548 | 269 | 149 |
| 9 | Damfa | 1,062 | 533 | 529 | 238 | 173 |
| 10 | Amrahia | 983 | 490 | 493 | 256 | 168 |
| 11 | Adoteiman | 930 | 483 | 447 | 275 | 156 |
| 12 | Nyamekrom | 824 | 410 | 414 | 187 | 162 |
| 13 | Amanfro | 816 | 403 | 413 | 240 | 119 |
| 14 | Aboman | 627 | 301 | 326 | 157 | 116 |
| 15 | Adenta | 588 | 296 | 292 | 144 | 117 |
| 16 | Kplenkoo | 557 | 278 | 279 | 146 | 89 |
| 17 | Malejor | 422 | 202 | 220 | 103 | 95 |
| 18 | Otinibi | 381 | 179 | 202 | 78 | 67 |
| 19 | Kweiman | 269 | 134 | 135 | 69 | 56 |
| 20 | New Kweiman | 84 | 47 | 37 | 26 | 24 |

Source: Ghana Statistical Service, 2010 Population and Housing Census

*Figure 11: Household population in communities in Accra*

3.2.5 TRADITIONAL METHODS OF EXTENDING SHELF LIFE OF PERISHABLE FOODS.

Due to the short shelf life of the perishable foods, most people in the community have now adopted a system of trading in seasonal commodities. When the season of the commodity comes, the perishable food is in abundance so its easily perishable nature is ignored as there is more than enough to do business with. But when its season passes, the perishable food becomes scarce. The quantity left after the fresh perishable is consumed by the people is the quantity that is preserved for consumption during the months when the perishable is not available. People resort to local methods of preserving food to extend the shelf life of the perishable commodity namely:

- Salting; is the use of salt in preserving food.it is one of the most extensively used preservatives in the preservation of fish and meat in the community. The salt is considered a preservative because of its behavior as an inhibitor of microbial growth. Through osmosis, it removes water from the food cells thereby reducing the amount of water

available for bacteria to reproduce and grow. It has been found to be also efficient in protection against the growth of molds and fermentation of yeast.

- Frying; is the process of cooking food by either placing it or immersing it in oil, which is heated to a temperature sufficient enough to brown the surface of the food, and partially or cook it. Frying is one of the quickest mode of preservation. Most households in the community prefer frying to many other methods because it give the food a crisp and firm outer coating to the food, while keeping the inside tender and juicy.

- Drying; is one of the simplest, safe, easy to learn and economical method of preservation used by many people in the community but it is a very slow and time consuming process since the unpredictable and uncontrollable weather in the community is the drying agent. It basically dehydrates moisture from food making them light weight. This simple action inhibits the growth of bacteria, mold and yeast. Moreover, it slows down the enzyme action without deactivating them.

- Smoking: is the process of curing, cooking or seasoning foods by exposing it for long periods of time to the smoke from a wood fire. This serves the purpose of preservation and increases their palatability by adding flavor and imparting a rich brown colour. Certain chemicals like formaldehyde and certain alcohols are natural preservatives present in the wood smoke.

*Figure 12: Salting (left) and frying food preservation (right)*

*Figure 13: Drying (left), and Smoking food preservation(right)*

### 3.2.4 LIMITATIONS OF THE TRADITIONAL METHODS OF PRESERVATION IN THE COMMUNITY.

- Most of the people engaged in the preservation of these perishables in the community are part of the unskilled labour force of the community. They do not follow any tested recipes or recommendations regarding how best these preservation techniques can be undertaken to produce optimum result. They perform these local methods of preservation on their knowledge best known to them and experience they gained over the years. Therefore, excess of substances like salt, oil etc. are found in these preserved food. This has contributed to the high level of fat and cholesterol. They have been linked with an increased risk of cancer at several sites, particularly the breast, lung, prostate and colon. Likewise, hypertension (high blood pressure) which is a risk factor for stroke and heart disease,

- Different bacteria and fungi also have different tolerance to heat, salt etc. which is used in the preservation of foods. So these methods like frying, salting, smoking and drying will not prevent all microbial growth.

