EXTENDING THE SHELF-LIFE OF COCOYAM LEAVES (*Xanthosoma sagittifolium*) THROUGH BLANCHING, IRRADIATION AND LOW TEMPERATURE STORAGE

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DECLARATION

This thesis is the result of research work undertaken by JOSEPHINE TWENEBOAA AFRIFA in the Department of Nuclear Agriculture and Radiation Processing of the school of Nuclear and Allied Sciences, University of Ghana under the supervision of Prof. Etor E.K.Takyi and Prof. (Mrs.) Victoria Appiah.

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DEDICATION

This project is dedicated to my parents, Mr. Sampson Afrifa and Ms. Comfort Peprah, and siblings for their immense contribution towards the successful completion of this programme. Also, to all my friends and loved ones, especially Afia Benewaa Domfeh, Emmanuel Bempong- Manful and Charles Prempeh for their encouragement throughout my studies.

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ABSTRACT

Cocoyam leaf (*Xanthosoma sagiitifolium) (*'Kontommire') is arguably one of the most readily available and cheap indigenous leafy vegetable that is commonly consumed in Ghana. It is noted to be a good source of minerals, vitamins and soluble fibre when consumed in its fresh (not raw though) state. However, this vegetable is highly perishable. Dehydration methods and jute sack storage are usually used for its preservation. However, these lead to discolouration, loss of some nutrients, and exposure to microbial contamination thus reducing the general acceptability by consumers.

In view of this, a study was conducted to process and preserve the leaves in their fresh state. Preservation methods investigated were: refrigeration, steam blanching, gamma irradiation and a combination of these methods. The effect of the various preservation methods on some physicochemical properties (moisture content and dry matter by gravimetric method, vitamin C (ascorbic acid) was determined by iodometric titration method, crude protein was determined by Kjeldahl method, colour change using a Minolta CR310 colorimeter , pH using the Mettler Toledo pH meter (model:T3KfTLH); phytochemical properties (total phenolic using the Folin ciocalteau method and total flavonoids using aluminium chloride colorimetric method); microbial quality (total viable count, total coliforms, yeast and moulds count using serial dilution); consumer acceptance using a 9-point hedonic scale to assess the colour, texture and odour. The best packaging material for effective storage was also investigated.

Fresh, fully opened leaves of cocoyam which were two (2) weeks old were collected from the Biotechnology and Nuclear Agriculture Research Institute (BNARI) farm and used for the study. They were decontaminated by washing in fifty (50) % of brine solution and shredded and apportioned for the various treatments, packaged into zip-lock polyethylene bags and hermetically sealed bags. The shelf-life study lasted for three weeks with sampling at weekly intervals. Data obtained were analysed using the Statgraphics Centurion (16^{th} edition).

Results showed that, all the preservation methods as well as the packaging materials used increased the moisture content of the fresh cut cocoyam leaves significantly

($p<0.05$) during storage and reduced the dry matter content. However, the moisture content of samples stored in hermetically sealed polyethylene bag was higher than that of the zip-lock polyethylene bag. Also blanching and its combinations showed significantly ($p<0.05$) higher moisture content. Vitamin C content also reduced significantly ($p<0.05$) with all the preservation methods and packaging materials used. However, while the reduction was significantly low in refrigeration ($4\pm2^{o}C$) storage and its combinations, it was significantly high in ambient temperature ($30\pm2^{o}C$) storage. Radiation doses of 0.5 kGy to 2 kGy also significantly reduced vitamin C. Crude protein content in all the processed leaves increased significantly ($p<0.05$) during storage but was significantly higher in samples stored in hermetically sealed polyethylene bag. The colour of all the preserved cocoyam leaves was significantly affected by storage. However, the control and samples irradiated at 0.5kGy did not significantly affect the green colour but doses of 1 kGy, 1.5 kGy and 2 kGy reduced the yellowing of the cocoyam leaf under refrigeration storage. Storage increased total phenolic and total flavonoid content in all preservation methods used but had significance only under refrigeration storage and also irradiation dose of 1.5 kGy recorded the highest amount during storage.

Microbiological quality assessment of the processed leaves also showed that blanching treatment significantly reduced the total viable count of the cocoyam leaf but increased the yeast and mould growth when stored for longer period. Samples stored in hermetically sealed bag package and ambient temperature ($30\ ^{o}C$) also had increase in the total viable count, yeast and mould count and total coliform count during storage. However, refrigeration after irradiation at 0.5 kGy to 1.5 kGy recorded a less count of microbial load in samples stored in hermetically sealed polyethylene bag after two weeks of storage. *Pseudomonas fluorescens and Pseudomonas viridiflava*, and *Citrobacter* spp were identified in samples stored by refrigeration.Sensory evaluation of the processed leaves showed that samples stored in zip-lock polyethylene bag were the most acceptable. Refrigeration alone in combination with radiation dose of 0.5 kGy and 1 kGy preserved the cocoyam leaf for three weeks with minimal effect whereas blanching, irradiation only and ambient temperature storage preserved the leaf for only a week.

It is recommended that cut-leafy vegetables should be preserved by packaging in zip-lock polyethylene bags and stored in a refrigerator at a temperature of $4\pm2^{o}C$.

CHAPTER ONE: INTRODUCTION

1.1 Background of the study

Indigenous leafy vegetables (ILVs) as defined by Maundu (1997) are plants (that are native or introduced into a society), whose leaves have been used as food over a long period of time and have become part of the culture and tradition of a community. There are about 150 food-plants commonly consumed by man. Out of this number, 115 are indigenous African species. The world's major regions of crop diversity include Ethiopian highlands, the Sahelian transitional zone, the Delta of Niger River and the humid forest zone of west and central Africa (Kiambi and Atta-Krah, 2003). Leafy vegetables found in humid tropical countries include: *Amaranthus* spp., *Corchorus* spp., *Bidens pilosa, Gynandropsis* spp., *Celosia* spp., *Basella* spp., *Solanum scabrum, Solanum americanum, Hibiscus sabdariffa, Xanthosoma sagittifolium, Talinium triangulare and Moringa oliefera*. Some of these vegetables are not cultivated widely, but they are normally gathered from the wild.

Vegetables are an integral food source in the diet of most Ghanaians. Many people obtain their nutrients from food plants, which are cheaper, more accessible and of high nutritional value (Kwenin *et al*., 2011). Studies on chemical composition of indigenous leafy vegetables and fruits have shown that they contain significant amounts of vitamins, minerals, crude protein and little amount of fat and oil and energy. (Adebooye, 1996; 2001; 2002; 2004; Adebooye and Bello, 1998; Chweya, 1997; USDA, 2002; 2003). For instance, 133g of cocoyam leaves (*Xanthosoma sagittifolium*) can supply the body's daily requirement of retinol (Bosland and Votava, 2000). The leaves of cassava contain about 20-25% crude protein on dry matter basis (Oke, 1990). Leafy vegetables such as *Talinium triangulare*

('Bokobokor'), *Amaranthus crentus* ('Aleefu') have also been known to make food more palatable and digestible (Oke, 1990). This is because they contain high amounts of digestible carbohydrates such as starch, sucrose, glucose and fructose. Also, they contain high moisture and are easy to digest (Lussier, 2010).They have also been known to contain antioxidants (lutein and zeaxanthin) that protect the eye tissues against free-radicals (Ribaya-Mercadoand Blumberg ,2004). Again, they are believed to minimise ageing related diseases as well as an anti-cancer agent that maintains and fights off infections (MacCalla, 1994; Abukutsa-Onyango, 2003; and ICRAF, 2004). Not only are these vegetables used as food source, some of them are also used for medicinal purposes. Modern science has isolated many natural products with active principles of medicinal importance from many indigenous plants. For example, *Brassica* spp have been shown to contain glucosinolates, which are highly effective against cancer and heart diseases. Baobab leaves *(Adansonia digitata*) are used for the treatment of kidney and bladder diseases, asthma, diarrhoea, urinary tract diseases, and as a blood cleanser, prophylactic, worm expeller, amongst others, whilst *Ceratotheca sesamoides* ('yaudo*)'* is used to cure exhaustion, scabies, scurf dysentery, and for difficult child-birth (Burkill, 1985). *Corchorus olitorius* ('ayoyo') is used to counter malnutrition, as a purgative, for fever and heart troubles (Burkill, 2000). 'Mmeduro' a special local palm nut soup specially prepared for lactating mothers, especially in the Ashanti region of Ghana, is prepared from different indigenous leafy vegetables to promote milk production and let-downs in lactating mothers.

In addition, indigenous leafy vegetables contribute in income generation and subsistence in some African countries. Adebooye (2004) identified that *Solanecio*

biafrae (Olive and Heirne) are indigenous leafy vegetables used in southwest Nigeria and are several times more expensive than the consistently cultivated species especially during the dry season. Research has also shown that other indigenous leafy vegetables such as *Telfairia occidentalis*, *Celosia argentea* ., *Amaranthus cruentus* and *Solanum macrocarpon* are also sold at high prices during the dry season in Southwest Nigeria. In Kenya, the cultivation of leafy vegetables is noted to provide job opportunities for those in the informal sector of the economy. This serves as a source of livelihood because indigenous leafy vegetables production can be done with little capital investment (Abukutsa-Onyago, 2003).

In Ghana, some of the popular leafy vegetables consumed include: the leaves of cocoyam *Xanthosoma sagittifolium* locally called 'Kontommire', water leaf (*Talinum triangulare*) locally called 'Bokobokor, *Amaranthus cruentus* locally called 'Aleefu', *Corchorus olitorius* locally called 'Ayoyo', Okro leaves (*Hibiscus esculentum*) and cassava leaves (*Manihot esculanta*). For this study,'kontommire' *(Xanthosoma sagittifolium*) has been used because it is one of the most widely consumed local leafy vegetables in Ghana.

1.2 Statement of problem

Vegetables are highly perishable and contribute as much as 50% of post-harvest loss throughout the developing world as a result of inadequate infrastructure for processing and storage. It is estimated that Ghana loses 30 - 40% of the starchy crops and vegetables annually because of lack of storage and preservation facilities (MOFA, 2010). Reduction of these losses through appropriate preservation methods could reduce the domestic shortfall in food supply by 20 - 30 % (FAO, 1985). Some

preservation methods that can be used include: refrigeration, sun-drying, solar drying, blanching, and irradiation. Although indigenous leafy vegetables (when in season) in their fresh state are highly nutritious and cheaper than the exotic leafy vegetables not much attention has been given in the literature to the preservation of these indigenous leafy vegetables. Traditionally, leafy vegetables have been preserved by sun drying, blanching, storing in clay pots, in baskets and jute sacks (Woodroof, 1975; Nazare *et al*., 2007). For instance, in the Northern Region of Ghana people may preserve leafy vegetables by drying them, keeping them in jute sacks and moistening the sack so as to preserve the freshness of the leaves for a day or two. Also, market women store leafy vegetables in plain polyethylene bags and sprinkle water on them to maintain their freshness. Though these methods may preserve the leaves for some days, there are changes in colour, texture and odour. There also tends to be contamination -microbial contamination may result from storage temperatures and other conducive factors that support the growth of microorganisms.

When leafy vegetables are sun- dried, they are exposed to direct sunlight resulting in heat-up of internal temperature without regulation. This results in an unevenly dried product, reduction in the colour, vitamins and flavour and an increase in microbial growth since producers do not adhere to the basic principles good hygienic practices (Kudjawu *et al*., 2011). Physical contamination and changes may result from contact with dust, soil, insect infestation, exposure to sunlight and contact with other pests. Where most vegetables are not cleaned before drying, the produce is heavily contaminated with bacteria and mould spores. This results in the formation of mycotoxins and pathogenic microorganism infections (Brennan and Day, 2006).

There is need to adopt automated modern methods and use of appropriate equipment for drying to avoid mould growth in storage since sun drying is unreliable.

Fresh leafy vegetables are known to have high nutritional value in their natural state. They, however, usually wither rapidly within a few days after harvesting. This results in discolouration due to respiration and enzymatic activity thus reducing the general acceptability by consumers. There is, therefore, the need to use preservation methods that will extend their shelf life and maintain their quality at the same time.

1.3 Justification and significance of the study

Indigenous leafy vegetables are highly perishable but cannot be marketed fast enough even when they are in season. Therefore, appropriate preservation and storage methods are needed in order to prolong the consumption of such nutritiously rich foods all year round.

Refrigeration, blanching, gamma irradiation and combination of these methods would be used to preserve the cocoyam leaf. Blanching is expected to inactivate the enzymes as well as remove all intracellular gases within the plant cells resulting in the brightening of the colour of the leafy vegetables and thus maintain the colour of the product. Refrigeration should control the in-flow of hot air or exchange of gases that would cause autolysis, microbial contamination and enzymatic reactions (Brennan and Day, 2006). Radiation preservation is a modern technique that uses ionizing radiations to minimise enzymatic activities, microbial growth and prevent food spoilage without making the food radioactive (Wardlaw, 2003).

Processing of leafy vegetables before storage would reduce time of preparation thus making it more convenient to consumers as well as improving the microbial status of the product. Preservation and storage would also extend the shelf-life of leaves and

ensure their supply over an extended period of time. Proper packaging would also provide a protective barrier to the product for easy transport.

1.4 Objectives of the study

The overall objective of the study is to determine whether low temperature storage, blanching, irradiation and a combination of these methods could significantly extend the shelf-life of *Xanthosoma sagittifolium* leaves ('Kontommire').

1.4.1 Specific Objectives

1. To determine the effect of the preservation methods on the physicochemical and phytochemical properties of the processed cocoyam leaves during the storage period.
2. To ascertain the effect of various preservation methods on the microbial status of the processed cocoyam leaves during the storage period.
3. To determine consumer acceptance of the processed cocoyam leaves during the storage periods.
4. To ascertain the best packaging material for the storage of the processed leafy vegetable**.**

CHAPTER TWO: LITERATURE REVIEW

2.1 Importance of indigenous leafy vegetables in diet

The term "indigenous leafy vegetable" (ILF's) has been used in generic terms to group crops that are peculiar to a particular locality over a period of time. These vegetables are now gaining recognition because of their importance for food security, health benefits and their significant contribution to income generation in their particular localities.

There are more than 45,000 species of plants in sub-Saharan Africa of which about 1000 can be eaten as green leafy vegetables which happen to be the major source of traditional African diets (MacCalla, 1994). Adebooye *et al*. (2003) reported that twenty-four (24) indigenous leafy vegetables are eaten by southwest Nigerians only. Also, a research conducted by Plant Resources of Tropical Africa showed that there are about 30,000 plant species for Tropical Africa and of these only 6,376 representing 21% are used by man. Of the 6,376 useful indigenous African plants, 1,975 are medicinal plants, 820 timbers, 611 forages, 533 ornamentals, 477 fruits, 397 vegetables, 377 fibres, 240 essential oil and exudates, 220 auxiliary plants, 176 carbohydrate plants, 130 spices and condiments, 129 dyes and tannins, 104 fuel plants, 80 cereals and pulses, 54 vegetable oils and 53 stimulants (PROTA, 2004).

A survey conducted by IUCN (1997) showed that leafy vegetables are very common in some countries in Africa: Cape Verde has 92, Gambia 3, Ghana 43, Guinea-Bissau 12, Nigeria 205 and Sierra-Leone 74. Some of the commonly consumed leafy vegetables include: Amaranthus (*Amaranthus spp*), Cowpea leaves (*Vigna spp*),

Nightshade (*Solanum Spp*), Spider plant (*Cleome spp*), Sweet potato leaves (*Ipomeas spp*), Pumpkin leaves (*Cucurbita spp*), Jute Mallow (*Corchorus spp*), Cassava leaves (*Manihot esculenta*), African eggplant (*Macrocarponspp*), slender leaf (*Crotalaria brevidens*), jute mallow (*Corchorus olitorius*), and African kale (*Brassicacarinata*) among many others (Abukutsa-Onyango *et al.*, 2006).

Most Ghanaians, especially those living in rural areas, depend largely on these abundant natural resources for food and sometimes substitute them for the protein part of their meal (Manning, 2005). They are inexpensive, easily accessible and provide consumers with health promoting compounds such as vitamins, minerals, anti-oxidants as well as anti-cancer factors needed to maintain health and fight off infections (MacCalla, 1994; Abukutsa-Onyango, 2003; and ICRAF, 2004). This has been verified from studies conducted by Johns and Sthapit (2004) who report that people in countries where leafy vegetables consumption is very high tend to be less affected by cardiovascular diseases, diabetes and other adverse consequences of malnutrition.

They are compatible in use with starchy staples and represent a cheap but quality nutrition to the poor both in urban and rural areas (Maundu, 1997).These vegetables are highly recommended as they form an important source of body-building nutrients, vitamins and minerals (Nazare *et al*., 2007), dietary fibre and proteins.

Green leafy vegetables have also been identified to be the richest in carotene. Some contain anti nutrients that interfere with the absorption of some nutrients in diet. These anti- nutrients include: phytic acid, oxalates, pro-anthrocyanidin, tannin and dietary fibres which reduce the bio availability of the nutrients. Aletar and Adeogun (1995) reported that anti- nutritional phytochemicals exhibit protective effects, thus

serving the dual purpose of reducing some essential nutrients and protecting the body against a number of biochemical, physiological and metabolic dis-orders. Green leafy vegetable acts as a buffer and maintains the proper alkalinity of the blood by balancing acid- producing foods like meats (Diplock, 1994).

Indigenous vegetables are usually rich in nutrients such as vitamin A and iron that are often lacking in the diets of children and pregnant women (Smith and Eyzaguirre, 2007). They are also important in food security during times of drought and poor harvest and are also vital for income generation (Madakadze *et al*., 2004; Parawira and Muchuweti, 2008) and are of medicinal value in some instances.

Household food insecurity has been a serious persistent problem for smallholder farmers and has resulted in nutritional deficiencies during the famine period. During these periods, staple foods are scarce and households rely on leafy vegetables as their main source of food and subsistence (Phakathi, 2008). They are also used as cheap but quality dish with starchy staples to minimise malnutrition to the poor both in urban and rural areas (Maundu, 1997). Indigenous leafy vegetables (ILV's) have made positive contribution toward world food production as compared to the exotic ones because they adapt easily to harsh or difficult environmental conditions and are highly resistant to pest and diseases thus requiring fewer chemicals and pesticides (Abukutsa-Onyango *et al*., 2006). This has made them suitable and advantageous for people living in areas with high population density like Africa. ILV's can act as a substitute for other cultivated crops to alleviate nutrient deficiencies by increasing nutrient supplies (Engle and Altoveras, 2000). They are inexpensive and easy to cook and their production can compensate for low vegetable supply during the off-season,

potentially helping to alleviate nutrition deficiency during this period (Engle and Altoveras, 2000).

Traditional vegetables have been noted for their superior attributes in alleviating a lot of diseases. More attention has been directed to fruits and vegetables because they are accessible and inexpensive and have health protecting properties of non-nutrient bioactive compounds found in them, making them vital components of daily diets.

2.2 Physiology and nutritional characteristics of *Xanthosoma sagittifolium* ('kontommire')

*Xanthosoma sagittifolium*is the most important food crop within the family Araceae, sub-family Aroideae and belongs to the two species *Colocasia esculenta (L.)* Schott (taro, "old" cocoyam, dasheen eddoe) and *Xanthosoma sagittifolium (L.)* Schott ("new" cocoyam, tannia). The name was derived from the Greek word 'xanthos' meaning yellow and 'soma' which means a plant of the yellow inner tissue. It is also known as the elephant plant. The elephant's-ear plant gets its name from the leaves, which are shaped like a large ear or shield. The cultivars of *C. esculenta* can be grouped roughly into two types: the one with a comparatively small corm surrounded by large, well-developed cormels, known in the West Indies as the eddoe and the other, which has a large central corm and few side cormels, is known as dasheen in the West Indies. However, the names dasheen and eddoe are not always strictly applied to these groups in this way. There are intermediate forms, and in the South Pacific islands the term taro is used for both types. *Colocasia* and *Xanthosoma* are particularly important food crops in the islands of the South Pacific, the Carribbean and West Africa (Alexander, 1969; Coursey, 1968; Lambert, 1979; Massal and

Barrau, 1955) and Colocasia is also a staple food in parts of the Philippines where it is known as gabi (Pardales, 1980).

Cocoyams are plants of the tropical rain forest that grow in their natural habitat under the forest canopy and usually sown with full exposure to sunlight (Giacometti and Leon, 1994).They are also herbaceous crop with a large corm just below the ground with leaves ranging from 20–150 cm (7.9–59 in) long, with a sagittate shape. The plant reproduces mostly by means of rhizomes (tubers, corms) but it also produces "clusters of two to five fragrant inflorescences in the leaf axils"(Grin, 2007). The leaves of this aroid are short-lived and can last some few weeks but the corms can last for months when stored in barns.

Like other members of the family, *Xanthosoma sagittifolium* contains an irritant which causes intense discomfort to the lips, mouth and throat. This acridity is produced in part by microscopic needle like raphides of calcium oxalate monohydrate and in part by the enzyme protease (Sakai, 1979). The presence of calcium oxalate raphides and other acrid substances make it irritating to the skin and this naturally deter herbivores from eating it. It must be processed by cooking, soaking or fermenting – sometimes along with an acid (lime or tamarind) before being eaten (Ramanatha *et al.*, 2010).

Xanthosoma sagittifolium needs shade so, it is mostly intercropped with perennial crops such as banana, coffee, coconut, rubber, oil palm and cocoa (Wilson, 1984). The corm and cormels of this plant, which are the main profitable parts, contain about 15 to 39% carbohydrates, 2 to 3% protein and 70 to 77% water. The young leaves contain 2% protein and are also rich in vitamin C, thiamine, riboflavin, niacin, calcium, phosphorus and iron (Ndon *et al.*, 2003). It has a nutritional value

comparable to potato but easier to digest (Sefa-Dedeh and Sackey, 2002). *Xanthosoma sagittifolia* has also been noted to contain759.24 mg/100g of calcium on dry weight basis (Amagloh and Nyarko, 2012).

Table 1: Nutritional content of matured *Xanthosoma sagittifolium* leaf

Constituents	***Xanthosoma sagittifolium***
Moisture content	85.76%
Crude protein	4.65%
Fat	3.19%
Carbohydrate	6.80 %
Fibre	10%
Energy	71.50%
Iron	14.64 mg/100g
Phosphorus	80.10 mg/100g

Kwenin *et al.*, (2011).

Although leafy vegetables are known to contain beta carotenes, phenolic and flavonoids, their percentage content is unknown. Some medicinal attributes have also been associated with the consumption of 'Kontommire'. It has been noted to give good eye-sight because it is rich in B-carotene, a precursor of vitamin A. It is also reported to be good for anaemic patients because of its high amount of iron and other useful minerals (Muinat *et al.*, 2009).

The edible portion of the plant is the leaves which are eaten as green vegetables and the corm or cormels which are used as staple food.

Cocoyam plant development consists of three major stages namely plant establishment (from planting to about 2 months after planting), rapid vegetative growth (2 – 5 months) and a third stage (after 5 or 6 months) characterized by tuber development and maturation (Adiobo *et al.*, 2011). The leaves and cormels which play major roles in the diet of Ghanaians need proper development to sustain the

plant. Adoption of technical innovation by farmers demands precise and detailed information on cost and return so that farmers can choose the right combination of resources or enterprises (Das *et al*., 2010).

2.3 Proximate compositions of some researched leafy vegetables.

2.3.1 Moisture Content

Moisture commonly refers to the presence of water, often in trace amounts (Moisture-www.wikipedia.com2012). Water is an important part of all cells and fluids in the body. It carries nutrients to and waste products from cells in the body, aids in digestion and absorption of food, and helps to regulate body temperature (Johnson, 1996). The maximum water content varies between individual vegetables because of structural differences and cultivation condition that influence structural differentiation. It may also have a marked effect on water levels in vegetables (Florkowski *et al.,* 2009). High moisture content in vegetables is indicative of its freshness as well as easy perishability (Adepoju and Oyediran, 2008). Higher moisture content in vegetables also suggests that the vegetable will not store for long after harvesting since a higher water activity could enhance microbial activity, bringing about food spoilage (Ejoh *et al.,* 2007). For vegetables to be kept for a long time before use, the moisture content has to be reduced to inhibit the autocatalytic enzymes (Ladan *et al.*, 1997).

2.3.2 Crude Protein

Proteins are essential organic compounds of high molecular weight found in all living tissues. They form an important part of enzymes, fluids and hormones of the body. They are formed from much similar building units called amino acids. Proteins may be categorized based on factors such as solubility and shape. They are broadly

divided in two groups namely: simple and conjugated. Simple proteins consist of only amino acids as building blocks while conjugated proteins contain amino acids but in addition, a non-protein or prosthetic group which may be glycoprotein, lipoprotein, chromo protein (Osei, 2003). Protein helps in the synthesis of antibodies to fight infection and supply energy to the body (Jonhson, 1996). How much protein is needed in a person's daily diet is determined in large part by overall energy intake, as well as by the body's need for nitrogen and essential amino acids. Physical activity and exertion as well as enhanced muscular mass increase the need for protein (Protein- www.wikipedia.com, 2010). The World Health Organization (WHO) protein figures translate into 56 g of protein day for a (70-75 kg) man and 48g for a (60-64 kg) woman.

Plant proteins may be less digestible because of intrinsic differences in the nature of the protein and the presence of other factors such as fibre, which may reduce protein digestibility by as much as 10 %. Nevertheless, dietary studies show the adequacy of plant foods, as sole sources of protein (AFPA, 2010). Requirements are also greater during childhood for growth and development, during pregnancy or when breast-feeding in order to nourish a baby, or when the body needs to recover from malnutrition or trauma or after an operation. Protein deficiency leading to Protein-Energy Malnutrition (PEM) is a serious cause of ill health and death in children in developing countries. Symptoms of (PEM) include: kwashiorkor, apathy, diarrhoea, inactivity, stunted growth, flaky skin, fatty liver, and edema of the belly and legs (Protein-www.wikipedia.com, 2012).

Heat denatures protein (Morris *et al.*, 2004). Food processing has inevitable consequences on the nutritional value of foods. The macro- and micro-nutrients

(carbohydrate, protein, fats, vitamins and minerals) contained within foods all show varying degrees of stability when foods are stored or processed and the degree of stability depends largely on the type and structure of the food/nutrient, food chemistry and the severity and duration of processing (Henry and Massey, 2001).

2.3.3 Dietary Crude Fibre

Dietary crude fibre is the edible part of plants or analogous carbohydrates that are resistant to digestion and absorption in the human small intestine with complete or partial fermentation in the large intestine. Dietary crude fibre includes polysaccharides, oligosaccharides, lignin, and associated plants substances. Fibre promotes beneficial physiological effects including laxation, and/or blood cholesterol attenuation, and/or blood glucose attenuation. Total fibre is the sum of dietary and functional fibre. Functional fibre consists of isolated, non-digestible carbohydrates which have beneficial physiological effects in humans (CFW, 2003).

'Dietary fibre', 'unavailable carbohydrate' or 'roughage' are the different terms used to define that part of the plant food which is not digested by the endogenous secretions of the human digestive system. The sum total of all these fractions, which go unhydrolysed, was first known as "Unavailable Carbohydrate". Since lignin is not a carbohydrate, recently the term "Plantix" has been given to this totally indigestible material. Dietary fibre may be classified into three major groups according to structure and properties. The groupings are cellulose, non-cellulose and lignin (Komal and Kaur, 1992).

Dietary fibre or foods containing a high amount of dietary fibre are very low in caloric content. Dietary fibre yields only 2 – 3calories /g. Thus a high fibre diet is recommended for weight reducing regimes (Komal and Kaur, 1992). Mensah *et al.*

(2008) reported crude fibre content of *Amaranthus cruentus*, *Cochorus olitorius* and *Basella rubra* as 1.8, 8.5 and 0.6 g/100 g respectively. Increasing the fibre content of the diet increases the faecal energy excretion, principally in the form of fat and nitrogen. By virtue of its water holding capacity, fibre also helps in the formation of soft stools with bulk, which can be easily evacuated (Komal and Kaur, 1992). An increased intake of dietary fibre appears to be useful for the treatment of both obesity and diabetes mellitus. Fibre-rich food is usually satisfying without being calorically dense. Gel forming fibres are particularly effective in reducing elevated cholesterol. The impaired glucose tolerance of manifest diabetes is also improved.

2.4 Micronutrients in leafy vegetables

2.4.1 Phosphorus

Leafy vegetables are one major source of phosphorus apart from fruits such as banana and phosphate food additives. (Soetan *et al.*, 2010). Phosphorus is an essential macronutrient for plants and one of the three nutrients generally added to soils in fertilizers because of its vital role of energy transfer in living organisms and plants. Adequate phosphorus availability stimulates early growth and hastens maturity in plants. Phosphorus is also needed for soil fertility. The phosphorus content of the plant is influenced markedly by the availability of phosphorus in the soil.

Phosphorus is part of every cell of the body and is vitally concerned with many metabolic processes (Hays and Swenson, 1985). It functions as a constituent of bones, teeth, adenosine triphosphate (ATP), phosphorylated metabolic intermediates and nucleic acids. It aids the buffering system (phosphate buffers, functions in the

formation of high energy compounds), and is involved in the synthesis of phospholipids and phosphoproteins. Practically, every form of energy exchange inside living cells involves the forming or breaking of high-energy bonds that link oxides of phosphorus to carbon or to carbon-nitrogen compounds. Deficiency disease in children causes rickets and in adults, it causes osteomalacia (Hays and Swenson, 1985).

2.4.2 Potassium

Plant products contain significant amounts of potassium (Soetan *et al.* 2010). Mensah *et al.,* (2008) reported that the potassium content of *Amaranthus cruentu, Cochorus olitorius Xanthosoma sagittifolia* and *Basella rubra* as 4.82 mg/100 g , 3.83 mg/100 g , 1574 mg/100 g and 5.8 mg/100 g respectively on dry matter basis.

Potassium is the principal cation in intracellular fluid and functions in acid-base balance, regulation of osmotic pressure, conduction of nerve impulse, muscle contraction particularly the cardiac muscle, cell membrane function and Na+/K+-ATPase. Potassium is also required during glycogenesis. It also helps in the transfer of phosphate from ATP to pyruvic acid and probably has a role in many other basic cellular enzymatic reactions. Its metabolism is regulated by aldosterone. Deficiency symptoms occur secondary to illness, functional and structural abnormalities including impaired neuromuscular functions of skeletal, smooth, and cardiac muscle, muscular weakness, paralysis and mental confusion. Others are cardiac arrythmias, impaired carbohydrate tolerance and altered electrocardiogram in calves. Potassium deficiency affects the collecting tubules of the kidney, resulting in the inability to concentrate urine. It also causes alterations of gastric secretions and intestinal motility (Hays and Swenson, 1985).

2.4.3 Calcium

Some leafy vegetables studied by Mensah *et al.* (2008) recorded an appreciable amount of calcium content. They were *Amaranthus cruentu, Cochorus olitorius* and *Basella rubra* with recorded values of 2.05 mg/100 g, 1.26 mg/100 g and 2.32 mg/100g respectively. Spider flower has a Calcium content of 213-434 mg/100 g. *Xanthosoma sagittifolia* has also been noted to contain759.24 mg/100g of calcium on dry weight basis (Amagloh and Nyarko, 2012).

Calcium is an important constituent of bones and teeth and is involved in regulation of nerve and muscle function. Growing children, pregnant and especially lactating humans and animals require substantial amounts of calcium and phosphorus.

In blood coagulation, calcium activates the conversion of prothrombin to thrombin. It plays a vital role in enzyme activation. Calcium activates a large number of enzymes such as Adenosine Triphosphatase (ATPase), Succinic Dehydrogenase and lipase. It is also required for membrane permeability, involved in muscle contraction, normal transmission of nerve impulses and in neuromuscular excitability (Soetan *et al.*, 2010). In children, calcium deficiency causes rickets due to insufficient calcification by calcium phosphate of the bones in growing children. The bones therefore remain soft and deformed by the body weight. In adults, it causes osteomalacia, a generalized demineralization of bones. It may also contribute to osteoporosis, a metabolic disorder resulting in decalcification of bone with a high incidence of fracture, that is, a condition where calcium is withdrawn from the bones and the bones become weak and porous and then breaks (Hays and Swenson, 1985; Malhotra, 1998; Murray *et al.*, 2000). Calcium deficiency also affects the dentition of both children and adult. Excess calcium depresses cardiac activity and leads to

respiratory and cardiac failure; it may cause the heart to stop in systole, although, normally, calcium ions increase the strength and duration of cardiac muscle contraction. Excess calcium and phosphorus are excreted by the kidney.

2.4.4 Magnesium

According to Soetan *et al.*,(2010), leafy vegetables contain substantial amount of magnesium. Mensah *et al.* (2008) recorded magnesium content of 2.53 mg/100 g in *Amaranthus cruentu,* , 0.59 mg/100 g in *Cochorus olitorius* and 0.06 mg/100 g in *Basella rubra.* Also Amagloh and Nyarko (2012) recorded 703.05mg/100g in cocoyam leaf (*Xanthosoma sagittifolium*).

Magnesium is an active component of several enzyme systems in which thymine pyrophosphate is a cofactor. It is also a constituent of bones, teeth and enzyme cofactor (Murray *et al.*, 2000). The health status of the digestive system and the kidneys significantly influence magnesium status. Magnesium is absorbed in the intestines and then transported through the blood to cells and tissues.

Deficiency diseases or symptoms are secondary to mal-absorption or diarrhoea, alcoholism. Acute magnesium deficiency results in vasodilation, with erythemia and hyperaemia appearing a few days on the deficient diet. The physiological deficiency of magnesium can be prevented by magnesium supplementation of a salt or grain mixture and adequate consumption (Hays and Swenson, 1985).

2.4.5 Iron

Xanthosoma sagittifolia has been reported to contain between 10.59±0.48 (Amagloh and Nyarko, 2012) and 14.64 /100mg of iron of iron on dry matter bases (Kwenien *et al.*, 2011).

Iron plays a significant role in the human metabolism. It helps in the transport of oxygen. In cellular respiration, it functions as essential component of enzymes involved in biological oxidation such as cytochromes C, C1, and A1 (Malhotra, 1998). Iron is an important constituent of succinate dehydrogenase as well as a part of the haeme of haemoglobin (Hb), myoglobin and the cytochromes (Chandra, 1990). Iron is required for proper myelination of spinal cord and white matter of cerebellar folds in brain and is a cofactor for a number of enzymes involved in neurotransmitter synthesis (Soetan *et al.,* 2010). Iron is involved in synthesis and packaging of neurotransmitters, their uptake and degradation into other iron-containing proteins which may directly or indirectly alter brain function.

Deficiency disease or symptoms include anaemia, (hypochromic, microcytic). Iron deficiency has been reported to have a role in brain development and in the pathophysiology of restless legs syndrome. Also, iron deficiency is associated with alterations in many metabolic processes that may impact brain function; this includes neurotransmitter metabolisms, protein synthesis and organogenesis (Soetan *et al.*, 2010).

2.5 The cultivation of indigenous leafy vegetables in Ghana

The cultivation of indigenous leafy vegetables has largely not been encouraged. Many people do not grow these on large scale but rather on peasant farming bases. Leaf production in Ghana is highest during the rainy season, where a plot of 1000m^2 yields 13 – 14bags per harvest which amount to about 27 bags or 600kg per month. In the dry season, monthly yields drop to 2 – 4 bags in the cool months and to 10-15 bags during the warmer months if irrigated. This is equivalent to an annual production of 27t/ha fresh leaves (Ministry of Food and Agriculture, 2010).

In Ghana the cormel is used as substitute for yams and plantain for the preparation of various dishes especially in the dry season. The young leaves are also widely used in the preparation of stews or sauces. In a socioeconomic survey conducted by Quaye *et al*.(2010), they found out that majority of the farmers in Ghana cultivated cocoyam for both the cormel and leaves, but very few of them cultivated it purposely for the cormels. Production and the area planted with cocoyam have been on the decline from 2001 to 2006. The mean annual growth rates for area planted and production during the period were 0.2 and 0.3%, respectively (Ministry of Food and Agriculture, 2010). The decline in production may be attributed to environmental problems such as deforestation, decreasing rainfall and poor soils (Sagoe, 2006). The crop is generally grown by small-scale farmers with no intensive management such as fertilization and the use of improved varieties for commercial cormel and cocoyam leaf production.

2.5.1 Harvesting of leafy vegetables and post- harvest handling practices of *Xanthasoma Sagitifolium*

Harvesting of leaves starts after one and half months after sowing (Grubben and Denton, 2004). Some leafy vegetables are harvested together with their branches and then later destocked examples include: *Amaranthuus cruentus, Talinium triangulare, Corchorus olitorius and Hibiscus esculentum.* Individuals engaged in fresh produce harvesting are sometimes trained in the selection of fresh produce of sound quality. Produce are handled in such a way as to avoid damage and contamination.

Mechanical harvesters are used in large operations to take handling closer to the source in the field, improving shelf-life and maintaining produce quality.

2.6 Product characteristic of leafy vegetables

Leafy vegetables are living organisms and they respire even after harvesting because they continue their normal metabolism and this reaction keeps them fresh. This reaction involves the absorption of oxygen resulting in the break-down of carbohydrate content in the product into carbon dioxide and water. When there is restriction of availability of oxygen, the chemical reaction changes and little amount of alcohol is produced. This reaction results in the development of off-odours and off-flavours as well as the breakdown of plant cells. Continuous reaction of this causes anaerobic decay and can spoil the vegetables within some few hours.

Fruits and vegetables have similar product characteristics. They have very high moisture content ranging from 75% -95% with equilibrium relative humidity as high as 98%. When they are stored under normal atmospheric condition they dry rapidly. This causes wilting and shrivelling due to loss of rigidity and shrinkage of the cells.

The use of appropriate packaging materials can help prolong the shelf-life by preventing moisture loss which results in the wilting of the leaves.

As leafy vegetables age, they produce ethylene gas which triggers them to ripe, wilt and rot faster. Spoilage of fruits and vegetables is also caused by microbes such as moulds, yeast and bacteria. These microorganisms can cause destruction by growing on the exterior of the product or may invade on the interior through bruises or cut and cause internal decay. Therefore, there is the need to handle them carefully during packaging in order to maintain their freshness and quality. Also appropriate preservation method has to be used to keep the product fresh and wholesome for consumption.

The storage period depends mostly on its intrinsic characteristics and perishability of the product. Shelf-life of leafy vegetables is relatively shorter, hence appropriate preservation methods and packaging should be employed in order to ensure continuity in supply.

2.7 Intrinsic factors that influence microbial spoilage of leafy vegetables

2.7.1 Product composition

The growth of microorganisms in a food is greatly influenced by the inherent characteristics of that food. If the intrinsic constituent of the food supports the growth of microbes then it would affect the shelf-life of the food product. In general, microorganisms multiply more rapidly in moist, nutritionally rich, pH neutral foods (Nesta *et al.*, 2001).

2.7.2 Water availability

Micro-organisms normally grow in moist environment (Featherstone, 2008). Food products differ intensely in terms of how much water is available to the organisms that might grow in them. Fresh meats and milk, for example, have ample water which supports growth of many microorganisms. Breads, nuts and dried foods, on the other hand, provide a relatively dry environment. Some sugar-rich foods such as jams and jellies are seemingly moist, but most of the water has chemically interacting with the sugar, making it unavailable for use by microbes. Highly salted foods, for similar reasons, have little available moisture (Nesta *et al.*, 2001).

Water activity (aW) is one of the key components that determine the microbial spoilage of food products. It is defined as the free water or the available water in the food product and it is used to express the required moisture that supports the growth of microbes. Therefore, water activity helps in the determination of the lower limit for microbial growth in a food product. At low water activity levels some types of microorganisms such as moulds could survive in the products (Kudjawu *et al*., 2011).

By definition, pure water has aW of 1.0. Most fresh foods have aW above 0.98. Most bacteria require an aW above 0.90 for growth. This explains why fresh moisture-rich foods spoil more quickly than dried, sugary or salted foods. Fungi can grow at an aW as low as 0.80, which explains why forgotten bread, cheese, jam, and dried foods often become mouldy (Nesta *et al.*, 2001).

Food products can be grouped into three main classes based on water activity; namely: high aw (>0.92), intermediate aw (0.85-0.92) and low aw (< 0.85). Leafy vegetables fall into the high or intermediate group because they mostly have more available water. As a result of this, leafy vegetables deteriorate very fast.

2.7.3 pH activity

pH is a measure of the acidity or alkalinity of a food product. It aids in determining which organisms can survive and thrive on a food product. All microorganisms have a pH range in which they can grow and an optimum pH at which they grow best (Garbutt, 1997).

Food products have been broadly classified into three major pH measurements: high acid (<3.5), Intermediate acid (3.5-4.5) and low acid (>4.5).The pH range of microbes is usually defined by the minimum value and a maximum value. The optimum pH value is the range at which microbial growth is best and most microorganisms grow best at or near a neutral pH (7.0). Many foods including meat, fish, poultry and vegetables are slightly acidic whiles fruits are intermediate to highly acidic. Normally the pHs of food products vary with time due to microbial activity and product composition or formulation. According to FAO and WHO consultation on human vitamin and mineral requirement, when pH is less acidic (>4) in any food products the vitamin C content decreases. This is because; oxidation reaction is faster at a higher pH. Therefore, control of pH and a quality control are required to promote product quality.

Many species of bacteria, including most pathogens, are inhibited by acidic conditions and cannot grow at pH below 4.5. A commercially viable exception is the lactic acid bacteria, which can grow at a pH as low as 3.5 and are used in the production of fermented foods such as yogurt and sauerkraut. Fungi can grow at a lower pH than most spoilage bacteria, leading to some foods such as fruits becoming mouldy. For example, the pH of lemon is approximately 2.2, which inhibit the growth of bacteria, including lactic acid group, but some fungi can grow on them.

The pH of a food product may also determine whether toxins can be produced. For example, *Clostridium botulinum*, that causative agent of botulism, does not grow or produce toxin below pH 4.5, so it is not considered danger in highly acidic foods (Nesta *et al.*, 2001). Adjusting the pH of foods using organic acids is an important method of food preservation, controlling the growth of both food poisoning and food spoilage bacteria.

2.7.4 Nutrients

All microbes require nutrients for growth, maintenance of basic metabolic functions and food commodities contain abundance of nutrients that are available for the growth of a wide range of microorganisms (Garbutt, 1997). The nutrients present in a food as well as other intrinsic factors determine the kinds of organisms that can grow in it. An organism requiring a particular nutrient cannot grow in a food that lacks that nutrient. However, a microbe that has the capability of synthesizing that nutrient can grow if other conditions are favourable. Members of the genus *Pseudomonas* often spoil foods because they can synthesize essential nutrients and can multiply in various environments including refrigeration (Nesta *et al.*, 2001).

2.7.5 Availability of oxygen

Although oxygen is essential for carrying out metabolic activities that support all forms of life, some micro-organisms use free atmospheric oxygen, while others metabolize the oxygen (reduced form) which is bound to other compounds such as carbohydrates. Micro-organisms can be broadly classified into two groups; aerobic and anaerobic. Aerobes grow in the presence of atmospheric oxygen, while anaerobes grow in the absence of atmospheric oxygen (Featherstone, 2008). The presence or absence of oxygen affects the type of microbial population able to grow

in food. For example, members of the genus *Pseudomonas* are obligate aerobes, and they cannot grow in foods stored under conditions that exclude all of their required oxygen (Nesta *et al.*, 2001).

2.7.6 Antimicrobial chemicals

Some foods contain antimicrobial chemicals that may help prevent spoilage. For instance, egg white is rich in lysozyme, natural acids such as malic and citric acids are in fruits and vegetables, allicin in garlic and onions, hydroxycinnamic acid in tea, fruits and vegetables have antioxidants that prevent the growth of microbes (Nesta *et al.*, 2001).

2.8 Extrinsic factors that affect the shelf-life of food

The extent of microbial growth varies greatly depending on the conditions under which that food is processed and stored. Microorganisms multiply rapidly in unhygienic environment, warm, oxygen-rich environments such as room temperature (Nesta *et al.*, 2001).

2.8.1 Storage temperature

Storage temperature of a food commodity is of great importance to measure the safety of a food product since this can be used to determine the survival and growth of microbes, inhabitation as well as the retardation of microorganisms. Hence it is one of the appropriate tools for examining the shelf-life of a food commodity. Microorganisms as a group are capable of active growth at temperatures well below freezing to temperatures above 100ºC (Garbutt, 1997).

All micro-organisms however do, have an optimum temperature as well as a range in which they will grow. This preference for temperature forms the basis of dividing

micro-organisms into groups. Psychrotrophs have an optimum from 20 to 30°C, but can grow at or below 7°C. However, a lot of these microorganisms can survive and grow at refrigeration temperatures (5°C).Examples of such microorganisms include: *Listeria monocytogens, Yersinia enterocolitica* and non-proteolytic *Clostridium botulinum* (type B,E and F). Mesophiles have an optimum of 30–40°C, but can grow between 20 and 45°C but many of these microbes can also grow and survive at temperatures between 20°C and 40°C.They include: *Samonella* species, *Verotoxigenic Escherichia coli*and *Styphylococococcus aureus.* Thermophiles grow optimally between 55 and 65°C, but can grow at a temperature as low as 45°C. However, they can grow and survive at a temperature of 45°C but not <30°C.An example of such microorganism is *Clostridium perfringes* (Featherstone, 2008).

The temperature of storage affects the rate of growth of microorganisms in food. Below its freezing point, water becomes crystalline and inaccessible, effectively halting microbial growth that requires moisture. At low temperatures above freezing, many enzymatic reactions are either very slow or non-existent, with the result that, some microorganisms are unable to grow. Those that can, do so at reduced rate (Nesta *et al.*, 2001).

2.8.2 Relative Humidity of the environment

Relative humidity is the measure of the amount of moisture in the atmosphere surrounding the food product. The humidity of the environment is important as it affects the water activity (aw) of the food as well as the moisture on its surface. Food can pick up moisture from the atmosphere. If a food product requires a specific aW to control microbial growth and survival of some particular pathogenic microbe, it would be necessary to store the food product in an environment that prevents the aW

of the product from changing. Usually for lower storage temperatures, relative humidity should be high and vice versa. However under such conditions of high relative humidity storage (e.g. in a refrigerator), surface spoilage can take place, unless food is adequately protected by packaging (Featherstone, 2008).

2.9 Effect of the various preservation methods on leafy vegetables

2.9.1 Refrigeration

Refrigeration is a preservation method that controls the in-flow of air or exchange of gases that can cause the autolysis, microbial contamination and enzymatic reactions in food products (Brennan and Day, 2006). As a result of this attribute, refrigerated products are gaining more importance in the marketplace due to the ability of this technology to maintain the flavour and nutritional attributes of food. Food products from refrigerated storage (chilling) have positive effect because it slows down enzymatic process and bacteria growth without allowing ice crystals to develop on the food product. The cool temperatures marginally above zero, prolong the food quality, taste and texture quality as well as keep food safer longer (FAO, 2011). The process of chilling foods to their correct storage temperature causes little or no reduction in the eating quality or nutritional properties of food. The most significant effect of chilling on the sensory characteristics of processed foods is hardening due to solidification of fats and oils. Chemical, biochemical and physical changes during refrigerated storage may lead to loss of quality, and in many instances it is these changes rather than micro-biological growth that limit the shelf life of chilled foods. These changes include enzymatic browning, lipolysis, colour and flavour deterioration in some products and retro-gradation of starch to cause staling of baked

products (which occurs more rapidly at refrigeration temperatures than at room temperature (Jeremiah, 1995).

According to Brown (2000), lipid oxidation is one of the main causes of quality loss in cook–chilled products, and cooked meats in particular rapidly develop an oxidised flavour termed 'warmed-over flavour' (WOF). Physico-chemical changes including migration of oils from mayonnaise to cabbage in chilled coleslaw, liquid separation in sauces and gravies due to changes in starch thickeners, evaporation of moisture from unpackaged chilled meats and cheeses, chilling injury in fruits and vegetables, more rapid staling of sandwich bread at reduced temperatures and moisture migration from sandwich fillings may each result in quality deterioration.

Bognar (1980) reported some nutritional losses that occur in pre-cooked foods that are refrigerated as insignificant for thiamine, riboflavin and retinol, but vitamin C losses were 3.3–16% a day at 2ºC. The large variation is due to differences in the chilling time, storage temperature, oxidation (the amount of food surface exposed to air) and reheating conditions. Vitamin C loss in lettuce is 4.8-9.7%, cabbage 0.1-0.2% per day. Vitamin C losses in cook–pasteurise–chill procedures are lower than cooked–chilled foods (for example spinach lost 66% within 3 days at 2–3ºC after cook–chilling compared with 26% loss within 7 days at 24ºC after cook–pasteurising and chilling.

2.9.2 Effect of Irradiation on vegetables

Food irradiation is a modern technology that is used in food preservation. This method employs the use of ionizing radiation in a controlled amount to achieve a technical aim. It is mainly used in processing to destroy pests and pathogens, as well as inhibit sprouting and control ripening of food and agricultural products. For

example: fruits and vegetables may be irradiated to extend shelf life by delaying the physiological and biochemical processes leading to ripening. Since 2003, the Food and Drugs Administration of the United States has federally approved irradiation protocols for a variety of uncooked food products. They regulate all aspect of irradiation; including the type of food that can be irradiated and the doses that can be used as well as the labelling of the product. It is required that products that are irradiated bears the international symbol called the radura, and also the processor must also add information explaining the reason for using irradiation on the food product (FDA, 2003).

Ionizing radiation is defined as radiation that has enough energy to remove electrons from atoms, thereby leading to the formation of ions. There are different types of ionizing radiation such as X-rays, gamma-rays, and beta-rays. In X-ray irradiation, rays are generated by colliding accelerated electrons with a dense material such as tantalum or tungsten in a process called bremsstrahlung-conversion. This type of irradiation has a deep penetration. Though it is scalable, electron source stops radiating when it is switched off but this does not occur when colbalt-60 source is used. The advantage of this is that, there is uniformity but the systems have low energetic efficiency during the conversion of electron to photon radiation. The nominal X-rays maximum energy is 5 MeV (Codex Alimentarius Commission 1984).

Gamma irradiation also involves radiation of photons in the gamma part of the electron magnetic spectrum. Radiation is achieved by using radioisotopes usually a colbalt-60 source or caesium -137. However, mostly food irradiation is done using a colbalt-60 source because of its high penetration ability. The irradiation sources that

have been internationally approved for food processing are gamma rays produced from the radioisotopes cobalt-60 (1.17 and 1.33 MeV) and cesium-137(0.662 MeV), machine-generated electron-beams (maximum energy 10 MeV). This colbalt-60 source is produced from colbalt-59 source (FAO, IAEA, WHO, 1981).The facilities that provide ionizing radiation share common features such as the irradiation source or sources, shielding, product handling systems, and safety/control systems (Olson 1995).

There are a number of purposes for irradiating fresh vegetables, including the extension of shelf life by the delay of ripening and senescence, and the control of fungal pathogens which lead to rotting and insect disinfestation. Fresh vegetables have living cells and irradiation can affect the life cycle of the cells. However such changes may not be immediately apparent, but may manifest in the latter. The main problems associated with these products are textural problems which result from radiation-induced depolymerisation of cellulose, hemicellulose, starch and pectin, leading to softening of the tissue. This effect is dose-related and hence low doses are usually used (Brennan and Day, 2006). Nutritional losses at such doses are minimal. Other disorders include discolouration of skin, internal browning and increased susceptibility to chilling injury. Tolerance to radiation varies. Combination treatments involving low dose irradiation and hot water or chemical dips, or modified atmospheres, may be effective (Kader, 1986).

The radiation doses suitable for food systems cause very little physicochemical damage to the actual food (Josephson, 1983).The mineral content of foods is unaffected by irradiation, although the status of minerals could be changed, for instance the extent of binding to other chemicals. This could feasibly affect their

bioavailability of the mineral content of the food product. The major effect of radiation on carbohydrates in food products is the breakdown of the glycosidic bond in starch, pectin or cellulose to give smaller carbohydrates. This can lead to a reduction in the viscosity of starches, or a loss of texture in some foods, for example leading to the softening of some fruits and vegetables (Josephson, 1983).

Irradiation of food products that are high in proteins at doses up to 35 kGy causes no noticeable reduction in amino acid content and hence no reduction in their protein nutritional quality. Moreover, changes in secondary and tertiary structures are also minimal, although there may be isolated examples where functionality is impaired. The effects on enzyme action are very limited and are probably undetectable at the doses likely to be used for foods (Brennan and Day, 2006).

Insignificant changes in the physical (viscosity, melting point) and many chemical properties (iodine value, peroxide number etc.) of lipids are produced by irradiation up to 50kGy. The major concern with fat-containing foods is the acceleration of autoxidation when irradiated in the presence of oxygen. Unsaturated fatty acids are converted to hydroperoxyl radicals, which form unstable hydro-peroxides, which break down to a range of mainly carbonyl compounds. Many of the latter have low odour thresholds and lead to rancid off flavours. However the same end products are found in even unirradiated lipids that are stored over a long period of time (Urbian, 1986).

Loss of vitamins during processing is an obvious concern and has been studied in great detail in a variety of foods and has been found to be the same as losses caused by heat processing methods. However, there are radiolytic products that are created by the interactions of radiations with the food substance. Mostly these products are

formed by the radiation breaking molecular bonds in water, leaving free radicals that in turn either recombine into water or react with other chemicals. Other radiolytic products form when complex protein molecules are broken into smaller units (WHO, 1994). Inactivation of vitamins results mainly from their reaction with radiolytic products of water and this is dependent on the chemical structure of the vitamin. The degree of inactivation is also determined by the composition of the food, as other food components can act as 'quenchers', in competition for the reactive products. This has led to an overestimation of vitamin losses in the literature where irradiation of pure solutions of vitamins has been studied.Though it is claimed that there are no changes in the nutritional values of irradiated foods, studies have shown that vegetables exposed to gamma radiation may have vitamin C levels decreased by as much as a 12 percent. Another consideration is the role of post irradiation storage where, in common with other processing methods, further breakdown of some vitamins may occur. Hence, losses of vitamins during irradiation vary from vitamin to vitamin and from food to food and are obviously dose-dependent. In addition, subsequent storage or processing of food must be considered (Stewart, 2001).

According to Stewart (2001), the sensitivity of water-soluble vitamins to radiation follows the order: vitamin B1>vitamin C>vitamin B6>vitamin B2>folate=niacin> vitamin B12, while the sensitivity of fat-soluble vitamins follows the order: vitamin E>carotene>vitamin A>vitamin D>vitamin K. As a general rule, vitamin losses during food irradiation are quite modest compared to other forms of processing.

2.9. 2.1 Effect of radiation on the microbial profile

During irradiation, there is a break in the bonds of the DNA molecules of the microbes that may be present in the food and this causes a defect in the genetic

instruction of the microbes (Goresline, 1973). The effectiveness of this depends on the organisms' sensitivity to irradiation and the rate at which it can repair its damaged DNA and also the amount of DNA in the target organism. Early work on the use of radiation on fruits and vegetables was to extend shelf life and as a quarantine treatment for export/import purposes. Even though quarantine-based irradiation is widely used (example: to export fruits from Hawaii onto the United States mainland (Bartek and Lukas 2003), there is considerable interest at this time in using ionizing radiation to eliminate human enteric pathogens on these products. This is because, biological systems do have a capacity to repair both single- and double-stranded breaks of the DNA backbone (Bartek and Lukas 2003), and the damage occurring from ionizing radiation is probably so extensive that bacterial repair of radiation damage at doses used in food irradiation is nearly impossible.

Microbial cells, depending on their physiological state, can exhibit varying resistance to ionizing radiation. Bacterial cells in logarithmic growth phase have multiple copies of their genomes in one cell. This is because; the presence or absence of multiple genome copies and the physiological status of the cell can dictate whether the cell can ultimately reproduce; that is, the probability of "survivors" in a pathogen population exposed to ionizing irradiation. Similarly, the formation of bacterial endospores can enhance the radiation resistance of these organisms.

Fruits and vegetables become contaminated with enteric pathogens at various stages of production, beginning at the farm-level (Endley *et al.,* 2003). Recent studies have also documented the internalization of enteric pathogens into fruits and vegetables. There have been foodborne outbreaks associated with the consumption of contaminated apples, mangoes, and tomatoes. Under this scenario, it is evident that

conventional intervention strategies will not be able to address internalized pathogens. Ionizing radiation is probably one of the few technologies that can be used to eliminate pathogens in fruits and vegetables once they are internalized. However, significant research related to preserving the sensory attributes of fruits and vegetables under such treatment conditions still remains to be done. Herbs and sprouts such as cilantro, parsley, and bean sprouts, which are very popular, are extremely vulnerable to enteric organisms such as *E. coli* O157:H7 has been found to be more sensitive to radiation than *Salmonella*. It has a D value ranging from 0.2-0.4 kGy. Bari *et al.*, (2003) have reported that an irradiation dose of 2.0 kGy in combination with dry heat eliminated *E. coli* O157:H7 completely from alfalfa and mung bean seeds, whereas a 2.5 kGy of radiation was required to eliminate the pathogen completely from radish seeds. While studying broccoli seeds and sprouts, Rajkowski *et al.*, (2003) reported that the germination percentage decreased at a dose level of 4 kGy, whereas the yield ratio, sprout length, and thickness decreased at the 2 kGy dose level. The radiation doses required to inactivate *Salmonella* spp. and strains of *E. coli* O157:H7 were different than previously reported values and depended on whether the strains were originally isolated from vegetables. The D_{10} values for the vegetative and non-vegetative *Salmonella* spp. isolates were 1.10 kGy and 0.74 kGy, respectively, whereas the D_{10} values for the vegetative and non-vegetative strains of *E. coli* O157:H7 were 1.11 kGy and 1.43 kGy, respectively.

Thayer *et al.*, (2003) reported that 2 kGy is capable of eliminating *Salmonella* spp. And *E. coli* O157:H7 while still retaining satisfactory yields of alfalfa sprouts.

