EFFECTIVENESS AND EFFICACY OF DIFFERENT WAXING MATERIALS ON THE QUALITY OF CUCUMBER FRUITS STORED UNDER DIFFERENT STORAGE CONDITIONS

BY

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DECLARATION

This is to certify that this thesis is the result of research undertaken by Robert Noble Ashalley towards the award of the Master of Philosophy Degree in Crop Science (Post Harvest Technology) in the Department of Crop Science, University of Ghana.

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ABSTRACT

Cucumber (*Cucumis sativus* L.) is an edible crop produced in Ghana for both the local and export markets. The perishable nature of the fruit results in huge postharvest losses. The use of edible coatings to preserve commodities is inexpensive, easy to apply, requires less labour, technology and improves fruit qualities. However usage of this technology has raised some concerns with major stakeholders of the fruits and vegetables industry regarding health, safety, availability and cost. The study therefore sought to assess the knowledge and perceptions of fruit and vegetable consumers and retailers regarding wax and waxed produce, the effect of different locally available wax materials on the physico-chemical and organoleptic quality attributes of cucumber fruits as well as their acceptability by consumers. To achieve this, structured questionnaires were administered to fruit and vegetable consumers and retailers in Accra. Experiments were also conducted using coconut oil (CO), shea butter (SB), coconut oil-shea butter combination (COSB) and synthetic wax (SW) against a control to assess the effect on various cucumber quality indices. The study revealed that all respondents were unaware of edible coating as a preservation method. However majority were willing to utilise this technology although they raised some concerns regarding health and safety. CO, SB and COSB maintained cucumber fruit quality (pH, titratable acidity, total soluble sugars, weight loss and extended shelf life). Consumers preferred SB and COSB over the other treatments. Although all respondents were ignorant of edible coatings as a preservation method, targeted education and advertisements by relevant institutions can convince the majority of willing respondents to wax usage and hence create a commercial product.

DEDICATION

To God Almighty and my family, both extended and nuclear.

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CHAPTER ONE

1.1. Introduction

Cucumber (*Cucumis sativus L.*) belongs to the Cucurbitaceae family (Mukherjee *et al.*, 2013) consisting of 90 genera and 750 species. The genus *Cucumis* contains nearly 40 species including three important cultivated ones (West Indian gherkin, cucumber and cantaloupe). Other important crops in this family are watermelon, muskmelon, squash, pumpkin and loofah gourd. Cucumber can be cultivated in the open field or in green houses.

Commercial vegetable production is gaining prominence in Ghana. This is partly due to the production of crops with export potential as well as public education from health experts and nutritionists on the need to consume more fruits and vegetables in the diet to avoid diseases like cancer, hypertension, coronary disease, diabetes, hepatitis B and anaemia (Gopalan, 2004). Vegetables produced in Ghana for both local and international markets include okra, garden eggs, chilli, onions, green beans and cucumber (Norman, 2003). Cucumber has been identified as one of the cultivated exotic vegetable crops that has gained popularity in Ghana because of its export potential (MOFA, 2002).

Cucumber can be eaten raw as a relish or used in the preparation of vegetable juice and salad, stew or sandwich (Sinnadurai, 1992). Cucumber is not only needed as food for good health but also as raw material in the cosmetic and pharmaceutical industries. The fruit is used to produce facial mask, body cream, lotion, soap and shampoo. The peels are also consumed and their extracts have been found to possess antioxidants and antidiabetic potentials (Miller *et al*., 2000 and Dixit and Kar, 2010). Cucumber like most fruits and vegetables is very perishable and it is easily affected by both primary and secondary causes of postharvest losses.

Wax has been applied in many fruits and vegetables primarily to reduce weight loss, respiration, ripening and evapotranspiration, improve gloss, control decay and carry postharvest fungicides. It has also been effective in reducing Chilling Injury (CI) symptoms in pineapple, papaya, orange and grapefruit (Mohammed and Wickham 1997; Dou 2004). The type of wax used could be organic or synthetic and in most cases the synthetic ones are used for commercial production. However these synthetic waxes are costly and not easily available. Even though recently some edible waxes have been developed, most of such improved materials are not easily available in the local market of Ghana. The use of food grade wax coating on fruits is safe and is approved for application on fresh fruits and vegetables (FAO, 2011). These waxes may be shellac, vegetable, beeswax or petroleum-based. There is a general concern that synthetic waxy finish found on supermarket commodities may contain harmful chemicals since most waxes are incorporated with preventive chemicals such as fungicides. Again most vegetarians and vegans also harbour some reservation on waxed fruits and vegetables in the light that most wax materials contain animal products as components. This concern has resulted in most waxed fruits particularly cucumber to be rejected by consumers and some retailers. Those who opt for these waxed commodities always peel them before use. Hence the consumer loses all of the nutritional benefits found in the cucumber and the few bold ones, who buy but peel the skin before consuming, lose the benefits in the peels. The concept of supermarket is appearing in our country and many leading corporate sectors and individuals have opened their outlets in various cities and towns. These are marketing outlets where various types of fruits and vegetables are displayed in packaging after coatings have been applied and this can have an added advantage of maintaining freshness. Hence the general aim of this research is to investigate if such perceptions exist among consumers here in Ghana and to study the effect

of some local wax coating on the shelf life and quality of cucumber fruits stored under cold conditions (20–22◦C and 80–85% RH) and tropical ambient conditions (30–32◦C and 60–65% RH) as a potential substitute for synthetic wax material.

The main objective of the study was to assess the effectiveness and efficacy of the different waxing materials on the quality of cucumber fruit stored under different source conditions.

The specific objectives were to assess the:

1. Knowledge and perceptions about fruit waxes, particularly waxed cucumber fruits, among traders and consumers in Accra.
2. Effect of different local waxing materials on the physico-chemical and organoleptic quality attributes of cucumber fruits.
3. Consumer acceptability of cucumber fruits that have been treated with the different local waxing materials.

With the alarming increase in human population growth in the less developed countries resulting in serious food security problems, the efficient harvesting, transportation, storage, processing, preservation and packaging of both durable and perishable food produce pose an ever greater challenge to mankind. Furthermore, the ever-increasing demand for high produce necessitates the need for sound technical, professional, as well as managerial expertise for handling farm produce to maintain quality and minimise losses during the postharvest chain before the produce is utilised. It is hoped that this study will promote the development of locally available materials such as coconut oil and shear butter to be used as organic wax materials on fruits and vegetables. This will help provide an alternative to imported synthetic wax materials. Again this will help defuse any consumer perceptions concerning the use and safety of

waxed fruits and vegetables, promote consumer purchases and increase income to retailers and farmers.

The entire study is organised into six (6) chapters. Chapter one (1) is made up of an introduction and background to the study, problem statement, the objectives and the significance of the study. Chapter two (2) covers the literature review on the study mainly from related journal publications and other published literature in the area of cucumber production and wax application on fruit quality. Chapter three (3) looks at the methodology adopted for the conduct of the study, providing relevant information on data sources and analyses. Findings of the study are presented in Chapter 4 and discussed in Chapter 5. Chapter 6 covers the summary, conclusion and recommendations which are based on the findings arrived at.

CHAPTER TWO

2.1. Taxonomy and Morphological description of cucumber.

Cucumber (*Cucumis sativus L.*), belongs to the Cucurbitaceae family. It is commercially cultivated worldwide as a seasonal vegetable crop. It is native to India; found wild in the Himalayas. It shares membership of the Cucurbitaceae family along with melons, squashes and many other horticulturally important species. Amongst 30 species of Cucumis, *C. sativus* has the most economic value. It is widely consumed fresh in salads or fermented (pickles) or as a cooked vegetable (Mukherjee *et al.*, 2013). Cucumber (*Cucumis sativus* L.) fruit are borne on indeterminate, tendril-bearing vines of subtropical and tropical origin (Robinson and Decker-Walters, 1997). The interior ovary has three united carpels in most cultivars. Compact, determinate cultivars have been developed for home gardeners and for once-over mechanical harvesting (Miller and Wehner, 1989).

Fruits are round to oblong or narrowly cylindrical, with small tubercles (warts) and spines of trichome origin on the rind (Miller and Wehner, 1989). Dark green and firm slicing cucumbers should not be pitted or have wrinkled (i.e., pinched) ends. Spine colour is associated with mature fruit colour and fruit netting. Fruit of white-spined cultivars are light green to yellow when mature and not netted. Black-spined fruits are orange or brown when mature and may be netted. The flesh is crisp and white, except in a few cultivars where it is pale orange.

Different varieties of cucumbers vary in length from about 10 to 76 cm. If the cucumber is allowed to mature, the fruit bulges in the middle, changes in colour from green to yellow, and is not fit to be eaten (Redmond, 2007). Having an enclosed seed and developing from a flower, cucumbers are scientifically classified as fruits. Much

like tomatoes and squash, however, their sour-bitter flavour contributes to cucumbers being perceived, prepared and eaten as vegetables (Mukherjee *et al.*, 2013).

Fruits are harvested at various stages of development. Immature fruits are green at the edible stage, except in a few cultivars where they are white or yellow. Fruits are generally harvested immature, at sizes ranging from a 5 cm long to near full size but before the seeds are fully enlarged and hardened. Firmness and external glossiness, and formation of jelly-like material around the seeds are indicators of proper harvest maturity. Greenhouse grown parthenocarpic fruits are generally harvested when the fruits have lengths from 12 – 14 inches and weigh about 1 pound each (Hochmuth, 2012). Straight, uniformly cylindrical fruits slightly tapered at both ends are of highest quality.

2.2. Uses and Benefits of cucumber

The medicinal properties of cucumber had been described since ancient times. Different parts of the plant viz. leaf, fruit and seed have been explored for their therapeutic benefits. C. sativus fruits and seeds have important therapeutic value in the Indian systems of medicine, particularly in Ayurveda where over 200 herbs, minerals and several formulations are available for management of aging (Mukherjee *et al.*, 2011). They are widely used for various skin problems including swelling under the eyes and sunburn. It is believed that they promote refreshing, cooling, healing, soothing, emollient and anti-itching effect to irritated skin (Franco *et al.*, 2002). In Chinese folk medicine the leaves, stems and roots are generally used as anti-diarrheal, detoxicant and anti-gonorrheal agents. Several pharmacological activities including the antioxidant, antiwrinkle, antimicrobial, antidiabetic and hypolipidemic potentials have been reported with this plant. Antihyaluronidase and anti-elastase activities have been

proved for its cosmetic potentials such as in facial mask, body creams, lotions and shampoo (Nema *et al.,* 2011). Few bioactive compounds have been derived from this plant belonging to different chemical groups (Mukherjee *et al.*, 2013).

The nutritional composition of cucumber per 100 g edible portion (ends trimmed, not peeled, edible part 97%) is: water 96.4 g, energy 42 kJ (10 kcal), protein 0.7 g, fat 0.1 g, carbohydrate 1.5 g, dietary fibre 0.6 g, Ca 18 mg, Mg 8 mg, P 49 mg, Fe 0.3 mg, Zn 0.1 mg, carotene 60 µg, thiamin 0.03 mg, riboflavin 0.01 mg, niacin 0.2 mg, folate 9 µg, ascorbic acid 2 mg (Holland *et al.*, 1991). Enzyme crepsin, proteolytic enzyme, ascorbic acid, oxidase, succinic and malic dehydrogenase have also been reported in fruits (Kapoor, 1990). Watson (2000) also reported Lycopene, which is found in cucumber, is a powerful antioxidant that is thought to prevent diseases, help fight certain types of cancer e.g. cervical and prostate cancers and to battle cardiovascular disease by prohibiting hardening of the arteries. Per one cup serving, cucumber has 9.09 mg of lycopene, compared to the 4 mg found in one cup of fresh tomatoes (National Watermelon Promotion Board, 2003).

Sotiroudis *et al*. in 2010 reported that cucumber fruits contain a high concentration of ascorbic acid whereas pulp and peel extracts contain lactic acid (~7 – 8% w/w), which showed antioxidant activity. They isolated essential oils and found 21 compounds including Z-6-nonenol(61.54%), E-2-nonenol (6.98%), E,Z-2,6-nonadienal (47.08%), E-2-nonenal (17.39%), Z-3-nonenol (14.79%), 3-nonenal (7.32%),pentadecanal (43.47%), 9,12,15-octadecatrienal (14.52%) and9,17-octadecadienal (12.33%) from three distinct cultivars. In another study with gas chromatography–mass spectrometry (GC-MS) Zhou and Mcfeeters (1998), identified thirty seven volatile compounds from the fermented cucumber when it was treated with common salt (2% NaCl). Lipid and fatty acid composition of cucumbers and their altering amount during storage were also

examined. It was found that fatty acids primarily lauric, myristic, palmitic, stearic, oleic, linoleic, tricosanoic, tricosenoic, lignoceric, and nervonic acids present in cucumber and their amount are increased when packed due to the diffusion of spice oils and loss of water.

Kapoor (1990) reported that seeds of cucumber are also rich in a number of constituents including crude proteins (42%) and fats (42.5%). The ash is rich with phosphate (P2O5, 0.62%). He said the extracted oil from seeds is clear and light yellow with specific gravity of0.91; acid value 0.22; sopanification value 1930; soluble fatty acid (as butyric acid) 0.4% and unsopanification matter (0.91%). The fatty acid components are palmitic (0.63%), stearic (16.2%), linoleic (40.11) and oleic acid (38.70). It contains a number of sterols such as codisterol, clerosterol, stigmasterol, campesterol, sitosterol, avenasterol as well as the gibberellin hormone. Seed cake contains water (1.13%) protein (72.53%) ash (9.7%), crude fibre (1%) and carbohydrates (8.64%) (Fiume, 2012). Wani *et al.*., 2010 also concluded that cucumber seeds have high levels of proteins and lipids of which arginine, glutamic acid; aspartic acid and leucine were the predominant amino acids. Hence the good nutritional and functional properties of watermelon and cucumber seed meal proteins suggest their potential use in food formulations.

Cucumber as a fruit and vegetable is a very important crop for the food, pharmaceutical and cosmetic industries. In spite of its many benefits and uses it remains very relatively unknown. This has won it this enviable idiomatic expression “As cool as cucumber”.

2.3. Varieties of cucumber in the world and in Ghana

Based on the purpose or use the fruit is classified as a slicing or pickling variety. The slicing varieties are mostly eaten as raw fruits or in salads whilst the pickled ones are

essentially for canning. Miller and Hughs (1969) described “slicing” variety as cucumbers sold fresh for immediate consumption usually as a salad item and that they are characterized by thick, uniform, dark green skins, slicing cucumbers are longer than pickling types, and their thicker skins are more resistant to damage during handling and shipping whereas “pickling" refers to cucumbers that are primarily used for processing or pickling. Pickling cucumbers have thin skins, are short and blocky, and usually have a colour gradient from dark green at the stem end to light green at the blossom end. They concluded that good pickling varieties will also have fewer seeds as well, unless they have been left too long to ripen. van Luijk (2004) reported some open pollinated cultivars to include Marketmore 76, Poinsett 76, Ashley and the hybrids Cyclone and the gynoecious Dasher II. He also noted Tokyo and Olympic hybrids as being widely distributed in Africa.

There are different cultivars of cucumber but the most commonly grown in Ghana are the Ashley, F1 Antilla, F1 Tropical and the Poinsett (Obeng-Ofori *et al.*, 2007). These varieties are highly resistant to downy mildew, powdery mildew, anthracnose and angular leaf spot (NISCAIR, 2010). These are monoecious cultivars and bear separate male and female flowers on the same plant but genetically the female flowers are far less than the male flowers as compared to the gynoecious cultivars which produce only female flowers (www.prota.org, 2014).

Cucumber farmers in Ghana are therefore faced with the problem of low yields since the female flowers which ultimately produce fruits are few on the plants. Pinching out technique which is the removal of terminal bud is not often practised by cucumber farmers in Ghana. However, Hickman (1998) stated that the activity does not kill the plant but promotes the production of auxillary or lateral shoots which tend to increase female flowers. Experiments conducted by Hikosaka and Sigiyama (2004) in a

greenhouse in France showed that pinching of terminal buds helped to increase female flower production in a monoecious type (multi-pistillate) of cucumber. If our farmers would be made aware of such a technology they would be producing more fruits over the same area of land under cultivation.

2.4. Production volumes in the world and in Ghana

The production of cucumber as compared to most fruits and vegetables in Ghana is on the very low side. Notwithstanding the fact that it is a relatively new exotic crop, its production and export is catching up with the traditionally well-known vegetables like lettuce, garden eggs, onion, okra and even cabbage, pepper and tomatoes in the Greater Accra Region of Ghana. Data from FAOSTAT (2013) indicates that the production of cucumber and gherkins in Ghana is growing steadily from 94 MT in 2001 to 117 MT in 2011. This performance placed Ghana on the 122th position on the world ranking of cucumber and gherkins production. In the Greater Accra Region of Ghana however estimates from Statistics, Research and Information Directorate (SRID) of Ministry of Food and Agriculture (MoFA) reveals rather interesting trends. It indicates that cucumber production alone grew by almost a double from 403 to 802 tons over the last 5 years (2008 to 2012). This growth rate is very significant compared to the other major vegetables being cultivated in the Region for the same period.

Table 1: Total Production Figures of Major Vegetables in the Greater Accra Region (Figures in Metric Tons)

	Year				
Vegetable	**2008**	**2009**	**2010**	**2011**	**2012**
Tomato	42,939	59,450	58,213	64,602	40,359
Pepper	14,269	15,220	12,584	14,615	11,143
Garden eggs	1,263	1,510	1,187	610	1,575
Okro	15,951	18,820	18,938	14,507	14,597
Lettuce	493	300	280	551	600
Onion	882	5,730	1,537	2,015	2,499
Cabbage	5,476	7,900	8,715	8,306	7,010
Cucumber	403	480	283	680	802

Source: Statistics, Research and Info. Directorate (SRID), Min. of Food & Agric.-March, 2013.

2.5. Post-harvest losses of the fruits in the World and in Ghana

Food losses refer to the decrease in edible food mass throughout the part of the supply chain that specifically leads to edible food for human consumption. Food losses take place at production, postharvest and processing stages in the food supply chain (Parfitt *et al.*, 2010). The losses that occur after the food is produced till its final consumption is referred to as postharvest losses. These include postharvest handling, storage, distribution, packaging and consumption. FAO (2011) grouped these losses as postharvest handling and storage, processing, distribution and consumption losses.

A recent study from the FAO in 2011 concerning global food losses and food wastes estimated that with respect to the total amounts of fruits and vegetables produced globally, somewhere between 15% and 50% are lost at the postharvest stage, before even reaching the tables of consumers. The highest losses were recorded in the developing countries of Africa and Asia, which lack the necessary technologies to prolong the storage life of fresh produce.

