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ASSESSMENT OF MICROBIOLOGICAL CONTAMINATION OF SOME INDIGENOUS SPICES SOLD IN SELECTED MARKETS IN THE KUMASI METROPOLIS.

BY

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MICROBIOLOGICAL CONTAMINATION OF SOME INDIGENOUS SPICES SOLD IN SELECTED MARKETS IN THE KUMASI METROPOLIS

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JOHN YANKEY

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DECLARATION

I hereby declare that except for references to other peoples' work which have been duly acknowledged this write up, submitted to the School of Research and Graduate Studies, KNUST, Kumasi is the result of my own original research and that this thesis has not been presented for any degree elsewhere.

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ABSTRACT

This study was carried out to assess the postharvest handling practices carried out on spices sold in the Kumasi Metropolis. The study was necessitated by the paucity of information on handling practices carried out on spices in Ghana. A survey was conducted in the Kumasi Metropolis covering farmers, wholesalers, retailers, and processors. Postharvest handling practices and microbial contamination of hot pepper and ginger at the Central, Asafo, and Bantama Markets in the Kumasi Metropolis were assessed. Total Viable Count, Mould Count, and Total Coliforms population were determined at various points being; farmer, wholesaler, retailer and processors points. The study revealed that the pepper was the leading spices sold in the Kumasi Metropolis. Farmers did not dry their pepper and ginger prior to selling them. Vehicles used were generally, not clean. Majority (86.2%) of the traders sun-dried their spices but on bare floor while others (10.3%) dried using polythene platform and raised platform (3.5%)**.**Traders stored spices on polythene sheets, wooden pallets and on the bare floor. All (100%) the farmers reused their packaging materials without cleaning, washing or disinfecting them. The greatest postharvest loss of pepper was attributed to breakages (4.2%).Spices sold at the Central market were highest in total mould count (5.45 cfu/g) followed by Bantama market with a total mould count (5.39 cfu/g) while Asafo market recorded the least count (5.22 cfu/g). Spices sold at the Central Market were highest in total viable count (5.48 cfu). Microbiological study showed that the spices in Kumasi markets had unacceptable microbial quality. It is therefore important to ensure proper handling to protect consumer’s health and quality of spices.

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DEDICATION

I dedicate this work to my lovely wife Phyllis Asubonteng and my dear children, Damian Nhyirah Yankey and Jayson Adom Yankey.

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CHAPTER ONE

1.0 INTRODUCTION

Spices a vegetable of indigenous or exotic origin which is or has a hot taste used to enhance taste of foods or to add to them the stimulant ingredients contained in them. It can also be defined as a dried seed, fruit, root, bark or vegetative substance derived from the non-leafy parts of plants. It is used as a food additive for the purpose of flavouring or food flavourings, and sometimes as a preservative by killing or preventing the growth of harmful bacteria (Adamson, 2004).

Some of the types of spices include Onion, Ginger, Garlic, Cloves, Dawadawa, Cinnamon, Rosemary, Thyme, Marjoram, Pepper, Black Pepper, and Olive, Lime, Anise, Nutmeg, Curry, Almond, Turmeric, Oregano, Sage, Lemon balm, Peppermint, Dill, and Coriander .Spices are known to possess a wide range of medicinal values. Such values include fight against cancer causing cells, reduction of cholesterol level in the blood and prevention of several skin diseases (Shils, 1999).

As with many other agricultural products, spices and herbs may be exposed to a wide range of microbial contamination during pre-and post-harvest. Such contamination may occur during processing, storage, distribution, sale and/or use (McKee, 1995). Having been dried material from plant origin, spices are commonly heavily contaminated with xerophilic storage moulds and bacteria (Dimić *et al.*, 2000; Romagnoli *et al.*, 2007).

Although spices are present in foods in small amounts, they are recognized as important carriers of microbial contamination mainly because of the conditions in which they were grown, harvested and processed. In addition, because of possible neglects during sanitation or processing, foods containing spices are more likely to deteriorate and also could exert harmful effects, having in mind health risks associated with mycotoxins produced by some fungal genera (Koci-Tanackov *et al*., 2007).

Fungal are the predominant contaminants of spices (Kneifel and Berger, 1994), but most of such microbial populations are probably regarded as commensal residents on the plant that survived drying and storage. Soil and air is the main inoculums source for causing contamination in crude spices in field. Other practices like harvesting, handling and packing, cause additional contamination. Moreover, spices are collected in tropical areas by simple methods and are commonly exposed to many contaminants before, being dry enough to prevent microbial growth. (Sharma A. K. *et al* 1984).For example, the traditional methods of drying spices is to spread them out on the ground to dry under the sun. However this potentially exposes them to the risk of contamination. Dried spices may contain high levels of microbial contamination, depending on whether they received a form of treatment or not (Hara-Kudo, 2006).

The Codex Code of Hygienic Practice (Codex.1995). Specifies that dried spices and herbs should be free from pathogenic microorganisms at levels that may represent a hazard to health and further requires that *Salmonella* should be absent in treated ready-to-eat spices. The European Spice Association (ESA) also specifies that *Salmonella* should be absent in 25g of spice, *Escherichia coli* to be present at less than 102 cfu/g, and other bacteria requirements to be agreed between buyer and seller.

Over the last several years, there have been multiple outbreaks linked to, and recalls of, various kinds of spices. From white pepper, to red pepper, to black pepper and beyond, spices are a potentially ideal vehicle for the transmission of food borne disease. More and more people are becoming ill from contaminated spices (Arce, 1990).

In Costa Rica, the microbiological quality of some of the powdered spices usually used in homes, without further thermal treatment was evaluated. Analysis of black, white and green peppers showed that the total plate counts and faecal coliforms exceeded the international commission on microbiological specifications for foods (ICMSF) standards and that contamination was probably due to drying conditions and post-harvest treatment (Arce,1990).

The main objective of this study was to assess the microbiological quality of spices sold in the Kumasi Metropolis. The specific objectives of the study were to:

1. Identify the types of indigenous spices sold in the Kumasi Metropolis.
2. Identify the postharvest practices carried out on indigenous spices at major markets in the Kumasi Metropolis.
3. To assess the postharvest loss of the indigenous spices sold in the Kumasi Metropolis.
4. To evaluate the microbiological contamination of some selected indigenous spices sold in the Kumasi Metropolis.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 GENERAL BACKGROUND

A spice is a dried seed, fruit, root, bark or vegetative substance used in nutritionally insignificant quantities as a food additive for the purpose of flavouring, and sometimes as a preservative by killing or preventing the growth of harmful bacteria (Adamson, 2004). Many of these substances are also used for other purposes, such as medicine, religious rituals, cosmetics, perfumery or eating as vegetables. For example, turmeric is also used as a preservative; licorice as a medicine, garlic as a vegetable (Dalby, 2001).

Though the term spice can be used to incorporate herbs, the distinction between herbs and spices can be described as follows, in the kitchen, spices are distinguished from herbs, which are leafy, green plant parts used for flavouring purposes (Bender and Bender, 2005).

2.2 HISTORY

The use of spices dates back to ancient times. Spices and herbs were used for medicinal purposes, to mask unpleasant tastes and odours of food, and to keep food fresh (Rosengarten, 1969). Early documentation suggests that hunters and gatherers wrapped meat in the leaves of bushes, accidentally discovering that this process enhanced the taste of the meat, as did certain nuts, seeds, berries, and bark (Rosengarten, 1969).

Historically, culinary spices and herbs have been used as food preservatives and health-enhancing properties. Papyri from Ancient Egypt in1555 BC classified coriander, fennel, juniper, cumin, garlic and thyme as health promoting spices (Tapsell *et al*., 2006).

2.3 CONVENTIONAL CLASSIFICATION OF SPICES

A conventional classification of spices is based on degree of taste as: hot spices, mild spices, aromatic spices herbs and aromatic vegetables.

Table 2.1: Classification of Spices

Classes	Spices
Hot spices	Capsicum (chillies), Cayenne pepper, black and white peppers, ginger, mustard
Mild spices	Paprika, coriander
Aromatic spices	Allspice (pimento), cardamom, cassia, cinnamon, clove, cumin, dill, fennel, fenugreek, mace and nutmeg
Herbs	Basil, bay, dill leaves, marjoram, tarragon, thyme
Aromatic vegetables	Onion, garlic, shallot, celery

Table 2.2: Parts of Plant used as spices

Plant organs	Spice crops
Aril	Mace of nutmeg
Barks	Cassia, cinnamon
Berries	Allspice, black pepper, chilli
Buds	Clove
Bulbs	Onion, garlic, leek
Pistil	Saffron
Kernel	Nutmeg
Leaf	Basil, bay leaf, mint, marjoram, sage, curry leaf
Rhizome	Ginger, turmeric
Latex	Asafoetida
Roots	Angelica, horse-radish
Seeds	Ajowan, aniseed, caraway, celery, coriander, dill, fennel, fenugreek, mustard, poppy seed

2.4 TYPES OF SPICES

There are so many types of spices, some very common and some not. They are Onion, Ginger, Garlic, Cloves, Dawadawa, Cinnamon, Rosemary, Thyme, Marjoram, Pepper, Black Pepper, Olive, Lime, Nutmeg, Curry, Allspice, Almond, Turmeric, Oregano, Sage, Lemon balm, Peppermint, Dill and Coriander.

2.5 IMPORTANCE OF SPICES

There are many reasons for which people use spices, though, taste probably tops the list. There are several spices that simply smell good and those smells can be alternately soothing or exciting. On the other hand, ginger is said to be a stimulant and the smell of ginger could be just what you need to pep up your mood. Over the centuries, certain spices have been said to heal every infection, disease and malady known to man but there's no doubt that spices do have value far beyond enhancing the taste of food (Ziegler and Filer, 1996).

Spices play an important role in the nutrition of our daily diet. Scientists have done a lot of research on this and have found out that spices contain more antioxidants than fruits and vegetables. Spices contain more antioxidants when they are dried than when they are raw or fresh. Half teaspoon of spices will contribute more amounts of antioxidants than half a cup of fruits. Spices play an active role by acting as medicines. Cloves, oregano, allspice, cinnamon, sage, peppermint, thyme and lemon balm are some of the spices. These spices may be of a significant dietary source (Pokorney, 1991).

Spices, the predominant flavouring, colouring and aromatic agents in foods and beverages, are now gaining importance for their diversified uses. In the present scenario, the anti-diabetic, anti-hypercholesterolemic, anti-carcinogenic, anti-inflammatory effects of spices have paramount importance, as the key health issues of mankind nowadays are diabetes, cardio-vascular diseases, arthritis and cancer. Spices or their active principles could be used as possible ameliorative or preventive agents for these health disorders (Shils, 1999).

Extensive studies on animal models carried out indicate that spices could be consumed at higher dietary levels without any adverse effects on growth, organ weights, and food efficiency ratio and blood constituents. Curcumin, the colouring pigment present in turmeric, capsaicin, the pungent principle in red pepper, allicin, the active principle in garlic, gingerol, the pungent principle in ginger, saponin and fibre present in fenugreek are immensely valuable in health care with their multiple physiological effects (Stipanuk, 2000).

However, until recent times, the desiccation and freezing of food was not a viable option for those living in hot, humid climates; these societies discovered chemical preservation, in the form of salt and spices. As the former was only available in certain areas spices were often the only other option to protect food from insect infestation and microbial putrefaction (Sethi and Meena, 1997). We now know that many of the strongly flavoured phytochemicals which give plants protection against insect and microbial attack are the same compounds that "preserve" our bodies, by protecting us against degenerative disease (Shils, 1999).

Spices are consumed in much greater quantity and variety in warm, humid countries than in colder climates. India and Thailand have the highest consumption of spices; the warm Mediterranean countries follow somewhat behind these and other Eastern countries but are ahead of the United States. Chilly Scandinavian countries have the lowest spice consumption of all. Moreover, the importance of spices in helping to prevent chronic degenerative disease can be seen to correspond to the varying levels of spice utilization that occurs across different temperature zones. Cold countries, typically the most developed countries, tend to have much higher incidences of chronic degenerative diseases when compared to hotter regions. There is the need to consume lots of spices on a daily basis as they could make one feel better, think better, age more slowly, and help to resist the onslaught of scourges like cardiovascular disease, cancer, diabetes, Alzheimer's disease and other chronic degenerative disorders (Shils, 1999).

2.6 SPICES AND THEIR HEALTH EFFECTS

Spices have numerous effects on the human body. Some of the health effects are discussed.

2.6.1 Cloves (*Sypzygium aromaticum)*

Like other spices, cloves are available throughout the year. Cloves are the unopened pink flower buds of the evergreen clove tree. The buds are picked by hand when they are pink and dried until they turn brown in colour. Cloves resemble tiny nails. In fact, it English name is actually derived from the Latin word clavus, which means nail. (Ensminger *et al.*, 1986).