However, viruses which are also related to food-borne illness are resistant to radiation. Hepatitis A, most notorious of the viral food –related illness which causes

about 5% of all cases of Hepatitis A are resistant to radiation even at conventional doses and higher doses would have undesirable effects on the characteristics of infected food and reduce the shelf-life of the product.

Irradiation of food products have also been found not to stop spoilage of product once it is in its deterioration state. This is because spoilage microbes multiply quickly and grow in a variety of conditions, so even if products are irradiated spoilage microbes still grow.

2.9.3 Effect of Blanching on Leafy Vegetables

One common technique employed to arrest enzyme activity and associated changes before processing is blanching (Masure and Campbell 1994). Blanching involves the use of mild heat in different heating systems such as steam, hot water and microwave. This causes cell death and physical and metabolic chaos within the cells of the vegetables. The heating effect leads to enzyme destruction as well as damage to the cytoplasmic and other membranes, which become permeable to water and solutes. An immediate effect is the loss of turgor pressure. Water and solutes may pass into and out of the cells, a major consequence being nutrient loss from the tissue. Also, cell constituents which had previously been compartmentalised in subcellular organelles, become free to move and interact within the cell (Brennan and Day, 2006).

The major purpose of blanching is generally to inactivate enzymes, which would otherwise lead to quality reduction in the processed product, and also reduce the microbial population on the surface of the fresh produce. It causes the removal of gases from plant tissues, especially intercellular gas which is useful in avoiding oxidation of the product and corrosion of the cans that may be used for packaging.

Removal of gases, along with the removal of surface dust, has a further effect in brightening the colour of some products, especially green vegetables (Fellows, 2000).

Shrinking and softening of the tissue is a further consequence of blanching. This is of benefit in terms of achieving filled weight into containers, so for example it may be possible to reduce the tinplate requirement in canning. It is important to control the time/temperature conditions to avoid over processing, leading to excessive loss of texture in some processed products. Addition of calcium chloride or sodium chloride to blanching water helps to maintain the texture of plant tissue through the formation of calcium pectate complexes. Also steam blanching is normally recommended since there is less loss of water-soluble vitamins. However, there is weight loss from the tissue since both water and solutes are lost from the cells after blanching (Akad, 2002).

Another advantage of blanching is that it acts as a final cleaning and decontamination process. Selman (1987) described the effectiveness of blanching in removing pesticide residues or radionuclides from the surface of vegetables, while toxic constituents naturally present (such as nitrites, nitrates and oxalate) are reduced. Very significant reductions in microorganism content can be achieved, which is useful in frozen or dried foods where surviving organisms can multiply on thawing or rehydration. It is also useful before heat sterilisation if large numbers of microorganisms are present before processing.

Steam blanching done within a short period has been identified by Gupta *et al.*, (2008) to have higher retention of ascorbic acid range from 11-25% than any other method as well as a better appearance.). A study by Mepba *et al.* (2007) indicated

that blanching and cooking significantly (P≤0.05) decreased levels of phosphorus, calcium in the leafy vegetables.

2.10 Packaging

Packaging is defined in terms of its protective role as a means of achieving safe delivery of products in sound condition to the final user at a minimum cost or it can be defined in business terms as 'a techno-economic function for optimising the costs of delivering goods whilst maximising sales and profits'. It is also one of the most important processes to maintain the quality of food products for storage, transportation and end-use (Kelsey, 1985). It prevents quality deterioration and facilitates distribution and marketing. The basic functions of packaging are protection, containment, information and convenience (Kelsey, 1985). A good package can not only preserve the food quality but also significantly contribute to a business profit. Beyond the major function of preservation, packaging also has secondary functions such as selling and sales promotion. However, the main function of food packaging is to achieve preservation and the safe delivery of food products until consumption. During distribution, the quality of the food product can deteriorate biologically and chemically as well as physically. Therefore, food packaging contributes to extending the shelf life and maintaining the quality and the safety of the food products.

The quality of the packaged food is directly related to the food and packaging material attributes. Most food products deteriorate in quality due to mass transfer phenomena, such as moisture absorption, oxygen invasion, flavour loss, undesirable odour absorption, and the migration of packaging components into the food (Kester and Fennema, 1986; Debeaufort *et al*., 1998). These phenomena can occur between

the food product and the atmospheric environment, between the food and the packaging materials, or among the heterogeneous ingredients in the food product itself (Krochta, 1997). Therefore, mass transfers studies on the migration of package components and food ingredients, on the absorption and desorption of volatile ingredients, flavours and moisture, on gas permeation, and on the reaction kinetics of oxidation and ingredient degradation are essential for food packaging system designs.

Packaging facilitates the delivery of fresh-cut products of good quality to the consumer. Packaging protects products from physical damage and prevents physical and microbiological contamination. Packaging can on some occasions, as in the case of modified atmosphere packaging (MAP), delay spoilage of products. Cut fruits and vegetables deteriorate more rapidly than intact or packaged products.

Attention must be paid to the compatibility of produce, where mixed fruit and vegetable combinations are packaged. Ethylene-sensitive and ethylene-producing fruits should not be mixed, as this could result in water soaking and rapid deterioration of ethylene-sensitive produce. Packaging formats for fresh-cut fruits and vegetables include plastic bags, thermoformed containers with film overwraps and rigid plastic containers. Packs are filled by hand in small operations, while automated equipment is used in larger operations. A metal detector is generally positioned at the end of the line in automated operations and bags of products pass through the detector as a control measure to test for metal contaminants.

MAP reduces the respiration rate of produce and thus slows the rate of spoilage. In addition, it creates anaerobic conditions or high carbon dioxide and low oxygen levels in the pack, to extend fresh produce shelf-life. Oriented polypropylene (OPP)

is generally used in the MAP of fresh-cuts. Other packaging films used include perforated, thin, low density polyethylene (LDPE), monolayer polyvinylchloride (PVC) and ethylene vinyl acetate.

2.10. 1 Factors affecting selection of packaging material for leafy vegetables

2.10.1.1 Mechanical damage

Fresh, processed and manufactured foods are highly susceptible to mechanical damage. The bruising of soft fruits, the breakup of heat processed vegetables are examples. Such damage may result from sudden impacts or shocks during handling and transport, vibration during transport by road, rail and air and compression loads imposed when packages are stacked in warehouses or large transport vehicles. Appropriate packaging can reduce the incidence and extent of such mechanical damage (Brennan and Day, 2006). Packaging alone is not the whole answer. Good handling and transport procedures and equipment are also necessary .The selection of a packaging material of sufficient strength and rigidity can reduce damage due to compression loads. Metal, glass and rigid plastic materials may be used for primary or consumer packages. Fibre board and timber materials are used for secondary or outer packages (Brennan and Day, 2006).

2.10. 1.2 Permeability characteristics

The permeation rate of water vapour, gases such as oxygen, carbon dioxide, nitrogen and ethylene and volatile odour compounds into or out of the package is an important consideration, in the case of packaging films, laminates and coated papers. This is because foods with relatively high moisture contents tend to lose water to the

atmosphere than those with low relative humidity. When there is loss of water, there is loss in weight and deterioration in appearance and texture of the food product. This is because; products with relatively low moisture contents will tend to pick up moisture, when exposed to a high humid atmosphere. To retain the pleasant odour associated with many foods, it is necessary to select a packaging material that is a good barrier to the volatile compounds which contribute to that odour. Such materials may also prevent the contents from developing taints due to the absorption of foreign odours. Where some movement of vapours and or gases is desirable, films that are semi permeable to them may be used. For products with high respiration rates the packaging material may be perforated. A range of micro perforated films is available for such applications (Brennan and Day, 2006).

2.10.1.3 Temperature

A good packaging material should be able to withstand the changes in temperature which it is likely to encounter, without any reduction in performance or undesirable change in appearance. This is of particular importance when foods are heated or cooled in the package. Some packaging films become brittle when exposed to low temperatures and are not suitable for packaging frozen foods. The rate of change of temperature may be important. For example, glass containers have to be heated and cooled slowly to avoid breakage (Brennan and Day, 2006).

2.10.1.4 Light

Many food components are sensitive to light, particularly at the blue and ultraviolet end of the spectrum. Vitamins in leafy vegetables may be destroyed and colours may fade when exposed to such light waves. The use of packaging materials which are opaque to light will prevent these changes. If it is desirable that the contents be

visible, high-density polyethylene or low-density polyethylene may be used for vegetables and fruits (Brennan and Day, 2006).

2.10.1.5 Protection against microbial contamination

Another role of the package may be to prevent or limit the contamination of the contents by microorganisms from sources outside the package. This is most important in the case of foods that are heat-sterilized in the package, where it is essential that post process contamination does not occur.

The permeability of the packaging material to gases and the packaging procedure employed can influence the type of microorganisms that grow within the package. Packaging foods in materials that are highly permeable to gases is not likely to bring about any significant change in the micro flora, compared to unpackaged foods (Brennan and Day, 2006).

CHAPTER THREE: MATERIALS AND METHODS

3.1 Sample collection and sample preparation

Fresh fully opened cocoyam leaves which were 2 weeks old were harvested from the Biotechnology and Nuclear Agriculture Research Institute (BNARI) farm and used for the study. After harvesting, the cocoyam leaves were sorted out to remove all debris, bruised leaves and other unwanted particles. They were then washed in 50% brine solution and put into a sterilized bowl. The chopping board used for shredding was first sterilized with 70% alcohol. After shredding, the cocoyam leaves were divided for the various treatments before packaging into zip-lock and hermetically sealed bags.

3.2 Determination of the best preservation method for storage of the leafy vegetables.

Two (2) major preservation methods and one pre-treatment method were used as treatments for storage of the leafy vegetables. Blanching was used as a pre-treatment and refrigeration and gamma irradiation were the preservation methods used. These treatments were combined to determine which of the combinations would significantly extend the shelf-life and maintain the product quality .The combinations used were: blanching and refrigeration, irradiation and refrigeration, blanching and irradiation, irradiation and refrigeration. Processed leaves were packaged and stored at ambient temperature and used as the control. The shelf-life study was carried out for a period of three weeks.

3.2.1. Refrigeration

Packaged processed leaves were stored in a West-point refrigerator (model WRG-110RS) at a temperature of 4 ± 2°C throughout the storage period of four (3) weeks. The refrigerator was calibrated at the mark of 7 that was the point at which the required temperature was attained. A thermometer was then placed in it to monitor the temperature required.

3.2.2. Blanching

Steam blanching method was used in order to retain most of the nutrients. This was done over boiling water containing 50% NaCl at a temperature of 100°C for two (2) minutes in a steamer for each of the leafy vegetables. The addition of the salt (NaCl) was to help improve the colour. After blanching, the leaves were allowed to cool to room temperature before packaging into the zip-lock polyethylene bag and hermetically sealed polyethylene bag. Some of the packaged leaves were stored at room temperature of 30±2°C and some in the refrigerator.

3.2.3. Irradiation

Packaged samples were irradiated at the Radiation Technology Centre for irradiation. Irradiation was done after packaging at absorbed doses of 0.5 kGy, 1.0 kGy, 1.5k Gy and 2.0kGy at a dose rate of 2.032kGy/hr. After irradiation, samples were stored at room temperature (30±2°C) and in the refrigerator. Unrradiated sample (0 kGy) was used as the control.

Plate 1: Photograph of shredded cocoyam leaves used for the shelf-life study

Plate 2: Photograph of steam blanched cocoyam leaves used for the study

Plate 3: Photograph of shredded cocoyam leaves stored in zip-lock polyethylene bags

Plate 4: Photograph of shredded cocoyam leaves stored in a hermetically sealed polyethylene bag

3.3 Microbiological Analysis

3.3.1Alkaline peptone water (Pw)

Fifteen grams of tryptone soya broth was mixed with 500 mL of distilled water. The mixture was put on the magnetic stirrer at a temperature of 250 °C for 10 minutes until the mixture was completely dissolved and warm. Ten millilitres (10 mL) of the mixture each was pipetted into universal bottle and autoclaved at 121 ^{0}C for 15 minutes, allowed to cool and stored. This was repeated until enough peptone was prepared for all the samples.

3.3.1.2 Plate Count Agar medium (PCA)

Tryptone glucose yeast agar (PCA, 17.5 g) was dissolved in 1 litre of distilled water. This mixture was stirred with a magnetic stirrer at 250 °C for 15 minutes. It was sterilized in an autoclave at 121 °C for fifteen minutes (15 minutes).

3.3.1.3 Violet Red Bile Agar medium (VRBA)

One litre of Violet Red Bile Agar medium was prepared by mixing 41.53 g of VRBA and 10 g of purified agar in a beaker and boiled in a water bath after the mixture had completely dissolved in one litre of distilled water. The medium was sterilized in an autoclave at 121 °C for fifteen minutes.

3.3.1.4 Eosine Methylene Blue Agar medium (EMB)

Ten (10) g and 53 g of purified agar and EMB agar were respectively weighed into a beaker and dissolved in one litre of distilled water. Aliquot of 10 mL of the sample was poured into screwed capped McCartney bottles for sterilization at 121 ^{0}C for 15 minutes and stored at 8 ± 2 ^{0}C.

3.3.1.5 OxytetracylineGlucose Yeast Extract Agar (OGYEA)

Yeast extract of 2.5 g, 7 g of purified agar and 10 g of glucose were weighed into a conical flask and mixed with 500 mL distilled water. The mixture was stirred with magnetic stirrer at 250 ^{o}C until it was completely dissolved. The media was stored in a laminar flow at room temperature after preparation.

3.3.1.6 Nutrient agar medium (NA)

Twenty eight (28) grams of Nutrient agar and 10 g of purified agar were completely dissolved in one litre of distilled water in beaker, boiled in water bath at 98 ^{0}C for 15 minutes after which 10 mL was aliquoted into McCartney bottles and autoclaved at 121 ^{0}C for 15 minutes. They are then stored at 8 ± 2 ^{0}C until they are used.

3.3.1.7 Xylose Lysine Desoxycholate (XLD) medium

XLD agar (53.5 g) was mixed with 10 g of purified agar and dissolved in one litre of distilled water in a beaker. The mixture was then put into a water bath for 15 minutes at 98 ^{0}C. Aliquot of 10 mL of the samples were put into McCartney bottles for sterilization at 121 ^{0}C for 15 minutes and stored under the laminar flow.

3.3.2 Determination of Total Plate Count (Aerobic Mesophiles)

Ten (10) grams of the leafy vegetables used was added to 90 mL of 0.1% peptone water (Pw) to form a stock solution which was agitated and then incubated at 37^{0}C for 15 minutes. The stock solution was serially diluted using 10 fold serial dilution up to 10^{5} into 10 other sterile McCartney bottles containing 9 mL peptone water. Using the pour plate method, One (1) mL of the suspension was picked onto a sterilized petri-dish and nine millilitres (9 mL) of the plate count agar was added. This was mixed by rotating the petri-dishes under the laminar flow at 45-50 ^{O}C. The

media were allowed to cool and set and then incubated at 37 ^{O}C for 18-24hours in a microbiological incubator (Westach). Plates were selected for count using the colony counter. Based on the dilution factor the count is expressed as A × 10^{B}cfu/g, where A is the colony counted, B is the dilution factor and CFU/g is colony forming unit per gram for microbiological determination.

3.3.3 Determination of Total coliform Count (TCC)

Using serial dilution method, one millilitre of the prepared sample was added to the 9 mL of Violent Red Bile Agar (VRBA), mixed well by rotating under the laminar flow and allowed to cool and incubated at 37^{0}C for 18 – 24 hours. Colonies were counted and expressed in CFU/g.

3.3.4 Determination of Moulds and Yeasts Count

Using the serial dilution technique, 1 mL suspension was dispensed into sterilised petri-dish and 9 mL of OGYEA agar was added. The mixture was agitated and allowed to solidify and incubated at 30 ^{0}C for 24 hours. Counting was done using colony counter from the plate that yielded between 30-300 colonies.

3.3.5 Isolation and Identification of Coliform Bacteria

Using a sterile inoculating loop, stock solution of sample was picked onto the Blood agar and McConkey medium and incubated at 37^{0}C for 18-24hours. Physiological characteristics of the colonies formed were examined separately. Pure colonies were sub cultured onto Nutrient agar (NA) medium and Eosine methyl blue agar (EMBA)-(Merck, Darmstadt-Germany) medium and incubated again at 37^{0}C for 18 -24 hours. Colonies were Gram stained using crystal violet stain and observed under light microscope at x100 with oil immersion for physiological characteristics and cellular

morphology. Based on these, catalase, oxidase motility indole urea and citrate tests were performed to identify organisms from coliform group.

3.3.5.1 Catalase test

The Becton Dickinson catalase package insert method (1999) was used for the catalase test. A pure culture of the organism was tested. An inoculum from the pure culture was picked with the inoculating needle and streaked on a sterile plate of general purpose growth medium. The inoculated plate was incubated at 35-37° C for 24 hours. One to two drops of catalase containing hydrogen peroxide was added to the smear and examined immediately for the evolution of bubbles. Small amount of the blood- containing agar was taken with a loop and used as the control.

Positive catalase reactions were denoted by the production of bubbles that occurred after the addition of the reagent to the culture. Microorganisms which produced the enzyme break down the hydrogen peroxide, and results in O_2 production which produces bubbles in the reagent drop. However, a negative catalase reaction may occur when organisms present lack the cytochrome system and the catalase enzyme and are unable to break down hydrogen peroxide, into O_2 and water.

3.3.5.2 Oxidase test

The Clinical Microbiology procedure (2004) was used for the oxidase test. This test was used for the screening of *Pseudomonas spp.* which gave a positive test and *Enterobacteriacea coli* which was not detected in all samples stored.

Oxidase test was conducted using the filter paper method. Oxidase reagent was specially prepared with 10g/ l M or 1 % solution of tetramethyl-p-phenylene diamine dihydrochloride. Filter paper was paper in petri dish and three (3) drops of freshly

prepared oxidase reagent was added. A sterile rod was used to remove a colony of test organisms from a culture plate and smeared onto the filter paper.

Oxidase positive organisms showed a blue colour within 5-10 seconds, and in oxidase negative organisms, colour did not change. Further work was done to examine the motility of the organisms detected.

3.3.5.3 Motility test

The motility test was conducted using the motility medium method (motility indole urea medium) following the Clinical Microbiology procedure (1999).

A wire loop was used to stab the medium in a tube containing the motility medium. The formation of a semisolid medium indicated the motility, ornithine decarboxylase activity and indole production of the organism. The formation of cloudiness throughout the medium indicated the motility of the organism. Whiles the formation of cloudiness along the stab-line indicated the non-motility of the organism.

Result was written as motile or non-motile. Non-motile organisms were identified by their lack flagella and the formation of a single line of growth that did not spread into the surrounding area. Whiles a motile bacterium grew and made a hazy zone around the stab line.

3.3.5.4 Citrate test

Manual of Clinical Microbiology procedure was used in conducting the citrate test. This was used for screening for *citrobacter spp, Enterobacteriacea coli and salmonella spp.*

Simmons citrate agar which contains mineral salts, sodium citrate, and ammonium phosphate was used for the test. The pH meter model Mettler Toledo (T 3KfTLH)

was used to assess the pH of the medium before it was used. The colour of the medium was green at neutral p*H*, yellow at acidic pH < 6.0 and blue at alkaline (basic) pH > 7.6.

An inoculum from a pure culture was transferred aseptically into a sterile tube of containing simmons citrate agar. The inoculated tube was incubated at 35-37° C for 24 hours and the results were determined. Copious growth on the slant and change in colour of the medium from green to blue indicated positive test for growth using citrate.

3.4. Physicochemical properties

3.4.1 Determination of Moisture content

The AOAC (1995) method was used to determine the moisture content of the processed cocoyam leaf. Two (2) grams of samples of each treatment was weighed on the scale and used for determining the moisture content. The weight of an empty petri- dish was determined and recorded as W_1 after which that of the petri- dish and 2 g of the sample was weighed and recorded as W_2. They were then dried in a

ventilated oven at 130 °C for one hour. Samples were removed and cooled in a desiccator and reweighed with the dried samples as W_3.

Percentage moisture (%) = $\frac{W_2 - W_3}{W_2 - W_1} \times 100$

3.4.2. Determination of Dry matter Content

This was obtained from the dry solids remaining in the moisture content determination.

Total solids = 100- % moisture content.

3.4.3 pH Determination

The pH of the green leaves were measured according to analysis AOAC (2000)

Ten grams of samples of each of the treatment used was taken and blended in a Binatone blender (model: BLG-401) in 100 mL of distilled water and then sieved with a cheese cloth. The pH was measured using pH meter model Mettler Toledo (T 3KfTLH).

3.4.4 Determination of Crude protein

3.4.4. 1 Digestion

Crude protein determination was done using the Kjeldahl Method (Block Digestion). Samples of each of the treatments was oven dried overnight in a ventilated oven at a temperature of 60 °C, cooled and then ground with mortar and pestle. Samples of each treatment of 0.1 g were weighed and transferred into digestion tubes. Five (5 mL) of sulphuric acid was added to each of the weighed sample and allowed to settle for 30 minutes before digestion was done. After a period of 30 minutes fumes

were seen and drops of hydrogen peroxide were added to each of the digestion mixture until no bubbles were seen and mixture became clear. After the set period, the block digester was turned off and allowed to cool. Each of the digest was poured into a clean 100 mL volumetric flask. Distilled water was added to each of the digests in the 100mL conical flask until the 100 mL mark was reached.

3.4.4. 2 Distillation/Titration Quantification

The distillation apparatus was set up. Five (5 mL) of NaOH and 5 mL of the digested extract were measured and poured into the alkali tank of the distillation apparatus simultaneously and locked to prevent its escape during the distillation process. 100 mL titrating flasks each containing 5 mL boric acid and two drops of mixed indicator were placed on the receiving platform of the condenser one after the other to collect the distillate from their respective digests. The taps were turned on and each digest was distilled, condensed and collected into one of the titrating flask containing the 5mL boric acid indicator. After the content of a titrating flask had reached the 50mL mark, the distillation was stopped for that sample. This was repeated for the distillation, condensation and collection of all the digests after the apparatus had been rinsed with distilled water. Each sample was analysed in replicate.

3.4.4. 3 Titration

Each distillate was titrated against 0.1N HCl solution until the bluish green colour of the distillate changed to wine. The volume of HCl that was required to neutralize each distillate was noted as sample titre (S). The volume of HCl that was required to titrate each reagent blank distillate was noted as Blank titre (B)

Percentage Nitrogen on Dry matter basis =

$$\frac{(Va-Vb)\times NA\ acid(Hcl)\times 14\times 100}{5\ mL\ of\ digested\ sample \times 100 \times sample\ weight}$$

Va= volume in mL of standard acid used in titration

Vb= volume in mL of standard acid used in blank

NA= normality of acid(HCl)

Percentage Crude Protein =Percentage Nitrogen (DM basis) × F

F (factor) = 6.25

3.4.5. Vitamin C (Ascorbic acid) analysis (AOAC, 2000)

Vitamin concentration was determined in each treatment sample using the radox titration using iodine solution. A standard solution was preparation with a single laboratory vitamin C tablet dissolved in 250 mL of distilled water in a volumetric flask.

An iodine solution of 0.005 mL/ L was prepared using 2 g of potassium iodide and 1.3 g of iodine solution dissolved in 1 litre of distilled water in a volumetric flask.

Starch indicator solution of 1 % was prepared by dissolving 0.5 g of potato starch in 50 mL of distilled water.

3.4.5. 1 Titration of the Standard Solution

A mixture of ten mililitres (10 mL) of the vitamin C standard solution, one mililitre (1 mL) of the distilled water and one (1 mL) of starch indicator was titrated with 0.005 mol/L iodine solution. This was replicated and the average was calculated.

3.4.5. 2 Titration of Sample

A mixture of 10 mL of each of the sample, 1 mL of distilled water and 1mL of starch indicator solution. Each sample was replicated and the average was calculated.

$$\text{Standard} = \frac{\text{Volume (mL) iodine solution}}{\text{Vitamin C (grams)}}$$

$$\text{Sample} = \frac{\text{Volume (mL) of iodine solution}}{\text{End point of titration}}$$

Standard volume of iodine solution =

0.005 × 176.12 × titre value of vitamin C tablet × 1000 mg

3.4.6 Colour analysis

The colour changes of each of the treated leafy vegetable were recorded weekly with a colorimeter (CR-310 Minolta). The colour reading was based on the instrument colour readings on L*a*b scale. This instrument has a data processor and a 50 mm diameter covering the head space that covers the specimen during reading. The headspace prevents external light from interfering with the colour of the specimen. It was calibrated using a standard white tile. The light projection aperture was positioned directly on top of the leaves, which were placed on a flat surface. The L-value is a representation of the amount of lightness of the sample(“0 for black, “100” for white) ; a-value represents the redness or greenness of the sample(+ “100” for red and “-80”for green). A positive a-value is an indication of redness and a negative a-value is a representation of the greenness of the sample, the higher the negative green value the more greenness contained in the sample. b-value represents the yellowness or blueness of a sample (“+70” for yellow and “-80” for blue). The higher the b-value, the more yellowness contained in the sample.

3.5 Phytochemical Analysis

3.5.1 Extraction of Phytochemical Compounds

Phenolic compounds and flavonoids in the leafy vegetable were extracted according to AOAC (1995). For each of the samples, 0.05 g was weighed on an analytical balance into extraction bottles. Five millilitres (5 mL) of 60 % methanol was added to each of the samples, shaken for two (2) minutes with the vortex and then placed into a water bath at 60^{o}C for 15minutes. Samples were removed from the water bath and the clear liquid was decanted into a 50 mL extraction bottles. This was repeated until the liquid on the residue became colourless. The extract and the residue were both stored in the refrigerator at 2^{o}C to monitor whether there would be any change in colour in the residue of the extract after sometime. Each extract was poured into 50 mL volumetric flask and topped up with 60% methanol and poured back into 50mL plastic tubes and stored in the refrigerator at 2^{o}C. The extract was used for both the phenolic and flavonoid analysis.

3.5.2 Total phenolic determination using the Folin- Ciocalteu method

According to the procedure of Singleton *et al.*, (1999). The total phenolic compounds in the cocoyam leaves extract was determined by the Folin-Ciocalteu method. A calibration curve was first prepared using the gallic acid standard with dilutions indicated in the Table 1 below:

Table 1: Gallic acid standard preparation and the dilution factors

Gallic acid standard	
Concentration	Dilution factor
0.6mg/L	4mL of distilled water
0.40 mg/L	6mL of distilled water
0.15 mg/L	8.5 mL of distilled water
0.1 mg/L	9.9 mL of distilled water

Three (3 mL) of distilled water was added to each of dilutions and two-hundred and fifty microlitres (250 µl) of folin ciocalteau in (1/10) % also added. Seven hundred and fifty microlitres (750 µl) of sodium carbonate ($NaC0_3$) was also added. This was then incubated at ambient temperature for 30 minutes and absorbance readings were taken using spectrophotometer (model: uv-1201) at 760 nm wavelength.

Fifty microliters (50 µl) of each sample extract was pipetted into glass a test tube after which 3 mL of distilled water was added to each of the sample extract. Two-hundred and fifty micolitres (250µl) of ten percent of folin ciocalteau was then added followed by 750µl of sodium carbonate ($NaC0_3$). This was then incubated at ambient temperature for 30 minutes and absorbance readings were taken at 760nm using spectrophotometer (uv-1201). All determinations were performed in triplicate. Total content of phenolic compounds in each sample extract in gallic acid equivalents (GAE) was calculated by the following formula:

$C = cV/m$

Where: C =total content of phenolic compounds in mg/g cocoyam leaf extract, in GAE; c = the concentration of gallic acid established from the calibration curve in mg/mL; v = the volume of extract in mL; m = the weight of vegetable aqueous extract in gram.

3.5.3 Total flavonoid using aluminum chloride colorimetric method

Total soluble flavonoids were expressed as quercetin equivalent (QE). Quercetin was used to make a calibration curve (standard solutions of 2.5, 6.25, 7.5, 12.5, and 25 µg per mile of distilled water). Five hundred microlitres (500µl) of the extract was mixed with 1500 µl of 95 % ethanol (v/v) and 100 µl of potassium acetate in 1M added to the mixture.100 µl of aluminum chloride ($AlCl_3$) (m/v) of 1 mol/L

potassium acetate was also added. A volume of 10% (m/v) $AlCl_3$ was substituted by the same volume of distilled water as blank. After incubation at room temperature for 30 minutes, the absorbance of the reaction mixture was measured with a spectrophotometre (uv-1201) at 415 nm wavelength. The total flavonoids content in the fractions was determined as µg quercetin equivalent by the calibration curve. The flavonoid content was expressed as mg QE/100g FW Where: FW = fresh weight.

3.6 Sensory quality

The affective sensory evaluation method was used to assess consumer acceptance for three attributes (colour, texture, and odour) of processed cocoyam leaf. The nine (9) point hedonic scale was used for the preference test. The following interpretations were given to the hedonic scale; 9.00 to 9.99 – like extremely; 8.00 to 8.99 – like very much; 7.00 to 7.99 – like moderately; 6.00 to 6.99 – like slightly; 5.00 to 5.99 – neither like nor dislike; 4.00 to 4.99 – dislike slightly; 3.00 to 3.99 – dislike moderately; 2.00 to 2.99 – dislike very much.

Fifty (50) untrained panellists were recruited (all workers of Ghana Atomic Energy Commission) were presented with coded samples of each of the treatments of the leafy vegetables and were asked to indicate their levels of acceptance by scoring and describing the odour, colour and texture.

3.7 Statistical analysis

Data obtained was analysed using the Statgraphics centurion software (version 16.0). The factorial experimental design was used for the study. The multifactor analysis of variance was used to assess whether the irradiation doses and the storage had an effect on the parameters analysed. The one-way analysis of variance (ANOVA) was used to determine the effect of treatments and storage without irradiation doses on the independent parameters analysed. The lowest significant difference (LSD) at 95 % confidence level was computed to ascertain the mean differences. Results were computed in graphs and tables using Microsoft Excel and Microsoft word on the Microsoft Office 2010 package.

CHAPTER FOUR: RESULTS

4.1 Effect of preservation methods on physicochemical properties of processed cocoyam leaves (*Xanthosoma sagittifolium*)'Kontomire'

4.1.1 Effect of irradiation on the physicochemical properties of processed cocoyam leaves (*Xanthosoma sagittifolium*)'Kontomire'

4.1.1.1 Effect of radiation and storage on the moisture content

Storage had significant effect ($p<0.05$) on the moisture content during storage in zip-lock polyethylene bag. There was an increase in moisture content after a week of storage in zip-lock polyethylene bag in all doses. For instance moisture content increased from 83.73 - 87.44 % during storage in the control and in 2 kGy it increased from 86.74 – 87 .62 % (Table 1a). Radiation doses during storage had no significant effect. (Appendix 1:A1). Also in the interaction of the doses and storage there was no significant difference ($p>0.05$) (Appendix 1:A1). The interaction of doses and storage showed no significant effect. There was an increase in moisture content with significant difference ($p<0.05$) in only the control at the initial week of storage. The lowest moisture content was recorded in the control with 83.73% and highest at 2 kGy with 86.74% at the initial storage period. However, after the storage period, the lowest moisture content was recorded at 0.5 kGy with 87.34 % whiles 2 kGy still recorded the highest moisture content of 87.64 % with signs of deterioration (Table 1a).

After irradiation and storage of processed cocoyam leaf in hermetically sealed polyethylene bag storage had no significant effect ($p<0.05$) on the doses (Appendix 1:A2). Storage also had significant effect ($p<0.05$).There was an increase during

storage, for instance there was an increase in moisture content in the control from 88.39 – 88.49 % (Table 1b). However there was no significant effect ($p>0.05$) in the interaction of the storage and doses (Appendix 1:A2). The increase moisture content in all the doses used were not significantly different ($p>0.05$) (Table 1b). Comparatively moisture content was significantly higher in samples stored in hermetically sealed polyethylene bag at all doses except 1.5 kGy (Figure 1). The highest mean of 88.99 % was recorded at 2 kGy from samples stored in hermetically sealed polyethylene bag and the lowest mean of 85.58 % was recorded at the control from samples stored in zip-lock polyethylene bag (Figure 1).

4.1.1.2 Effect of radiation and storage on dry matter content

In samples stored in zip-lock polyethylene bag, storage significantly ($p<0.05$) affected the dry matter. (Appendix 1:A3) There was reduction in the dry matter content with storage at all doses. For instance in the control, it decreased from 16.27 - 12.56 % and from 13. 26 - 12. 38 % at 2 kGy (Table 1a). However, storage had no significant effect ($p>0.05$) on dry matter (Appendix 1:A3) at 0.5kGy to 2 kGy (Figure 2).The interaction of doses and storage also showed no significant difference ($p>0.05$) (Appendix 1:A3).

In samples stored in hermetically sealed polyethylene bag, storage and interaction of doses and storage did not significantly ($p>0.05$) affect the dry matter content. (Appendix 1:A4).There was a decrease in the dry matter during storage at all doses which were not due to variations in doses. For instance the control recorded dry matter content of 12.58 % at the initial week but decreased to 11.20 % after a week of storage. Samples irradiated at 1 kGy recorded the lowest moisture content during storage. (Table 1b).Comparatively, dry matter was significantly different from each

packaging material at the control, 0.5 kGy, 1 kGy and 2 kGy except at 1.5 kGy (Figure 2). The highest mean of 14.42 % was recorded at the control from samples that were stored in zip-lock polyethylene bag and the lowest mean of 11.34 % was also recorded at 1 kGy from samples that were stored in hermetically sealed polyethylene bag (Figure 2).

4.1.1.3 Effect of radiation and storage on pH

Storage had significant effect on pH in samples stored in zip-lock polyethylene bag. (Appendix1:A5). There was an increase in pH at all doses during storage. For instance, the pH increased from 6.41 to 6.54 in the control and from 6.07 to 6.12 at 2 kGy during storage. The highest mean pH value was recorded at the control and 1kGy after the storage (Table 1a). Though there was an increase in pH at all doses during storage, they were no significant difference ($p>0.05$) (Figure3). In samples stored in hermetically sealed bag, storage did not have any significant ($p>0.05$) effect on the pH although there was an increase during storage (Table 1b).The highest pH was recorded at 2 kGy with 6.32, 6.37 and the lowest at 0.5 kGy with 5.52, 5.54 at the initial and final week of storage respectively. However, radiation doses had significant effect on the pH (Appendix 1:A6). Comparatively, there was significant difference between packaging materials in the control, 0.5 kGy and 1 kGy (Figure 3). The highest pH value was recorded in samples irradiated at 1 kGy stored in zip-lock polyethylene bag with 6.54 and lowest of 5.53 at 0.5 kGy from samples that were stored in the hermetically sealed polyethylene bag (Figure 3).

4.1.1.4 Effect of radiation and storage on vitamin C (ascorbic acid)

Storage had significant effect on the vitamin C content in both packaging materials (Appendix 1:A7 and A8). Storage reduced the vitamin C content after irradiation and storage in both zip-lock polyethylene bag and hermetically sealed polyethylene bag (Table 1a and 1b). For instance at the initial week, vitamin C content was 34. 58 mg/100g in the control of samples stored in zip-lock bag but decreased to 27.3 m g/100g during storage (Table 1a). Also with samples stored in hermetically sealed polyethylene bags, the lowest vitamin C content was recorded at 1.5 kGy with 1.7 mg/100g (Table 1b). Doses also significantly affected the vitamin C content in both packaging materials (Appendix 1:A7 and A8). There was a reduction and this was dose dependent (Figure 4). Comparatively, there were no significant differences ($p>0.05$) in vitamin C content between the two packaging materials (Figure 4).

4.1.1.5 Effect of radiation on crude protein

After irradiation and storage of processed leaf in zip-lock polyethylene bag storage, irradiation doses and interaction of doses and storage had significant effect on the crude protein content (Appendix 1:A9). There was an increase at irradiation doses of 0.5 kGy to 2 kGy during storage, but the increase was not significantly different ($p>0.05$) from each other in the control, 0.5 kGy and 1 kGy. For instance crude protein content was 1.38 % at 1.5 kGy but increased to 3.13 % during storage (Table 1a). There was also no significant difference ($p>0.05$) between 1.5 kGy and 2 kGy (Table 1a). Crude protein content in samples stored in hermetically sealed bag showed no significant ($p>0.05$) effect during storage. Also interaction of storage and doses showed no significant difference ($p>0.05$) on the crude protein content (Appendix 1: A 10).There was slight increase in the control during storage from 2.61

– 2.62 % (Table 1b). However, there was no significant differences ($p>0.05$) in the values recorded from doses of 0.5 kGy to 2 kGy (Table 1b). Dose had significant ($p<0.05$) effect on the crude protein content. (Appendix 1: A 10). There were variations in crude protein in doses (Figure 5). Comparatively, crude protein content was significantly different from each packaging material at the control, 1.5 kGy and 2 kGy (Figure 5). The highest mean of 2.61 % of crude protein content was recorded at the control of samples stored in hermetically sealed bag and the lowest mean of 1.28 % was recorded at 2 kGy in samples stored in hermetically sealed polyethylene bag (Figure 5).

4.1.1.6 Effect of radiation on colour

Storage and irradiation doses had significant effect on the L-value in samples stored in zip-lock bag, but no significant effect was seen in the interaction between storage and doses. (Appendix 1: A11).The L-value of the control showed tremendous increase from 16.93 to 43.08 during storage (Table 1a). Storage, irradiation doses as well as the interaction between storage and doses significantly affected the a-value during storage in zip-lock polyethylene bag (Appendix 1:A13). The a-value decreased at all irradiation doses but only control recorded an amount of -13.16 that was significantly higher during storage (Table 1a). However, there were no significance differences ($p>0.05$) in samples irradiated at 0.5 kGy to 2 kGy. The control of both packing materials recorded highest a- value of mean that was significantly different from all irradiated doses during storage (Figure7). Storage had significant effect, doses also had significant effect on the b-value in samples stored in the zip-lock bag, but no significant effect in the interaction of doses and storage

(Appendix 1:A15). Although there was an increase, there were no significant differences in the means during storage (Table1a).

In samples stored in hermetically sealed bag, storage had significant effect ($p<0.05$), doses had significant effect ($p<0.05$) but interaction of doses and storage had no significant effect ($p>0.05$) on the L value. (Appendix 1: A 12). L-value increased tremendously in the control from16.93 to 37.70 during storage but there was a reduction in samples irradiated at 0.5 kGy , 1 kGy ,1.5 kGy and 2 kGy (Table 1b). The increase in the control was significantly different ($p<0.05$) from the other doses used (Table 1b). Dose had significant effect on L-value on the control (Figure 6). Comparatively, L-value recorded the highest mean of 21.03 at 1 kGy from samples stored in zip-lock polyethylene bag but this was not significantly different from that recorded at 0.5 kGy, 1.5 kGy and 2 kGy (Figure 6).The lowest mean of L-value of 12.13 was recorded at the control of samples stored in hermetically sealed polyethylene bag (Figure 6). The a-value showed a decrease at all doses after the storage in hermetically sealed bag. For instance at the initial week of storage, mean a- value recorded for the initial week was -19.42 but it decreased to -13.16 during storage which was significantly different ($p<0.05$) from that recorded in the other doses (Table 1b). The a-value was significantly high with -17.74 in the control and the lowest of -2.04 was recorded at 2 kGy from samples stored in hermetically sealed polyethylene bag (Figure 7). However, there were no significant differences in means from each packaging materials at all doses (Figure 7). The b-value showed an increase in all doses during storage but the increase was less in 0.5kGy, 1 kGy, 1.5 kGy and 2 kGy (Table 1b). The b-value showed an increase in mean values at all doses but the increase was not significant (Table 1b). The mean for b-value (yellowness) of the control was the highest with 18.74 from stored in zip-lock

polyethylene bag but this was significantly different from that recorded from samples stored in hermetically sealed bag; whiles the lowest of 4.75 was recorded at 1.5 kGy from samples stored in zip-lock polyethylene bag (Figure 8).

Table 1a: Treatment means for the effect of irradiation and storage on the physicochemical properties of processed cocoyam leaf

	Storage week	Doses (kGy)	Moisture content (%)	Dry matter (%)	pH	Vitamin C(mg/100g)	Crude protein	L-value	a-value	b-value
ZIP-LOCK BAG	0	0	83.73±0.40^{a}	16.27±0.40^{a}	6.41±0.01^{a}	34.58±0.44^{a}	1.53±0.05^{a}	16.93±0.78^{a}	-19.42±0.13^{a}	16.38±0.79^{a}
		0.5	86.49±0.40^{b}	13.51±0.40^{b}	5.99±0.01^{b}	9.90±0.44^{b}	2.23±0.05^{b}	21.05±0.78^{ca}	-3.46±0.13^{c}	5.80±0.79^{b}
		1	86.53±0.40^{b}	13.47±0.40^{b}	6.53±0.01^{ca}	9.67±0.44^{b}	1.96±0.05^{c}	22.7±0.78^{ca}	-1.88±0.13^{de}	4.04±0.79^{d}
		1.5	86.39±0.40^{b}	13.61±0.40^{b}	5.97±0.01^{d}	2.50±0.44^{cd}	1.38±0.05^{d}	20.91±0.78^{ca}	-2.24±0.13^{cdf}	4.21±0.79^{d}
		2	86.74±0.40^{b}	13.26±0.40^{b}	6.07±0.01^{d}	2.28±0.4^{c}	1.28±0.05^{d}	20.88±0.78^{ca}	-2.56±0.13^{cdf}	4.57±0.79^{d}
	1	0	87.44±0.40^{c}	12.56±0.40^{c}	6.54±0.01^{a}	27.3±0.44^{a}	1.53±0.05^{a}	43.08±0.78^{b}	-13.16±0.13^{b}	21.10±0.79^{ea}
		0.5	87.34±0.40^{c}	12.66±0.40^{c}	6.00±0.01^{b}	8.19±0.44^{bc}	2.40±0.05^{b}	15.89±0.78^{ca}	-1.54±0.13^{cd}	6.61±0.79^{b}
		1	87.48±0.40^{c}	12.51±0.40^{c}	6.54±0.01^{a}	1.60±0.44^{ecd}	2.05±0.05^{c}	19.35±0.78^{ca}	-1.35±0.13^{cd}	7.46±0.79^{bc}
		1.5	87.51±0.40^{c}	12.49±0.40^{c}	6.22±0.01^{be}	2.28±0.44^{cd}	3.13±0.05^{e}	16.79±0.78^{a}	-2.14±0.13^{cdf}	5.29±0.79^{bcd}
		2	87.62±0.40^{c}	12.38±0.40^{c}	6.12±0.01^{d}	1.73±0.44^{ecd}	3.03±0.05^{e}	16.67±0.78^{a}	-2.46±0.13^{cdf}	5.77±0.79^{bcd}

Means with the same alphabets within the same column are not significantly different from each other (p>0.05)

Table 1b: Treatment means for the effect of irradiation and storage on the physicochemical properties of processed cocoyam leaf

	Storage week	Doses (kGy)	Moisture content (%)	Dry matter (%)	pH	Vitamin C(mg/100g)	Crude protein	L-value	a-value	b-value
HERMETICALLY SEALED BAG	**0**	0	88.39±0.41^{a}	12.58±0.68^{a}	5.72±0.02^{a}	34.58±0.44^{a}	2.61±0.07^{a}	16.93±0.40^{a}	-19.42±0.13^{a}	16.38±0.79^{a}
		0.5	88.39±0.41^{ab}	12.92±0.68^{ab}	5.52±0.02^{b}	9.90±0.44^{b}	2.23±0.07^{a}	22.21±0.40^{c}	-3.46±0.13^{c}	5.80 ±0.79^{c}
		1	87.35±0.41^{c}	12.30±0.68^{c}	6.18±0.02^{c}	9.67±0.44^{b}	1.96±0.07^{a}	22.64±0.40^{c}	-2.35±0.13^{cd}	4.04±0.79^{cd}
		1.5	86.10±0.41^{e}	13.48±0.68^{e}	5.99±0.02^{c}	2.50±0.44^{bc}	1.38±0.07^{b}	21.28±0.40^{c}	-2.24±0.13^{cd}	4.21±0.79^{cd}
		2	88.29±0.41^{ab}	12.44±0.68^{ab}	6.32±0.02^{cd}	2.28±0.44^{bc}	1.28±0.07^{bc}	21.33±0.40^{c}	-2.56±0.13^{cd}	4.57±0.79^{cd}
	1	0	88.49±0.41^{a}	11.20±0.68^{a}	5.83±0.02^{a}	27.30±0.44^{a}	2.62±0.07^{a}	37.70±0.40^{b}	-13.16±0.13^{b}	21.1±0.79^{a}
		0.5	89.45±0.41^{ab}	11.25±0.68^{ab}	5.54±0.02^{b}	8.19±0.44^{b}	2.23±0.07^{a}	19.60±0.40^{cd}	-1.54±0.13^{cd}	6.61±0.79^{b}
		1	89.58±0.41^{ab}	10.37±0.68^{ab}	6.1±0.02^{c}	2.28±0.44^{bc}	1.96±0.07^{a}	19.28±0.40^{cd}	-1.88±0.13^{cd}	7.46±0.79^{cde}
		1.5	87.15±0.41^{d}	12.15±0.68^{d}	6.0±0.02^{c}	1.73±0.44^{bcd}	1.38±0.07^{b}	16.42±0.40^{cde}	-2.14±0.13^{cd}	5.29±0.79^{cd}
		2	89.49±0.41^{ab}	11.41±0.68^{ab}	6.37±0.02^{cd}	1.59±0.44^{bcd}	1.28±0.07^{bc}	16.57±0.40^{cde}	-2.46±0.13^{cd}	5.77±0.79^{cd}

Means with the same alphabets within the same column are not significantly different from each other (p>0.05)

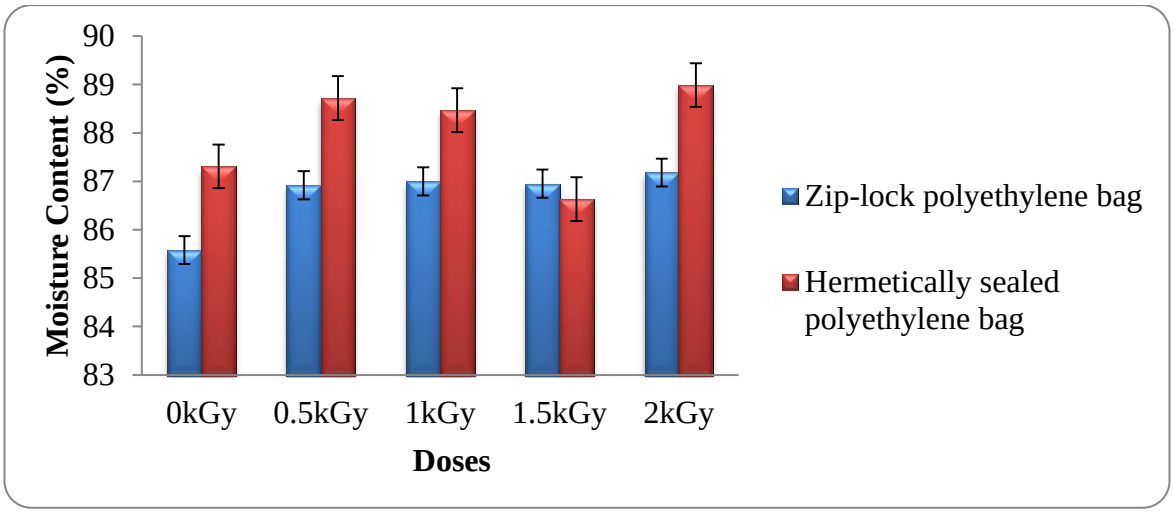

Figure1: Effect of doses on the moisture content of processed cocoyam leaf after irradiation

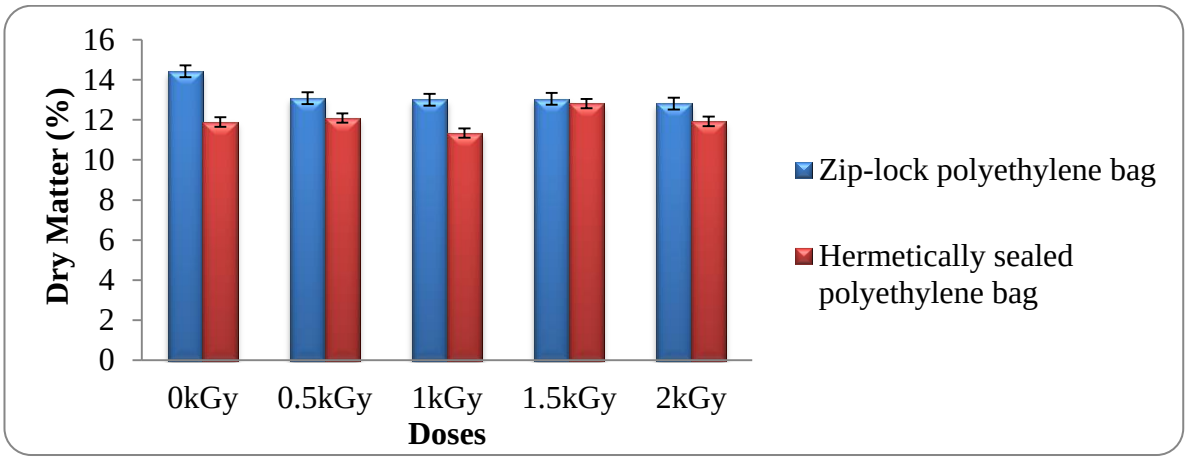

Figure2: Effect of doses on dry matter of processed cocoyam leaf after irradiation

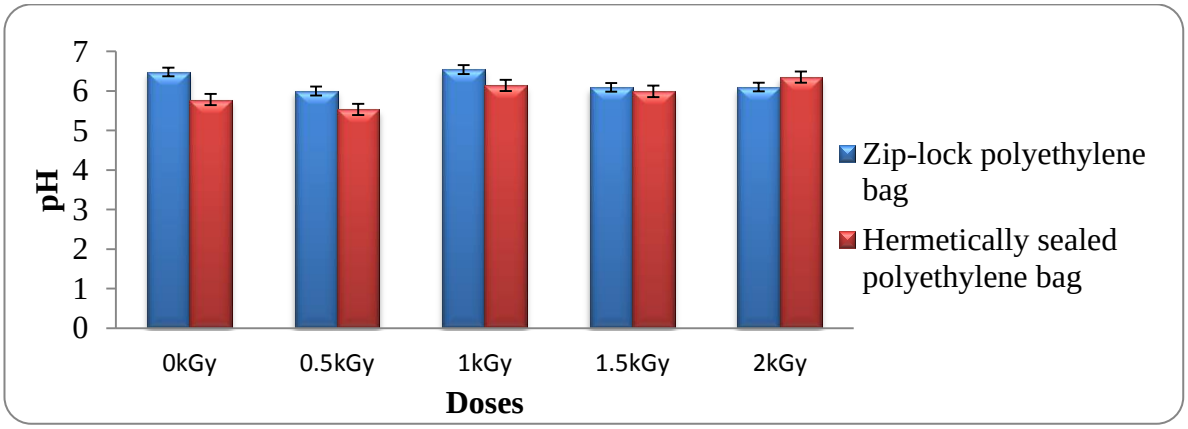

Figure 3: Effect of doses on pH of processed cocoyam leaf after irradiation

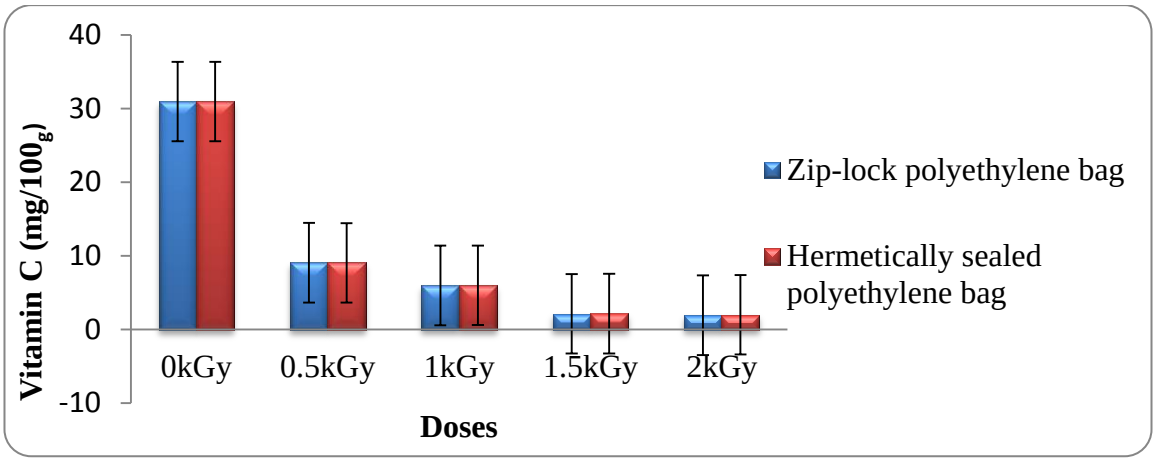

Figure 4: Effect of doses on the Vitamin C content of processed cocoyam leaf after irradiation

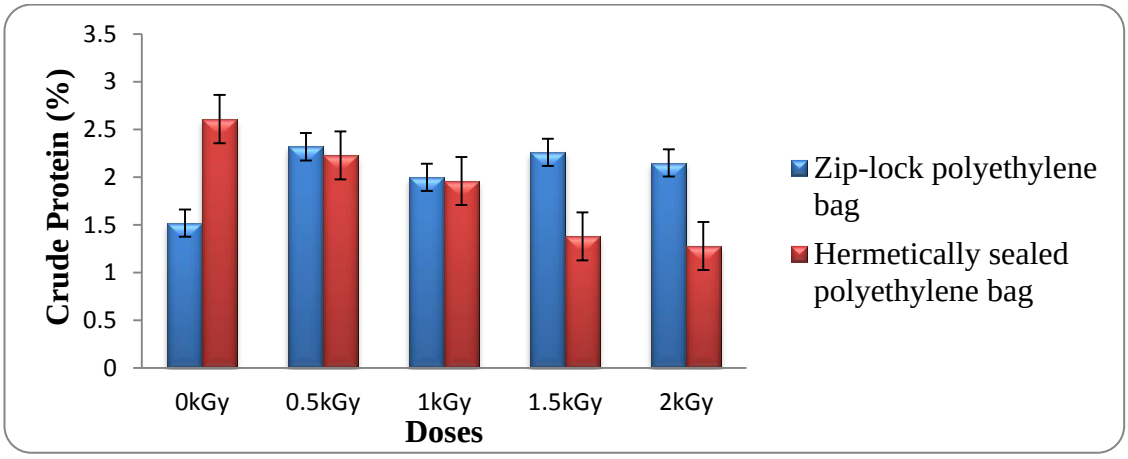

Figure 5: Effect of doses on crude protein content of processed cocoyam yam leaf after irradiation

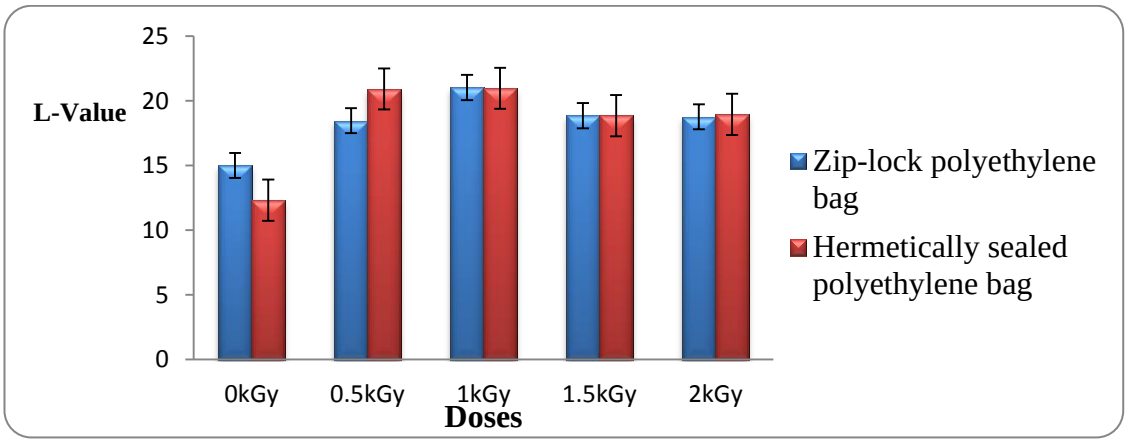

Figure 6: Effect of doses on L-value of processed cocoyam yam leaf after irradiation

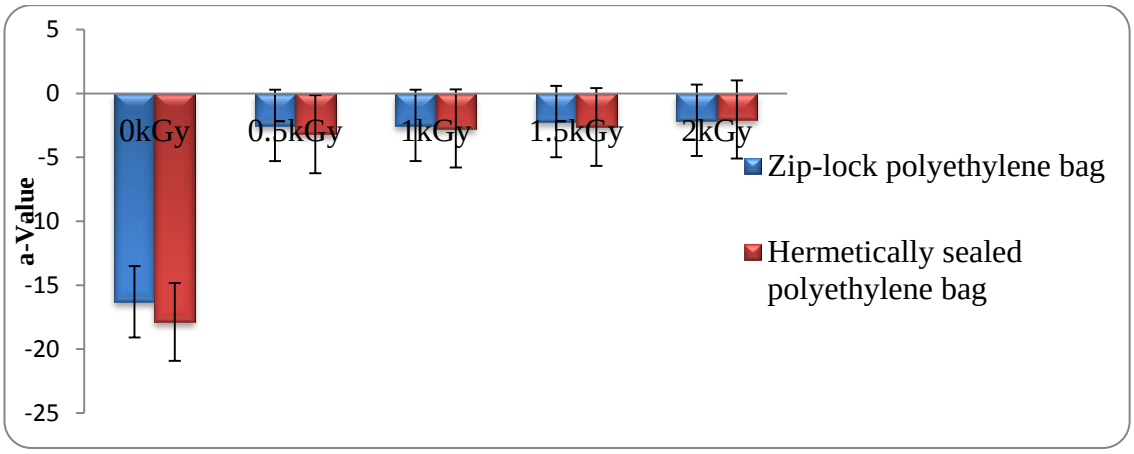

Figure 7: Effect of doses on a-value of processed cocoyam yam leaf after irradiation

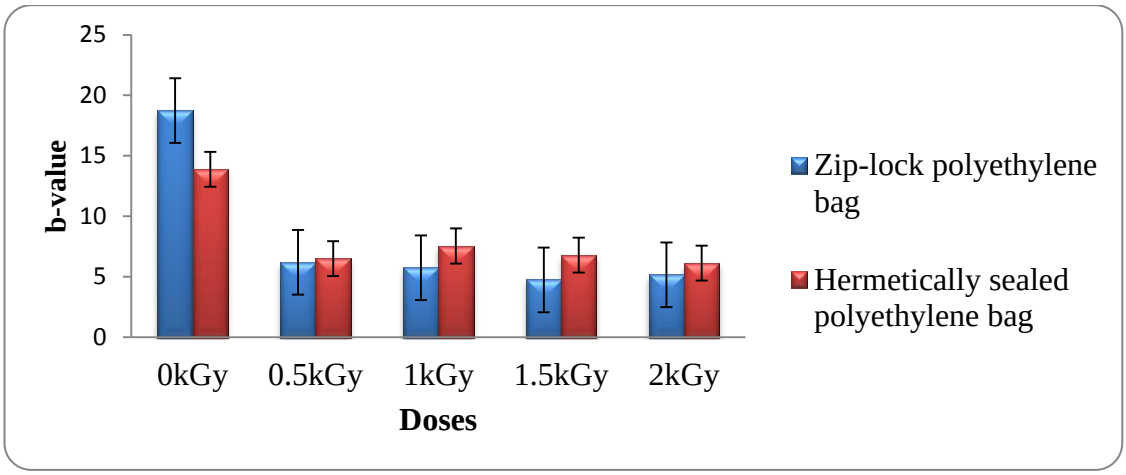

Figure 8: Effect of doses on b-value of processed cocoyam yam leaf after irradiation

4.1.2 Effect of refrigeration and ambient temperature storage on moisture content and on the physicochemical properties of processed cocoyam leaf

4.1.2.1 Effect of refrigeration and ambient temperature storage on moisture content

Storage had no significant ($p<0.05$) effect on the moisture content after refrigeration (Appendix 1:B1). However, there was an increase from 83.73 to 91.12 % after the storage period (Figure 9). Ambient temperature storage also showed no significant effect ($p>0.05$) (Appendix 1:B2). There was an increase from 83.73% to 92.32% after the storage period (Figure 9). Comparatively moisture content was less but not significant in refrigerated samples than at ambient temperature storage (Figure 9). Storage also significantly ($p<0.05$) affected the moisture content of samples stored in hermetically sealed bag after refrigeration storage (Appendix 1:B3). There were fluctuations in moisture during storage (Figure 9). Storage also had no significant effect ($p>0.05$) on the moisture content in samples stored at ambient temperature storage (Appendix 1:B4). Although there was an increase in moisture content at the initial week of storage, it was not significantly different from that recorded in subsequent weeks of storage (Figure 9). Comparatively, between the two storage temperatures, moisture content was higher in hermetically sealed polyethylene bags but means were not significantly different from each other (Figure 9).