Unfortunately the SRID of MoFA has no database or records of how much of the fruits and vegetables produced here in Ghana actually become lost. The unavailability of such critical information makes planning and development of this relatively young industry quite challenging. Considering the fact that the population of Ghana increased by 30.4% from 2000 to 2010 (GSS, 2012) and there is more public education on the need to consume more fruits and vegetables, information such as this would help determined how secure our fruit and vegetable industry is in meeting the ever increasing demand of consumers.

2.6. Post-Harvest handling and storage practices of cucumber fruits in the supply chain.

All edible commodities go through various processes and stages of production before they get to the market and then to the tables of consumers. These processes and stages if not handled properly can enhance or facilitate the rapid deterioration of the commodity's quality. A supply chain is the network of all individuals, organizations, resources, activities and technology involved in the creation and sale of cucumber, from the delivery of source materials from the supplier to the cultivation, through to its eventual delivery to the end user (consumer). All activities and actions taken after the fruits are harvested till they finally get to the consumer are the postharvest handling and storage practices. These activities include harvesting, cleaning, sorting, packing, transporting, distributing and storage.

2.6.1. Harvesting operations

Cucumbers for fresh consumption should be harvested at an immature stage, near full size but before the seeds fully enlarge, usually starting about 50 - 60 days after planting. Harvesting is a deliberate effort of separating the matured fruit from the

parent plant or stem. Fruit size is the main attribute used to measure maturity of fruits. Firmness and external glossiness, and formation of jelly-like material around the seeds are indicators of proper harvest maturity. Skin colour should be an even dark green with a noticeable wax deposit on the fruit surface (Hochmuth, 2012). Again fruits for the fresh markets must be firm, green and the size typical of the cultivar.

Cucumbers should be harvested during the coolest time of the day, if possible in the morning when fruits have their highest water content. Cucumbers should be harvested every other day and the fruit should be handled carefully to prevent bruising and surface injury. Harvesting is mostly done by hand but in some cases small knives are used. However, in Ghana matured fruits are harvested by farmers with bare hands. This they do by twisting the fruit from the stem or vine, leaving an exposed cut on the fruit which serves as entry points for pathogen attack. However the appropriate approach is to use a small knife to cut the fruit stem from the vine at a point just above the shoulder of the fruit. Harvesting marks the end of production and the beginning of postharvest activities.

2.6.2. Cleaning, sorting and grading of harvested cucumber fruits

Cleaning, sorting and grading are some of the activities that follow harvesting. The main focus of these activities are to make the produce clean and to grade them into their appropriate sections for pricing and sales. Since most of the cucumber harvested in Ghana are for the local fresh vegetable markets, very little sorting, cleaning and grading are done until they get to the market centres where retailers and traders clean and grade them for differentiated pricing.

On-farm cleaning and sorting are mostly not carried out since farmers sell straight to the middlemen on demand. However any soil or other surface stains should be removed

at the time of harvest. This can be done manually by rubbing the fruit surface with a soft damp cloth or cotton gloves. Washing the fruit is more efficient if the cucumbers are particularly dirty, or if the quantity of fruit is large. In this case, the fruit are submerged in a large wash tank and the surface is rubbed clean by hand or with a soft brush. The wash water should be clean and properly sanitized to reduce the potential for the spread of disease. Sodium hypochlorite (household bleach) is commonly used since it is an inexpensive and readily available wash water sanitizing agent. Washing also serves as a cooling operation reducing field heat especially when done immediately after harvesting. Unfortunately most of our fruits are not sanitized when washing except in large commercial production where the fruits are washed in sterilised water in pack houses.

Grading cucumber quality is primarily based on size, evenness of shape, firmness and skin colour. Additional quality indicators are the amount of surface damage, peel injury and rate of decay. High quality cucumber fruit should be straight, evenly green in colour, with a diameter greater than 5.7 cm and a length greater than 15 cm. Over-mature fruit with white or yellowish colours should not be marketed, as they usually have a bitter flavour and tough texture (PHTB, 2004). In Ghana there is no grading standard for fresh cucumber fruits. However in North American market, size is based on diameter and length. Large size cucumbers have a diameter greater than 6 cm and a length greater than 15 cm. Small size cucumbers have diameters between 1.3 cm and 5 cm (PHTB, 2004).

2.6.3. Packing, Transporting, Distributing and Storage

Postharvest quality control begins in the field. Harvested cucumbers should be handled as gently as possible and never be allowed to remain in the sun for extended periods.

Cucumbers should be packed in strong, well-ventilated containers. Wooden or durable plastic containers that can be stacked without collapsing are appropriate for the domestic market. Mesh sacks are not a good container as they provide little protection to the fruit. Use of synthetic sacks filled with more than 25 kg of fruit should also be avoided. Cucumbers for export should be packed in strong well-ventilated fibreboard cartons typically containing 25 kg of fruit. If cucumbers are packed in smaller cartons they are sold by count. Jute and polythene sacks are the most common packaging materials used in Ghana. These materials offer very little protection to the fruits in terms of bruising, cuts, exposure to unfavourable temperature and humidity, moisture loss and postharvest pets like rodents.

Cucumbers should be handled with care as they get damaged easily during transport. The optimum temperature for storage and transport of cucumbers is 10°C. Recommended conditions for commercial storage of cucumbers are 10 to 12.5 ºC at 95% RH (Hardenburg *et al..*, 1986). Hardenburg *et al.* suggested that at this temperature range, cucumbers can be expected to have a 2 week market life. Shrivelling, yellowing and or decay are likely to be apparent beyond two weeks. Peel colour will start to change to yellow after about 10 days at 10°C. Storage of cucumbers below 10°C should be avoided, as this will result in chilling injury. Chilling sensitivity limits storage temperatures to a narrow range. Storage below 10 °C results in chilling injury in as little as 2 to 3 days, whilst storage at 15 °C results in rapid yellowing and loss of quality. Holding cucumbers without refrigeration at ambient temperature will result in noticeable shrivelling and decay after one week. Although cucumbers have a waxy skin, they are susceptible to water loss during storage and marketing. Small sunken lesions may appear on the fruit surface within several days at a low relative humidity (RH). In addition, the fruit loses its firm crisp texture. A small depression at

the point of stem attachment may develop. The ideal relative humidity for holding cucumbers is 95%. Storage-life is generally less than 14 days, with visual and sensory quality rapidly declining thereafter. When fruits are kept in appropriate packaging materials and stored in the suitable environments, fruits will maintain their quality over a long time and hence guarantee good market and prices.

2.7 Postharvest loss prevention measures

Cucumber like other fruits is a perishable commodity. It is also sensitive to temperature, ethylene and humidity. Uncontrolled exposure of fruits to such conditions will result in fruits developing undesirable characteristics such as high respiration rate, evapotranspiration, weight loss, shrinking, yellowing and ripening, shrivelling and chilling injury (Hardenburg *et al*., 1986). Many approaches have been used to delay these processes and extend shelf life of the fruit. Several techniques that have been used to minimize these deleterious effects include refrigeration, high pressure, controlled atmosphere packaging, modified atmosphere packaging, edible coatings and films, non-ionizing artificial ultraviolet-C (UV-C), infrared radiation and chemical preservatives (Erkan *et al*., (2001), Rivera-Pastrana *et al.,* (2007), Allende *et al.,* (2006), Gonzalez-Aguilar *et al*., (2010) and Sandhya, 2010). For best results, a combination of methods has been used.

2.7.1 Wax and edible coatings as a preservation technique

The concept of edible films as protective films has been used since the 1800s (Guilbert *et al.,* 1996). The first edible coating used was wax in China (Park, 1999). Extensive research in this area has paved the way for different effective edible films and coatings. An edible coating or film could be defined as primary packaging made from edible

components. An edible coating is a thin layer of edible material (hydrocolloid or lipid) applied on the surface of a food product with the purpose of generating a semi-permeable barrier to gases, water vapour, volatile compounds, mechanical properties, sensory perceptions, convenience, microbial protection and prolong the shelf life of various products (Krochta, (2002) and Janjarassku and Krochta, (2010)).

Edible films are distinguished from coatings by their method of manufacture and application to the food product. Films are dried preformed thin material structures that are used on or between layers of food components. Edible coating are also defined as thin layers of edible materials, but these are usually applied as a liquid of varying viscosity to the outer surface of the product by spraying, dipping, brushing or other appropriate methods. Edible films are usually between 50 to 250 μm in thickness and can be used to wrap the product or make pouches and bags. Several films can be combined to from laminated sheets. If desired, they could also be applied between layers of food components. To accomplish their intended functions, coatings are usually allowed to dry on the product after contacting the surface (Pascall and Lin, 2013).

2.7.2 Benefits and uses of edible coatings (ECs) and films (EFs)

Edible coatings were found to be able to extend shelf life of fresh products by decreasing respiration, senescence and protecting aroma, texture and colour (Gonzalez-Aguilar *et al*., (2010)). Other applications of its use include health benefits by incorporating nutrients such as vitamins, minerals and bioflavonoids within the film matrix (Park *et al*., (2001) and Park and Zhao, (2006)). In addition, the biodegradable and environmental friendliness of edible films and coatings are other desirable benefits associated with their use (Siracusa *et al*., (2008) and Janjarassku and Krochta, (2010)).

They also improve consumer appeal and reduce the use of synthetic packaging. The major benefit of EC is that they can be consumed along with food, can provide additional nutrients, may enhance sensory characteristics and may include quality enhancing antimicrobials (Guilbert *et al.,* 1996).

Guilbert *et al.,* also proposed that edible coatings and biodegradable films must meet a number of special functional requirements, for example, moisture barrier, solute or gas barrier, water/lipid solubility, colour and appearance, mechanical and rheological characteristics, non-toxicity, etc. These properties depend on the type of material used, its formation and application.

2.7.3 Types of Edible Coatings and Films

Edible coatings may be composed of polysaccharides, proteins, lipids or a blend of these compounds (Park *et al.,* 1994 and Guilbert *et al.,* 1996). Their presence and abundance determine the barrier properties of material with regard to water vapour, oxygen, carbon dioxide and lipid transfer in food systems (Guilbert *et al.,* 1996). However, none of the three constituents can provide the needed protection by themselves and so are usually used in a combination for best results (Guilbert *et al.,* 1996; McHugh and Krochta, 1994). Compounds most commonly used to form edible coatings include chitosan, starch, cellulose, alginate, carrageenan, zein, gluten, whey, carnauba, beeswax and fatty acids (Gonzalez-Aguilar *et al*., (2010). However, cereal grains, tubers, legumes, and pulses possess higher protein and oil contents than fruits and vegetables. These proteins and oils have been isolated and studied for film formation.

Zein is a natural corn protein produced from corn gluten meal and is insoluble in water, but soluble in aqueous alcohol, glycols and glycol esters (Martin-Polo, 1995). Carnauba

wax is obtained from the leaves of carnauba palm, which is native to Brazil and its GRAS (generally recognised as safe) (Baldwin *et al*., (1996). They also reported that soya and gluten proteins, starch (cassava, corn, wheat and rice starch) and some vegetable oils (soya, cow pea, sheabutter, coconut, sunflower, custard, etc.) can also be used as edibles coatings. Other compounds have been used to form coatings for fruits and vegetables, such as pullulan, gellan, aloe vera, cactus–mucilage and fruit puree (Embuscado and Huber, (2009)).

2.7.4 Some challenges with the use of edible coatings and films

Whilst coatings have very desirable effects in reducing colour changes, firmness loss, and decay, there are some disadvantages. These disadvantages could be overcome by suitable selection of the type and thickness of the coating and by avoiding treatment of immature, flavourless fruit and storage of coated fruits at high temperature (Park *et al.*, 1994). However, since consumers are concerned with additives, including wax, acceptability of edible coatings must be recognized (Watada *et al.*, 1996). Thick coatings could restrict the respiratory gas exchange, causing the product to accumulate high levels of ethanol and to develop off- flavours (El Ghaouth *et al.*, 1992 and Howard and Dewi, 1995). The spoilage could be rapid for coatings such as whey protein in moist environments, which serves as nutrient for microbial growth (Avena-Bustillos *et al.*, 1997). Addition of antimicrobials like potassium sorbate to the coatings will be able to eliminate this problem. Basic information on film-coating formulation, properties, methods of application to food surfaces and demonstration of effectiveness are lacking. Tremendous research is required in the area of applications of edible coatings of foods, especially with the use and application of local vegetable oils in Ghana.

2.8 Quality attributes of cucumber fruits

Quality is a measure of how much the end-user values a product. Product quality is very important to growers and exporters because it determines marketable yield and can affect price (Radovich, 2010). Kader and Rolle in 2004 reported that quality, the degree of excellence or superiority, is a combination of attributes, properties or characteristics that give each commodity value, in terms of its intended use. They also said the relative importance given to a specific quality attribute varies in accordance with the commodity concerned and with the individual (producer, consumer and handler) or market concerned with quality assessment.

Consumers' perception of quality is influenced by the product's intrinsic attributes as well as by extrinsic indicators and cues provided by the seller of the product (Caswell *et al.*, 2002). Because quality can be subjective, objective market standards have been developed for many commodities that define what is "marketable" and establishes "grade" of marketable produce. For this reason, many produce require a judgment or a certification by an authority figure such as a governmental agency, or organizations that consumers trust to lend information on credence attributes (Becker, 1999). Many agro-food produce and products fall into this category (Caswell and Mojduska, 1996).

Experiential eating quality of a product is made up of a composite of attributes whose relative importance varies with the product. The main components are flavour – defined as being made up of taste (sweetness, acidity, astringency, bitterness) and aroma – texture (defined as firmness, juiciness, succulence) and colour and shape (Tan, 2000). Visual, smell and aroma components are often top rated among quality attributes of fruits and vegetables. This is very logical since they represent the basic components of eating pleasure (Zanoli *et al.*., 2003; Ernst *et al.*, 2006). Hence consumers judge the

quality of fresh fruits, ornamentals, and vegetables on the basis of appearance (including 'freshness') at the time of initial purchase (Kader and Rolle, 2004).

Some of the intrinsic attributes they look out for include maturity, size, colour, absence of damage and other defects. The absence of harmful substances is also important indicator of quality especially in products consumed raw like fresh cucumber. Despite this complexity, there are often one or two dominant characteristic that overrides other attributes to influence consumer preference. In cucumber, fruit size, shape and firmness, colour, seediness, price, maturity and absences of any blemishes are the dominant attributes consumers look out for. Kader and Rolle also alluded to the fact that where consumers' purchasing power is low, price becomes the single most important factor in determining the consumers' choice of quality. In addition to these dominant attributes, pH, total soluble solids, total titratable acidity, internal colour of fruit, rate of deterioration, shelf life and chemical residual levels are determined for fruits intended for exports.

2.8.1 Fruit Shape and Size

The cucumber fruit is roughly cylindrical, elongated, with tapered ends. Different varieties of cucumbers vary in length from about 10 to 76 cm. If the cucumber is allowed to mature, the fruit bulges in the middle, changes in colour from green to yellow, and is not fit to be eaten (Redmond, 2007). Having an enclosed seed and developing from a flower, cucumbers are scientifically classified as fruits. Much like tomatoes and squash, however, their sour-bitter flavour contributes to cucumbers being perceived, prepared and eaten as vegetables. The shape and size is mostly not affected by many control measures such as the application of edible coatings and films, modified atmosphere, fungicides, irradiation, etc. However the use of high and low

temperatures may affect the skin appearance and shape of the fruit. Due to their chilling-sensitive nature, it is recommended that cucumbers be stored at 7 to 10 ºC and 85 to 95% relative humidity (RH) in air (DeEll *et al.*., 2000; Thompson, 2002), 8 to 12 ºC in 1% to 4% 0_2 and 0% CO_2 (Cantwell and Kasmire, 2002), or 10 ºC to 12.5 ºC (Kader, 2002; Suslow, 2002). Storing the commodity at temperatures below the recommended storage temperature will not only limit the quality (appearance and firmness) and shelf life of a product but is also an avoidable cost.

2.8.2 Fruit Colour

Colour is hugely important in terms of consumer preference and quality assessment. A fall in skin chlorophyll content is correlated with advancing maturity (Abbott, 1999) and depending on the fruit, it is often the most obvious sign of maturity (Wills *et al.*, 2007). Pigment species responsible for colour intensity include the fat-soluble chlorophylls (green) and carotenoids (yellow, orange, and red) and the water-soluble flavonoids and anthocyanins (yellow, red, blue) (Barrett *et al*., 2010). The decline in the green skin colour of cucumber fruit can be attributed to both chlorophyll degradation and carotenoid synthesis (Tanaka *et al.*, (2008) and Liu *et al*., (2009)).

2.8.3 Fruit Firmness

Firmness or texture is one of the physical intrinsic quality attributes consumers look out for when choosing or grading fruits and vegetables. It is a measure of the fruit flesh or skin to resistance compression or puncture force which can also account for tensile strength of the cell wall. Firmness is a gross measurement that has elements of crispness, mealiness and juiciness which all contribute to quantitation of firmness (Chen and Opara, 2013). During ripening, water-soluble polyuronides increase whilst

insoluble and covalently bound pectin decreases. The loss of firmness during ripening is associated with the activity of several cell wall-modifying enzymes (Brummell, 2006). On the other hand, loss of fruit firmness, an important quality factor for all perishables, is not solely dependent on cell wall metabolism and there may be other factors such as water status(turgor pressure) and cuticle structure that also contribute to postharvest life (Saladie *et al.*, 2007). Edible coatings have been used to delay the development of moisture and weight loss. Weight and moisture losses were significantly reduced using edible coatings as reported by Chien *et al*., 2007, Tapia *et al.*, 2007 and Olivas *et al.*, 2003 in mango, cut-fruits and pear respectively.

2.8.4 Fruit total soluble sugars (TSS)

Perceived flavour quality, especially in fleshy fruits, represents a delicate interplay between texture, mixed with the proper concentrations of free sugars, organic acids and volatile compounds (Thammawong *et al.*, 2009). Thammawong *et al.* also stated that the principal sugars responsible for perception of sweetness are sucrose, fructose, glucose and sometimes a sugar alcohol sorbitol. As climacteric fruit ripen, free sugar content increases as starch is hydrolysed, thus providing the characteristic sweetness. Delaying the formation of these sugars until fruits are ready to be utilised are some of the benefits of using edible coatings. Togrul and Arslan (2004) and Jacobi *et al*., (1998) recorded similar results with mandarins and 'Kensington' mango respectively.