Clove contains significant amounts of an active component called eugenol, which has made it the subject of numerous health studies, including studies on the prevention of toxicity from environmental pollutants like carbon tetrachloride, digestive tract cancers, and joint inflammation. In the United States, eugenol extracts from clove have often been used in dentistry in conjunction with root canal therapy, temporary fillings, and general gum pain, since eugenol and other components of clove (including beta-caryophyllene) combine to make clove a mild anaesthetic as well as an anti-bacterial agent (Amaechi *et al.*, 1999***).*** Eugenol, the primary component of clove's volatile oils, functions as an anti-inflammatory substance. Clove also contains a variety of flavonoids, including kaempferol and rhamnetin, which also contribute to clove's anti-inflammatory and antioxidant properties (Friedman *et al*., 2002**).** Like its fellow spices, clove's unique phytonutrient components are accompanied by an incredible variety of traditionally-recognized nutrients. Cloves are excellent source of manganese, a very good source of dietary fibre, vitamin C and omega-3 fatty acids and a good source of calcium and magnesium (Ensminger and Esminger, 1986).

2.7.2 Onion *(Allium cepa)*

Onions like garlic, are a member of the Allium family, and are rich in powerful sulphur-containing compounds that are responsible for their pungent odours and for many of their health-promoting effect. Onions contain allyl propyl disulphide, (while garlic is rich in allicin, diallyl disulphide, diallyl trisulfide and others). In addition, onions are very rich in chromium, a trace mineral that helps cells respond to insulin, plus vitamin C, and numerous flavonoid (Augusti, 1996).

Onions have been singled out as one of the small number of vegetables and fruits that contributed to the significant reduction in heart disease risk seen in a meta-analysis of seven prospective studies (Huxley and Neil, 2003). Quercitin, an antioxidant in onions, and curcumin, a phytonutrient found in the curry spice turmeric, reduce both the size and number of precancerous lesions in the human intestinal tract (Yang *et al.*, 2004).

Making onion and garlic a staple in your healthy way of eating may greatly lower your risk of several common cancers (Fukushima *et al.*, 1997). In addition, quercitin, the thiosulfinates exhibit antimicrobial properties and other flavonoids found in onions work with vitamin C to help kill harmful bacteria. Onion is effective against many bacteria including *Bacillus subtilis, Salmonella,* and *E. coli, making* onions an especially good addition to soups and stews during cold and flu season **(**Augusti, 1996).

The World Health Organization (WHO) supports the use of onions for the treatment of poor appetite and to prevent atherosclerosis. In addition, onion extracts are recognized by WHO for providing relief in the treatment of coughs and colds, asthma and bronchitis. Onions are known to decrease bronchial spasms. An onion extract was found to decrease allergy-induced bronchial constriction in asthma patients. Onions have a universal appeal. They are safely consumed by most people. However, consuming large quantities of onions can lead to stomach distress and gastrointestinal irritation that may result in nausea and diarrhea (Winston, 2002).

2.7.3 Pepper

With pepper, two separate parts of the plant, the fruit, which is an edible herb, and the ground seed which is used as a spice are of importance. The fruit of the sweet pepper, which is large and hollow, is popular for adding colour and flavour to salads and stir fry dishes.

2.7.3.1 Black pepper *(Piper nigrum)*

Black pepper (*Piper nigrum*) is a flowering vine in the family Piperaceae, cultivated for its fruit, which is usually dried and used as a spice and seasoning. The same fruit is also used to produce white pepper, red/pink pepper, and green pepper. The fruit, known as a peppercorn when dried, is a small drupe five millimetres in diameter, dark red when fully mature, containing a single seed.

Dried ground pepper is one of the most common spices in European cuisine and its descendants, having been known and prized since antiquity for both its flavour and its use as a medicine. The spiciness of black pepper is due to the chemical piperine (McGee, 2004). Black pepper has long been recognized as a carminitive, (a substance that helps prevent the formation of intestinal gas), a property likely due to its beneficial effect of stimulating hydrochloric acid production. In addition, black pepper has diaphoretic (promotes sweating), and diuretic (promotes urination) properties (Abila *et al.*, 1996).

Not only does black pepper help derive the most benefit from food, the outer layer of the peppercorn stimulates the breakdown of fat cells, keeping ones slim and giving energy. Black pepper is an excellent source of manganese, a very good source of iron and vitamin K, and a good source of dietary fibre (Ensminger *et al*., 1986).

2.7.3.2 White pepper *(Piper nigrum)*

White pepper consists of the seed only, with the fruit removed. This is usually accomplished by allowing fully ripe berries to soak in water for about a week, during which the flesh of the fruit softens and decomposes. Rubbing then removes what remains of the fruit, and the naked seed is dried. Alternative processes are used for removing the outer fruit from the seed, including removal of the outer layer from black pepper produced from unripe berries (McGee, 2004).

2.7.3.3 Red pepper (chilli) *(Capsicum annuum)*

Red pepper is fruit pod. It is also called cayenne pepper and provides the dominant flavour of chilli. The chilli pepper, or more simply just "chilli", is the fruit of the plant Capsicum from the nightshade family, Solanaceae. These terms usually refer to the smaller, hotter types of capsicum; the mild larger types are called bell pepper (simply pepper in Britain and Ireland or capsicum in Australasia).

Red chillies are very rich in vitamin C and provitamin A. Yellow and especially green chillies (which are essentially unripe fruit) contain a considerably lower amount of both substances. In addition, peppers are a good source of most B vitamins, and vitamin B6 in particular. They are very high in potassium and high in magnesium and iron. Pepper also has antimicrobial properties (Dorman and Deans ,2000).

Experts say capsaicin, the chemical that gives spicy food its kick, could be used to kill tumours with few or no side effects for the patient Chilli peppers also have cardiovascular benefits, weight loss properties (by inducing thermogenesis) and helps to clear mucus from stuffed noses or congested lungs (Heidi, 2002). Chilli also helps to lower the risk of diabetes; according to a study by the American Journal of Clinical Nutrition, the amount of insulin required to lower blood sugar after a meal is reduced if the meal contains chilli pepper. Canadian researchers believe that chillies could play a vital role in curing diabetes (Ahuja *et al.*, 2006).

Red chili peppers, such as cayenne, have been shown to reduce blood cholesterol, triglyceride levels, and platelet aggregation, while increasing the body's ability to dissolve fibrin, a substance integral to the formation of blood clots. Cultures where hot pepper is used liberally have a much lower rate of heart attack, stroke, pulmonary embolism and also help fight against prostate cancer (Mori *et al*., 2006).

The 5th century Syriac Book of Medicines prescribes pepper (or perhaps long pepper) for such illnesses as constipation, diarrhoea, earache, gangrene, heart disease, hernia, hoarseness, indigestion, insect bites, insomnia, joint pain, liver problems, lung disease, oral abscesses, sunburn, tooth decay, and toothaches (Turner, 2004).

2.7.4 Garlic *(Allium sativum)*

Garlic is a member of the lily or Allium family, which also includes onions. Garlic is rich in a variety of powerful sulphur-containing compounds including thiosulfinates (of which the best known compound is allicin), sulfoxides (among which the best known compound is alliin), and dithiins (in which the most researched compound is ajoene). While these compounds are responsible for garlic's characteristically pungent odour, they are also the source of many of its health-promoting effects including cancer prevention. In addition, garlic is an excellent source of manganese, a very good source of vitamin B6 and vitamin C and a good source of selenium (Fukushima *et al*., 1997; Andorfer *et al*., 2003).

Numerous studies have demonstrated potential benefits of regular garlic consumption on blood pressure, platelet aggregation, serum triglyceride level, and cholesterol levels. Routine eating of garlic may also help stimulate the production of nitric oxide in the lining of blood vessel walls, which may help to relax them (Apitz-Castro *et al*., 1986; Spigelski and Jones, 2001).

As a result of these beneficial actions, garlic can be described as a food that may help prevent cancer, atherosclerosis and diabetic heart disease, as well as reducing the risk of heart attack or stroke (Berthold and Sudhop, 1998; Fleischauer *et al*., 2000). The compounds in garlic responsible for its pungency also excite a neuron pathway providing cardiovascular benefits. Garlic's numerous beneficial cardiovascular effects are due to not only its sulphur compounds, but also to its vitamin C, vitamin B6, selenium, manganese calcium, potassium, iron and copper (Fugh-Berman, 2000;

Bautista *et al*., 2005). One reason for garlic's beneficial effects may be its ability to lessen the amount of free radicals present in the bloodstream (Dillon *et al*., 2003).

Garlic is a very good source of vitamin C, the body's primary antioxidant defender in all aqueous (water-soluble) areas, such as the bloodstream, where it protects Low-density lipoprotein (LDL) cholesterol from oxidation. Since it is the oxidized form of LDL cholesterol that initiates damage to blood vessel walls, reducing levels of oxidizing free radicals in the bloodstream can have a profound effect on preventing cardiovascular disease (Superko and Krauss, 2000; Bhattacharya *et al*., 2004).

2.7.6 Ginger *(Zingiber officinale)*

Ginger is a perennial spice which grows from underground rhizomes, which are often mistakenly called the "roots." Botanically it is the rhizome that provides the slightly hot, citrus-like taste, and wonderful aroma. Its family name is Zingiberaceae. The rhizome has thick lobes coloured from tan to white. A highly valued variety, especially for medicinal uses, has a blue ring circling the fleshy inside of the rhizome. The nutrients present inside ginger, especially its volatile oils - gingerols and shogaols, accord a number of health benefits to its users (Chen *et al*., 2007). In fact, ginger has also been found to be effective in fighting some fatal ailments like cancer (Afshari and Taghizade, 2007).

Ginger has been found to be helpful in blocking the harmful effects of prostaglandin, a substance that can lead to inflammation of the blood vessels in the brain and even cause migraines. Ginger has been associated with alleviation of the feeling of nausea, even in case of pregnant women (Portnoi *et al.*, 2003).

Ginger is quite effective for relief of cramps caused by stomach gas. Ginger makes the platelets less sticky and is thus, pretty helpful in case of circulatory disorders. Preliminary studies suggest that ginger may lower cholesterol and prevents the clotting of blood. Each of these effects may protect the blood vessels from blockage and the damaging effects of blockage such as atherosclerosis, which can lead to a heart attack or stroke. (Bordia *et al*., 1997).

There are a variety of uses suggested for ginger. Tea brewed from ginger is a folk remedy for colds. Ginger ale and ginger beer have been recommended as "stomach settlers" for generations in countries where the beverages are made, and ginger water was commonly used to avoid heat cramps in the US. Ginger has also been historically used to treat inflammation which several sugar, soluble and insoluble fibre, sodium, vitamins, minerals, fatty acids and amino acids. (Ensminger and Esminge, 1986).

2.7.7 Rosemary (*Rosmarinus officinalis)*

Rosemary is generally considered safe when taken in recommended doses. However, there have been occasional reports of allergic reactions. Large quantities of rosemary leaves, because of their volatile oil content, can cause serious side effects, including vomiting, spasms, coma and, in some cases, pulmonary edema (fluid in the lungs).

Because larger doses of rosemary may cause miscarriage, pregnant and nursing women should not use it in quantities other than those used for cooking (Lemonica *et al.*, 1996). People with high blood pressure, ulcers, Crohn’s disease, or ulcerative colitis should not take rosemary (Atsumi *et al.,* 2007).

2.7.8 Thyme *(Thymus vulgaris)*

Thyme leaves are curled, elliptically shaped and very small, measuring about one-eighth of an inch long and one-sixteenth of an inch wide. The upper leaf is green-grey in colour on top, while the underside is a whitish colour.

Thyme has a long history of use in natural medicine in treatment of chest and respiratory problems including coughs, bronchitis, and chest congestion. The volatile oil components of thyme include carvacolo, borneol, geraniol, but most importantly, thymol (Bagamboula *et al*., 2004). Thymol - named after the spice itself - is the primary volatile oil constituent of thyme, and its health-supporting effects are well documented.

In studies on aging in rats, thymol has been found to protect brain, kidney, and heart cell membranes when dietary supplementation with thyme was increased. Thyme also contains a variety of flavonoids, including apigenin, naringenin, luteolin, and thymonin. These flavonoids increase thyme's antioxidant capacity, and combined with its status as a very good source of manganese, give thyme a high standing on the list of anti-oxidant foods (Kelm *et al*., 2000). The volatile oil components of thyme have also been shown to have antimicrobial activity against a host of different bacteria and fungi. *Staphalococcus aureus, Bacillus subtilis, Escherichia coli* and *Shigella sonnei* are a few of the species for which thyme has been shown to have antibacterial activity (Kulevanova *et al*., 2000).

For thousands of years, herbs and spices have been used to help preserve foods and protect them from microbial contamination. Research shows that both thyme and basil contain constituents that can both prevent contamination and decontaminate previously contaminated foods). It is an excellent source of iron, a very good source of calcium, manganese and a food source of dietary fibre (Cosentino *et al*., 1999).

2.7.9 Anise *(Pimpinella anisum)*

Anise seed is a gray brown oval seed from plant in the parsley family. It is related to caraway, dill, cumin and fennel. Anise seeds smell and taste like licorice. Anise is native to Middle East and has been used as a medicine and as a flavour for medicine since prehistotoric times. Ancient Romans hung anise plant near their pillows to prevent bad dreams. They also used anise to aid digestion and ward off epileptic attacks (Chopra and Chandler, 1928) intestinal gas and spasmodic coughs (Blumenthal *et al*., 1998). Anise has been combined with cathartic laxatives to reduce the spasmodic cramping. It has modest antiparasitic actions and has been recommended by some practitioners to treat mild intestinal parasite infections (Weiss, 1985).