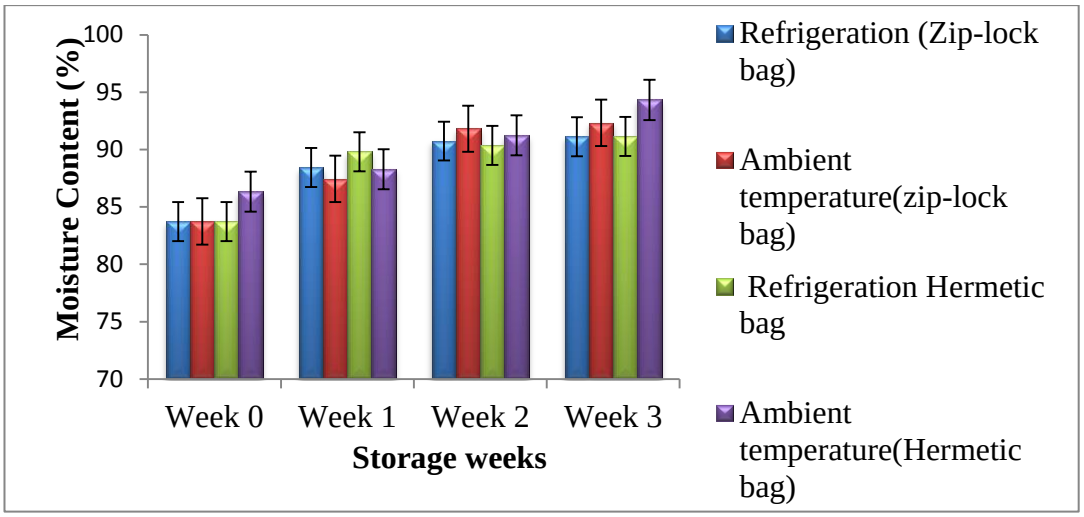

Figure 9: Effect of refrigeration (4±2°C) and ambient temperature (30±2°C) storage on moisture content of processed cocoyam leaf during storage

4.1.2.2 Effect of refrigeration and ambient temperature storage on dry matter

Storage at both ambient temperature and refrigeration showed no significant effect on the dry matter content of samples stored in zip-lock polyethylene bag (Appendix 1:B5 and B6). There was a reduction in dry matter content after every storage week in ambient temperature and a reduction at the first and second week of storage in refrigerated samples which were not significant (Figure 10). In both refrigerated and ambient temperature stored samples in hermetically sealed bag storage had significant effect (Appendix 1:B7 and B8). There was a decreasing trend in the dry matter content during storage at both ambient temperature and refrigeration in both packaging materials. At the initial stage of storage dry matter content recorded in refrigerated samples stored in zip-lock polyethylene bag was 16.27 % but decreased to 8.88 % at the third week of storage whiles that of ambient temperature storage was also 16.27% but reduced to 7.68 % after the storage period. Refrigerated samples stored in hermetically sealed bag recorded16.27 % at the initial week but 8.86 % at the third week of storage; that of ambient temperature recorded 12.58 % at the initial

week and the lowest of 5.68 % at the third week of storage but there were no significant differences in the means (Figure 10).

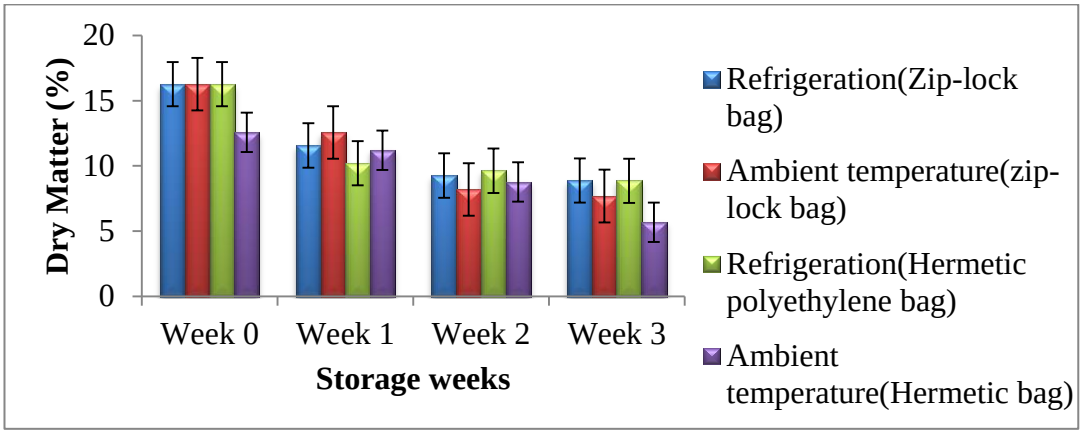

Figure 10: Effect of refrigeration (4±2°C) and ambient temperature (30±2°C) storage on dry matter of processed cocoyam leaf

4.1.2.3 Effect of refrigeration and ambient temperature storage on pH

Storage significantly ($p<0.05$) affected the pH in both refrigerated and ambient temperature stored samples in zip-lock polyethylene bag. (Appendix 1:B9 and 10). There were fluctuations in pH of samples stored under both storage temperatures (Figure 11). In refrigerated samples stored in the zip-lock bag, there was a decrease from in the pH after a week of storage but an increase in subsequent weeks of storage. Ambient temperature storage recorded an increase in the first week, a decrease in the second week and an increase in the third week of storage. The pH values recorded were significantly different from each storage temperature at the first, second and third weeks of storage. In samples stored in hermetically sealed bag, storage had significant ($p< 0.05$) effect in samples stored at ambient temperature (Appendix 1: B 12) and also significant effect in samples stored by refrigeration (Appendix 1: B 11). The pH values were not consistent during storage; there were fluctuations at both ambient temperature storage and refrigeration storage but this was significantly different from each storage temperature (Figure 11).

Comparatively, pH value was significantly higher with 6.91 in refrigerated samples stored in zip-lock polyethylene bag at the second week of storage than all other samples stored and the lowest of 5.72 was recorded from ambient temperature storage in hermetically sealed polyethylene bag during the initial week of storage. (Figure11).

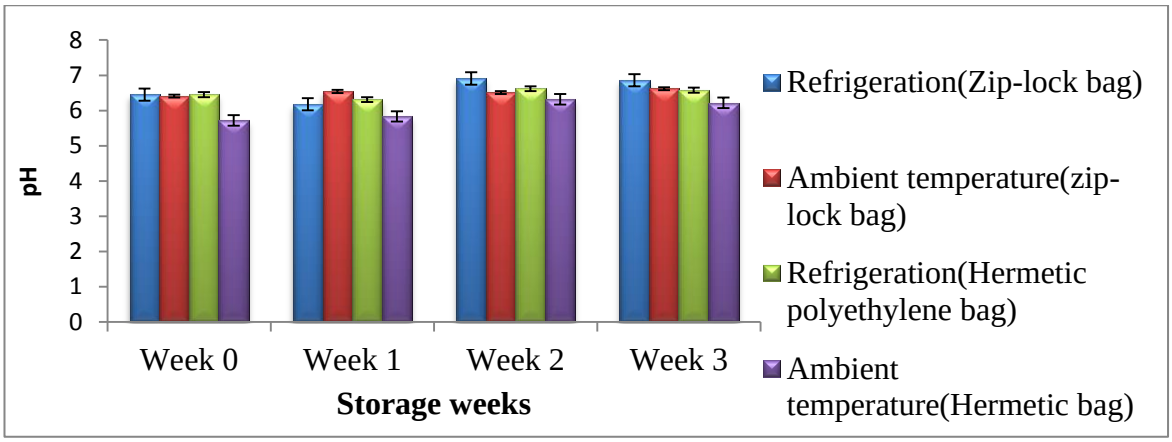

Figure 11: Effect of refrigeration (4±2°C) and ambient temperature (30±2°C) storage on pH of processed cocoyam leaf

4.1.2.4 Effect of refrigeration and ambient temperature storage on vitamin C

Storage significantly affected the vitamin C content under all storage conditions (Appendix 1: B 13-16).Vitamin C content showed a reduction in both packaging materials and storage temperatures after every storage week with no significant differences in the means (Figure 12). Samples stored in hermetically sealed polyethylene bags recorded the highest vitamin C content of 36.41 mg/100g at both ambient temperature and refrigeration storage at the initial week of storage but was not significant (Figure 12). However, it reduced to 8.42 mg/100g in refrigerated stored samples and in ambient temperature storage it reduced to 5.45 mg/100g at the third week of storage. Comparatively, reduction was less in refrigerated samples stored in hermetically sealed bag but was not significant (Figure 12). The lowest

vitamin C content of 5.23 mg/100g was recorded at ambient temperature storage of samples stored in zip-lock polyethylene bag (Figure 12).

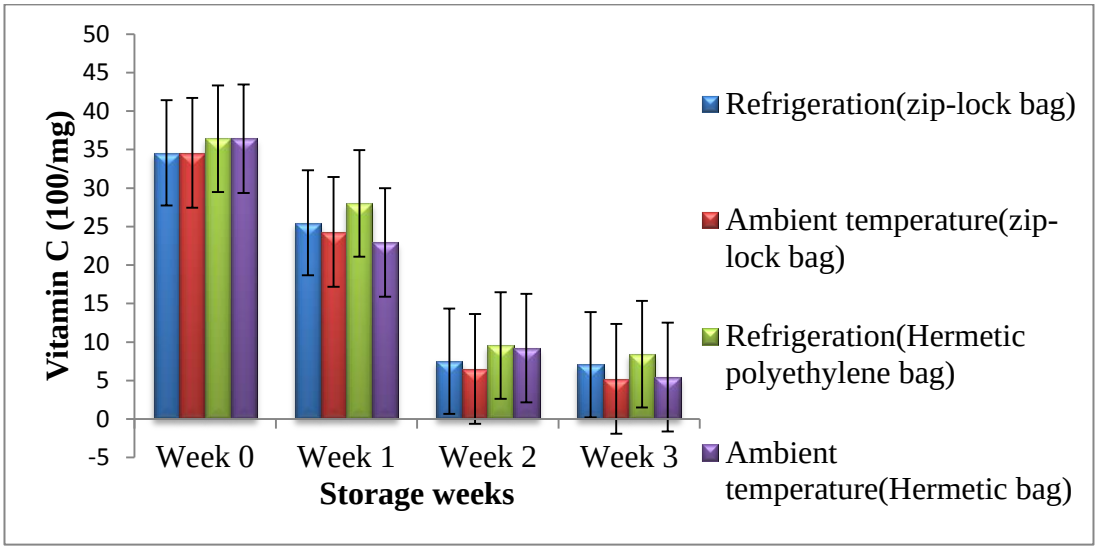

Figure 12: Effect of refrigeration (4±2°C) and ambient temperature (30±2°C) storage on Vitamin C (ascorbic acid) of processed cocoyam leaf

4.1.2.5 Effect of refrigeration and ambient temperature storage on crude protein

Storage significantly ($p<0.05$) affected the crude protein content in samples stored in zip-lock pouches at ambient temperature and in hermetically sealed bag stored by refrigeration (Appendix 1:B18 and B19). However this is not significantly different ($p>0.05$) from samples stored in zip-lock polyethylene bag (Appendix 1:B17) and in samples stored in hermetically sealed bag stored at ambient temperature (Appendix 1:B20). Crude protein content was very low in refrigerated stored samples in both packaging materials throughout the storage period but significantly higher at the third week of storage in ambient temperature stored samples with the highest mean value of 18.23 % (Figure 13). Comparatively crude protein content was higher with 18.32% in samples stored at ambient temperature in hermetically sealed bag but this was not significantly different from that recorded from zip-lock bag at the third week

of storage; refrigerated storage of samples stored in zip-lock polyethylene bag recorded the lowest crude protein content of 2.31 % at the third week of storage but was not significantly different from that recorded from refrigerated samples stored in hermetically sealed polyethylene bag (Figure13).

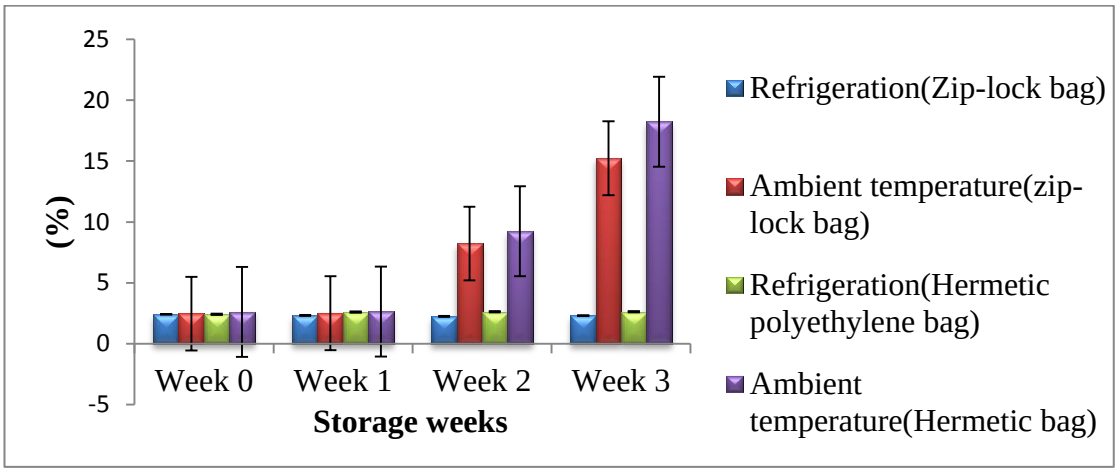

Figure 13: Effect of refrigeration (4±2°C) and ambient temperature (30±2°C) storage on crude protein of processed cocoyam leaf

4.1.2.6 Effect of refrigeration and ambient temperature storage on colour

Storage had significant ($p<0.05$) effect on the L-value in refrigerated samples stored in both packaging materials used and also in ambient temperature samples stored in hermetically sealed bag (Appendix 1:B21, 23 and 24); but storage had no significant effect ($p>0.05$) in samples stored at ambient temperature in zip-lock bag (Appendix 1:B22). In refrigerated samples stored in hermetically sealed bag, L-value showed a decreasing trend but there were fluctuations in the mean values in all stored samples (Figure 14). At the initial week of storage L- value was 46.93 at all storage conditions but at the third week of storage, it had reduced in all the samples and samples stored in zip-lock polyethylene bag under ambient temperature recorded the lowest mean value of 18.22 (Figure 14). Comparatively, ambient temperature stored samples recorded less L-values but was not significantly different from packaging materials during storage (Figure 14).

Storage had significant effect on the a-value in both packaging and storage temperatures (Appendix 1:B25-28).There was a decrease after the storage period in both refrigerated and ambient temperature storage (Figure 15). At the initial week of storage, the a-value recorded was -19.4 under all storage condition but it decreased with storage with the lowest value of -4.25 recorded in samples stored in zip-lock bag at ambient temperature during the third week of storage (Figure 15). The decrease in a-value of ambient temperature storage of samples packaged in zip-lock polyethylene bag was not significantly different ($p<0.05$) from all refrigerated samples of both packaging materials (Figure15). Storage had significant effect on the b-value in refrigerated samples stored in both the zip-lock polyethylene bag and the hermetically sealed bag (Appendix1:B29 and 31). Also there was significant effect in ambient temperature stored samples in hermetically sealed bag (Appendix 1:B32). However, storage had no significant effect on ambient temperature stored samples in zip-lock bag (Appendix 1:B30). At the initial week of storage, the mean b-value was 16.33 for all samples under all storage conditions. There was an increase in the b-value of refrigerated samples stored in zip-lock bag after only the first week of storage but consistent increase in ambient temperature stored samples which was significantly different ($p<0.05$) at the second and third week of storage (Figure 16). In samples stored at both temperatures in hermetically sealed bag, there was an increase in ambient temperature stored samples at the end of the storage period (Figure 16). Comparatively, b - value was significantly higher at ambient temperature of samples stored in zip-lock polyethylene bag with 45.23 mean at the third week of storage and the lowest of 13.12 was recorded from refrigerated samples that were packaged in hermetically sealed polyethylene bag (Figure16).

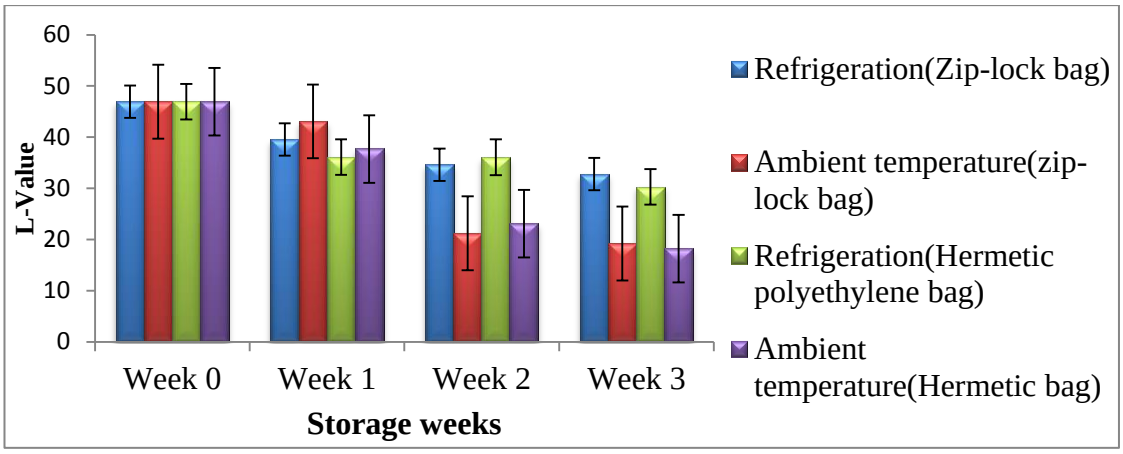

Figure 14: Effect of refrigeration and ambient temperature (30±2°C) storage on L- value of processed cocoyam leaf

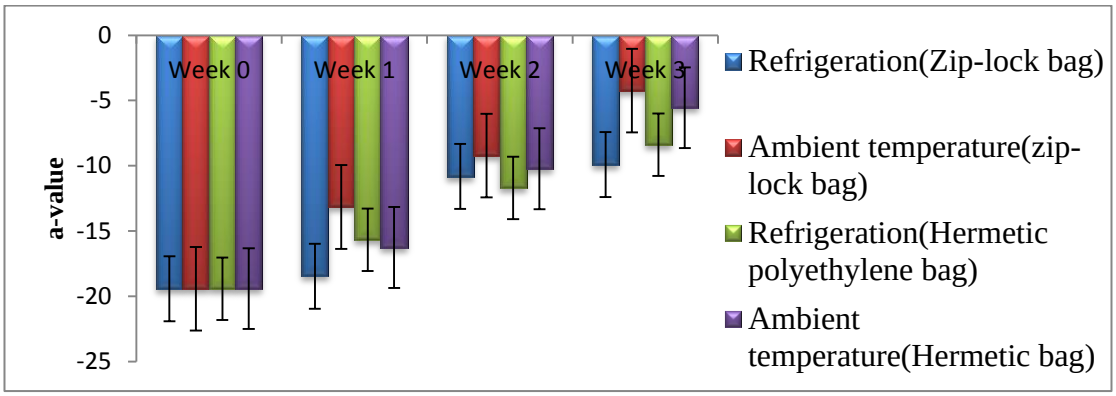

Figure 15: Effect of refrigeration and ambient temperature (30±2°C) storage on a- value of processed cocoyam leaf

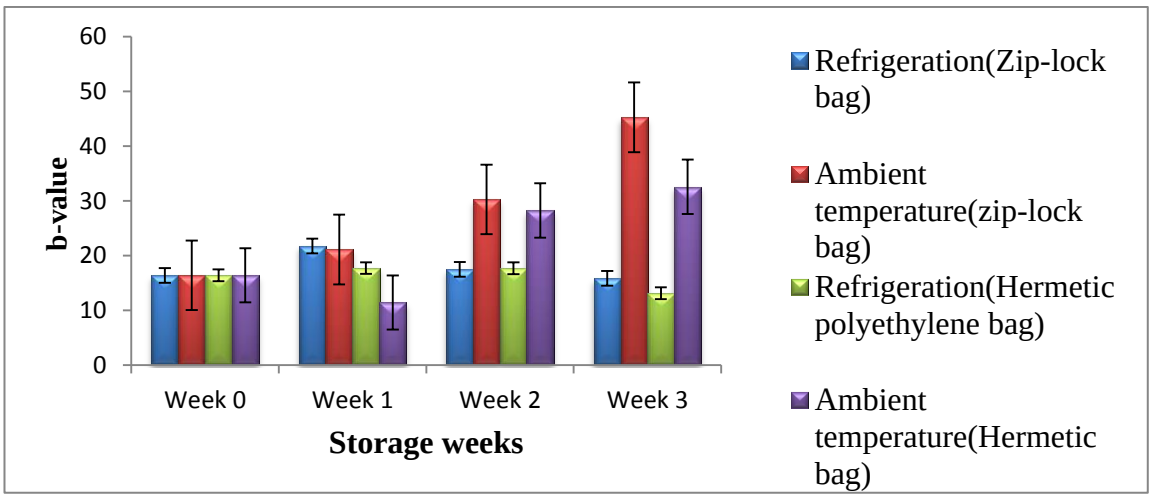

Figure 16: Effect of refrigeration and ambient temperature (30±2°C) on b-value of processed cocoyam leaf during storage

4.1.3. Effect of blanching and ambient temperature storage, blanching and refrigeration on the physicochemical properties of processed cocoyam leaf during storage

4.1.3.1 Effect of blanching, blanching and refrigeration storage on moisture content

Storage had significant effect on the moisture content in samples stored in zip-lock bag at ambient temperature storage and also in refrigerated samples stored in hermetically sealed bag. However storage had no significant effect ($p>0.05$) on samples stored in hermetically sealed bag stored at ambient temperature and also in refrigerated samples stored in zip-lock bag (Figure 17). There was an increasing trend in samples stored in zip-lock bag at both temperatures. At the initial week of storage the mean moisture content recorded was 89.87 % for all samples under all storage conditions. However, after the second week of storage samples stored in zip-lock polyethylene bags under ambient temperature recorded 96.23 % moisture content which was significantly different whiles samples that were stored in hermetically sealed polyethylene also increased to 93.23 % (Figure 17). Comparatively, moisture content was very high at the third week of storage with 96.42 % in blanched samples stored at ambient temperature (30±2^{o}C) that were packaged in the hermetically sealed polyethylene bag but was not significantly different from that recorded from samples stored in zip-lock polyethylene bag (Figure17). A significant lower moisture content of 89.61 % was recorded from refrigerated samples that were packaged in zip-lock polyethylene bag at the third week of storage (Figure 17).

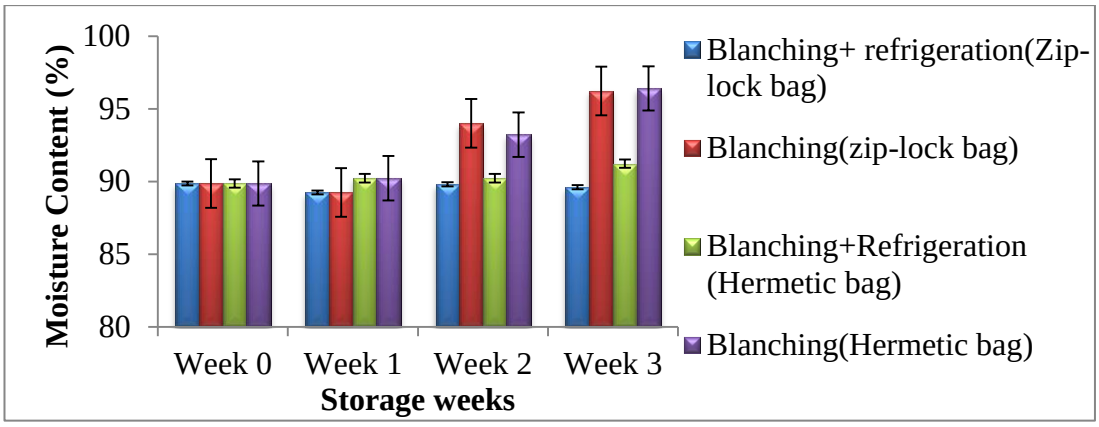

Figure 17: Effect of blanching (30±2°C), blanching and refrigeration (4±2°C) on moisture content of processed cocoyam leaf during storage

4.1.3.2 Effect of blanching, blanching and refrigeration storage on dry matter

Storage had significant affect ($p<0.05$) on the dry matter content in samples zip-lock bag at ambient temperature and in blanched and refrigerated samples stored in hermetically sealed polyethylene bag. However, storage did not have any significant effect ($p>0.05$) on blanched and refrigerated samples stored in zip-lock polyethylene and also on blanched and ambient temperature stored samples in hermetically sealed bag. Dry matter content recorded at the initial week of storage was 10.75 % for all samples stored under different conditions. However, samples stored in zip-lock polyethylene under both ambient temperature and refrigeration recorded the highest mean value of 10.75 % after a week of storage. There was a decrease in dry matter content in the subsequent weeks of storage which was significantly different ($p<0.05$) from each packaging material but storage conditions had no significant effect (Figure 18). At the third week of storage, samples stored at ambient temperature in both packaging materials recorded a significant lower amount of dry matter content of 3.7 % whiles the highest of 10.39% was recorded from refrigerated samples that were packed in zip-lock polyethylene bag which was significant (Figure 18).

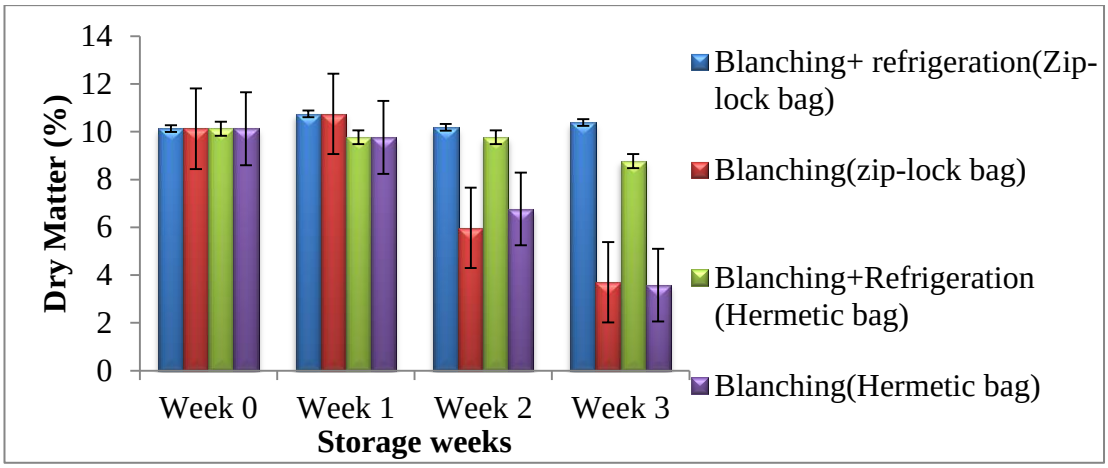

Figure 18: Effect of blanching (30±2°C), blanching and refrigeration (4±2°C) on dry matter of processed cocoyam leaf during storage

4.1.3.3 Effect of blanching, blanching and refrigeration storage on pH

Storage of the processed leaf had significant effect on the pH in all the packaging materials and storage temperatures. The pH value showed fluctuations in storage in processed leaf stored in both hermetically sealed bag and zip-lock polyethylene bag under all the storage temperatures (Figure 19). Comparatively, pH was significantly ($p>0.05$) higher with 8.1 for ambient temperature stored samples in zip-lock polyethylene bag at the third week of storage and a significant lower pH of 6.58 in samples that were packaged in hermetically sealed bag that were refrigerated (Figure19).

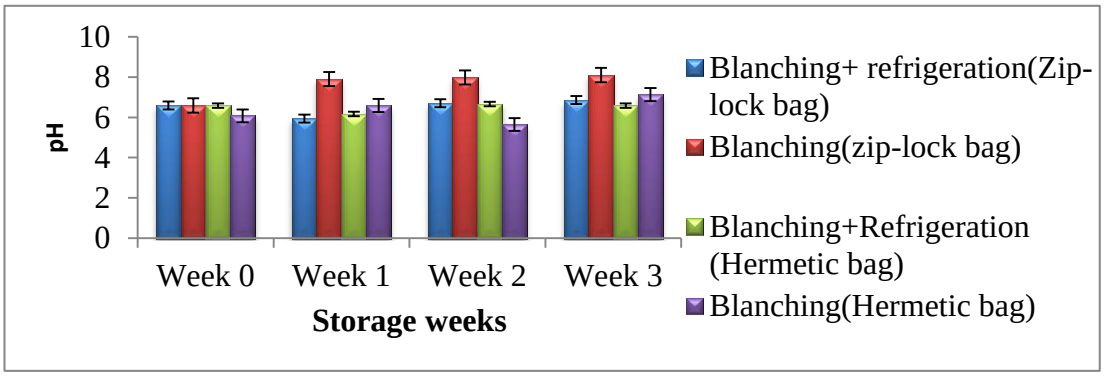

Figure 19: Effect of blanching (30±2°C), blanching and refrigeration (4±2°C) on the pH of processed cocoyam leaf during storage

4.1.3.4 Effect of blanching, blanching and refrigeration storage on vitamin C

Vitamin C was significantly affected by storage ($p<0.05$) in both packages and storage temperatures. There was a decrease after every storage week (Figure 20). At the initial week of storage, the vitamin C content was 13.2 mg/100g for samples stored in zip-lock polyethylene bags under both ambient temperature and refrigeration; but after the storage period, it had reduced to 7.51 mg/100g in refrigerated samples and 5.32 mg/100g. Samples that were stored in hermetically sealed polyethylene samples also recorded vitamin C content of 14.33 mg/100g at the initial week of storage for all storage temperatures but a decrease at the third week of storage with 9.33 mg/100g for refrigerated storage and 5.43 mg/100g for ambient temperature storage. However, the decrease was not significantly different ($p>0.05$) from storage temperatures in both packaging materials. Comparatively, blanched and refrigerated samples stored in hermetically sealed bag recorded the lowest reduction of vitamin C content of 9.33 mg/100g after the storage period but it was not significant (Figure 20).

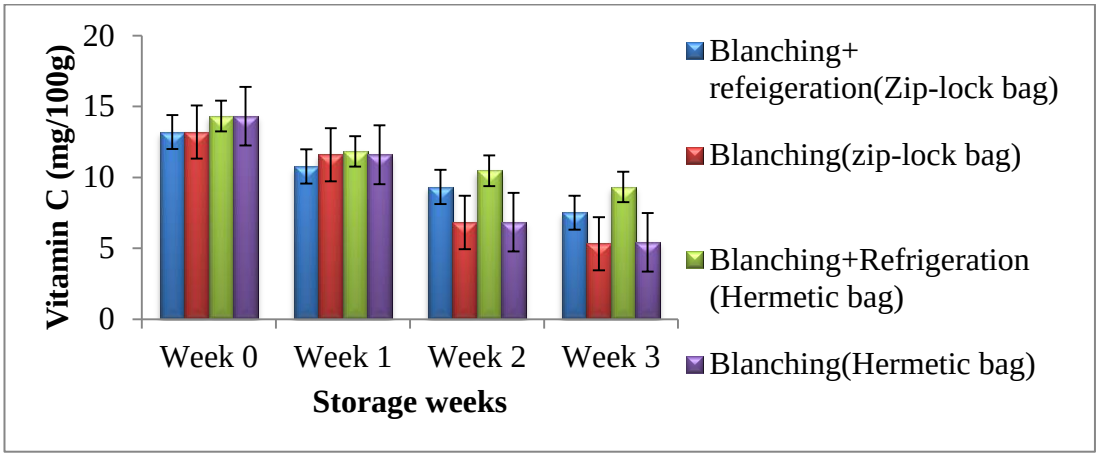

Figure 20: Effect of blanching (30±2°C), blanching and refrigeration (4±2°C) on vitamin C (ascorbic acid) content of processed cocoyam leaf during storage

4.1.3.5 Effect of blanching, blanching and refrigeration storage on crude protein

Storage of processed leaf stored in zip-lock polyethylene bag had no significant effect ($p<0.05$) on the crude protein content under both ambient temperature storage and refrigeration storage. However, there was an increasing trend in ambient temperature stored samples (Figure 21). At the initial week of storage, crude protein content for all the samples stored under various conditions was 2.14 %. At the third week of storage, crude protein content increased to 10.01 % in samples stored in zip-lock polyethylene bag and 12.01 % for samples stored in hermetically sealed polyethylene bags at ambient temperature storage (Figure 21). There was also a significant ($p<0.05$) effect of storage on refrigerated samples stored in hermetically sealed bag (Appendix 1:C19), but storage did not have any significant effect ($p>0.05$) on samples stored at ambient temperature for the same packaging material (Appendix 1: C 20). Comparatively, blanched samples stored at ambient temperature (30± 2°C) in hermetically sealed bag recorded the highest crude protein content at the third week of storage but this was not significantly different ($p>0.05$) from that recorded for samples stored in zip-lock polyethylene under the same temperature storage (Figure 21).

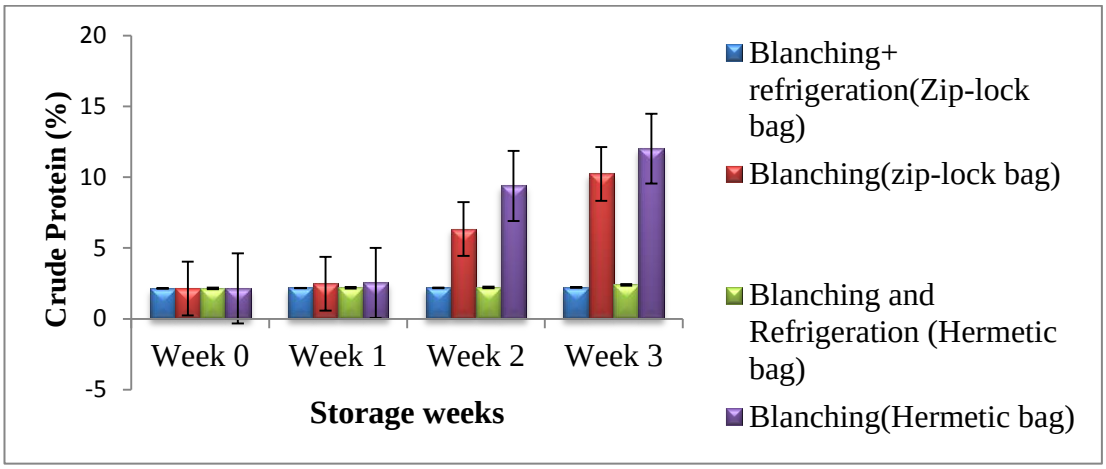

Figure 21: Effect of blanching (30±2°C), blanching and refrigeration (4±2°C) on the crude protein content of processed cocoyam leaf during storage

4.1.3.6 Effect of blanching, blanching and refrigeration storage on colour

Blanching and ambient temperature storage, blanching and refrigeration storage significantly ($p<0.05$) affected the L-value. There was an increase in L- value after the storage periods in both packaging materials and storage temperatures (Figure 22). At the initial week of storage, the L- value for all stored samples was 27.67; however, at the third week of storage it had increased to 43.45 in samples stored in zip-lock polyethylene under refrigeration storage and 43.22 in ambient temperature storage of the same packaging material (Figure 24).

Storage also significantly decreased the a-value in both packaging materials and temperatures. There was a decrease a- in both packaging materials and storage temperatures with storage but there was no significant difference in the a-value ($p>0.05$) from week one to week three (Figure 23). At the initial week of storage, a-value recorded was -10.86 for refrigerated samples stored in hermetically sealed polyethylene bag and -9.56 for samples stored at ambient temperature of the same packaging material. However, after the storage periods the a-value reduced to -4.3 for refrigerated samples and -3.32 for ambient temperature storage. The a- value for samples stored in zip-lock polyethylene bag was -9.55 under all storage conditions but it reduced to -1.1 for ambient temperature storage and -1.5 for refrigerated storage (Figure 23) . Comparatively, there were no significant difference on the a-value in both packaging materials and storage temperatures (Figure 23). The b-value increased in all the samples stored at both ambient temperature and refrigerated temperature after the storage period (Figure 24). At the initial week of storage, the b-value recorded for refrigerated samples stored in zip-lock polyethylene bag was 13.86 and that of ambient temperature storage was 13.06. However there was an

increase at the third week of storage with refrigerated samples recording 18.07 and ambient temperature storage recording 19.23 which was the highest b-value amongst all other treatments but was not significant. Also refrigerated samples stored in hermetically sealed polyethylene bag recorded 11.34 b-values at the initial week of storage and 13.06 in ambient temperature storage (Figure 24). Comparatively, b value was significantly higher in hermetically sealed bag during the first week of storage (Figure 24).

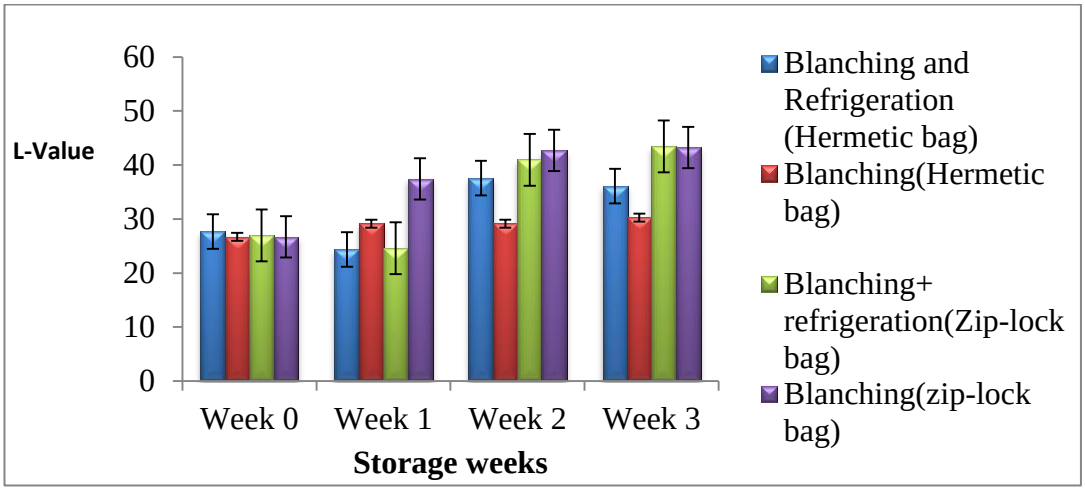

Figure 22: Effect of blanching (30±2°C), blanching and refrigeration (4±2°C) on the L-value of processed cocoyam leaf during storage

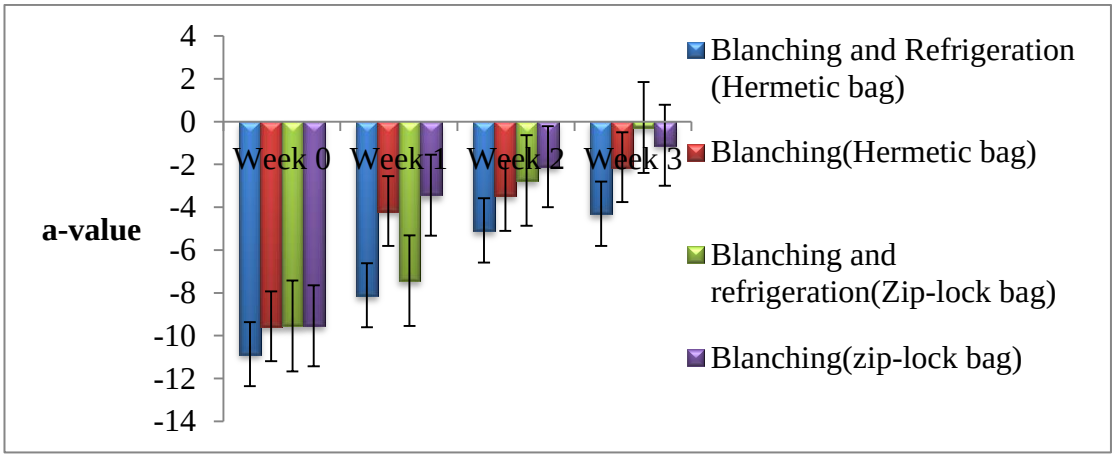

Figure 23: Effect of blanching (30±2°C), blanching and refrigeration (4±2°C) on the a-value processed cocoyam leaf during storage

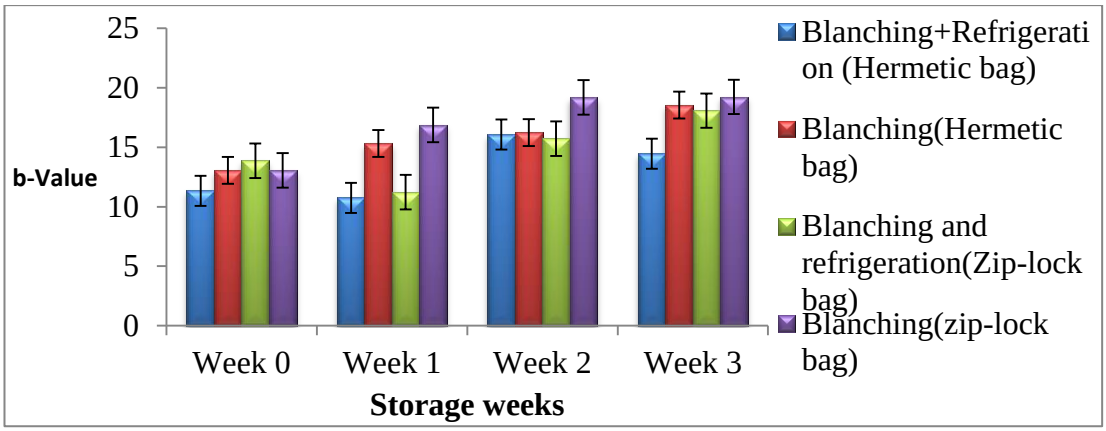

Figure 24: Effect of blanching (30±2°C), blanching and refrigeration (4±2°C) on the b-value of processed cocoyam leaf during storage

4.1.4 Effect of radiation and refrigeration storage on the physicochemical properties of processed cocoyam leaf

4.1.4.1 Effect of radiation and refrigeration storage on moisture content

Storage and interaction of storage with irradiation doses had significant ($p<0.05$) effect on the moisture content during storage for both packaging materials. The moisture of the control and 1.5 kGy samples stored in zip-lock polyethylene bag showed significant difference at the initial week of storage (Table 2a). Also in samples irradiated at 0.5 kGy, 1 kGy, 1.5 kGy and 2 kGy, moisture content increased with storage but the increase was significantly different after a week of storage (Table 2a). Also samples irradiated at 0.5 kGy, 1 kGy, 1. 5 kGy and 2 kGy moisture content increased with storage but this was significant only after a week of storage (Table 2). During storage of the cocoyam leaves in hermetically sealed polyethylene bag, moisture content was significantly different after only the first week of storage (Table 2b). Although samples irradiated at 0.5 kGy, 1.5 kGy and 2 kGy showed an increase in moisture, it was not significant ($p<0.05$); but samples irradiated at 1 kGy showed significant increase in moisture content after the first and second week of storage (Table 2b). Radiation doses also had significant effect on the processed leaf.

Moisture content was not significantly different ($p>0.05$) from each packaging material at only the control (Figure 25). Comparatively moisture content was significantly high in hermetically sealed polyethylene bag at the control with 88.56% and lowest mean of 86.78 % was recorded at 0.5 kGy from samples stored in zip-lock polyethylene bag (Figure 25).

4.1.4.2 Effect of irradiation and refrigeration storage on dry matter

Storage had significant effect on the dry matter content ($p<0.05$) in both packaging materials. Samples showed a decreasing trend in dry matter content during storage in both packaging materials (Table 2a and 2b). At the initial week of storage, samples stored in zip-lock polyethylene bag recorded16.41 % for the control, 13.98 % for 0.5 kGy, 13.50 % for 1 kGy, 14.74 % for 1.5 k Gy and 13.24 % for 2 kGy; but there was a decrease at the third week of storage with the control recording, 8.88%, 11.77 % for 0.5 kGy, 11.61 % for 1 kGy, 12.51% for 1.5 kGy and 13.09 % for 2 kGy (Table 2a). Samples irradiated at 1.5 kGy and stored in zip-lock polyethylene bag showed significant difference ($p<0.05$) at the first and second week of storage whiles samples irradiated at 2 kGy showed significant difference after only a week of storage Also samples irradiated at 1 kGy showed significant difference during the second week of storage. At the third week of storage significant difference was recorded at 0.5 kGy (Table 2a).

Samples stored in hermetically sealed bag, recorded no significant difference ($p>0.05$) in dry matter content in 0.5 kGy and 1.5 kGy irradiated samples, but samples irradiated at 1 kGy recorded significant difference ($p<0.05$) in dry matter content after every storage week (Table 2b). Comparatively, dry matter content was not significantly different ($p>0.05$) from each packaging materials except at the control (Figure 26).

4.1.4.3 Effect of irradiation and refrigeration storage on pH

Storage and irradiation doses had significant ($p<0.05$) effect on the pH value of the fresh-cut cocoyam leaf stored in both packaging materials. The interaction of irradiation doses and storage also had significant effect on the cocoyam leaf. In samples stored in zip-lock polyethylene bag there was an increase in the control from the initial week of storage to the second week, but a reduction at the third week of storage. At the initial week of storage the pH recorded was 6.41 but it increased to 6.91 (Table 2a). In samples irradiated at 0.5 kGy, pH increased after every storage week but there was no significant difference ($p>0.05$) in the means. At the initial week the pH was 6.28, 6.43 at the first week, and 6.66 at the second week and 6.70 at the third week of storage (Table 2a). Samples irradiated at 1.5 kGy also showed fluctuations in pH. The pH was 6.16 at the initial week, 6.60 at the first week, 5.94 at the second week of storage and 6.14 at the third week of storage (Table 2a). At 1 kGy and 2 kGy, there was a decrease in pH at the first week of storage but an increase in the subsequent weeks (Table 2a).

Samples stored in hermetically sealed polyethylene bag, showed fluctuations in pH in the control and 0.5 kGy (Table 2b). At 1 kGy, there was an increase in pH after every storage week but there was no significant difference ($p<0.05$) in the means from week one to week three. At the initial week the pH recorded was 5.63, 6.28 at the first week, and 6.53 at the second week and 6.84 at the third week of storage (Table 2b). Also samples irradiated at 1.5 kGy during storage showed an increase in pH from 5.78 to 6.71 at the first and 6.93 at second week of storage but decreased at the third week of storage to 6.60. Samples irradiated at 2 kGy also showed a decrease in pH at the first week of storage; initially it was 6.01 but it dropped to 5.76 but increased in the subsequent week but this was not significantly different($p<0.05$)

from that recorded at 0.5 kGy, 1 kGy and 1.5 kGy at the third week of storage (Table 2b). Comparatively between the two packaging materials, pH values were significantly different ($p<0.05$) from each other at the control, 1 kGy and 1.5 kGy (Figure 27).

4.1.4.4 Effect of irradiation and refrigeration storage on vitamin C

Storage and irradiation doses had significant effect on the vitamin C content .There was a decrease in vitamin C content at all doses used after every storage week in both packaging materials and this was dose dependent (Table 2a and 2b). At the initial week of storage vitamin was very high in all the controls of both packaging materials with samples stored in zip-lock polyethylene bag recording 34.58 mg/100g, 25.48 mg/100g at the first week, 7.51 mg/100g at the second week and 7.05 mg/100g at the third week of storage; and at the initial week 36.41 mg/100g for samples stored in hermetically sealed bag, 27.99 mg/100g at the first week of storage, 9.56 mg/100g at the second week of storage and 8.42 mg/100g at the third week of storage (Table 2a and 2b). The vitamin C content for samples irradiated at 0.5 kGy that were stored in zip-lock polyethylene bag was 11.15 mg/100g at the initial week of storage but it reduced to 1.59 mg/100g after the storage period. That of samples irradiated at 1 kGy was 9.78 mg/100g at the initial week of storage but after the storage period, it had reduced to 2.50 mg/100g after the storage period (Table 2a). The highest reduction was in samples irradiated at 2 kGy which recorded 3.41 mg/100g at the initial week of storage and 1.37 mg/100g after the storage period (Table 2a). Samples stored in hermetically sealed polyethylene bag, also recorded a decreased after every storage week at all doses (Table 2b). Of all the irradiated dose samples irradiated at 2 kGy recorded the lowest vitamin C content at both the initial

week and the end of the storage week. At the initial week amount of vitamin C recorded in sample was 4.10 mg/100g and after the storage period it had reduced to 2.05 mg/100g (Table 2 b). The highest mean of vitamin C content of 20.59 mg/100 was recorded from the control samples stored in hermetically sealed bag but this was not significantly different ($p<0.05$) from that recorded from samples packaged in zip-lock polyethylene bag (Figure 28). The lowest vitamin C content was recorded at 2 kGy with 2.5 mg/100g from samples stored in zip-lock polyethylene bag but not significant (Figure 28).

4.1.4.5 Effect of irradiation and refrigeration storage on crude protein

Storage, irradiation doses and interaction of doses and storage had significant effect on the crude protein content in both packaging materials. Samples stored in zip-lock polyethylene bag at all doses showed fluctuations during storage (Table 2a). In samples stored in zip-lock bag, crude protein content was not significantly different from each dose from 0.5 kGy to 2 kGy (Table 2a). Also crude protein content was not significantly different from each storage week in the control. However, in samples irradiated at 0.5 kGy there were significant difference ($p<0.05$) in protein content after a week of storage; at 1 kGy at the first and third weeks of storage. Whiles samples irradiated at 1.5 kGy and 2 kGy recorded significant difference ($p<0.05$) in crude protein after the second and third weeks of storage (Table 2a). Crude protein content increased only after a week of storage in only the control of samples stored in hermetically sealed polyethylene bag and this was maintained throughout the storage period with no significant differences ($p>0.05$) (Table 2b). There were fluctuations in crude protein content at 0.5 kGy to 2 kGy. Samples irradiated at 0.5 kGy initially recorded crude protein content of 2.03 % but at the

second week of storage it had reduced to 0.62 % and increases again at the third week of storage to 2.17 % (Table 2b). Samples irradiated at 1 kGy had significantly higher amount of crude protein content at the third week of storage; at the initial week of storage the crude protein content was 0.60 % but at the third week of storage 2.05% was recorded (Table 2b). Samples irradiated at 1.5 kGy had significantly lower amounts of 0.35 % crude proteins in the second week of storage but at the third week of storage 3.27 % was recorded which was significantly different($p<0.05$) from that recorded at all the storage periods (Table 2b). Samples irradiated at 2 kGy also showed lower amounts of crude proteins recorded at first week of storage with 0.46 % but an amount of 3.27 % were recorded at the third week of storage (Table 2b). Comparatively, crude protein content was significantly different from each packaging material at the control, 0.5 kGy and 1 kGy. With the highest mean of 2.57% recorded in samples irradiated at a dose of 0.5 kGy stored in hermetically sealed bag. However this was not significantly different from unirradiated samples that were stored in zip-lock polyethylene bag (Figure 29).

4.1.4.6 Effect of irradiation and refrigeration storage on colour

Storage, irradiation doses and interaction of irradiation doses with storage had significant effect on the L-value on samples stored in both packaging materials. The L-value of processed leaf stored in both zip-lock polyethylene bag showed a decrease at 0 kGy after every week of storage but this was not significantly different ($p<0.05$) from the first week to the third week of storage (Table 2a). At 0.5 kGy and 1 kGy, L-value increased after every week of storage with no significant difference ($p>0.05$) in the means (Table 2a). There were fluctuations at 1.5 kGy and 2 kGy but there was no significant differences ($p>0.05$) in the means (Table 2a). Samples stored in

hermetically sealed bag showed fluctuations in the control and 0.5 kGy whiles samples irradiated at 1 kGy, 1.5kGy and 2 kGy showed an increase in L-value after every week of storage but there were no significance difference ($p>0.05$) (Table 2b). Comparatively between the two packaging materials, L-value showed no significant differences from each other at all dose (Figure 30).

Storage and interaction of irradiation doses and storage had significant effect on the a-value and b-value in both packaging materials. There was a decrease in a-value of samples stored in zip-lock polyethylene bag after every storage week and the decrease was dose dependent. The higher the dose the higher the reduction but the decrease was not significant (Table 2a). Whiles control samples recorded a- value of -19.42 at the initial week of storage and -9.91 at the third week of storage, samples irradiated at 2 kGy recorded an a- value of -2.11 at the initial week of storage and -1.03 at the third week of storage (Table 2a). Also samples stored in hermetically sealed bag showed a decrease of a-value after every storage week but this was not dose dependent (Table 2b). For instance, samples irradiated at 1 kGy recorded an a-value of -7.86 at the initial week of storage which was higher than that recorded in samples irradiated at 0.5 kGy with -3.19; also at the third week of storage the a-value recorded for samples irradiated at 1 kGy was -6.34 whiles that of samples irradiated at 0.5kGy was -3.10 which was again less than that recorded from samples irradiated at 1 kGy (Table 2b). Comparatively, the decrease in a-value was less in hermetically sealed bag than zip-lock polyethylene bag but this was not significant (Figure 31).

The b-value showed fluctuations in the control. However samples irradiated at 0.5 kGy, 1 kGy, 1.5 kGy and 2 kGy stored in zip-lock bag showed an increase in the b-value (Table 2a). The highest b- value of 15.81 was recorded after the storage period in the control and the lowest of 8.42 was recorded in samples irradiated at 2 kGy

(Table 2a). Samples stored in hermetically sealed bag recorded an increased in b-value after every storage week in the control, 0.5kGy, 1.5 kGy and 2 kGy. However, at 1 kGy, samples showed fluctuations in the b-value means recorded (Table 2b). After the storage period the highest b- value of 18.12 was recorded in the control and the lowest was recorded from samples irradiated at 2 kGy (Table 2b). Comparatively b-value was not significantly different from each packaging material at all doses (Figure 32).