2.8.5 Fruit pH and total titratable acidity (TTA)

Acidity is an important component of fruit flavour and in combination with TSS, contributes to overall organoleptic quality (Harker *et al.*, 2008). In their paper, Harker *et al.*, reported that total organic acid content declines in fruit as they mature, ripen and

store, with apples having a reasonably high acid content compared to pears. However fruit acidity should be considered in conjunction with other quality parameters, especially firmness and TSS as consumer studies show a strong relationship between the three. Organic acids, being respiratory substrates, are always metabolized in stored crops as a function of maturity at harvest. Immature fruit have a relative abundance of acids, which slowly declines during the ripening period (Forney *et al*., 2012). It follows that any postharvest condition that delays the rate of ripening also preserves the acid content, especially in climacteric fruits. Ripening and carbonic acid content breakdown in mango, apples and garden eggs were delayed significantly when fruits were treated with edible coatings (Abbasi *et al*., (2011), Harker *et al*., (2008) and Ubani and Suleiman, (2008)).

2.8.6 Fruit weight loss or loss of moisture

Weight is one of the key physical intrinsic qualities consumers look out for when grading and buying fruits and vegetables. Therefore any loss in weight be it generic or induced will have direct implications on market acceptability and price. Mallardi and Hirst, 2010 reported that fruit development is characterised by an initial period of cell division and expansion, followed by continued cell expansion until harvest. Fruit size and weight, are influenced by the rate and duration of these phases and consequently has some effect on other quality attributes including firmness, dry matter and soluble solids content.

On the other hand loss of fruit weight and firmness, important quality factors for all perishables, are not solely dependent on cell wall metabolism but also on other factors such as water status (turgor pressure) and cuticle structure that also contribute to postharvest life (Saladie *et al.*, 2007). Saladie *et al.* emphasised that as turgor pressure

determined by water potential is an important component of weight and firmness quality, limiting water loss during storage is of manifest importance for overall quality maintenance. Therefore any postharvest condition that delays the rate of moisture loss also preserves the weight, firmness and other intrinsic qualities of the produce. Tapia *et al.*, 2007 reported edible coatings and films were able to preserve weight and moisture in fresh-cut fruits. Similar findings were observed by Chien *et al*., 2007 and Olivas *et al.*, 2003 with mangoes and pears respectively.

2.9 Consumer perceptions, purchase decision and acceptability of fruits and vegetables

Consumers' perception of quality is influenced by the product's intrinsic attributes as well as by extrinsic indicators and cues provided by the seller of the product (Caswell *et al.*, 2002). Some of the intrinsic attributes have been discussed earlier so now let's focus on the extrinsic attributes. These attributes are consumer evaluations and are more important from the marketing point of view. Sulé *et al.*, (2002) posits that perceived quality is understood as "a global or multidimensional valuation made by the consumer of a product who imbues it with expectations based on certain attributes conditioning his choice, which will differ from the evaluation of another consumer, given the moment, the type of product and the consumer's sociodemographic profile". Although human decision-making processes appear seemingly simple, they are very complex behaviours that are determined by numerous interacting factors and interrelated determinants.

The Total Food Quality Model states that consumers form quality expectations based on different attributes or cues which are traded off against each other before deciding whether or not to buy a food product and which product to choose (Engel and Blackwell, 1982). Attributes are thus to be considered as evaluative criteria from which

consumers form beliefs, develop attitudes and build up intentions. They are commonly classified in 'search', 'experience' and 'credence' attributes (Darby and Karni, 1973). Search attributes (e.g. appearance, price) can be ascertained before purchase, whilst many other product properties (i.e. experience and credence attributes) cannot. Experience characteristics (e.g. flavour, taste) can only be determined after consuming the food product. Credence properties (e.g. health and nutritional benefits) are a matter of credibility and trust and cannot be validated, neither before nor after trying the product (Brunsø *et al*., 2002). The relationship between quality expectations, formed before purchase, and quality experiences after consumption determines consumer satisfaction and hence the probability of repeated behaviour (Grunert, 2002). Now let us try to understand how each of these relates on consumer perceptions and purchase decisions.

2.9.1 Search attributes

Important search attributes for fruit selection are freshness, firmness, size, colour and smell. Visually appealing fruits may act as a prompt for purchase and consumption intentions (Dixon *et al.*, 2004). Batt (2004) investigated the criteria used by consumers for selecting fresh fruits from a retail store and concluded that expected overall fruit quality is generally more influential than price in ultimate purchase decisions. Nonetheless, price does play a significant role in consumers' intentions to purchase fresh and processed fruit products (Pollard *et al.*, (2002) and Yeh *et al.*, (2008)). Availability, packaging, convenience and brand are other search determinants often cited in literature to affect consumer food choices (Pollard *et al*., (2002) and Shaikh *et al*., (2008)).

2.9.2 Experience attributes

Pollard *et al.,* (2002) reviewed the factors affecting consumer food choices in relation to fruit intake, and found that sensory appeal - such as taste, texture and smell - is an essential prerequisite for consuming fruit. Harker *et al.,* (2003) showed that consumer preferences for apples are based on interactions between texture and taste. For example, people may prefer a sweet and hard apple, whereas others prefer juicy and acidic apples. The study by Lyly *et al.,* (2007) confirmed that taste plays a dominant role in the acceptance of a fruit product and strongly affects the willingness to consume the product. It is often assumed that sensory pleasure must be sacrificed to some extent in order to achieve a healthier diet and that consumers associate healthy food with less acceptable flavours. However Luckow and Delahunty (2004) demonstrated that consumers expect nutritious fruit juices to have good sensory quality. That is, fruit juices should be able to provide health benefits without compromising taste.

2.9.3 Credence attributes

Credence attributes (e.g. healthiness of food product, sustainability of production process) are a matter of credibility and trust; they cannot be discerned upon purchase or consumption (Brunsø *et al.,* 2002). Consumers may thus face difficulties to form quality expectations about the credence qualities of a food product. Therefore, credence characteristics of a food product are usually signalled to consumers through the use of extrinsic information cues, such as labels (Verbeke *et al.,* 2008). That is, labels provide consumers with information about the credence characteristics of a food product and help consumers to make better-informed food choices.

2.9.4 Attitudes, beliefs and familiarity

Consumers' choices and their decisions to eat fruits and derived fruit products are often underpinned by their beliefs, attitudes and perceptions towards this food category (Harker *et al*., 2003). In an earlier study, Cox *et al*., (1998) assessed attitudes, determinants of intention and barriers to increase fruit intake. The authors found that beliefs with respect to health, nutritional value, taste and cost are strongly associated with general attitudes towards fruit and with the intention to increase fruit consumption. Chéron and Hayashi (2001) determined familiarity as a composite measure of cognitive and behavioural experience, and found that the level of familiarity with a product or product category has a major impact on purchase behaviour. Past experiences can thus be considered as substantive predictors of later behaviour.

2.9.5 Socio-demographic characteristics

Many studies have emphasised socio-demographic characteristics as important determinants of fruit intake. Large variations exist in fruit intake according to gender, age, education, social position and place of living (Pollard *et al*., 2001, Granner *et al*., 2004, Kvaavik *et al*., 2005, Riediger *et al*., 2007). Pollard *et al*., (2002) investigated factors affecting fruit consumption among women in United Kingdom. Among this group of women, the higher fruit consumers were identified to be older, with a degree level of education and of higher socio-economic status. IARC (2003) indicated a similar fruit consumption pattern between men and women in Greece, Spain and Italy, whereas in Germany, Denmark, the Netherlands, Sweden and United Kingdom women have a higher fruit intake. Similarly, other studies indicated that social status impacts fruit consumption, with level of education and income being positively related to fruit intake (Turrell *et al*., (2002), Kvaavik *et al*., (2005) and Riediger *et al*., (2007)).

2.9.6 Social influences

The Theory of Planned Behaviour (Ajzen, 1991) has often been used to demonstrate the positive effect of subjective norm - which refers to the perceived social pressure to perform or not to perform a behaviour - on consumers' intention to eat fruit (Kvaavik *et al.*, (2005) and Blanchard *et al.*, (2009)). Similarly, results presented by Cox *et al.*, (1998) showed that social pressure is strongly associated with consumers' intention to increase fruit intake. Prättälä *et al.*, (2007) indicated that, in Finland, marital status is associated with fruit consumption: married Finns eat fruit more often than unmarried ones.

2.9.8 Consumers' perceptions and acceptability of edible coatings and films on fruits and vegetables

Since the introduction of edible coatings and films in the 1880's, there have been great concerns about its use in the food industry particularly with fruits and vegetables and demands for higher quality food products. This has led to great and extensive research, which is still ongoing, into the use of this preservation technology to alleviate or settle the fears of stakeholders in the food industry particularly consumers and retailers. The major objection or concern raised is on health grounds followed by others mostly on the economic and visual concerns.

2.9.8.1 Health and safety concerns

The use of edible coatings and films is grouped under a collective method known as modified atmosphere packages. However, a number of problems have also been associated with edible coatings and films. For example, modification of the internal gas composition of the product due to high CO_2 and low O_2 can cause problems such as

anaerobic fermentation of apples and bananas, rapid weight loss of tomatoes, elevated levels of core flush for apples, rapid decay in cucumbers, and so on (Park *et al.*, 1994). Again low O_2 levels inhibit the growth of most aerobic spoilage microorganisms whilst the growth of pathogens, especially the anaerobic psychrotrophic, nonproteolytic clostridia, may be allowed or even stimulated. Richert *et al.*, (2000) who, although not studying MAP, reported that *E. coli* O_{157}: H_7 could survive on produce (broccoli, cucumbers and green peppers) stored at 4°C (39.2°F) and proliferate rapidly when stored at 15°C. Very low O_2 atmospheres may instead trigger anaerobic metabolism in fresh-cut fruit and result in an increase in fermentation (Solomos, 1997). On the other hand, high CO_2 concentrations inhibit several enzymes of the Krebs' cycle (Soliva-Fortuny *et al.*, 2003). However, exposure to O_2 or CO_2 levels outside the limits of tolerance may lead to anaerobic respiration with the production of undesirable metabolites and other physiological disorders in fruits and vegetables (Soliva-Fortuny *et al.*, 2002). Most of these conditions have heightened the fears and concerns of consumers and retailers in the food industry.

2.9.8.2 Off-flavour appearance or development

All fruits and vegetables are living organisms and require an intake of O_2 and release of CO_2 for normal metabolism. Waxing restricts gas exchange through the peel and thus reduces internal O_2 levels and increases internal CO_2 levels. Low O_2 levels not only may stimulate anaerobic respiration and the production of compounds that impart off-flavours, but may also cause a peel disorder that severely reduces marketability. The incorporation of edibles coatings with nutraceuticals, antioxidants, anti-browning compounds, nutrients, probiotics, plasticizers and antimicrobial agents should not adversely affect consumer acceptance.

However the taste contributed by these ingredients has been considered to be particularly important, since many nutraceuticals compounds have natural bitter, astringent, or other undesirable off-flavours (Drewnowski and Gomez-Carneros, 2000) that can lead to unacceptable attributes in these products (LeClair, 2000). Han *et al.*, (2005) evaluated sensory attributes of fresh strawberries treated with chitosan-based edible coating material, with and without addition of vitamin E incorporated into the coating. Results from consumer testing 1 week after coating application indicated that all chitosan coatings evaluated increased the appearance scores of strawberries. On the other hand however, the incorporation of vitamin E reduced the glossiness of coated strawberries, which could affect consumer acceptance.

This problem can also occur when pure shellac is the waxing ingredient. When the temperature gradient between the commodity and ambient air is large, sweating is induced on the product surface. The condensation of the moisture causes the shellac to become partly solubilized and subsequently results in white deposits that are translucent in appearance. Heavy shellac coatings tend to aggravate the problem. Whitening may also occur when too much residual moisture is present during waxing. Whey protein films plasticized with sucrose have excellent oxygen barrier properties and display high gloss; however, sucrose tends to crystallize with time and lose its properties (Dangaran and Krochta, 2007). Some consumers prefer the natural colour and appearance of the commodity rather than a shinny, waxed product. Waxing may be construed by these consumers as a type of alteration in the product, changing the real external appearance into something more artificial.

2.9.8.3 Allergic responds and dietary consideration

Four basic materials used for edible films are lipids, resins, polysaccharides and proteins, to which a variety of antimicrobials, plasticizers and texturizers are added. Compounds most commonly used to form edible coatings include chitosan, starch, cellulose, alginate, carrageenan, zein, gluten, whey, carnauba, beeswax, gluten, soy proteins and fatty acids. The materials that have received the greatest attention for edible films use are cellulose ethers, starch, hydroxypropylated starch, corn zein, wheat gluten, soy protein and milk proteins.

Since it is not mandatory for food processors to indicate the ingredient content and composition of the edible coating and film on pre-packaged fresh fruits or vegetables that are packaged in a wrapper or confining band of less than ½ inch in width, it raises serious health concerns for consumers and the general public with allergy and food intolerance concerns (www.cpma.ca). Some consumers have wheat gluten intolerance (Celiac Disease), milk protein allergies, or lactose intolerance whilst others are vegetarians and vegans whose produce should be free from animal and animal products. Again the lack of such information also has religious implications (Muslims with respect with the use of pork and pork products).

Use of such films as coatings on foods must be declared appropriately to the consumer, no matter how small the amount used (Druchta and Johnston, 1997). Although labelling of such foods is not a legal requirement because these products are exempted from carrying a label, such actions can help reduce some of the perceptions of the general public.

2.9.8.4 Cost and availability

Waxing adds cost to the commodity and slightly extends the time required to prepare the product for market. The added costs are due to the extra labour and/or equipment needed to apply and dry the wax, along with the cost of the wax material and the storage environment (PHTB, 2004).

To maintain product safety and eating quality, all film-forming components, as well as any functional additives in the film-forming materials, should be food-grade, nontoxic materials; further, all process facilities should be acceptable for food processing and should strictly observe current Good Manufacturing Practice (cGMP) (Guilbert *et al.*, 1996; Guilbert and Gontard, 1995 and Han, 2002). Ingredients acceptable for use in edible films and coatings should be generally recognised as safe (GRAS), and used within any limitations specified by the Food and Drug Administration (FDA). Further studies on edible films coating should put the light to the important steps to consider when commercializing edible films coating, which are to evaluate sensory attributes of integrated coated products, to properly label ingredients of edible films coating with a focus on marketing the natural ingredients added and to target marketing strategies to advertise direct consumer benefits of the resulting edible film coating products (Wan *et al.*, 2007).

CHAPTER THREE

3.0 METHODOLOGY

3.1 Introduction

This section explains the methods and approaches applied in achieving the research objectives. Following the discussions in the literature review and the establishment of a sound foundation on the fruit, the threat posed to its consumption by postharvest perception and some of the conventional methods used to manage them, a pragmatic approach was adopted for the conduct of this study and each objective was tackled by adopting approaches used in previous studies. Modifications were made where necessary.

3.2 Sampling technique and sample size

The cucumber variety used in this study is the Ashley Variety, which is one of the most popular varieties aside Poinsett cultivated by farmers in Ghana. Physiologically matured fruits of uniform size, shape with no defects were selected for the experiments. All cucumber fruits used in the experiment were cultivated on the University of Ghana School Farm from October 2013 to June 2014. Completely Randomized Design (CRD) was used to select the fruits into plots with each plot containing ten (10) fruits. Each plot was replicated three (3) times. All experiments were conducted in the Physiology Laboratory and the Screen House in the Crop Science Department of the College of Agriculture and Consumer Sciences in the University of Ghana, Legon, Ghana.

3.3 Types and Sources of Data

The study used primary data obtained from the experiments carried out in the laboratory and screen house. However ideas and information from published works were also used to confirm or otherwise, of observations made in the course of the work.

3.4 Scope and Limitations of the study

Quality is very essential in the fruit and vegetable markets. It is very difficult to meet all the quality attributes required by consumers particularly in Ghana where there are no specific quality standard and enforcement for the cucumber industry. The different groups of consumers and their diverse uses for the fruit was also a major concern during the research. This young fruit industry produces barely enough to meet all the demands of the population. The sales points are also very scattered in many markets which make locating traders and consumers of this commodity rather challenging. As a young industry now developing the use and adoption of new improved technologies on the fruits is also not very well established. Hence the use of waxing materials both organic and synthetic is not so widely used. Locating users of such technology to obtain information about its use was not easy. Cucumber being a perishable fruit and very sensitive to high temperature and ethylene, makes storing this fruit in the warm tropical condition like Ghana a very challenging thing. The use of locally available materials such as beewax, coconut, palm, soya bean and other vegetable oils, shea butter and cassava starch can all be used to prolong the shelf life and preserve quality of food commodities.

The use of such locally available wax materials in the postharvest chain is very crucial for the farmer, trader and the consumer as a whole. The loss of fruits and vegetables be it through fruit rejection by consumers or by spoilage, is a great loss of income, efforts,

resources and livelihoods. The study therefore focused on practical, simple and convenient approaches that can easily be adopted by these stakeholders to maintain if not extend commodity shelf life and quality in the postharvest chain.

3.5 Knowledge and perception about waxed fruits and vegetables among consumers and traders in Accra.

Semi-structured questionnaires was designed and administered to traders and consumers of cucumber in the some selected markets in Accra. 50 consumers each was interviewed from both supermarkets and traditional markets. Considering the fact that supermarkets that sell fresh fruits and vegetables in Accra are few, snowball sampling approach was used to get as many of them as possible. The supermarkets and retailers visited include MaxMart, Shoprite, Koala, Marina Mall, Quick 'N' Fine, Timen's Farmers market, Palace, Sneda, Fruit Master and Eden Foods Limited. About 50 willing traders and consumers each were interviewed from the traditional markets visited include Madina, Okaishie, Kantamanto and Agbogbloshie Markets. Notwithstanding traders in the supermarkets, all other respondents were selected on random. Respondents were questioned on their demographics, purchase decision, fruit quality expectations, experiences with waxed fruits and their overall perception about waxed fruits.

3.6 Effect of the wax materials on the physico-chemical and organolepticquality attributes of cucumber fruits.

Laboratory experiments were conducted in the Physiology Laboratory and Screen House in cold storage and room temperature conditions i.e. (20–22^{O}C and 80–85% RH) and (30–32^{0}C and 60–65% RH) respectively. Four (4) wax materials used are coconut

oil, shea butter, synthetic food grade wax (vegetable glycerine), coconut oil-shea butter combination (1:1) and control under cold temperature storage and ambient room temperature conditions. A 5 x 2 factorial experiment layout in Complete Randomized Design with 10 treatment combinations was deployed. Ashley cucumber variety was cultured in the school farm of the University of Ghana. Physiologically matured fruits of uniform sizes, shape, free from diseases and defects were used. Fruits were washed in chlorinated water, air dried and divided into 10 slots with each slot containing 10 fruits. Each treatment was replicated three times.