- Some methods for example; drying have proven to extend the shelf life of some perishable goods such as fruits etc. However, they have been limited in terms of many other perishables such as vegetables, dairy products and fruits since they have low sugar and acid content.

- Most of these traditional methods such as salting, frying etc. have dire effects on the texture, structure, flavor and especially the taste of the food. It is very difficult to retain desirable qualities of the perishable food if extending the shelf life to an appreciable level is the main target.

# CHAPTER FOUR: CHEMICAL ENGINEERING

## 4.1 CHEMICAL ENGINEERING AS A PROGRAM OF STUDY

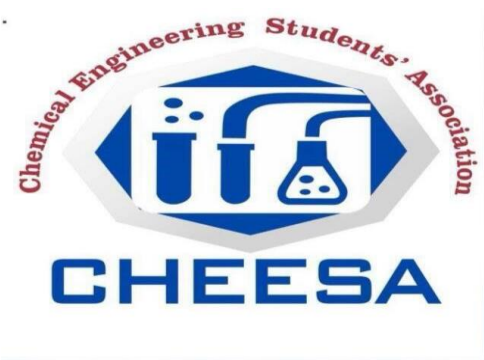


*Figure 14: KNUST Chemical Engineering department logo*

Chemical engineering is a broad discipline dealing with processes (industrial and natural) involving the transformation (chemical, biological, physical) of matter or energy into forms useful for mankind, economically and without compromising the environment, safety or finite resources. This branch of engineering is concerned with the design, construction, and management of factories in which the essential processes consist of chemical reactions. It is the task of the chemical engineer to select and specify the design that will meet the particular requirements of production and the most appropriate equipment for the new applications.

Chemical engineers use chemistry, physics and mathematics along with engineering tools to solve problems relating to the production and use of chemicals. This includes things like refining gasoline and other fuels from petroleum, purification of drinking water, treating waste, recovering raw materials, and processing food, etc. chemical engineering graduates will understand and be able to analyze entire chemical processes, learn independently, and participate effectively in-group discussion, design, effectively perform laboratory experiments and analyze and interpret results. Chemical engineering also works with fields such as nanotechnology and bioengineering.

## 4.2 DUTIES OF A CHEMICAL ENGINEER

A chemical engineer:

- Conducts research to develop an improved manufacturing process
- Provides safety measures for those working with dangerous chemicals
- Works on making products like food, and drinks
- Helps in managing world's resources.
- Protect the environment by providing health and safety standards.

## 4.3 SCOPE OF CHEMICAL ENGINEERING

Chemical engineer work in offices as well as laboratories. They find employment at industrial plants, refineries and locations where they monitor or direct chemical operations. They usually work with design professional and technicians or work on-site.

The industries that employ chemical engineers are as follows:

- Architectural, engineering, and related services
- Basic chemical manufacturing
- Scientific research and development services
- Resin, synthetic rubber, and artificial synthetic fibers and filaments manufacturing
- Petroleum and coal products manufacturing
- Biotechnology and pharmaceutical companies
- Business service
- Health-care industries
- Food manufacturing unites
- Electronic and energy manufacturers.

Chemical engineering branch has many characteristics of a core branch of engineering.it is more or less an evergreen branch. Chemical industry is showing no signs of slowing down. Actually, it is expanding and with this expansion, new job opportunities are also being generated.

Government and private sector jobs are available for graduates in ample amounts. Graduates may bag following roles in the above mentioned sectors-

- Plant managers
- Production engineer
- Purchase and quality control executive
- Safety management officer
- Chemical engineer
- Plant designer

# CHAPTER FIVE: PROBLEM SOLUTION

## 5.1 PRODUCTION PROCESS

A production process is concerned with transforming a range of inputs into those outputs that are required by the market.