Table 2a: Treatment means for the effect of irradiation and refrigeration storage on the physicochemical properties of processed cocoyam leaf during storage in zip-lock polyethylene bag

Storage	Doses (kGy)	Moisture content (%)	Dry matter (%)	pH	Vitamin C(mg/100g)	Crude protein (%)	L-value	a-value(-)	b-value
0	0	83.73±0.32^{a}	16.27±0.32^{a}	6.41±0.01^{a}	34.58±0.57^{x}	2.37 ± 0.02^{d}	46.93±0.72^{a}	-19.42±0.79^{n}	16.38±0.14^{a}
	0.5	86.02±0.32^{d}	13.98±0.32^{d}	6.28±0.01^{c}	11.15±0.57^{vy}	1.37 ± 0.02^{e}	19.94±0.72^{c}	-2.89±0.79^{r}	4.13±0.14^{d}
	1	86.50±0.32^{de}	13.50±0.32^{de}	6.37±0.01^{a}	9.78±0.57^{vy}	1.44 ± 0.02^{e}	22.20± 0.72^{cd}	-2.7±0.79^{r}	4.77±0.14^{d}
	1.5	85.26±0.32^{i}	14.74±0.32^{i}	6.16±0.01^{e}	7.96±0.57^{y}	1.63 ± 0.02^{e}	21.62±0.72^{cd}	-2.16±0.79^{rt}	4.31±0.14^{d}
	2	86.76±0.32^{de}	13.24±0.32^{de}	6.31±0.01^{c}	3.41±0.57^{vga}	1.31 ± 0.02^{e}	20.21±0.72^{cd}	-2.11±0.79^{rt}	4.15±0.14^{d}
1	0	88.4±0.46^{b}	11.6±0.46^{b}	6.53±0.01^{a}	25.48±0.76^{x}	2.35±0.11^{d}	39.56±0.65^{ab}	-18.5±0.18^{n}	21.75±0.41^{ab}
	0.5	86.63±0.46^{de}	13.37±0.46^{de}	6.43±0.01^{a}	9.784±0.76^{vy}	2.08±0.11^{fd}	21.22±0.65^{cd}	-2.49±0.18^{r}	6.61±0.41^{de}
	1	87.73±0.46^{f}	12.30±0.46^{f}	6.19±0.01^{e}	3.87±0.76^{vg}	0.43±0.11^{h}	29.35±0.65^{de}	-2.55±0.18^{r}	7.46±0.41^{ef}
	1.5	86.72±0.46^{de}	13.28±0.46^{de}	6.60±0.01^{ab}	2.73±0.76^{vgi}	1.09±0.11^{ek}	26.79±0.65^{ef}	-2.11±0.1^{8rt}	5.29±0.41^{fd}
	2	87.5±0.46^{fgh}	12.5±0.46^{fgh}	6.11±0.01^{e}	2.96±0.76^{vga}	2.10±0.11^{ed}	26.65±0.65^{ef}	-2.06±0.18^{rtv}	5.77±0.41^{fdl}
2	0	89.39±0.51^{b}	10.61±0.36^{b}	6.91 ±0.004^{b}	7.51±0.76^{y}	2.30±0.04^{d}	34.60±0.58^{ab}	-10.82±0.40^{m}	17.48±0.41^{a}
	0.5	86.23±0.51^{de}	13.78±0.36^{de}	6.66±0.004^{ab}	4.55±0.76^{vyu}	1.98±0.04^{edf}	24.38±0.58^{cd}	-2.48±0.40^{r}	7.41±0.41^{ef}
	1	89.46±0.51^{fg}	10.54±0.36^{fg}	6.63±0.004^{ab}	2.73±0.76^{vgi}	0.33±0.04^{h}	29.45±0.58^{de}	-2.44±0.40^{rs}	8.48±0.41^{fg}
	1.5	88.58±0.51^{fgh}	11.42±0.36^{fgh}	5.94±0.004^{e}	2.50±0.76^{vgi}	0.36±0.04^{h}	24.67±0.58^{efg}	-2.09±0.40^{rtv}	8.47±0.41^{efg}
	2	87.68±0.51^{fgh}	12.32±0.36^{fgh}	6.28±0.004^{c}	2.28±0.76^{vga}	0.37±0.04^{h}	24.48±0.58^{efg}	-2.04±0.40^{rtv}	6.45±0.41^{de}
3	0	91.12±0.75^{c}	8.88±0.75^{c}	6.86±0.004^{b}	7.05±0.41^{y}	2.33±0.15^{d}	32.79 ±0.31^{ab}	-9.91±0.15^{m}	15.81±0.10^{ca}
	0.5	88.23±0.75^{f}	11.77±0.75^{f}	6.70±0.004^{ab}	1.59±0.41^{w}	1.92±0.15^{fgd}	25.12±0.31^{cd}	-2.30±0.15^{rs}	8.63±0.10^{efg}
	1	88.39±0.75^{fgh}	11.61±0.75^{fgh}	7.24±0.004^{d}	2.50±0.41^{vgi}	2.53±0.15^{di}	30.42±0.31^{deb}	-2.29±0.15^{rs}	9.34±0.10^{ghi}
	1.5	87.49±0.75^{fgh}	12.51±0.75^{fgh}	6.14±0.004^{e}	1.59±0.41^{w}	2.49±0.15^{di}	30.26±0.31^{deb}	-1.4±0.15^{rtu}	9.26±0.10^{gh}
	2.0	86.07±0.75^{de}	13.9±0.75^{de}	6.59±0.004^{ab}	1.37±0.41^{wga}	2.84±0.15^{udi}	25.39±0.31^{efh}	-1.03±0.15^{rtw}	8.42±0.10^{gh}

Means followed by the same alphabet within the same column are not significantly different from each other (p>0.05)

Table 2b: Treatment means for the effect of irradiation and refrigeration storage on the physicochemical properties of processed cocoyam leaf during storage in hermetically sealed bag

Storage	Doses (kGy)	Moisture content (%)	Dry matter (%)	pH	Vitamin C(mg/100g)	Crude protein (%)	L-value	a-value	b-value
0	0	83.73±0.78^{a}	16.27±0.78^{a}	5.83±0.01^{v}	36.41±0.38^{x}	2.43±0.39^{l}	46.93±0.41^{x}	-19.52±0.08^{r}	16.38±0.18^{a}
	0.5	87.12±0.78^{d}	12.88±0.78^{d}	5.85±0.01^{v}	11.83±0.38^{a}	2.03±0.39^{lu}	22.66±0.41^{w}	-3.74±0.08^{d}	5.94±0.18^{g}
	1	86.60±0.78^{d}	13.40±0.78^{d}	5.63±0.01^{x}	10.24±0.38^{a}	0.60±0.39^{h}	27.38±0.41^{wi}	-7.86±0.08^{kd}	10.37±0.18^{cb}
	1.5	88.09±0.78^{hfe}	11.91±0.78^{hfe}	5.78±0.01^{v}	8.87±0.38^{df}	1.53±0.39^{ki}	21.87±0.41^{vw}	-3.19±0.08^{dh}	5.22±0.18^{cge}
	2	88.33±0.78^{hf}	11.67±0.78^{hf}	6.01±0.01^{vi}	4.10±0.38^{f}	1.56±0.39^{ki}	22.07±0.41^{vw}	-3.49±0.08^{dit}	5.61±0.18^{cge}
1	0	89.8± 0.74^{b}	10.2±0.74^{b}	5.94±0.04^{v}	27.99±0.47^{xy}	2.61±0.08^{lk}	36.13±0.1^{u}	-15.68±0.1^{rs}	17.70±0.30^{a}
	0.5	86.84±0.74^{df}	13.17±0.74^{df}	6.83±0.04^{tv}	10.47±0.47^{a}	2.71±0.08^{lk}	21.60±0.18^{vw}	-3.65±0.10^{de}	7.53±0.30^{b}
	1	84.91±0.74^{ag}	15.09±0.74^{ag}	6.28±0.04^{v}	8.19±0.47^{bd}	1.24±0.08^{hi}	28.28±0.18^{i}	-7.59±0.10^{kd}	8.60±0.30^{cbd}
	1.5	88.26±0.74^{hf}	11.74±0.74^{hf}	6.71±0.04^{tv}	3.87±0.47^{cu}	1.97±0.08^{kiu}	22.75±0.18^{vw}	-3.14±0.10^{dhi}	7.78±0.30^{b}
	2	86.96±0.74^{df}	13.04±0.74^{df}	5.76±0.04^{v}	2.96±0.47^{cuv}	0.46±0.08^{h}	23.57±0.18^{vw}	-3.31±0.10^{dit}	6.69±0.30^{bh}
2	0	89.55± 0.33^{bc}	10.45±0.33^{bc}	6.62±0.01^{u}	9.56 ±0.57^{a}	2.62±0.037^{lk}	36.08±0.10^{u}	-11.7±0.09^{rst}	17.68±0.07^{a}
	0.5	88.02±0.33^{fe}	11.98±0.33^{fe}	6.27±0.01^{v}	9.78±0.57^{a}	0.62 ±0.03^{h}	24.41±0.10^{pw}	-3.54±0.09^{de}	8.44±0.07^{b}
	1	88.18±0.33^{fe}	11.83±0.33^{fe}	6.53±0.01^{u}	2.96±0.57^{ce}	0.3±0.03 ^{h}	29.55±0.10^{ij}	-6.50±0.09^{kdg}	9.30±0.07^{cbd}
	1.5	88.95±0.33^{hfu}	11.05±0.33^{hfu}	6.93±0.01^{tv}	3.64±0.57^{cu}	0.35±0.03^{h}	24.52±0.10^{pw}	-3.12±0.09^{dhi}	8.27±0.07^{cbf}
	2	88.82±0.33^{hfu}	11.19±0.33^{hfu}	6.14±0.01^{i}	2.50±0.57^{cuv}	0.21±0.03 ^{h}	24.48±0.10^{pw}	-3.32±0.09^{dit}	7.38±0.07^{b}
3	0	91.14±0.29^{cb}	8.86±0.29^{cb}	6.57±0.004^{u}	8.42±0.53^{ab}	2.62 ±0.17^{lk}	30.28±0.24^{v}	-8.39±0.05^{k}	18.12±0.10^{a}
	0.5	88.95±0.29^{hfu}	11.05±0.29^{hfu}	6.70 ±0.004^{tv}	3.41±0.53^{c}	2.17±0.17^{luv}	25.04±0.24^{pw}	-3.37±0.05^{def}	8.70±0.10^{b}
	1	87.69±0.29^{dh}	12.43±0.29^{dh}	6.84±0.004^{tv}	3.87±0.53^{cu}	2.05±1.7^{lk}	30.44±0.24^{ijk}	-6.34±0.05^{dg}	10.37±0.10^{cb}
	1.5	88.29±0.29^{hf}	11.71±0.29^{hf}	6.60±0.004^{u}	3.19±0.53^{cuv}	3.27±0.17^{m}	30.32±0.24^{ijk}	-3.10±0.05^{dhi}	8.59±0.10^{cbv}
	2	89.75±0.29^{bc}	10.25±0.29^{bc}	7.03±0.004^{tvb}	2.05±0.53^{cvw}	3.27±0.17^{m}	25.52±0.24^{pw}	-3.17±0.05^{dhi}	8.38±0.10^{cdf}

Means followed by the same alphabet within the same column are not significantly different from each other (p>0.05)

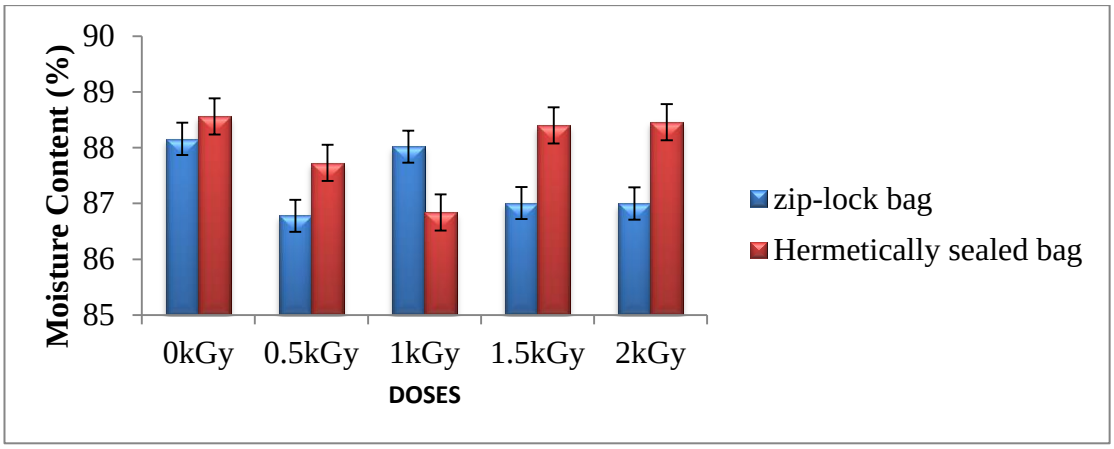

Figure 25: Effect of doses on the moisture content of processed cocoyam leaf after irradiation and refrigeration storage

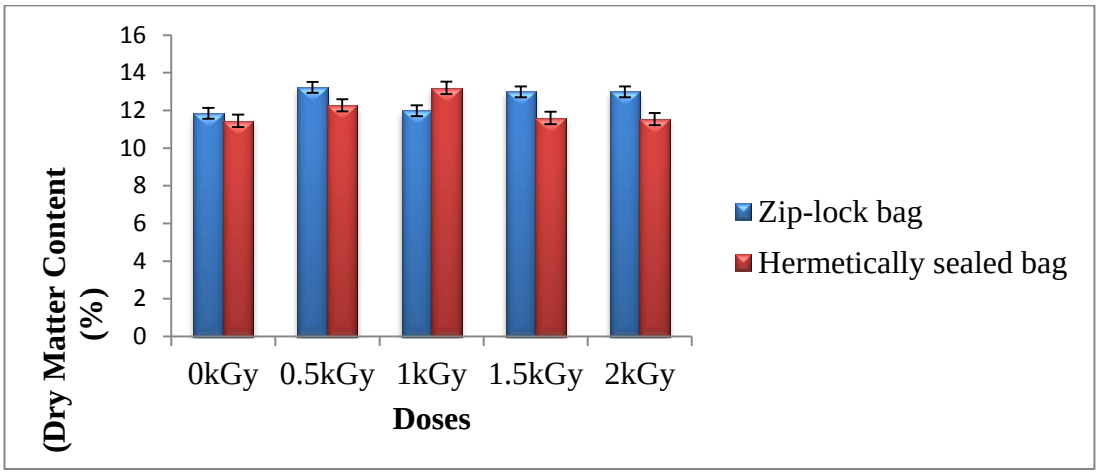

Figure 26: Effect of doses on the dry matter of processed cocoyam leaf after irradiation and refrigeration storage

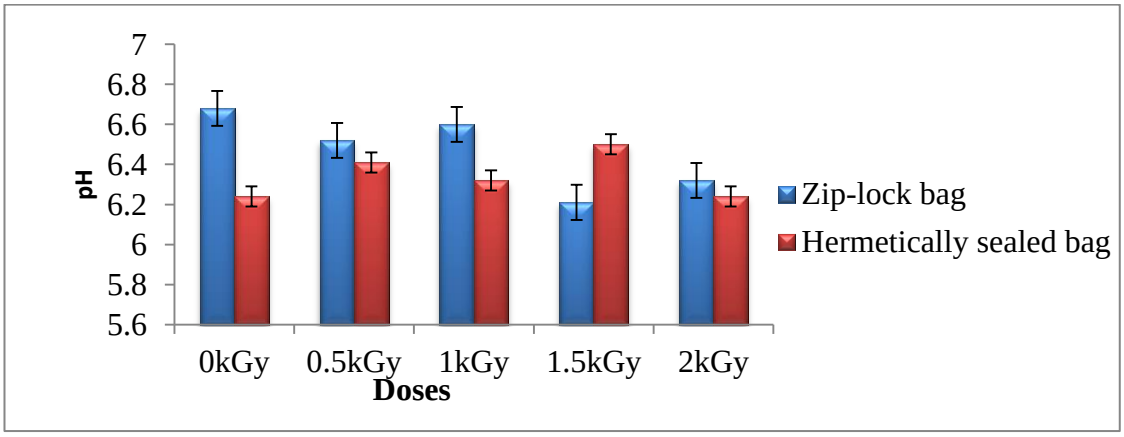

Figure 27: Effect of doses on the pH of processed cocoyam leaf after irradiation and refrigeration storage

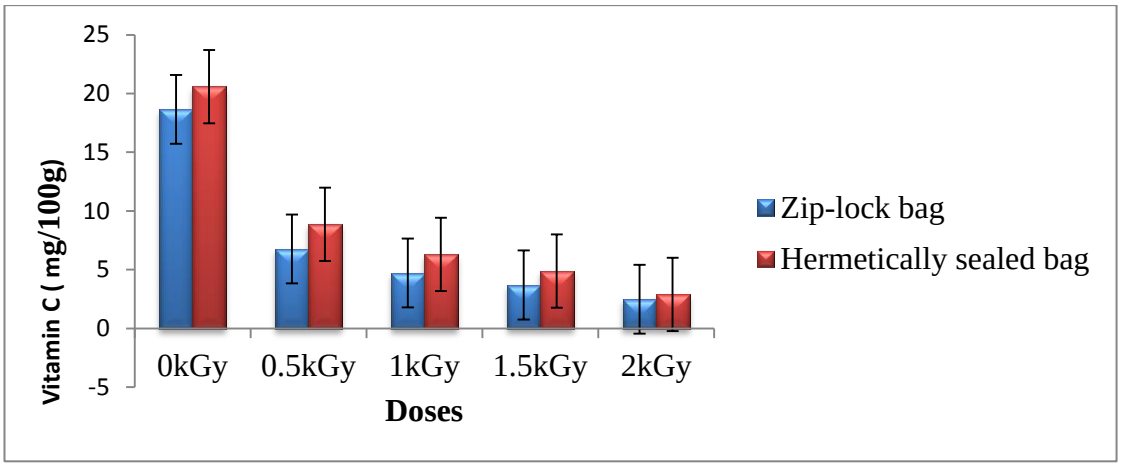

Figure 28: Effect of doses on the vitamin C content of processed cocoyam leaf after irradiation and refrigeration storage

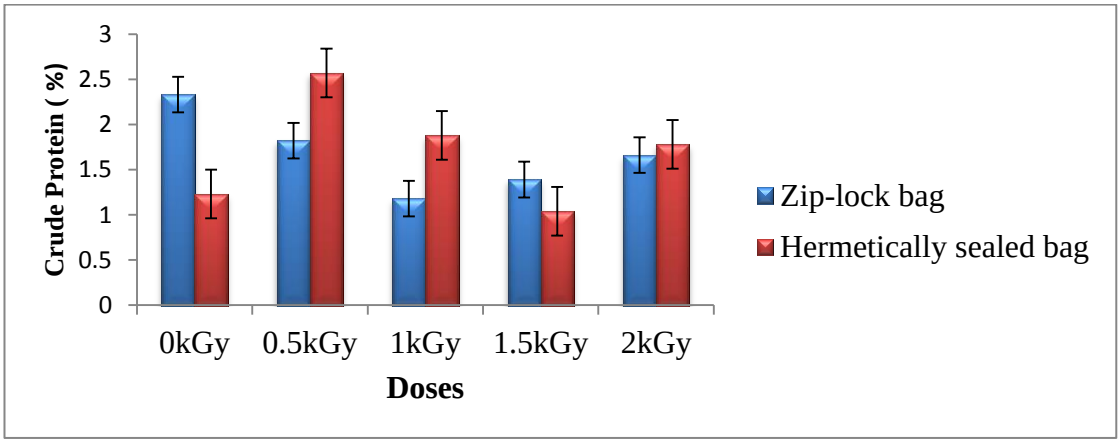

Figure 29: Effect of doses on the crude protein of processed cocoyam leaf after irradiation and refrigeration storage

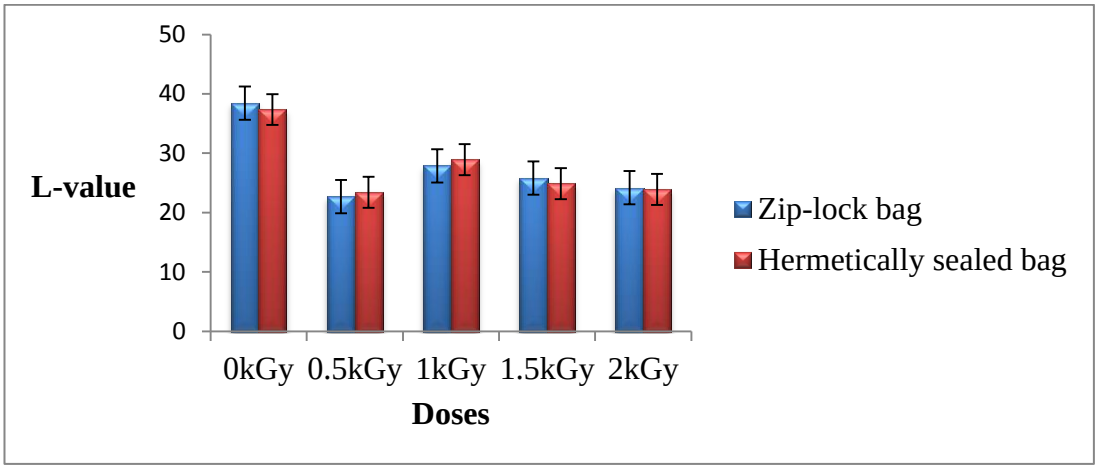

Figure 30: Effect of doses on the L-value of processed cocoyam leaf irradiation and refrigeration storage

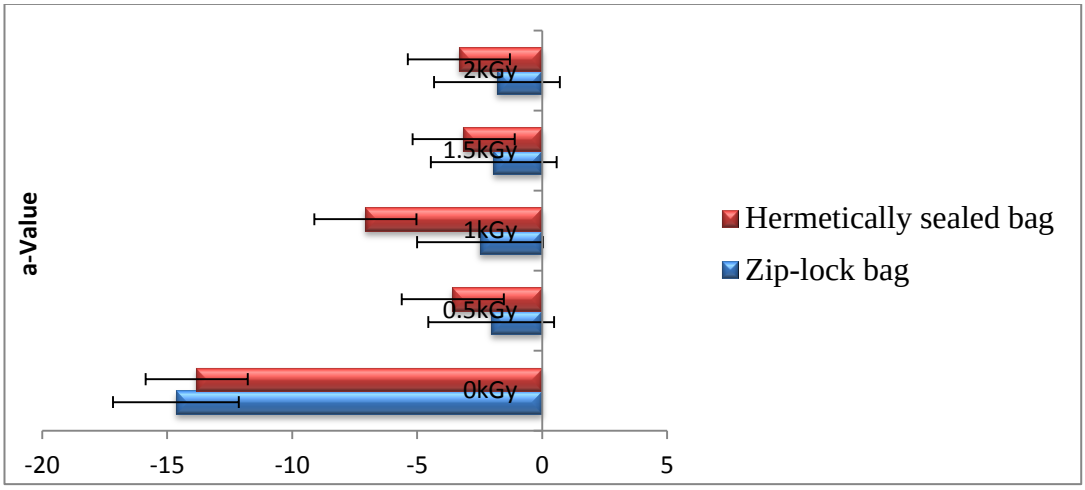

Figure 31: Effect of doses on the a-value of processed cocoyam leaf after irradiation and refrigeration storage

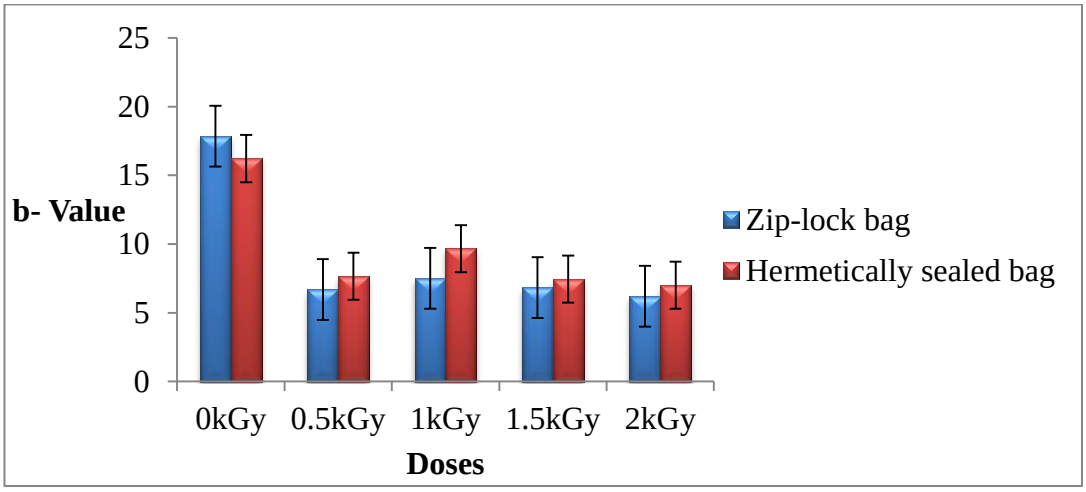

Figure 32: Effect of doses on the b-value of processed cocoyam leaf after irradiation and refrigeration storage

4.1.5 Effect of blanching, irradiation and ambient temperature storage on the physicochemical properties of processed cocoyam leaf

4.1.5.1 Effect of blanching, irradiation and ambient temperature storage on moisture content

Storage and interaction of doses with storage had significant ($p<0.05$) effect on the moisture content in samples stored in both zip-lock bag and hermetically sealed bag. Moisture content increased with storage at all doses and in both packaging materials

(Table 3). Comparatively, between packaging materials, moisture content was high at 0.5 kGy with 92 % from samples stored in zip-lock bag but this was not significantly different from the moisture content recorded at 1 kGy 90.93 % in samples stored in hermetically sealed bag (Table 3). The lowest moisture content of 85.20 % was recorded at 0.5 kGy in samples stored in hermetically sealed polyethylene bag (Table 3).

4.1.5.2 Effect of blanching, irradiation and ambient temperature storage on dry matter content

Storage and interaction doses with storage had significant ($p<0.05$) effect on the dry matter in samples stored in both zip-lock bag and hermetically sealed bag. Moisture content decreased at all doses in all samples stored in both packages (Table 3). Comparatively, between packaging materials moisture was low with 7.49 % in samples stored in zip-lock bag at 0.5 kGy but was not significantly different from that recorded in 1 kGy samples stored in hermetically sealed bag; and the highest mean of 14.80 % was recorded after the storage period from samples stored in hermetically sealed polyethylene bag (Table 3).

4.1.5.3 Effect of blanching, irradiation and ambient temperature storage on pH

Storage, irradiation doses and interaction of doses and storage in both packaging materials had significant effect on the pH. After the storage period, there was an increase in pH of samples stored in zip-lock polyethylene bag at 0 kGy to 1 kGy but a decrease at 1.5 kGy and 2 kGy (Table 3). Also, pH increased during storage in hermetically sealed polyethylene bag at the control but a decrease at 0.5 kGy, 1 kGy, 1.5 kGy and 2 kGy (Table 3). Comparatively, pH was higher with 6.14 from

samples irradiated at 1 kGy that were stored in zip-lock polyethylene bag during storage and the lowest of 5.47 recorded at 2kGy from samples stored in hermetically sealed polyethylene bag (Table 3).

4.1.5.4 Effect of blanching and Irradiation on vitamin C (Ascorbic acid)

Storage, irradiation doses and interaction of doses with storage had significant effect on the vitamin C content in both packaging materials (Appendix 1:E7 and E8).There was a decrease in the vitamin C content at all doses in both packaging materials after the storage period (Table 3).

However during storage, the control of sample stored in hermetically sealed bag recorded the highest vitamin C content of 14.33 mg/100g at the initial week of storage and 10.33 mg/100g after the storage period. However, this was not significantly different from that recorded from zip-lock bag at the same dose (Table 3). Throughout the storage period, a significant lower amount of vitamin C content of 0.68 mg/100g was recorded from samples stored in zip-lock polyethylene bag that was irradiated at 2 kGy at the second week storage (Table 3).

4.1.5.5 Effect of blanching, irradiation and ambient temperature storage on crude protein

Storage and irradiation doses had significant effect on the crude protein content stored in zip-lock polyethylene bag. However, there was no significant effect in the interaction of doses and storage. There was an increase in crude protein at all doses during storage (Table 3). Processed cocoyam leaf stored in hermetically sealed bag showed significant effect in crude protein content in all interactions. Crude protein content increased at all doses during storage (Table 3). Comparatively crude protein content was higher with 2.49 % in samples stored in hermetically sealed

polyethylene bag at 2 kGy but this was not significant; and the lowest of 1.32 % was recorded from samples irradiated at 1 kGy that were stored in hermetically sealed polyethylene bag (Table 3).

4.1.5.6 Effect of blanching, irradiation and ambient temperature storage on colour

Storage, irradiation doses and interaction of doses and storage showed no significant effect on the L and a-values in stored samples in both packaging materials. There was an increase in the L-value of all samples stored and at all doses. The highest L-value of 40.52 was recorded at 1 kGy from samples stored in hermetically sealed polyethylene bag and the lowest of 29.79 was recorded at the control of samples stored in hermetically sealed bag (Table 3). The a-value also showed a decrease at all doses and packaging materials used for storage. A significantly higher a- value of -9.52 was recorded during storage at the control from samples that were stored in hermetically sealed polyethylene bag at the initial week of storage and the lowest of 2.16 was also recorded from samples irradiated at 2 kGy that were stored in zip-lock polyethylene bag after the storage period (Table 3). Storage, irradiation doses and interaction of doses and storage showed no significant effect on the b-values of samples stored in zip-lock polyethylene bag. However there was an increase in b-value during storage (Table 3). Samples stored in hermetically sealed bag also showed significant effect of storage, irradiation doses and interaction of storage and doses on the b-value (Appendix 1:E16). There was an increase at all doses during storage (Table 3). A significantly higher b-value of 15.56 was recorded at the control of samples stored in zip-lock bag at the initial week of storage and the lowest of 9.01

was recorded at 1.5 kGy in samples stored in hermetically sealed polyethylene bag (Table 3).

Table 3: Treatment means for the effect of blanching and irradiation on the physicochemical properties of processed cocoyam leaf during storage at ambient temperature

	Storage week	Doses (kGy)	Moisture content (%)	Dry matter (%)	pH	Vitamin C(mg/100g)	Crude protein (%)	L-value	a-value	b-value
ZIP-LOCK BAG	0	0	89.87±0.93^{a}	10.13±0.93^{a}	6.60±0.004^{x}	13.20±0.30^{a}	1.98±0.10^{y}	26.71±0.12^{n}	-9.54±0.04^{a}	13.06±0.07^{s}
		0.5	92.3±0.93^{de}	7.70±0.93^{d}	5.55±0.004^{u}	2.73±0.30^{c}	1.67±0.10^{j}	22.87±0.12^{k}	-3.69±0.04^{c}	10.84±0.07^{r}
		1	88.91±0.93^{fa}	11.09±0.93^{fa}	6.10±0.004^{v}	6.60±0.30^{fe}	1.67±0.10^{j}	22.87±0.12^{k}	-3.19±0.04^{cd}	9.733±0.07^{r}
		1.5	88.18±0.93^{ab}	11.82±0.93^{ab}	6.62±0.004^{x}	2.28±0.30^{c}	1.94±0.10^{y}	22.56±0.12^{k}	-3.49±0.04^{c}	9.60±0.07^{r}
		2	86.62±0.93^{dg}	13.38±0.93^{dg}	6.26±0.004^{xv}	1.14±0.30^{cd}	1.67±0.10^{y}	22.76±0.12^{k}	-3.71±0.04^{ce}	10.53±0.07^{r}
	1	0	89.08±0.93^{ab}	10.92±0.93^{ab}	6.70±0.004^{x}	11.60±0.30^{ab}	2.49±0.10^{z}	32.01±0.12^{m}	-8.78±0.04^{a}	15.56±0.07^{rs}
		0.5	92.51±0.93^{de}	7.49±0.93^{de}	5.72±0.004^{uv}	1.37±0.30^{cd}	1.74±0.10^{jh}	39.10±0.12^{l}	-3.34±0.04^{c}	10.60±0.07^{r}
		1	89.08±0.93^{f}	10.92±0.93^{f}	6.14±0.004^{v}	3.41±0.30^{ce}	1.91±0.10^{y}	37.92±0.12^{l}	-2.66±0.04^{cd}	5.85±0.07^{u}
		1.5	90.67±0.93^{d}	9.33±0.93^{d}	6.06±0.004^{v}	1.59±0.30^{cd}	2.32±0.10^{z}	38.93±0.12^{l}	-2.49±0.04^{cd}	5.30±0.07^{uc}
		2	89.69±0.93^{a}	10.31±0.93^{a}	5.61±0.004^{u}	0.68±0.30^{hcd}	1.86±0.10^{y}	39.11±0.12^{l}	-2.16±0.04^{cd}	5.95±0.07^{u}
HERMETICALLY SEALED BAG	0	0	90.16±0.72^{ca}	9.85±0.72^{ca}	6.08±0.05^{v}	14.33 ±0.37^{a}	2.41±0.06^{z}	27.63±0.82^{n}	-10.86±0.07^{ab}	11.34±0.07^{r}
		0.5	88.96±0.72^{fa}	11.04±0.72^{fa}	6.07±0.05^{v}	4.78±0.37^{ced}	2.34±0.06^{z}	29.56±0.82^{m}	-3.42±0.07^{ce}	5.92±0.07^{u}
		1	90.59±0.72^{de}	9.41±0.72^{de}	6.10±0.05^{v}	8.19±0.37^{fg}	1.43±0.06^{j}	22.85±0.82^{k}	-3.56±0.07^{ce}	6.46±0.07^{uv}
		1.5	90.50±0.72^{d}	9.50±0.72^{d}	6.26±0.05^{xu}	2.50±0.37^{c}	2.11±0.06^{z}	23.60±0.82^{k}	-3.26±0.07^{c}	6.66±0.07^{uv}
		2	90.50±0.72^{d}	9.50±0.72^{d}	5.84±0.05^{uv}	1.37±0.37^{cd}	2.20±0.06^{z}	23.46±0.82^{k}	-3.13±0.07^{c}	5.87±0.07^{u}
	1	0	91.61±0.72^{da}	8.39±0.72^{da}	6.11±0.05^{v}	10.33±0.37^{ab}	2.46±0.06^{z}	29.79±0.82^{m}	-9.52±0.07^{a}	12.41±0.07^{r}
		0.5	85.20±0.72^{g}	14.80±0.72^{g}	5.87±0.05^{uv}	4.58±0.37^{ced}	2.51±0.06^{z}	37.82±0.82^{l}	-3.38±0.07^{c}	10.43±0.07^{r}
		1	89.58±0.72^{a}	10.42±0.72^{a}	5.54±0.05^{uv}	4.19±0.37^{ce}	1.32±0.06^{j}	40.52±0.82^{li}	-3.34±0.07^{c}	9.64±0.07^{r}
		1.5	90.93±0.72^{dx}	9.08±0.72^{dx}	5.73±0.05^{uv}	1.50±0.37^{cd}	2.24±0.06^{z}	38.61±0.82^{l}	-2.44±0.07^{cd}	9.01±0.07^{rb}
		2	88.67±0.72^{a}	11.34±0.72^{a}	5.47±0.05^{uv}	1.28±0.37^{cd}	2.50±0.06^{zd}	37.14±0.82^{l}	-2.17±0.07^{cd}	10.06±0.07^{r}

Means followed by the same alphabet within the same column are not significantly different from each other (p>0.05)

4.1.6 Effect of blanching, irradiation and refrigeration storage on the physicochemical properties of processed cocoyam leaf

4.1.6.1. Effect of blanching, irradiation and refrigeration storage on moisture content

Storage and irradiation doses had significant effect on moisture content of samples stored in zip-lock bag ($p<0.05$). There were variations in moisture content in doses (Figure 33). Interaction of storage and irradiation doses did not show significant effect on the moisture content ($p>0.05$). The control showed an increase after every storage week. There were fluctuations in the moisture content of samples irradiated at 0.5 kGy, 1 kGy, 1.5 kGy and 2 kGy at storage (Table 4a). The highest moisture content of 94.09 % was recorded at 0.5kGy at the third week of storage, but was not significantly different from that recorded at 2 kGy. Whiles the lowest of 89.92 % was recorded at 1 kGy after the storage period but this was also not significantly different from that recorded at the control, 1.5 kGy and 2kGy (Table 4a).

With samples stored in hermetically sealed polyethylene bag, storage, irradiation doses and interaction of irradiation doses with storage had significant effect on the moisture content ($p<0.05$). There was an increase in moisture content at all doses after the storage period (Table 4b). After the storage period, the highest moisture content of 92.90 % was recorded at 0.5 kGy but was not significantly different from that recorded at control, 0.5 kGy and 2 kGy; but a significantly lower percentange of 87.65 was recorded at 1 kGy (Table 4b). Comparatively, moisture content was significantly different from each packaging material at 0.5 kGy, 1 kGy and 1.5 kGy (Figure 33). Comparatively, the highest mean moisture content of 92.08% was recorded at 0.5 kGy from samples stored in zip-lock polyethylene bag and the lowest mean of 88.13 % was also recorded at 1 kGy from samples stored in hermetically sealed polyethylene bag which was significantly different ($p<0.05$) (Figure 33).

4.1.6.2. Effect of blanching, irradiation and refrigeration storage on dry matter

Storage, irradiation doses had significant effect on the dry matter content on samples stored in zip-lock bag. However, interaction of doses and storage showed no significant effect on dry matter. After the storage period, the highest dry matter content of 10.08 % was recorded at 1 kGy but was not significantly different from that recorded at the control, 1.5 kGy and 2 kGy and the lowest of 5.91 % at 0.5 kGy but not significantly different from that recorded at 2 kGy (Table 4a).

Storage and irradiation doses had significant effect ($p<0.05$) on the dry matter content in samples stored in hermetically sealed bag. Dry matter reduced at all doses used during storage; with the highest 13.13 % of dry matter recorded during storage at 1 kGy but was not significantly different from that recorded at the control and the a significant lower amount of 6.5% recorded at 1.5 kGy (Table 4b). Comparatively dry matter content of samples irradiated at 1.5 kGy was significantly different from all other samples (Figure 34). The highest mean of 12.19 % was recorded at the control from samples that were stored in hermetically sealed polyethylene bag and the lowest of 7.93 % was at 0.5 kGy from samples stored in zip-lock polyethylene bag (Figure 34).

4.1.6.3 Effect of blanching, irradiation and refrigeration storage on pH

Storage, irradiation doses and interactions had significant effect on the pH on samples stored in both packaging materials. Storage after every storage week showed fluctuations in pH at 0.5 kGy, 1 kGy, 1.5 kGy and 2 kGy from both packaging materials (Table 4a and 4b). However, pH of the control from samples stored in hermetically sealed polyethylene bag showed consistent increase (Table 4a). The pH

at all doses in both packaging materials were significantly different from each packaging material at only 0.5 kGy (Figure 35).

4.1.6.4 Effect of blanching, irradiation and refrigeration storage on vitamin C

Storage, irradiation doses and interaction of storage with doses had significant effect on the vitamin C content on samples stored in both packaging materials. There was reduction in the vitamin C content after every storage week (Table 4a). Also there was a decrease in vitamin C after every storage week in the control, 1 kGy and 2 kGy but fluctuations at 0.5 kGy. The highest vitamin C content of 13.20 mg/100g at the control and the lowest of 2.50 mg/100g from samples irradiated at 2 kGy. However during the storage period, the highest vitamin C content of 7.51 mg/100g was recorded at the control and the lowest of 0.91 mg/100g was recorded from samples irradiated at 0.5 kGy (Table 4a). Samples stored in hermetically sealed bag, recorded a decrease in vitamin C content after every storage week. Samples irradiated at 1 kGy showed consistent decrease but inconsistent vitamin C content was recorded from samples irradiated at 0.5 kGy, 1.5 kGy and 2 kGy (Table 4b). The highest vitamin C was recorded at the control with 14.33 mg/100g and the lowest mean of 3.19 mg/100g from samples irradiated at 2 kGy (Table 4b). Comparatively, the vitamin C content was not significantly different for packaging materials at all doses (Figure 36).

4.1.6.5 Effect of blanching, irradiation and refrigeration storage on crude protein

Storage, irradiation doses and interaction of doses with storage no significant effect ($p>0.05$) on the crude protein content on samples stored in zip-lock polyethylene bag but a significant effect ($p<0.05$) in samples stored in hermetically sealed polyethylene bag. There was an increase after each storage week at the control of samples stored in zip-lock polyethylene bag and fluctuations at doses between 0.5 kGy to 2 kGy (Table 4a). At the initial week of storage, the highest crude protein content of 1.99% was recorded from samples irradiated at 2 kGy but this was not significantly different from that recorded at the control and the lowest of 1.32 % from samples irradiated at 0.5 kGy but was also not significantly different from that recorded at 1 kGy, 1.5 kGy and 2 kGy (Table 4a). However at the third week of storage the highest crude protein content of 10.42 % was recorded from samples irradiated at 1.5 kGy which was not significantly different from that recorded at control, 1 kGy and 2 kGy. Whiles the lowest significant amount was recorded from samples irradiated at 1 kGy of 7.54 % (Table 4a).

Samples stored in hermetically sealed bag showed an increase in crude protein content after every storage week at the control, 1 kGy and 2 kGy and fluctuations at 0.5 kGy and 1.5 kGy (Table 4b). At the initial week of storage, a significant higher amount of crude protein content from samples irradiated at 1.5 kGy and the lower of 1.04 % from samples irradiated at 2 kGy which was also significant (Table 4b). However at the third week of storage the highest crude protein of 10.81% was recorded from samples irradiated at 1.5 kGy but this was not significantly different from that recorded at 0.5 kGy but a significant lower percentage of 7.42 were

recorded from samples irradiated at 1 kGy (Table 4b). Comparatively crude protein was significantly different form each packaging materials at 0.5 kGy (Figure 37).

4.1.6.6 Effect of blanching, irradiation and refrigeration storage on colour

Storage, irradiation doses and interaction of doses and storage had significant effect on the L, a, and b-values on samples stored in both packaging materials. There was also an increase after each storage week in samples stored in zip-lock polyethylene bag (Table 4a). At the initial week of storage, there were no significance differences in L-values recorded (Table 4a). However, at the third week of storage, a significantly higher L- value of 43.45 was recorded at the control (Table 4a). Samples stored in hermetically sealed bag showed fluctuations in the L-value at 0 kGy but a consistent increase after every storage week at doses between 0.5 kGy to 2 kGy (Table 4b). At both the initial and final week of storage, there were no significant differences in L-value (Table 4b). Comparatively, L-value was different from each packaging material at only the control (Figure 38).

Samples stored in zip-lock bag showed a decrease of a- value after every storage week at 0 kGy, 0.5 kGy, 1 kGy and 2 kGy but fluctuations at 1.5 kGy (Table 4a). The initial week of storage recorded a significant difference in a – value at only the control in both packaging materials but no significant difference at the third week of storage (Tables 4a and 4b). There was a decrease with storage in the a-value in samples stored in hermetically sealed bag at all doses (Table 4b). Comparatively, significant differences were recorded at only the control (Figure 39).

There was an increase in the b-value after every storage week in samples stored in hermetically sealed bag at all doses (Table 4b). Significant differences were recorded in only the control from both packaging materials at the initial week of storage

(Tables 4a and 4b). However during the third week of storage, significant differences were recorded at only 2 kGy from samples stored in zip-lock polyethylene bag and at 1.5 kGy in samples stored in hermetically sealed polyethylene bag (Tables 4a and 4b). Comparatively, the b-value was significantly different from each packaging material at only the control (Figure 40).

Table 4a: Treatment means for the effect of blanching, irradiation and refrigeration on the physicochemical properties of processed cocoyam leaf during storage in zip-lock polyethylene bag

Storage	Doses (kGy)	Moisture content (%)	Dry matter (%)	pH	Vitamin C(mg/100g)	Crude protein	L-value	a-value	b-value
0	0	89.87±0.10^{a}	10.13±0.10^{a}	6.59±0.004^{x}	13.20±0.44^{t}	1.98±0.02^{a}	26.97±0.22^{v}	-9.55±0.08^{f}	13.86±0.07^{t}
	0.5	90.35±0.10^{ac}	9.66±0.10^{ac}	6.20±0.004^{vy}	4.78±0.44^{u}	1.32±0.02^{e}	23.19±0.22^{y}	-2.29±0.08^{g}	5.25±0.07^{b}
	1	89.85±0.10^{a}	10.15±0.10^{a}	6.35±0.004^{vy}	7.51±0.44^{vsu}	1.38±0.02^{e}	22.63±0.22^{y}	-2.57±0.08^{g}	5.46±0.07^{b}
	1.5	91.44±0.10^{c}	8.56±0.88^{a}	6.22±0.004^{vy}	3.53±0.44^{uvw}	1.72±0.02^{eg}	22.72±0.22^{y}	-2.12±0.08^{g}	5.39±0.07^{b}
	2	89.56±0.10^{a}	10.44±0.88^{a}	6.643±0.004^{x}	2.50±0.44^{w}	1.99±0.02^{a}	23.35±0.22^{y}	-2.23±0.08^{g}	4.84±0.07^{bn}
1	0	89.25±0.89^{ab}	10.75±0.88^{ab}	5.94±0.01^{v}	9.78±0.44^{s}	2.18±0.19^{ab}	24.58±0.22^{x}	-7.43±0.16^{fh}	11.23±0.13^{u}
	0.5	91.13±0.89^{c}	8.90±0.88^{c}	6.88±0.01^{x}	3.64±0.44^{uv}	1.3±0.19^{e}	38.10±0.22^{a}	-2.22±0.16^{gi}	10.70±0.13^{u}
	1	89.82±0.89^{a}	10.18±0.88^{a}	6.25±0.01^{vy}	4.10±0.44^{uv}	1.18±0.19^{g}	37.92±0.22^{a}	-2.40±0.16^{g}	8.68±0.13^{ux}
	1.5	86.61±0.89^{h}	13.39±0.88^{h}	6.5±0.01^{x}	2.28±0.44^{w}	1.18±0.19^{g}	39.6±0.22^{cb}	-2.38±0.16^{g}	7.30±0.13^{k}
	2	91.40±0.89^{c}	8.60±0.88^{a}	6.03±0.01^{v}	2.28±0.44^{w}	1.06±0.19^{e}	39.11±0.22^{ab}	-2.08±0.16^{gi}	6.28±0.13^{kg}
2	0	89.81±0.89^{a}	10.19±0.88^{a}	5.94±0.01^{v}	9.33±0.44^{sr}	2.19±0.19^{ab}	40.95±0.22^{v}	-5.28±0.16^{u}	15.72±0.13^{tv}
	0.5	92.74±0.89^{cd}	7.26±0.88^{cd}	6.36±0.01^{vy}	1.8±0.44^{v}	2.67 ±0.19^{f}	39.21±0.22^{ab}	-2.08±0.16^{gi}	10.37±0.13^{u}
	1	89.30±0.89^{af}	10.70±0.88^{ab}	6.65±0.01^{x}	3.87±0.44^{vu}	1.72±0.19^{eg}	39.43±0.22^{ab}	-2.34±0.16^{g}	9.41±0.13^{x}
	1.5	89.51±0.89^{a}	10.49±0.88^{a}	6.57±0.01^{x}	2.96±0.44^{wy}	1.84±0.19^{eg}	39.27±0.22^{ab}	-2.19±0.16^{gi}	8.44±0.13^{ux}
	2	90.32±0.89^{c}	9.68±0.88^{c}	6.88±0.01^{x}	2.28±0.44^{w}	0.45±0.19^{gi}	39.4±0.22^{ab}	-2.08±0.16^{gi}	7.34±0.13^{k}
3	0	90.50±0.89^{ac}	9.50±0.88^{ac}	6.86±0.01^{xu}	7.51±0.44^{sru}	8.90±0.19^{c}	43.45±0.22^{u}	-4.75±0.16^{uv}	18.07±0.13^{v}
	0.5	94.09±0.89^{de}	5.91±0.88^{de}	6.64±0.01^{x}	0.91±0.44^{uvx}	9.56±0.19^{cd}	40.46±0.22^{ab}	-2.08±0.16^{gi}	12.34±0.13^{ui}
	1	89.92±0.89^{a}	10.08±0.88^{a}	6.85±0.01^{xu}	3.41±0.44^{uvw}	7.54±0.19^{j}	40.69±0.22^{ab}	-2.22±0.16^{g}	12.26±0.13^{ui}
	1.5	90.86±0.89^{ac}	9.14±0.88^{ac}	6.46±0.01^{vy}	2.50±0.44^{w}	10.42±0.19^{cdk}	41.28±0.22^{abc}	-2.21±0.16^{g}	10.33±0.13^{u}
	2	92.60±0.89^{cd}	7.40±0.88^{cd}	6.63±0.01^{x}	1.59±0.44^{v}	8.94±±0.19^{c}	41.23±0.22^{abc}	-1.66±0.16^{g}	9.74±±0.13^{x}

Means followed by the same alphabet within the same column are not significantly different from each other (p>0.05)

Table 4b: Treatment means for the effect of blanching, irradiation and refrigeration storage on the physicochemical properties of processed cocoyam leaf during storage in hermetically sealed bag

Storage week	Doses (kGy)	Moisture content (%)	Dry matter (%)	pH	Vitamin C(mg/100g)	Crude protein	L-value	a-value	b-value
0	0	87.91 ± 0.10^{a}	12.09 ±1.22^{a}	5.44±0.01^{x}	14.33±0.53^{a}	2.41±0.23^{r}	22.63±0.11^{a}	-10.86± 0.1^{j}	11.34±69.7^{a}
	0.5	88.25 ±0.10^{a}	11.75 ±1.22^{a}	6.57±0.01^{u}	8.87±0.53^{bd}	2.22±0.23^{r}	22.14±0.11^{ab}	-3.40± 0.1^{bd}	6.09±69.7^{e}
	1	90.57 ± 0.10^{b}	9.43 ±1.22^{b}	6.03±0.01^{vi}	10.24±0.53^{b}	2.15±0.23^{gb}	22.83±0.11^{a}	-2.49±0.1^{bd}	6.33±69.7^{e}
	1.5	91.38 ± 0.10^{b}	8.62 ±1.22^{b}	6.66±0.01^{u}	3.64±0.53^{gb}	2.53±0.23^{f}	22.87±0.11^{a}	-2.31± 0.1^{d}	6.19±69.7^{ei}
	2	86.15 ± 0.10^{ca}	13.85 ±1.22^{ca}	6.21±0.01^{v}	3.19±0.53^{efv}	1.04±0.23^{n}	23.80±0.11^{ac}	-2.15± 0.1^{d}	6.69±69.7^{eis}
1	0	90.23 ± 0.10^{b}	10.87 ±1.22^{b}	6.17±0.01^{v}	11.83±0.53^{ab}	2.46±0.23^{r}	24.35±0.11^{at}	-8.11± 0.1^{jt}	10.74±69.7^{ab}
	0.5	91.17 ± 0.10^{b}	8.83 ±1.22^{b}	6.19±0.01^{v}	4.10±0.53^{e}	3.23±0.23^{u}	37.82±0.11^{v}	-3.40± 0.1^{b}	12.95±69.7^{f}
	1	87.43 ± 0.10^{a}	12.57 ±1.22^{a}	6.34±0.01^{vt}	7.28±0.53^{gbd}	2.60±0.23^{f}	38.52±0.11^{vm}	-2.44± 0.1^{bd}	9.64±69.7^{b}
	1.5	90.58 ± 0.10^{b}	9.48 ±1.22^{b}	6.37±0.01^{vt}	2.96±0.53^{ef}	2.51±0.23^{f}	38.61±0.11^{vm}	-2.24± 0.1^{bd}	9.01±69.7^{bv}
	2	89.92 ± 0.10^{b}	10.08 ±1.22^{b}	6.61±0.01^{u}	4.10±0.53^{e}	1.43±0.23^{ni}	37.14±0.11^{v}	-2.14± 0.1^{d}	8.37±69.7^{g}
2	0	90.23 ± 0.10^{b}	12.68±1.22^{a}	6.17±0.01^{v}	10.47±0.53^{b}	2.47±0.23^{r}	37.57±0.11^{v}	-5.08± 0.1^{e}	16.06±69.7^{c}
	0.5	91.55 ± 0.10^{b}	13.46 ±1.22^{a}	6.19±0.01^{v}	2.73±0.53^{ef}	2.02±0.23^{g}	39.58±0.11^{vi}	-3.32± 0.1^{ba}	10.51±69.7^{ab}
	1	87.86 ± 0.10^{a}	12.14 ±1.22^{a}	6.92±0.01^{ua}	5.23±0.53^{ei}	2.89±0.23^{fd}	38.69±0.11^{vm}	-2.37± 0.1^{bd}	10.78±69.7^{ab}
	1.5	90.64 ± 0.10^{b}	9.36 ±1.22^{b}	6.65±0.01^{u}	5.46±0.53^{ei}	2.75±0.23^{fd}	39.87±0.11^{vi}	-2.23± 0.1^{bd}	9.83±69.7^{bg}
	2	85.91± 0.10^{c}	14.09 ±1.22^{ac}	6.5±0.01^{u}	3.86±0.53^{gbe}	1.99±0.23^{gb}	38.23±0.11^{v}	-2.08± 0.1^{d}	10.45±69.7^{ab}
3	0	91.23 ± 0.10^{bc}	13.13±1.22^{ad}	6.58±0.01^{u}	9.33±0.53^{bc}	9.52±0.23^{t}	36.11±0.11^{vd}	-4.31± 0.1^{cb}	14.46±69.7^{dc}
	0.5	92.90 ± 0.10^{bcd}	9.10 ±1.22^{bd}	6.24±0.01^{v}	3.41±0.53^{f}	10.42±0.23^{tv}	40.44±0.11^{vin}	-3.21± 0.1^{ba}	13.45±69.7^{d}
	1	87.65 ± 0.10^{a}	13.36 ±1.22^{a}	6.81±0.01^{aus}	4.10±0.53^{e}	7.42±0.23^{k}	40.86±0.11^{vin}	-2.28± 0.1^{bd}	12.46±69.7^{f}
	1.5	93.5 ± 0.10^{b}	6.5 ± 1.22^{f}	6.29±0.01^{v}	2.96±0.53^{ef}	10.81±0.23^{tv}	41.63±0.11^{vig}	-2.20± 0.1^{d}	11.74±69.7^{a}
	2	90.22 ± 0.10^{b}	9.78 ± 1.22^{b}	6.33±0.01^{vt}	3.64±0.53^{gb}	10.17±0.23^{tvb}	42.49±0.11^{vg}	-2.02± 0.1^{d}	11.74±69.7^{a}

Means followed by the same alphabet within the same column are not significantly different from each other (p>0.05)

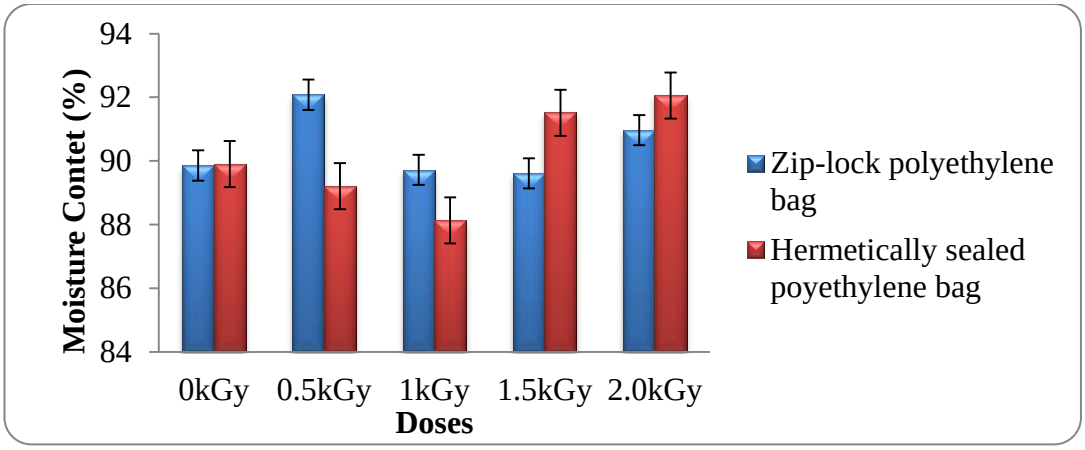

Figure 33: Effect of doses on the moisture content of processed cocoyam leaf after irradiation, blanching and refrigeration storage

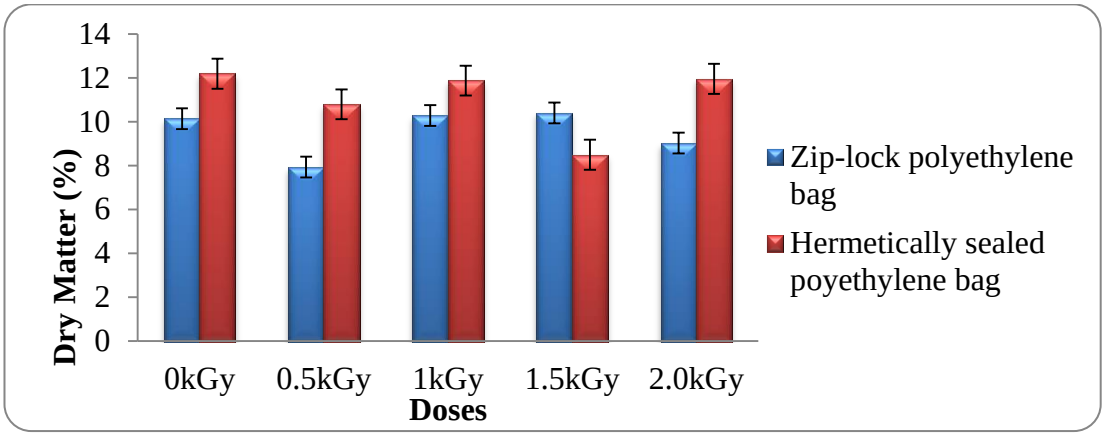

Figure 34: Effect of doses on the dry matter of processed cocoyam leaf after irradiation, blanching and refrigeration storage