With the exception of shea butter and bee wax which were solid at room temperature, the remaining waxes were manually rubbed on the fruit surface using soft cotton. Shea butter and bee wax were melted before rubbing on the fruits. The waxed fruits were air dried at room conditions. The control fruits were also waxed with distilled water and placed in their appropriate trays after which they were stored under the required storage conditions. The effects of the various wax materials on the quality attributes of the fruits were recorded over a 28 day period (0, 7, 14, 21 and 28 days). The quality attributes recorded over the period were weight loss (WL), colour change (CC), fruit firmness (FF), pH, total soluble solids (TSS), total titratable acid (TTA) and shelf life (SL).

3.6.1 Data Collection

Fruits were selected at random from each treatment lot on every data day (0, 7, 14, 21 and 28).

3.6.1.1Percentage Weight Loss (% WL) Determination

About 3 fruits in each plot were selected and marked at random and used to determine the weight loss for the period. The initial weights of the fruits were determined (at day 0) using Benson Electronic Balance (± 0.01g) at room temperature and subsequently at day 7, 14, 21 and 28. Three different readings were taken with their simple averages computed. The percentage weight loss (%) was computed using the equation:

$$\mathbf{WL}\ (\%) = \frac{\boldsymbol{Wo} - \boldsymbol{Wi}}{\boldsymbol{Wo}} \times \mathbf{100}$$

WL (%) = Percentage weight loss over a period

$\boldsymbol{Wo}$ = Initial weight of fruit (Day 0)

$\boldsymbol{Wi}$ = Finial weight of fruit (Days 7, 14, 21and 28)

3.6.1.2 Colour Change (CC) Determination

The same 3 marked fruits randomly selected were used for the colour changed. Changes in the external skin colour of the 3 fruits were taken from the equator region using a reflectance colorimeter. Three different readings were taken and the average score computed.

3.6.1.3 Fruit Firmness (FF) Determination

A fruit each was selected at random for each treatment lot and used for determining their firmness by using a hand penetrometer (Interest Benelux Model FT011 ± 1% max value) as directed by the manufacturer's instructions. Three different readings were taken from the equator region of each fruit and the averages computed.

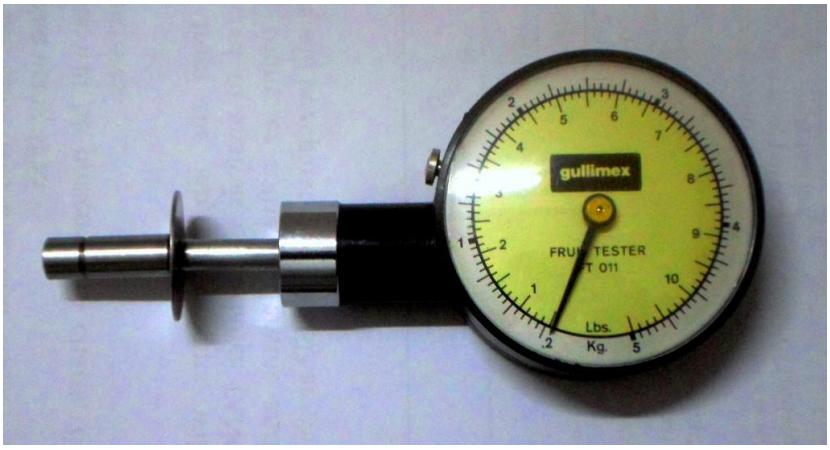

Plate 1: Interest Benelux Hand Penetrometer

Juice Preparation: After fruit firmness has been measured with the hand penetrometer, the same fruit was washed off all the wax traces. About 100g of the fruit was weighed, cut into pieces and placed into a blender. About 50mls of distilled water was added, blended and the juice extracted. The juice extract was then used to determine the pH, TSS and TTA.

3.6.1.4 Total Soluble Solids (TSS) Determination

Aliquots of the juice were used to determine the TSS. A bench top refractometer (Hanna Instrument (HI) Model 96801, ± 0.02% Brix / ± 0.03◦C) with a range 0 – 85% Brix was used to determine TSS by placing 3 – 4 drops of the fine juice on the prism. Three different readings were recorded at room temperature and the average TSS value computed.

Plate 2: A Bench Top HI Refractometer

3.6.1.5 pH Determination

The aliquots of the fruit juices from the various treatment combinations were tested for their pH level using digital pH meter at room temperature (Symphony pH meter, Model SB70P). The measurements were done according to manufactures instructions at 25◦C room temperature. At least 3 reading was taken per plot and the means were computed.

Plate 3: Symphony Digital pH meter

3.6.1.6 TTA Determination (TTA)

About 10mls of the juice was measured and poured into a beaker. About 50mls of distilled water was added to the juice and titrated against 0.1M solution of NaOH until a pH of 8.0 is recorded. The titre value was recorded. Three (3) more readings were obtained and means computed. The percentage acidity was computed from the equation below.

$$\%\ \boldsymbol{Acidity} = \frac{\textbf{Titre} \times \textbf{acid factor} \times \textbf{100}}{\textbf{10}(\boldsymbol{ml\ juice})}$$ Citric Acid Factor is **0.0064**

3.6.1.7 Shelf Life Determination (SL)

Three (3) fruits per treatment were marked and used for determining the shelf life for each treatment. SL was determined as the number of days for the marked fruits to show a minimum of 25% yellowness of external skin colour. The average of the days was computed as the shelf life for the fruits.

3.7 Consumer acceptability of fruits waxed with the different waxing materials.

Semi-structured questionnaires were used to collect data on consumer acceptability of cucumber fruits treated with different waxing materials at storage. The questionnaires addressed issues pertaining to consumers' willingness to accept cucumber that has been waxed. A panel of ten assessors were selected from the college and asked to assess the visual quality of cucumber fruits that have been treated with different waxing materials after seven (7) days of storage. Samples were coded per treatment and assessed by each member of the 10 panelists for the sensory evaluation. A five-point Hedonic scale was used to score samples for skin colour, attractiveness, firmness, smell / aroma and overall acceptability.

3.8 Data Analysis

This section deals with the approaches used to scrutinise the collected data so as to answer the objectives of this research. The data collected on consumer and trader perceptions of waxed fruits and vegetables, effects of the waxing materials on the quality attributes of the cucumber fruits as well as the sensory evaluation results were compared with that found in literature.

Completed questionnaires were coded and analysed using SPSS software, frequencies and cross tabulations after administering. The collected data on all experiments were subjected to analysis of variance (ANOVA) using GenStat and where means were significant they were separated using LSD at 5%. The results or findings to the objectives of this research have been presented using tables, graphs and pictures for easy appreciation and understanding.

CHAPTER FOUR

4.0 RESULTS

4.1 Introduction

This section analyses and discusses all the issues regarding knowledge and perceptions of waxed fruits particularly cucumber fruits among retailers / traders and consumers in Accra and how some locally available materials in Ghana can be used as waxing materials. The methodologies discussed in the previous chapter are applied to collected data, to verify the outcome and the results are explained accordingly. The findings are presented in manner such that they follow the order of the objectives of the study.

4.2 Knowledge and perceptions about fruit waxes, particularly waxed cucumber fruits, among traders and consumers in Accra.

Under this objective, the study seeks to establish the knowledge and level of perception of consumers and traders of fruits and vegetables concerning fruit waxes under the two market environments in Accra. It seeks to establish a trend or relationship between the demographics of the respondents and their knowledge and perception about waxed fruits and vegetables in Accra during the research period.

4.2.1 Demographics of respondents

This section looks at how the demographical characteristic of the respondents are distributed in terms of gender, age, marital status, number of dependents and their educational level. These dynamics affect the results and hence they are key in understanding the knowledge and perception base of the respondents concerning wax and waxed fruits and vegetables.

4.2.1.1 Demographics of cucumber consumers

4.2.1.1.1 Gender of consumers

A total of 100 consumers of cucumber were interviewed from both the traditional open markets and supermarkets in Accra. From the results, the majority of respondents were females accounting for 84% whilst males accounted for 16%. 46 females and 4 males were interviewed from the open markets whilst as 38 females and 12 males were interviewed from the supermarkets (Table 4.2.1.1a).

Table 4.2.1.1a. Gender distribution of cucumber consumers from different markets.

	Open Market		Supermarket		Consumer Total	
Gender	Frequency	Percentages (%)	Frequency	Percentage (%)	Frequency	Percentage (%)
Male	4	8	12	24	16	16
Female	46	92	38	76	84	84
Total	50	100	50	100	100	100

4.2.1.1.2 Age of consumers

From the results most consumers (51%) were between the ages of 31 and 40 years. The least age group of consumers (51 – 60 yrs.) was recorded to be 5% of the total consumers interviewed. All respondents from the open market had ages above 21years and below 41 years whilst their counterpart from the supermarkets have over 95% of their ages between 21 and 50 years respectively (Table 4.2.1.1b).

Table 4.2.1.1b. Age distribution of cucumber consumers from different markets.

	Open Market		Supermarket		Consumer Total	
Age (yrs.)	Frequency	Percentage (%)	Frequency	Percentage (%)	Frequency	Percentage (%)
21- 30	23	46	0	0	23	23
31- 40	27	54	24	48	51	51
41- 50	0	0	21	42	21	21
51- 60	0	0	5	10	5	5
Total	50	100	50	100	100	100

4.2.1.1.3 Marital status of consumers

Of respondents from the open markets, 48% were married whilst 32% and 20% of the remaining were either single or divorced respectively. 84% of consumers from supermarkets were married, 12% divorced and 4% were not married. Majority of all respondents (82%) were either married or divorced (Table 4.2.1.1c).

Table 4.2.1.1c. Marital status of cucumber consumers from different markets

	Open Market		Supermarket		Consumer Total	
Marital status	Frequency	Percentage (%)	Frequency	Percentage (%)	Frequency	Percentage (%)
Single	16	32	2	4	18	18
Married	24	48	42	84	66	66
Divorced	10	20	6	12	16	16
Total	50	100	50	100	100	100

4.2.1.1.4 Dependency level of consumers

Seventy-seven percent (77%) of all consumers interviewed had at least one dependant and 23% did not have any dependents. Majority of consumers (92%) from the open markets had not more than 2 persons who relied on them for support as compared to 80% with those from the supermarkets (Table 4.2.1.1d).

Table 4.2.1.1d. Dependency levels of cucumber consumers from different markets.

	Open Market		Supermarket		Consumer Total	
Dependant No.	Frequency	Percentage (%)	Frequency	Percentage (%)	Frequency	Percentage (%)
0	18	36	5	10	23	23
1	11	22	16	32	27	27
2	17	34	19	38	36	36
3	4	8	5	10	9	9
4	0	0	5	10	5	5
Total	50	100	50	100	100	100

4.2.1.1.5 Educational level of consumers

From the results, all supermarket consumers interviewed had at least secondary education. 54% of consumers of open markets had basic education as the highest level

of education attained whilst 8% had tertiary education as the highest level attained. Over 95% of all respondents interviewed had at least a basic education (Table 4.2.1.1e).

Table 4.2.1.1e. Educational level of cucumber consumers from different markets.

	Open Market		Supermarket		Consumer Total	
Educational Level	Frequency	Percentage (%)	Frequency	Percentage (%)	Frequency	Percentage (%)
No formal Education	3	6	0	0	3	3
Basic Education	27	54	0	0	27	27
Secondary Education	16	32	5	10	21	21
Tertiary Education	4	8	45	90	49	49
Total	50	100	50	100	100	100

4.2.1.2 Demographics of cucumber retailers

4.2.1.2.1 Gender of retailers

Out of a total of 60 retailers interviewed, 73% and 26.7% were females and males respectively. However more females (76%) were interviewed in the open markets than in the supermarkets (60%). On the other hand, male retailers in the supermarkets were more, accounting for 40% as against those in the open markets (24%) (Table 4.2.1.2a).

Table 4.2.1.2a. Gender distribution of cucumber retailers from different markets

	Open Market		Supermarket		Retailers Total	
Gender	Frequency	Percentages (%)	Frequency	Percentages (%)	Frequency	Percentages (%)
Male	12	24	4	40	16	26.7
Female	38	76	6	60	44	73.3
Total	50	100	10	100	60	100.0

4.2.1.2.2 Age of retailers

All retailers interviewed were above 21 years of age. However the youngest retailer interviewed from the supermarkets was at least 31 years old. 92% of retailers from the

open markets were between the ages of 31 and 50 years old whereas all retailers (100%) from the supermarkets fell within this age range.

Table 4.2.1.2b. Age distribution of cucumber retailers from different markets

	Open Market		Supermarket		Retailers Total	
Age (yrs.)	Frequency	Percentage (%)	Frequency	Percentage (%)	Frequency	Percentage (%)
21-30	4	8	0	0	4	6.7
31-40	24	48	5	50	29	48.3
41-50	22	44	5	50	27	45.0
Total	50	100	10	100	60	100.0

4.2.1.2.3 Marital status of retailers

The frequencies of the marital status of retailers were as follows: 4 were single, 26 were married and divorced and widowed were 16 and 4 respectively. At the supermarkets, 90% and 10% were either married or single. Married or divorced retailers of cucumber accounted for a total of 85% of the total retailers interviewed in Accra.

Table 4.2.1.2c. Marital status of cucumber retailers from different markets

	Open Market		Supermarket		Retailers Total	
Marital status	Frequency	Percentage (%)	Frequency	Percentage (%)	Frequency	Percentage (%)
Single	4	8	1	10	5	8.3
Married	26	52	9	90	35	58.3
Divorced	16	32	0	0	16	26.7
Widowed	4	8	0	0	4	6.7
Total	50	100	10	100	60	100.0

4.2.1.2.4 Dependency level of retailers

All retailers from the open markets had at least 1 dependant whilst those from the supermarkets had at most 2 dependents. Out of 100 retailers interviewed 1.7%, 31.7%, 26.7%, 16.7% and 23.3% of them had 0, 1, 2, 3 and 4 dependents respectively.

Table 4.2.1.2d. Dependency level of cucumber retailers from different markets.

	Open Market		Supermarket		Retailers Total	
Dependant No.	Frequency	Percentage (%)	Frequency	Percentage (%)	Frequency	Percentage (%)
0	0	0	1	10	1	1.7
1	14	28	5	50	19	31.7
2	12	24	4	40	16	26.7
3	10	20	0	0	10	16.7
4	14	28	0	0	14	23.3
Total	50	100	10	100	60	100.0

4.2.1.2.5 Educational level of retailers

The highest level of education attained by retailers in the open markets was secondary education whilst 44% of them had no formal education. Whereas the minimum educational level attained by retailers in the supermarkets was secondary education (40%). Majority of all retailers interviewed (63.3%) had had at least a basic education.

Table 4.2.1.2e. Educational level of cucumber retailers from different markets

	Open Market		Supermarket		Retailers Total	
Educational Level	Frequency	Percentage (%)	Frequency	Percentage (%)	Frequency	Percentage (%)
No formal Education	22	44	0	0	22	36.7
Basic Education	12	24	0	0	12	20.0
Secondary Education	16	32	4	40	20	33.3
Tertiary Education	0	0	6	60	6	10.0
Total	50	100	10	100	60	100.0

4.2.2 Experience and purchase decision of respondents

Under this section the experience of respondents is established. For consumers, the researcher wanted to know how often consumers went shopping, what produce was often bought and what informed their decision to buy or not to buy notwithstanding the price as a factor for their choice. Retailers however provided answers based on how

long they had been in business and how their experiences affected their purchase decision of commodities regardless of the prices.

4.2.2.1 Shopping experience of consumers

4.2.2.1.1 Shopping frequency of consumers

From the table below 76% and 18% of the consumers in the open markets went shopping weekly and fortnightly whilst that from the supermarkets was 50% and 40% respectively. 92% of all consumers shopped at least once every fortnight.

4.2.2.1a. Shopping frequency of cucumber consumers from different markets

	Open Market		Supermarket		Consumer Total	
Shopping Frequency	Frequency	Percentage (%)	Frequency	Percentage (%)	Frequency	Percentage (%)
Weekly	38	76	25	50	63	63
Forth Nightly	9	18	20	40	29	29
Monthly	3	6	5	10	8	8
Total	50	100	50	100	100	100

4.2.2.1.2 Commodities often purchased by consumers

All consumers interviewed purchased vegetables with 33% of them buying vegetables only and 67% buying both vegetables and fruits often. Majority (66%) of consumers from the open markets bought vegetables only with 34% opting for both vegetables and fruits. However the reverse occurred with their counterpart in the supermarkets as shown in the Table 4.2.2.1b.

Table 4.2.2.1b. Commodities / produce often purchased by cucumber consumers from different markets

	Open Market		Supermarket		Consumer Total	
Produce often purchased	Frequency	Percentage (%)	Frequency	Percentage (%)	Frequency	Percentage (%)
Vegetables	33	66	0	0	33	33
Fruits and vegetables	17	34	50	100	67	67
Total	50	100	50	100	100	100

4.2.2.1.3 Cucumber purchasing frequency by consumers from different markets

From the table below, out of a total of 100 consumers interviewed 92 representing 92% bought cucumber at least every fort night from the market with only 8 (8%) of them shopping for cucumber once every month. 94% and 92% of open market and supermarket consumers bought cucumber at least every fortnight respectively.

Table 4.2.2.1c. Cucumber purchasing frequency of consumers from different markets

	Open Market		Supermarket		Consumer Total	
Cucumber purchase Frequency	Frequency	Percentage (%)	Frequency	Percentage (%)	Frequency	Percentage (%)
Weekly	36	72	20	40	56	56
Forth Nightly	11	22	25	50	36	36
Monthly	3	6	5	10	8	8
Total	50	100	50	100	100	100

4.2.2.1.4 Variety purchased, quality expectations and ranking of cucumber quality attributes at purchase by consumers from different markets

All respondents interviewed did not know which particular variety of cucumber was purchased by them. They however indicated that they bought both local and imported varieties displayed at sales point. They all agree that cucumber fruit size, shape, texture / firmness, glossiness and skin colour were some of the major quality attributes that

informed their decision to purchase aside the commodity prize. Consumers of open markets ranked skin colour, fruit size and fruit glossiness as the most important quality attributes that informed their decision to purchase scoring 34%, 30% and 17% respectively. Those from supermarkets scored skin colour, fruit size and texture / firmness (33%, 22% and 17%) as the most important quality attributes that informed their decision to purchase as shown in Figure 4.2.2a.