The anise fruit has a nice taste and is used in phytotherapy. As a ripe fruit or juice, it is recommended for curing asthenia and for stimulating suckling mothers' lactation. It is also recommended for curing nervous asthenia, migraines, vertigos, rheumatism, bronchial asthma, gastric pains, and slow digestion (Chopra and Chandler, 1998**).**

2.7.10 Aidan (Prekese) (*Tetrapleura tetraptera)*

Prekese (*Tetrapleura tetraptera*) which is an indigenous tree species belonging to the Mimosaceae family. In West Africa, the plant Tetrapleura tetraptera (locally known as Prekese) is popular among the Akans of Ghana for its use as a spice, as a dietary supplement rich in vitamins and a medicine for many ailments. Traditionally, the fruits, leaves, bark and roots are seen to have important medicinal properties (Thomas *et al*., 2001).

Research has demonstrated how careful planting of Tetrapleura tetraptera in areas of high Billharzia transmission can reduce the rates of infection, offering countries with limited resource a more environmentally and financially friendly way of protecting their populations from this dreaded disease. It was found that it had anti-ulcer and anti-convulscant properties, confirming its ethno medicinal use to treat these symptoms. The active ingredients were found to be rapidly passed through the mammalian body, with little retention in tissues. They were also found to exhibit very few toxic effects, and were mutagenic only in the presence of other more dangerous chemicals which are not frequently found. (Thomas *et al.*, 2001)**.**

Prekese has many potential uses for instance it is a potential source of raw material for the growing pole industry of Ghana, which is currently based on teak. Farmers are critical of negative environmental impact of teak therefore it is a suitable indigenous substitute which is agro-forestry and environmentally friendly (Adewunmi, 2008).

Biological study has shown that Prekese extract has some useful therapeutic action easing hypertension, and Asthma. Active constituents include Scopletin which appears to have a relaxing action on smooth muscle, helping to ease constriction in the Bronchioles of the lung, and on constricted blood vessels (Adewunmi, 2008).

2.7.11 Senegal pepper (Hwentea) *(Xylopia aethiopia)*

There are several widely used indigenous forest species which are harvested from the wild. *Xylopia aethiopia* or Ethiopia pepper or Senegal pepper or locally known as (hwentea), the seeds are used as spice and a substitute for pepper. As a spice Sénégal Pepper should always be used whole and grounded, as the hull of the fruit lends the spice its aromatic notes whilst the seeds within lend pungency and bitterness to the flavour (Burkill, 1985).

The chemical composition and mineral constituents of Senegal pepper, which is valued as a spice in Nigeria, were determined along with the physicochemical characteristics of the seed oil. The seeds had the following chemical compositions: moisture, ash, crude lipid, crude protein crude fibre and carbohydrate. Calcium and potassium were the major minerals in the seed. The extracted lipid was examined for the fatty acid composition. Linoleic and oleic acids were the predominant unsaturated fatty acids, while palmitic acid was the major saturated acid (Tatsadjieu *et al*., 2003).

The essential oils of Senegal pepper and four Cameroonian plants used as spices in local food, showed antibacterial and antifungal activity (Tatsadjieu *et al*., 2003).

2.7.12 Ashanti pepper (Soro Wisa) *(Piper guineense)*

“False cubeb pepper” also known as “soro wisa” by the akans of Ghana, stems from Central Africa of the species *Piper guineense*. It belongs to the Piperaceae (pepper family). Its fruits, also known as “ashanti pepper”, indeed strongly resemble cubeb berries, but are prolate-elliptically shaped, smaller, smoother in surface and somewhat reddish coloured. Ashanti pepper tastes like the cubeb pepper, but fresher and less bitter. The stalked berries are a little bit larger than pepper corns, having a furrowed surface. Most berries are hollow. They are sold whole and should be crushed or ground before usage). It has a pungent and bitter with a strong terpene aroma. It has anti-convulscant properties (Abila *et al*., 1996).

2.8 MICROBIAL CONTAMINATION OF SPICES

Spices normally carry a great number of bacterial and molds often of soil origin. Practices such as harvesting, handling and production often cause additional contamination and microbial growth (Weiser *et al*., 1971) .The microbial flora on many spices and related materials general dominated by aerobic spore-forming bacterial (Goto *et al*.,1971).

Spices having essential oils which exhibit antimicrobial effects generally show the lowest microbial populations (Weiser *et al*., 1971). During the cleaning and processing of spices there is a progressive reduction in the number and types of microorganisms. Those organisms remaining after physical cleaning operations are generally mixtures of aerobic sporforming bacteria and common molds (Powers *et al.,* 1975).

Coliform bacteria, among others species in the enterobacteriaceae family, occur sporadically and usually in small populations (Mundt, 1976) and are associated with fecal contaminations. Bacterial spores of the *Bacillaceae* family are resistant to thermal treatments usually applied in infusion preparation and this thermal shock may stimulate spore germination. Some of this bacterial like *Bacillus cereus* and *Clostridium perfringens* are recognized as having potential pathogenicity and have been incriminated in food poisoning(Kunene *et al.,* 999) and are occasionally present but at very low level(Power *et al.*, 1975).

Pathogens such as salmonella, shigella and coagulase-positive staphylococci are really found in species (Guarino, 1974). Yeasts and mold densities vary considerably with the individual species, but are usually quite low. They range from less than 10 per gram in the case of such species as Mace, Mustard seed and cloves (Julseth *et al.,* 1974) greater than 10000 per gram for a variety of other species, mainly Basil, Black pepper, Capsicum, Celery seed and Cinnamon (Guarino, 1974).

Keeping quality of species is directly related to the condition of the product at harvest. When properly dried and stored, spices are generally resistant to microbial spoilage *(*Halt, 1998). However, spices are raw agricultural material and if the moisture content is too high toxigenic molds, like *Aspergillus spp,penicillium spp and Fusarium spp* may grow offering the opportunity for aflatoxins production (Aziz *et al.,* 1998).

Presence of pathogenic and spoilage microorganisms in spices could act as vehicles for microorganisms to enter in foods. Frequently, spices are grown and harvested in warm and humid areas where the growth of wide variety of microorganisms is readily supported (Mousuymi and Sarkat, 2003). As many other agricultural commodities, spices are exposed to a wide range of environmental microbial contamination during harvest, processing, and in retail markets by dust, waste water, and animal and even human excreta (Freire and Offord, 2003).

The Codex Code of Hygienic Practice (Codex.1995) specifies that dried spices and herbs should be free from pathogenic microorganisms at levels that may represent a hazard to health and further requires that *Salmonella* should be absent in treated ready-to-eat spices.

Brazilian Microbiological Standard for Foods has set maximum limit of 5 x 10^2 and 10^2 CFU/g for faecal coliforms and positive coagulase *Staphhylococcus*, respectively, and absence in 25g of spices for *Salmonella* (ANVISA, 2001). In German legislation, standard limit value for TAMB, *Bacillus cereus* and *S. aureus* is 10^5, 10^4 and 10^2 CFU per gram of spices, respectively (Mousuymi and Sarkat, 2003).

2.9 POST HARVEST HANDLING OF SPICES

2.9.1Transport

Harvested raw plant material of the spice crop should be transported promptly to in clean, dry conditions. The crop may be placed in clean baskets, dry sacks, trailers, hoppers or other well-aerated containers and carried to a central point for transport to the processing facility. Containers used at harvest should be kept clean and free from contamination by previously-harvested plant products and other foreign matter. If plastic containers are used, particular attention should be paid to any possible retention of moisture that could lead to the growth of mould (Harnischfeger, 2000).
When containers are not in use, they should be kept in dry conditions, in an area that is protected from insects, rodents, birds and other pests, and inaccessible to livestock and domestic animals. Conveyances used for transporting bulk plant materials from the place of production to storage for processing should be cleaned between loads (Harnischfeger, 2000).

2.9.2 Drying

This the most critical process in the production of dried herbs and spices. The aim of drying is to reduce the moisture content of the product from actively growing in the field to a level that prevents deterioration of the product and allows storage in a stable condition (Okoh *et al.*, 2008). Drying is a two stage process: firstly the transfer of heat to the moist product to vaporize the water in the product and secondly mass transfer of moisture from the interior to the product surface where it evaporates (Okoh *et al*., 2008).

The drying phase of post-harvest management can include four preliminary stages - the selection of high quality produce from the field; cleaning the crop by washing and disinfection; preparing the crop for drying by peeling or slicing; pre-treating with anti-oxidants, blanching or sulfurizing (Douglas *et al*., 2005). In some cases, washing prior to processing is desirable to remove field contaminants (dust, soil) using anti-microbial solutions to reduce the microbial populations to a low level prior to the drying process (Douglas et *al.*, 2005).The most basic method of drying is to spread the crop on a surface exposed to the sun .In this case, the process is aided by a cover system that prevents wetting with rainfall. (Douglas *et al.*, 2005).

An improved method to speed up drying is to use a fuel source (wood, oil/diesel, gas or electricity) to heat the drying room. Solar drying systems together with solar powered fans are also available (Heindl, 2000). The drying process should dry the crop as quickly as possible, at temperature levels which do not drive off the volatile flavour compounds. The drying temperature regime will be specific to each crop as will be the final moisture percentage for storage (Heindl, 2003).

The traditional open sun drying that is widely used in developing countries has major inherent limitations when trying to preserve product quality. High crop loss and low product quality result from inadequate drying, long drying times, fungal spoilage, insect infestations, bird and rodent damage and contamination plus the effects of sunlight and the weather. Even in the most favourable climate it is often not possible to get the moisture content of the product low enough for safe storage. In the tropics the high relative humidity of the air prevents drying of harvested crop products during the wet season (Douglas *et al.*, 2005).

2.9.3 Packaging

Processed plant materials should be packaged as quickly as possible to prevent deterioration of the product and as a protection against exposure to pest attacks and other sources of contamination. Continuous quality control measures should be implemented to eliminate substandard materials, contaminants and foreign matter prior to and during the final stages of packaging (Douglas *et al.*, 2005).

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Processed plant materials should be packaged in clean, dry boxes, sacks, bags or other containers in accordance with standard operating procedures and national and/or regional regulations of the producer and the end-user countries. Materials used for packaging should be non-polluting, clean, dry and in undamaged condition and should conform to the quality requirements for the plant materials concerned. (Douglas *et al.*, 2005).

Fragile plant materials should be packaged in rigid containers. Whenever possible, the packaging used should be agreed upon between supplier and buyer. Re-usable packaging material such as jute sacks and mesh bags should be well cleaned (disinfected) and thoroughly dried prior to re-use, so as to avoid contamination by previous contents. All packaging materials should be stored in a clean and dry place that is free from pests and inaccessible to livestock, domestic animals and other sources of contamination (Douglas *et al.*, 2005).

According to Douglas *et al.*, (2005) a label affixed to the packaging should clearly detail the product name of the spice, the plant name, the place of production, the harvest date and the names of the grower and the processor, and quantitative information. The label should also contain information indicating quality approval and comply with other national and/or regional labeling requirements. The label should bear a number that clearly identifies the production batch. Additional information about the production and quality of the plant materials may be added in a separate certificate, which is clearly linked to the package carrying the same batch number. Records should be kept of batch packaging, and should include the product name, place of origin, batch number, weight, assignment number and date.

2.9.4 Cleaning

Cleaning the spice prior to packaging and sale is to ensure that the spice is of the highest quality and will obtain the highest price. Cleaning should remove all the foreign matter that lowers the quality and endangers the sale. Sieves, grading tables, flotation tanks and screens can all be used to ensure that the quality standards are met and an even line of high quality spice is obtained.

2.9.5 Storage

Spices deteriorate rapidly in adverse conditions and should be stored in well-prepared and maintained storage facilities. It is essential the moisture level of the spice to be stored is at a safe level prior to storage. This is usually below 10% moisture. The storehouses should be damp-proof, vermin- p roof and bird- proof and where possible have controlled ventilation and devices to control humidity and temperature. A dehumidifier fitted to a storage room, by keeping the atmosphere always dry, can eliminate mould and insect attacks. (Douglas *et al*., 2005).

According to WHO guidelines on Good agricultural and collection practices (GACP) (2003), Store room should be fumigated before storage, the walls whitewashed regularly and the facility kept dry. Only registered chemicals agents authorized by the regulatory authorities of the source country and the countries of intended end-use should be used (Douglas *et al*., 2005).

2.10 POSTHARVEST LOSSES

The major losses in postharvest and production are dependent on many factors. Poor harvesting methods with immature crop product, disease or pest contaminated material, or rotten and damaged material, all encourage crop losses. There is a need to have facilities such as artificial driers and dry storage to minimize the problem of rainfall interrupting the crop drying. The consequences of poor drying and storage multiply into microbial invasion which can have disastrous results on the potential sale and can lead to rejection of the crop. Poor processing methods, creating damage, can lead to loss of quality and losses, while poor storage facilities can also lead to losses to pests and to quality (Douglas *et al*., 2005).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 RESEARCH DESIGN

The research is in two parts; a survey and experiment. The two approaches were chosen in order to achieve all the research objectives

3.1.1 The Survey

A preliminary survey was conducted to sample views from traders in spices. This led to the identification of the various places where spices are sold in the Kumasi Metropolis. The survey targeted the various indigenous spices sold in the Kumasi Metropolis and those that are largely patronized and the postharvest practices that are practiced.