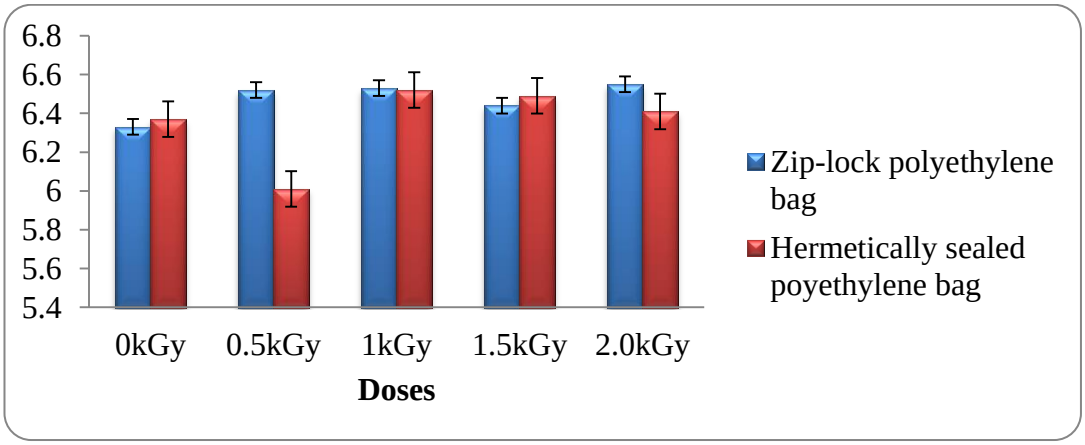

Figure 35: Effect of doses on the pH of processed cocoyam leaf after irradiation, blanching and refrigeration storage

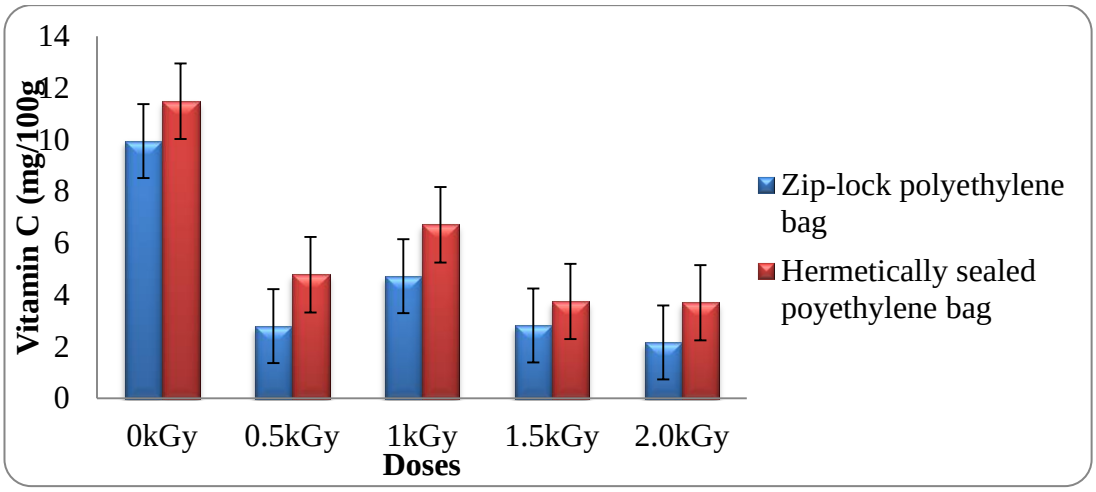

Figure 36: Effect of doses on the vitamin C content of processed cocoyam leaf after blanching, irradiation and refrigeration storage

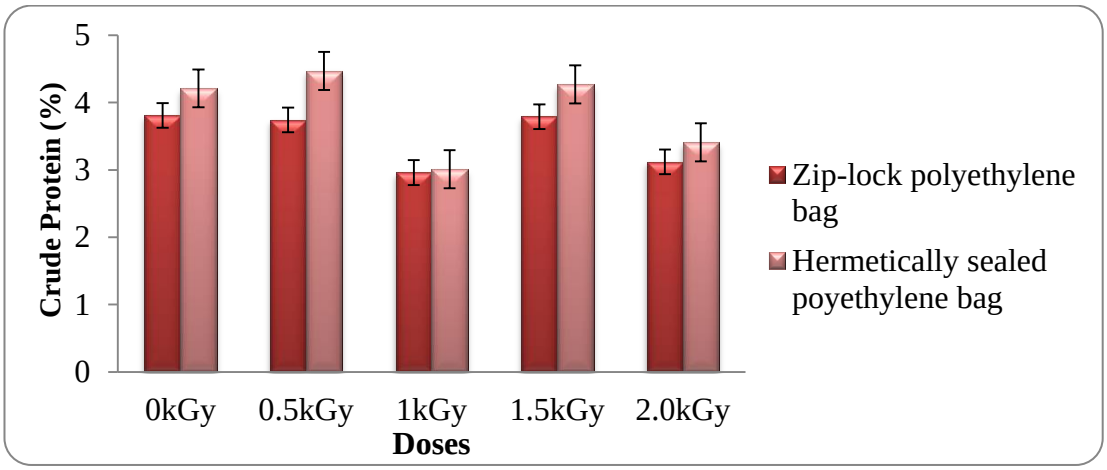

Figure 37: Effect of doses on the crude protein of processed cocoyam leaf after blanching, irradiation and refrigeration storage

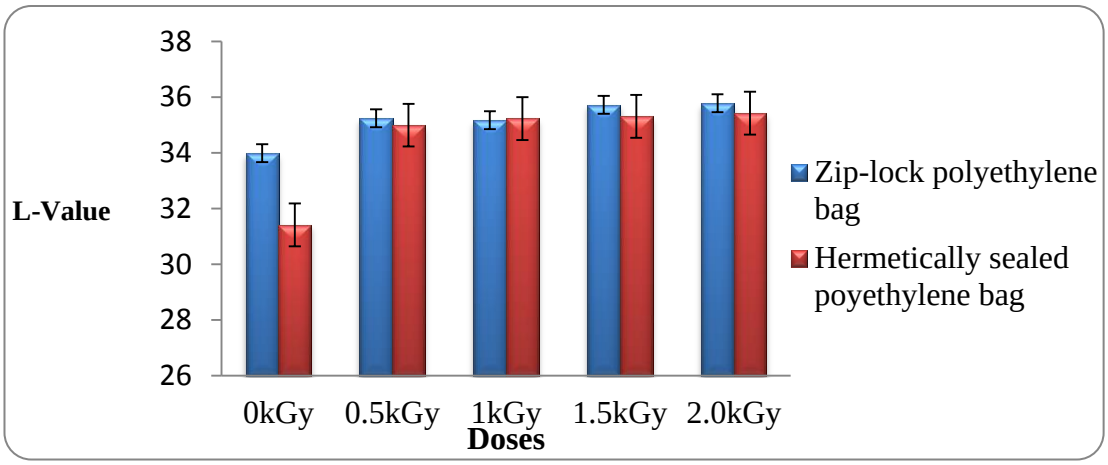

Figure 38: Effect of doses on the L-value of processed cocoyam leaf after blanching, irradiation and refrigeration storage

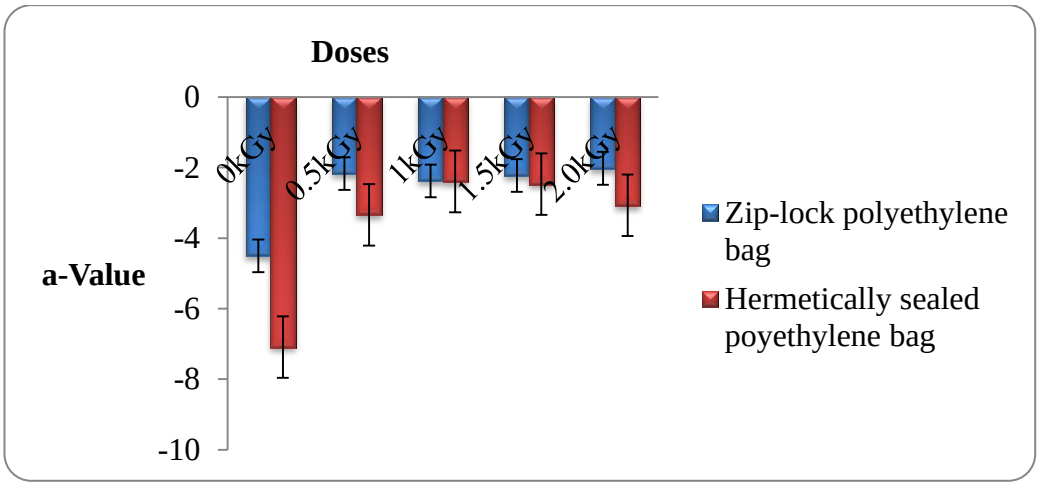

Figure 39: Effect of doses on the a-value of processed cocoyam leaf after blanching, irradiation and refrigeration storage

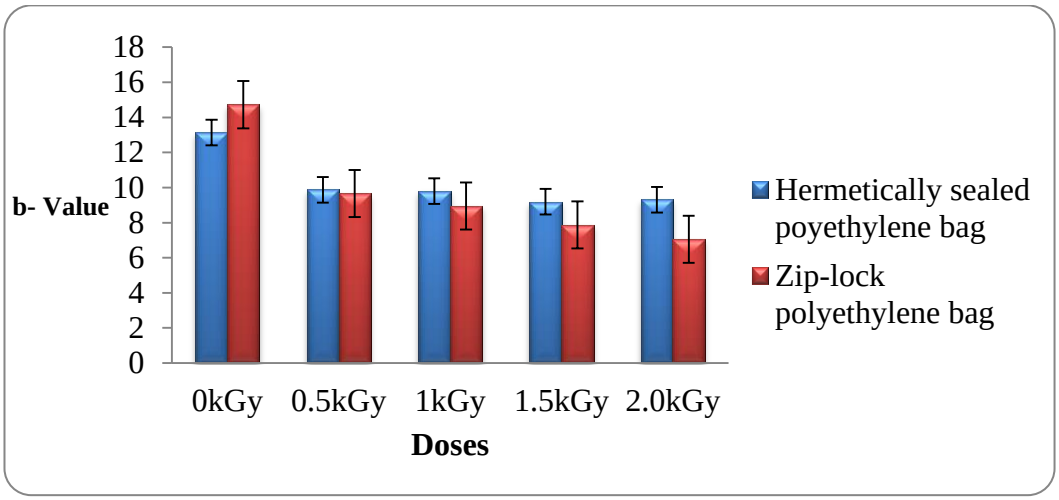

Figure 40: Effect of doses on b-value of processed cocoyam leaf after blanching, irradiation and refrigeration storage

4.2 Effect of preservation methods on phytochemical properties of processed cocoyam leaf

4.2.1 Effect of preservation methods on the total phenolic content of processed leaf

4.2.1.1 Effect of radiation and storage on total phenolic content

Storage and irradiation doses had significant effect ($p<0.05$) on the phenolic content during storage in both the zip-lock bag and hermetically sealed bag (Appendix 2:A2 and A3). However interaction of storage and doses showed no significant effect on the total phenolic content on the processed cocoyam leaf. In samples stored in zip-lock polyethylene bag, total phenolic content increased at all doses after each storage week but was maintained at 2 kGy (Table 5a). Also total phenolic content showed an increasing trend at all doses in samples stored in hermetically sealed bag. At the third week of storage, the amount was comparatively higher with 4.46 mgGAE/100g in hermetically sealed bag of the control and the lowest of 1.40 mgGAE/100g was recorded at the second week at 1 kGy of samples stored in zip-lock polyethylene but there were no significant differences in the means (Table 5a). Samples had gone bad after a week of storage, but had significant amount of phenolic compound

4.2.1.2 Effect of irradiation and refrigeration on total phenolic content

Storage, irradiation doses had significant effect ($p<0.05$) on the phenolic content in processed leaf stored in both packaging materials (Appendix 2:B4 and B1). However, interaction of storage with doses showed significant effect ($p<0.05$) in samples stored in zip-lock bag but no significant effect ($p>0.05$) in samples stored in hermetically sealed bag (Appendix 2:B4 and B1). In samples stored in zip-lock

polyethylene bag, there were fluctuations in phenolic content in the control, 0.5 kGy and 1.5 kG ; a decrease at 1 kGy and an increase after each storage period in samples irradiated at 2 kGy (Table 5a).Whereas samples stored in hermetically sealed bag showed a decreasing trend in only unirradiated samples but an increasing trend in samples irradiated at 0.5 kGy,1 kGy 1.5kGy and 2 kGy. Comparatively at the third week of storage, total phenolic content was significantly high with 4.68 mgGAE/100g of the control of samples stored in hermetically sealed bag and the lowest was recorded at 1 kGy with 1.66 mgGAE/100g in samples stored in zip-lock polyethylene bag (Table 5a).

4.2.1.3 Effect of blanching and irradiation on total phenolic content

Storage and interaction of storage with doses showed no significant effect ($p>0.05$) during storage in zip-lock polyethylene bag (Appendix 2: C 2). However, irradiation doses and storage of samples in hermetically sealed bag had significant effect on total phenolic content, but interaction of doses and storage showed no significant effect ($p>0.05$). During the storage period, samples stored in zip-lock bag showed a slight reduction in phenolic content; the amount was maintained at 0.5 kGy and an increase from 1 kGy to 2 kGy. Samples stored in hermetically sealed bag also showed a decrease at the control and an increase from 0.5 kGy to 2 kGy irradiated samples. Although samples had gone bad after a week of storage, significant amount of phenolic compound was recorded. After the storage periods, the highest total phenolic content of 4.76 mgGAE/100g was recorded at the control of samples stored in hermetically sealed polyethylene bag which was significantly different from that recorded from samples stored in zip- lock polyethylene bag and the lowest of 1.80

mgGAE/100g was recorded at 0.5 kGy of samples stored in hermetically sealed polyethylene bag but this was not significantly different from that recorded at 1 k

Gy, 1.5 kGy and 2 kGy (Table 5a).

4.2.1.4 Effect of blanching, irradiation and refrigeration on total phenolic content

Storage, irradiation doses and interaction of storage with doses had significant effect on the total phenolic content in samples stored in both packaging materials. At the control, samples stored in zip-lock bag, showed a decrease after a week of storage but an increase in subsequent weeks. Samples irradiated at 0.5 kGy, 1 kGy and 2 kGy showed fluctuations but 1 kGy showed an increasing trend (Table 5a). Samples stored in hermetically sealed bag showed an increasing trend at 0 kGy, 0.5 kGy, 1.5 kGy and 2 kGy but fluctuations at 1 kGy. The control recorded the highest phenolic content of 4.71 mgGAE/100g during the storage period at both the second and third weeks of storage in both packaging materials and the lowest of 1.17 mgGAE/100g was recorded at 0.5 kGy of samples stored in zip-lock polyethylene bag but this was not significantly different from that recorded at 1 kGy, 1.5 kGy and 2 kGy in the samples of the same packaging material but significantly different from samples stored in hermetically sealed polyethylene bag (Table 5a).

4.2.1.5 Effect of refrigeration and ambient temperature storage on total phenolic content

Storage of processed leaf in both packaging materials had significant effect ($p<0.05$) on the total phenolic content. There was an increasing trend during storage in samples stored (Table 5b). Ambient temperature storage had no significant effect ($p>0.05$) on the total phenolic content in samples of both packaging materials. There were fluctuations in the total phenolic content during storage of samples in zip-lock polyethylene bag but an increase at the first week of storage in samples stored in hermetically sealed polyethylene but a consistent amount of 4.29 mgGAE/100g was recorded at the second and third week of storage (Table 5b). After the storage periods, a significant higher amount of total phenolic content of 5.55 mgGAE/100g was recorded from refrigerated samples that were packaged in zip-lock polyethylene bag and the lowest of 4.29 mgGAE/100g was recorded from samples that were packaged in both hermetically sealed polyethylene and zip-lock polyethylene bag but this was not significantly different (Table 5b).

4.2.1.6 Effect of blanching and ambient temperature storage, blanching and refrigeration storage on total phenolic content

Blanching and refrigeration had significant effect on samples stored in zip-lock bag but no significant effect in samples stored in hermetically sealed bag. Samples stored in zip-lock bag showed a decrease whiles samples stored in hermetically sealed bag showed an increase in total phenolic content after the storage periods (Table 5b). Blanching and ambient temperature storage had significant effect on total phenolic

content. Blanching reduced the phenolic content after each storage week in samples stored in zip-lock bag and fluctuated in samples stored in hermetically sealed bag (Table 5b).

Comparatively amongst all the treatments, refrigeration storage in zip-lock polyethylene bag recorded the highest phenolic content during storage with a mean value of 5.5mg GAE/100g and the lowest of 3.98 mgGAE/100g was recorded from blanched and refrigerated samples that were packaged in zip-lock polyethylene bag (Table 5b).

4.2.2 Effect of preservation methods on the total flavonoid content

4.2.2.1 Effect of radiation on total flavonoids during storage

Storage, irradiation doses had significant effect on the total flavonoids but no interaction of doses and storage had no significant effect. In samples stored in zip-lock bag there was an increase at all doses, but the content was very high at 1 .5 kGy with 15.81 mgQE/100g after a week of storage (Table 6a). Samples stored in hermetically sealed bag also showed an increase after a week of storage at the control, 0.5 kGy, 1 kGy and 2 kGy but a decrease at 1.5 kGy (Table 6a). Though samples had gone bad after a week of storage, flavonoids were still present in smaller quantities after the third week of storage. The highest total flavonoids content of 15.94 mgQE/100g was recorded at the control at the first week of storage in hermetically sealed polyethylene bag but was not significant and the a significant lower amount was recorded at 1 kGy during the third week of storage from samples stored in zip-lock polyethylene bag (Table 6a).

4.2.2.2 Effect of irradiation and refrigeration on total flavonoids during storage

Storage, irradiation doses and interaction of storage and doses had significant effect in both packaging materials (Appendix 2:B2 and B3). There was an increase in total flavonoids content in samples stored in zip-lock polyethylene bag at the control, 0.5 kGy, and 1.5 kGy but fluctuations at 1 kGy and 2 kGy irradiated samples (Table 6a). Samples stored in hermetically sealed bag also showed an increase at the control, 1 kGy and 1.5 kGy but fluctuations at 2 kGy (Table 6a). Comparatively samples irradiated at 1.5 kGy stored in hermetically sealed bag recorded the highest flavonoid content with a mean value of 28.31 mgQE/100g after the storage period but this was not significant and the lowest was recorded at 2 kGy of 20.53 mgQE/100g was recorded from samples stored in zip-lock polyethylene bag which was also not significantly different from that recorded at 1.5 kGy of the same packaging material but significantly different from means recorded for samples stored in hermetically sealed polyethylene bag (Table 6a).

4.2.2.3. Effect of blanching and irradiation on total flavonoids during storage

Storage in packaging materials, doses and interaction of doses and storage had significant effect (Appendix 2:C1 and C3). Samples stored in both packing materials showed an increase at all doses but at the third week of storage flavonoid content was very high at the control with 15.56 mgQE/100g of samples stored in zip-lock polyethylene bag but was not significantly different from that recorded at 1.5 kGy of the same packaging material (Table 6a). Whiles the lowest of 2.36 mgQE/100g was recorded at 1.5 kGy from samples that were stored in hermetically sealed polyethylene bag which was significant from each packaging material (Table 6a).

4.2.2.4 Effect of blanching, irradiation and refrigeration storage on total flavonoids

Storage in packaging materials, doses and interaction of doses and storage had significant effect on total flavonoid content. In samples stored in hermetically sealed bag, the content increased after every storage period at all doses. However, in samples stored in zip-lock bag, there was an increase at the control and 0.5 kGy but fluctuations at 1kGy, 1.5 kGy and 2 kGy (Table 6a). Comparatively, significant higher amount of total flavonoid content was recorded after the storage periods at control from samples stored in hermetically sealed polyethylene bag and the lowest was at 1.5 kGy with 2.12 mgQE/100g from samples stored in zip-lock polyethylene bag (Table 6a).

4.2.2.5. Effect of refrigeration storage on total flavonoids

Storage in both packages had significant effect ($p<0.05$) on the total flavonoid content. Storage of processed leaf in both packages showed an increase after every storage week under refrigeration (Table 6b). Ambient temperature storage had significant ($p<0.05$) effect in both packaging materials. There were fluctuations in samples stored in both packages (Table 6b). A significant higher amount of total flavonoids content of 23.08 mgQE/100g was recorded in refrigerated samples that were packaged in zip-lock polyethylene bag and a significant lower amount of 12.49 mgQE/100g was recorded from samples stored at ambient temperature ($30\pm2^{\circ}C$) (Table 6b).

4.2.2.6. Effect of blanching and ambient temperature storage, blanching and refrigeration storage on total flavonoids

Storage of samples after blanching and storage at ambient temperature in both packaging materials had significant ($p<0.05$) effect on total flavonoid content. The amount increased after each storage week in samples stored in both packages. (Table 6b).After blanching, refrigeration and storage, there was significant effect on samples stored in both packaging materials (Table 6b). A significant higher amount of 17.21 mgQE/100g was recorded from blanched and refrigerated samples that was packaged in hermetically sealed polyethylene bag and the lowest of 14.21 mgQE/100g from samples blanched and packaged in zip-lock polyethylene bag stored under ambient temperature (30±2°C) but this was not significantly different from packaging material (Table 6b).

Of all the treatments, refrigeration storage recorded consistent increase in total flavonoid content with the highest recorded in samples stored in hermetically sealed bag with a mean value of 23.08 mgQE/100g that was significant (Table 6b). However, irradiation and refrigeration treatment recorded the highest value at 1.5 kGy with a mean score of 28.31 mgQE/100g after the storage period (Table 6a).

Table 5a.Treatment means for the effect of effect of irradiation and irradiation combinations treatments on phenolic content of processed cocoyam leaf

Storage	Doses (kGy)	Irradiation (Zip-lock bag) (mgGAE/100g)	Irradiation (Hermetic bag) (mgGAE/100g)	Irradiation and refrigeration (Zip-lock bag) (mgGAE/100g)	Irradiation and refrigeration (Hermetic bag) (mgGAE/100g	Blanching and Irradiation (Zip-lock bag) (mgGAE/100g)	Blanching and Irradiation (Hermetic bag) (mgGAE/100g)	Blanching, Irradiation and refrigeration (Zip-lock bag) (mgGAE/100g)	Blanching ,irradiation and refrigeration (Hermetic bag) (mgGAE/100g)
0	0	4.24±0.10^{s}	4.32±0.10^{a}	4.27±0.14^{t}	4.32±0.11^{k}	4.57±0.09^{f}	4.64±0.12^{b}	4.57±0.07^{h}	4.64±0.06^{x}
	0.5	1.55±0.10^{d}	1.83±0.10^{b}	2.32±0.14^{v}	1.94±0.11^{m}	1.83±0.09^{e}	1.61±0.12^{d}	1.94±0.07^{g}	1.83±0.06^{v}
	1	1.00±0.10^{db}	1.66±0.10^{bc}	2.43±0.14^{vy}	1.83±0.11^{m}	2.05±0.09^{eg}	2.05±0.12^{de}	2.16±0.07^{gx}	2.32±0.06^{voh}
	1.5	1.41±0.10^{d}	1.44±0.10^{bd}	2.37±0.14^{v}	1.50±0.11^{hm}	2.37±0.09^{egd}	1.64±0.12^{d}	1.77±0.07^{gv}	1.83±0.06^{v}
	2	1.66±0.10^{de}	1.83±0.10^{b}	1.55±0.14^{yi}	1.72±0.11^{m}	1.61±0.09^{e}	1.83±0.12^{df}	1.44±0.07	1.61±0.06^{vg}
1	0	4.35±0.10^{sa}	4.46±0.10^{a}	4.02±0.14^{t}	4.13±0.11^{kl}	4.49±0.09^{f}	4.46±0.12^{bc}	4.46±0.07^{h}	4.68±0.06^{x}
	0.5	1.66±0.10^{de}	1.94±0.10^{b}	2.32±0.14^{v}	2.15±0.11^{mn}	1.83±0.09^{e}	1.77±0.12^{dg}	1.88±0.07^{g}	1.94±0.06^{vi}
	1	1.33±0.10^{db}	1.77±0.10^{bc}	1.72±0.14^{y}	2.05±0.11^{mn}	2.21±0.09^{eg}	2.26±0.12^{de}	2.21±0.07^{gx}	2.43±0.06^{voh}
	1.5	1.66±0.10^{de}	1.55±0.10^{bd}	1.86±0.14^{y}	1.83±0.11^{m}	2.59±0.09^{egd}	1.99±0.12^{df}	1.88±0.07^{g}	1.94±0.06^{vi}
	2	1.66±0.10^{de}	2.40±0.10^{bf}	1.61±0.14^{yi}	1.66±0.11^{hm}	2.05±0.09^{eg}	2.16±0.12^{de}	1.66±0.07	1.75±0.06^{vg}
2	0	4.39±0.10^{sa}	4.32±0.10^{a}	4.06±0.14^{t}	4.38±0.11^{k}	4.51±0.09^{f}	4.64±0.12^{b}	4.71±0.07^{hz}	4.71±0.06^{x}
	0.5	1.75±0.10^{de}	1.98±0.10^{b}	2.26±0.14^{v}	2.26±0.11^{mn}	1.93±0.09^{e}	1.78±0.12^{dg}	1.06±0.07^{gi}	2.59±0.06^{vo}
	1	1.40±0.10^{db}	1.86±0.10^{bc}	1.56±0.14^{yi}	2.19±0.11^{mn}	2.35±0.09^{eg}	2.35±0.12^{de}	1.99±0.07^{g}	2.26±0.06^{voi}
	1.5	1.68±0.10^{d}	1.64±0.10^{bd}	1.99±0.14^{ve}	2.05±0.11^{mn}	2.67±0.09^{egd}	1.99±0.12^{df}	2.16±0.07^{gx}	2.21±0.06^{voc}
	2	1.66±0.10^{de}	2.43±0.10^{b}	1.77±0.14^{y}	2.05±0.11^{mn}	2.61±0.09^{e}	2.83±0.12^{dy}	1.55±0.07^{gv}	2.1±0.06^{vi}
3	0	4.45±0.10^{sa}	4.46±0.10^{a}	4.49±0.14^{ts}	4.68±0.11^{kg}	4.69±0.09^{f}	4.76±0.12^{bc}	4.71±0.07^{hz}	4.71±0.06^{x}
	0.5	1.76±0.10^{de}	1.99±0.10^{b}	2.26±0.14^{v}	2.43±0.11^{mnj}	2.83±0.09^{et}	1.80±0.12^{dg}	1.17±0.07^{gi}	2.65±0.06^{vo}
	1	1.53±0.10^{db}	1.97±0.10^{b}	1.66±0.14^{yi}	2.59±0.11^{mj}	2.41±0.09^{eg}	2.46±0.12^{de}	2.05±0.07^{gx}	2.32±0.06^{voh}
	1.5	1.66±0.10^{de}	1.75±0.10^{bd}	2.26±0.14^{v}	2.43±0.11^{mnj}	2.79±0.09^{egd}	2.01±0.12^{df}	2.32±0.07^{gxd}	2.43±0.06^{voh}
	2	1.66±0.10^{de}	2.45±0.10^{bf}	1.99±0.14^{ve}	2.65±0.11^{mj}	2.75±0.09^{egd}	2.96±0.12^{dy}	1.61±0.07^{gv}	2.21±0.06^{voc}

Means followed by the same alphabet within the same column are not significantly different from each other (p>0.05)

Table 5b Treatment means for the effect of refrigeration, ambient temperature storage, blanching and its combination on the total phenolic content during storage

Storage	Refrigeration (Zip-lock bag)(mgGAE/100g	Refrigeration (Hermetic bag)(mgGAE/100g)	Ambient temperature (Zip-lock bag)(mgGAE/100g)	Ambient temperature (Hermetic bag)(mgGAE/100g	Blanching (Zip-lock bag) (mgGAE/100g)	Blanching (Hermetic bag) (mgGAE/100g)	Blanching and refrigeration (Zip-lock bag) (mgGAE/100g)	Blanching and refrigeration (Hermetic bag) (mgGAE/100g)
0	4.27±0.10^{a}	4.13±0.10^{a}	4.24±0.07^{a}	4.13±0.06^{v}	4.57±0.07^{a}	4.64±0.10^{b}	4.57±0.05^{a}	4.64±0.06^{a}
1	4.22±0.10^{a}	4.31±0.10 ^{a}	4.35±0.07^{a}	4.46±0.06^{v}	4.49±0.07^{ab}	4.46±0.10^{ab}	4.47±0.05^{a}	4.68±0.06^{a}
2	5.06±0.10^{b}	4.38±0.10^{ab}	4.25±0.07^{a}	4.29±0.06^{v}	4.48±0.07^{ab}	4.47±0.10^{ab}	4.05±0.05^{b}	4.71±0.06^{a}
3	5.55±0.10^{c}	4.68±0.10 ^{b}	4.29±0.07^{a}	4.29±0.06^{v}	4.29±0.07^{b}	4.29±0.10^{a}	3.98±0.05^{b}	4.71±0.06^{a}

Means followed by the same alphabet within the same column are not significantly different from each other (p>0.05)

Table 6a. Treatment means for the effect of effect of irradiation and irradiation combinations treatments on total flavonoids content of processed cocoyam leaf

Storage	Doses (kGy)	Irradiation (Zip-lock bag) (mgQE/100g)	Irradiation (Hermetic bag) (mgQE/100g)	Irradiation and refrigeration (Zip-lock bag) (mgQE/100g)	Irradiation and refrigeration (Hermetic bag) (mgQE/100g)	Blanching and Irradiation (Zip-lock bag) (mgQE/100g)	Blanching and Irradiation (Hermetic bag) (mgQE/100g)	Blanching, Irradiation and refrigeration (Zip-lock bag) (mgQE/100g)	Blanching ,irradiation and refrigeration (Hermetic bag) (mgQE/100g)
0	0	13.94±0.22^{a}	14.37±0.42^{y}	14.20±0.68^{t}	14.37±0.60^{m}	15.22±0.15^{t}	15.39±0.13^{a}	15.22±0.31^{x}	15.39±0.19^{a}
	0.5	10.32±0.22^{c}	15.3±0.42^{x}	18.11±0.68s^{j}	16.58±0.60^{mnh}	5.74±0.15^{x}	7.01±0.13^{c}	10.97±0.31^{v}	10.58±0.19^{d}
	1	10.07±0.22^{c}	15.05±0.42^{x}	19.64±0.68^{jg}	6.63±0.60^{r}	9.31±0.15^{je}	12.24±0.13^{abd}	11.99±0.31^{vt}	10.97±0.19^{d}
	1.5	15.3±0.22^{abe}	15.68±0.42^{x}	14.79±0.68^{tf}	22.87±0.60^{kpg}	12.88±0.15^{er}	4.72±0.13^{ce}	14.79±0.31^{xg}	11.22±0.19^{de}
	2	8.54±0.22^{cf}	14.03±0.42^{y}	17.73±0.68^{jk}	20.10±0.60^{h}	9.82±0.15^{jeq}	6.38±0.13^{cf}	12.37±0.31^{svj}	8.54±0.19^{y}
1	0	14.79±0.22^{ab}	15.94±0.42^{xv}	14.71±0.68^{t}	15.13±0.60^{mn}	15.56±0.15^{ts}	15.56±0.13^{ab}	15.68±0.31^{xy}	15.94±0.19^{ab}
	0.5	11.09±0.22^{cd}	15.43±0.42^{x}	18.62±0.68^{j}	16.19±0.60^{hm}	8.42±0.15^{jx}	8.16±0.13^{cd}	11.60±0.31^{vs}	11.09±0.19^{de}
	1	10.58±0.22^{c}	15.68±0.42^{x}	20.02±0.68^{s}	6.89±0.60^{rs}	10.58±0.15^{e}	13.13±0.13^{abd}	11.99±0.31^{vt}	11.09±0.19^{de}
	1.5	15.81±0.22^{abe}	12.62±0.42^{u}	14.92±0.68^{tf}	23.72±0.60^{gp}	13.26±0.15^{ert}	5.36±0.13^{e}	15.17±0.31^{x}	10.97±0.19^{der}
	2	9.95±0.22^{cf}	15.3±0.42^{x}	18.74±0.68^{j}	20.91±0.60^{ho}	10.58±0.15^{e}	8.80±0.13^{cfg}	12.88±0.31^{svj}	8.80±0.19^{yt}
2	0	2.94±0.22^{tu}	4.37±0.42^{h}	20.02±0.68^{s}	21.80±0.60^{p}	5.22±0.15^{t}	5.59±0.13^{h}	6.19±0.31^{y}	16.58±0.19^{ac}
	0.5	2.32±0.22^{t}	5.3±0.42^{w}	19.76±0.68^{s}	20.15±0.60^{hmo}	3.74±0.15^{x}	7.21±0.13^{n}	2.11±0.31^{s}	11.60±0.19^{de}
	1	2.07±0.22^{c}	3.15±0.42^{g}	17.94±0.68^{jk}	18.49±0.60^{hme}	9.31±0.15^{je}	2.44±0.13^{k}	2.71±0.31^{va}	11.35±0.19^{de}
	1.5	1.43±0.22^{y}	3.48±0.42^{gi}	17.23±0.68^{lk}	26.27±0.60^{gpx}	12.88±0.15^{er}	3.72±0.13^{p}	3.65±0.31^{d}	10.97±0.19^{der}
	2	1.54±0.22^{y}	3.03±0.42^{g}	16.96±0.68^{l}	17.22±0.60^{mh}	9.82±0.15^{jeq}	3.38±0.13^{p}	3.23±0.31s	11.73±0.19^{de}
3	0	1.79±0.22^{yz}	3.94±0.42^{gik}	22.57±0.68^{h}	23.08±0.60^{pd}	15.56±0.15^{ts}	4.26±0.13^{hu}	3.75±0.31^{xye}	17.21±0.19^{cda}
	0.5	1.19±0.22^{y}	3.43±0.42^{gi}	23.59±0.68^{hg}	23.84±0.60^{pdf}	8.42±0.15^{jx}	5.12±0.13^{hj}	3.92±0.31^{xy}	11.99±0.19^{def}
	1	0.58±0.22^{v}	1.68±0.42^{o}	22.19±0.68^{h}	21.04±0.60^{pg}	10.58±0.15^{e}	3.13±0.13^{p}	3.23±0.31^{vg}	11.22±0.19^{de}
	1.5	1.31±0.22^{y}	2.62±0.42^{p}	21.04±0.68^{sd}	28.31±0.60^{gpy}	13.26±0.15^{ert}	2.36±0.13^{pl}	2.12±0.31^{vq}	11.48±0.19^{de}
	2	1.25±0.22^{y}	1.30±0.42^{o}	20.53±0.68^{s}	22.31±0.60^{kp}	10.58±0.15^{e}	2.50±0.13^{pl}	2.61±0.31^{vgz}	14.28±0.19^{ae}

Means followed by the same alphabets within the same column are not significantly different from each other(p>0.05)

Table 6b.Treatment means for the effect of refrigeration, ambient temperature, blanching and combination of treatments on the total flavonoid content during storage

Storage	Refrigeration (Zip-lock bag) (mgQE/100g)	Refrigeration (Hermetic bag) (mgQE/100g)	Ambient temperature (Zip-lock bag) (mgQE/100g)	Ambient temperature (Hermetic bag) (mgQE/100g)	Blanching Zip-lock bag) (mgQE/100g)	Blanching (Hermetic bag) (mgQE/100g)	Blanching, refrigeration (Zip-lock bag) (mgQE/100g)	Blanching refrigeration (Hermetic bag) (mgQE/100g)
0	14.20 ±0.30 ^{a}	14.37±0.37 ^{x}	13.94±0.39^{a}	14.37±0.31^{x}	15.22±0.07^{a}	15.39±0.15^{a}	15.22±0.08^{a}	15.39±0.10^{a}
1	14.71±0.30 ^{a}	15.13±0.37 ^{x}	14.79±0.39^{a}	15.43±0.31^{y}	15.39±0.07^{a}	15.81±0.15^{a}	15.68±0.08^{a}	15.94±0.10^{b}
2	20.08±0.30 ^{b}	21.80±0.37 ^{y}	14.24±0.39^{a}	13.96±0.31^{x}	15.40±0.07^{a}	15.42±0.15^{a}	16.19±0.08^{b}	16.58±0.10^{c}
3	22.57±0.30 ^{c}	23.08±0.37 ^{z}	12.52±0.39^{b}	12.49±0.31^{t}	14.22±0.07^{b}	14.21±0.15^{b}	16.70±0.08^{b}	17.21±0.10^{d}

Means followed by the same alphabet within the same column are not significantly different from each other (p>0.05)

4.3. Effect of preservation methods on the microbial quality of processed cocoyam leaf (*Xanthosoma sagittifolium*)

4.3.1 Effect of irradiation and storage on the microbial load

4.3.1.1 Effect of irradiation on total coliform count

Storage, irradiation doses and interaction of doses with storage had significant effect on the total coliform count in samples stored in both packaging materials (Appendix 3:A1 and A4). Storage increased counts in both packaging materials (Figure 41). After irradiation treatment and storage in zip-lock bag, total coliform count increased after every storage week, but was only significantly different ($p<0.05$) after the first week of storage (Figure 41).There was an increase from 0.76 to7.9±0.01 log CFU/g (Figure 41). Also in samples stored in hermetically sealed bag, there was an increase from 0.64 to 8.02±0.01 log CFU/g during storage (Figure 41). Interaction of storage with doses also showed that radiation doses of 0.5 kGy to 2 kGy were effective in reducing coliform counts by 2 log cycles in both packaging materials at the initial week of storage but counts increased in subsequent weeks of storage (Table 7).

Within the doses, coliform counts at 0 kGy were higher with 5.48±0.02 log CFU/g during storage in hermetically sealed bag. However, dose between 0.5 kGy to 2 kGy reduced count by almost 1 log cycle during storage. (Figure 42).Total coliform count in samples stored in zip-lock bag were very high at 0 kGy with a mean of 5.76 ± 0.02 log CFU/g. Radiation doses reduced the growth by 1 log cycle after the storage period. Comparatively, counts in samples irradiated at 0.5kGy to 2 kGy that were stored in zip-lock bag were significantly less than that recorded from samples stored in hermetically sealed polyethylene (Figure 42).

4.3.1.2 Effect of irradiation on total viable count

Storage had significant ($p<0.05$) effect on the total viable count. Doses and interaction of doses and storage also had significant ($p<0.05$) effect in samples stored in both packaging materials (Appendix 3:A2 and A5). Storage of processed leaf in both zip-lock bag and hermetically sealed bag showed an increase after every week of storage (Figure 43). There was an increase from 0.87 to 7.91 log CFU/g during storage in hermetically sealed bag and from 0.87 to 7.64 log CFU/g after the storage period but there were no significance differences ($p>0.05$) in their means. At the initial week of storage, irradiation doses were effective in reducing viable counts. Samples stored in zip-lock polyethylene bag showed a reduction by 1 log cycle at the initial week of storage in samples irradiated at 1 kGy, 1.5 kGy and 2 kGy whiles samples stored in hermetically sealed polyethylene bag also showed a reduction in count by 3 log cycles at 0.5 kGy, 1 kGy, 1.5 kGy and 2 kGy (Table 7).

Within doses after irradiation treatment and storage in zip-lock bag, count was reduced by one log cycle at doses of 0.5 kGy to 2 kGy (Figure 43). In samples stored in hermetically sealed bag, 0.5 kGy reduced viable count by almost 2 log cycles and 1 kGy to 2 kGy by 1 log cycle (Figure 43). The highest count was recorded at the control with 6.70±0.03 log CFU/g, and the lowest recorded in 1.5 kGy with mean count of 4.89±0.03 log CFU/g. Comparatively, total viable count was significantly higher in hermetically sealed bag at the control with a mean of 6.70 log CFU/g (Figure 43).

4.3.1.3 Effect of irradiation on yeast and moulds count

Storage had significant effect on yeast and mould counts in both packaging materials (Appendix 3:A3 and A6). Storage increased counts in both zip-lock bag and hermetically sealed bag after every storage week (Figure 45). There was an increase

from 0 to 7.34 log CFU/g in samples stored in zip- lock bag and from 0 to 8.06 log CFU/g in samples stored in hermetically sealed bag (Figure 45). Amongst the two packaging materials, yeast and mould count were not significant different from each other (Figure 45). Doses also had significant effect on yeast and mould count (Appendix 3:A3 and A6).Counts during storage in zip-lock bag was less at 0 kGy with a mean of 3.72 ± 0.01 log CFU/g but higher at all other irradiation doses (Figure 45). The higher the dose the higher the growth with 2 kGy recording the highest count of 4.43 ± 0.01 log CFU/g. At the initial storage week, there was no growth of yeast and moulds at all doses (Table 7). However, in subsequent weeks of storage, there was growth. Samples stored in hermetically sealed bag also recorded more growth of yeast and moulds at doses of 0.5 kGy,1 kGy and 2 kGy than at the control (Figure 45). Comparatively counts were significantly higher in samples stored in hermetically sealed bag than the zip-lock polyethylene bag at 1.5 kGy and 2 kGy. (Figure 46).Interaction of doses and storage also had significant effect (Appendix 3:A3 and A6). Samples irradiated at 2 kGy recorded the highest count in both packaging materials.

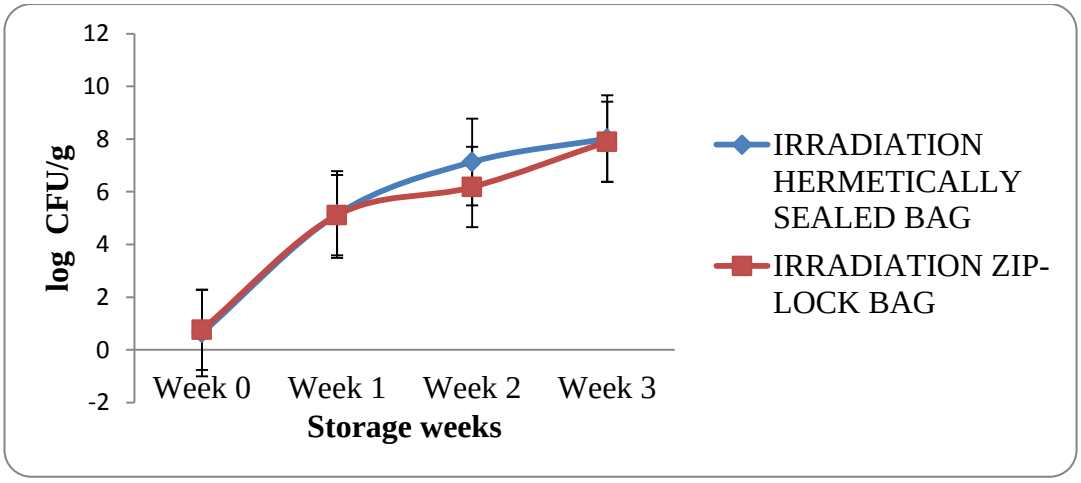

Figure 41: Effect of storage on total coliforms count after irradiation

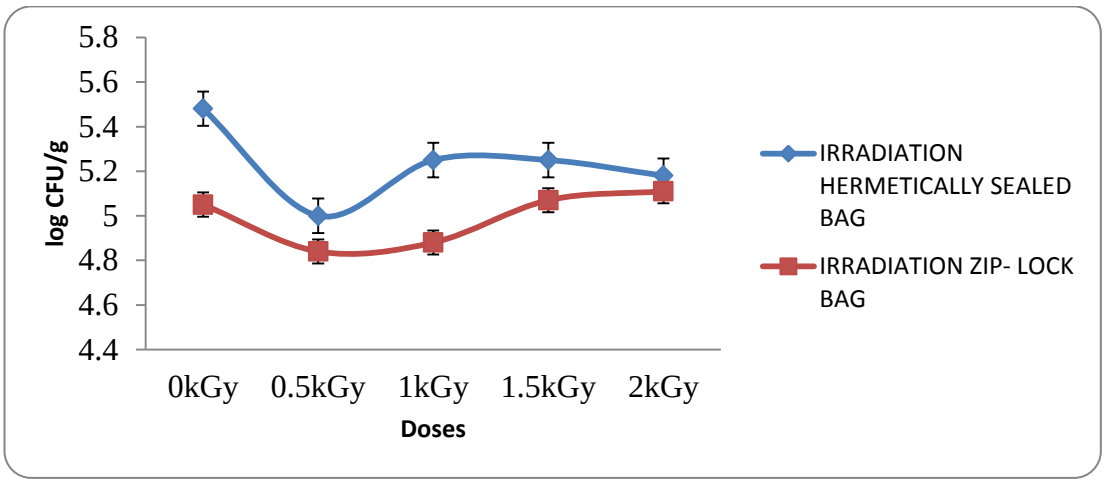

Figure 42: Effect of doses on total coliforms after irradiation

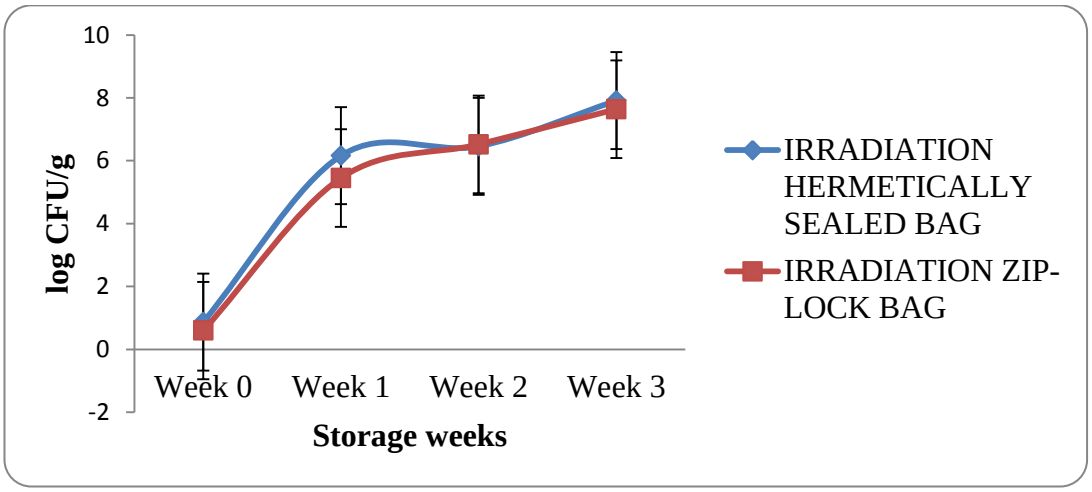

Figure 43: Effect of storage on total viable count after irradiation

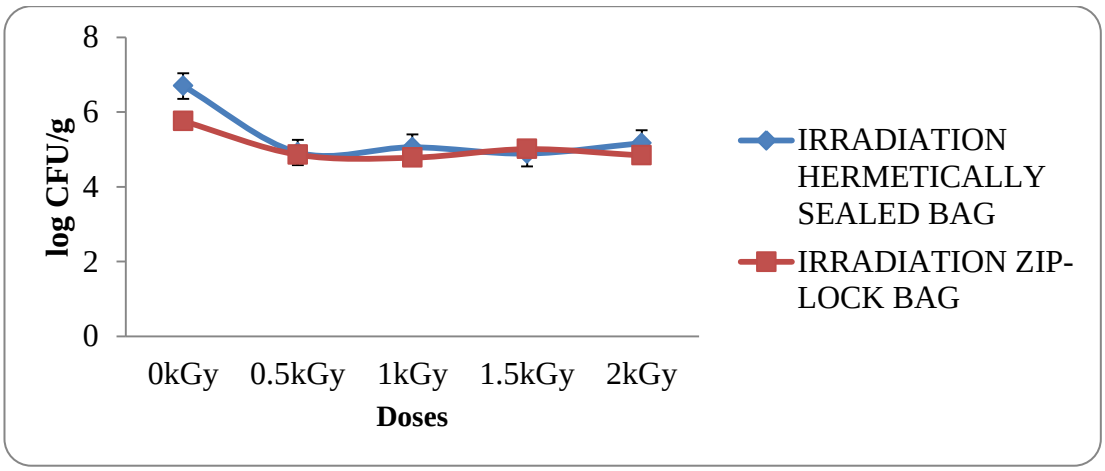

Figure 44: Effect of doses on the total viable count after irradiation

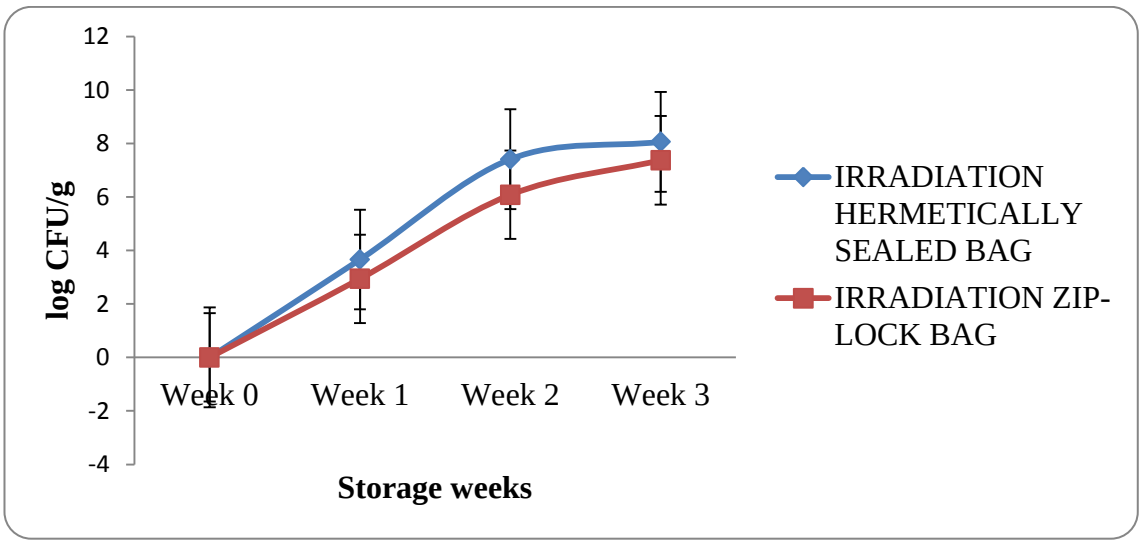

Figure 45.Effect of storage on yeast and mould count after irradiation

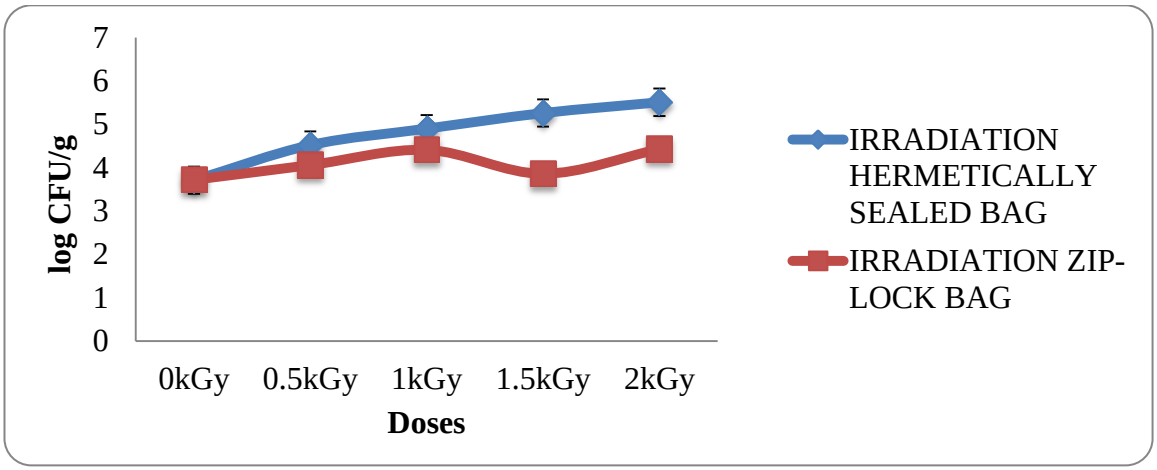

Figure 46: Effect of doses on yeast and moulds count after irradiation

Table 7.Treatment means for microbial counts after irradiation and storage

Storage	Doses(kGy)	Total coliform count(Hermetically sealed bag)	Total coliform (Zip-lock bag)	Total viable count (hermetically sealed bag)	Total viable count (zip-lock bag)	Yeast and moulds count (hermetically sealed bag)	Yeast and moulds count (Zip-lock bag)
0	0	2.23±0.04^{x}	2.67±0.02^{k}	3.24±0.06^{f}	1.47±0.05^{y}	0±0.01^{w}	0±0.01^{d}
	0.5	0.37±0.04^{a}	0.42±0.02^{l}	0.47±0.06^{s}	1.06±0.05^{y}	0±0.01^{w}	0±0.01^{d}
	1	0.27±0.04^{a}	0.32±0.02^{l}	0.18±0.06^{s}	0.25±0.05^{d}	0±0.01^{w}	0±0.01^{d}
	1.5	0.241±0.04^{a}	0.24±0.02^{l}	0.18±0.06^{s}	0.18±0.05^{d}	0±0.01^{w}	0±0.01^{d}
	2	0.056±0.04^{a}	0.17±0.02^{l}	0.24±0.06^{s}	0.02±0.05^{d}	0±0.01^{w}	0±0.01^{d}
1	0	4.77±0.04^{y}	4.01±0.02^{d}	7.11±0.06^{j}	5.86±0.05^{m}	2.79±0.01^{t}	2.84±0.01^{e}
	0.5	4.81±0.04^{y}	4.76±0.02^{d}	5.51±0.06^{d}	4.69±0.05^{a}	3.52±0.01^{r}	2.84±0.01^{e}
	1	4.77±0.04^{y}	5.50±0.02^{h}	6.26±0.06^{ed}	5.40±0.05^{u}	3.81±0.01^{r}	2.77±0.01^{e}
	1.5	5.6±0.04^{yi}	5.62±0.02^{h}	5.90±0.06^{ed}	5.64±0.05^{u}	4.07±0.01^{rs}	2.74±0.01^{e}
	2	5.75±0.04^{yi}	5.64±0.02^{h}	6.03±0.06^{ed}	5.68±0.05^{u}	4.09±0.01^{rs}	3.49±0.01^{f}
2	0	6.88±0.04^{s}	6.02±0.02^{e}	7.55±0.06^{j}	7.17±0.05^{s}	5.56±0.01^{t}	5.55±0.01^{g}
	0.5	6.92±0.04^{s}	6.12±0.02^{e}	6.16±0.06^{ed}	6.18±0.05^{b}	6.64±0.01^{tv}	6.35±0.01^{h}
	1	7.49±0.04^{z}	6.15±0.02^{e}	6.21±0.06^{ed}	6.28±0.05^{b}	7.40±0.01^{vu}	7.09±0.01^{hj}
	1.5	7.22±0.04^{z}	6.26±0.02^{e}	5.94±0.06^{ed}	6.47±0.05^{b}	8.47±0.01^{vux}	5.59±0.01^{g}
	2	7.15±0.04^{z}	6.33±0.02^{e}	6.43±0.06^{ed}	6.50±0.05^{b}	8.97±0.01^{vuq}	5.83±0.01^{g}
3	0	8.03±0.04^{z}	7.50±0.02^{f}	8.91±0.06^{k}	8.54±0.05^{o}	6.48±0.01^{tv}	6.50±0.01^{h}
	0.5	7.91±0.04^{z}	8.04±0.02^{g}	7.54±0.06^{j}	7.53±0.05^{s}	7.94±0.01^{u}	7.05±0.01^{hy}
	1	8.47±0.04^{zt}	7.53±0.02^{f}	7.59±0.06^{j}	7.19±0.05^{s}	8.40±0.01^{vux}	7.79±0.01^{hyx}
	1.5	7.93±0.04^{z}	8.16±0.02^{g}	7.52±0.06^{j}	7.75±0.05st	8.50±0.01^{vux}	7.12±0.01^{hy}
	2	7.77±0.04^{z}	8.28±0.02^{g}	7.98±0.06^{ji}	7.18±0.05^{s}	8.99±0.01^{vuq}	8.41±0.01^{x}

* Means followed by same alphabets within the same column are not significantly different (p>0.05)*

4.3.2 Effect of refrigeration and ambient temperature storage on the microbial load

4.3.2.1 Effect of refrigeration and ambient temperature storage on the total viable count

Refrigeration storage had significant effect on total viable counts in samples stored in both packages (Appendix 3:B2 and B5).Total viable count of the processed cocoyam leaf during refrigeration storage at 4°C ± 2 increased during storage in samples stored in (Figure 47).Counts increased from 0.41 to 4.72± 0.05 log CFU/g in samples stored in hermetically sealed bag, whiles that of zip-lock polyethylene increased from 1.42 to 7.37 ± 0.02 log CFU/g. Storage at ambient temperature also had significant effect ($p<0.05$) on the total viable count (Appendix 3:B8 and B11).Total viable counts in samples stored at ambient temperature (30 ± 2^{o}C) in both packages showed an increase during storage. Samples stored in zip-lock bag recorded an increase in count from 1.58 to 7.62± 0.07 log CFU/g and that of hermetically sealed bag increased from 1.49 to 8.86± 0.07 log CFU/g. Comparatively counts were higher in samples stored in hermetically sealed bag at ambient temperature but there were no significant differences throughout the storage period (Figure 47).