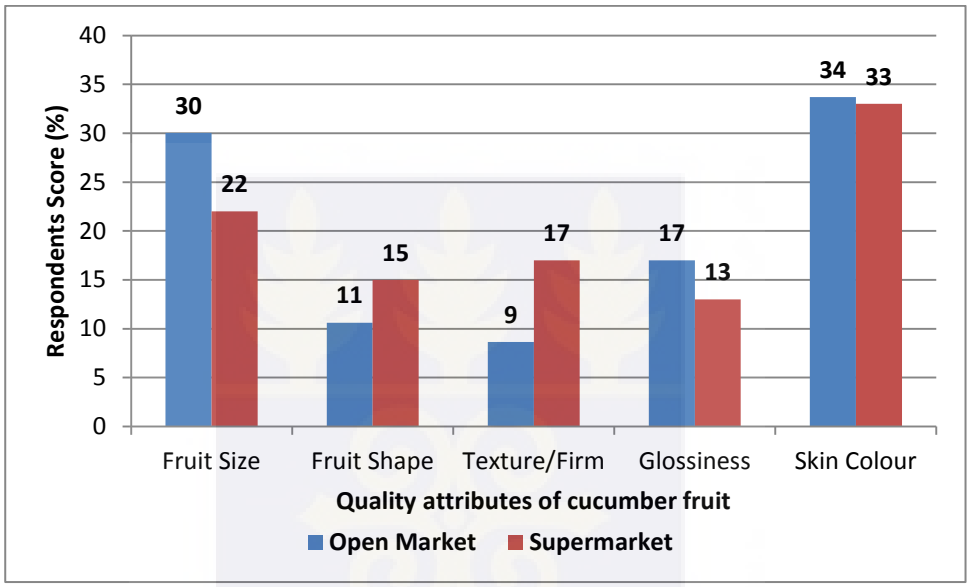

Figure 4.2.2a: Ranking of cucumber quality attributes at purchase by consumers from different markets.

4.2.2.2 Work / Purchasing experience of retailers

4.2.2.2.1 Work experience of retailers

From table 4.2.2.2a, all retailers of cucumber from the open markets had at least sold cucumber for over 3 years. The majority (52%) of the retailers had over 9 years of experience whilst the least years of experience were between 7 and 9 years. However only 1 retailer had either less than 3 or over 9 years of experience in trading cucumber in the supermarkets. The majority of the retailers (80%) had between 4 to 9 years of

working experience in retailing cucumber in the supermarkets. Over 97% of all retailers had a minimum of 4 years working experience in retailing cucumber in Accra.

4.2.2.2a. Work experience of cucumber retailers from different markets

	Open Market		Supermarket		Retailers Total	
Work Experience	Frequency	Percentage (%)	Frequency	Percentage (%)	Frequency	Percentage (%)
1 – 3	0	0	1	10	1	2
4 – 6	14	28	6	60	20	33
7 – 9	10	20	2	20	12	20
> 9	26	52	1	10	27	45
Total	50	100	10	100	60	100

4.2.2.2.2 Other produce sold by retailers

All retailers in the open markets sold vegetables only whilst those from the supermarkets sold both fruits and vegetables. Of the 60 retailers interviewed 83.3% and 16.7% sold vegetables only, and both fruits and vegetables respectively.

Table 4.2.2.2b. Other produce sold by cucumber retailers from different markets

	Open Market		Supermarket		Retailers Total	
Other produce sold	Frequency	Percentage (%)	Frequency	Percentage (%)	Frequency	Percentage (%)
Vegetables	50	100	0	0	50	83.3
Fruits and vegetables	0	0	10	100	10	16.7
Total	50	100	10	100	60	100.0

4.2.2.2.3 Varieties and source of produce purchased and sold by retailers from different markets

All retailers interviewed from both markets sold different varieties of cucumber. Six retailers interviewed from the local markets indicated that they obtained their produces from other local markets whilst the remaining 44 obtained theirs directly from local

importers or from other retailers in other local markets. All retailers from the supermarkets get their produces from local suppliers or retailers and imports (Table 4.2.2.2c)

Table 4.2.2.2c. Source of produce sold by cucumber retailers from different markets

	Open Market		Supermarket		Retailers Total	
Produce Source	Frequency	Percentage (%)	Frequency	Percentage (%)	Frequency	Percentage (%)
Local market	6	12	0	0	6	10
Imports and local Market	44	88	10	100	54	90
Total	50	100	10	100	60	100

4.2.2.2.4 Quality expectations and ranking of cucumber quality attributes at purchase by retailers from different markets

All retailers agree that cucumber fruit size, shape, texture / firmness, glossiness and skin colour were some of the major quality attributes that inform their purchase decision aside commodity prize. Retailers of open market ranked skin colour, fruit size and fruit glossiness as the most important quality attributes that inform their purchase decision scoring 36%, 26% and 20% respectively. Those from supermarkets scored skin colour, glossiness and texture / firmness (33%, 25% and 20%) as the most important quality attributes that inform their purchase decision as shown in Figure 4.2.2.1b.

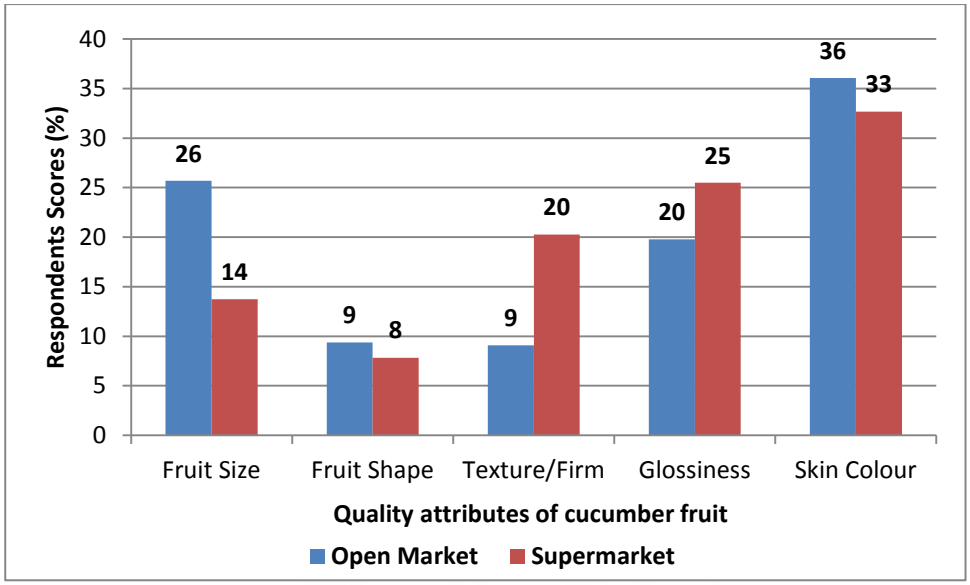

Figure 4.2.2b: Ranking of cucumber quality attributes at purchase by retailers from different markets.

4.2.3 Respondents perception about wax and waxed fruits

Respondents in this section were required to provide responses pertaining to their awareness of wax as a preservation media and method, their experiences with any waxed produce, willingness to buy and consume any waxed product particularly cucumber and to provide some explanation for their choice of willingness.

4.2.3.1 Consumers perception about wax and waxed produces / products

4.2.3.1.1 Consumers awareness of wax and waxed fruits and vegetables

All consumers interviewed were not aware that fruits and vegetables and for that matter cucumber in particular can be waxed. They also claim they have neither bought nor consumed waxed produces (fruits and vegetables) before.

4.2.3.1.2 Consumers' willingness to buy and consume waxed fruits and vegetables and explanations

From Table 4.2.3.1a, 68% of the consumers indicated willingness to purchase and consume waxed fruits and vegetables whilst 32% were unwilling to purchase waxed produce. A similar response (70% for "Yes" and 30% for "No") was given from consumers of the supermarkets. The majority of respondents (69%) responded in the affirmative to being willing and ready to purchase and use waxed produces. Some of the reasons provided for their choice were that waxed produce / product should be safe from chemical residues such as insecticides, pesticides, etc. The coated produce should not increase the cost of the product. Another concern was that the waxed produce must meet the expected physical quality attributes of cucumber fruit such as colour, odour / aroma and taste.

Table 4.2.3.1a:Consumers' willingness to buy and consume waxed fruits and vegetables

	Open Market		Supermarket		Consumer Total	
Willingness response	Frequency	Percentage (%)	Frequency	Percentage (%)	Frequency	Percentage (%)
Yes	34	68	35	70	69	69
No	16	32	15	30	31	31
Total	50	100	50	100	100	100

4.2.3.1.3 Consumers quality expectations of waxed cucumber fruits

The quality expectations of waxed cucumber fruits included improved texture / firmness, appearance / glossiness, skin colour, extend shelf life and reduce spoilage of fruits. From Figure4.2.3a, consumers at the open market scored improved skin colour (33.6%), appearance / glossiness (32.1%) and extended shelf life (12.4%) as the three most important quality attributes expected of waxed cucumber fruits. Improved skin colour, improved appearance / glossiness and improved texture / firmness had the three

highest percentage score of 35%, 25.7% and 24.8% respectively by consumers from supermarkets.

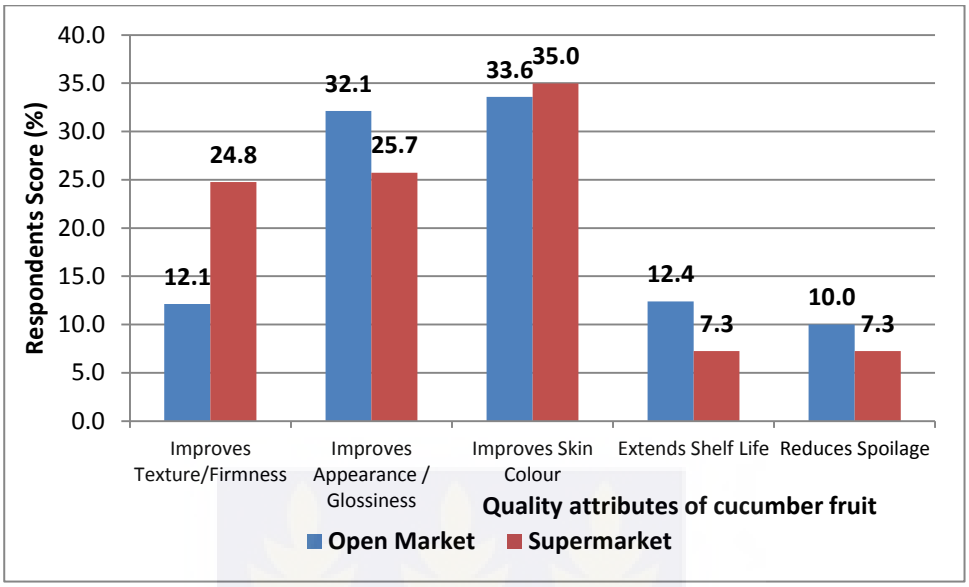

Figure 4.2.3a: Ranking of quality expectations of waxed cucumber fruits by consumers from different markets.

4.2.3.2 Retailers perception about wax and waxed produces / products

4.2.3.2.1 Retailers awareness of wax and waxed fruits and vegetables

All retailers interviewed were not aware that fruits and vegetables and for that matter cucumber in particular can be waxed. The retailers indicated that they neither bought nor waxed their produces (fruits and vegetables) before selling. However during field visits, some imported waxed fruits were on display for sale. When the retailers' attention was drawn to this they claimed they had no knowledge and training on how to detect such waxed produces or products.

4.2.3.2.2 Retailers' willingness to buy and sell waxed fruits and vegetables and explanations

From Table 4.2.3.2a, 84% of open market retailers indicated willingness to purchase and sell waxed fruits and vegetables whilst 16% were unwilling to purchase. A similar response (60% for "Yes" and 40% for "No") was given from retailers of the supermarkets. The majority of respondents (80%) responded in the affirmative to being willing and ready to purchase and sell waxed produce. Some of the reasons provided for their choice were that waxed produce / product should be safe from chemical residues such as insecticides, pesticides, etc. Again the retailer should incur very marginal cost in acquiring wax materials, labour and time in waxing and maintaining waxed produce. Furthermore the wax material should be approved by the regulatory authorities and waxed products must be acceptable by consumers in terms of colour, odour / aroma and taste. It should add value to the produce.

Table 4.2.3.2a: Retailers' willingness to buy and sell waxed fruits and vegetables

	Open Market		Supermarket		Retailers Total	
Willingness response	Frequency	Percentage (%)	Frequency	Percentage (%)	Frequency	Percentage (%)
Yes	42	84	6	60	48	80
No	8	16	4	40	12	20
Total	50	100	10	100	60	100

4.2.3.2.3 Retailers quality expectations of waxed cucumber fruits

Retailers' quality expectations of waxed cucumber fruits included improved texture / firmness, appearance / glossiness, skin colour, extended shelf life and reduced spoilage of fruits. From Figure 4.2.3b, retailers at the open market scored extended shelf life (35.4%), improved skin colour (24.5%) and appearance / glossiness (24.5%) as the three most important quality attributes expected of waxed cucumber fruits. Improved

skin colour, improved appearance / glossiness and improved texture / firmness had the three highest percentage score of 33.3%, 26.7% and 25.86% respectively by retailers from supermarkets.

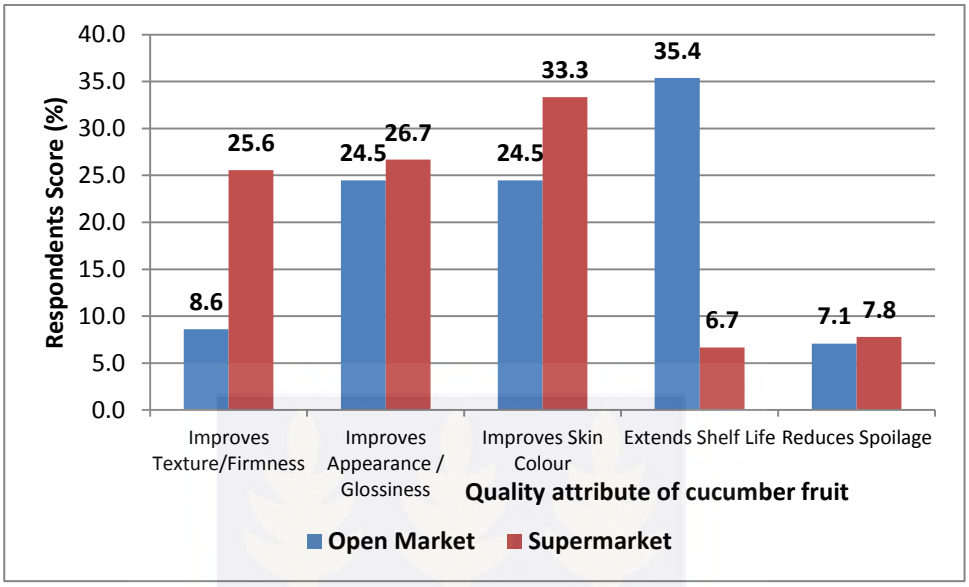

Figure 4.2.3b: Ranking of quality expectations of waxed cucumber fruits by retailers from different markets.

4.2.4 Cross tabulation analysis of respondents' demographics and study variables

Cross tabulation analysis of the association between demographic variables and study variables (i.e., fruit quality expectations, wax awareness, willingness to wax and waxed fruit quality expectations) were examined for meaningful relationships using chi-square test. The study seeks to investigate if there are any significant relationships between respondents' demographic characteristics and their knowledge, perception and expectations of wax and waxed fruits and vegetables.

4.2.4.1 Cross tabulation analysis of consumers' demographics and study variables

Consumers' demographic characteristics are cross tabulated against their responses concerning knowledge, perceptions and quality expectations of wax and waxed fruits

and vegetables in the two different market conditions to establish the relationship among them and how this relationship influenced the consumers' decisions. Chi-square test was used to determine any significant difference that exists among the demographic characteristics and the consumers' variables.

4.2.4.1.1 Cross tabulation analysis of open market consumers' demographics and study variables

4.2.4.1.1.1 Open market consumers' demographics and fruit quality expectations

From the previous section it has been established that fruit skin colour and fruit size are the most and least quality attributes that influence consumer purchase decision. From Table 4.2.4.1.1a, 2 males representing 11.8% and 15 females representing 88.2% opted for fruit skin colour, whilst a male and 3 females opted for texture. The majority of consumers aged between 21 and 30 years consider fruit skin colour (9, 52%) more when purchasing whilst they consider fruit texture as the least (2, 50%). Similar observation can be drawn from those aged between 31-40yrs. Married consumers considered fruit skin colour (9, 52.9%) than single and divorced respondents (5, 29.4% and (3, 17.6%) respectively. Out of 17 consumers who considered skin colour 5 (29.4%) have 0, 1 and 2 dependants each whilst 2 (11.8%) have 3 dependants. Consumers who prefer skin colour most, 10 (58.8), 4 (23.5%), 2 (11.8) and 1 (5.9%) had basic, secondary, tertiary and no formal education respectively. There is no significant difference between demographics and fruit quality expectation.

Table4.2.4.1.1a Cross tabulation analysis of open market consumers' demographics and fruit quality expectations

Demographic Variables		Fruit quality expectations						X^2
		FSz *f* (%)	FS *f* (%)	T't/Fm *f* (%)	Ap/Gl *f* (%)	SC *f* (%)	Total *f* (%)	
Gender	Male	1 (6.7)	0 (0)	1 (25)	0 (0)	2 (11.8)	4 (8)	3.152
	Female	14 (93.3)	10 (100)	3 (75)	9 (100)	15 (88.2)	46 (92)	
Age	21-30	6 (40)	3 (60)	2(50)	3 (33.3)	9 (52.9)	23 (46)	1.549
	31-40	9 (60)	2 (40)	2 (50)	6 (66.7)	8 (47.1)	27 (54)	
Marital Status	Single	5 (33.3)	1(20)	2 (50)	3 (33.33)	5 (29.4)	16 (32)	2.734
	Married	7 (46.7)	2 (40)	2 (50)	4(44.4)	9 (52.9)	24 (48)	
	Divorced	3 (20)	2 (40)	0 (0)	2 (22.2)	3 (17.6)	10 (20)	
No. of dependants	0	6 (40)	1 (20)	2 (50)	4 (44.4)	5 (29.4)	18 (36)	4.804
	1	3 (20)	1 (20)	1 (25)	1 (11.1)	5 (29.4)	11 (22)	
	2	5 (33.3)	2 (40)	1 (25)	4 (44.4)	5 (29.4)	17 (34)	
	3	1 (6.7)	1 (20)	0 (0)	0 (0)	2 (11.8)	4 (8)	
Educational level	No formal Edu.	1 (6.7)	0 (0)	0 (0)	1 (11.1)	1 (5.9)	3 (6)	6.258
	Basic Edu	7 (46.7)	4 (80)	2 (50)	4 (44.4)	10 (5.9)	27 (54)	
	Sec. Sch. Edu.	6 (40)	1 (20)	1 (25)	0 (0)	2 (11.8)	4 (8)	
	Tertiary	1 (6.7)	0 (0)	1 (25)	0 (0)	2 (11.8)	4 (8)	
Total		15 (100)	5 (100)	4 (100)	9(100)	17 (100)	50 (100)	

Note. *N* = 50; **p*< 0.05. FSz is fruit size; FS is fruit shape; T't/Fm is fruit texture / Firmness; Ap/Gl is Appearance / Glossiness, SC is fruit skin colour.