3.1.2 Sampling Area

The study was carried out in the Kumasi Metropolis. Three sampling sites were selected in the Metropolis. The three sample sites were; the Central market, the Asafo Market, and the Bantama Market in the Kumasi Metropolis.

3.1.3 Sampling Size

A sample size of one hundred and thirteen (113) respondents was chosen for the study. This comprised 70 spices sellers (30 wholesalers and 40 retailers), 19 indigenous spice farmers and 24 processors were used as the respondents for the study.

3.1.4 Sampling Methods

This selection was done using purposive sampling and the stratified random sampling techniques. The spices wholesalers and processors were chosen using the purposive sampling method because they are specific people known whiles the retailers and farmers were chosen randomly to enable each respondent have an equal chance of being represented in the study.

3.1.5 Data Collection Procedure

Semi structured questionnaire as well as interviews were used for the data collection. The survey was carried out by administering questionnaires in the Kumasi metropolis (local dialect) to assess respondent's views. The questionnaire was also administered to establish the main source of the indigenous spices, the various types of indigenous spices, hygienic nature of the market among others. The questionnaire also sought information on the post harvest handling practices. The information collected from the survey was used to establish associations with the microbiological results.

3.2 LABORATORY EXPERIMENT

An experiment to find out the microbiological contamination level of spices (ginger and pepper) was carried out at the laboratories of the Department of Biological Science of the Kwame Nkrumah University of Science and Technology (KNUST) Kumasi.

3.2. 1 Source of Spice Samples

A total of eighteen (18) random samples of ginger powder and hot pepper powder, the most patronized spices in the metropolis, were collected from retailers, processors and wholesalers at central market, Asarfo market and Bantama market in the Kumasi Metropolis with six samples from each market. The powdered spices packaged in Low Density Polyethylene bags with each weighing ten grams were transported to the laboratory.

3.2.2 Experimental Design

A 2x3x3 factorial experimental design was employed for the research with three (3) replicates. Two spices (ginger and pepper) were applied on three markets (Central, Bantama and Asafo market) and three point of sales (processers, retailers and wholesalers). A total of eighteen treatment combination repeated three times were used for the study.

3.2.3 Parameters Studied

- Total Viable Count
- Total Mould count
- Total Coliforms

3.2.4 Experimental Procedure

3.2.4.1 Total Viable Count (TVC)

Microbes were isolated and total viable counts were enumerated by pour plate method and growth on plate count agar (PCA). Serial dilutions of 10^{-1} to 10^{-4} were prepared by diluting a 1g of the sample into 10ml of sterilized distilled water. One milliliter aliquots from each of the dilutions were inoculated into on Petri dishes with already prepared PCA. The plates were then inoculated at 35^{o}C for 24 hrs. After incubation all white spots or spread were counted and recorded as total viable count using the colony counter.

3.2.4.2 Bacterial Identification

A drop of culture from TVC plate was placed on a slide, spread with a flamed sterile loop, allowed to dry and fixed the bacterial by passing the slide two times through a Bunsen flame. The bacterial smear was stained with 0.5% crystal violet for two minutes. It was washed with water, drained off the water and stained with dilute iodine for 2 minutes. The crystals violet and iodine form a purple/ black complex inside the bacterial cell. A drip of absolute alcohol was dropped into the smear and allowed to run off. It was repeated three times and washed off with water (the alcohol dissolves the lipid layer surrounding the gram negative cells and allows the crystals violet and iodine complex to wash out). It was counterstained with 1% safranin for 2 minutes and then washed and slide drained. The slide was observed under the microscope and cells which were stained purple or black were gram positive cells whiles gram negative cells were stained light pink

3.2.4.3 Total Coliforms Count

The Most Probable Number (MPN) method was used to determine total coliforms in the samples. Serial dilution of 10^{-1} to 10-^{4} was prepared by picking 1 ml of the sample into 9 ml sterile distilled water. One millilitre aliquots from each of the dilutions were inoculated into 5ml of MacConkey Broth with inverted Durham tubes an incubated at 35^{0}C for 18-24 hours. Tubes showing colour change from purple to yellow after 24 hours were identified as positive for total coliforms. Counts per 100ml were calculated from Most Probable Number (MPN) tables.

3.2.5 Analysis of Data

The survey data was analyzed using Statistical Package for Social Scientist version 17 (SPSS).The results were presented in tables and graphs. Data resulting from the studied parameters were subjected to analysis of variance (ANOVA) using Tukey HSD and means were separated at least significant difference (Lsd) of 1 and 5 percent.

CHAPTER FOUR

4.0 RESULTS

4.1 INTRODUCTION

This chapter presents the analysis of survey and experimental results. In the study farmers, wholesalers, retailers and processors were interviewed. The perception and practices of the farmers have been presented in Table 4.1.

4.1.1 Farmers

4.1.1.1 Types of spices grown

Table 4.1 shows that 52.7 % of the farmers grew pepper whiles 47.4 % grew ginger. Pepper was the commonest spice grown by farmers in the Kumasi Metropolis.

Farmers were asked if they dried some of the spices before selling them. All the farmers responded in the negative indicating that farmers sold spices to the wholesalers, retailers or processors immediately after harvest without drying.

Table 4.1: Handling of spices by farmers

		Frequency	
Percentage (%)			
Types of spices	Pepper	10	52.6
	Ginger	09	47.4
Drying of spice by farmers	Yes	0	0
	No	19	100
Packaging material use	Fertilizer sack	10	52.6
	Jute sack	7	37.4
	Others	2	10
Reuse of packaging material	Yes	19	100
	No	0	0
Vehicle used	Minibuse	11	56.2
	Cargo truck	8	43.8
Cleaning of vehicles	Yes	2	10.5
	No	17	89.5
Mixed loading of spices	18	94.7	
	No	1	5.3

Most (52.6%) of farmers used fertilizer sacks, 37.4 % used jute sack while10 %used other packaging materials to package spices for transportation. It was also observed that every farmer re-used the packaging materials again to package spices for transportation.

The study also shows that 56.2 % of farmers used commercial vehicles (minibuses) whiles 47.4 % used cargo trucks to transport spices produce. According to most of the farmers (89.5 %) vehicles used for transporting the spices were not cleaned before loading spices while 10.5 % reported that their vehicles were cleaned.

Most (94.7 %) of the farmers indicated that the spices were loaded with other farm produce whiles 5.3 % answered in the negative.

4.1.2 Markets where farmers sold their spices

It was found that 67.9 % of the farmers sold their spices at the Central market, 28.6% at Bantama market while only 3.6% sold at the Asafo Market (Figure 4.1).

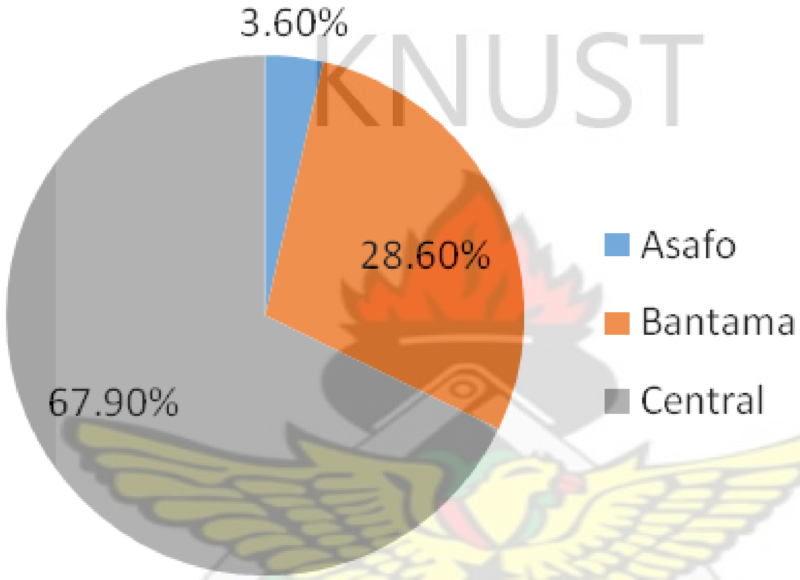

Figure 4.1: Markets where farmers sold spices

4.2 WHOLESALERS/ RETAILERS

4.2.1 Types of spices sold

The survey revealed that seven (7) major types of spices were sold at the markets in Kumasi Metropolis. The spices were as presented in Table 4.2.

Table 4.2: Types of Spices Sold

Common Name	Scientific Name
1. Ashanti Pepper (sorowisa)	*Piper guineese*
2. Grain of paradise (famu wisa)	*Aframomum melegueta*
3. Senegal pepper (Hwentea)	*Xylopia aethiopia*
4. Aidan (Prekese)	*Tetrapleura tetraptera*
5. Ginger	*Zingiber officinale*
6. Red pepper (chilli)	*Capsicum annuum*
7. White (black) pepper	*Piper nigrum*

Plate 1: Packaged spices sold in the Kumasi metropolis

4.2.2 Platforms for sun drying

From Figure 4.2, it was seen that 86.2 % of traders sun-dried spices on bare floor, 10.3% used polythene bags and 3.5 % used raised platform for sun drying spices.

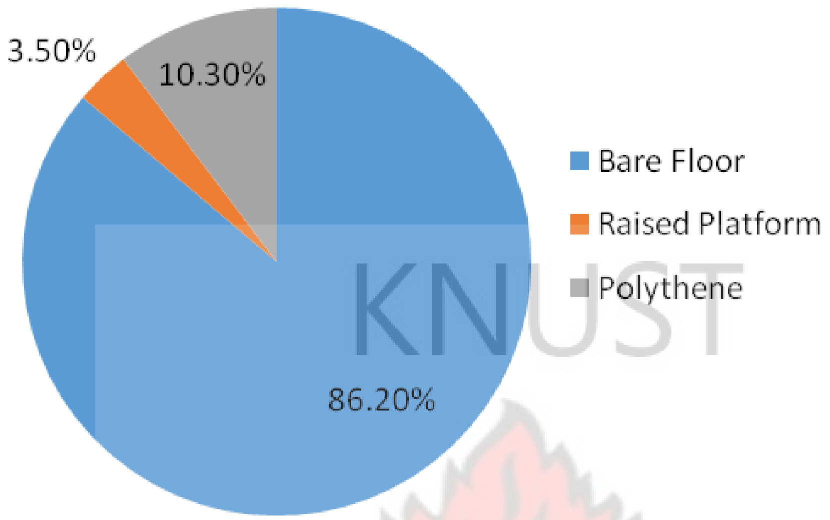

Figure 4.2: Platforms for sun drying of spices

4.2.3 Arrangement of spice bags in the store house

It was seen from figure 4.3 that 62.1 % of traders stored spices on polythene sheets, 24.1% stored spices on wooden pallets and 13.8% stored their spices on the bare floor.

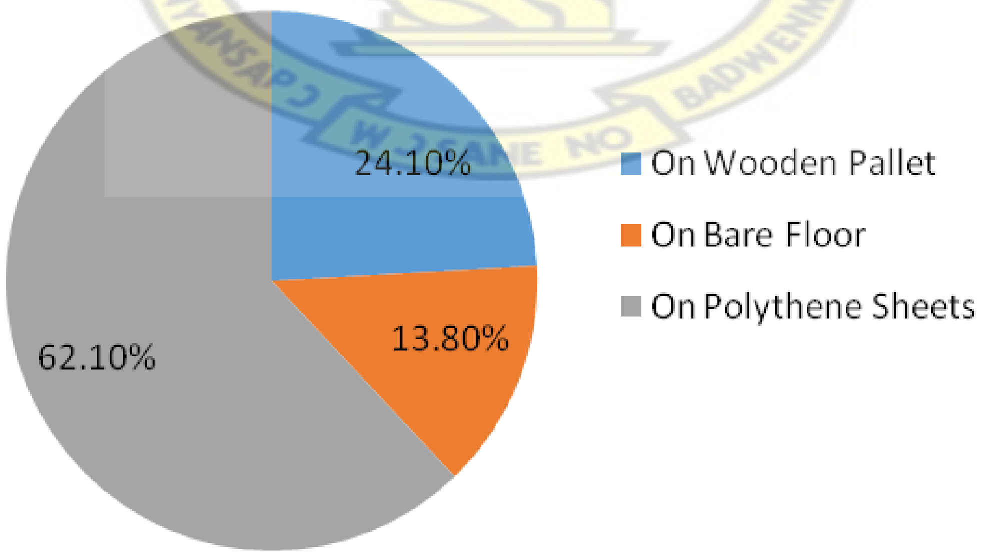

Figure 4.3: Arrangement of spice bags in the store house

4.2.4 Postharvest Losses of Pepper

Assessment of losses in the spices at the wholesale and retail points showed that pepper suffered postharvest losses in many forms. Loss due to decay was 0.89% and 0.92% for the retailers and wholesalers respectively. Loss due to insect damage was 0.99% (wholesalers) and 1.26 % (retailers).