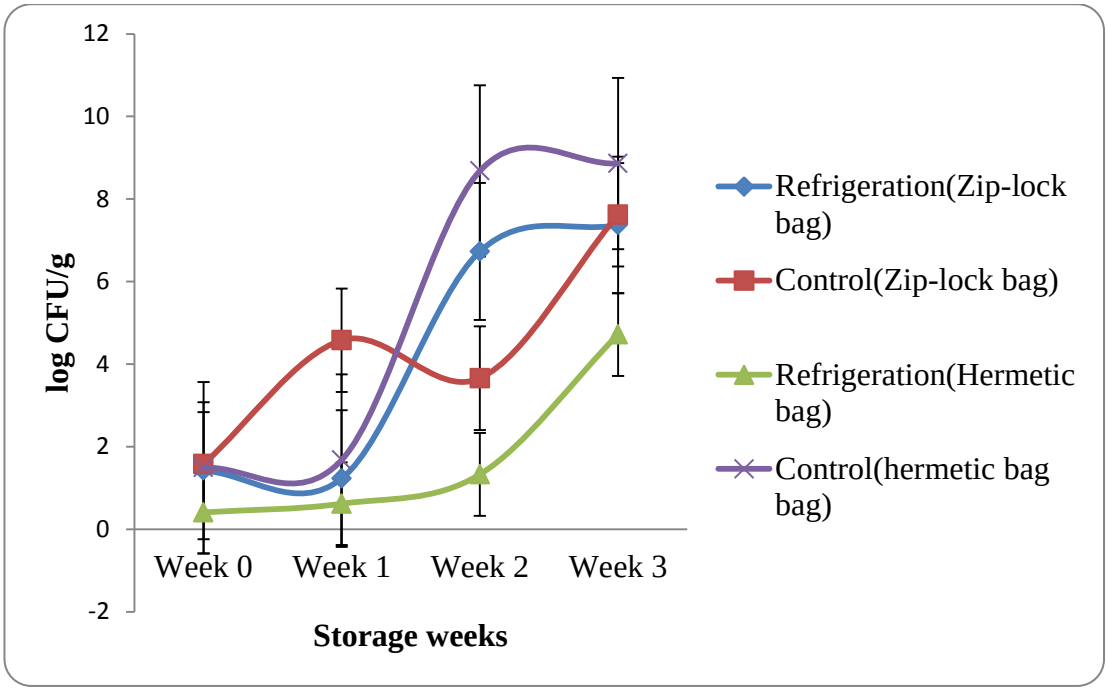

Figure: 47 Total viable count after refrigeration and ambient temperature storage

4.3.2.2 Effect of refrigeration and ambient temperature storage on total coliform count

Refrigeration storage had significant effect on the total coliform counts (Appendix 3:B1 and B4). Total coliforms count in samples stored in both packaging materials increased during storage (Figure 48). Samples stored in zip-lock bag recorded an increase from1.90to 4.98±0.02log CFU/. Also counts in refrigerated samples stored in hermetically sealed polyethylene bag increased from 1.98 to 4.98 ± 0.24 log CFU/g during storage (Figure 48). Storage at ambient temperature also showed a significant effect (Appendix 3:B 10 and B7). There was an increase in counts during storage in both packaging materials. (Figure 48).Count in samples stored in zip-lock pouches increased from 2.11 to 6.93± 0.24 log CFU/g; whereas samples stored in hermetically sealed bag counts increased from 1.46 to 6.67± 0.10 log CFU/g after the

storage period. Comparatively count was significantly different in samples stored in zip-lock bag at only the second week of storage (Figure 48).

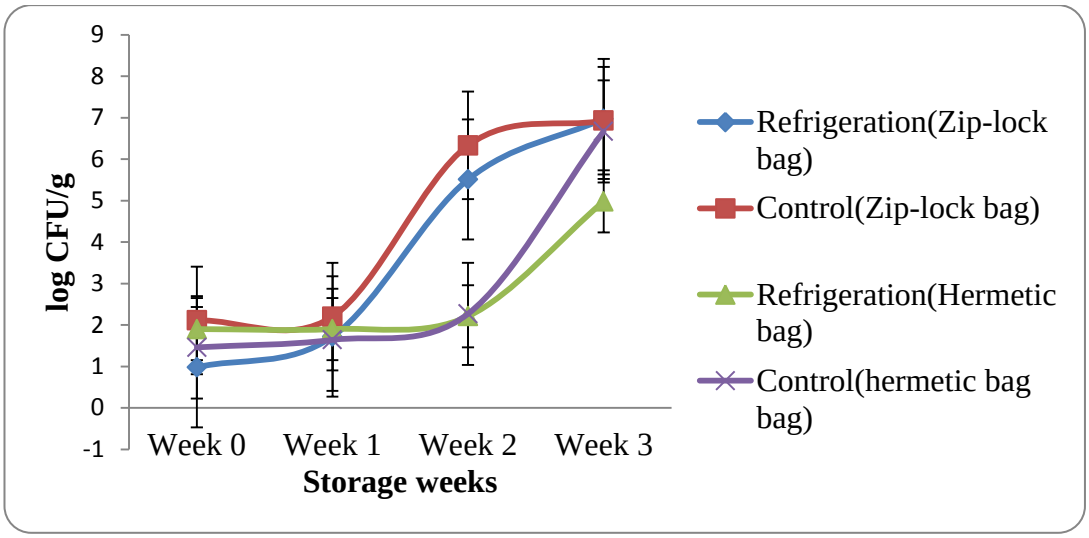

Figure: 48 Total coliforms after refrigeration and ambient temperature storage

4.3.2.3 Effect of refrigeration and ambient temperature storage on yeast and moulds count

Refrigeration storage had significant effect on the yeast and mould counts (Appendix 3:B3).There was an increase in counts during storage (Figure 49). Refrigerated samples stored in zip-lock polyethylene bag recorded no growth at the initial and first week of storage there were no growth. However, after the three weeks of storage counts increased to5.07±0.002 log CFU/g (Figure 49).Counts increased in samples stored in hermetically sealed polyethylene bag after the storage period from 0 to 5.07± 0.02log CFU/g after the storage period. Storage at ambient temperature also had significant effect (Appendix B9 and B 12). Storage increased counts in both packaging materials (Figure 49). Counts increased from 0 to 7.24 ±0.02 after the storage period in samples stored in hermetically sealed bag; whiles samples stored in zip-lock bag also recorded an increase from 0 to 4.82 ± 0.05 log CFU/g after the

storage period (Figure 49). Counts were significantly higher in samples stored at ambient temperature in hermetically sealed bag throughout the storage periods (Figure 49).

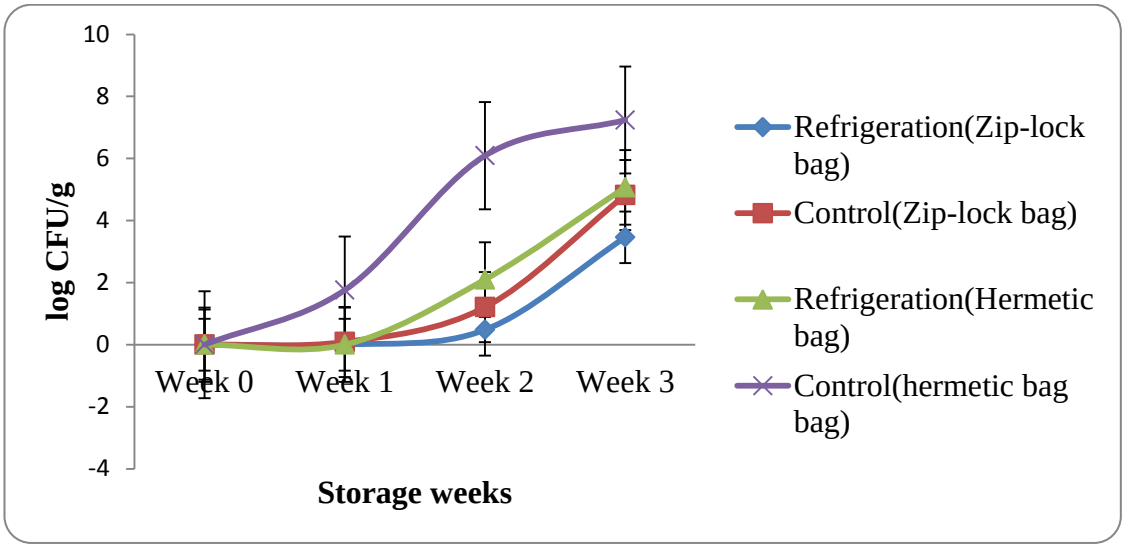

Figure: 49 Yeast and moulds after refrigeration and ambient temperature storage

4.3.3 Effect of blanching and ambient temperature, blanching and refrigeration

4.3.3.1 Effect of blanching and ambient temperature, blanching and refrigeration on total viable count

Storage had significant effect ($p<0.05$) after blanching and refrigeration storage (Appendix C2 and C5). Storage increased the viable counts in both packaging materials and storage temperatures (Figure 50). During storage in zip-lock polyethylene bag total viable count showed an increased from 0.01 to 7.98± 0.02 log CFU/g during storage (Figure 50). Samples stored in hermetically sealed bag also recorded an increase from 0.01 to 8.71 ± 0.02 log CFU/g after the storage period (Figure 50). Also ambient temperature storage had significant effect on viable counts (Appendix 3:C8 and C 11). After the storage period counts of samples stored in

hermetically sealed bag counts increased from 0 to 8.69 log CFU/g. Storage in of samples in zip-lock bag was also increased from 0 to at 8.48log CFU/g. The increase in counts is an indication of spoilage and shorter shelf-life. Comparatively counts in hermetically sealed bag were not significantly different from that recorded higher that recorded from zip-lock polyethylene bag at all storage temperatures (Figure 50).

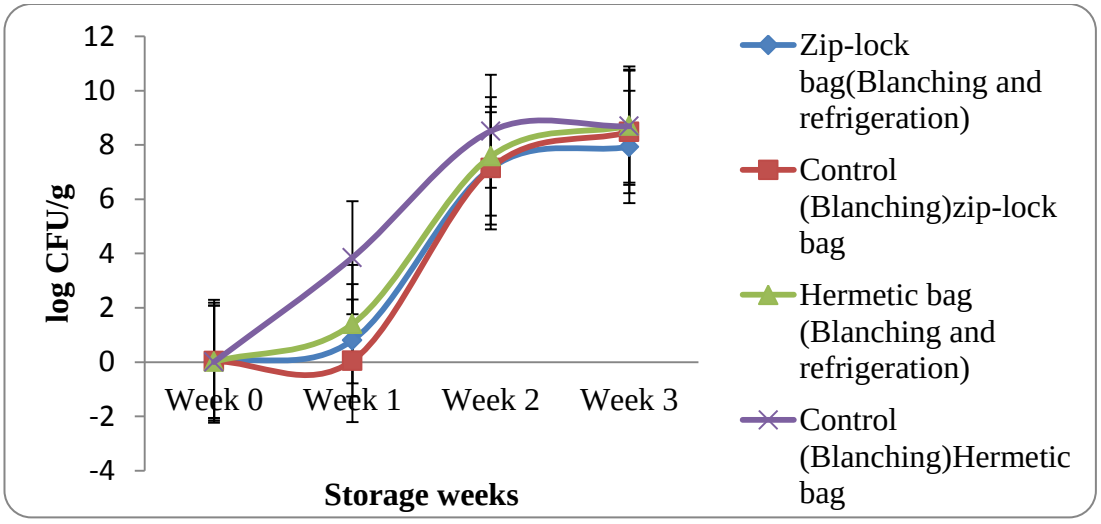

Figure: 50 Total viable count after blanching and ambient temperature storage and blanching and refrigeration storage

4.3.3.2 Effect of blanching and ambient temperature, blanching and refrigeration on total coliforms

Storage had significant effect on the total coliform count after blanching and refrigeration storage (Appendix 3:C1 and C4). Storage increased the coliform counts at all storage conditions (Figure 51). Total coliform count after blanching and refrigeration and storage in hermetically sealed bag increased from 0.01to 8.71± 0.01 log CFU/g after the storage period. Samples stored in zip-lock polyethylene bag also recorded an increase from 0 to 7.73± 0.01 log CFU/g. Ambient temperature storage also had significant effect on counts (Appendix 3:C7 and C 10). Storage increased counts (Figure 51). Total coliform counts in samples stored in hermetically sealed

bag increased from 0 to 8.57± 0.01 log CFU/g and that zip-lock lock polyethylene bag stored samples from 0.03 to 8.48. Comparatively, there were no significant differences ($p<0.05$) in counts recorded the mean values recorded at all storage conditions (Figure 51).

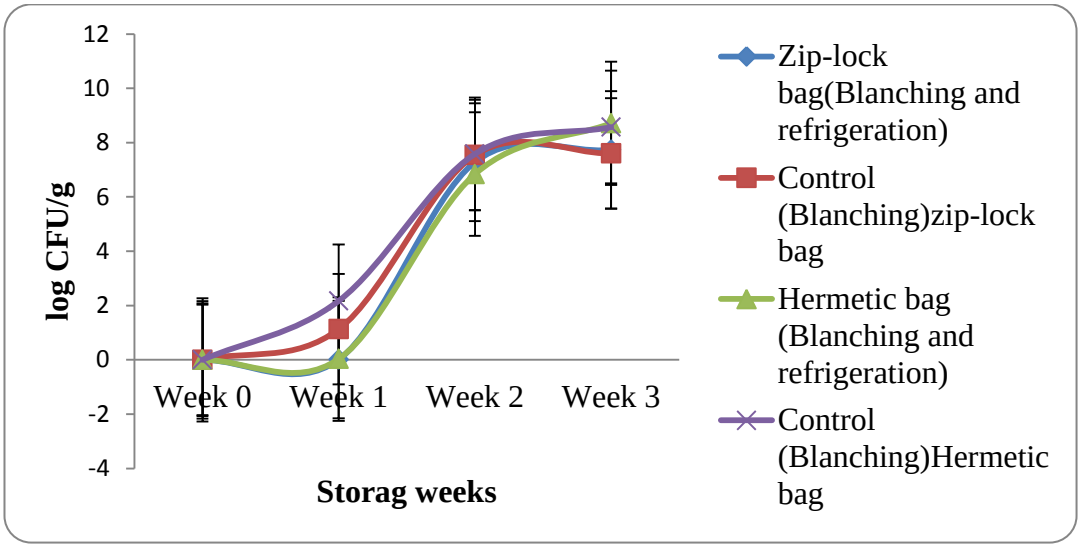

Figure: 51 Total coliforms after blanching, blanching and refrigeration storage

4.3.3.3 Effect of blanching and ambient temperature storage, blanching and refrigeration on yeast and moulds count

Storage had significant effect on the yeast and moulds counts in blanched and refrigerated samples (Appendix 3:C3 and C 6). Storage increased counts in both packaging materials (Figure 52). Counts in samples stored in hermetically sealed bag increased from 0 to 7.80± 0.02 log CFU/g after the storage period. Whiles counts in samples stored in zip-lock bag also increased from 6.51 ± 0.04 log CFU/g. Ambient temperature storage also had significant effect on the yeast and mould growth (Appendix 3:C9 and C12).There was an increase in counts during storage (Figure 52). Samples stored in zip-lock bag recorded an increase from 0 to 8.53 ± 0.02 log CFU/g and hermetically sealed bag counts was also increased from 0 to 8.99± 0.02

log CFU/g. Comparatively yeast and moulds count was significantly different from storage temperatures during the first week of storage (Figure 52).

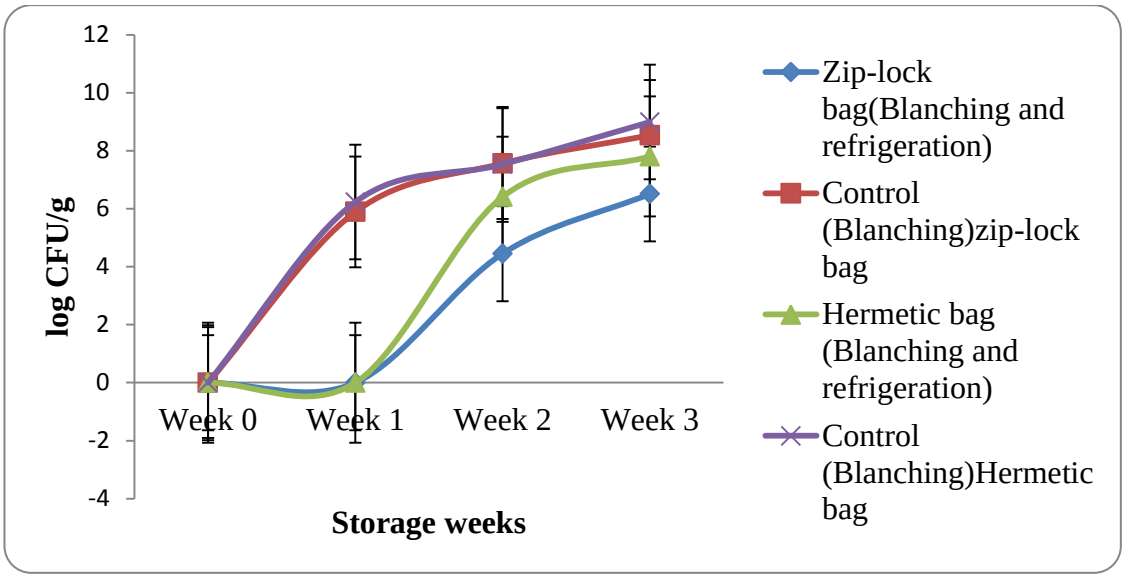

Figure: 52 Yeast and moulds counts after blanching, blanching and refrigeration storage

4.3.4 Effect of irradiation and refrigeration on microbial load of processed leaf

4.3.4.1 Effect of irradiation and refrigeration on total viable count

Storage, irradiation doses and interaction of doses and storage had significant effect on total viable counts in both packaging materials. Storage increased the viable counts (Figure 53). There was an increase in samples stored in from 0.10 to 5.57 ± 0.01 log CFU/g during storage in hermetically sealed bag. Also samples stored in zip-lock bag had an increase in count from 0.17 to 6.13 log ± 0.03 CFU/g. Interaction of storage and doses also showed an increase in counts at all doses after every storage week (Table 8). However, samples irradiated at 1.5 kGy recorded lower counts of 1.20 log CFU/g after the storage period in samples stored in hermetically sealed polyethylene bag (Table 8). Also the control of the same packaging material

recorded the highest counts 8.99 log CFU/g after the storage period (Table 8).Comparatively counts were not significantly different from each packaging material during storage (Figure 53).

Compared to unirradiated samples stored in zip-lock bag recorded a reduction in counts by 1 log cycle in samples irradiated at 0.5 kGy and 1.5 kGy and an increase at 2 kGy and 1 kGy (Figure 54). Samples stored in hermetically sealed bag also recorded a reduction in counts by 4 log cycles at 1.5 kGy, 2 log cycles at 2 kGy and 1 log cycle reduction at 0.5 kGy,1 kGy (Figure 54). Comparatively significant differences in counts were recorded in packaging materials at 1 kGy, 1.5 kGy and 2 kGy

4.3.4.2 Effect of irradiation and refrigeration on total coliforms count

Storage, irradiation doses and interaction of storage and doses had significant effect on the total coliforms count in both packages. Storage increased viable count (Table 8). Total coliform count during storage of samples in zip-lock polyethylene bag showed an increase in count at all irradiation doses (Figure 55). Interaction of doses and storage showed a reduction in counts in samples stored in hermetically sealed bag.There was a reduction by 1 log cycle at the initial week of storage in samples irradiated at 0.5 kGy, 1 kGy, 1.5 kGy and 2 kGy. After the storage period counts were lower at 1 kGy and 1.5 kGy. Compared to the control samples,counts were reduced by 7 log cycles (Table 8). Samples stored in zip-lock bag showed an increse in counts at all doses.Counts were even higher in irradiated samples tha the unirradiated samples after the storage period (Table 8).

Comparatively counts were significantly higher in samples stored in zip-lock polyetylene bag (Figure 55).

Radiation doses of 1 kGy, 1.5 kGy and 2 kGy were not effective in reducing total coliform count of samples stored in hermetically sealed polyethylene bag (Figure 56). Compared to 0 kGy samples, 1.5 kGy reduced total coliform counts by 3 log cycles and by 2 log cycles at 0.5 kGy, 1 kGy and 2 kGy (Figure 56). Comparatively counts were significantly differences from each packaging material at the control, 1kGy, 1.5 kGy and 2 kGy (Figure 56).

4.3.4.3 Effect of storage on yeast and mould count after irradiation and refrigeration

Storage had significant effect on the yeast and mould count. Storage increased counts in both packaging materials (Figure 57). Counts increased in samples stored in hermetically sealed bag from 0 to3.81± 0.19 log CFU/g whiles samples stored in zip-lock bag count increased from 0- 4.16log CFU/g after the storage period. In the interaction of storage with doses, showed an increase in counts after the storage period at all doses (Figure 57). However, counts were less in samples stored in hermetically sealed bag in samples irradiated at 0.5 kGy , 1 kGy, 1 .5 kGy and 2 kGy but higher at 2 kGy in samples stored in zip-lock polyethylene bag (Table 8).

Comparatively count was higher in in samples stored in zip-lock bag but was not significant (Figure 57). Doses also had significant effect on counts. Samples stored in hermetically sealed bag had less counts at 1 kGy with a reduction in counts by 2 log cycles as compared to unirradiated samples but this was not significantly different from that recorded from samples stored in zip-lock polyethylene bag (Figure 58). Comparatively there were significant differences between packaging materials at the control and 2 kGy (Figure 58).

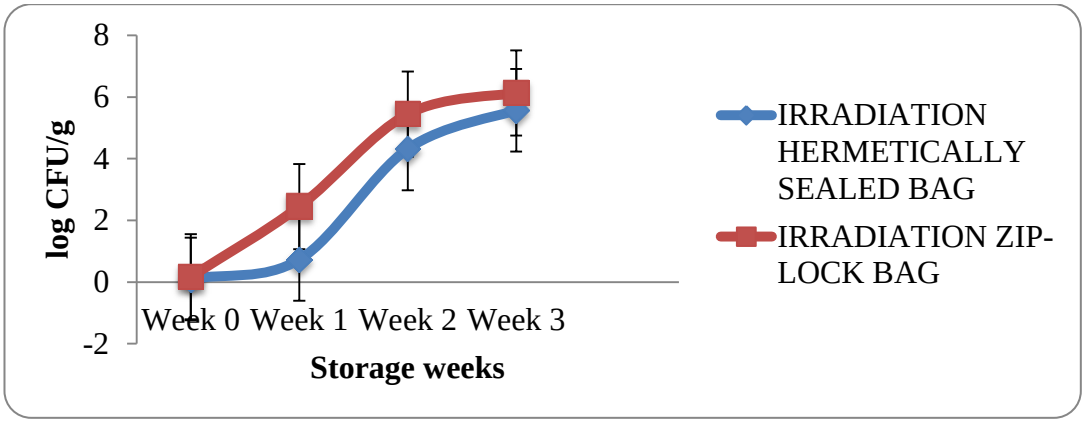

Figure 53: Effect of storage on total viable count after irradiation and refrigeration

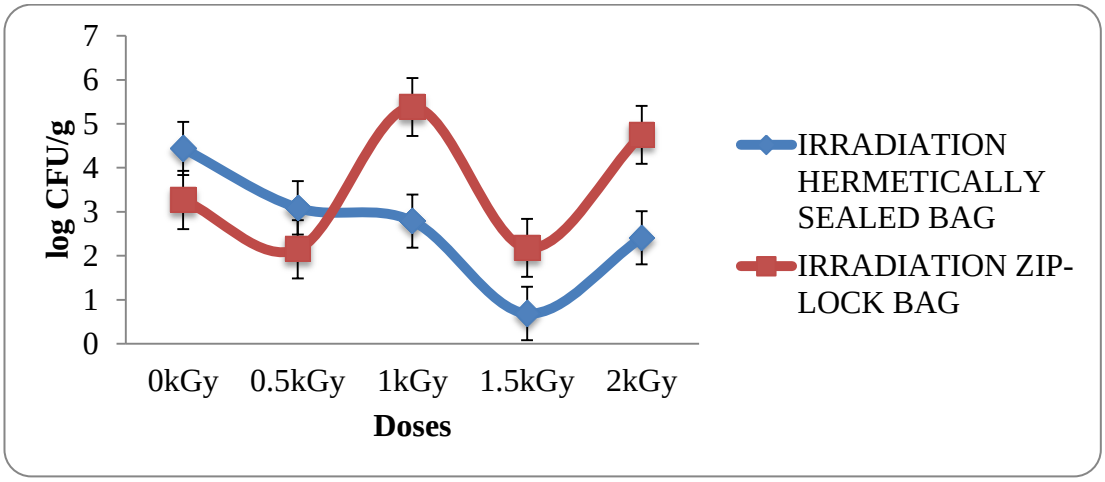

Figure 54: Effect of doses on the total viable count after irradiation and refrigeration

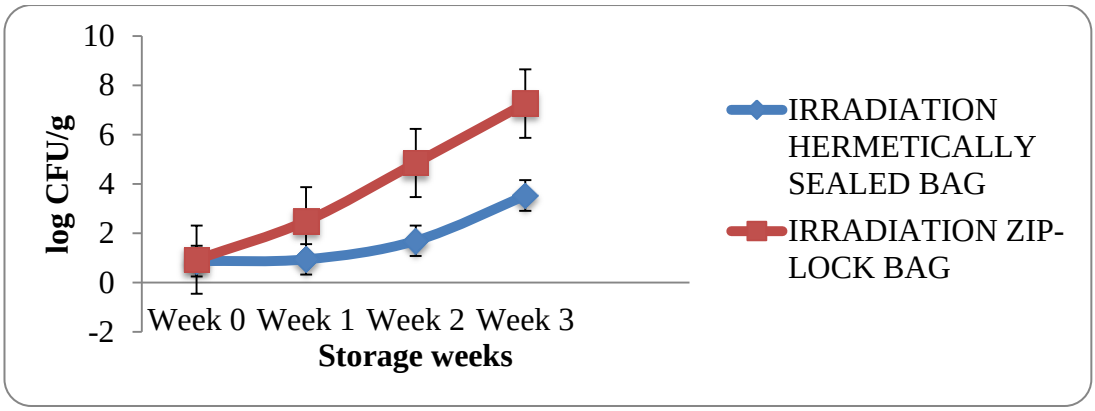

Figure 55: Effect of storage on total coliforms count after irradiation and refrigeration

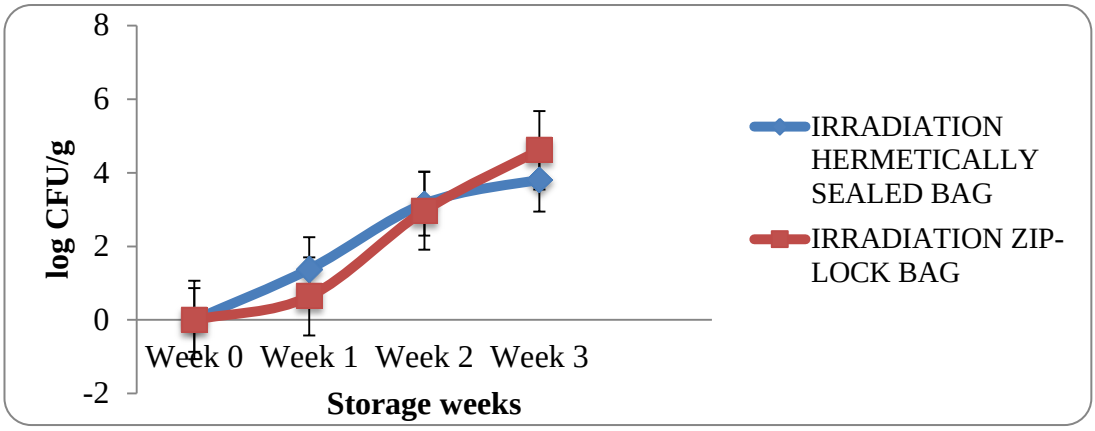

Figure 56: Effect of doses on the total coliforms after irradiation and refrigeration

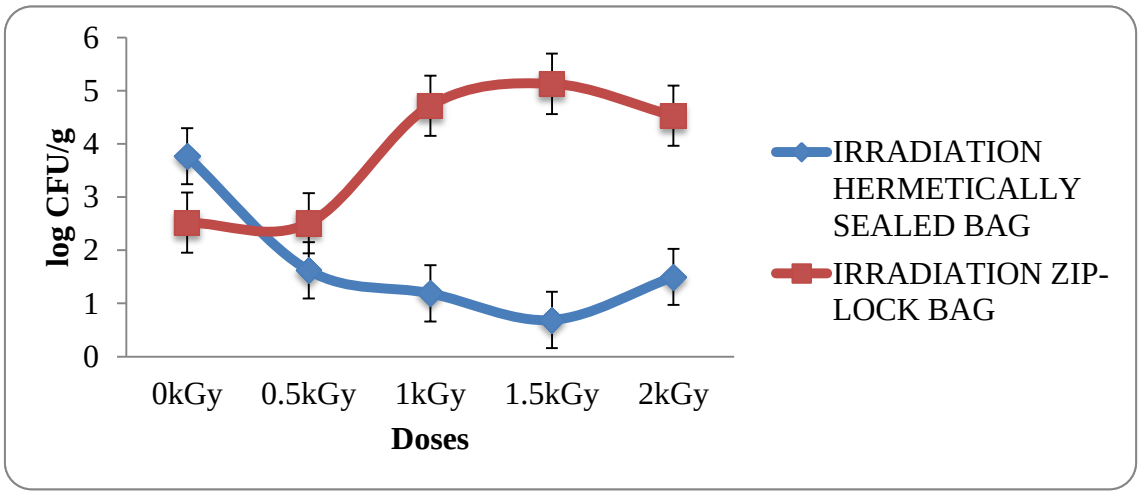

Figure 57: Effect of storage on yeast and moulds count after irradiation and refrigeration

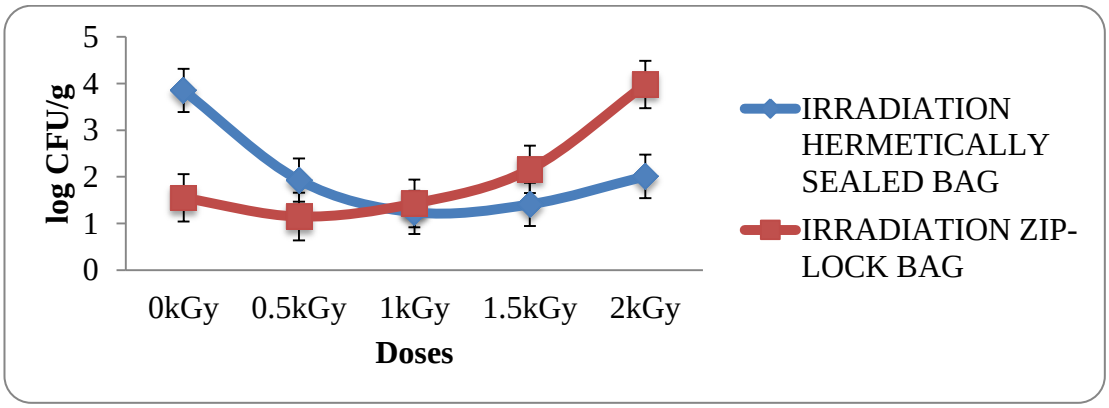

Figure 58: Effect of dose on yeast and moulds after irradiation and refrigeration

Table 8.Treatment means for microbial counts of processed cocoyam leaf after irradiation and refrigeration and storage

Storage	Doses(kGy)	Total coliform count(Hermetically sealed bag)	Total coliform (Zip-lock bag)	Total viable count (hermetically sealed bag)	Total viable count (zip-lock bag)	Yeast and moulds count (hermetically sealed bag)	Yeast and moulds count (Zip-lock bag)
0	0	1.90 ± 0.03^{r}	0.98 ± 0.01^{a}	0.32 ± 0.02^{x}	0.64 ± 0.06^{i}	0 ± 0.42^{w}	0 ± 0.05^{e}
	0.5	0.44 ± 0.03^{f}	0.01 ± 0.01^{a}	0.17 ± 0.02^{x}	0.10 ± 0.06^{i}	0 ± 0.42^{w}	0 ± 0.05^{e}
	1	0.98 ± 0.03^{f}	0.96 ± 0.01^{a}	0.01 ± 0.02^{x}	0.06 ± 0.06^{i}	0 ± 0.42^{w}	0 ± 0.05^{e}
	1.5	0.02 ± 0.03^{f}	0.96 ± 0.01^{a}	0.01 ± 0.02^{x}	0.07 ± 0.06^{i}	0 ± 0.42^{w}	0 ± 0.05^{e}
	2	0.01 ± 0.03^{f}	0.73 ± 0.01^{a}	0.01 ± 0.02^{x}	0.02 ± 0.06^{i}	0 ± 0.42^{w}	0 ± 0.05^{e}
1	0	1.98 ± 0.03^{r}	0.96 ± 0.01^{a}	0.64 ± 0.02^{xs}	1.42 ± 0.06^{ij}	2.26 ± 0.42^{v}	0.17 ± 0.05^{e}
	0.5	0.88 ± 0.03^{f}	0.79 ± 0.01^{a}	1.98 ± 0.02^{v}	0.24 ± 0.06^{i}	2.08 ± 0.42^{v}	0.93 ± 0.05^{u}
	1	0.61 ± 0.03^{f}	3.81 ± 0.01^{d}	0.47 ± 0.02^{xs}	6.23 ± 0.06^{n}	0.97 ± 0.42^{wv}	0.42 ± 0.05^{ue}
	1.5	0.69 ± 0.03^{f}	3.92 ± 0.01^{d}	0.47 ± 0.02^{xs}	0.36 ± 0.06^{i}	0.05 ± 0.42^{w}	0.77 ± 0.05^{u}
	2	0.52 ± 0.03^{f}	2.97 ± 0.01^{fd}	0.09 ± 0.02^{xs}	4.02 ± 0.06^{m}	1.54 ± 0.42^{v}	0.90 ± 0.05^{u}
2	0	2.24 ± 0.03^{rs}	1.41 ± 0.01^{ab}	7.80 ± 0.02^{t}	4.25 ± 0.06^{m}	6.19 ± 0.42^{y}	1.61 ± 0.05^{d}
	0.5	1.86 ± 0.03^{r}	3.13 ± 0.01^{d}	4.56 ± 0.02^{h}	1.31 ± 0.06^{ij}	3.00 ± 0.42^{vd}	1.16 ± 0.05^{du}
	1	1.26 ± 0.03^{r}	6.41 ± 0.01^{e}	4.29 ± 0.02^{h}	6.48 ± 0.06^{n}	1.51 ± 0.42^{v}	1.30 ± 0.05^{d}
	1.5	0.93 ± 0.03^{f}	7.81 ± 0.01^{te}	1.10 ± 0.02^{v}	7.86 ± 0.06^{np}	1.80 ± 0.42^{vt}	3.31 ± 0.05^{g}
	2	2.15 ± 0.03^{r}	5.50 ± 0.01^{y}	3.83 ± 0.02^{hq}	7.34 ± 0.06^{np}	3.29 ± 0.42^{vd}	7.45 ± 0.05^{m}
3	0	8.95 ± 0.03^{c}	6.73 ± 0.01^{e}	8.99 ± 0.02^{tz}	6.77 ± 0.06^{n}	6.95 ± 0.42^{yz}	4.41 ± 0.05^{gh}
	0.5	2.33 ± 0.03^{rs}	5.09 ± 0.01^{y}	5.64 ± 0.02^{hr}	6.96 ± 0.06^{n}	2.64 ± 0.42^{v}	2.49 ± 0.05^{df}
	1	1.93 ± 0.03^{r}	7.73 ± 0.01^{te}	6.38 ± 0.02^{hru}	8.77 ± 0.06^{g}	2.49 ± 0.42^{v}	4.00 ± 0.05^{g}
	1.5	1.11 ± 0.03^{rv}	7.83 ± 0.01^{et}	1.20 ± 0.02^{v}	7.49 ± 0.06^{np}	3.78 ± 0.42^{vd}	4.57 ± 0.05^{gh}
	2	3.31 ± 0.03^{rt}	8.93 ± 0.01^{t}	5.72 ± 0.02^{hr}	7.64 ± 0.06^{np}	3.20 ± 0.42^{vd}	7.56 ± 0.05^{m}

Means followed by the same letter within the same letter within the same column are not significantly different from each other ($p>0.05$)

4.3.5 Effect of blanching and irradiation on the microbial load

4.3.5. 1 Effect of blanching and irradiation on total viable count

Storage had significant effect on the total viable count. Storage increased counts in samples stored in both packaging materials (Figure 59). Total viable count increased in samples stored in hermetically sealed bag from0.11 to 7.52±0.01 log CFU during storage. Samples stored in zip-lock bag increased from 0.02 to 8.02± 0.01 log CFU/g after the storage period. Comparatively, counts were not significantly different from packaging material during storage (Figure 59). Interaction of doses and storage week also recorded less counts at the initial week of storage in both packages but an increase in counts at all doses at the end of the storage period (Table 9).

Doses also had significant effect. There was an increase in total viable counts (Table 9). However there were no significant differences in counts between packaging materials (Figure 60).

4.3.5. 2 Effect of storage on total coliform count after blanching and irradiation

Storage, irradiation doses and interaction of storage week and doses had significant effect on total coliform counts. Storage increased total coliform counts in samples stored in both packaging materials (Figure 61). Interaction of storage and doses also recorded an increase in count after every storage period from both packaging materials (Table 9). Counts increased from 0.19 to 5.34 ± 0.05 log CFU/g during storage in zip-lock bag whiles that of hermetically sealed bag increased from 0.19 to 5.82 log CFU/g. Comparatively, coliform counts were less in samples stored in zip-lock bag with counts of 5.34 ± 0.05 log CFU/g after the storage period but was not significant (Figure 61). Dose was not effective in reducing coliform counts in samples after the storage period (Figure 62). This is because unirradiated samples

recorded less counts of 2.54 log CFU/g from samples stored in zip-lock polyethylene bag and the highest mean of 4.35 log CFU/g (Figure 62). However there were significant differences in count between packaging materials (Figure 62).

4.3.5.3 Effect of storage on yeast and moulds count after blanching and irradiation treatment

Storage, irradiation doses and interaction of storage with doses had significant effect on the yeast and moulds counts. Storage increased the growth of yeast and moulds in samples stored in both packaging materials (Figure 63).Count increased from 0 to 6.89 ± 0.01 log CFU/g during storage of samples in hermetically sealed bag and from 0 to 7.69 ± 0.02 log CFU/g in samples stored zip-lock bag after the storage period (Figure 63). Interaction of storage with doses, there were no counts at the initial week of storage at all doses but there was growth of yeast and moulds in the subsequent weeks of storage (Table 9). However, there were no significant differences in counts between packaging materials during storage (Figure 63).

Radiation doses of 0.5 kGy, 1 kGy, and 2 kGy were not effective in reducing yeast and mould growth during storage of processed leaf in hermetically sealed bag. Counts increased in samples during storage (Figure 64). Compared to the control, samples stored in zip-lock bag recorded a reduction in count at 1 kGy (Figure 64). The lowest count of 2.52 ± 0.02 log CFU/g was recorded at the control of samples stored in hermetically sealed polyethylene bag and the highest was at 2 kGy in samples stored in zip-lock polyethylene bag (Figure 64). Comparatively, counts were significantly different from each packaging material at all doses (Figure 64).

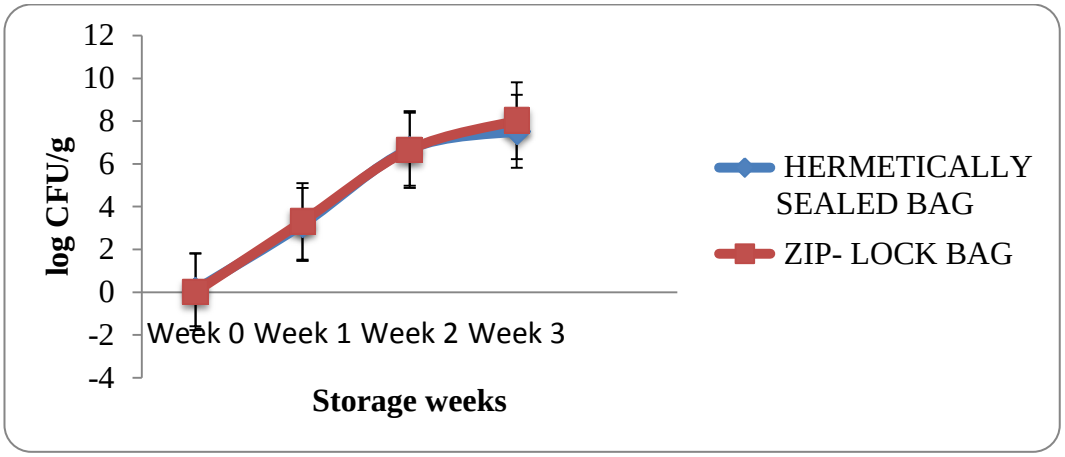

Figure: 59 Effect of storage on total viable count after blanching and irradiation

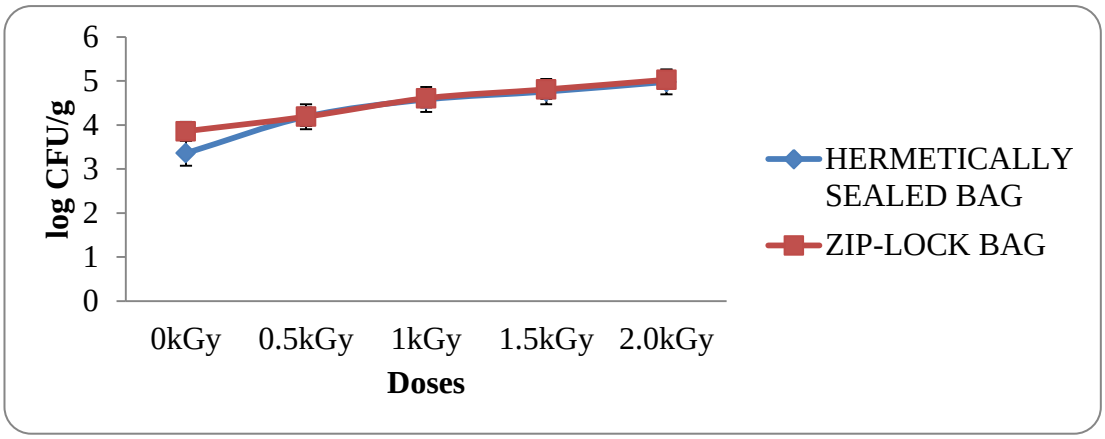

Figure: 60 Effect of doses on total viable count after blanching and irradiation

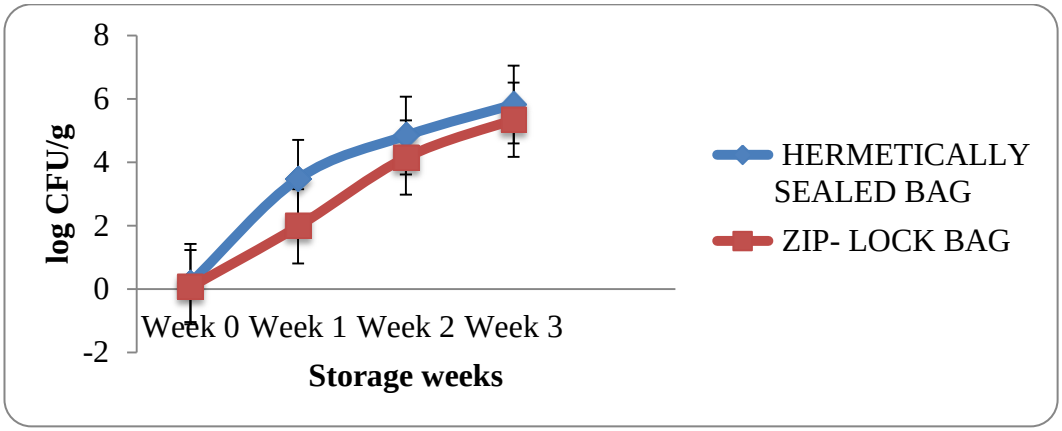

Figure: 61 Effect of storage on total coliforms after blanching and irradiation

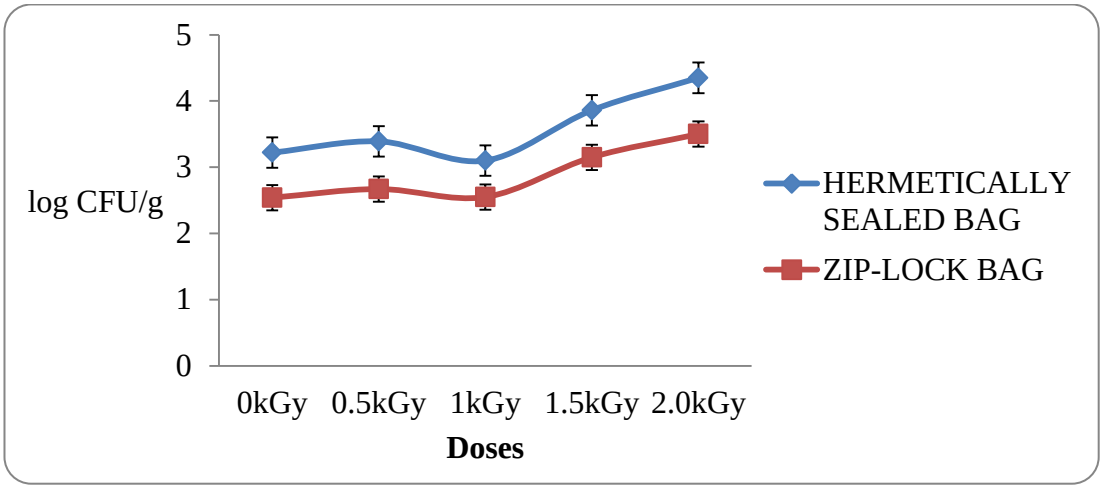

Figure: 62 Effect of doses on total coliform counts after blanching and irradiation

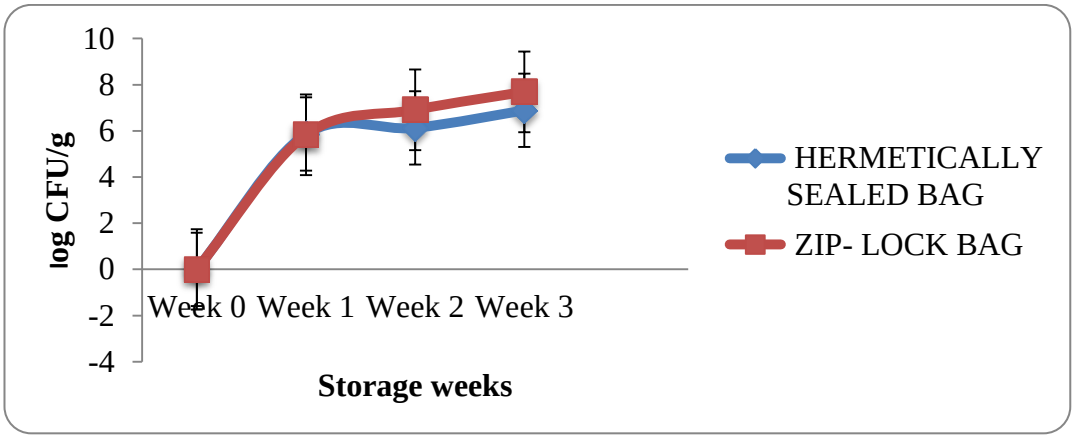

Figure: 63 Effect of storage on yeast and moulds count after blanching and irradiation

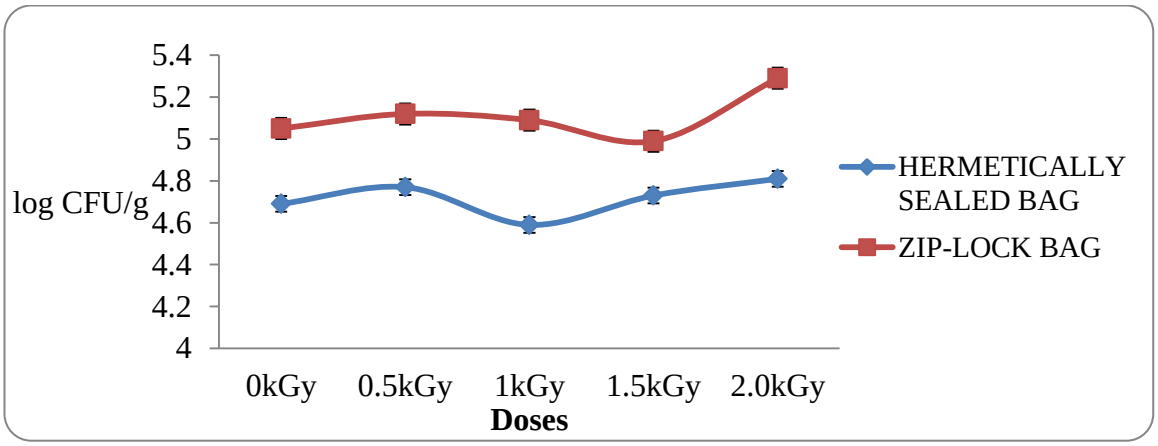

Figure: 64 Effect of doses on yeast and moulds count after blanching and irradiation

Table 9: Treatment means for microbial counts after blanching and irradiation and storage at ambient temperature

Storage	Doses(kGy)	Total coliform count(Hermetically sealed bag)	Total coliform (Zip-lock bag)	Total viable count (hermetically sealed bag)	Total viable count (zip-lock bag)	Yeast and moulds count (hermetically sealed bag)	Yeast and moulds count (Zip-lock bag)
0	0	0.20 ± 0.01^{x}	0.20 ± 0.05^{a}	0.01 ± 0.01^{b}	0.01 ± 0.02^{x}	0 ± 0.03^{q}	0 ± 0.04^{d}
	0.5	0.29 ± 0.01^{x}	0.03 ± 0.05^{a}	0.23 ± 0.01^{b}	0.02 ± 0.02^{x}	0 ± 0.03^{q}	0 ± 0.04^{d}
	1	0.20 ± 0.01^{x}	0.02 ± 0.05^{a}	0.16 ± 0.01^{b}	0.01 ± 0.02^{x}	0 ± 0.03^{q}	0 ± 0.04^{d}
	1.5	0.13 ± 0.01^{x}	0.01 ± 0.05^{a}	0.09 ± 0.01^{b}	0.01 ± 0.02^{x}	0 ± 0.03^{q}	0 ± 0.04^{d}
	2	0.13 ± 0.01^{x}	0.01 ± 0.05^{a}	0.09 ± 0.01^{b}	0.01 ± 0.02^{x}	0 ± 0.03^{q}	0 ± 0.04^{d}
1	0	1.97 ± 0.01^{t}	3.96 ± 0.05^{u}	0.60 ± 0.01^{bc}	2.15 ± 0.02^{y}	5.95 ± 0.03^{e}	5.91 ± 0.04^{e}
	0.5	2.93 ± 0.01^{tb}	2.07 ± 0.05^{v}	2.67 ± 0.01^{s}	2.41 ± 0.02^{y}	6.02 ± 0.03^{e}	5.96 ± 0.04^{e}
	1	3.25 ± 0.01^{tb}	1.85 ± 0.05^{v}	3.93 ± 0.01^{sy}	3.72 ± 0.02^{w}	5.21 ± 0.03^{f}	5.91 ± 0.04^{e}
	1.5	4.31 ± 0.01^{tbc}	2.62 ± 0.05^{v}	3.94 ± 0.01^{sy}	3.74 ± 0.02^{w}	6.02 ± 0.03^{e}	5.27 ± 0.04^{e}
	2	4.93 ± 0.01^{tbd}	2.42 ± 0.05^{v}	4.67 ± 0.01^{syv}	4.50 ± 0.02^{wd}	6.09 ± 0.03^{e}	6.08 ± 0.04^{e}
2	0	4.60 ± 0.01^{tbc}	3.97 ± 0.05^{u}	6.03 ± 0.01^{k}	5.97 ± 0.02^{h}	6.03 ± 0.03^{e}	6.79 ± 0.04^{t}
	0.5	4.39 ± 0.01^{tbc}	3.75 ± 0.05^{u}	6.52 ± 0.01^{ln}	6.47 ± 0.02^{ht}	6.15 ± 0.03^{e}	6.92 ± 0.04^{t}
	1	4.20 ± 0.01^{tbc}	3.65 ± 0.05^{u}	6.69 ± 0.01^{l}	6.70 ± 0.02^{ht}	6.19 ± 0.03^{e}	6.90 ± 0.04^{t}
	1.5	5.02 ± 0.01^{tbd}	4.55 ± 0.05^{fu}	7.07 ± 0.01^{z}	7.07 ± 0.02^{g}	6.07 ± 0.03^{e}	6.95 ± 0.04^{t}
	2	5.97 ± 0.01^{e}	4.88 ± 0.05^{fu}	7.13 ± 0.01^{z}	7.12 ± 0.02^{g}	6.19 ± 0.03^{e}	6.97 ± 0.04^{t}
3	0	6.09 ± 0.01^{e}	9.06 ± 0.05^{t}	6.78 ± 0.01^{l}	7.30 ± 0.02^{g}	6.79 ± 0.03^{er}	7.48 ± 0.04^{y}
	0.5	5.94 ± 0.01^{e}	5.81 ± 0.05^{o}	7.33 ± 0.01^{u}	7.86 ± 0.02^{gr}	6.92 ± 0.03^{er}	7.58 ± 0.04^{y}
	1	4.73 ± 0.01^{tbc}	5.4 ± 0.05^{o}	7.53 ± 0.01^{ug}	8.01 ± 0.02^{gr}	6.97 ± 0.03^{er}	7.56 ± 0.04^{y}
	1.5	6.00 ± 0.01^{e}	6.70 ± 0.05^{yu}	7.96 ± 0.01^{ug}	8.42 ± 0.02^{grz}	6.83 ± 0.03^{er}	7.74 ± 0.04^{yq}
	2.0	6.36 ± 0.01^{e}	7.38 ± 0.05^{ynu}	8.02 ± 0.01^{ugp}	8.48 ± 0.02^{grz}	6.97 ± 0.03^{er}	8.11 ± 0.04^{w}

Means followed by the same letter within the same column are not significantly different from each other ($p>0.05$)

4.3 .6 Effect of blanching, irradiation and refrigeration on the microbial load

4.3.6.1 Effect of blanching, irradiation and refrigeration on total viable count

Storage, irradiation doses as well as interaction of doses and storage had significant effect on the total viable counts in recorded in both packaging materials. Storage increased counts in both packaging materials (Figure 65). Counts increased from 0.44 to 5.19 ± 0.1 log CFU/g after the storage in hermetically sealed bag and in samples stored in zip-locked counts increased from 0.42 to 5.14 ± 0.01 log CFU/g during storage. Comparatively counts in hermetically sealed bag were higher than that recorded in zip-lock bag but there was no significant difference in their means (Figure 65). Interactions of storage and doses also recorded less counts at the initial storage week but an increase at the end of the storage period at all doses. However, counts were significantly less in samples irradiated at 1.5 kGy with 0.75 and 0.76 ± 0.02 log CFU/g in both hermetically sealed and zip-lock polyethylene bag respectively at the second week of storage (Table 10).

Compared to the control, samples irradiated at 1.5 kGy recorded the lowest viable count in both packaging materials. A dose of 1.5 kGy was effective in reducing counts of total viable count by 2 log cycles (Figure 66). Also samples irradiated at 0.5 kGy recorded a reduction in count by 1 log cycle but an increase in counts at 1 kGy and 2 kGy. However, there were no significant differences between packaging materials at all doses (Figure 66).

4.3.6.2 Effect of blanching, irradiation and refrigeration on total coliform count

Storage, irradiation doses and interaction of storage and doses had significant effect in samples stored in both packaging materials. Storage increased coliform counts in both packaging materials (Figure 67).Counts increased from of 0.42 to5.19 ± 0.01 log CFU/g during storage in hermetically sealed bag ; whilst samples stored in zip-lock bag increased from 0.41 to 6.56 ± 0.01log CFU/g but there were no significant differences between packaging materials (Figure 67).

Samples stored in zip-lock bag recorded the effective irradiation dose at 2 kGy with the lowest count of 2.22 ± 0.01 log CFU/g (Figure 68). However, at all irradiation doses, samples stored in hermetically sealed bag recorded more counts with the highest count of 4.21± 0.01 log CFU/g recorded in samples irradiated at 1.5 kGy which was significantly different from packaging material (Figure 68).

4.3.6.3 Effect of blanching, irradiation and refrigeration treatment on yeast and moulds

Storage, irradiation doses and interaction of storage and doses had significant effect ($p<0.05$) on yeast and moulds count. Storage increased counts in samples stored in both packaging materials (Figure 69). Counts increased from 0 to 4.23 log CFU/g after the storage period. Also samples stored in hermetically sealed bag increased from 0 to 6.46 ± 0.01 log CFU/g during storage. Comparatively, counts were not significantly different from packaging material used for storage (Figure 69)

Compared to the control, samples irradiated at 0.5 kGy, 1.5 kGy and 2 kGy recorded a reduction by 1 log cycle in yeast and mould counts of samples stored in zip-lock bag with the lowest count of 1.57 ± 0.01 log CFU/g recorded at 2 kGy (Figure 70). Counts were significantly differently from each packaging material at 1 kGy, 1.5 kGy and 2 kGy (Figure 70).