4.2.4.1.1.2 Open market consumers' demographics and wax awareness

From Table 4.2.4.1.1b, 4 males and 46 females representing 8% and 92% respectively were not aware that fruits and vegetables can be waxed. Of the 50 open market consumers interviewed about the knowledge of wax, 23 (46%) and 27 (54%) were aged between 21-30 yrs and 31-40yrs respectively. Again 16 (32%), 24 (48%) and 10 (20%) of them were single, married or divorced. Considering their unawareness of wax usage, 18 (36%), 11 (22%) 17 (34%) and 4 (8%) of them had 0, 1, 2 and 3 persons who depended on them for livelihood. Only 4 (8%), 16 (32%) and 27 (54%) have had tertiary, secondary and basic education whilst 3 representing 6% of 50 consumers had no formal education. However there was no significant difference between the demographic characteristics of open market consumers and wax awareness.

Table 4.2.4.1.1b Cross tabulation analysis of open market consumers' demographics and wax awareness

Demographic Variables		Wax awareness No *f* (%)	X^2
Gender	Male	4 (8)	-
	Female	46 (92)	
Age	21-30	23 (46)	-
	31-40	27 (54)	
Marital Status	Single	16 (32)	-
	Married	24 (48)	
	Divorced	10 (20)	
Total		50 (100)	
Note. *N* = 50, '-' = no results			

Demographic Variable		Wax awareness No *f* (%)	X^2
No. of dependants	0	18 (36)	-
	1	11(22)	
	2	17 (34)	
	3	4 (8)	
Educational level	No formal Edu.	3 (6)	-
	Basic Edu	27 (54)	
	Sec. Sch. Edu.	16 (32)	
	Tertiary	4 (8)	
Total		50 (100)	

4.2.4.1.1.3 Open market consumers' demographics and willingness to wax

Out of the 34 consumers who answered "Yes" to willingness to wax, 4 (11.8%) and 30 (88.2%) were male and female respectively. Considering the ages of those who were willing, 44.1% and 55.9% were aged between 21-30 yrs and 31-40 yrs respectively. For their marital status, 21.5% were single whilst 47.1% and 29.4% were married or divorced correspondingly. With respect to number of dependants, 23.5%, 23.5%, 41.2% and 11.8% of them had 0, 1, 2 and 3 persons in that order. Yet again considering their educational level, 16, 11 and 4 of those willing to use waxed produce had basic, secondary and tertiary education. Marital status, number of dependants and educational level were statistically significant with respect to willingness to use wax. However gender and age did not show any significant difference considering willingness to wax.

Table 4.2.4.1.1c Cross tabulation analysis of open market consumers' demographics and willingness to wax

Demographic Variables		Willingness to wax			X^2
		Yes *f* (%)	No *f* (%)	Total *f* (%)	
Gender	Male	4 (11.8)	0 (0)	4 (8)	2.046
	Female	30 (88.2)	16 (100)	46 (92)	
Age	21-30	15 (44.1)	8 (50)	23 (46)	0.152
	31-40	19 (55.9)	8 (50)	27 (54)	
Marital Status	Single	8 (23.5)	8 (50)	16 (32)	7.108*
	Married	16 (47.1)	8 (50)	24 (48)	
	Divorced	10 (29.4)	0 (0)	10 (20)	
No. of dependants	0	8 (23.5)	10 (62.5)	18 (36)	8.195*
	1	8 (23.5)	3 (18.8)	11 (22)	
	2	14 (41.2)	3 (18.8)	17 (34)	
	3	4 (11.8)	0 (0)	4 (8)	
Educational level	No formal Edu.	0 (0)	3 (18.8)	3 (6)	12.001*
	Basic Edu	16 (47.1)	2 (12.5)	27 (54)	
	Sec. Sch. Edu.	11 (41.2)	2 (12.5)	16 (32)	
	Tertiary	4 (11.8)	0 (0)	4 (8)	
Total		34 (100)	16 (100)	50 (100)	

Note. N = 50; *p < 0.05.

4.2.4.1.1.4 Open market consumers' demographics and waxed fruit quality expectations

Table 4.2.4.1.1d shows the cross tabulation analysis of open market consumers' demographics and waxed fruit quality expectations. Since improved skin colour (ISC) was the most preferred quality attribute of waxed fruits by consumers (17), the presentation focused on how the individual parameters affected this choice. Out of the 17 consumers who opted for ISC, 5.9% were males whilst 94.1% were females. In that very same group, 41.2% and 58.8% were aged between 21-30yrs and 31-40 yrs respectively. With respect to marital status, 6, 8 and 3 of them were single, married or divorced respectively. Again with respect to number of dependants, 7, 3, 6 and 1 had 0, 1, 2 and 3 wards in that order. However 1 consumer representing 5.9% had no formal education whilst the others 9 (52.9%), 6 (35.3%) and 1 (5.9%) had basic, secondary and tertiary education. There was no significant relationship between demographic

characteristics of consumers of open market and the quality expectations of waxed cucumber fruits.

Table 4.2.4.1.1d Cross tabulation analysis of open market consumers' demographics and waxed fruit quality expectations

Demographic Variables		Waxed fruit quality expectations						X^2
		IT't/Fm *f* (%)	IAp/Gl *f* (%)	ISC *f* (%)	ESL *f* (%)	RSP *f* (%)	Total *f* (%)	
Gender	Male	0 (0)	2 (12.5)	1 (5.9)	0 (0)	1 (20)	4 (8)	0.2566
	Female	6 (100)	14 (87.5)	16 (94.1)	6 (100)	4 (80)	46 (92)	
Age	21-30	2 (33.3)	8 (50)	7 (41.2)	3 (50)	3 (60)	23 (46)	1.083
	31-40	4 (66.7)	8 (50)	10 (58.8)	3 (50)	2 (40)	27 (54)	
Marital Status	Single	3 (50)	4 (25)	6 (35.3)	1 (16.7)	2 (40)	16 (32)	4.037
	Married	1 (16.7)	9 (56.2)	8 (47.1)	4 (66.7)	2 (40)	24 (48)	
	Divorced	2 (33.3)	3 (18.8)	3 (17.6)	1 (16.7)	1 (20)	10 (20)	
No. of dependants	0	4 (66.7)	4 (25)	7 (41.2)	1 (16.7)	2 (40)	18 (36)	8.470
	1	0 (0)	5 (31.2)	3 (17.6)	2 (33.3)	1 (20)	11 (22)	
	2	2 (33.3)	5 (31.2)	6 (35.3)	3 (50)	1 (20)	17 (34)	
	3	0 (0)	2 (12.5)	1 (5.9)	0 (0)	1 (20)	4 (8)	
Educational level	NF Edu.	0 (0)	1 (62)	1 (5.9)	1 (16.7)	0 (0)	3 (6)	8.087
	Basic Edu	2 (33.3)	9 (56.2)	9 (52.9)	4 (66.7)	3 (60)	27 (54)	
	Sec. Sch. Edu.	4 (66.7)	4 (25)	6 (35.3)	1 (16.7)	1 (20)	16 (32)	
	Tertiary	(0)	2 (12.5)	1 (5.9)	0 (0)	1 (20)	4 (8)	
Total		6 (100)	16 (100)	17 (100)	6 (100)	5 (100)	50 (100)	

Note. N = 50; *p< 0.05. IT't/Fm is improved fruit texture / firmness; IAp/Gl is improves appearance / Glossiness, ISC is improves fruit skin colour; ESL is extend shelf life; RSP is reduces spoilage

4.2.4.1.2 Cross tabulation analysis of supermarket consumers' demographics and study variables

4.2.4.1.2.1 Supermarket consumers' demographics and fruit quality expectations

From Table 4.2.4.1.2a, out of 17 supermarket consumers interviewed who chose skin colour (SC), 23.5% were males and 76.5% were females. 8, 7 and 2 of the consumers in this group were aged between 31-40 yrs, 41-50 yrs and 51-60 yrs respectively. With respect to their marital status, 5.9% were single, 82.4% were married and 11.8% were divorced respectively. Considering the number of dependants, 2 (11.8%), 5 (29.4%), 7 (41.2%), 1 (5.9%) and 2 (11.8%) of them had 0, 1, 2, 3 and 4 persons in that order. All

17 (100%) had tertiary education. Demographic characteristics of supermarket consumers had no significant relationship with their fruit quality expectations.

Table 4.2.4.1.2a Cross tabulation analysis of supermarket consumers' demographics and fruit quality expectations

Demographic Variables		Fruit quality expectations						X^2
		FSz *f* (%)	FS *f* (%)	T't/Fm *f* (%)	Ap/Gl *f* (%)	SC *f* (%)	Total *f* (%)	
Gender	Male	2 (18.2)	2 (28.6)	3 (13.3)	1 (16.7)	4 (23.5)	12 (24)	0.893
	Female	9 (81.9)	5 (71.4)	6 (66.7)	5 (83.3)	13 (76.5)	38 (76)	
Age	31-40	5 (54.5)	3 (42.9)	4 (44.4)	3 (50)	8 (47.1)	24 (48)	1.162
	41-50	4 (36.4)	3 (42.9)	4 (44.4)	3 (50)	7 (41.2)	21 (42)	
	51-60	1 (9.9)	1 (14.3)	1 (11.1)	0 (0)	2 (11.8)	5 (10)	
Marital Status	Single	0 (0)	0 (0)	1 (11.1)	0 (0)	1 (5.9)	2 (4)	5.986
	Married	10 (90.9)	7 (100)	7 (77.8)	4 (66.7)	14 (82.4)	42(84)	
	Divorced	1 (9.1)	0 (0)	1 (11.1)	2 (33.3)	2 (11.8)	6 (12)	
No. of dependants	0	1 (9.1)	1 (14.3)	1 (11.1)	0 (0)	2 (11.8)	5 (10)	4.447
	1	4 (36.4)	1 (14.3)	4 (44.4)	2 (33.3)	5 (29.4)	16 (32)	
	2	4 (36.4)	3 (42.9)	2 (22.2)	3 (50)	7 (41.2)	19 (38)	
	3	1 (9.1)	1 (14.3)	1 (11.1)	1 (16.7)	1 (5.9)	5 (10)	
	4	1 (9.1)	1 (14.3)	1 (11.1)	0 (0)	2 (11.8)	5 (10)	
Educational level	Sec. Sch. Edu.	2 (18.2)	1 (14.3)	0 (0)	2 (33.3)	0 (0)	5 (10)	7.480
	Tertiary	9 (81.8)	6 (85.7)	9 (100)	4 (66.7)	17 (100)	45 (90)	
Total		11(100)	7 (100)	9 (100)	6 (100)	17 (100)	50 (100)	

Note. $N = 50$; $^*p < 0.05$. FSz is fruit size; FS is fruit shape; T't/Fm is fruit texture / Firmness; Ap/Gl is Appearance / Glossiness, SC is fruit skin colour.

4.2.4.1.2.2 Supermarket consumers' demographics and wax awareness

All consumers interviewed were not aware that fruits and vegetables can be waxed. From Table 4.2.4.2.1b 24 % and 76% were male and female respectively. With respect to age, 24 (48%), 21 (42%) and 5 (10%) were aged between 31-40 yrs, 41-50 yrs and 51-60 yrs correspondingly. In terms of marital status, 4%, 84% and 12% of the consumers were single, married or divorced with 5 (10%) having attained secondary and 45 (90%) having tertiary education in that order. Irrespective of the demographic characteristics, consumers were unaware of wax as a preservation method.

Table 4.2.4.1.2b Cross tabulation analysis of supermarket consumers' demographics and wax awareness

Demographic Variables		Wax awareness: No *f* (%)	X^2
Gender	Male	12 (24)	-
	Female	38 (76)	
Age	31-40	24 (48)	-
	41-50	21 (42)	
	51-60	5 (10)	
Marital Status	Single	2 (4)	-
	Married	42 (84)	
	Divorced	6 (12)	
Total		50 (100)	

Demographic Variables		Wax awareness: No *f* (%)	X^2
No. of dependants	0	5 (10)	-
	1	16 (32)	
	2	19 (38)	
	3	5 (10)	
	4	5 (10)	
Educational level	Sec. Edu.	5 (10)	-
	Tertiary	45 (90)	
Total		50 (100)	

Note. $N = 50$, '-' = no results

4.2.4.1.2.3 Supermarket consumers' demographics and willingness to wax

Out of a total of 35 consumers who were willing to use waxed produce, 5.7% were males whilst 94.3% were females (Table 4.2.4.1.2c). With respect to those who responded positively, 68.6% and 31.4 % were between the ages of 31-40 yrs and 41-50 yrs. Again for the affirmative side, 5.7% were single, 77.1% were married and 77.1% were divorced. For educational level, 5 and 30 of them have had secondary and tertiary education respectively. There was no significant relationship between willingness to wax and the demographic characteristics of consumers from supermarkets.

Table4.2.4.1.2c Cross tabulation analysis of supermarket consumers' demographics and willingness to wax

Demographic Variables		Willingness to wax			X^2
		Yes *f* (%)	No *f* (%)	Total *f* (%)	
Gender	Male	2 (5.7)	10 (66.7)	12 (24)	21.387
	Female	33 (94.3)	5 (33.3)	38 (76)	
Age	31-40	24 (68.6)	0 (0)	24 (48)	25.057
	41-50	11(31.4)	10 (66.7)	21 (42)	
	51-60	0 (0)	5 (33.3)	5 (10)	
Marital Status	Single	2 (5.7)	0 (0)	2 (4)	4.082
	Married	27 (77.1)	15 (100)	42 (84)	
	Divorced	27 (77.1)	15 (100)	42 (84)	
No. of dependants	0	5 (14.3)	0 (0)	5 (10)	32.456
	1	16 (45.7)	0 (0)	16 (32)	
	2	14 (40)	5 (33.3)	19 (38)	
	3	0 (0)	5 (33.3)	5 (10)	
	4	0 (0)	5 (33.3)	5 (10)	
Educational level	Sec. Sch. Edu.	5 (14.3)	0 (0)	5 (10)	2.381
	Tertiary	30 (85.7)	15 (100)	45 (90)	
Total		35(100)	15(100)	50 (100)	

Note. N = 50; *p < 0.05.

4.2.4.1.2.4 Supermarket consumers' demographics and waxed fruit quality expectations

17 out of 50 supermarket consumers interviewed expected improved skin colour (ISC) to be the most important waxed fruit quality attribute (Table 4.2.4.1.1d). 11.8% and 88.2% of them were males and females with secondary and tertiary education respectively. Considering their ages, 47.1% were aged between 31-40 yrs and 41-50 yrs whilst 5.9% were 51-60 yrs old. 13 of them were married and 4 were divorced. With respect to their dependency level, 1 (5.9%), 5 (29.4%), 9 (52.9%), 1 (5.9%), 1 (5.9%) and 2 (11.8%) had 0, 1, 2, 3 and 4 wards in that order. However there was no significant relationship between demographic characteristics of supermarket consumers and the quality expectations of waxed cucumber fruits.

Table 4.2.4.1.2d Cross tabulation analysis of supermarket consumers' demographics and waxed fruit quality expectations

Demographic Variables		Waxed fruit quality expectations						X^2
		IT't/Fm *f* (%)	IAp/Gl *f* (%)	ISC *f* (%)	ESL *f* (%)	RSP *f* (%)	Total *f* (%)	
Gender	Male	2 (16.7)	5 (11.8)	2 (11.8)	1 (25)	2 (50)	12 (24)	4.724
	Female	10 (83.3)	8 (61.5)	15 (88.2)	3 (75)	2 (50)	38 (76)	
Age	31-40	6 (50)	6 (46.2)	8 (47.1)	2 (50)	2 (50)	24 (48)	2.506
	41-50	5 (41.7)	5 (38.5)	8 (47.1)	1 (25.1)	2 (50)	21 (50)	
	51-60	1 (8.3)	2 (15.4)	1 (5.9)	1 (25)	0 (0)	5 (10)	
Marital Status	Single	0 (0)	1 (7.7)	0 (0)	0 (0)	1 (25)	2 (4)	11.177
	Married	11 (91.7)	12 (92.3)	13 (76.5)	3 (75)	3 (75)	42 (84)	
	Divorced	1 (8.3)	0 (0)	4 (23.5)	1 (25)	0 (0)	6 (12)	
No. of dependants	0	1 (8.3)	2 (15.4)	1 (5.9)	0 (0)	1 (25)	5 (10)	9.985
	1	4 (33.3)	4 (30.8)	5 (29.4)	1 (25)	2 (50)	16 (32)	
	2	5 (41.7)	3 (23.1)	9 (52.9)	2 (50)	0 (0)	19 (38)	
	3	1 (8.3)	2 (15.4)	1 (5.9)	0 (0)	1 (25)	5 (10)	
	4	1 (8.3)	2 (15.4)	1 (5.9)	1 (25)	0 (0)	5 (10)	
Educational level	Sec. Sch. Edu.	2 (16.7)	1(7.7)	2 (11.8)	0 (0)	0 (0)	5 (10)	1.617
	Tertiary	10 (83.3)	12 (92.3)	15 (88.2)	4 (100)	4 (100)	45 (100)	
Total		12 (100)	13 (100)	17 (100)	4 (100)	4 (100)	50 (100)	

Note. *N* = 50; **p*< 0.05. IT't/Fm is improved fruit texture / firmness; IAp/Gl is improves appearance / Glossiness, ISC is improves fruit skin colour; ESL is extend shelf life; RSP is reduces spoilage

4.2.4.1.3 Cross tabulation analysis of all consumers' demographics and study variables

So now that the relationship of how the demographic characteristics of the consumers in both open markets and supermarkets have been established, it is just fair their overall responses as consumers is also recognised. The association between the demographic characteristics and study variables of all consumers irrespective of their market condition is also established.