Broken spices were 3.17 % and 4.27 % for the wholesalers and retailers respectively. Loss due to change in colour was 1.74% and 1.31 % at the retailers and wholesalers points. Loss of pungency on the other hand accounted for 3.19% and 3.21% at the retailers and wholesalers ends respectively (Table 4.3).

Table 4.3: Postharvest losses of pepper

Type of Loss	% Loss	
	Retailers	Wholesalers
Breakages	3.17	4.27
Insects damage	0.99	1.26
Decay	0.89	0.92
Change in colour	1.74	1.31
Loss of pungency	3.19	3.21
Total	100	100

4.2.5 Postharvest Loss of Ginger

Assessment of losses in the spices at the wholesale and retail points also showed that ginger suffered postharvest losses in many forms. Loss due to loss of moisture was 2.46% and 4.52% for the retailers and wholesalers respectively. Loss due to insect damage was 0.71% (wholesalers) and 0.93 % (retailers) rotten spices were 3.17 % and 4.27 % for the wholesalers and retailers respectively. Loss due to change in colour was 1.74% and 1.31 % at the retailers and wholesalers points. Loss of pungency on the other hand accounted for 1.23% and 1.25% at the retailers and wholesalers ends respectively (Table 4.4).

Table 4.4: Postharvest loss of ginger

Type of Loss	% Loss	
	Retailers	Wholesalers
Rot	0.72	0.81
Insects damage	0.71	0.93
Loss of moisture	2.46	4.52
Loss of pungency	1.23	1.25
Total	100	100

4.2.6 Disposal of solid waste at retailer/ wholesalers shop

The study sought to find out the waste disposal conditions at the retailers and wholesalers ends. As shown in table 4.5, 85.7 % of the retailers and 89.3 % of the wholesalers disposed solid waste in waste bins, 10.7 % of retailers and 7.1 % of wholesalers indicated that they burned their solid waste whiles 3.6 % of each of the retailers and wholesalers disposed solid waste on refuse dump.

Table 4.5: Disposal of solid waste at Retailer/ Wholesalers shop

Disposal Means	Seller (%)	
	Retailers	Wholesalers
Waste bin	85.7	89.3
Burnt	10.7	7.1
Refuse Damp	3.6	3.6
Total	100	100

4.2.7 Cleaning and disinfection of shop

Table 4.6 shows that 86.2 % of retailers and 96.6 % of wholesalers cleaned and disinfected by spraying with insectides daily whiles 13.7% of retailers and 3.4 % of wholesalers did so in two (2) to three (3) days.

Table 4.6: Cleaning and disinfection of shop

Disposal Means	Seller (%)	
	Retailers	Wholesalers
Daily	86.2	96.6
2-3 days	13.7	3.4
Total	100	100

4.3 PROCESSORS

Processors of spices in the Kumasi Metropolis were interviewed about their handling practices.

4.3.1 Cleaning and disinfection of pest at processing site.

The results, presented in Table 4.7 showed that 83.3 % of the processors cleaned and disinfected their premises daily while 16.7 % processors cleaned in two (2) to three (3) days.

Table 4.7: Response by spices processors

		Frequency	Percentage (%)
Cleaning and	Daily	20	83.3
Disinfection	2-3 days	4	16.7
Entry of pest and rodents	Yes	24	100
In building	No	0	0

All (100%) the processors reported that pests and rodents could be potential vectors for microbial contamination of spices as shown in Table 4.2.

4.3.2 Changing facilities and washroom for workers

The results in Table 4.8 reveal that 95.8 % of the spices processing facilities had Washroom and changing facilities for workers located in the market but not in proper condition while only 4.2 % were lacking in such amenities.

Table 4.8: Changing facilities and washroom for workers

Response	Frequency	Percentage (%)
Yes	23	95.8
No	01	4.2
Total	24	100

4.4 LABORATORY EXPERIMENT

4.4.1 Total Coliforms

The results presented in Table 4.9 showed the total coliform count (TCC) of spices at the various markets. The results showed that spices sold at the Central market were marginally higher in total coliform count (6.08 cfu), followed by Bantama market with a count of (5.38 cfu) and Asafo market with a total coliform count of (5.30 cfu). However, there were no significant differences ($p>0.01$) observed in total coliform count of spices at the various markets

Table 4.9: Total coliform count (TCC) at the various markets

Market	LogTCC (cfu)
Central	6.08
Asafo	5.30
Bantama	5.38
Tukey $HSD_{(0.01)}$	1.18
Cv%	20.36

4.4.2 Total coliform count (TCC) of the spices sold at the market

From the study (Table 4.10) the results showed that ginger sold was marginally higher in total coliform count (5.62 cfu) as compared to pepper sold at the markets (5.55 cfu). No significant differences ($p>0.01$) was observed for total coliform count in the two spices sold.

Table 4.10: Total coliform count (TCC) of the spices sold at the market

Spices	logTCC (cfu)
Pepper	5.55
Ginger	5.62
Tukey $HSD_{(0.01)}$	0.84
Cv%	20.36

4.4.3 Total coliform count (TCC) of spices at point of sale

The results from the total coliform count of the spices at the point of sale (Table 4.11) showed that spices found at the retailer were marginally higher in total coliform count (5.70 cfu). This was followed by spices sold at the wholesale level with a count of (5.55 cfu) and lastly spices sold at the processor level (5.50 cfu). However, no significant differences ($p>0.01$) were observed in total coliform count of spices found at the point of sales.

Table 4.11: Total coliform count (TCC) of spices at point of sale

Point of sales	logTCC (cfu)
Processor	5.50
Retailer	5.70
Wholesaler	5.55
Tukey $HSD_{(0.01)}$	1.18
Cv%	20.36

4.4.4 Total coliform count (TCC) in the spices sold at the various markets

Table 4.12 shows the total coliform count in spices sold at the various markets. The results showed that ginger and pepper sold at the Central market were high in total coliform count of (6.45 cfu) and (5.70 cfu) respectively. Ginger sold at Asafo market recorded the lowest total coliform count of (5.14 cfu) .However, no significant differences ($p>0.01$) were observed in total coliform count in spices sold at the various markets.

Table 4.12: Total coliform count (TCC) in the spices sold at the various markets.

Market	Spices		MEAN
	Pepper	Ginger	
Central	5.70	6.45	6.08
Asafo	5.47	5.14	5.3
Bantama	5.49	5.26	5.38
MEAN	5.55	5.62	

Market Tukey $HSD_{(0.01)} = 1.18$ P = 0.09

Spices Tukey $HSD_{(0.01)} = 0.84$ P = 0.84

Market x Spices Tukey $HSD_{(0.01)} = 1.96$ P = 0.30

4.4.5 Total coliform count (TCC) of spices at the point of sales of the various markets

The results in Table 4.13 show the total coliform count of spices at point of sales of the various markets. The results showed that spices found at the retailer, wholesaler and processors levels at Central market were high in total coliform count of (6.35 cfu, 5.98 cfu and 5.90 cfu) respectively. However, spices found at both retailer and wholesaler points at Asafo market were low in total coliform count of (5.26 cfu and 5.23 cfu) respectively. No significant differences ($p>0.01$) were observed in total coliform count of spices at the point of sales of the various markets.

Table 4.13: Total coliform count (TCC) of spices at the point of sales of the various markets

Market	Point of sales			MEAN
	Retailer	Processor	Wholesaler	
Central	6.35	5.90	5.98	6.08
Asafo	5.26	5.41	5.23	5.30
Bantama	5.48	5.35	5.30	5.38
MEAN	5.70	5.55	5.50	

Market	Tukey $HSD_{(0.01)} = 1.18$	$P = 0.09$
Point of sales	Tukey $HSD_{(0.01)} = 1.18$	$P = 0.87$
Market x Point of sales	Tukey $HSD_{(0.01)} = 2.58$	$P = 0.98$

4.4.6 Total coliform (TCC) of Spices sold at the different point of sales

Results presented in Table 4.14 show the total coliform count of spices sold at the different point of sales. The results showed that both pepper and ginger found at the retailer were higher in total coliform count of (5.72 cfu) and (5.67 cfu) respectively followed by ginger found at the wholesale level with a count of (5.62 cfu). Pepper sold at both the processor and wholesaler points were low in total coliform count of

(5.45 cfu) and (5.48 cfu) respectively. However, no significant differences ($p>0.01$) were observed in total coliform count of spices sold at the different points of sale.

Table 4.14: Total coliform count (TCC) of spices sold at the different point of sales

Point of sales	Spices		MEAN
	Pepper	Ginger	
Retailer	5.72	5.67	5.70
Wholesaler	5.48	5.62	5.55
Processor	5.45	5.56	5.51
MEAN	5.55	5.62	

Point of sales	Tukey $HSD_{(0.01)} = 1.18$	P = 0.87
Spices	Tukey $HSD_{(0.01)} = 0.84$	P = 0.84
Point of sales x Spices	Tukey $HSD_{(0.01)} = 1.96$	P = 0.96

4.4.7 Total Mould Count (TMC)

Results from Table 4.15 show the total mould count (TMC) of spices at the various markets. The results obtained shows that spices sold at the Central market were highest in total mould count of (5.45 cfu). The second highest count was recorded at Bantama market with a total mould count o f(5.39) cfu with Asafo market recording a count of (5.22 cfu). Significant differences ($p<0.01$) were, however, observed in total mould count of spices at the various markets.

Table 4.15: Total mould count (TMC) of spices at the various markets

Market	logTMC (cfu)
Asafo	5.22
Bantama	5.39
Central	5.45
Tukey $HSD_{(0.01)}$	0.20
Cv%	3.59

4.4.8 Total mould count (TMC) in the spices sold

The study (Table 4.16) shows the total mould count of the two spices sold. From the results, gingers sold were marginally higher in total mould count (5.412 cfu) as compared to pepper at the markets (5.29 cfu). No significant differences ($p>0.01$) was observed in total mould count in the two spices sold.

Table 4.16: Total mould count (TMC) in the spices sold

Spices	logTMC (cfu)
Ginger	5.41
Pepper	5.29
Tukey $HSD_{(0.01)}$	0.14
Cv%	3.59

4.4.9 Total mould count (TMC) of spices at point of sale

Table 4.17 shows the total mould count of the spices at the point of sale. The results showed that spices found at the wholesale level had slightly higher levels of total mould count (5.39 cfu), followed by spices found at the retailed level with a count of (5.36 cfu) then spices at the processed level which recorded a total mould count of (5.30 cfu). No significant differences ($p>0.01$) were observed in total mould count of spices found at the point of sales.

Table 4.17: Total mould count (TMC) of spices at point of sale

Point of sales	logTMC (cfu)
Retailer	5.36
Processor	5.30
Wholesaler	5.39
Tukey $HSD_{(0.01)}$	0.20
Cv%	3.59

4.4.10 Total mould count (TMC) in the spices sold at the various markets

The result presented in Table 4.18 shows the total mould count in spices sold at the various markets. The results showed that ginger sold at Bantama and pepper spices sold at Central markets were higher in total mould count of (5.47 cfu) and (5.45 cfu) respectively. Ginger sold at Asafo market, however, recorded the lowest total mould count of (5.08 cfu). No significant differences ($p>0.01$) observed in total coliform count in spices sold at the various markets.

Table 4.18: Total mould count (TMC) in the spices sold at the various markets

Market	Spices		MEAN
	Pepper	Ginger	
Asafo	5.36	5.08	5.22
Central	5.45	5.35	5.40
Bantama	5.42	5.47	5.45
MEAN	5.41	5.30	

Market	Tukey $HSD_{(0.01)} = 0.20$	P = 0.00
Spices	Tukey $HSD_{(0.01)} = 0.14$	P = 0.03
Market x Spices	Tukey $HSD_{(0.01)} = 0.33$	P = 0.05

4.4.11 Total mould count of spices at the point of sales of the various markets

The results in Table 4.19 show the total mould count of spices at point of sales of the various markets. From the results, spices from Bantama market at the wholesaler levels and spices from Central markets at the retailer levels were marginally higher in total mould count of (5.47 cfu)and(5.45 cfu) respectively. However, spices from Bantama market at the processor level were low in total mould count of (4.44 cfu). No significant differences ($p>0.01$) were observed in total mould count of spices at the point of sales of the various markets.

Table 4.19: Total mould count (TMC) of spices at the point of sales of the various markets

Market	Point of sales			MEAN
	Wholesaler	Processor	Retailer	
Asafo	5.24	5.12	5.30	5.22
Central	5.36	5.35	5.45	5.39
Bantama	5.47	4.4	5.42	5.11
MEAN	5.36	4.97	5.39	

Market	Tukey HSD $_{(0.01)}$ = 0.20	P = 0.00
Point of sales	Tukey HSD $_{(0.01)}$ = 0.20	P = 0.38
Market x Point of sales	Tukey HSD $_{(0.01)}$ =0.43	P = 0.70

4.4.12 Total mould count (TMC) in the spices sold at the different point of sales

Table 4.20 shows the total mould count of spices sold at the different point of sales. Ginger found at the wholesale and processor level were marginally higher in total mould count of (5.48 cfu) and (5.42 cfu) respectively. Pepper sold at the processor points were low (5.27 cfu) in total mould count. However, no significant differences (p>0.01) were observed in total mould count of spices sold at the different points of sale.