A production process which produces dried fruits and vegetables from high demand perishables (fresh fruits and vegetables) could solve the problem at hand in the community. Drying is one of the traditional methods used in the community to preserve fruits and vegetables because it removes most of the water needed by enzymes and micro-organisms to spoil them. However, drying can also cause unacceptable changes to the colour, flavor and texture if the drying conditions are not properly controlled. In this production process, measures are put in place using knowledge from chemical engineering to address these limitations hence, extending appreciably the shelf life of these perishable foods longer than any of the traditional methods without destroying desirable traits from the perishable. Dried fruits, vegetables, herbs and spices are low volume, high-value foods that can be profitable for small scale processing.

The production process is divided into four stages namely:

- Moderation stage: Inspection, decontamination and grading of the fruits and vegetables are key operations under this processing stage to moderate and control conditions of the fresh produce to be processed.

- Inducing stage: Each operation under this stage is optional, depending on what type of fruit or vegetable- the necessary steps are chosen to work with. Blanching, acid dipping, sulphuring and sulphiting are some of the operations under this stage. This steps under the inducing stage arrest most of the physical and chemical limitations of the traditional methods of the community.

Blanching: This is mostly done for vegetables. They are blanched before drying to prevent colour changes and to reduce the number of contaminating micro-organisms, because the temperature of drying is not high enough to kill them. In hot water blanching, vegetables are immersed in boiling water in a wire. For this processing unit, steam blanching is preferred over water blanching. This ensures fewer nutrients are lost.

| Food | Blanching time | (minutes) using |
|---|---|---|
| | Steam | Water |
| **Leafy vegetables** | 2-2.5 | 1.5 |
| **Sliced beans** | 2-2.5 | 1.5-2 |
| **Cabbage** | 2.5 | 2 |
| **Peas** | 3 | 3.5 |
| **Cauliflower** | 4-5 | 5-6 |
| **Potatoes** | 6-8 | 8-12 |
| **Squashes** | 2.5 | 1.5-2 |
| **Carrots** | 3-3.5 | 3-4 |

*Table 3: Examples of food perishables and their appropriate blanching time using steam and water*

Acid dipping: This is done to prevent browning of light coloured fruits and vegetables.

Sulphuring and sulphiting: Sulphur dioxide protects the natural colour of some fruits (banana, pineapple etc.), although it should not be used with red fruits because it bleaches the colour. it can be produced either by burning sulphur(sulphuring) or using a solution of sodium sulphite, sodium meta bisulphite or potassium metabisulphite. Sulphiting can also be used to temporarily preserve fruits and spread production throughout the year. Processing using this preservative should be done based on the acceptable residual sulphur dioxide level.

- Desiccation stage: The time needed for drying depends on the temperature, humidity and speed of the air, the type of dryer and the size of the food pieces.

- Dissemination stage: It entails packaging, labelling and storing of the processed perishable foods.

Dried fruits and vegetables absorb moisture from the air and should therefore be packed in airtight, moisture-proof containers. Some also need protection from light to maintain their colour. Potassium permanganate acts as ethylene absorbers and reduce the loss in fresh fruit matter, consistency and pulp electrolyte leakage. The oxidation of ethylene by $KMNO_4$ leads to the formation of water and $CO_2$ (sorbentsystems, 2005). dried fruits and vegetables need a cardboard carton for storage and distribution to prevent crushing and to exclude light.

| Treatment | $CO_2$ production (mg $CO_2$ $kg^{-1}$ per hour) | CI | FML (%) | PC (kPa) | EL (%) | TSS (°Brix) |
|---|---|---|---|---|---|---|
| 0.0 g $KMnO_4$ per bag | 117.48* | 1.4 | 0.941* | 2,205 | 14.929 | 10.8* |
| 0.5 g $KMnO_4$ per bag | 122.79* | 1.2 | 1.046* | 2,443 | 12.432 | 10.7* |
| 1.0 g $KMnO_4$ per bag | 108.09 | 1.2 | 1.089* | 2,553 | 11.207 | 10.7* |
| 1.5 g $KMnO_4$ per bag | 80.29 | 1.0 | 1.176* | 2,440 | 9.604 | 10.4 |
| 2.0 g $KMnO_4$ per bag | 107.30 | 1.0 | 1.126* | 2,561 | 11.749 | 9.9 |
| Storage beginning | 94.64 | 1.0 | 0.000 | 2,540 | 9.389 | 9.4 |

(1)Determined by visual scale described by Martins & Malavassi (2003). *Value different from the observed at the storage beginning, by the Dunnett test, at 5% probability.