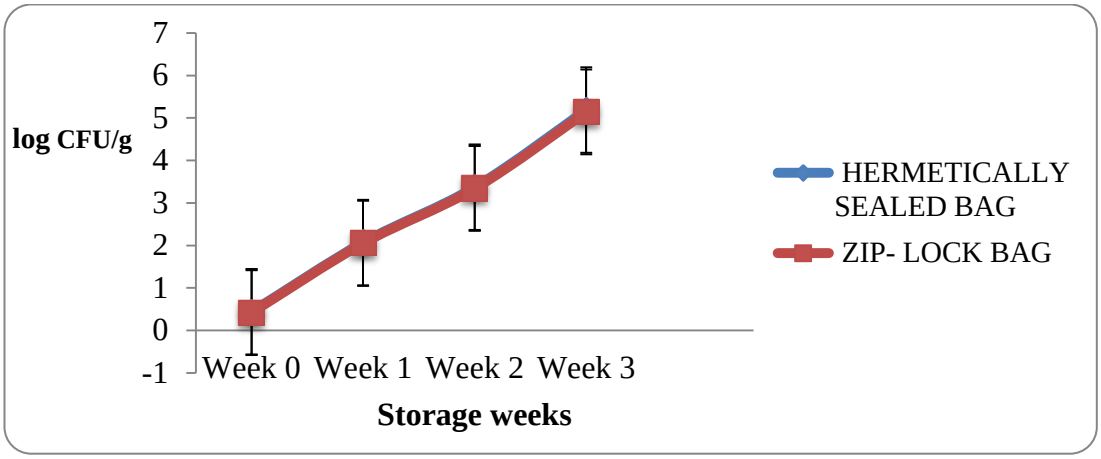

Figure: 65 Effect of storage on total viable count after blanching, irradiation and refrigeration

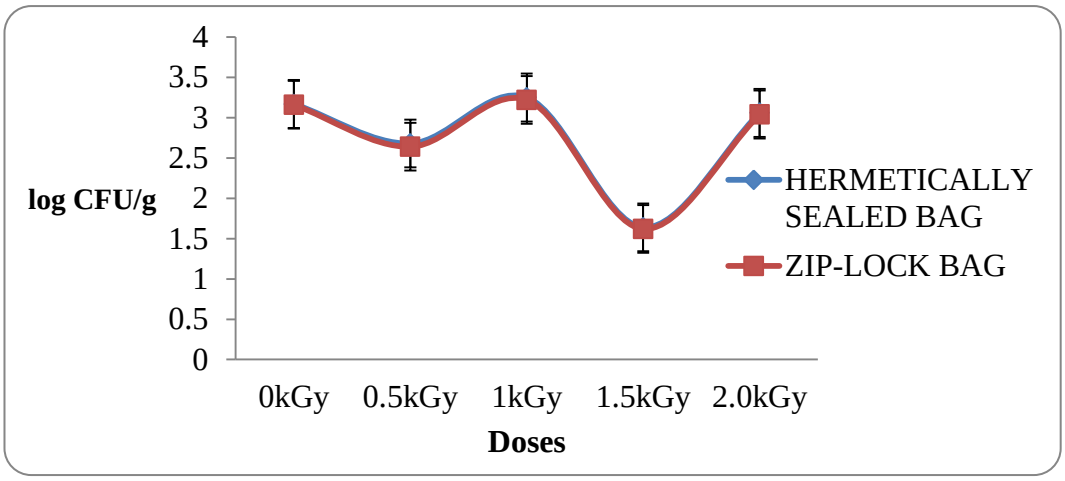

Figure: 66 Effect of doses on total viable count after blanching, irradiation and refrigeration treatment

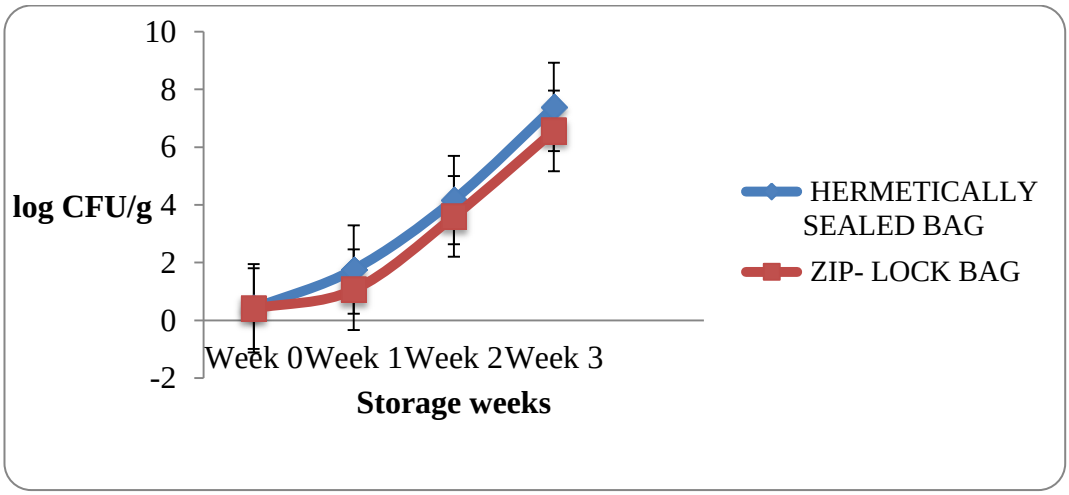

Figure: 67 Effect of storage on total coliforms count after blanching, irradiation and refrigeration

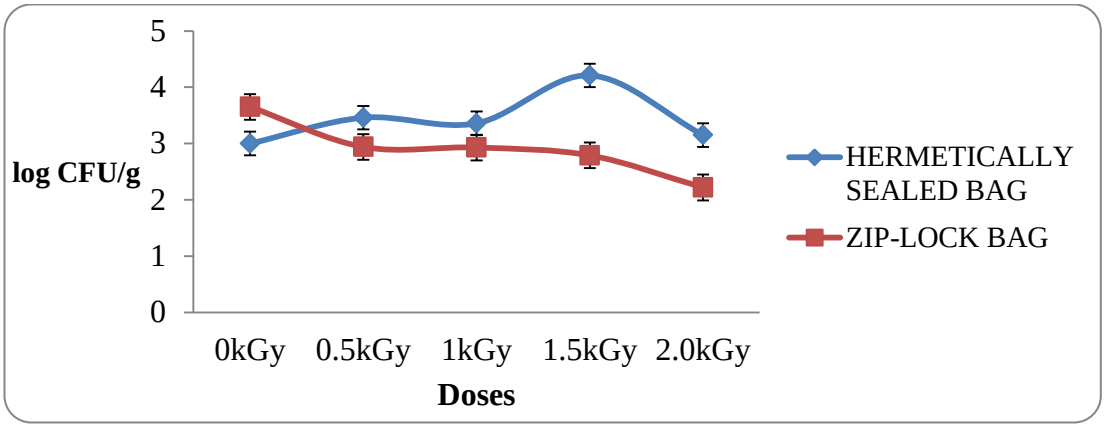

Figure: 68 Effect of doses on total coliforms after blanching, irradiation and refrigeration treatment

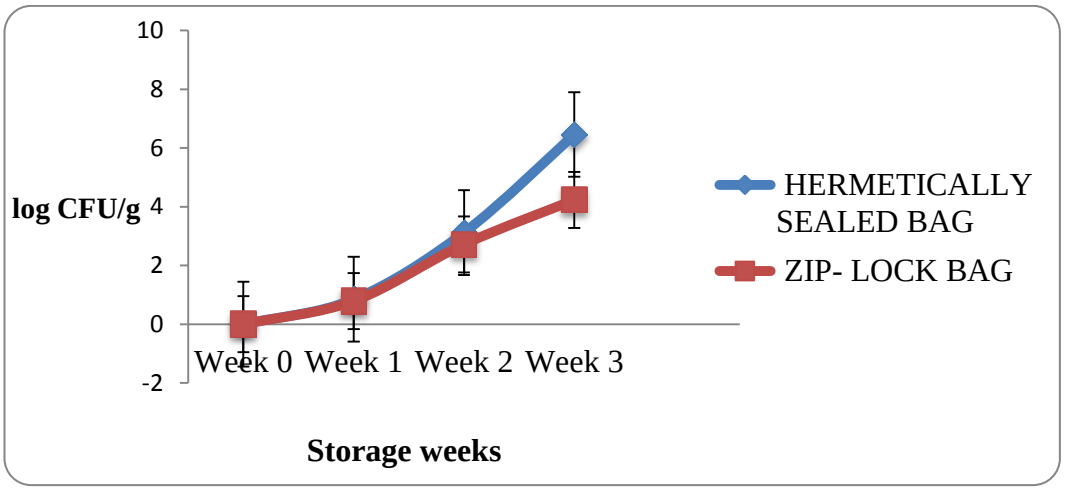

Figure: 69 Effect of storage on yeast and moulds count after blanching, irradiation and refrigeration storage

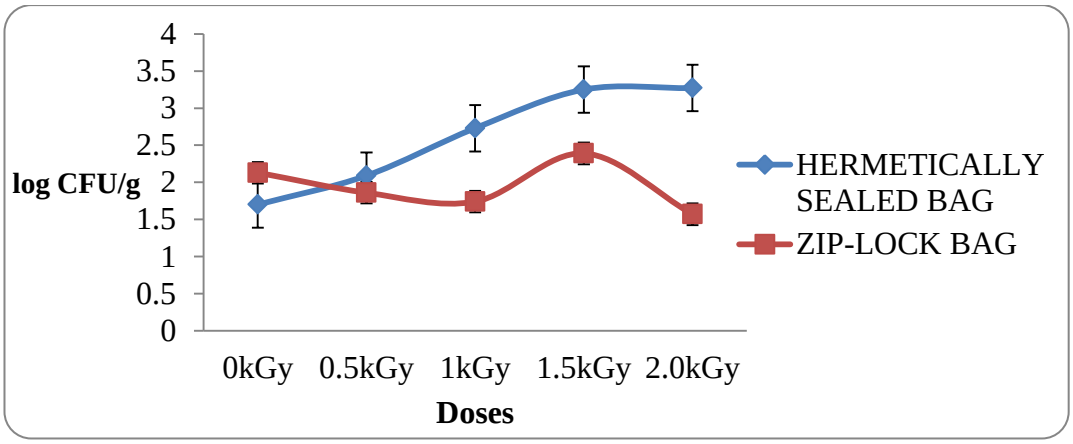

Figure: 70 Effect of doses on yeast and moulds after blanching, irradiation and refrigeration storage

Table 10.Treatment means for microbial counts of processed cocoyam leaf after blanching, irradiation and refrigeration storage

Storage	Doses(kGy)	Total coliform count(Hermetically sealed bag)	Total coliform (Zip-lock bag)	Total viable count (hermetically sealed bag)	Total viable count (zip-lock bag)	Yeast and moulds count (hermetically sealed bag)	Yeast and moulds count (Zip-lock bag)
0	0	0.003 ± 0.014^{a}	0.003 ± 0.02^{m}	0.17 ± 0.008^{x}	0.17 ± 0.02^{a}	0±0.01 s	0 ± 0.05^{y}
	0.5	0.07 ± 0.014^{a}	0.08 ± 0.02^{m}	0.47 ± 0.008^{x}	0.46 ± 0.02^{ab}	0 ± 0.01^{s}	0 ± 0.05^{y}
	1	0.20 ± 0.014^{a}	0.18 ± 0.02^{m}	0.75 ± 0.008^{x}	0.74 ± 0.02^{ab}	0 ± 0.01^{s}	0 ± 0.05^{y}
	1.5	1.01 ± 0.014^{e}	0.99 ± 0.02^{u}	0.37 ± 0.008^{x}	0.36 ± 0.02^{ab}	0 ± 0.01^{s}	0 ± 0.05^{y}
	2	0.83 ± 0.014^{a}	0.80 ± 0.02^{u}	0.36 ± 0.008^{x}	0.37 ± 0.02^{ab}	0 ± 0.01^{s}	0 ± 0.05^{y}
1	0	0.11 ± 0.014^{a}	0.01 ± 0.02^{m}	0.80 ± 0.008^{x}	0.80 ± 0.02^{ab}	0.64 ± 0.01^{r}	0.92 ± 0.05^{q}
	0.5	2.04 ± 0.014^{e}	2.03 ± 0.02^{o}	2.15 ± 0.008^{v}	2.15 ± 0.02^{e}	0.93 ± 0.01^{ru}	1.24 ± 0.05^{q}
	1	1.48 ± 0.014^{eh}	1.45 ± 0.02^{ok}	3.67 ± 0.008^{y}	3.94 ± 0.02^{ef}	0.86 ± 0.01^{ru}	0.84 ± 0.05^{q}
	1.5	4.11 ± 0.014^{bt}	1.64 ± 0.02^{ok}	0.76 ± 0.008^{x}	0.76 ± 0.02^{ab}	1.19 ± 0.01^{f}	0.19 ± 0.05^{q}
	2	1.07 ± 0.014^{eh}	0.18 ± 0.02^{m}	2.61 ± 0.008^{vu}	2.61 ± 0.02^{e}	0.62 ± 0.01^{r}	0.76 ± 0.05^{q}
2	0	4.58 ± 0.014^{b}	7.28 ± 0.02^{n}	4.47 ± 0.008^{y}	4.48 ± 0.02^{fg}	2.62 ± 0.01^{t}	2.55 ± 0.05^{w}
	0.5	3.93 ± 0.014^{e}	3.89 ± 0.02^{p}	3.46 ± 0.008^{y}	3.46 ± 0.02^{ef}	2.74 ± 0.01^{t}	2.71 ± 0.05^{w}
	1	4.47 ± 0.014^{ej}	3.53 ± 0.02^{p}	3.94 ± 0.008^{yv}	3.67 ± 0.02^{ef}	3.70 ± 0.01^{g}	2.45 ± 0.05^{w}
	1.5	4.38 ± 0.014^{ej}	1.90 ± 0.02^{okt}	0.75 ± 0.008^{x}	0.76 ± 0.02^{ab}	3.09 ± 0.01^{pt}	4.65 ± 0.05^{xc}
	2	3.47 ± 0.014^{e}	1.38 ± 0.02^{ok}	4.33 ± 0.008^{y}	4.33 ± 0.02^{fg}	3.46 ± 0.01^{p}	1.27 ± 0.05^{q}
3	0	7.32 ± 0.014^{c}	7.32 ± 0.02^{n}	7.21 ± 0.008^{z}	7.21 ± 0.02^{d}	3.55 ± 0.01^{p}	5.06 ± 0.05^{x}
	0.5	7.78 ± 0.014^{f}	5.76 ± 0.02^{w}	4.50 ± 0.008^{y}	4.49 ± 0.02^{fg}	4.68 ± 0.01^{pl}	3.48 ± 0.05^{vw}
	1	7.29 ± 0.014^{k}	6.55 ± 0.02^{n}	4.54 ± 0.008^{y}	4.54 ± 0.02^{fg}	6.36 ± 0.01^{kp}	3.68 ± 0.05^{vw}
	1.5	7.34 ± 0.014^{k}	6.63 ± 0.02^{n}	4.60 ± 0.008^{y}	4.60 ± 0.02^{fg}	8.78 ± 0.01^{h}	4.71 ± 0.05^{xc}
	2	7.21 ± 0.014^{k}	6.55 ± 0.02^{n}	4.86 ± 0.008^{y}	4.86 ± 0.02^{fg}	8.92 ± 0.01^{h}	4.24 ± 0.05^{xc}

Means followed by same alphabet within the same column are not significantly different from each other (p>0.05)

4. 3.7 Isolation and identification

After isolation and identification, there were no *Escherichia coli* and *Salmonella* spp., on all the preserved leaf. However, *Pseudomonas fluorescens*, *Pseudomonas viridiflava*, and *Citrobacter* spp were identified in samples stored by refrigeration and its combinations.

4.4 Consumer acceptance of processed cocoyam leaf

4.4.1 Consumer acceptance for irradiated samples

4.4.1.1 Consumer acceptance for colour of irradiated cocoyam leaf

Storage and packaging materials had significant effect on the acceptability of colour of the processed leaf (Appendix 5:1A). Storage reduced the acceptance level (Table 11). The initial week of storage recorded the highest acceptance mean score of 7.56 was recorded from samples that were not irradiated and packaged in zip-lock polyethylene bag because the colour was more appealing. The lowest accepted sample recorded a mean of 1.6 from samples irradiated at 2 kGy that were packed in hermetically sealed polyethylene bag after the storage period (Table 11).

4.4.1.2 Consumer acceptance for texture of irradiated cocoyam leaf

Storage, packaging materials and doses had significant effect ($p<0.05$) on the acceptability of texture. (Appendix 5:1B).The initial storage period recorded the highest acceptance score of 7.52 for texture from unirradiated samples that was packaged in zip-lock bag that was significantly different from that recorded from other doses (Table 11); whiles samples stored in hermetically sealed polyethylene bag irradiated at 2 kGy recorded the lowest acceptance level with a mean of 5.08

(Table 11). After the storage period, the most acceptable sample was recorded at 0.5 kGy with a mean of 4.4 from samples that were stored in zip-lock polyethylene bag and the lowest accepted sample was samples irradiated at 1 kGy that were packaged in hermetically sealed polyethylene bag with a mean of 1.9 (Table 11)

4.4.1.3 Consumer acceptance for odour of irradiated cocoyam leaf

Storage, packaging materials and doses had significant effect ($p<0.05$) on the acceptability of odour (Appendix 5:1C). Again, unirradiated samples stored in zip-lock polyethylene bag were the most preferred choice at both the initial and final week storage week and the most unaccepted odour was recorded from samples that were irradiated at 2 kGy and packaged in hermetically sealed polyethylene bag. (Table 11)

Table 11: Treatment means for consumer acceptance of irradiated cocoyam leaf

PACKAGING MATERIAL	D0SES(kGy)	WEEKS	COLOUR	TEXTURE	ODOUR
Zip-lock bag	0	0	7.5 ± 0.17^{a}	7.52 ± 0.17^{u}	7.36 ± 0.23^{i}
Hermetic bag	0	0	5.58 ± 0.17^{ed}	6.22 ± 0.17^{xv}	6.06 ± 0.23^{lk}
Zip-lock bag	0.5	0	7.52 ± 0.17^{a}	6.52 ± 0.17^{wv}	5.34 ± 0.23^{kj}
Hermetic bag	0.5	0	5.24 ± 0.17^{e}	5.96 ± 0.17^{x}	4.96 ± 0.23^{l}
Zip-lock bag	1	0	6.26 ± 0.17^{c}	6.94 ± 0.17^{v}	5.36 ± 0.23^{j}
Hermetic bag	1	0	5.3 ± 0.17^{e}	5.88 ± 0.17^{x}	4.1 ± 0.23^{l}
Zip-lock bag	1.5	0	5.62 ± 0.17^{ed}	6.0 ± 0.17^{x}	4.24 ± 0.23^{l}
Hermetic bag	1.5	0	5.82 ± 0.17^{dc}	6.0 ± 0.17^{x}	5.22 ± 0.23^{l}
Zip-lock bag	2.0	0	5.54 ± 0.17^{ed}	6.6 ± 0.17^{wv}	4.74 ± 0.23^{kj}
Hermetic bag	2.0	0	3.74 ± 0.17^{f}	5.08 ± 0.17^{y}	3.6 ± 0.23^{m}
Zip-lock bag	0	1	5.02 ± 0.23^{hi}	4.04 ± 0.25^{t}	3.14 ± 0.27^{mn}
Hermetic bag	0	1	3.3 ± 0.23^{fg}	2.78 ± 0.25^{i}	2.56 ± 0.27^{nb}
Zip-lock bag	0.5	1	4.46 ± 0.23^{h}	4.4 ± 0.25^{t}	3.56 ± 0.27^{m}
Hermetic bag	0.5	1	3.06 ± 0.23^{j}	2.9 ± 0.25^{if}	2.74 ± 0.27^{nb}
Zip-lock bag	1	1	3.76 ± 0.23^{f}	3.54 ± 0.25^{f}	3.02 ± 0.27^{n}
Hermetic bag	1	1	2.36 ± 0.23^{k}	1.9 ± 0.25^{h}	2.32 ± 0.27^{nbc}
Zip-lock bag	1.5	1	3.5 ± 0.23^{fg}	3.36 ± 0.25^{fj}	3.08 ± 0.27^{mn}
Hermetic bag	1.5	1	2.56 ± 0.23^{kl}	2.3 ± 0.25^{k}	2.52 ± 0.27^{nb}
Zip-lock bag	2.0	1	3.08 ± 0.23^{j}	3.24 ± 0.25^{f}	2.86 ± 0.27^{mnb}
Hermetic bag	2.0	1	2.32 ± 0.23^{k}	2.24 ± 0.25^{kh}	2.14 ± 0.27^{b}

Means followed by the same alphabet within same column denote not significantly different ($p>0.05$)

4.4.2 Consumer acceptance of refrigerated and ambient temperature stored leaf

4.4.2.1 Consumer acceptance for colour of refrigerated and ambient temperature storage

Storage, packaging materials and storage temperatures had significant effect ($p<0.05$) on the acceptance of colour (Appendix 5:2A).The mean score values recorded indicated that there was significant difference ($p<0.05$) in colour of the processed cocoyam leaf from one level of storage to the other as well as between packaging materials (Table 12). The highest acceptance level recorded a mean score of 7.56 at the initial week of storage in refrigerated samples stored in zip-lock polyethylene bag and was significantly different ($p<0.05$) from the mean score recorded after the storage period. Samples stored at ambient temperature in hermetically sealed polyethylene bag recorded the lowest score throughout the period of storage (Table 12). After the storage period, the most acceptable sample was refrigerated samples that were stored in zip-lock polyethylene bag with a mean of 4.68 whiles ambient temperature stored samples of the same packaging material recorded the most lowest mean of 1.64 (Table 12).

4.4.2.2 Consumer acceptance for texture of refrigerated and ambient temperature storage

Storage, packaging materials and storage temperatures had significant effect ($p<0.05$) on the texture (Appendix 5:2B). The level of acceptance decreased as storage increased with the lowest mean value recorded in the third week of storage in samples stored at ambient temperature ($30\pm2^{o}C$) in hermetically sealed polyethylene

bag (Table 12). After the storage period, refrigerated samples stored in zip-lock polyethylene bag recorded the most acceptable sample with a mean of 4.9 which was significantly different ($p<0.05$) from the mean score recorded from the other treatment and the lowest accepted sample were samples that were stored in hermetically sealed polyethylene bag under ambient temperature storage (Table 12).

4.4.2.3 Consumer acceptance for odour of refrigerated and ambient temperature storage

Storage, packaging materials and storage temperatures had significant effect ($p<0.05$) on the odour (Appendix 5:2B). The mean values recorded was significantly different ($p<0.05$) from one packaging material to the other (Table 12). Again the most acceptable sample was recorded from refrigerated samples stored in zip-lock polyethylene at both the initial and final week of storage while the lowest mean value was recorded in samples stored at ambient temperature in hermetically sealed polyethylene bag (Table 12)

Table 12: Treatment means for consumer acceptance of refrigerated and ambient temperature stored cocoyam leaf

PACKAGING MATERIAL	WEEKS	COLOUR	TEXTURE	ODOUR
Zip-lock bag(Refrigeration)	0	7.56 ± 0.18^{b}	7.52 ± 0.19^{s}	7.36 ± 0.19^{g}
Zip-lock bag(Ambient temperature)	0	6.5 ± 0.18^{a}	6.5 ± 0.19^{ut}	6.32 ± 0.19^{h}
Hermetic bag(Refrigeration)	0	5.56 ± 0.18^{dc}	5.72 ± 0.19^{u}	4.72 ± 0.19^{j}
Hermetic bag(Ambient temperature)	0	5.38 ± 0.18^{c}	6.22 ± 0.19^{uv}	6.06 ± 0.19^{h}
Zip-lock bag(Refrigeration)	1	6.84 ± 0.18^{bc}	6.94 ± 0.19^{t}	6.44 ± 0.19^{h}
Zip-lock bag(Ambient temperature)	1	5.02 ± 0.18^{ed}	4.04 ± 0.19^{x}	3.14 ± 0.19^{l}
Hermetic bag(Refrigeration)	1	4.56 ± 0.18^{e}	4.88 ± 0.19^{w}	4.62 ± 0.19^{j}
Hermetic bag(Ambient temperature)	1	3.3 ± 0.18^{g}	2.78 ± 0.19^{y}	2.56 ± 0.19^{n}
Zip-lock bag(Refrigeration)	2	5.76 ± 0.18^{c}	6.14 ± 0.19^{uv}	5.46 ± 0.19^{i}
Zip-lock bag(Ambient temperature)	2	2.72 ± 0.18^{h}	3.92 ± 0.19^{x}	2.32 ± 0.19^{m}
Hermetic bag(Refrigeration)	2	3.96 ± 0.18^{f}	4.22 ± 0.19^{x}	3.28 ± 0.19^{l}
Hermetic bag(Ambient temperature)	2	1.74 ± 0.18^{i}	4.22 ± 0.19^{a}	1.5 ± 0.19^{n}
Zip-lock bag(Refrigeration)	3	4.64 ± 0.18^{e}	4.9 ± 0.19^{w}	3.86 ± 0.19^{k}
Zip-lock bag(Ambient temperature)	3	1.64 ± 0.18^{i}	2.22 ± 0.19^{az}	1.4 ± 0.19^{n}
Hermetic bag(Refrigeration)	3	3.38 ± 0.18^{g}	2.7 ± 0.19^{zy}	2.26 ± 0.19^{m}
Hermetic bag(Ambient temperature)	3	2.1 ± 0.18^{i}	1.26 ± 0.19^{b}	1.28 ± 0.19^{n}

* Means followed by same alphabet in the same column are not significantly different ($p>0.05$)*

4.4.3 Consumer acceptance of blanched, blanched and refrigerated stored cocoyam leaf

4.4.3.1 Consumer acceptance for colour of blanched, blanched and refrigerated stored cocoyam leaf

Storage, packaging materials and storage temperatures had significant effect ($p<0.05$) on acceptability of the colour (Appendix 5:3A).The level of acceptance decreased as storage time increased under all storage conditions (Table 13). Blanched and refrigerated samples stored in zip-lock polyethylene bag recorded the most acceptable sample of a mean of 6.98 at the initial and third week which was significantly different ($p<0.05$) from the mean score recorded in the subsequent weeks of storage. The low accepted sample at both the initial and after the storage period was recorded in ambient temperature stored samples in hermetically sealed polyethylene bag (Table 13).

4.4.3.2 Consumer acceptance for texture of blanched, blanched and refrigerated stored cocoyam leaf

Storage, packaging materials and storage temperatures had significant effect ($p<0.05$) on the acceptability of texture.(Appendix 5:3B).Storage decreased the acceptance level for texture (Table 13).The most acceptable sample after the storage period was samples stored in zip-lock polyethylene bag that were blanched and refrigerated with a mean score of 3.06 (Table 13). The least preferred sample was recorded from blanched and ambient temperature both hermetically sealed and zip-lock polyethylene bag (Table 13).

4.4.3.3 Consumer acceptance for odour of blanched, blanched and refrigerated cocoyam leaf

Storage, packaging materials and storage temperatures had significant effect ($p<0.05$) on the acceptability of odour (Appendix 5:3C). Storage reduced the acceptance level (Table 13). After the storage period, the most acceptable sample was blanched and refrigerated stored in zip-lock polyethylene bag and the least acceptable were recorded in samples stored at ambient temperature in both zip-lock bag and hermetically sealed bag in the third week of storage (Table 13).

Table 13: Treatment means for consumer acceptance of blanched and ambient temperature storage, blanched and refrigerated stored cocoyam leaf

PACKAGING MATERIAL	WEEKS	COLOUR	TEXTURE	ODOUR
Zip-lock bag(Refrigeration)	0	6.94±0.17^{a}	5.58±0.18^{s}	4.72±0.19^{g}
Zip-lock bag(Ambient temperature)	0	6.78±0.17^{ba}	5.04±0.18^{t}	3.92±0.19^{h}
Hermetic bag(Refrigeration)	0	6.34±0.17^{c}	5.36±0.18^{ts}	4.72±0.19^{g}
Hermetic bag(Ambient temperature)	0	6.2±0.17^{cb}	4.52±0.18^{u}	3.52±0.19^{ihj}
Zip-lock bag(Refrigeration)	1	5.86 ±0.17^{c}	3.86±0.18^{v}	3.82±0.19^{hj}
Zip-lock bag(Ambient temperature)	1	4.8±0.17^{ed}	2.62±0.18^{zy}	2.82±0.19^{l}
Hermetic bag(Refrigeration)	1	5.22±0.17^{d}	3.2±0.18^{xw}	3.44±0.19^{kihj}
Hermetic bag(Ambient temperature)	1	4.02±0.17^{g}	2.26±0.18^{az}	2.86±0.19^{l}
Zip-lock bag(Refrigeration)	2	2.0±0.17^{h}	3.46±0.18^{wv}	3.42±0.19^{kihj}
Zip-lock (Ambient temperature	2	1.5±0.17^{h}	1.5±0.18^{ba}	2.0±0.19^{m}
Hermetic bag(Refrigeration)	2	4.54±0.17^{fe}	2.82±0.18^{yx}	3.16±0.19^{lki}
Hermetic bag(Ambient temperature)	2	2.0±0.17^{h}	2.0±0.18^{ba}	2.0±0.19^{m}
Zip-lock bag(Refrigeration)	3	4.24±0.17^{gf}	3.06±0.18^{yxw}	3.32±0.19^{lkihj}
Zip-lock bag(Ambient temperature)	3	1.16±0.17^{ih}	1.3±0.18^{b}	1.0±0.19^{n}
Hermetic bag (Refrigeration)	3	4.06±0.17^{gf}	2.74±0.18^{zyx}	2.92±0.19^{lk}
Hermetic bag(Ambient temperature)	3	1.0±0.17^{i}	1.0±0.18^{b}	1.0±0.19^{n}

* Means followed by same alphabet within the same column are not significantly different from each other (p>0.05)*

4.4.4 Consumer acceptance of irradiated and refrigerated stored cocoyam leaf

4.4.4.1 Consumer acceptance for colour of irradiated and refrigerated stored samples

Storage, packaging materials and doses had significant effect ($p<0.05$) on the colour acceptability level (Appendix 5: 4A). Storage reduced the acceptance level of colour (Table 14). At the initial week of storage, the most acceptable samples were samples unirradiated that was stored in the zip-lock polyethylene bag. After a week of storage, samples stored in zip-lock polyethylene bag unirradiated and 0.5 kGy samples were the most acceptable samples. At the second week of storage, again unirradiated samples and 0.5 kGy irradiated samples stored in zip-lock polyethylene bag recorded the highest mean of 6.44 and 6.42 respectively whiles the least acceptable sample was 0.5 kGy irradiated samples stored in hermetically sealed bag. At the end of the storage period, unirradiated samples stored in zip-lock bag recorded the most accepted colour with a mean of 5.84 but this was not significantly different from that which was irradiated at 0.5 kGy and 1.5 kGy of the same packaging material (Table 14). The least acceptable samples were samples irradiated at 0.5 kGy and1.5 kGy that were packaged in hermetically sealed polyethylene bag (Table 14).

4.4.4.2 Consumer acceptance for texture of irradiated and refrigerated stored samples

Storage, packaging materials and doses had significant effect ($p<0.05$) on the texture acceptability (Appendix 5: 4B). Storage reduced the acceptance level of the processed leaf (Table 14).At the initial week of storage, unirradiated samples stored in zip-lock polyethylene bag were the most acceptable whiles the least acceptable

sample was sample irradiated at 1.5 kGy that was stored in hermetically sealed bag (Table 14). After a week of storage, samples irradiated at 0.5 kGy and stored in zip-lock polyethylene bag were the most acceptable and the least acceptable was samples irradiated at 2 kGy stored in hermetically sealed bag. At the second of storage, unirradiated samples stored in zip-lock polyethylene bag was the most preferred sample with a mean of 6.42 but this was not significantly different ($p<0.05$) from the mean value recorded at samples irradiated at 0.5 kGy while the lowest was recorded in samples stored in hermetically sealed polyethylene bag (Table 14). After the third week of storage, the most preferred sample for texture was recorded from samples irradiated at 1 kGy that were packaged in zip-lock polyethylene bag and the most unliked sample was sample that were irradiated at 2 kGy that were packaged in hermetically sealed polyethylene bag (Table 14).

4.4.4.2 Consumer acceptance of odour of irradiated and refrigerated stored samples

Storage, packaging materials and doses had significant effect ($p<0.05$) on the acceptability of odour (Appendix 5: 4C). Storage reduced the acceptance level of the processed leaf (Table 14). Unirradiated samples that were packaged in the zip-lock polyethylene bag was the most acceptable sample through-out the storage period and the least acceptable sample after the storage period was recorded in samples stored in hermetically sealed polyethylene bag irradiated that was irradiated at 1.5 kGy (Table 14).

Table 14: Treatment means for consumer acceptance of Irradiated and refrigerated processed cocoyam leaf

PACKAGING MATERIAL	D0SE(kGy)	WEEKS	COLOUR	TEXTURE	ODOUR
Zip-lock bag	0	0	6.56±0.18^{vx}	6.5±0.19^{f}	6.32±0.19^{h}
Hermetic bag	0	0	5.36±0.18^{u}	5.72±0.19^{yz}	4.72±0.19^{edfg}
Zip-lock bag	0.5	0	5.8±0.18^{u}	6.08±0.19^{y}	4.96±0.19^{c}
Hermetic bag	0.5	0	4.4±0.18^{y}	4.88±0.19^{a}	4.02±0.19^{ed}
Zip-lock bag	1	0	5.78±0.18^{u}	5.88±0.19^{yz}	4.96±0.19^{c}
Hermetic bag	1	0	4.66±0.18^{y}	5.22±0.19^{ab}	4.9±0.19^{c}
Zip-lock bag	1.5	0	6.4±0.18^{v}	5.74±0.19^{yz}	5.18±0.19^{edf}
Hermetic bag	1.5	0	4.56±0.18^{y}	4.88±0.19^{a}	4.56±0.19^{edf}
Zip-lock bag	2.0	0	6.18±0.18^{v}	6.1±0.19^{y}	4.66±0.19^{edf}
Hermetic bag	2.0	0	4.96±0.18^{yz}	4.98±0.19^{a}	4.1±0.19^{ed}
Zip-lock bag	0	1	6.84±0.18^{w}	6.94±0.19^{g}	6.44±0.19^{h}
Hermetic bag	0	1	4.56±0.18^{y}	4.88±0.19^{a}	4.62±0.19^{edf}
Zip-lock bag	0.5	1	6.98±0.18^{w}	6.62±0.19^{fg}	5.7±0.19^{b}
Hermetic bag	0.5	1	4.42±0.18^{y}	4.4±0.19^{cd}	3.78±0.19^{d}
Zip-lock bag	1	1	6.46±0.18^{vx}	6.6±0.19^{f}	5.68±0.19^{b}
Hermetic bag	1	1	3.98±0.18^{ay}	4.36±0.19^{c}	4.2±0.19^{ed}
Zip-lock bag	1.5	1	6.18±0.18^{v}	5.88±0.19^{yz}	5.38±0.19^{fg}
Hermetic bag	1.5	1	3.96±0.18^{ya}	4.08±0.19^{ecd}	3.88±0.19^{d}
Zip-lock bag	2.0	1	6.2±0.18^{v}	6.44±0.19^{f}	5.22±0.19^{fg}
Hermetic bag	2.0	1	3.96±0.18^{ya}	4.22±0.19^{cd}	4.42±0.19^{ed}
Zip-lock bag	0	2	6.44±0.18^{vx}	6.42±0.19^{f}	6.1±0.19^{b}
Hermetic bag	0	2	4.38±0.18^{ya}	4.44±0.19^{cd}	4.5±0.19^{edf}
Zip-lock bag	0.5	2	6.42±0.18^{vx}	5.94±0.19^{yz}	4.82±0.19^{edfg}
Hermetic bag	0.5	2	3.48±0.18$^{ab\ c}$	4.24±0.19^{cd}	2.74±0.19^{c}
Zip-lock bag	1	2	6.28±0.18^{v}	5.84±0.19^{yz}	5.38±0.19^{fg}
Hermetic bag	1	2	4.2±0.18^{ya}	4.08±0.19^{ecd}	3.84±0.19^{d}
Zip-lock bag	1.5	2	5.86±0.18^{u}	4.88±0.19^{a}	5.1±0.19^{fg}
Hermetic bag	1.5	2	3.58±0.18^{a}	4.02±0.19^{w}	3.44±0.19^{d}
Zip-lock bag	2.0	2	5.92±0.18^{u}	6.02±0.19^{y}	4.68±0.19^{edf}
Hermetic bag	2.0	2	3.86±0.18^{ab}	3.94±0.19^{w}	4.16±0.19^{ed}
Zip-lock bag	0	3	5.84±0.18^{u}	3.9±0.19^{w}	5.48±0.19^{a}
Hermetic bag	0	3	4.02±0.18^{ya}	3.9±0.19^{w}	3.78±0.19^{d}
Zip-lock bag	0.5	3	5.72±0.18^{u}	4.96±0.19^{a}	3.32±0.19^{d}
Hermetic bag	0.5	3	2.68±0.18^{c}	3.24±0.19^{u}	2.3±0.19^{c}
Zip-lock bag	1	3	4.96±0.18^{yz}	5.2±0.19^{a}	4.92±0.19^{edf}
Hermetic bag	1	3	3.38±0.18^{acb}	3.16±0.19^{u}	2.7±0.19^{c}
Zip-lock bag	1.5	3	5.38±0.18^{u}	4.04±0.19^{w}	4.42±0.19^{ed}
Hermetic bag	1.5	3	2.82±0.18^{cbd}	3.38±0.19^{wj}	2.5±0.19^{c}
Zip-lock bag	2.0	3	5.64±0.18^{u}	4.52±0.19^{cd}	4.62±0.19^{edf}
Hermetic bag	2.0	3	3.58±0.18^{acb}	3.02±0.19^{u}	2.68±0.19^{c}

* Means followed by same alphabet within the same column are not significantly different from each other (p>0.05)*

4.4.5 Consumer acceptance of blanched and irradiated stored samples

4.4.5.1 Consumer acceptance for colour of blanched and irradiated stored samples

Storage, packaging materials and doses had significant effect ($p<0.05$) on acceptability of the colour (Appendix 5: 5A). Storage at ambient temperature reduced the acceptance level of the processed leaf (Table 15). The most acceptable sample was found in unirradiated sample stored in zip-lock polyethylene bag at both the initial and final week of storage while the lowest was found in samples irradiated at 1.5 kGy stored in zip-lock polyethylene bag (Table 15).

4.4.5.2 Consumer acceptance for texture of blanched and irradiated stored samples

Storage, packaging materials and doses had significant effect ($p<0.05$) on the texture acceptability (Appendix 5: 5B). Storage of blanched samples under ambient temperature reduced the acceptance level of the processed leaf (Table 15). Again, unirradiated samples stored in zip-lock polyethylene bag recorded the most acceptable sample with a mean 5.04 score at the initial week of storage and 2.62 after the storage period and the least acceptable sample with a mean score of 1.0 was recorded in samples irradiated at 0.5 and 1 kGy of samples stored in both zip-lock and hermetically sealed polyethylene bags (Table 15)

4.4.5.2 Consumer acceptance for odour of blanched and irradiated stored samples

Storage, packaging materials and doses had significant effect ($p<0.05$) on the acceptability of odour (Appendix 5: 5A). Storage at ambient temperature reduced the acceptance level of the processed leaf (Table 15). After the storage period,

unirradiated samples of both samples stored in zip-lock and hermetically sealed polyethylene bag were the most acceptable samples with a mean of 2.82 and 2.86 respectively and the least acceptable samples were those irradiated at 1.5 kGy and 2 kGy stored in zip-lock bag polyethylene bag (Table 15).

Table 15: Treatment means for consumer acceptance of blanched and irradiated processed cocoyam leaf

PACKAGING MATERIAL	D0SES(kGy)	WEEKS	COLOUR	TEXTURE	ODOUR
Zip-lock bag	0	0	6.94 ± 0.12^{a}	5.04 ± 0.17^{u}	3.92 ± 0.17^{a}
Hermetic bag	0	0	6.34 ± 0.12^{cb}	4.52 ± 0.17^{v}	3.52 ± 0.17^{cba}
Zip-lock bag	0.5	0	6.08 ± 0.12^{dcb}	4.76 ± 0.17^{vu}	3.3 ± 0.17^{cb}
Hermetic bag	0.5	0	6.36 ± 0.12^{b}	4.5 ± 0.17^{v}	3.26 ± 0.17^{dcba}
Zip-lock bag	1	0	6.02 ± 0.12^{dc}	4.82 ± 0.17^{vu}	3.64 ± 0.17^{ba}
Hermetic bag	1	0	6.1 ± 0.12^{dcb}	4.5 ± 0.17^{v}	3.1 ± 0.17^{fdcb}
Zip-lock bag	1.5	0	5.9 ± 0.12^{d}	4.7 ± 0.17^{vu}	3.36 ± 0.17^{cb}
Hermetic bag	1.5	0	6.34 ± 0.12^{cb}	4.76 ± 0.17^{vu}	3.2 ± 0.17^{fdcba}
Zip-lock bag	2.0	0	5.56 ± 0.12^{e}	4.66 ± 0.17^{vu}	3.06 ± 0.17^{fdcb}
Hermetic bag	2.0	0	6.24 ± 0.12^{cb}	4.34 ± 0.17^{v}	2.76 ± 0.17^{f}
Zip-lock bag	0	1	4.8 ± 0.12^{f}	2.62 ± 0.17^{w}	2.82 ± 0.17^{fd}
Hermetic bag	0	1	4.02 ± 0.12^{g}	2.26 ± 0.17^{xw}	2.86 ± 0.17^{fdc}
Zip-lock bag	0.5	1	1.5 ± 0.12^{h}	1.5 ± 0.17^{y}	2.0 ± 0.17^{g}
Hermetic bag	0.5	1	2.0 ± 0.12^{hj}	1.0 ± 0.17^{z}	1.5 ± 0.17^{h}
Zip-lock bag	1	1	1.5 ± 0.12^{h}	1.0 ± 0.17^{z}	1.5 ± 0.17^{h}
Hermetic bag	1	1	1.5 ± 0.12^{h}	1.5 ± 0.17^{y}	1.5 ± 0.17^{h}
Zip-lock bag	1.5	1	1.5 ± 0.12^{h}	1.5 ± 0.17^{y}	1.0 ± 0.17^{i}
Hermetic bag	1.5	1	1.0 ± 0.12^{i}	1.5 ± 0.17^{y}	1.5 ± 0.17^{h}
Zip-lock bag	2.0	1	1.5 ± 0.12^{h}	2.0 ± 0.17^{x}	1.0 ± 0.17^{i}
Hermetic bag	2.0	1	1.5 ± 0.12^{h}	1.5 ± 0.17^{y}	1.5 ± 0.17^{h}

* Means followed by same alphabet within the same column are not significantly different ($p>0.05$)*

4.4.6 Consumer acceptance of blanched, irradiated and refrigerated stored samples

4.4.6.1 Consumer acceptance for colour of blanched, irradiated and refrigerated stored samples

Storage, packaging materials and doses had significant effect ($p<0.05$) on the acceptability of colour (Appendix 5: 6A). The acceptance level of colour showed a reduction after every storage week (Table 16). At the initial week of storage, the most acceptable sample was found in unirradiated samples stored in both the zip-lock bag and hermetically sealed polyethylene bag. After a week of storage, all samples stored in zip-lock polyethylene bag were acceptable to most of the panellist but with a decrease in the mean scores. At the second and third week of storage, 0.5 kGy irradiated samples stored in both packaging materials were the most acceptable and the least acceptable was found in samples irradiated at 2 kGy stored in hermetically sealed polyethylene bag (Table 16).

4.4.6.2 Consumer acceptance for texture of blanched, irradiated and refrigerated stored samples

Storage, packaging materials and doses had significant effect ($p<0.05$) on the texture acceptability (Appendix 5: 6B). Storage reduced the acceptance level of the processed leaf (Table 16). At the initial week of storage, unirradiated samples stored in both the zip-lock and hermetically sealed polyethylene bags were the most acceptable with the highest mean score of 4.72. After the storage period, the most acceptable sample was samples irradiated at 0.5 kGy that were packaged in zip-lock polyethylene bag (Table 16).

4.4.6.3 Consumer acceptance of odour of blanched, irradiated and refrigerated stored samples

Storage, packaging materials and doses had significant effect ($p<0.05$) on the odour acceptability (Appendix 5: 6C). Storage reduced the acceptance level of the processed leaf (Table 16). At the initial week of storage samples stored in both zip-lock and hermetically sealed polyethylene bag of unirradiated samples and 0.5 kGy of samples stored in zip-lock polyethylene bag were the most acceptable samples. However, after the storage period, samples irradiated at 0.5 kGy stored in zip-lock polyethylene bag and unirradiated samples stored in both the zip-lock and hermetically sealed bag were the most acceptable samples; and the least acceptable sample was recorded at 2 kGy of samples stored in both packaging material (Table 16)

Table 16: Treatment means for consumer acceptance of blanched, Irradiated and refrigerated processed cocoyam leaf

PACKAGING MATERIAL	D0SES(kGy)	WEEKS	COLOUR	TEXTURE	ODOUR
Zip-lock bag	0	0	6.78±0.22^{a}	5.58±0.23^{x}	4.72±0.24^{a}
Hermetic bag	0	0	6.2±0.22^{cba}	5.36±0.23^{xy}	4.72±0.24^{a}
Zip-lock bag	0.5	0	6.78±0.22^{a}	5.56±0.23^{x}	3.58±0.24^{d}
Hermetic bag	0.5	0	6.0±0.22^{dcb}	3.3±0.23^{g}	3.0±0.24^{g}
Zip-lock bag	1	0	6.46±0.22^{ba}	5.3±0.23^{xy}	3.44±0.24^{f}
Hermetic bag	1	0	5.72±0.22^{dcb}	4.92±0.23^{yv}	3.78±0.24^{bc}
Zip-lock bag	1.5	0	6.36±0.22^{ba}	5.0±0.23^{yv}	3.4±0.24^{f}
Hermetic bag	1.5	0	5.9±0.22^{dcb}	5.0±0.23^{yv}	4.3±0.24^{b}
Zip-lock bag	2.0	0	6.28±0.22^{cba}	5.48±0.23^{x}	3.66±0.24^{d}
Hermetic bag	2.0	0	5.3±0.22^{gfh}	4.68±0.23^{v}	3.4±0.24^{f}
Zip-lock bag	0	1	5.86±0.22^{edc}	3.86±0.23^{u}	3.82±0.24^{bc}
Hermetic bag	0	1	5.22±0.22^{gfh}	3.2±0.23^{g}	3.44±0.24^{f}
Zip-lock bag	0.5	1	5.5±0.22^{edc}	3.66±0.23^{uw}	3.1±0.24^{g}
Hermetic bag	0.5	1	4.5±0.22^{fg}	3.52±0.23^{uw}	3.08±0.24^{g}
Zip-lock bag	1	1	4.88±0.22^{ef}	3.48±0.23^{uw}	2.82±0.24^{g}
Hermetic bag	1	1	4.12±0.22^{gk}	3.16±0.23^{g}	2.92±0.24^{g}
Zip-lock bag	1.5	1	5.26±0.22^{edc}	3.66±0.23^{u}	3.44±0.24^{f}
Hermetic bag	1.5	1	4.44±0.22^{fg}	3.34±0.23^{gh}	3.14±0.24^{gh}
Zip-lock bag	2.0	1	4.88±0.22^{ef}	3.44±0.23^{uw}	3.52±0.24^{d}
Hermetic bag	2.0	1	4.26±0.22^{gk}	3.54±0.23^{u}	3.0±0.24^{g}
Zip-lock bag	0	2	4.8±0.22^{ef}	3.46±0.23^{uw}	3.42±0.24^{f}
Hermetic bag	0	2	4.54±0.22^{fg}	2.82±0.23^{i}	3.16±0.24^{gh}
Zip-lock bag	0.5	2	5.42±0.22^{edc}	3.58±0.23^{uw}	2.88±0.24^{d}
Hermetic bag	0.5	2	4.4±0.22^{fg}	3.26±0.23^{gh}	2.84±0.24^{d}
Zip-lock bag	1	2	4.62±0.22^{fg}	3.24±0.23^{g}	2.56±0.24^{d}
Hermetic bag	1	2	4.08±0.22^{gk}	2.82±0.23^{i}	2.84±0.24^{d}
Zip-lock bag	1.5	2	5.06±0.22^{ef}	3.52±0.23^{uw}	3.3±0.24^{ed}
Hermetic bag	1.5	2	4.32±0.22^{fg}	3.08±0.23^{g}	2.96±0.24^{d}
Zip-lock bag	2.0	2	5.06±0.22^{ef}	3.14±0.23^{g}	3.08±0.24^{g}
Hermetic bag	2.0	2	3.62±0.22^{l}	3.02±0.23^{i}	2.66±0.24^{i}
Zip-lock bag	0	3	4.24±0.22^{gk}	3.06±0.23^{g}	3.32±0.24^{ed}
Hermetic bag	0	3	4.06±0.22^{gk}	2.74±0.23^{i}	2.92±0.24^{d}
Zip-lock bag	0.5	3	4.78±0.22^{ef}	3.46±0.23^{uw}	2.76±0.24^{i}
Hermetic bag	0.5	3	4.36±0.22^{fg}	3.02±0.23^{i}	2.76±0.24^{i}
Zip-lock bag	1	3	4.54±0.22^{fg}	3.1±0.23^{i}	2.5±0.24^{i}
Hermetic bag	1	3	3.92±0.22^{fk}	2.58±0.23^{i}	2.82±0.24^{d}
Zip-lock bag	1.5	3	4.82±0.22^{ef}	3.44±0.23^{uw}	3.12±0.24^{gh}
Hermetic bag	1.5	3	4.22±0.22^{fg}	2.82±0.23^{i}	2.82±0.24^{d}
Zip-lock bag	2.0	3	4.6±0.22^{fg}	2.94±0.23^{i}	2.4±0.24^{i}
Hermetic bag	2.0	3	3.38±0.22^{i}	2.52±0.23^{i}	2.44±0.24^{i}

* Means followed by same alphabets within the same column are not significantly different from each other (p>0.05)*

CHAPTER FIVE: GENERAL DISCUSSION

5.1. Effect of treatments on physicochemical properties of processed cocoyam leaf

5.1.1. Moisture content

Moisture content of fresh leafy vegetables plays a significant role in the determination of its freshness, apart from it governing the deterioration process due to enzymatic activities (Nesta *et.al*, 2002). In the experiment carried out, the moisture recorded was 85.98% at the initial storage week in fresh stored samples. This is similar to that reported by Kwenin *et al.*, (2011). According to Kwenin *et al.*,(2011) , moisture content of *Xanthosoma sagittifolium* is 85.76%. There was an increase in the moisture content during the storage periods in both packaging materials in all the preservation methods used. This may be due to shredding of the leaves. Since this disrupts plant tissues, breaks the protective epidermal layers resulting in the release of cellular fluid according to Varo-Quaux and Wiley, (1994). Also an increase in respiratory activity may have accounted for increase in moisture content. The packaging material may have been liable to exchange of gases. Since packaging materials that are permeable to water vapour, gases such as oxygen, carbon dioxide, nitrogen ethylene and volatile odour compounds pick up moisture, when exposed to a high humid atmosphere (Brennan and Day, 2006).

It was discovered that samples packaged in the hermetically sealed bag recorded higher moisture content than samples stored in zip-lock bag. This may be due to the prevention of exchange of gases. Anon (1995) reported that packaging materials that

have too much of moisture barrier cause an excessive high relative humidity in the package and an increase in moisture content since leafy vegetables are living organisms and still respire even when shredded and packaged.

Moisture content in refrigerated samples was higher compared to ambient temperature stored samples due to the variations in the temperature used for the storage. Since low temperature stored products have high relative humidity and low moisture content (Featherstone, 2008). Also the increase in moisture content may be due to the fact that low temperature storage controls the exchange of gases that can cause autolysis, microbial contamination and enzymatic browning (Brennan and Day, 2006).

Samples that were blanched before storage, recorded higher moisture content. For instance, blanching and refrigeration preserved leaf recorded moisture content of 89.87% at the initial week of storage in zip-lock polyethylene bag. This may be due to the absorbance of the vapour during steaming. Brennan and Day,(2006) reported on a similar issue that blanching of leafy vegetables leads to the destruction of enzymes and cytoplasmic membrane in the plant cell which makes the membrane become permeable to water and water vapour.

5.1.1.2 Dry matter

In all the preservation methods used, dry matter content reduced during storage. Moisture content increase caused the reduction in dry matter content. Since reported Adeboju (2003) reported that as moisture content increases dry matter content reduces.

5.1.1.3 Vitamin C (ascorbic acid) and pH

From the study it was observed that the pH value was within the range of 6.41 to 7.05.There was an increase after irradiation and storage, fluctuations after both refrigeration and ambient temperature storage; and also after blanching and ambient temperature storage and blanching and refrigeration (Figure 10 and 19).Whilst after blanching and irradiation there was an increase at the control and 1 kGy samples stored in zip-lock bag, and an increase at all doses during storage in hermetically sealed bag; an increase after irradiation and refrigeration and fluctuations after blanching, irradiation and refrigeration preservation. Similarly, Bolin, *et al*., (1997) reported from the storage of cabbage that vegetables usually have pH near neutrality of 6.41 and usually varies with storage time due to microbial activity and product composition.

Significant amount of vitamin C (ascorbic acid) was found in the processed leaf. This is because ascorbic acid serves as a major metabolite for photosynthesis hence it was found in significant quantities in the plant tissues (Smirnoff, 1996). The vitamin C content in all the samples reduced during storage and this is related to change in pH. At pH value of above 4.0 vitamins C content in foods decreases due to faster rate of oxidation at higher pH (FAO and WHO, 1993). According to Gille and Sigler, (1995) ascorbic acid is also a liable bio-active compound that declines even under optimal post-harvest handling storage. Favell (1998) reported greater losses of ascorbic acid in spinach stored for three days than was observed in the present study. In irradiated samples, the reduction in vitamin C content appeared greater at higher dose but this was not statistically significant. However, Stewart (2001) has reported that vitamin C reduction by irradiation doses is dose dependent.

As expected, blanching resulted in some loss of vitamin C content. In fresh cocoyam leaf samples analysed, the vitamin C content ranged from 34 -36 mg/100g whilst in blanched samples from 13- 14 mg/100g .The loss of vitamin C during blanching was due to thermal degradation, diffusion and leaching as reported by Negi and Roy, (2000) Also it was reported in the study that hermetically sealed polyethylene bag has higher retention of ascorbic acid since more oxygen is prevented from entering the packaging material. Also, refrigeration storage help reduce the loss of vitamin C as compared to ambient temperature stored samples. This emphasises the fact that, the presence of heat, light and oxygen lead to a reduction in vitamin C (Russell 1999). Previous studies have reported that lowering the storage temperature results in greater retention of ascorbic acid, but oxidation continues even under refrigeration storage conditions owing to the activity of the enzyme ascorbate oxidase (Smirnoff, 1996).

5.1.1.4 Crude protein

Crude protein was present in processed leaf after using all the preservation methods. This is in conformity with a report made by Osei, (2003) that proteins are found in all living tissues. As a result of its presence it can be anticipated that the consumption of cocoyam leaf can help in building and maintaining body tissues. Jonhson,(1996) reported that, protein helps in building and maintaining all tissues in the body and also forms an important part of enzymes of fluids and hormones of the body and also helps form antibodies to fight infection and sometimes supplies energy.

From the study, the amount of crude proteins in cocoyam leaf was between the ranges of 1.53 to 3.13 % in samples stored in zip-lock bag after irradiation and storage whiles that stored in hermetically sealed bag was at ranges of 1.28 to 2.61%. Refrigeration storage also recorded percentage range of 2.42 to 2.31, and ambient

temperature range was between 2.41 to 15.23 %; blanching and refrigeration at range of 2.14 to 12.01 %; blanching and irradiation range was between 1.98 to 2.49%; irradiation and refrigeration range between 0.33 to 2.84% and blanching, irradiation and refrigeration was at range of 0.45 to 10.42%. However, Ndon *et al*., (2003) reported that cocoyam leaves contain 2% crude protein. The variations may be due to the variations in soil fertility, environment, and age of the plant as well as the different preservation methods used. This was in conformity to the observations made in a study by Chweya and Mnzava (1997) on the preservation of spider plant leaves.

It was also observed that crude protein content increased during storage in most of the preservation method used and also irradiation and its combinations caused fluctuations of crude protein content in the processed cocoyam leaf during storage.

5.1.1.5 Colour

From the study, it was observed that storage time and preservation methods significantly affected the L*a* and b* values of the fresh stored cocoyam leaf. The L value increased significantly with storage time ($P < 0.05$), indicating a lightening in the colour of the leafy vegetable. The b value of the cocoyam leaves showed significant increases during storage, indicating an increase in yellow colour, but b values did increase significantly in irradiation and its combinations with other preservation methods. There were also significant reductions in a-value (measures the green colour) under all storage conditions. For instance, refrigeration and ambient temperature storage of fresh cocoyam leaf significantly decreased the L and a-values and increased after each storage period. At the end of storage, visual observation of the leaves showed yellow to brown patches on the surface of the samples stored at ambient temperature. The changes in values may be due to the prolonged storage.

Irradiation and its combinations and storage also decreased the a-value and b-values during storage and this was dose dependent. The results of the present study are in agreement with Lee *et al*., (2005) who reported that the L∗ values, a∗ and b∗ values of the samples of green tea leaves decreased after gamma irradiation due to the alteration or bleaching of chlorophyll of the leaves by the ionizing radiations.

Blanching and combination treatment with other preservation methods also significantly decreased the a-value of the cocoyam leaf as compared to refrigeration storage only. A similar study on the effect of pre-treatment, temperature and length of frozen storage on the retention of chlorophylls in frozen brassicas by Waldemar *et al*., (2008), showed that blanching decreases both chlorophyll a and chlorophyll b significantly after treatment and storage. Although L* a* b* values were significantly affected after blanching and its combinations, the colour of the leaves seemed to be better preserved when blanching was combined with refrigeration.

5.2. Effect of the various treatments on the phytochemical properties of cocoyam leaves

5.2.1 Total phenolic compound

There was significant amount of phenolic compound in the processed cocoyam leaf. Leafy vegetables are reported to be good sources of phenolic compound which are usually stored in the vacuole (Sakihama *et al*., 2005).

Observations made from the study, showed an increase in phenolic content during storage in some preservation methods and fluctuations in others. The increase in total phenolic compounds during storage may be due to fact that the cocoyam leaf is a biological material which is still living hence carries out biosynthesis of phenolic

compounds. This confirms the observation by Wiley, (2008) that polyphenols synthesis increase during storage, and contributes to the firmness of fruits and vegetables thus protecting the fruits and vegetables against mechanical injuries during postharvest handling. Sakihama *et al.*, (2005), have also reported that phenolic compounds serve as antioxidant or pro-oxidants that act as a protectant against oxidative stress and healing reactions after cells have been damaged during postharvest storage and handling, and thus increase in amount thereby extending the shelf-life. Also irradiation may have contributed to the increase; as reported by Fan, (2005), that the irradiation of leafy vegetables results in the increase or activation of phenylalanine ammonia-lyase (PAL) enzymes activity which has positive correlation with production of phenolic compounds in fruits and vegetables.