Table 4.20: Total mould count (TMC) in the spices sold at the different point of sales

Point of sales	Spices		MEAN
	Ginger	Pepper	
Retailer	5.42	5.30	5.36
Processor	5.34	5.27	5.31
Wholesaler	5.48	5.31	5.40
MEAN	5.41	5.29	

Point of sales	Tukey HSD $_{(0.01)}$ = 0.20	P = 0.38
Spices	Tukey HSD $_{(0.01)}$ = 0.14	P = 0.03
Point of sales x Spices	Tukey HSD$_{(0.01)}$ =0.33	P = 0.7

4.4.13 Total Viable Count (TVC)

Results presented in Table 4.21 shows the total viable count (TVC) of spices at the various markets. The results showed that total viable count at Central market was high with a count of (5.48 cfu,) with Bantama market recording a total viable count of (5.27 cfu) then Asafo market also recording a count of (5.19 cfu). Significant differences ($p<0.01$) were observed in total viable count in spices sold at the various markets.

Table 4.21: Total viable count (TVC) of spices at the various markets

Market	logTVC (cfu)
Bantama	5.27
Asafo	5.19
Central	5.48
Tukey $HSD_{(0.01)}$	0.25
Cv%	4.49

4.4.14: Total viable count in the spices sold

The study revealed the total viable count of the two spices sold (Table 4.22). From the study, pepper sold was marginally higher in total viable count (5.34 cfu) than ginger sold at the markets (5.29 cfu). No significant differences ($p>0.01$) was observed in total viable count between the two spices sold.

Table 4.22: Total viable count (TVC) in the spices sold

Spices	logTVC (cfu)
Pepper	5.34
Ginger	5.29
Tukey $HSD_{(0.01)}$	0.18
Cv%	4.49

4.4.15 Total viable count of spices at point of sales

The results in Table 4.23 are the total viable count of the spices at the point of sale. The results showed that spices found at the retail point were marginally higher in total viable count (5.41 cfu). This was followed by spices sold at the wholesale level with a count of (5.29 cfu) and lastly spices found at the processor level (5.25 cfu). However, no significant differences ($p>0.01$) were observed in total viable count of spices found at the point of sales.

Table 4.23: Total viable count (TVC) of spices at point of sales

Point of sales	logTVC (cfu)
Processor	5.25
Retailer	5.41
Wholesaler	5.29
Tukey $HSD_{(0.01)}$	0.25
Cv%	4.49

4.4.16 Total viable count in the spices sold at the various markets

A result presented in Table 4.24 shows the total viable count in spices sold at the various markets. Pepper and ginger sold at Central market were high in total viable count of (5.49 cfu) and (5.47 cfu) respectively. Ginger sold at Asafo market, however, recorded the lowest total viable count of (5.03 cfu.) Significant differences ($p<0.01$) were observed in total viable count in spices sold at the various markets.

Table 4.24: Total viable count (TVC) in the spices sold at the various markets

Market	Spices		MEAN
	Pepper	Ginger	
Bantama	5.17	5.38	5.28
Asafo	5.36	5.03	5.20
Central	5.49	5.47	5.48
MEAN	5.34	5.29	

Market	Tukey $HSD_{(0.01)} = 0.25$	$P = 0.00$
Spices	Tukey $HSD_{(0.01)} = 0.18$	$P = 0.48$
Market x Spices	Tukey $HSD_{(0.01)} = 0.41$	$P = 0.01$

4.4.17 Total viable count (TVC) of spices at the point of sales of the various markets

From the results, (Table 4.25) spices found at the processors and wholesaler levels at central market were both high in total viable count with (5.50 cfu) each. This was followed by spices from Central and Bantama markets at retailers each with a total viable count of (5.44 cfu) and (4.52) respectively. However, spices from Asafo market at the processor level were low in total viable count (5.07 cfu). No significant differences ($p>0.01$) were observed in total viable count of spices at the point of sales of the various markets.

Table 4.25: Total viable count (TVC) of spices at the point of sales of the various markets

Market	Point of sales			MEAN
	Processor	Retailer	Wholesaler	
Bantama	5.19	5.42	5.22	5.28
Asafo	5.07	5.37	5.15	5.20
Central	5.50	5.44	5.50	5.48
MEAN	5.25	5.41	5.29	

Market	Tukey $HSD_{(0.01)} = 0.25$	$P = 0.00$
Point of sales	Tukey $HSD_{(0.01)} = 0.25$	$P = 0.14$
Market x Point of sales	Tukey $HSD_{(0.01)} = 0.54$	$P = 0.35$

4.4.18: Total viable count in the spices sold at the different point of sales

Table 4.26 shows the total viable count of spices sold at the different point of sales. The results showed that both pepper found at the wholesale and ginger found at the retail levels were marginally higher in total viable count of (5.43 cfu) and (5.42 cfu) respectively followed by pepper spices found at the retail level with a count of (5.40 cfu). Ginger spices sold at the wholesale points were the lowest with total viable count of (5.15 cfu). However, no significant differences ($p>0.01$) were observed in total viable count of spices sold at the different points of sale.

Table 4.26: Total viable count (TVC) in the spices sold at the different point of sales

Point of sales	Spices		MEAN
	Pepper	Ginger	
Processor	5.19	5.31	5.25
Retailer	5.40	5.42	5.41
Wholesaler	5.43	5.15	5.29
MEAN	5.34	5.29	

Point of sales	Tukey $HSD_{(0.01} = 0.25$	$P = 0.14$
Spices	Tukey $HSD_{(0.01)} = 0.18$	$P = 0.48$
Point of sales x Spices	Tukey $HSD_{(0.01)} = 0.41$	$P = 0.0$

CHAPTER FIVE

5.0 DISCUSSION

5.1 INTRODUCTION

This chapter presents the discussion of the results and itis presented according to the specific objectives of the study.

5.1.1 Common Indigenous Spices in the Kumasi Metropolis

The study revealed that pepper was the most common spice in the Kumasi Metropolis. It was found that pepper was mostly grown at Nkawie and Ahwiankwanta Districts. The observation that pepper was most common could be attributable to its high demand and probably favourable ecological and climatic conditions. The study revealed that there were seven types of spices commonly grown in Kumasi. These were Ashanti Pepper *(Piper guineese*), Grain of paradise *(Aframomum melegueta),* Senegal pepper *(Xylopia aethiopia,* Aidan *(Tetrapleura tetraptera),* Ginger (*Zingiber officinale),* Red pepper *(Capsicum annuum)* and White (black) pepper (Piper nigrum). However, only pepper and ginger were grown in commercial quantities. Those not grown in commercial quantities were usually picked from the wild as reported by Olife *et al.,* (2013).

As to the drying, all the respondent farmers reported that they did not dry their spices for the market. According to them there was immediate demand for the spices and customers were willing to pay good prices for the fresh spices. They therefore, thought that it was not economical to incur extra cost to dry their spices. On the other hand, they indicated that they did not have the technology to dry. However, dying the spices will store longer and fetch them higher prices than the fresh one and also ensure continue supply of the spices all year round. It would be desirable to train farmers on drying technologies so as to help them dry in periods of bumper harvest as reported by Olife *et al.*, (2013)

5.2 POST-HARVEST PRACTICES USED IN THE HANDLING OF INDIGENOUS SPICES IN THE MARKETS

5.2.1 Spice Farmers

The commonest packaging material used for packaging spices was the nylon sac, popularly known as fertilizer bags. According to the farmers they used nylon sacs because they were readily available, cheap and robust to rough handling. Although, these reasons given by them were valid, the worry has to do with the thermal problems related to nylon sacs. They allow easy build-up of heat without enhancing dissipation of heat. This subsequently results in rapid deterioration. Improved packaging materials such as the use of paper cartoons could be exploited.

The survey also revealed that almost all the respondent farmers re-used the same packaging material to package the spices for transportation. Re-using the same packaging material could be a source of contamination to the spices. Used packaging material should be discarded to avoid been re-used.

The survey results revealed that majority of spices were transported from the farmers to the markets using unclean commercial vehicles loaded with passengers and other farm produce which could be an avenue for spice contamination. Under the existing transportation networks between the Kumasi Metropolis and spices growing areas, traders and agro-processors have no choice but to use the commercial vehicles due to high cost in renting a full cargo for transporting their spices. The use of unclean vehicle and mixed loading in transporting spices could contribute to the microbial contamination of spices been sold in the market in the Kumasi metropolis. Vehicles used for transporting fresh produce should not be used for carrying other materials that may compromise the safety of the spices.

5.2.2 Wholesalers/ Retailers

The study further revealed that the greatest postharvest loss of pepper occurred at the wholesalers end due to breakages. This may be due to transportation and packaging of the spices. The bags are stacked on top of each other during transportation resulting in further spice damage during transportation.

Most spice traders used the traditional basket and sacks as their packaging material in conveying produce resulting into massive postharvest losses. These practices by the traders often resulted in reduction of profit. Improved packaging materials such as the use of paper cartoons could be exploited.

The main mode of transportation was by road and this involved the use of open and closed lorry (including buses) .Most of the mechanical damage to pepper result from the vibrations and impacts received by the produce as reported by Singh and Singh (1992). These vibrations are as a result of the impact of irregularities of the road surfaces which are transmitted through the suspension systems of the vehicles to the produce. Storage and packaging practices and mechanical damage during harvesting, handling and transportation resulting from vibration by undulation and irregularities on the road mechanical can enhance wastages as was revealed in a study by Idah *et al.*, (2007).

The use of good packaging material that will not restrict ventilation, not allow produce to move easily, will not allow the produce to rest directly on each other and will be easy to carry should be adopted for use to reduce this problem.

The greatest postharvest loss of ginger also occurred at the wholesalers end due to loss of water. Water loss represents the loss of weight, which could have attracted income, if not lost (Wilson *et al.*, 1995). Janet and Richard (2000) also reported that mechanical damage also increases loss of moisture. Mechanical damage not only affects appearance, but also provides entrance to decay organisms as well.

There were good solid waste disposal practices at the retailers and wholesalers shop which could contribute to the prevention of contamination not spices. It was found out that some of the sellers had cleaning schedule to ensure that the environment was clean. The survey also revealed that the spices were sun dried by spreading them out on the ground on a polythene sheet with few traders using raised platform. This traditional method of drying method however, exposes the spices to the risk of contamination. The use of solar drying facilities should be encouraged.

Kneifel and Berger (1994) reported that common practices like harvesting, handling and packing also can cause contamination. These contaminants may be carried through to the market centers where they may cause deterioration. Good hygienic handling practices should therefore be practiced along the value chain.

5.2.3 Processors

A further explanation by the spice processors revealed that they used chemicals to prevent pests and rodents. This could also be a source of contamination. There is an indication of a good cleaning condition in the majority of the processing sites. A further enquiry from the processors revealed cleaning schedule drawn up at the site to ensure that all areas are cleaned. The processors also explained that there is also a continuous program for disinfestations and pest control in the processing facility and storage areas though the workers does not wear gloves and other protective devices during spices processing. Not wearing of gloves and touching the spices with bare hands is very worrying as handlers may end up contaminating the spices they come into contact. People that come into contact with the spices should be educated on the needs for personal hygiene

5.3 MICROBIOLOGICAL QUALITY STATUS OF INDIGENOUS SPICES SOLD IN THE KUMASI METROPOLIS

5.3.1 Total Coliform Count

The results revealed that (Table 4.11) the total coliform count of spices at the three markets were high with Central market being marginally higher followed by Bantama and finally Asafo market. The fact that there was no significant in total coliform count of spices at the various markets indicates that all the markets in the Kumasi metropolis had similarity with respect to total coliform count. However, total coliform level exceeded the international commission on microbiological specifications for foods (ICMSF) standard. There could be health implication in the consumption of spices on this market if not properly processed. This is similar to earlier report by Addo (2005) that there is serious health implication in the consumption of spices on the market. Spice consumers, therefore, faced the same level of coliform contamination irrespective of the market they bought from in the Kumasi Metropolis.

Ginger turned to be marginally higher in total coliform count than pepper sold in the Kumasi Metropolis (Table 4.12). Pepper, in general, has higher antimicrobial resistance than ginger against pathogens .It has been found that ginger extract exhibited maximum inhibitory effect against *Pseudomonas aeruginosa (P. aeruginosa)* while it showed no effect against *Klebsiella pneumoniae* (*K. pneumonia)* while the antimicrobial activity against *Escherichia coli (E. coli)* and *Candida albicans (C. albicans)* were found to be moderate. On the other hand, pepper has been found to exhibit moderate antimicrobial activity against *E. coli* and Staphylococcus aureus (*S. aureus)*. Pepper can actively reduce bacteria proliferation including *E. Coli* (Arun, 2001).