4.2.4.1.3.1 All consumers' demographics and fruit quality expectations

Skin colour (SC) was the most important quality attribute all consumers expect in their fruits (Table 4.2.4.1.3a). Out of the 34 who chose SC, 17.6% and 82.4% were males and females respectively. Their ages ranges from between 21-30 yrs, 31-40 yrs, 41-50

yrs and 51-60 yrs distributed as 26.5%, 47.1%, 20.6% and 5.9% respectively. With respect to marital status, 17.6% were single, 67.6 % were married and 14.7% were divorced. 7, 10, 12, 3 and 2 of them have 0, 1, 2, 3 and 4 wards as dependants. 2.9% of them had no formal education whilst 29.4%, 11.8% and 55.9% had basic, secondary and tertiary education respectively. However there was no significant relationship between demographic characteristics of all consumers interviewed and the quality expectations of cucumber fruits.

Table 4.2.4.1.3a Cross tabulation analysis of all consumers' demographics and fruit quality expectations

Demographic Variables		Fruit quality expectations						X^2
		FSz *f* (%)	FS *f* (%)	T't/Fm *f* (%)	Ap/Gl *f* (%)	SC *f* (%)	Total *f* (%)	
Gender	Male	3 (11.5)	2 (16.7)	4 (30.8)	1 (6.7)	6 (17.6)	16 (16)	3.540
	Female	23 (88.5)	10 (83.3)	9 (69.2)	14 (93.3)	28 (82.4)	84 (84)	
Age	21-30	6 (23.1)	3 (25)	2 (15.4)	3 (20)	9 (26.5)	23 (23)	3.83
	31-40	15 (57.7)	5 4.7v	6 (46.2)	9 (60)	16 (47.1)	51 (51)	
	41-50	4 (15.4)	3 (25)	4 (30.8)	3 (20)	7 (20.6)	21 (21)	
	51-60	1 (3.8)	1 (8.3)	1 (7.7)	0 (0)	2 (5.9)	5 (5)	
Marital Status	Single	5 (19.2)	1 (8.3)	3 (23.1)	3 (20)	6 (17.6)	18 (18)	3.087
	Married	17 (65.4)	9 (75)	9 (69.2)	8 (53.3)	23 (67.6)	66 (66)	
	Divorced	4 (15.4)	2 (16.7)	1 (7.7)	4 (26.7)	5 (14.7)	16 (16)	
No. of dependants	0	7 (26.9)	2 (16.7)	3 (23.1)	4 (26.7)	7 (20.6)	23 (23)	5.489
	1	7 (26.9)	2 (16.7)	5 (38.5)	3 (20)	10 (29.4)	27 (27)	
	2	9 (34.6)	5 (41.7)	3 (23)	7 (46.7)	12 (35.3)	36 (36)	
	3	2 (7.7)	2 (16.7)	1 (7.7)	1 (6.7)	3 (8.8)	9 (9)	
	4	1 (3.8)	1 (8.3)	1 (7.7)	0 (0)	2 (5.9)	5 (5)	
Educational level	No formal Edu.	1 (3.8)	0 (0)	0 (0)	1 (6.7)	1 (2.9)	3 (3)	13.247
	Basic Edu.	7 (26.9)	4 (33.3)	2 (15.4)	4 (26.7)	10 (29.4)	27 (27)	
	Sec. Sch. Edu.	8 (30.8)	2 (16.7)	1 (7.7)	6 (40)	4 (11.8)	21 (21)	
	Tertiary	10 (38.5)	6 (50)	10 (76.9)	4 (26.7)	19 (55.9)	49 (49)	
Total		26 (100)	12(100)	13 (100)	15(100)	34 (100)	100(100)	

Note. $N = 100$; $*p < 0.05$. FSz is fruit size; FS is fruit shape; T't/Fm is fruit texture / Firmness; Ap/Gl is Appearance / Glossiness, SC is fruit skin colour.

4.2.4.1.3.2 All consumers' demographics and wax awareness

All consumers were not aware that fruits and vegetables can be waxed. Of the 100 consumers interviewed, concerning the awareness of wax 16% and 84% were males

and females. With respect to age, 23%, 51%, 21% and 5% were aged between 21-30, 31-40, 41-50 and 51-60 yrs respectively. Considering the marital status 18%, 66% and 16% of them were single, married and divorced accordingly. 36% and 5% were the highest and lowest number of wards (2 and 4) respectively. Only 3% have had no formal education with 27%, 21% and 49% having attained basic, secondary and tertiary education. Irrespective of the demographic characteristics consumers remain unaware of wax as a preservation method.

Table 4.2.4.1.3b Cross tabulation analysis of all consumers' demographics and wax awareness

Demographic Variables		Wax awareness No *f* (%)	X^2
Gender	Male	16 (16)	-
	Female	84 (84)	
Age	21-30	23 (23)	-
	31-40	51 (51)	
	41-50	21 (21)	
	51-60	5 (5)	
Marital Status	Single	18 (18)	-
	Married	66 (66)	
	Divorced	16 (16)	
Total		100 (100)	

Demographic Variables		Wax awareness No *f* (%)	X^2
No. of dependants	0	23 (23)	-
	1	27 (27)	
	2	36 (36)	
	3	9 (9)	
	4	5 (5)	
Educational level	No formal Edu.	3 (3)	-
	Basic Edu.	27 (27)	
	Sec. Edu.	21 (21)	
	Tertiary	49 (49)	
Total		100 (100)	

Note. *N* = 100, '-' = no results

4.2.4.1.3.3 All consumers' demographics and willingness to wax

69 out of the 100 consumers interviewed were willing to use waxed produce (Table 4.2.4.1.3c). Of those willing, 8.7% were males whilst 91.3% were females. With respect to age 31-40 yrs age range scored the highest (62.3%) whilst none of those aged between 51-60 yrs were willing to use waxed produce. Considering the marital status of those willing, 14.5%, 62.3% and 23.2% were single, married or divorced. With regards to the number of dependants, those with 2 wards scored 40.6% whilst those with 4 wards were not willing to use wax. All willing consumers had basic, secondary and

tertiary education representing 23.2%, 27.5% and 49.3% accordingly. Consequently there was a significant relationship between the demographic characteristics of all consumers and their willingness to use waxed fruits.

Table 4.2.4.1.3c Cross tabulation analysis of all consumers' demographics and willingness to wax

Demographic Variables		Willingness to wax			
		Yes *f* (%)	No *f* (%)	Total *f* (%)	X^2
Gender	Male	6 (8.7)	10 (32.3)	16 (16)	8.836*
	Female	63 (91.3)	21 (7.7)	84 (84)	
Age	21-30	15(21.7)	8 (25.8)	23 (23)	19.586*
	31-40	43 (62.3)	8 (25.8)	51 (51)	
	41-50	11 (15.9)	10 (32.3)	21 (21)	
	51-60	0 (0)	5 (16.1)	5 (5)	
Marital Status	Single	10 (14.5)	8 (25.8)	18 (18)	9.166*
	Married	43 (62.3)	23 (74.2)	66 (66)	
	Divorced	16 (23.2)	0 (0)	16 (16)	
No. of dependants	0	13 (18.8)	10 (32.3)	23 (23)	21.630*
	1	24 (34.8)	3 (9.7)	27 (27)	
	2	28 (40.6)	8 (25.8)	36 (36)	
	3	4 (5.8)	5 (16.1)	9 (9)	
	4	0 (0)	5 (16.1)	5 (5)	
Educational level	No formal Edu.	0 (0)	3 (9.7)	3 (3)	12.407*
	Basic Edu.	16 (23.2)	11 (35.5)	27 (27)	
	Sec. Sch. Edu.	19 (27.5)	2 (6.5)	21 (21)	
	Tertiary	34 (49.3)	15 (48.4)	49 (49)	
Total		69 (100)	31 (100)	100 (100)	

Note. N = 100; *p < 0.05.

4.2.4.1.3.4 All consumers' demographics and waxed fruit quality expectations

Table 4.2.4.13d shows the quality expectations of waxed cucumber fruits cross tabulated against the demographic characteristics of all consumers. Improve skin colour (ISC) was the most important receiving 34 out of the 100 consumers interviewed. Of this 8.8% and 91.2 % were males and females respectively. With respect of age, 31-40 yrs were the majority with 52.9% and 51-60 yrs were the least (2.9%). 17.6%, 61.8% and 20.6% of the 34 consumers were single, married or divorced respectively. Again

those with 2 wards were the most with 44.1% and the least is 2.9% for those with 4 dependants. With respect to educational level, 47.1% had tertiary education being the highest and 2.9% had no formal education. However there was no significant relationship between demographic characteristics of all consumers and quality expectations of waxed fruits.

Table 4.2.4.1.3d Cross tabulation analysis of all consumers' demographics and waxed fruit quality expectations

Demographic Variables		Waxed fruit quality expectations						X^2
		IT't/Fm *f* (%)	IAp/Gl *f* (%)	ISC *f* (%)	ESL *f* (%)	RSP *f* (%)	Total *f* (%)	
Gender	Male	2 (11.1)	7 (24.1)	3 (8.8)	1 (10)	3 (33.3)	16 (16)	5.332
	Female	16 (88.9)	22 (75.9)	31 (91.2)	9 (90)	6 (66.7)	84 (84)	
Age	21-30	2 (11.1)	8 (27.6)	7 (20.6)	3 (30)	3 (33.3)	23 (23)	5.040
	31-40	10 (55.6)	14 (48.3)	18 (52.9)	5 (50)	4 (44.4)	51 (51)	
	41-50	5 (27.8)	5 (17.2)	8 (23.5)	1 (10)	2 (22.2)	21 (21)	
	51-60	1 (5.6)	2 (6.9)	1 (2.9)	1 (10)	0 (0)	5 (5)	
Marital Status	Single	3 (16.7)	5 (17.2)	6 (17.6)	1 (10)	3 (33.3)	18 (18)	3.274
	Married	12 (66.7)	21 (72.4)	21 (61.8)	7 (70)	5 (55.6)	66 (66)	
	Divorced	3 (16.7)	3 (10.3)	7 (20.6)	2 (20)	1 (11.1)	16 (16)	
No. of dependants	0	5 (27.8)	5 (20.7)	8 (23.5)	1 (10)	3 (33.3)	23 (23)	10.827
	1	4 (22.2)	9 (31)	8 (23.5)	3 (30)	3 (33.3)	27 (27)	
	2	7 (38.9)	8 (27.6)	15 (44.1)	5 (50)	1 (11.1)	36 (36)	
	3	1 (5.6)	4 (13.8)	2 (5.9)	0 (0)	2 (22.2)	9 (9)	
	4	1 (5.6)	2 (6.9)	1 (2.9)	1 (10)	0 (0)	5 (5)	
Educational level	No formal Edu.	0 (0)	1 (3.4)	1 (2.9)	1 (10)	0 (0)	3 (3)	8.113
	Basic Edu.	2 (11.1)	9 (31)	9 (26.5)	4 (40)	3 (33.3)	27 (27)	
	Sec. Sch. Edu.	6 (33.3)	5 (17.2)	8 (23.5)	1 (10)	1 (11.1)	21 (21)	
	Tertiary	10 (55.6)	14 (48.3)	16 (47.1)	4 (40)	5 (55.6)	49 (49)	
Total		18 (100)	29 (100)	34 (100)	10 (100)	9 (100)	100 (100)	

Note. N =100; *p < 0.05. IT't/Fm is improved fruit texture / firmness; IAp/Gl is improves appearance / Glossiness, ISC is improves fruit skin colour; ESL is extend shelf life; RSP is reduced spoilage.

4.2.4.2 Cross tabulation analysis of retailers' demographics and study variables

Retailers' demographic characteristics were cross tabulated against their responses concerning knowledge, perceptions and quality expectations of wax and waxed fruits

and vegetables in the two different market conditions to establish the relationship among them and how this relationship influences the retailers' decisions. Chi-square test was used to determine any significant difference that exists among the demographic characteristics and the retailers' variables.

4.2.4.2.1 Open market retailers' demographics and study variables

4.2.4.2.1.1 Open market retailers' demographics and fruit quality expectations

Out of 50 retailers interviewed 18 of them chose skin colour (SC) as most the important quality they expected. Of this number, 33.3% were males and 66.7% were females. With respect to their ages 55.6% being the majority were aged between 31-40 yrs whilst the least were aged 21-30 yrs (5.6%). Married retailers were the majority (55.6%) with single retailers being the least (5.6%). Additionally, those with wards of 2 and 4 in number were in the majority with 27.8% each. Considering educational level of these 18 retailers, the majority forming 44.4% had no formal education with 27.8% of the remaining having basic and tertiary education. However there was no significant relationship between the demographic characteristics of open market retailers and the quality attributes they expect from cucumber fruits.

Table 4.2.4.2.1a Cross tabulation analysis of open market retailers' demographics and fruit quality expectations

Demographic Variable		Fruit quality expectations						X^2
		FSz *f* (%)	FS *f* (%)	T't/Fm *f* (%)	Ap/Gl *f* (%)	SC *f* (%)	Total *f* (%)	
Gender	Male	4 (30.8)	1 (25)	1 (20)	0 (0)	6 (33.3)	12 (24)	4.390
	Female	9 (69.2)	3 (75)	4 (80)	10 (100)	12 (66.7)	38 (76)	
Age	21-30	1 (7.7)	0 (0)	0 (0)	2 (20)	1 (5.6)	4 (8)	6.419
	31-40	8 (61.5)	1 (25)	2 ()40	3 (30)	10 (55.6)	24 (48)	
	41-50	4 (30.8)	3 (75)	3 (60)	5 (50)	7 (38.9)	22 (44)	
Marital status	Single	1 (7.7)	0 (0)	0 (0)	2 (20)	1 (5.6)	4 (8)	6.382
	Married	7 (53.8)	2 (50)	3 (60)	4 (40)	10 (55.6)	26 (52)	
	Divorced	4 (30.8)	1 (25)	2 (40)	4 ()40	5 (27.8)	16 (32)	
	Widowed	1 (7.7)	1 (25)	0 (0)	0 (0)	2 (11.1)	4 (8)	
No. of dependants	1	3 (23.1)	0 (0)	2 (40)	5 (50)	4 (22.2)	14 (28)	7.086
	2	4 (30.8)	1 (25)	1 (20)	1 (10)	5 (27.8)	12 (24)	
	3	3 (23.1)	1 (25)	0 (0)	2 (20)	4 (22.2)	10 (20)	
	4	3 (23.1)	**1** (25)	0 (0)	2 (20)	5 (27.8)	14 (28)	
Educational level	No formal Edu.	5 (38.5)	3 (75)	1 (20)	5 (50)	8 (44.4)	22 (44)	8.324
	Basic Edu.	4 (30.8)	1 (25)	0 (0)	2 (20)	5 (27.8)	12 (24)	
	Sec. Sch. Edu.	4 (30.8)	0 (0)	4 (80)	3 (30)	5 (27.8)	16 (32)	
Total		13 (100)	4 (100)	5 (100)	10 (100)	18 (100)	50 (100)	

Note. *N* = 50; **p*< 0.05. FSz is fruit size; FS is fruit shape; T't/Fm is fruit texture / Firmness; Ap/Gl is Appearance / Glossiness, SC is Fruit Skin Colour.

4.2.4.2.1.2 Open market retailers' demographics and wax awareness

All retailers interviewed were not aware that fruits and vegetables can be waxed (Table 4.2.4.2.1b). 24% and 76% were males and females respectively. With respect to age, majority (48%) were 31-40 yrs whilst 21-30 yrs were the least (8%). 26 (52%) who formed the majority were married with single and divorced retailers sharing the least with 8%. All retailers had less than 5 dependants. Those with 1 and 4 wards were in the majority (28%) whilst those with 3 wards were the minority (20%). About 44% of retailers interviewed had no formal education whilst 24% had basic education.

Table 4.2.4.2.1b Cross tabulation analysis of open market retailers' demographics and wax awareness

Demographic Variable		Wax awareness FSz *f* (%)	X^2
Gender	Male	12 (24)	-
	Female	38 (76)	
Age	21-30	4 (8)	-
	31-40	24 (48)	
	41-50	22 (44)	
Marital Status	Single	4 (8)	-
	Married	26 (52)	
	Divorced	16 (32)	
	Widowed	4 (8)	
No. of dependants	1	14 (28)	-
	2	12 (24)	
	3	10 (20)	
	4	14 (28)	
Educational level	No formal Edu.	22 (44)	-
	Basic Edu.	12 (24)	
	Sec. Sch. Edu.	16 (32)	
Total		50 (100)	

Note. $N = 50$, '-' = no results

4.2.4.2.1.3 Open market retailers' demographics and willingness to wax

42 of the 50 retailers interviewed from open markets were willing to purchase and sell waxed produce (Table 4.2.4.2.1c). Males accounted for 28.8% whilst females accounted for 71.4% of the 42 willing retailers. Those aged between 31-40 yrs representing 57.1% were in the majority whilst those between 21-30 yrs were the majority (9.5%). Married retailers formed the majority of 61.9% whilst widowed retailers were not willing to wax their produce. With respect to number of dependants, the majority of retailers (33.3%) had 1 ward whilst the least had 3 wards (14.3%). Retailers with no formal education accounted for 19%. With the exception of gender and educational level, demographic characteristics of open market retailers were statistically significant with willingness to wax.

Table 4.2.4.2.1c Cross tabulation analysis of open market retailers' demographics and willingness to wax

Demographic Variables		Willingness to wax			X^2
		Yes *f* (%)	No *f* (%)	Total *f* (%)	
Gender	Male	12 (28.8)	0 (0)	12 (24)	3.008
	Female	30 (71.4)	8 (100)	38 (76)	
Age	21-30	4 (9.5)	0 (0)	4 (8)	12.121*
	31-40	24 (57.1)	0 (0)	24 (48)	
	41-50	14 (33.3)	8 (100)	22 (44)	
Marital status	Single	4 (9.5)	0 (0)	4 (8)	27.679*
	Married	26 (61.9)	0 (0)	26 (52)	
	Divorced	12 (28.6)	4 (50)	16 (32)	
	Widowed	0 (0)	4 (50)	4 (48)	
No. of dependants	1	14 (33.3)	0 (0)	4 (8)	10.884*
	2	12 (28.6)	0 (0)	12 (24)	
	3	6 (14.3)	4 (50)	10 (20)	
	4	10 (23.8)	4 (50)	14 (28)	
Educational level	No formal Edu.	18 (42.9)	4 (50)	22 (44)	5.808
	Basic Edu.	8 (19)	4 (50)	12 (24)	
	Sec. Sch. Edu.	16 (38.1)	0 (0)	16 (32)	
Total		42 (100)	8 (100)	50 (100)	

Note. N = 50; *p < 0.05.