5.2.2 Total flavonoid compound

There was significant amount of total flavonoid compounds during storage of in all the preservation methods used. Lampila *et al.*, (2009) have reported that flavonoid is naturally present in most edible vegetable plants. Observations made from the study showed consistent increase in the total flavonoid content in refrigeration stored samples and fluctuations in irradiation and its combinations. The variations may be due to different preservation methods used, packaging material used and the analytical method used in assessment.

The presence of the compound is an indication that, cocoyam leaves have the potential to maintain the body and fight against diseases since it has been proven by epidemiological and clinical studies that naturally occurring flavonoids help in lowering the risk of coronary heart diseases, neurodegenerative diseases, diabetes, osteoporosis and lung cancer (Lampila *et al.*,2009).

5.3 Effect on microbial Quality

Microbial growth increased in all the processed leaves under the different storage conditions. The increase in microbial growth may have been facilitated by the shredding of the leaves before storage which increased the surface area exposed to more microbes and also, from contaminations from the soil, water used in washing, and equipment used in processing. Allende *et a*l., (2004) reported that shredding, rinsing, and centrifugation of red lettuce Lollo Rosso increased coliform, lactic acid bacteria, and psychotrophic bacterial counts.

Jacxsens, *et al*., (2003) reported that microbial load of log 10^{4-7}/g in vegetables is acceptable by the Foods and drugs quality assurance department. After refrigeration storage, samples stored in hermetically sealed bag recorded total viable counts of 4.72 log CFU/g, total coliform counts of 4.98 log CFU/g and yeast and mould counts of 4.82 log CFU/g. All microbial counts recorded were within the acceptance range of log 10^{4-7}/g. Whiles samples stored in zip-lock polyethylene bag recorded viable count of 7.37 log CFU/g, coliform counts of 6.97 log CFU/g and yeast and mould counts of 3.46 log CFU/g after the storage period. With the exception of the yeast and mould counts all other microbial counts were above the acceptable level. Also, microbial counts recorded from ambient temperature stored cocoyam leaves were above the acceptance level by the quality assurance department of the Food and Drugs Board of the USA. Samples stored in hermetically sealed bag recorded viable counts of 8.8 log CFU/g, coliform counts of 6.67 log CFU/g and yeast and moulds counts of 7.24 log CFU/g; whiles samples stored in zip-lock bag during storage recorded viable counts of 6.93 log CFU/g, coliform counts of 6.93 log CFU/g and yeast and mould counts of 4.82 log CFU/g.

After blanching and storage, microbial counts were higher in samples stored at ambient temperature than in refrigerated samples in both the zip-lock bag and hermetically sealed bag. However, there were no growth of yeast and moulds, less growth of total viable counts and total coliforms in all blanched samples at the initial week. Thus blanching was effective in controlling microbial growth during the first week of storage. Similarly, Selman (1987) reported that blanching is effective in removing pesticide residues or radionuclides from the surface of vegetables as well as reducing micro-organisms and toxic constituents that are naturally present (nitrites, nitrates and oxalate). Moreover, after the storage period, microbial growth was very high because moisture content was higher at the end of the storage period.

Radiation was very effective in reducing coliform counts at the initial week of storage and counts were within the acceptable level in samples stored in both packages. However after a week of storage, the leaves showed signs of decay from samples stored in hermetically sealed polyethylene bag at the control, 0.5 kGy and 1 kGy treated samples but counts were within the acceptable level and samples stored in zip-lock bag recorded acceptable counts in unirradiated samples and 0.5 kGy irradiated samples. Total viable counts were also within the acceptable level at all doses at the initial week of storage in both packages. Though samples had deteriorated, samples stored in hermetically sealed bag 0.5 kGy and 1.5 kGy irradiated samples recorded counts that were within the acceptable level whiles in zip-lock bag stored samples all doses counts were within the acceptable level. Yeast and moulds counts were at all doses within the acceptable level at the initial week and also after a week of storage.

After irradiation and refrigeration storage, coliform counts were within the acceptable level at the control and also samples treated with 0.5 kGy, 1 kGy, 1.5 kGy

and 2 kGy during storage in hermetically sealed bag after two weeks of storage. After the third week of storage all the samples still recorded acceptable coliform counts except the unirradiated samples. For samples stored in zip-lock bag the unirradiated and all irradiated samples at all doses recorded acceptable coliform counts after a week of storage. However, after the second week the unirradiated samples and samples irradiated with 0.5 kGy and 2 kGy recorded acceptable coliform counts. In subsequent week counts were all above the acceptable level. The population of aerobic mesophiles in all the irradiated samples were within the acceptable level in samples stored in both packaging materials after a week of storage. However, in second week of storage samples stored in hermetically sealed bag acceptable counts were recorded in samples irradiated at 0.5 kGy, 1 kGy,1.5 kGy and 2 kGy; and in zip-lock bag at 0.5 kGy and unirradiated samples. Yeast and mould counts were above the acceptable level at 2 kGy in samples stored in zip-lock bag after the storage period and at control of samples stored in hermetically sealed bag after the storage period. This is because at these doses it was observed that, the leaves became very marshy and soggy. Brennan and Day, (2006) noted that fresh vegetables have living cells, hence irradiation may affect the life cycle on the product and causes textural problems which result from induced-radiation depolymerisation of cellulose, hemicellulose, starch and pectin, leading to softening of the tissue. In blanching and irradiation, blanching, irradiation and refrigeration treated stored samples; microbial counts were within the acceptable level only after a week of storage.

Also it was observed from the study that microbial growth was predominantly more in samples stored in hermetically sealed bag since higher moisture content were recorded during storage. This is an indication that moisture supports the growth of

microbes. Ejoh *et al*., (2007) reported that higher moisture content is an indication that a product will not store for long period without spoilage by micro-organism during storage. Similarly, George (2003) stated that moisture content makes an important contribution to the texture of the leaves and helps in maintaining the protoplasmic content of the cells; it also makes them perishable and susceptible to spoilage by microorganisms.

Another observation made was that crude protein in the preserved cocoyam leaf increased during storage period. This may have caused the increase in microbial growth. Other studies by Conway *et al.*, (1984, 1989) on the post-harvest pathology of fruits and vegetables showed that high nitrogen content in plant tissues generally increased microbial growth and deterioration.

From the study the pH of the preserved cocoyam leaf ranged was at 6.54 in most of the stored samples at the initial week but increased after every storage week to a figure nearer to the neutral pH and this may have accounted for the increase in yeasts and mould growth and the softening of the leaves. Previous study conducted by Fleming, *et al.,* (1989) reported that softening of vegetables result from yeasts consuming lactic acid, resulting in an increase of pH which produces degradable enzymes. Similarly, Tournas, (2005) reported that the optimum pH for growth of most microorganisms is near neutrality (pH 7.0). However, yeasts and moulds are acid tolerant and can even grow in acidic foods. Yeasts can grow in a pH range of 3-10 whiles moulds can grow from pH 2 – 11. In terms of water requirements for growth, yeasts are intermediate between bacteria and moulds. Nguyen and Carlin, (1994) also identified yeasts and mould populations in various types of fresh-cut fruits and vegetables.

Total coliform count increased under all the treatments of preservation. However, no faecal contaminating microbes (*Escherichia coli* and *Samonella*) were present. Thus, the presence of coliforms or faecal coliforms on raw fruits and vegetables did not necessarily provide an index of faecal contamination but rather other microorganisms capable of causing human disease were present. The absence of these common faecal coliforms (*E.coli* and *Salmonella*) may be due to the fact that cocoyam leaf cultivation is mostly rain-fed and also was grown under a confined environment (green-house). Contamination of raw vegetables with enterhaemorrhagic *E. coli* O157:H7 and *Salmonella*as reported by Abdul-Raouf *et al*., (1993) usually occurs when herbivorous accidentally enter fields, or when improperly composted faecal manure is applied as a fertilizer to enrich the soil and this contaminates the airborne dust particles that cause possible contamination in the vines and on the surface of the leafy vegetable. However, because cocoyam leaves contain an irritant it deters herbivorous from grazing on them and also because they can grow under harsh conditions without any enrichment of the soil no faecal coliforms were found. (Ramanatha *et al.*, (2010).

However, *Pseudomonas fluorescens and Pseudomonas viridiflava* were present and might have caused the decay of the leaves. Similarly, Liao *et al*., (1997) reported that *Pseudomonas* spp microbes are capable of decaying plant tissue at temperatures at or below 4˚C.

5.4 Sensory evaluation of preserved leaves

Consumer acceptance of colour, texture and odour decreased under all the storage methods used after each storage week. This may be due to changes in colour, odour and texture of the cocoyam leaf. This discolouration observed in the cocoyam leaf influenced consumer's acceptance. It was observed that, samples stored at ambient temperature scored a lowest mean in colour. Similarly in a study conducted by McEvily *et al.* (1992) browning or surface darkening was one of the main physiological effects of fresh-cut processing which resulted in a reduction in the quality of fresh-cut produce. This was attributed to the oxidation of phenolic substrates present in the produce by polyphenol oxidase (PPO) enzymes (McEvily *et al.*, 1992). Also Kader (2002) further explained that the extent of browning is dependent on the concentrations of active polyphenol oxidase (PPO) and phenolic compounds in the product tissue, pH, temperature and oxygen available to the tissues as well as on the presence of antioxidant compounds.

However, in all the treatments, refrigeration storage and its combinations were the most acceptable preservation methods. This may be because samples showed less signs of deteriorations, were firmer and more appealing to the consumers. Previous studies by Brennan and Day, (2006) indicated that, low-temperature storage controls the exchange of gases that would cause autolysis, microbial contamination and enzymatic reactions

Decrease in the firmness of fresh-cut cocoyam leaves resulted in its rejection by most of the consumers. The decrease in acceptance level of texture by most of the panellists might have been due to the marshy nature of the samples during storage. Similarly, Brennen and Day,(2006) reported that shredding breaks-down plant cell and also ionizing radiations further breaks-down plant cells. This may have

accounted for a less acceptance of texture for irradiation treatments and its combination. Also, McEvily *et al.*, (1992) reported that softening of fresh-cut cocoyam leaf tissues during storage results from structural changes in the primary cell walls which are caused by enzymatic activity that lead to dissolution of the rigid pectic cells and a decrease in their resistance to pressure.

A decrease in the score for odour may have been due to the pungent odour that was developed in the leaf during storage. Similarly, Fan *et al*., (2003) reported an off-flavour development in cut- bell peppers. Flavour has been identified to be a key component to acidity, astringency, sweetness and bitterness in fresh fruits. However, many flavour and aromatic components are lost in fresh-cut fruits and vegetables through enzymatic reactions and increase in respiration rates that are developed from fresh-cut produce (McEvily *et al.,* 1992). This might have informed consumers in the selection of the most liked sample.

Microbial spoilage might have contributed to a reduction in acceptance of fresh-cut leaves. Previous studies conducted by Jennylynd and Tipvanna, (2010) reported that, fresh-cut products can acquire off-flavours with the growth of lactic acid bacteria resulting in fermentation and the production of acids, alcohols and carbon dioxide gas (CO_2). Since two species of *Pseudomonas spp* were identified from the study it may have contributed to the pungent odour that was developed in the stored leaves. Also, Masson, (2002) observed that irradiation doses greater than or equal to 3 kGy cause changes in flavour and aroma of fresh vegetables and are highly associated with microbial spoilage. Thus, low irradiation doses generally inhibit or delay development of off-flavours related to growth of spoilage organisms. This is in support of the high acceptance level of unirradiated samples, 0.5 kGy and 1 kGy.

CHAPTER 6: CONCLUSION AND RECOMMENDATION

6.1 Conclusion

Minimally processed cocoyam leaves were best preserved by either refrigeration alone at 4°C or radiation at 0.5 kGy and 1kGy and refrigeration at 4°C or blanching, radiation (0.5 kGy and 1 kGy) and refrigeration at 4°C. In each case, samples stored by this method lasted for three storage weeks with minimal effect on physicochemical properties; phytochemical properties, microbial load and also the most acceptable sensory qualities. In particular, cocoyam leaves packaged in zip-lock polyethylene bag and stored under refrigeration was the most acceptable treatment to sensory panel since it recorded the highest mean value in colour, texture and odour. Higher doses of radiation ≥ 2 kGy were not effective since they rendered the leaves marshy with increase in microbial activity. However, samples irradiated at 1.5 kGy and refrigerated at 4°C stored in hermetically sealed polyethylene bags had lower microbial load than samples stored in zip-lock polyethylene bag.

Irradiation, blanching and irradiation, blanching, irradiation and refrigeration treatments can preserve cut cocoyam leaves for only a week with less microbial load and minimal effect on the physicochemical properties.

6.2 Recommendations for further work

- Handlers should use the appropriate equipment needed to minimize damage during harvest, for example sharp harvesting knives, bags and padded boxes.
- Modified atmosphere packaging (MAP), a packaging technique that utilizes package atmosphere other than air in a sealed package should be further investigated for the extension of shelf life of minimally processed leafy vegetables.
- It is also important to minimize the amount of residual surface moisture on leafy vegetables after processing because fresh fruits and vegetables have a high water activity hence reducing water activity may be an option for controlling microbial spoilage in fresh-cut products.
- Good manufacturing practices (GMPs) should be implemented since this also influences the microbial spoilage and subsequent shelf life of fresh cut produce.
- It is also important to train all employees in GMPs before they can work in processing operations. Beginning with proper training and employing good hygienic practices will have a positive influence on the microbiological shelf life of fresh-cut produce at the commercial level.
- To minimize qualitative and nutritive losses, it is recommended that cut-leafy vegetables should be preserved by packaging in either the hermetically sealed polyethylene bag or zip-lock polyethylene bag and stored in a refrigerator at a temperature of $4^{o}C\pm2$.
- Pre-treatment with sanitizing solution before packaging should be studied.

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APPENDICES

APPENDIX 1

ANOVA for physicochemical analysis

A.1. Analysis of Variance for MOISTURE CONTENT after irradiation treatment and storage in zip-lock bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
A:C.WEEKS	16.923	1	16.923	35.09	0.0000
B:C.DOSES	10.0502	4	2.51256	5.21	0.0048
INTERACTIONS					
AB	9.14443	4	2.28611	4.74	0.0075
RESIDUAL	9.64645	20	0.482323		
TOTAL (CORRECTED)	45.7642	29			

All F-ratios are based on the residual mean square error.

A.2.Analysis of Variance for MOISTURE CONTENT after irradiation treatment and storage in hermetically sealed bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
A:WEEKS	16.0572	1	16.0572	31.54	0.0000
B:DOSES(IRR)	24.3389	4	6.08472	11.95	0.0000
INTERACTIONS					
AB	2.08466	4	0.521166	1.02	0.4191
RESIDUAL	10.1816	20	0.509081		
TOTAL (CORRECTED)	52.6623	29			

All F-ratios are based on the residual mean square error.

A.3. Analysis of Variance for DRY MATTER after irradiation treatment and storage in zip-lock bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
A:C.WEEKS	16.923	1	16.923	35.09	0.0000
B:C.DOSES	10.0502	4	2.51256	5.21	0.0048
INTERACTIONS					
AB	9.14443	4	2.28611	4.74	0.0075
RESIDUAL	9.64645	20	0.482323		
T00OTAL (CORRECTED)	45.7642	29			

All F-ratios are based on the residual mean square error.

A. 4. Analysis of Variance for DRY MATTER after irradiation treatment and storage in hermetically sealed bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
A:WEEKS	16.1759	1	16.1759	11.57	0.0028
B:DOSES(IRR)	6.76786	4	1.69196	1.21	0.3374
INTERACTIONS					
AB	0.713545	4	0.178386	0.13	0.9707
RESIDUAL	27.9579	20	1.39789		
TOTAL (CORRECTED)	51.6152	29			

All F-ratios are based on the residual mean square error.

A.5.Analysis of Variance for pH after irradiation treatment and storage in zip-lock bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
A:DOSES(IRR)P.B	1.46688	4	0.36672	4584.00	0.0000
B:WEEKS	0.0625633	1	0.0625633	782.04	0.0000
INTERACTIONS					
AB	0.0600533	4	0.0150133	187.67	0.0000
RESIDUAL	0.0016	20	0.00008		
TOTAL (CORRECTED)	1.5911	29			

All F-ratios are based on the residual mean square error.

A.6.Analysis of Variance for pH after irradiation treatment and storage in hermetically sealed bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
A:WEEKS	0.003	1	0.003	2.61	0.1219
B:DOSES(IRR)	2.40118	4	0.600295	522.00	0.0000
INTERACTIONS					
AB	0.0275	4	0.006875	5.98	0.0025
RESIDUAL	0.023	20	0.00115		
TOTAL (CORRECTED)	2.45468	29			

All F-ratios are based on the residual mean square error.

A.7 Analysis of Variance for VIT C after irradiation treatment and storage in zip-lock bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
A:C.WEEKS	95.4618	1	95.4618	161.33	0.0000
B:C.DOSES	3498.07	4	874.516	1477.92	0.0000
INTERACTIONS					
AB	72.0435	4	18.0109	30.44	0.0000
RESIDUAL	11.8344	20	0.591719		
TOTAL (CORRECTED)	3677.41	29			

All F-ratios are based on the residual mean square error.

A.8.Analysis of Variance for VIT C after irradiation treatment and storage in hermetically sealed bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
A:DOSES(IRR)P.B	3498.07	4	874.516	1477.92	0.0000
B:WEEKS	95.4618	1	95.4618	161.33	0.0000
INTERACTIONS					
AB	72.0435	4	18.0109	30.44	0.0000
RESIDUAL	11.8344	20	0.591719		
TOTAL (CORRECTED)	3677.41	29			

All F-ratios are based on the residual mean square error.

A.9.Analysis of Variance for CRUDE PROTEIN (%) after irradiation treatment and storage in zip-lock bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
A:WEEKS	4.2473	1	4.2473	636.09	0.0000
B:DOSES(IRR)P.B	2.42814	4	0.607034	90.91	0.0000
INTERACTIONS					
AB	4.99767	4	1.24942	187.12	0.0000
RESIDUAL	0.133544	20	0.0066772		
TOTAL (CORRECTED)	11.8066	29			

All F-ratios are based on the residual mean square error.

A.10. Analysis of Variance for CRUDE PROTEIN after irradiation treatment and storage in hermetically sealed bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
A:WEEKS	0	1	0	0.00	1.0000
B:DOSES(IRR)	7.65384	4	1.91346	146.20	0.0000
INTERACTIONS					
AB	0	4	0	0.00	1.0000
RESIDUAL	0.261767	20	0.0130883		
TOTAL (CORRECTED)	7.91561	29			

All F-ratios are based on the residual mean square error.

A.11 Analysis of Variance for L-value after irradiation treatment and storage in zip-lock bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
A:C.WEEKS	128.754	1	128.754	70.84	0.0000
B:C.DOSES	3201.23	4	800.307	440.33	0.0000
INTERACTIONS					
AB	2.65603	4	0.664008	0.37	0.8304
RESIDUAL	36.3503	20	1.81752		
TOTAL (CORRECTED)	3368.99	29			

All F-ratios are based on the residual mean square error.

A.12. Analysis of Variance for L-VALUE after irradiation treatment and storage in hermetically sealed bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
A:WEEKS	184.81	1	184.81	389.62	0.0000
B:DOSES(IRR)	2432.33	4	608.082	1281.96	0.0000
INTERACTIONS					
AB	39.5781	4	9.89452	20.86	0.0000
RESIDUAL	9.48673	20	0.474337		
TOTAL (CORRECTED)	2666.2	29			

All F-ratios are based on the residual mean square error.

A.13. Analysis of Variance for a-value after irradiation treatment and storage in zip-lock bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
A:C.WEEKS	18.8021	1	18.8021	373.90	0.0000
B:C.DOSES	935.701	4	233.925	4651.84	0.0000
INTERACTIONS					
AB	45.8666	4	11.4666	228.03	0.0000
RESIDUAL	1.00573	20	0.0502867		
TOTAL (CORRECTED)	1001.38	29			

All F-ratios are based on the residual mean square error.

A.14. Analysis of Variance for a-VALUE after irradiation treatment and storage in hermetically sealed bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
A:WEEKS	5.33408	1	5.33408	463.83	0.0000
B:DOSES(IRR)	1114.68	4	278.669	24232.08	0.0000
INTERACTIONS					
AB	11.1753	4	2.79382	242.94	0.0000
RESIDUAL	0.23	20	0.0115		
TOTAL (CORRECTED)	1131.42	29			

All F-ratios are based on the residual mean square error.

A.15. Analysis of Variance for b-value after irradiation treatment and storage in zip-lock bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
A:C.WEEKS	37.9013	1	37.9013	20.42	0.0002
B:C.DOSES	852.806	4	213.201	114.87	0.0000
INTERACTIONS					
AB	18.0573	4	4.51431	2.43	0.0811
RESIDUAL	37.1216	20	1.85608		
TOTAL (CORRECTED)	945.886	29			

All F-ratios are based on the residual mean square error.

A.16.Analysis of Variance for b-VALUE after irradiation treatment and storage in hermetically sealed bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
A:WEEKS	1.60083	1	1.60083	30.13	0.0000
B:DOSES(IRR)	252.06	4	63.0149	1185.98	0.0000
INTERACTIONS					
AB	56.2109	4	14.0527	264.48	0.0000
RESIDUAL	1.06267	20	0.0531333		
TOTAL (CORRECTED)	310.934	29			

All F-ratios are based on the residual mean square error.

B.1 ANOVA Table for MOISTURE CONTENT after refrigeration and storage in zip-lock bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	103.789	3	34.5964	14.36	0.0014
Within groups	19.2712	8	2.4089		
Total (Corr.)	123.061	11			

All F-ratios are based on the residual mean square error.

B.2. ANOVA Table for MOISTURE CONTENT (AMBIENT TEMPERATURE) during storage in zip-lock bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	20.5683	1	20.5683	87.14	0.0007
Within groups	0.944179	4	0.236045		
Total (Corr.)	21.5125	5			

All F-ratios are based on the residual mean square error.

B.3. ANOVA Table for MOISTURE CONTENT after refrigeration and storage in hermetically sealed bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	103.727	3	34.5757	9.91	0.0045
Within groups	27.9144	8	3.48931		
Total (Corr.)	131.641	11			

All F-ratios are based on the residual mean square error.

B.4.ANOVA Table for MOISTURE CONTENT (AMBIENT TEMPERATURE) during storage in hermetically sealed bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	5.81741	1	5.81741	3.28	0.1444
Within groups	7.09788	4	1.77447		
Total (Corr.)	12.9153	5			

All F-ratios are based on the residual mean square error.

B.5. ANOVA Table for DRY MATTER after refrigeration and storage in zip-lock bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	103.789	3	34.5964	14.36	0.0014
Within groups	19.2712	8	2.4089		
Total (Corr.)	123.061	11			

All F-ratios are based on the residual mean square error.

B.6. ANOVA Table for DRY MATTER during storage at ambient temperature in zip-lock bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	20.5683	1	20.5683	87.14	0.0007
Within groups	0.944179	4	0.236045		
Total (Corr.)	21.5125	5			

All F-ratios are based on the residual mean square error.

B.7.ANOVA Table for DRY MATTER after refrigeration and storage in hermetically sealed bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	103.727	3	34.5757	9.91	0.0045
Within groups	27.9144	8	3.48931		
Total (Corr.)	131.641	11			

All F-ratios are based on the residual mean square error.

B.8 ANOVA Table for DRY MATTER during storage at ambient temperature in hermetically sealed bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	2.87042	1	2.87042	17.39	0.0140
Within groups	0.660123	4	0.165031		
Total (Corr.)	3.53054	5			

All F-ratios are based on the residual mean square error.

B.9. ANOVA Table for pH after refrigeration and storage in zip-lock bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	1.09403	3	0.364675	106.22	0.0000
Within groups	0.0274667	8	0.00343333		
Total (Corr.)	1.12149	11			

All F-ratios are based on the residual mean square error.

B.10.ANOVA Table for pH after ambient temperature storage in zip-lock bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	0.0266667	1	0.0266667	400.00	0.0000
Within groups	0.000266667	4	0.0000666667		
Total (Corr.)	0.0269333	5			

All F-ratios are based on the residual mean square error.

B.11. ANOVA Table for pH after refrigeration and storage in hermetically sealed bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	0.177867	3	0.0592889	20.33	0.0004
Within groups	0.0233333	8	0.00291667		
Total (Corr.)	0.2012	11			

All F-ratios are based on the residual mean square error.

B.12. ANOVA Table for pH during storageat ambient temperature in hermetically sealed bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	0.0170667	1	0.0170667	64.00	0.0013
Within groups	0.00106667	4	0.000266667		
Total (Corr.)	0.0181333	5			

All F-ratios are based on the residual mean square error.

B.13. ANOVA Table for VITAMIN C after refrigeration and storage in zip-lock bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	1677.66	3	559.22	80.01	0.0000
Within groups	55.9118	8	6.98897		
Total (Corr.)	1733.57	11			

All F-ratios are based on the residual mean square error.

B.14. ANOVA Table for VITAMIN C(mg/100g) during storage at ambient temperature in zip-lock bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	79.5194	1	79.5194	64.02	0.0013
Within groups	4.96815	4	1.24204		
Total (Corr.)	84.4876	5			

All F-ratios are based on the residual mean square error.

B.15. ANOVA Table for VITAMIN C after refrigeration and storage in hermetically sealed bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	1724.09	3	574.696	336.40	0.0000
Within groups	13.6668	8	1.70835		
Total (Corr.)	1737.75	11			

All F-ratios are based on the residual mean square error

B.16 ANOVA Table for VITAMIN C (mg/100g) during storage at ambient temperature in hermetically sealed bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	44.7283	1	44.7283	71.99	0.0011
Within groups	2.48521	4	0.621303		
Total (Corr.)	47.2135	5			

All F-ratios are based on the residual mean square error.

B.17. ANOVA Table for CRUDE PROTEIN after refrigeration and storage in zip-lock bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	0.0412937	3	0.0137646	0.24	0.8629
Within groups	0.450048	8	0.056256		
Total (Corr.)	0.491342	11			

All F-ratios are based on the residual mean square error.

B.18. ANOVA Table for CRUDE PROTEIN after ambient temperature storage in zip-lock bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	1.4065	1	1.4065	687.89	0.0000
Within groups	0.00817867	4	0.00204467		
Total (Corr.)	1.41468	5			

All F-ratios are based on the residual mean square error.

B.19. ANOVA Table for CRUDE PROTEIN after refrigeration and storage in hermetically sealed bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	0.0888777	3	0.0296259	4.52	0.0390
Within groups	0.052378	8	0.00654725		
Total (Corr.)	0.141256	11			

All F-ratios are based on the residual mean square error.

B.20.ANOVA Table for CRUDE PROTEIN during storage at ambient temperature in hermetically sealed bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	0.000054	1	0.000054	0.00	0.9637
Within groups	0.0923653	4	0.0230913		
Total (Corr.)	0.0924193	5			

All F-ratios are based on the residual mean square error.

B.21.ANOVA Table for L-value after refrigeration and storage in zip-lock bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	359.927	3	119.976	31.89	0.0001
Within groups	30.0986	8	3.76233		
Total (Corr.)	390.026	11			

All F-ratios are based on the residual mean square error.

B.22.ANOVA Table for L-VALUE after ambient temperature storage in zip-lock bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	22.2337	1	22.2337	2.49	0.1895
Within groups	35.6723	4	8.91808		
Total (Corr.)	57.9061	5			

All F-ratios are based on the residual mean square error.

B.23. ANOVA Table for L-VALUE after refrigeration treatment and storage in hermetically sealed bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	434.256	3	144.752	202.05	0.0000
Within groups	5.73127	8	0.716408		
Total (Corr.)	439.987	11			

All F-ratios are based on the residual mean square error.

B.24.ANOVA Table for L-VALUE during storage at ambient temperaturein hermetically sealed bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	127.789	1	127.789	65.48	0.0013
Within groups	7.80573	4	1.95143		
Total (Corr.)	135.595	5			

All F-ratios are based on the residual mean square error.

B.25.ANOVA Table for a-value after refrigeration and storage in zip-lock bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	223.216	3	74.4053	104.90	0.0000
Within groups	5.67413	8	0.709267		
Total (Corr.)	228.89	11			

All F-ratios are based on the residual mean square error.

B.26.ANOVA Table for a-VALUE during storage at storage in zip-lock bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	58.7814	1	58.7814	1475.68	0.0000
Within groups	0.159333	4	0.0398333		
Total (Corr.)	58.9407	5			

All F-ratios are based on the residual mean square error.

B.27. ANOVA Table for a-VALUE after refrigeration and storage in hermetically sealed bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	206.349	3	68.7829	1715.28	0.0000
Within groups	0.3208	8	0.0401		
Total (Corr.)	206.669	11			

All F-ratios are based on the residual mean square error.

B.28. ANOVA Table for a-VALUE VALUE during storage at storage in hermetically sealed bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	14.9784	1	14.9784	2442.13	0.0000
Within groups	0.0245333	4	0.00613333		
Total (Corr.)	15.0029	5			

All F-ratios are based on the residual mean square error.

B.29. ANOVA Table for b-value after refrigeration treatment and storage in zip-lock bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	64.9262	3	21.6421	8.78	0.0065
Within groups	19.7123	8	2.46403		
Total (Corr.)	84.6385	11			

All F-ratios are based on the residual mean square error

B.30.ANOVA Table for b-VALUE during storage at ambient temperature in zip-lock bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	33.5121	1	33.5121	3.66	0.1285
Within groups	36.6749	4	9.16873		
Total (Corr.)	70.187	5			

All F-ratios are based on the residual mean square error.

B.31.ANOVA Table for b-VALUE after refrigeration and storage in hermetically sealed bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	41.8701	3	13.9567	36.93	0.0000
Within groups	3.0234	8	0.377925		
Total (Corr.)	44.8935	11			

All F-ratios are based on the residual mean square error

B.32.ANOVA Table for b-VALUE during storage at ambient temperature in hermetically sealed bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	37.0017	1	37.0017	268.00	0.0001
Within groups	0.552267	4	0.138067		
Total (Corr.)	37.5539	5			

All F-ratios are based on the residual mean square error.

APPENDIX 2

PHYTOCHEMICAL ANALYSIS

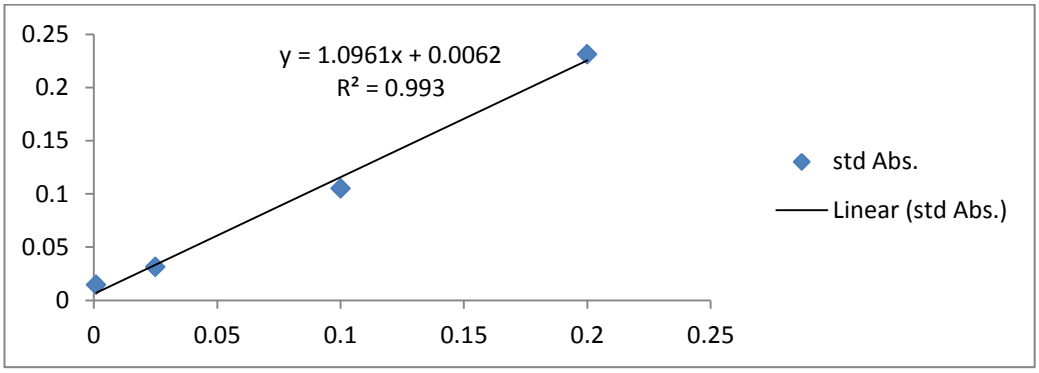

Figure 1: Standard curve for phenolic

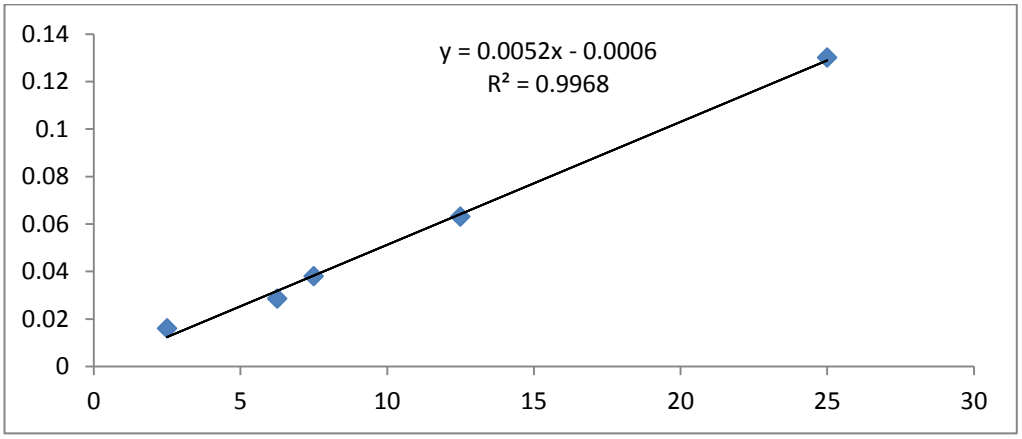

Figure 2: Standard curve for flavonoids

A.1 Analysis of Variance for TOTAL FLAVONOIDS after irradiation and storage in zip-lock polyethylene bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
A:DOSES(IRR)	181.68	4	45.4199	323.63	0.0000
B:WEEKS	4.89002	1	4.89002	34.84	0.0000
INTERACTIONS					
AB	0.801678	4	0.200419	1.43	0.2612
RESIDUAL	2.80691	20	0.140346		
TOTAL (CORRECTED)	190.178	29			

All F-ratios are based on the residual mean square error.

A.2. Analysis of Variance for TOTAL PHENOLICS after irradiation and storage in zip-lock polyethylene bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
A:WEEKS	3.193122	3	0.193122	5.99	0.0237
B:DOSES(IRR)	38.5174	4	9.62934	298.82	0.0000
INTERACTIONS					
AB	41.102492	12	0.025623	0.80	0.5422
RESIDUAL	0.644501	40	0.032225		
TOTAL (CORRECTED)	57.4575	59			

All F-ratios are based on the residual mean square error.

A3.Analysis of Variance for TOTAL FLAVONOIDS after irradiation and storage in hermetically sealed bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
A:WEEKS	5.09974	3	5.09974	9.61	0.0056
B:DOSES(IRR)	40.1691	4	10.0423	18.93	0.0000
INTERACTIONS					
AB	45.642596	12	0.160649	0.30	0.8726
RESIDUAL	10.6099	40	0.530496		
TOTAL (CORRECTED)	56.5213	59			

All F-ratios are based on the residual mean square error.

A4.Analysis of Variance for TOTAL PHENOLIC after irradiation and storage in hermetically sealed bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
A:WEEKS	3.329701	3	0.329701	10.20	0.0046
B:DOSES(IRR)	33.2157	4	8.30394	256.87	0.0000
INTERACTIONS					
AB	39.248997	12	0.0622492	1.93	0.1454
RESIDUAL	0.646555	40	0.0323278		
TOTAL (CORRECTED)	34.441	59			

All F-ratios are based on the residual mean square error.

B1.Analysis of Variance for Total phenolic after irradiation and refrigeration and storage in hermetically sealed bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
A:WEEKS	4.26686	4	1.42229	36.41	0.0000
B:DOSES(IRR+REF)	51.1265	3	12.7816	327.19	0.0000
INTERACTIONS					
AB	0.749581	12	0.0624651	1.60	0.1311
RESIDUAL	1.56257	40	0.0390643		
TOTAL (CORRECTED)	57.7055	59			

B2.Analysis of Variance for Total Flavonoids after irradiation and refrigeration and storage in hermetically sealed bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
A:WEEKS	590.319	3	196.773	180.35	0.0000
B:DOSES(IRR+REF)	882.456	4	220.614	202.20	0.0000
INTERACTIONS					
AB	319.778	12	26.6482	24.42	0.0000
RESIDUAL	43.6423	40	1.09106		
TOTAL (CORRECTED)	1836.2	59			

All F-ratios are based on the residual mean square error.

B3. Analysis of Variance for TOTAL FLAVONOIDS after irradiation and refrigeration and storage in zip-lock polyethylene bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
A:DOSES(IRR+REF)	83.1816	4	20.7954	14.91	0.0000
B:WEEKS	237.496	3	79.1654	56.76	0.0000
INTERACTIONS					
AB	94.0596	12	7.8383	5.62	0.0000
RESIDUAL	55.7915	40	1.39479		
TOTAL (CORRECTED)	470.529	59			

All F-ratios are based on the residual mean square error.

B4. Analysis of Variance for TOTAL PHENOLIC after irradiation and refrigeration and storage in zip-lock polyethylene bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
A:WEEKS	0.935	3	0.311667	5.37	0.0034
B:DOSES(IRR+REF)	49.4219	4	12.3555	212.77	0.0000
INTERACTIONS					
AB	1.78503	12	0.148753	2.56	0.0128
RESIDUAL	2.32273	40	0.0580682		
TOTAL (CORRECTED)	54.4646	59			

All F-ratios are based on the residual mean square error**.**

C1.Analysis of Variance for TOTAL FLAVONOIDS after blanching and irradiation and storage in zip-lock polyethylene bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
A:WEEKS	8.87699	3	8.87699	138.83	0.0000
B:DOSES(BLA+IRR)	24.388	4	60.8469	951.61	0.0000
INTERACTIONS					
AB	5.58412	12	1.39603	21.83	0.0000
RESIDUAL	1.27883	40	0.0639413		
TOTAL (CORRECTED)	59.128	59			

All F-ratios are based on the residual mean square error.

C2.Analysis of Variance for TOTAL PHENOLIC after blanching and irradiation and storage in zip-lock polyethylene bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
A:WEEKS	0.167851	3	0.167851	6.47	0.0193
B:DOSES(BLA+IRR)	30.9016	4	7.72539	297.98	0.0000
INTERACTIONS					
AB	0.240632	12	0.060158	2.32	0.0921
RESIDUAL	0.518511	40	0.0259256		
TOTAL (CORRECTED)	31.8285	59			

All F-ratios are based on the residual mean square error.

C3.Analysis of Variance for TOTAL FLAVONIDS after blanching and irradiation and storage in hermetically sealed polyethylene bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
A:DOSES(BLA+IRR)	437.355	3	109.339	2017.78	0.0000
B:WEEKS	8.33187	4	8.33187	153.76	0.0000
INTERACTIONS					
AB	4.29458	12	1.07365	19.81	0.0000
RESIDUAL	1.08375	40	0.0541875		
TOTAL (CORRECTED)	451.065	59			

All F-ratios are based on the residual mean square error.

C4.Analysis of Variance for TOTAL PHENOLIC after blanching and irradiation and storage in hermetically sealed polyethylene bag

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
A:DOSES(BLA+IRR)	34.0823	3	8.52057	195.85	0.0000
B:WEEKS	0.230914	4	0.230914	5.31	0.0321
INTERACTIONS					
AB	0.274945	12	0.0687362	1.58	0.2183
RESIDUAL	0.870109	40	0.0435054		
TOTAL (CORRECTED)	35.4583	59			

All F-ratios are based on the residual mean square error

APPENDIX 3
ANOVA for microbial analysis

A1.Irradiation (Storage in hermetically sealed bag)
Analysis of Variance for TOTAL COLIFORMS- Type III Sums of Squares

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
A:WEEKS	488.187	3	162.729	35372.86	0.0000
B:DOSES(HSB)	1.38904	4	0.347259	75.48	0.0000
INTERACTIONS					
AB	12.8434	12	1.07028	232.65	0.0000
RESIDUAL	0.184015	40	0.00460039		
TOTAL (CORRECTED)	502.603	59			

All F-ratios are based on the residual mean square error.

A2.Analysis of Variance for TOTAL PLATE COUNT- Type III Sums of Squares

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
A:WEEKS	428.574	3	142.858	15355.83	0.0000
B:DOSES(HSB)	28.2552	4	7.06379	759.29	0.0000
INTERACTIONS					
AB	6.47543	12	0.539619	58.00	0.0000
RESIDUAL	0.372127	40	0.00930318		
TOTAL (CORRECTED)	463.677	59			

All F-ratios are based on the residual mean square error.

A3.Analysis of Variance for YEAST AND MOULDS- Type III Sums of Squares

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
A:WEEKS	626.633	3	208.878	718158.45	0.0000
B:DOSES(HSB)	23.9876	4	5.99691	20618.44	0.0000
INTERACTIONS					
AB	13.2849	12	1.10707	3806.32	0.0000
RESIDUAL	0.0116341	40	0.000290852		
TOTAL (CORRECTED)	663.917	59			

All F-ratios are based on the residual mean square error.

Irradiation (Storage in zip-lock bag)

A4.Analysis of Variance for TOTAL COLIFORM - Type III Sums of Squares

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
A:WEEKS	416.378	3	138.793	108445.77	0.0000
B:Doses	0.716416	4	0.179104	139.94	0.0000
INTERACTIONS					
AB	20.8517	12	1.73764	1357.71	0.0000
RESIDUAL	0.0511934	40	0.00127983		
TOTAL (CORRECTED)	437.997	59			

All F-ratios are based on the residual mean square error.

A5.Analysis of Variance for TOTAL PLATE COUNT - Type III Sums of Squares

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
A:WEEKS	433.054	3	144.351	22948.53	0.0000
B:Doses	7.81797	4	1.95449	310.72	0.0000
INTERACTIONS					
AB	4.97306	12	0.414421	65.88	0.0000
RESIDUAL	0.251609	40	0.00629022		
TOTAL (CORRECTED)	446.097	59			

All F-ratios are based on the residual mean square error.

A6.Analysis of Variance for YEAST AND MOULDS - Type III Sums of Squares

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
A:WEEKS	491.938	3	163.979	320469.28	0.0000
B:Doses	4.88899	4	1.22225	2388.67	0.0000
INTERACTIONS					
AB	7.86204	12	0.65517	1280.42	0.0000
RESIDUAL	0.0204674	40	0.000511685		
TOTAL (CORRECTED)	504.71	59			

All F-ratios are based on the residual mean square error.

B. Refrigeration (storage in hermetically sealed bag)

B1.ANOVA Table for TOTAL COLIFORMS by WEEKS (REF)

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	55.922	3	18.6407	10880.97	0.0000
Within groups	0.0137052	8	0.00171314		
Total (Corr.)	55.9357	11			

B2.ANOVA Table for TOTAL PLATE COUNT (REF) by WEEKS (REF)

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	192.978	3	64.3259	10426.10	0.0000
Within groups	0.0493576	8	0.0061697		
Total (Corr.)	193.027	11			

B3.ANOVA Table for YEAST AND MOULDS by WEEKS (REF)

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	131.442	3	43.8139	3818001.14	0.0000
Within groups	0.0000918049	8	0.0000114756		
Total (Corr.)	131.442	11			

B4.Refrigeration (Storage in zip-lock bag)

ANOVA Table for TOTAL COLIFORMS by WEEKS

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	88.249	3	29.4163	3209.85	0.0000
Within groups	0.0733152	8	0.0091644		
Total (Corr.)	88.3223	11			

B5.ANOVA Table for TOTAL PLATE COUNT by WEEKS

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	65.9511	3	21.9837	20037.76	0.0000
Within groups	0.0087769	8	0.00109711		
Total (Corr.)	65.9599	11			

B6.ANOVA Table for YEAST AND MOULDS by WEEKS

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	24.192	3	8.064	84841.29	0.0000
Within groups	0.000760384	8	0.0000950481		
Total (Corr.)	24.1928	11			

B7.Ambient Temperature storage in hermetically sealed bag
ANOVA Table for TOTAL COLIFORMS by WEEKS

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	19.71	3	6.57001	223.72	0.0000
Within groups	0.234938	8	0.0293672		
Total (Corr.)	19.945	11			

B8.ANOVA Table for TOTAL PLATE COUNT by WEEKS

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	25.5948	3	8.5316	630.66	0.0000
Within groups	0.108224	8	0.013528		
Total (Corr.)	25.703	11			

B9.ANOVA Table for YEAST AND MOULDS by WEEKS

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	24.192	3	8.064	84841.29	0.0000
Within groups	0.000760384	8	0.0000950481		
Total (Corr.)	24.1928	11			

B10.Ambient Temperature storage in zip-lock bag
ANOVA Table for TOTAL COLIFORMS by WEEKS

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	88.249	3	29.4163	3209.85	0.0000
Within groups	0.0733152	8	0.0091644		
Total (Corr.)	88.3223	11			

B11.ANOVA Table for TOTAL PLATE COUNT by WEEKS

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	65.9511	3	21.9837	20037.76	0.0000
Within groups	0.0087769	8	0.00109711		
Total (Corr.)	65.9599	11			

B12.ANOVA Table for YEAST AND MOULDS by WEEKS

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	42.8406	3	14.2802	18935.39	0.0000
Within groups	0.00603323	8	0.000754154		
Total (Corr.)	42.8467	11			

Blanching and refrigeration (Hermetically sealed bag)

C1.ANOVA Table for TOTAL COLIFORM by WEEKS

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	185.659	3	61.8862	553513.57	0.0000
Within groups	0.000894449	8	0.000111806		
Total (Corr.)	185.66	11			

C2.ANOVA Table for TOTAL PLATE COUNT by WEEKS

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	190.541	3	63.5136	10343.32	0.0000
Within groups	0.0491244	8	0.00614055		
Total (Corr.)	190.59	11			

C3.ANOVA Table for YEAST AND MOULDS by WEEKS

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	154.386	3	51.462	63163.68	0.0000
Within groups	0.00651793	8	0.000814741		
Total (Corr.)	154.393	11			

Blanching and refrigeration (Storage in Zip-lock bag)

C4.ANOVA Table for TOTAL COLIFORMS by WEEKS

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	88.249	3	29.4163	3209.85	0.0000
Within groups	0.0733152	8	0.0091644		
Total (Corr.)	88.3223	11			

C5.ANOVA Table for TOTAL PLATE COUNT by WEEKS

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	65.9511	3	21.9837	20037.76	0.0000
Within groups	0.0087769	8	0.00109711		
Total (Corr.)	65.9599	11			

C6.ANOVA Table for YEAST AND MOULDS by WEEKS

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	24.192	3	8.064	84841.29	0.0000
Within groups	0.000760384	8	0.0000950481		
Total (Corr.)	24.1928	11			

C7.Blanching and ambient temperature storage (Hermetically sealed bag) ANOVA Table for TOTAL COLIFORM by WEEKS

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	155.029	3	51.6763	128440.16	0.0000
Within groups	0.0032187	8	0.000402337		
Total (Corr.)	155.032	11			

C8.ANOVA Table for TOTAL PLATE COUNT by WEEKS

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	139.768	3	46.5894	36477.61	0.0000
Within groups	0.0102176	8	0.0012772		
Total (Corr.)	139.778	11			

C9.ANOVA Table for YEAST AND MOULDS by WEEKS

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	140.838	3	46.9461	1132963.06	0.0000
Within groups	0.000331492	8	0.0000414366		
Total (Corr.)	140.839	11			

C10.Blanching and ambient temperature storage(Storage in zip-lock bag) ANOVA Table for TOTAL COLIFORMS by WEEKS

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	169.079	3	56.3596	544031.71	0.0000
Within groups	0.00082877	8	0.000103596		
Total (Corr.)	169.08	11			

C11.ANOVA Table for TOTAL PLATE COUNT by WEEKS

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	168.074	3	56.0247	35929.69	0.0000
Within groups	0.0124743	8	0.00155929		
Total (Corr.)	168.087	11			

C12.ANOVA Table for YEAST AND MOULDS by WEEKS

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	96.5807	3	32.1936	7361.93	0.0000
Within groups	0.0349838	8	0.00437298		
Total (Corr.)	96.6157	11			

APPENDIX 4

SENSORY EVALUATION OF PROCESSED KONTOMMIRE

Test product: Kontomire Name:

Test Subject Number: Date:

SAMPLE CODES: **A** **A1** **A2** **A3** **A4**

You are presented with five samples as labelled above. Please examine the samples, assign scores to them based on your preference, using the 9-point hedonic scale below. Re-examination is allowed.

9-Like extremely 6-Like slightly 3 Dislike slightly

8- Like very much 5- Neither like nor dislike 2- Dislike very much

7- Like moderately 4- Dislike slightly 1- Dislike extremely

Attribute	**Score for A**	**Score for A1**	**Score for A2**	**Sore for A3**	**Score for A4**
Colour					
Texture					
Odour					

SAMPLE CODES: **A0** **A01** **A02** **A03** **A04**

You are presented with five samples as labelled above. Please examine the samples and assign scores to them based on your preference, using the 9-point hedonic scale below. Re-examination is allowed.

9-Like extremely 6-Like slightly 3 Dislike slightly

8- Like very much 5- Neither like nor dislike 2- Dislike very much

7- Like moderately 4- Dislike slightly 1- Dislike extremely

Indicate the acceptability or otherwise of the samples.

Attribute	**Score for A0**	**Score for A01**	**Score for A02**	**Sore for A03**	**Score for A04**
Colour					
Texture					
Odour					

SAMPLE CODES: **B** **B1** **B2** **B3** **B4**

You are presented with five samples as labelled above. Please examine the samples and assign scores to them based on your preference, using the 9-point hedonic scale below. Re-examination is allowed.

9-Like extremely 6-Like slightly 3 Dislike slightly

8- Like very much 5- Neither like nor dislike 2- Dislike very much

7- Like moderately 4- Dislike slightly 1- Dislike extremely

Indicate the acceptability or otherwise of the samples.

Attribute	**Score for B**	**Score for B1**	**Score for B2**	**Sore for B3**	**Score for B4**
Colour					
Texture					
Odour					

SAMPLE CODES: **B0** **B01** **B02** **B03** **B04**

You are presented with five samples as labelled above. Please examine the samples and assign scores to them based on your preference, using the 9-point hedonic scale below. Re-examination is allowed.

9-Like extremely 6-Like slightly 3 Dislike slightly

8- Like very much 5- Neither like nor dislike 2- Dislike very much

7- Like moderately 4- Dislike slightly 1- Dislike extremely

Indicate the acceptability or otherwise of the samples.

Attribute	**Score for B0**	**Score for B01**	**Score for B02**	**Sore for B03**	**Score for B04**
Colour					
Texture					
Odour					

SAMPLE CODES: **C** **C 1** **C2** **C3** **C4**

You are presented with five samples as labelled above. Please examine the samples and assign scores to them based on your preference, using the 9-point hedonic scale below. Re-examination is allowed.

9-Like extremely 6-Like slightly 3 Dislike slightly

8- Like very much 5- Neither like nor dislike 2- Dislike very much

7- Like moderately 4- Dislike slightly 1- Dislike extremely

Indicate the acceptability or otherwise of the samples.

Attribute	**Score for C**	**Score for C1**	**Score for C2**	**Sore for C3**	**Score for C4**
Colour					
Texture					
Odour					

SAMPLE CODES: **C0** **C01** **C02** **C03** **C04**

You are presented with four samples as labelled above. Please examine the samples and assign scores to them based on your preference, using the 9-point hedonic scale below. Re-examination is allowed.

9-Like extremely 6-Like slightly 3 Dislike slightly

8- Like very much 5- Neither like nor dislike 2- Dislike very much

7- Like moderately 4- Dislike slightly 1- Dislike extremely

Indicate the acceptability or otherwise of the samples.

Attribute	**Score for C0**	**Score for C01**	**Score for C02**	**Sore for C03**	**Score for C04**
Colour					
Texture					
Odour					

SAMPLE CODES: **D** **D1** **D2** **D3** **D4**

You are presented with five samples as labelled above. Please examine the samples and assign scores to them based on your preference, using the 9-point hedonic scale below. Re-examination is allowed.

9-Like extremely 6-Like slightly 3 Dislike slightly

8- Like very much 5- Neither like nor dislike 2- Dislike very much

7- Like moderately 4- Dislike slightly 1- Dislike extremely

Indicate the acceptability or otherwise of the samples.

Attribute	**Score for D**	**Score for D1**	**Score for D2**	**Sore for D3**	**Score for D4**
Colour					
Texture					
Odour					

SAMPLE CODES: **D0** **D01** **D02** **D03** **D04**

You are presented with five samples as labelled above. Please examine the samples and assign scores to them based on your preference, using the 9-point hedonic scale below. Re-examination is allowed.

9-Like extremely 6-Like slightly 3 Dislike slightly

8- Like very much 5- Neither like nor dislike 2- Dislike very much

7- Like moderately 4- Dislike slightly 1- Dislike extremely

Indicate the acceptability or otherwise of the samples.

Attribute	**Score for D0**	**Score for D01**	**Score for D02**	**Sore for D03**	**Score for D04**
Colour					
Texture					
Odour					

APPENDIX 5

SENSORY EVALUATION

1. SENSORY EVALUATION FOR IRRDIATED SAMPLES

1A. ANOVA Table for Colour by sample and packaging material

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
Packaging materials	902.506	18	61.192	54.64	0.0000
Storage	134.456	3	8.32	52.32	0.0000
Total (Corr.)	2340.34	950	4.42367	52.32	0.0000

1B.ANOVA Table for Texture by sample and packaging material

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
Packaging materials	490.138	18	54.460	24.75	0.0000
Storage	2315.42	980	4.72535		0.0000
Total (Corr.)	2805.56	998			

All F-ratios are based on the residual mean square error.

1C. ANOVA Table for Odour by sample and packaging material

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
Packaging materials	596.82	18	57.2642	24.74	0.0000
Storage	3095.16	980	2.63433		0.0000
Total (Corr.)	3691.98	998			

2. SENSORY EVALUATION FOR REFRIGERATION AND AMBIENT TEMPERATURE STORED SAMPLES

2A. Anova Table For Colour by sample and packaging material

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
Packaging materials	2505.29	15	167.019	97.93	0.0000
Storage	1337.1	784	1.70548		0.0000
Total (Corr.)	3842.39	799			

2B.ANOVA Table for TEXTURE by sample and packaging material

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
Packaging materials	2800.16	15	186.677	98.64	0.0000
Storage	1483.74	784	1.89253		0.0000
Total (Corr.)	4283.9	799			

All F-ratios are based on the residual mean square error.

2C.ANOVA Table for ODOUR by sample and packaging material

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
Packaging materials	2969.36	15	197.957	108.28	0.0000
Storage	1433.34	784	1.82824		0.0000
Total (Corr.)	4402.7	799			

All F-ratios are based on the residual mean square error.

3. SENSORY EVALUATION FOR BLANCHING, BLANCHING AND REFRIGERATION STORAGE

3A.ANOVA Table for COLOUR by SAMPLE-PACKAGING MATERIAL

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
Packaging materials	2936.06	15	195.737	129.85	0.0000
Storage	1181.78	784	1.50737		0.0000
Total (Corr.)	482.7	799			

3B.ANOVA Table for TEXTURE by SAMPLE-PACKAGING MATERIAL

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
Packaging materials	1514.42	15	100.961	60.76	0.0000
Storage	1302.76	784	1.66168		0.0000
Total (Corr.)	2817.18	799			

3C.ANOVA Table for ODOUR by SAMPLE-PACKAGING MATERIAL

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
Packaging materials	799		60.7893	32.14	0.0000
Storage	1482.88	784	1.89143		0.0000
Total (Corr.)	2394.72	799			

All F-ratios are based on the residual mean square error.

4. SENSORY EVALUATION FOR IRRADIATION AND REFRIGERATION STORAGE

4A.ANOVA Table for COLOUR by DOSES –PACKAGE

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
Packaging materials	799		69.6929	43.72	0.0000
Storage	3124.12	1960	1.59394		0.0000
Total (Corr.)	5842.14	1999			

All F-ratios are based on the residual mean square error.

4B.ANOVA Table for TEXTURE by DOSES –PACKAGE

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
Packaging materials	2258.81	39	57.9181	33.63	0.0000
Storage	3375.38	1960	1.72213		0.0000
Total (Corr.)	5634.19	1999			

All F-ratios are based on the residual mean square error.

4C.ANOVA Table for ODOUR by DOSES –PACKAGE

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
Packaging materials	2038.7	39	52.2743	28.28	0.0000
Storage	3622.46	1960	1.84819		0.0000
Total (Corr.)	5661.16	1999			

All F-ratios are based on the residual mean square error.

5. SENSORY EVALUATION FOR BLANCHING AND IRRADIATION TREATMENT AND STORAGE

5A.ANOVA Table for COLOUR by SAMPLE-PACKAGING MATERIAL

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
Packaging materials	4990.92	19	262.68	363.67	0.0000
Storage	707.86	980	0.722306		0.0000
Total (Corr.)	5698.78	999			

All F-ratios are based on the residual mean square error.

5B.ANOVA Table for TEXTURE by SAMPLE-PACKAGING MATERIAL

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
Packaging materials	2515.26	19	132.382	86.53	0.0000
Storage	1499.36	980	1.52996		0.0000
Total (Corr.)	4014.62	999			

All F-ratios are based on the residual mean square error.

5C.ANOVA Table for ODOUR by SAMPLE-PACKAGING MATERIAL

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
Packaging materials	876.115	19	46.1113	31.97	0.0000
Storage	1413.66	980	1.44251		0.0000
Total (Corr.)	2289.78	999			

All F-ratios are based on the residual mean square error

6. SENSORY EVALUATION FOR BLANCHING, IRRADIATION AND REFRIGERATION AND STORAGE

6A.ANOVA Table for COLOUR by SAMPLE-PACKAGING

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
Packaging materials	1620.84	39	41.56	17.57	0.0000
Storage	4636.3	1960	2.36546		0.0000
Total (Corr.)	6257.14	1999			

All F-ratios are based on the residual mean square error.

6B.ANOVA Table for TEXTURE by SAMPLE-PACKAGING

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
Packaging materials	1605.0	39	41.1538	16.12	0.0000
Storage	5004.44	1960	2.55329		0.0000
Total (Corr.)	6609.44	1999			

All F-ratios are based on the residual mean square error.

6C.ANOVA Table for ODOUR by SAMPLE-PACKAGING

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
Packaging materials	575.54	39	14.7574	5.19	0.0000
Storage	5575.86	1960	2.84483		0.0000
Total (Corr.)	6151.4	1999			

All F-ratios are based on the residual mean square error.