Total Coliform counts were made at the processing, wholesaling and retailing points of sale (Table 4.13). The results showed that spices found at the retailing point were higher in total coliform count. Total coliform count at the retailers' end was higher because it is the last point along the spice value chain therefore spices at this point carry the cumulative contamination from the farmers, wholesalers and processors. There is also an over exposure of the spices and multiple handling by consumers at the retailers end. Since there were no significant differences in total coliform count at the various points of sales, it can be concluded that the consumers faced the same level of contamination irrespective of which point they buy spices from in the Kumasi Metropolis.

As regards the interaction, the results showed that ginger and pepper sold at the Central market were higher in total coliform count with spices found at the retailer, wholesaler and processors levels at Central market also higher in total coliform count. This could be due to the poor hygienic and poor handling methods at the central market. On the other hand both pepper and ginger found at the retailer were higher in total coliform count. Again this could be as a result of cumulative contamination from the farmers, wholesalers and processors. However, since no significant differences were observed in total coliform count, it could be concluded that spice consumers faced the same level of coliform contamination irrespective of the spice, the sales point and the market they bought from in the Kumasi Metropolis.

5.3.2 Total Mould Count

The study showed that spices sold at the Central market were highest in total mould count, followed by Bantama market which was similar to Asafo market.Central market in the Kumasi Metropolis has generally poor hygienic conditions; therefore the level of contamination was not surprising. Asafo, was found to be cleaner and consequently reflected in its count. The significant differences in the total mould at the various markets indicated that spices sold at the Central market could be considered as posing higher risk to consumers if not properly processed prior to consumption.

Ginger turned to be marginally higher in total mould count than pepper at the markets under study in the Kumasi Metropolis. The similarity in the mould population could be attributed to similarity in handling procedures carried out by the various actors in the value change.

Total mould count was also determined at processors, wholesalers and retailers points of sale. The results showed that spices found at the wholesalers point were marginally higher in total mould count than at the retailer and the processor points.

Since there were no significant differences at the various points of sales, it can be concluded that the consumers faced the same level of mould contamination irrespective of which point they bought spices from in the Kumasi Metropolis.

With the interaction, it was found out that ginger sold at the Bantama market was higher in mould count than the rest. This may be due to improper handling of spices at the market since they were in direct contact with the ground. On the other hand, retailers at the central market recorded the highest mould count. This could be due to the general poor hygiene and the improper handling at the central market. The levels of mould could be considered as in excess of the acceptable safe limit of (3.4 log10CFU /g) per the international commission on microbiological specifications for foods (ICMSF) standard. This contamination was probably due to drying conditions and post harvest treatment as reported by Arce, (1990). Spices handlers should adopt good handling processes to ensure safety for consumers.

5.3.3 Total Viable Count

The results showed that that spices sold at the Central market were highest in total viable count, followed by spices sold at the Bantama market which was similar to Asafo market recording the lowest count. As with the mould population, Central market in the Kumasi Metropolis was generally poorer in hygiene than the rest. The significant differences in the total viable at the various markets indicates that spices sold at the Central market posed high threat to spice consumers than buying from the rest of the market under study.

Pepper turned to be higher in viable count than ginger sold in the Kumasi Metropolis. This could be attributed to the high demand of pepper which results in overexposure of it to handlers causing accumulation of contamination and probably due the drying conditions which involves spreading them on the ground during sun drying.

Total Viable count was also determined at processors, wholesalers and retailers points of sale. The results showed that spices found at the retailer were marginally higher in total viable count followed by spices sold at the wholesaler points and lastly spices sold at the processor level. The observed high total viable count at the retailers' end was because it is the last point along the spice value chain therefore spices at this point carry the cumulative contamination from the farmers, wholesalers and processors. There was also an over exposure of the spices and multiple handling by consumers at the retailers end. Since there were no significant differences in total viable count at the various points of sales, it can be concluded that the consumers faced the same level of contamination irrespective of which point they buy spices from in the Kumasi Metropolis.

As regards the interaction, it was found that Pepper and ginger sold at Central market were high in total viable count with Ginger sold at Asafo market, being the least. The significant differences observed in total viable count in spices sold at the various markets indicates the generally poor hygienic condition at the central market.

Also, spices found at the processors and wholesaler levels at central market were both higher in total viable count probably as a result of poor handling methods and the general poor hygienic nature at the central market. Pepper found at the wholesale and gingers found at the retail levels were higher in total viable count than the rest.

Since there were no significant differences at the various points of sales, it can be concluded that the consumers faced the same level of contamination irrespective of which point they bought spices from in the Kumasi Metropolis if not properly treated before consumption

Spices handlers should adopt good handling processes to ensure safety for consumers. Adequate precautions should be taken to prevent spices from being contaminated (Arce, 1990). The level of contamination could be considered as in excess of the acceptable safe limit hence serious health implication. This is similar to earlier report by Addo (2005) that there is serious health implication in the consumption of spices on the market.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATION

6.1 INTRODUCTION

This chapter presents the summary of findings of the study, the conclusion and recommendations for improving the post harvest handling of indigenous spices.

6.1.1 Conclusion

6.1.1.1 Types of indigenous spices sold in the Kumasi Metropolis.

Ginger and peppers rates as the leading indigenous spices sold in the Kumasi Metropolis. The survey revealed that Seven (7) major types of indigenous spices were sold in the selected markets. The spices were: Ashanti Pepper (*Piper guineese*), Grain of Paradise (*Aframomum melegueta*), Senegal pepper (*Xylopia aethiopia*), Aida (*Tetrapleura tetraptera*), Ginger (*Zingiber officinale*), Red Pepper (*Capsicum annuum*), and White (black) pepper *Piper nigrum*).

However, ginger and pepper were the commonest. Farmers sell spices produce to the sellers and processors straight after harvest Majority of farmers' package their spices produce for transportation using fertilizer sack. Farmer's continuous use of the same packaging material could be a source of spice contamination.

Majority of farmers transport spices using unclean commercial vehicles which could be an avenue for germ contamination since commercial vehicles are also loaded with other items. Almost all spices are loaded with other farm produce which could be a source of contamination to spices.

The poor handling practices observed with the farmers shows that they require proper and extensive training on how to reduce their losses especially through proper pre-harvesting, harvesting and post-harvesting practices .

6.1.2 Sellers (Retailers/ Wholesalers) and processors

Spices are sun dried by spreading them out on the ground, on a polythene sheet with few traders using raised platform. Spices are stored on wooden pallets, polythene sheets and in some cases on the bare floor. There is improper handling and generally poor hygienic condition at the markets under study in the Kumasi Metropolis with the central market rates as leading.

The major post harvest loss of pepper is revealed as loss due to broken of the spices whiles that of ginger was due to moisture loss. Almost all the people that come into contact with the spices do not wear gloves and other protective clothing which could be an avenue for microbial contamination.

6.1.3 Microbiological contamination of spices sold in the Kumasi metropolis

6.1.3.1Total Coliforms

The results revealed that the total coliform count of spices at the three markets were high with Central market being marginally higher followed by Bantama and finally Asafo market. The levels of coliforms could be considered as in excess of the acceptable safe limit.

Ginger turned to be marginally higher in total coliform count than pepper sold in the Kumasi Metropolis. Spices found at the retailing point were higher in total coliform count. Ginger and pepper sold at the Central market were higher in total coliform count with spices found at the retailer, wholesaler and processors levels at Central market also higher in total coliformcount. Both pepper and ginger found at the retailer were higher in total coliform count .Spice consumers faced the same level of coliforms contamination irrespective of the market they bought from in the Kumasi Metropolis.

6.1.3.2 Total Mould Count

The study showed that spices sold at the Central market were highest in total mould count, followed by Bantama market which was similar to Asafo market. The significant differences in the total mould at the various markets indicated that spices sold at the Central market could be considered as posing higher risk to consumers if not properly processed prior to consumption. Ginger turned to be marginally higher in total mould count than pepper at the markets under study in the Kumasi Metropolis.

Spices found at the wholesalers point were marginally higher in total mould count than at the retailer and the processor points.Ginger sold at the Bantama market was higher in mould count than the rest.Retailers at the central market recorded the highest mould count. The levels of mould could be considered as in excess of the acceptable safe limit.

6.1.3.3 Total Viable Count

The results show that that spices sold at the Central market were highest in total viable count, followed by spices sold at the Bantama market which was similar to Asafo market. The significant differences in the total viable at the various markets indicates that spices sold at the Central market posed high threat to spice consumers than buying from the rest of the market under study.

Pepper turned to be higher in viable count than ginger sold in the Kumasi Metropolis. Spices found at the retailer were marginally higher in total viable count followed by spices sold at the wholesaler points and lastly spices sold at the processor level. Pepper and ginger sold at Central market were high in total viable count with Ginger sold at Asafo market, being the least.

Spices found at the processors and wholesaler levels at central market were both higher in total viable count. Pepper found at the wholesale and gingers found at the retail levels were higher in total viable count than the rest. The levels of total viable count are in excess of the acceptable safe limit.

6.2 RECOMMENDATION

6.2.1 General Recommendation

The following recommendations are suggested as a result of the outcome of this study

- To ensure effective food safety management in Kumasi, tolerance levels of mycotoxins and bacteria should include measures to control mycotoxin formation through good agricultural practices, proper storage and handling methods (Odamtten, 2005).
- Food safety control measures should also be used at each stage in the spice production chain as prescribed by the hazard analysis critical control point (HACCP) concept.

- Chemical applications are now banned in many countries. Processors and sellers should refrain from chemical disinfection of spice processing sites and shops. Gamma irradiation of food has been proposed and is being used in 26 countries worldwide to curtail the resident microorganisms in foods
- Consumers should be educated to apply heat and proper cooking of spices to reduce microbial infestations
- Spices handlers should adopt good handling methods in spices value chain to ensure safety for consumers.
- Periodic monitoring of the levels of microbial load in spices should be encouraged.

6.3 RECOMMENDATION FOR FURTHER RESEARCH

- The level of addition of contaminations at various stages of the spices value chain which is not covered by this study should be determined
- Future studies should look at the moist- heat and radiation combination treatment of spices in order to advance this present study and make it widely applicable in the food industry

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APPENDIX A

Student Edition of Statistix 9.0 data, 24/04/2013, 12:03:10 PM

Analysis of Variance Table for TC

Source	DF	SS	MS	F	P
Rep	2	2.418E+19	1.209E+19		
Market	2	2.418E+19	1.209E+19	1.24	0.3027
Spices	1	1.204E+19	1.204E+19	1.23	0.2746
Category	2	1.765E+19	8.826E+18	0.90	0.4146
Market*spices	2	2.409E+19	1.204E+19	1.23	0.3040
Market*category	4	3.530E+19	8.825E+18	0.90	0.4728
Spices*category	2	1.758E+19	8.790E+18	0.90	0.4160
Market*spices*category	4	3.516E+19	8.791E+18	0.90	0.4747
Error	34	3.320E+20	9.766E+18		
Total	53	5.222E+20			

Grand Mean 4.74E+08 CV 659.97

Analysis of Variance Table for TMC

Source	DF	SS	MS	F	P
Rep	2	4.628E+10	2.314E+10		
Market	2	1.037E+11	5.187E+10	3.81	0.0320
Spices	1	9.441E+09	9.441E+09	0.69	0.4106
Category	2	2.474E+09	1.237E+09	0.09	0.9133
Market*spices	2	3.700E+10	1.850E+10	1.36	0.2703
Market*category	4	2.702E+10	6.755E+09	0.50	0.7383
Spices*category	2	5.118E+10	2.559E+10	1.88	0.1679
Market*spices*category	4	2.057E+10	5.143E+09	0.38	0.8227
Error	34	4.625E+11	1.360E+10		
Total	53	7.602E+11			

Grand Mean 248630 CV 46.91

Analysis of Variance Table for TVC

Source	DF	SS	MS	F	P
Rep	2	3.036E+10	1.518E+10		
Market	2	1.450E+11	7.252E+10	5.15	0.0111
Spices	1	4.931E+09	4.931E+09	0.35	0.5579
Category	2	1.898E+10	9.489E+09	0.67	0.5164
Market*spices	2	1.370E+11	6.851E+10	4.87	0.0139
Market*category	4	1.035E+11	2.588E+10	1.84	0.1443
Spices*category	2	1.225E+11	6.128E+10	4.35	0.0208
Market*spices*category	4	2.239E+11	5.599E+10	3.98	0.0094
Error	34	4.788E+11	1.408E+10		
Total	53	1.265E+12			

Grand Mean 252259 CV 47.04

APPENDIX B

Student Edition of Statistix 9.0 data, 24/04/2013, 12:05:05 PM

<u>TOTAL COLIFORMS/100ml (cfu) Colonies form Unit</u>

Tukey HSD All-Pairwise Comparisons Test of logTC for market

```
Market      Mean Homogeneous Groups
Central     6.0751 A
Bantama     5.3762 A
Asafo       5.3007 A

Alpha 0.01   Standard Error for Comparison 0.3789
Critical Q Value 4.415     Critical Value for Comparison 1.1828
Error term used: rep*market*spices*category, 34 DF
There are no significant pairwise differences among the means.
```

Tukey HSD All-Pairwise Comparisons Test of logTC for spices

```
Spices    Mean Homogeneous Groups
Ginger 5.6157 A
Pepper 5.5523 A

Alpha 0.01     Standard Error for Comparison 0.3094
Critical Q Value 3.847     Critical Value for Comparison 0.8416
Error term used: rep*market*spices*category, 34 DF
There are no significant pairwise differences among the means.
```

Tukey HSD All-Pairwise Comparisons Test of logTC for category

```
Category       Mean Homogeneous Groups
Processor      5.5027 A
Wholesaler     5.5524 A
Retailer       5.6970 A

Alpha 0.01     Standard Error for Comparison 0.3789
Critical Q Value 4.415     Critical Value for Comparison 1.1828
Error term used: rep*market*spices*category, 34 DF
There are no significant pairwise differences among the means.
```

Tukey HSD All-Pairwise Comparisons Test of logTC for market*spices

```
Market spices    Mean Homogeneous Groups
Central Ginger 6.4523 A
Central Pepper 5.6978 A
Bantama Pepper 5.4935 A
Asafo   Pepper 5.4655 A
Bantama Ginger 5.2590 A
Asafo   Ginger 5.1359 A

Alpha 0.01     Standard Error for Comparison 0.5358
Critical Q Value 5.165     Critical Value for Comparison 1.9571
```

Error term used: rep*market*spices*category, 34 DF
There are no significant pairwise differences among the means.