*Figure 15: Image showing different amounts of $KMNO_4$ and their formation of $CO_2$*

## 5.2 METHOD:

5.2.1 MODERATION STAGE.

- The mouldy, rotten, and badly damaged fruits and vegetables are removed. Other visible foreign material (physical contaminants): leaves, stems, stalks, sticks and stones are also removed from the harvested fresh perishables. Poor quality raw materials produce poor quality, and perhaps unsafe, finished products.
- Wash tanks and special washers are used to remove surface contaminants from the fresh perishables surface with clean, portable water to remove surface contaminants such as pesticide residues, insects, soil or dirt etc. The wash tanks and other apparatus used undergo chlorination before use.
- Fruits and vegetables are selected of the same colour, size or maturity (fully mature but not over-ripe) by hand. Uniform size and maturity are important to get uniform drying times for all pieces. Over-ripe fruits have poorer flavor colour and appearance.
- The outer covering of fruits and some undesirable parts of vegetables are peeled by hand using knives or peelers or using small peeling machines. Peel prevents moisture leaving the food and allows faster blanching, sulphur dioxide treatment and drying. The perishable food is checked whether all traces of peel are removed.
- Depending on the type of fruit or vegetable, the perishables are cut by hand using sharp stainless steel knives, corers etc. or using choppers, cutters, slicing or dicing machines into desirable uniform sized pieces.

5.2.2 INDUCING STAGE.

- The vegetables are placed are placed in a strainer over a pan of boiling water and covered with a lid to prevent the steam from escaping. Steaming takes longer than water blanching.
- The bright green colour of some vegetables can be protected using 1% sodium bicarbonate in the blancher water.
- The vegetables are rinsed in a 2% calcium chloride solution. This ensures that the texture of soft vegetables is protected.
- The fruits or vegetable is transferred into a food-grade plastic tank where they are soaked in 2% citric acid, lemon or lime juice for 5-10 minutes.
- In sulphuring, cut or shredded fruit is placed on mesh trays inside a wooden cabinet.350-400g sulphur are burned per 100kg fruit for 1-3 hours depending on the type of fruit, its moisture content and legal limits on residual sulphur dioxide in the product.
- In sulphiting, the chemical is either dipped to the blancher water or made into a sulphite dip. fruits are dipped for 5-10 minutes. About two-thirds of the weight of sodium metabisulphite is present as sulphur dioxide when it is dissolved in water. A 0.001% (1000 ppm or 1g/litre) solution is therefore made by dissolving 1.5g sodium metabisulphite/litre.

5.2.3 DESICCATION STAGE.

- The cut fruits or vegetables are placed in a drying chamber. Hot air is being blown on it at a temperature range of 61-63C for about 5 minutes.

5.2.4 DISSEMINATION STAGE.

- They are transferred into a food grade drum where high pressure (about 700MPa) is applied to the perishable foods for a short time to inactivate any microbe still present before packaging.
- The processed perishables are wrapped in low density polyethene films (28μm thick) containing sachets of $KMNO_4$ at 1.5-2g per bag.
- The bags are sealed using an electric heat sealer to produce moisture-proof, airtight plastic bags.

- They are stored and stored at 10.4±0.9°C and 90±5% relative humidity. $KMNO_4$ product oxidizes the ethylene produced by the fruit during ripening, extending the pre-climacteric period and the post-harvest life (Resend et al., 2001).

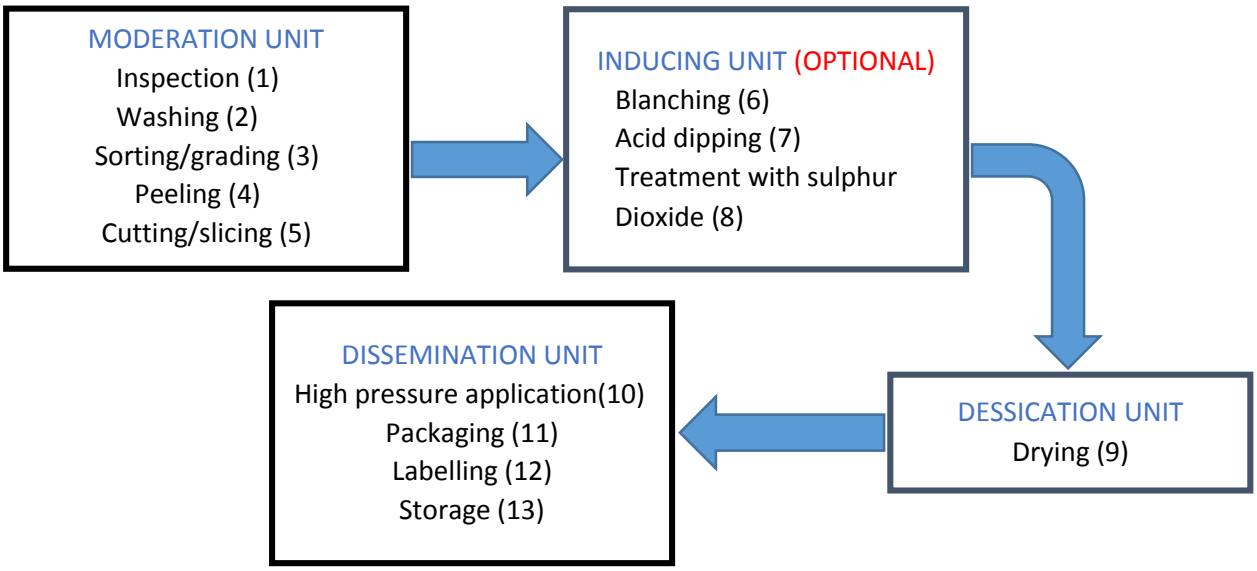


*Figure 16: Production process flow chart*

The production process could:

- Extend the shelf life of these perishable goods to a period range of 6-8 weeks.
- Be a source of employment to the unemployed 7.7% of the economically active population of people living in the community.

# CHAPTER SIX

## 6.1 CONCLUSION

- The production process is successful in the elimination of the limitations of the traditional methods of preservation therefore appreciably extending the shelf life of the food perishables.
- High pressure processing doesn't disrupt chemical bonds, so its application in this processing plant does not affect the taste, texture, colour and nutritional value in any way.
- Sodium bicarbonate helps prevent the decolourization of green vegetables.
- Calcium chloride is a useful additive in protecting the texture of green vegetables during unit operations like drying, boiling etc.
- Sodium metabisulphate is a permitted chemical preservative that is particularly more effective in terms of its combined action against moulds and yeasts compared to its contemporaries; sodium benzoate, potassium sorbate, tert-butyl hydroquinone, etc.
- Potassium permanganate delays fruit ripening, and the dose of at least 0.5g of $KMNO_4$ per bag is sufficient to preserve perishable fruit and vegetables during storage for 25 days.
- Refrigeration combined with fruit wrapping with low density polyethylene film preserve and maintain fruit and vegetable appearance and some quality attributes during storage.

## 6.2 RECOMMENDATION

- For the sake of exportation and most especially, the health benefit of the consumers, more research and experimentation should be done to address the issue of the residual level of additives/ preservatives present in the processed food. Possibly, deduce or search for other chemical preservatives to replace preservatives like sodium bimetasulphite since many importers specify either very low levels or do not allow its presence.

- To achieve optimum consumer protection, it is essential that safety be incorporated in food products from production through consumption. All participants in the food chain from primary producer to the processor to the vendor must play their vital roles in ensuring the processed food is under suitable conditions for it to serve its purpose efficiently.

- Polythene is the most widely available and cheapest film in the community, but it is not a good barrier to air and moisture. Funds should be invested to secure more efficient options like polypropylene films. They are well proven to offer better protection.