Tukey HSD All-Pairwise Comparisons Test of logTC for market*category

Market	category	Mean	Homogeneous Groups
Central	Retailer	6.3512	A
Central	Wholesaler	5.9773	A
Central	Processor	5.8967	A
Bantama	Retailer	5.4848	A
Asafo	Processor	5.4124	A
Bantama	Processor	5.3480	A
Bantama	Wholesaler	5.2959	A
Asafo	Retailer	5.2550	A
Asafo	Wholesaler	5.2348	A

Alpha 0.01 Standard Error for Comparison 0.6562
Critical Q Value 5.550 Critical Value for Comparison 2.5755
Error term used: rep*market*spices*category, 34 DF
There are no significant pairwise differences among the means.

Tukey HSD All-Pairwise Comparisons Test of logTC for spices*category

Spices	category	Mean	Homogeneous Groups
Pepper	Retailer	5.7245	A
Ginger	Processor	5.6695	A
Ginger	Retailer	5.6208	A
Ginger	Wholesaler	5.5570	A
Pepper	Wholesaler	5.4840	A
Pepper	Processor	5.4484	A

Alpha 0.01 Standard Error for Comparison 0.5358
Critical Q Value 5.165 Critical Value for Comparison 1.9571
Error term used: rep*market*spices*category, 34 DF
There are no significant pairwise differences among the means.

Total Mould Count, Mould/1ml cfu

Tukey HSD All-Pairwise Comparisons Test of logTMC for market

Market	Mean	Homogeneous Groups
Central	5.4458	A
Bantama	5.3884	AB
Asafo	5.2199	B

Alpha 0.01 Standard Error for Comparison 0.0640
Critical Q Value 4.415 Critical Value for Comparison 0.1997
Error term used: rep*market*spices*category, 34 DF
There are 2 groups (A and B) in which the means are not significantly different from one another.

Tukey HSD All-Pairwise Comparisons Test of logTMC for spices

Spices   Mean Homogeneous Groups
Ginger 5.4118 A
Pepper 5.2910 A

Alpha 0.01   Standard Error for Comparison 0.0522
Critical Q Value 3.847   Critical Value for Comparison 0.1421
Error term used: rep*market*spices*category, 34 DF
There are no significant pairwise differences among the means.

Tukey HSD All-Pairwise Comparisons Test of logTMC for category

Category Mean Homogeneous Groups
Wholesaler 5.3920 A
Retailer 5.3590 A
Processor 5.3032 A

Alpha 0.01   Standard Error for Comparison 0.0640
Critical Q Value 4.415   Critical Value for Comparison 0.1997
Error term used: rep*market*spices*category, 34 DF
There are no significant pairwise differences among the means.

Tukey HSD All-Pairwise Comparisons Test of logTMC for market*spices

Market spices   Mean Homogeneous Groups
Bantama Ginger 5.4690 A
Central Pepper 5.4512 A
Bantama Pepper 5.4227 A
Asafo   Pepper 5.3615 AB
Central Ginger 5.3257 AB
Asafo   Ginger 5.0783 B

Alpha 0.01 Standard Error for Comparison 0.0905
Critical Q Value 5.165   Critical Value for Comparison 0.3304
Error term used: rep*market*spices*category, 34 DF
There are 2 groups (A and B) in which the means are not significantly different from one another.

Tukey HSD All-Pairwise Comparisons Test of logTMC for market*category

Market category   Mean Homogeneous Groups
Bantama Wholesaler 5.4746 A

Central Retailer 5.4519 A
Bantama Processor 5.4431 A
Bantama Retailer 5.4198 A
Central Wholesaler 5.3640 A
Central Processor 5.3494 A
Asafo   Retailer 5.3042 A
Asafo   Wholesaler 5.2384 A
Asafo   Processor 5.1170 A

Alpha 0.01   Standard Error for Comparison 0.1108
Critical Q Value 5.550   Critical Value for Comparison 0.4348
Error term used: rep*market*spices*category, 34 DF

There are no significant pairwise differences among the means.

Tukey HSD All-Pairwise Comparisons Test of logTMC for spices*category

Spices	category	Mean	Homogeneous Groups
Pepper	Wholesaler	5.4752	A
Pepper	Processor	5.4197	A
Pepper	Retailer	5.3404	A
Ginger	Wholesaler	5.3088	A
Ginger	Processor	5.2984	A
Ginger	Retailer	5.2659	A

Alpha 0.01 Standard Error for Comparison 0.0905
Critical Q Value 5.165 Critical Value for Comparison 0.3304
Error term used: rep*market*spices*category, 34 DF
There are no significant pairwise differences among the means.

Total Viable Count 1ml/cfu

Tukey HSD All-Pairwise Comparisons Test of logTVC for market

Market	Mean	Homogeneous Groups
Central	5.4787	A
Bantama	5.2746	AB
Asafo	5.1939	B

Alpha 0.01 Standard Error for Comparison 0.0796
Critical Q Value 4.415 Critical Value for Comparison 0.2486
Error term used: rep*market*spices*category, 34 DF
There are 2 groups (A and B) in which the means are not significantly different from one another.

Tukey HSD All-Pairwise Comparisons Test of logTVC for spices

Spices	Mean	Homogeneous Groups
Pepper	5.3391	A
Ginger	5.2924	A

Alpha 0.01 Standard Error for Comparison 0.0650
Critical Q Value 3.847 Critical Value for Comparison 0.1769
Error term used: rep*market*spices*category, 34 DF
There are no significant pairwise differences among the means.

Tukey HSD All-Pairwise Comparisons Test of logTVC for category

Category	Mean	Homogeneous Groups
Retailer	5.4077	A
Wholesaler	5.2874	A
Processor	5.2522	A

Alpha 0.01 Standard Error for Comparison 0.0796
Critical Q Value 4.415 Critical Value for Comparison 0.2486
Error term used: rep*market*spices*category, 34 DF

There are no significant pairwise differences among the means.

Tukey HSD All-Pairwise Comparisons Test of logTVC for market*spices

Market	spices	Mean	Homogeneous Groups
Central	Pepper	5.4873	A
Central	Ginger	5.4702	A
Bantama	Ginger	5.3812	AB
Asafo	Pepper	5.3619	AB
Bantama	Pepper	5.1680	AB
Asafo	Ginger	5.0260	B

Alpha 0.01 Standard Error for Comparison 0.1126
Critical Q Value 5.165 Critical Value for Comparison 0.4113
Error term used: rep*market*spices*category, 34 DF
There are 2 groups (A and B) in which the means
are not significantly different from one another.

Tukey HSD All-Pairwise Comparisons Test of logTVC for market*category

Market	category	Mean	Homogeneous Groups
Central	Processor	5.5022	A
Central	Wholesaler	5.4978	A
Central	Retailer	5.4362	A
Bantama	Retailer	5.4165	A
Asafo	Retailer	5.3703	A
Bantama	Wholesaler	5.2189	A
Bantama	Processor	5.1884	A
Asafo	Wholesaler	5.1455	A
Asafo	Processor	5.0660	A

Alpha 0.01 Standard Error for Comparison 0.1379
Critical Q Value 5.550 Critical Value for Comparison 0.5413
Error term used: rep*market*spices*category, 34 DF
There are no significant pairwise differences among the means.

Tukey HSD All-Pairwise Comparisons Test of logTVC for spices*category

Spices	category	Mean	Homogeneous Groups
Pepper	Wholesaler	5.4265	A
Ginger	Retailer	5.4165	A
Pepper	Retailer	5.3988	A
Ginger	Processor	5.3126	A
Pepper	Processor	5.1918	A
Ginger	Wholesaler	5.1482	A

Alpha 0.01 Standard Error for Comparison 0.1126
Critical Q Value 5.165 Critical Value for Comparison 0.4113
Error term used: rep*market*spices*category, 34 DF
There are no significant pairwise differences among the means.

APPENDIX C

BACKGROUND INFORMATION

1. Gender: A. male ( ) B. Female ( )

2. Age: A. under 20 years ( ) B. 21-30 years ( ) C. 31-40 years ( ) D. 41-50years ( ) E. 51-60 years ( ) E. above 60 years ( ).

3. Level of Education A. No Formal Education ( ) B. Basic Education ( ) C. Secondary Education ( ). D. Tertiary ( ) E. Others please specify ………

PART ONE

QUESTIONARE FOR SPICES FARMERS

4. What spices do you grow? ………………………………………………………

5. What is the size of your farm?. …………………………………………………

6. How long have you been growing spices? ……………………………………

7. What time do you harvest your spices? A. morning ( ) B. afternoon ( ) C. evening

8. How do handle the spices after harvesting? A. gather them under a shade ( ) B. leave them on the field ( ) C. cover them with materials ( ) D. other place specify…………………………………………………………………………...

9. At the farm how is the spices packaged A. open plastic container ( ) B. seal plastic container ( ) C. fertilizer sack ( ) d. Basket e. other specify ………

10. How do you transport spices to the market A. open truck ( ) B. container truck ( ) C. others specify…-……………………………………………..

11. How long does it take to transport the spices to the market?………………………

12. Do you have problem with your transportation? a. Yes [ ] b. No [ ]

If yes state the problems …………………………………………………………

13. Do you store the spices a. Yes [ ] b. No [ ]

If yes where do you store the spices a. room ( ) b. ware house ( ) c. Farm ( )

Others please specify …………………………………………………………………

14. What storage method do you use? ……………………………………………

15. Do you have problems with then storage a. Yes [ ] b. No [ ]

If yes what kind of problem a, spoilage ( ) b. mould growth ( ) c. others please specify ……………………………………………………………………..…..

16. Do you process some of the spices? a. Yes [ ] b. No [ ]

If yes what process does the spices goes through …………………………………

17. Where do you sell your spices …………………………………………………

PART 2

QUESTIONNARE FOR SPICE PROCESSORS

18. What spices do you process ……………………………………………………

19. What process does the spice go through ………………………………………

20.Do you have any problem with processing a. Yes [ ] b. No [ ]

if yes state the problem………………………………………

21. How is the spice packaged ………………………………………………………

22. Do you store the spices a. Yes [ ] b. No [ ]

if yes where do you store the spices ………………………………………………

23. Do you have any problem with the storage a. Yes [ ] b. No [ ]

If yes indicate the problem ………………………………………………………

PART 3 QUESTIONNARE FOR WHOLE SALERS

24. Where do you get your spices from ………………………………………………

25. Where do you store then spices a. room ( ) b. ware house ( ) c. others please specify ……………………………………………

26. At wholesale how is the spices stored………………………………………………

27. Do you have any problem with storage ……………………………………………

28. Is there adequate ventilation at the store house? a. Yes [ ] b. No [ ]

29. How is the spices packaged at the ware house a. plastic containers ( ) b. polythene sack ( ) C. others please specify ……………………………………

30. Do you process some of the spices a. Yes [ ] b. No [ ]

If yes what processing does the spices goes through …………………………………

31.Do you have any problem with the processing a. Yes [ ] b. No [ ]

If yes indicate the problem ………………………………………………………………

PART 4 QUESTIONNARE FOR RETAILERS

32. Where do you get your spices from ………………………………………………

33. Where do you store then spices a. room ( ) b. ware house ( ) c. others please specify ……………………………………………………………….

34. How is the spices stored………………………………………………………………

35. Do you have any problem with storage ……………………………………………

36. Is there adequate ventilation at the store house? a. Yes [ ] b. No [ ]

37. How is the spices packaged? A. plastic containers ( ) b. polythene sack ( ) C. others please specify ………………………………………………………

38. Do you process some of the spices a. Yes [ ] b. No [ ]

If yes what processing does the spices goes through …………………………………

39. Do you have any problem with the processing a. Yes [ ] b. No [ ]

If yes indicate the problem ……………………………………………………………

40. How is the spices displayed at the market? a. open pack ( ) b. seal pack ( ) c. others please specify…………………………………………………………………