# CHAPTER SEVEN

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## 7.2 APPENDICE

7.2.1 QUESTIONNAIRE SAMPLE 1

Name: ……

1. Which locality in Madina do you reside in? *Please tick below*

   Madina Zongo ☐

   Madina Estate ☐

   Madina Market ☐

   Madina old road ☐

2. How many years have you lived in Madina? ……
3. What do you do for a living? .....
4. State any two major problems confronting you and your household as a whole in Madina.

(i) ……

(ii) ……

5. Which of the following below would you always buy when you visit the market or a mall?

*Please, answer by ticking only **one** of the options below.*

Fruits and vegetables ☐

Meat and fish product ☐

Dairy products ☐

7.2.2 QUESTIONNAIRE SAMPLE 2

Name: ……

1. Which of the following categories below can you classify yourself under? *Tick **one** only*

☐ Primary producer (farmer)

☐ Vendor (trader)

☐ Consumer (*you neither sell nor cultivate crops*)

2. How long have you been in this community? …….
3. Do you agree that the short shelf life of perishable foods is a major challenge confronting you in this community? ……..
4. How has it affected you in the community?

   ……

   …….**.....**
5. Do you have any idea on what might be the cause of this problem? if yes, please state them……

   **.....**
6. In what ways have the Government been able to help with the situation?

   ……

   ……
7. In what ways have you been able to manage the situation until now

……

……....

8. Do you have any suggestions on what must be done in the community to tackle or solve the problem better?

   (i) Yes/ No

   (ii) If yes, please state below:

……

……

……

……

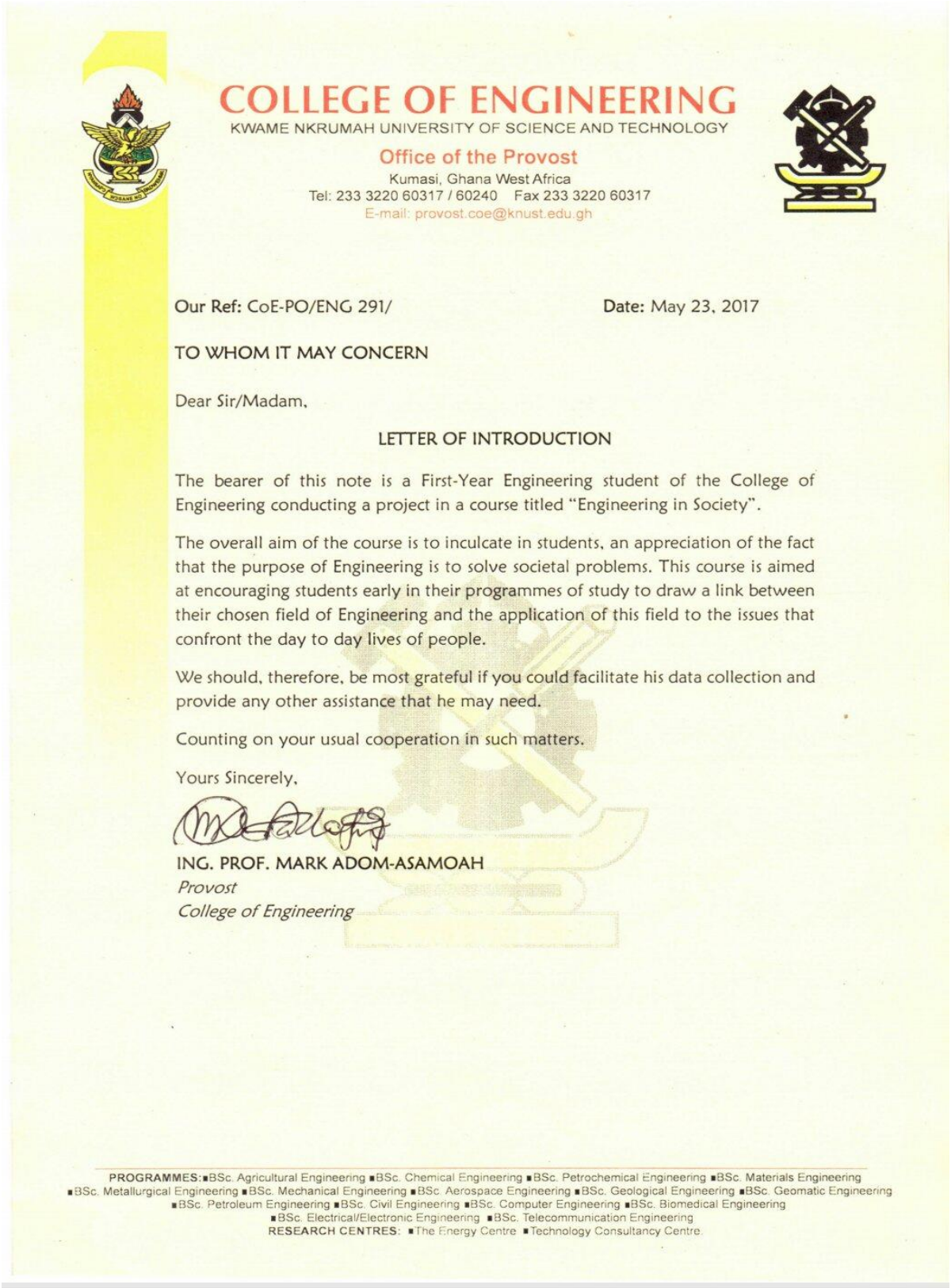
7.2.3 GLOSSARY AND ACRONYMS

| | |
|---|---|
| Blanching | it is a cooking process wherein the food substance, usually a vegetable fruit is softened using heat. It could be either steam or water blanching. |
| Chlorination | the addition of chlorine to water to destroy the microorganism |
| Desiccation stage | this is the third stage of the production process. It ensues the use of warm air to get rid of any germs still present. |
| Dissemination stage | the final stage of the production process. It entails the measures put in place to address packaging, labelling, and storing of the processed food products |
| Enzymes | natural proteins in food that cause change to colour, flavor, texture in the food. |
| Inducing stage | it is a dynamic operational unit. The operations under this stage ensures physical and chemical limitations of drying as a traditional method of preservation is dealt with. |
| Micro-organism | tiny forms of life, invisible until they are in large numbers, moulds, yeast and bacteria. |
| Moderation stage | the first stage of the production process. This stage allows the alteration to the physical state of the raw perishable food material before processing. |

| | |
|---|---|
| PHC | Population and Housing Census |
| Shelf life | the time that a food product can be stored before changes in texture, colour, flavor, or the number of microorganisms make it unacceptable. |
| Sodium metabisulphite | a chemical preservative that is effective against moulds and yeast |

## 7.3 OTHER MAPS.

## 7.4 INTRODUCTORY LETTER



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Our Ref: CoE-PO/ENG 291/ Date: May 23, 2017

TO WHOM IT MAY CONCERN

Dear Sir/Madam,

LETTER OF INTRODUCTION

The bearer of this note is a First-Year Engineering student of the College of Engineering conducting a project in a course titled "Engineering in Society".

The overall aim of the course is to inculcate in students, an appreciation of the fact that the purpose of Engineering is to solve societal problems. This course is aimed at encouraging students early in their programmes of study to draw a link between their chosen field of Engineering and the application of this field to the issues that confront the day to day lives of people.

We should, therefore, be most grateful if you could facilitate his data collection and provide any other assistance that he may need.

Counting on your usual cooperation in such matters.

Yours Sincerely,

ING. PROF. MARK ADOM-ASAMOAH
*Provost*
*College of Engineering*

PROGRAMMES: ■BSc. Agricultural Engineering ■BSc. Chemical Engineering ■BSc. Petrochemical Engineering ■BSc. Materials Engineering ■BSc. Metallurgical Engineering ■BSc. Mechanical Engineering ■BSc. Aerospace Engineering ■BSc. Geological Engineering ■BSc. Geomatic Engineering ■BSc. Petroleum Engineering ■BSc. Civil Engineering ■BSc. Computer Engineering ■BSc. Biomedical Engineering ■BSc. Electrical/Electronic Engineering ■BSc. Telecommunication Engineering
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