4.2.4.2.1.4 Open market retailers' demographics and waxed fruit quality expectations

Considering the quality expectations of waxed fruits, retailers prefer extended shelf life (ESL) as the most important quality attribute (Table 4.2.4.2.1d). 19 out of 50 retailers who chose ESL, 26.3% were males and 73.7% were females. 18 (94.8%) of them were aged between 31-50 yrs with only 1 (5.3%) person was between 21-30 yrs of age. Again the majority (52.6%) of those who opted for ESL were married whilst the least were single (5.3%). With respect of dependency level, 31.6% had 4 wards whilst 21.1% had 1 or 3 wards respectively. Majority (42.1%) of retailers had no formal education whilst those with basic education (26.3%) were the least. There was no significant relationship between demographic characteristics of open market retailers and waxed fruit quality expectations.

Table 4.2.4.2.1d Cross tabulation analysis of open market retailers' demographics and waxed fruit quality expectations

Demographic Variable		Waxed fruit quality expectations						X^2
		IT't/Fm *f* (%)	IAp/Gl *f* (%)	ESC *f* (%)	ESL *f* (%)	RSP *f* (%)	Total *f* (%)	
Gender	Male	0 (0)	4 (33.3)	2 (16.7)	5 (26.3)	1 (25)	12 (24)	1.932
	Female	3 (100)	8 (66.7)	10 (83.3)	14 (73.7)	3 (75)	38 (76)	
Age	21-30	1 (33.3)	0 (0)	1 (8.3)	1 (5.3)	1 (25)	1 (8)	7.865
	31-40	1 (33.3)	8 (66.7)	4 (33.3)	9 (47.4)	2 (50)	24 (48)	
	41-50	1 (33.3)	4 (33.3)	7 (58.3)	9 (47.4)	1 (25)	22 (44)	
Marital status	Single	1 (33.3)	0 (0)	1 (8.3)	1 (5.3)	1 (25)	4 (8)	8.695
	Married	1 (33.3)	7 (88.3)	6 (50)	10 (52.6)	2 (50)	26 (52)	
	Divorced	1 (33.3)	3 (25)	5 (41.7)	6 (31.6)	1 (25)	16 (32)	
	Widowed	0 (0)	2 (16.7)	0 (0)	2 (10)	0 (0)	4 (8)	
No. of dependants	1	1 (33.3)	2 (16.7)	5 (41.7)	4 (21.1)	2 (50)	14 (28)	6.134
	2	1 (33.3)	4 (33.3)	1 (8.3)	5 (26.3)	1 (25)	12 (24)	
	3	0 (0)	3 (25)	2 (25)	4 (21.1)	0 (0)	10 (20)	
	4	1 (33.3)	3 (25)	3 (25)	6 (31.6)	1 (25)	14 (28)	
Educational level	No formal Edu.	1 (33.3)	5 (41.7)	7 (58.3)	8 (42.1)	1 (25)	22 (44)	3.410
	Basic Edu.	1 (33.3)	4 (33.3)	1 (8.3)	5 (26.3)	1 (25)	12 (24)	
	Sec. Sch. Edu.	1 (33.3)	3 (25)	4 (33.3)	6 (31.6)	2 (50)	16 (32)	
Total		3 (100)	12 (100)	12 (100)	19 (100)	4 (100)	50 (100)	

Note. N = 50; *p < 0.05. IT't/Fm is improved fruit texture / firmness; IAp/Gl is improves appearance / Glossiness, ISC is improves fruit skin colour; ESL is extend shelf life; RSP is reduced spoilage

4.2.4.2.2 Cross tabulation analysis of supermarket retailers' demographics and study variables

4.2.4.2.2.1 Supermarket retailers' demographics and fruit quality expectations

From Table 4.2.4.2.2a, the majority of retailers prefer skin colour (SC) over the other quality attributes of cucumber. More males (66.7%) preferred SC than females (33.3%). Considering age, only retailers aged between 41-50 yrs opted for SC. Those aged between 31-40 yrs and 41-50 yrs accounted for 66.7% and 33.3% respectively. All retailers who chose SC were married. Again with respect to number of dependants, retailers who opted for SC had 1 or 2 wards with those with 2 wards being the majority (66.7%). Considering the educational level, majority of retailers with tertiary education

preferred SC than their counterpart with secondary education. However there was no significant relationship between retailers and their fruit quality expectations.

Table 4.2.4.2.2a Cross tabulation analysis of supermarket retailers' demographics and fruit quality expectations

Demographic Variable		Fruit quality expectations						X^2
		FSz *f* (%)	FS *f* (%)	T't/Fm *f* (%)	Ap/Gl *f* (%)	SC *f* (%)	Total *f* (%)	
Gender	Male	0 (0)	0 (0)	1 (50)	1 (33.3)	2 (66.7)	4 (40)	2.361
	Female	1 (100)	1 (100)	1 (50)	2 (66.7)	1 (33.3)	6 (60)	
Age	31-40	0 (0)	1 (100)	2 (100)	2 (66.7)	0 (0)	5 (50)	7.333
	41-50	1 (100)	0 (0)	0 (0)	1 (33.3)	3 (100)	5 (50)	
Marital status	Single	0 (0)	0 (0)	1 (50)	0 (0)	0 (0)	1 (10)	4.444
	Married	1 (100)	1 (100)	1 (50)	3 (100)	3 (100)	9 (90)	
No. of dependants	0	0 (0)	0 (0)	1 (50)	0 (0)	0 (0)	1 (10)	7.750
	1	0 (0)	1 (100)	0 (0)	2 (66.7)	2 (66.7)	5 (50)	
	2	1 (100)	0 (0)	1 (50)	1 (33.3)	1 (33.3)	4 (40)	
Educational level	Sec. Sch. Edu.	0 (0)	1 ()100	0 (0)	2 (66.7)	1 (33.3)	4 (40)	4.444
	Tertiary	1 (100)	0 (0)	2 (100)	1 (33.3)	2 (66.7)	6 (60)	
Total		1 (100)	1 (100)	2 (100)	3 (100)	3 (100)	10 (100)	

Note. N = 10; *p< 0.05. FSz is fruit size; FS is fruit shape; T't/Fm is fruit texture / Firmness; Ap/Gl is Appearance / Glossiness, SC is fruit skin colour.

4.2.4.2.2.2 Supermarket retailers' demographics and wax awareness

All supermarket retailers were not aware that fruits and vegetables can be waxed (table 4.2.4.2.2b). About 40% and 60% of retailers were males and females respectively. There was equal number of retailers aged between 31-40 yrs and 41-50 yrs (50%). Majority (90%) of the retailers were married with 90% of them having 1 or 2 wards. 60% of the retailers had tertiary education whilst only 40% had secondary education.

Table 4.2.4.2.2b Cross tabulation analysis of supermarket retailers' demographics and wax awareness

Demographic Variable		Wax awareness FSz *f* (%)	X^2
Gender	Male	4 (40)	-
	Female	6 (60)	
Age	31-40	5 (50)	-
	41-50	5 (50)	
Marital Status	Single	1 (10)	-
	Married	9 (90)	
No. of dependants	0	1 (10)	-
	1	5 (50)	
	2	4 (40)	
Educational level	Sec. Sch. Edu.	4 (40)	-
	Tertiary Edu.	6 (60)	
Total		10 (100)	

Note. *N* =10, '-' = no results

4.2.4.2.2.3 Supermarket retailers' demographics and willingness to wax

Table 4.2.4.2.2c shows the cross tabulation analysis of supermarket retailers' demographic characteristics and willingness to wax. Out of the 6 willing retailers, 16.7% were males whilst 83.3% were females. The majority (66.7%) of them were aged between 31-40 yrs whilst 33.3 % were between 41-50 yrs. All willing retailers had either secondary or tertiary education. However there was a significant relationship between demographic characteristics of retailers in supermarkets with their willingness to purchase or sell waxed produce.

Table 4.2.4.2.2c Cross tabulation analysis of supermarket retailers' demographics and willingness to wax

Demographic Variables		Willingness to wax			X^2
		Yes *f* (%)	No *f* (%)	Total *f* (%)	
Gender	Male	1 (16.7)	3 (75)	4 (40)	3.403
	Female	5 (83.3)	1 (25)	6 (60)	
Age	31-40	4 (66.7)	1 (25)	5 (50)	1.667
	41-50	2 (33.3)	3 (75)	5 (50)	
Marital status	Single	0 (0)	1 (25)	1 (10)	1.667
	Married	6 (100)	3 (75)	9 (90)	
No. of dependents	0	0 (0)	1 (25)	1 (10)	1.875
	1	3 (50)	2 (50)	5 (50)	
	2	3 (50)	1 (25)	4 (40)	
Educational level	Sec. Sch. Edu.	3 (50)	1 (25)	4 (40)	0.625
	Tertiary Edu.	3 (50)	3 (75)	6 (60)	
Total		6 (100)	4 (100)	10 (100)	

Note. N = 10; *p < 0.05.

4.2.4.2.2.4 Supermarket retailers' demographics and waxed fruit quality expectations

From Table 4.2.4.2.2d, majority of retailers interviewed in the supermarkets preferred their waxed cucumber to have improved skin colour (ISC). More females preferred ISC than males. All retailers who preferred ISC were split between 31-40 yrs and 41-50 yrs with the latter being the majority (66.7%). All retailers who chose ISC were married with a minimum of 2 wards. Considering educational level, the majority (66.7%) of retailers who chose ISC had tertiary education with 33.3% being the least for secondary education. Again there was no significant relationship between supermarket retailers' demographics and waxed fruit quality expectations.

Table 4.2.4.2.2d Cross tabulation analysis of supermarket retailers' demographics and waxed fruit quality expectations

Demographic Variable		Waxed fruit quality expectations						X^2
		IT't/Fm *f* (%)	IAp/Gl *f* (%)	ISC *f* (%)	ESL *f* (%)	RSP *f* (%)	Total *f* (%)	
Gender	Male	0 (0)	2 (66.7)	1 (33.3)	0 (0)	1 (100)	4 (40)	4.444
	Female	2 (100)	1 (33.3)	2 (66.7)	1 (100)	0 (0)	6 (60)	
Age	31-40	1 (50)	3 (100)	1 (33.3)	0 (0)	0 (0)	5 (50)	5.333
	41-50	1 (50)	0 (0)	2 (66.7)	1 (100)	1 (100)	5 (500)	
Marital status	Single	0 (0)	1 (33.3)	0 (0)	0 (0)	0 (0)	1 (10)	2.593
	Married	2 (100)	2 (66.7)	3 (100)	1 (100)	1 (100)	9 (90)	
No. of dependants	0	0 (0)	1 (33.3)	1 (33.3)	1 (100)	1 (100)	5 (100)	5.083
	1	1 (50)	1 (33.3)	1 (33.3)	1 (100)	1 (100)	5 (50)	
	2	1 (50)	1 (33.3)	2 (66.6)	0 (0)	0 (0)	4 (40)	
Educational level	Sec. Sch. Edu.	1 (50)	1 (33.3)	1 (33.3)	1 (100)	0 (0)	4 (40)	2.361
	Tertiary Edu.	1 (50)	2 (66.6)	2 (66.7)	0 (0)	1 (100)	6 (60)	
Total		2 (100)	3 (100)	3 (100)	1 (100)	1 (100)	10 (100)	

Note. N = 10; *p < 0.05. IT't/Fm is improved fruit texture / firmness; IAp/Gl is improved appearance / glossiness, ISC is improved fruit skin colour; ESL is extend shelf life; RSP is reduced spoilage

4.2.4.2.3 Cross tabulation analysis of all retailers' demographics and study variables

4.2.4.2.3.1 All retailers' demographics and fruit quality expectations

21 of all retailers responded that skin colour (SC) was the most important quality attribute that informed their decision to purchase (Table 4.2.4.2.3a). Males accounted for 38.1% whilst females accounted for 61.9% of the 21 retailers. About 95.2 % of them were aged between 21-50 yrs and were married, divorced or widowed (61.9%, 23.8% and 9.5%) in that order. All the 21 retailers had between 1 and 4 dependants. The majority (38.1%) had no formal education whilst the remaining had basic,

secondary and tertiary education (23.8%, 28.6% and 9.5%) respectively. There was no significant relationship between the demographics of all retailers and the quality expectations of fruits.

Table 4.2.4.2.3a Cross tabulation analysis of all retailers' demographics and fruit quality expectations

Demographic Variable		Fruit quality expectations						X^2
		FSz *f* (%)	FS *f* (%)	T't/Fm *f* (%)	Ap/Gl *f* (%)	SC *f* (%)	Total *f* (%)	
Gender	Male	4 (28.6)	1 (20)	2 (28.6)	1 (7.7)	8 (38.1)	16 (26.7)	3.949
	Female	10 (71.4)	4 (80)	5 (71.4)	12 (92.3)	13 (61.9)	44 (73.3)	
Age	21-30	1 (7.1)	0 (0)	0 (0)	2 (1.54)	1 (4.8)	4 (6.7)	3.636
	31-40	8 (57.1)	2 (40)	4 (57.1)	5 (38.5)	10 (47.6)	29 (48.3)	
	41-50	5 (35.7)	3 (60)	3 (42.9)	6 (46.2)	10 (47.6)	27 (45)	
Marital status	Single	1 (7.1)	0 (0)	1 (14.3)	2 (15.4)	1 (4.8)	5 (8.3)	5.120
	Married	8 (57.1)	3 (60)	4 (57.1)	7 (53.8)	13 (61.9)	35 (58.3)	
	Divorced	4 (28.6)	1 (20)	2 (28.6)	4 (38.8)	5 (23.8)	16 (26.7)	
	Widowed	1 (7.1)	1 (20)	0 (0)	0 (0)	2 (9.5)	4 (6.78)	
No. of dependants	0	0 (0)	0 (0)	1 (14.3)	0 (0)	0 (0)	1 (1.7)	14.054
	1	3 (21.4)	1 (20)	2 (28.6)	7 (53.8)	6 (28.6)	19 (31.7)	
	2	5 (35.7)	1 (20)	2 (28.6)	2 (15.4)	6 (28.6)	16 (26.7)	
	3	3 (21.4)	1 (20)	0 (0)	2 (15.4)	4 (19)	10 (16.7)	
	4	3 (21.4)	**2** (40)	2 (28.6)	2 (15.4)	5 (23.8)	14 (23.3)	
Educational level	No formal Edu.	5 (35.7)	3 (60)	1 (14.3)	5 (38.5)	8 (38.1)	22 (36.7)	8.831
	Basic Edu.	4 (28.6)	1 (20)	0 (0)	2 (15.4)	5 (23.8)	12 (20)	
	Sec. Sch. Edu.	4 (28.6)	1 ()20	4 (57.1)	5 (28.5)	6 (28.6)	20 (33.3)	
	Tertiary	1 (7.1)	0 (0)	2 (28.6)	1 (7.7)	2 (9.5)	6 (10)	
Total		14 (100)	5 (100)	7 (100)	13 (100)	21 (100)	50 (100)	

Note. *N* = 60; **p*< 0.05. FSz is fruit size; FS is fruit shape; T't/Fm is fruit texture / Firmness; Ap/Gl is Appearance / Glossiness, SC is fruit skin colour.

4.2.4.2.3.2 All retailers' demographics and wax awareness

All retailers interviewed were ignorant of wax as a preservation method (Table 4.2.4.2.3b). Males represented 26.7% and females represented 73.3% of all 50 retailers interviewed. 31-40 yrs and 21-30 yrs group had the most and least number of retailers (29 and 4) respectively. 91.7 % of all retailers were married or had experienced marriage before. 98.3% of all retailers have at least 1 dependant. Majority of all retailers (36.7%) had no formal education whilst only 10% had tertiary education.

Table 4.2.4.2.3bCross tabulation analysis of all retailers' demographics and wax awareness

Demographic Variable		Wax awareness: No *f* (%)	X^2
Gender	Male	16 (26.7)	-
	Female	44 (73.3)	
Age	21-30	4 (6.7)	-
	31-40	29 (48.3)	
	41-50	27 (45)	
Marital Status	Single	5 (8.3)	-
	Married	35 (58.3)	
	Divorced	16 (26.7)	
	Widowed	4 (6.7)	
No. of dependants	0	1 (1.7)	-
	1	19 (31.7)	
	2	16 (26.7)	
	3	10 (16.7)	
	4	14 (23.3)	
Educational level	No formal Edu.	22 (36.7)	-
	Basic Edu.	12 (20)	
	Sec. Sch. Edu.	20 (33.3)	
	Tertiary	6 (10)	
Total		60 (100)	

Note. $N = 60$, '-' = no results

4.2.4.2.3.3 All retailers' demographics and willingness to wax

From Table 4.2.4.2.3c, 48 of 60 retailers were willing to use wax. Males accounted for 27.1% whilst females accounted for 72.9% respectively. 91.7% of them aged between 31-50 yrs and were either married or were once married. All willing retailers had at least 1 dependant. With respect to educational level, the majority (39.6%) of willing retailers had secondary education whilst the least (6.2%) were trained up to the tertiary level. All demographic characteristics except gender and educational level had a significant relationship with willingness to use wax.

Table 4.2.4.2.3c Cross tabulation analysis of all retailers' demographics and willingness to wax

Demographic Variables		Willingness to wax			
		Yes *f* (%)	No *f* (%)	Total *f* (%)	X^2
Gender	Male	13 (27.1)	3 (25)	16 (26.7)	0.021
	Female	35 (72.9)	9 (75)	44 (73.3)	
Age	21-30	4 (8.3)	0 (0)	4 (6.7)	13.225*
	31-40	28 (58.3)	1 (8.3)	29 (48.9)	
	41-50	16 (33.3)	11 (91.7)	27 (45)	
Marital status	Single	4 (8.3)	1 (8.3)	5 (8.3)	19.107*
	Married	32 (66.7)	3 (25)	35 (58.3)	
	Divorced	12 (25)	4 (33.3)	16 (26.7)	
	Widowed	0 (0)	4 (33.3)	4 (6.7)	
No. of dependants	0	0 (0)	1 (8.3)	1 (1.7)	10.099*
	1	17 (35.4)	2 (16.7)	19 (31.7)	
	2	15 (31.2)	1 (8.3)	16 (26.7)	
	3	6 (12.5)	4 (33.3)	10 (16.7)	
	4	10 (20.8)	4 (33.3)	14 (23.3)	
Educational level	No formal Edu.	18 (37.5)	4 (33.3)	22 (36.7)	7.566
	Basic Edu.	8 (16.7)	4 (33.3)	12 (20)	
	Sec. Sch. Edu.	19 (39.6)	1 (8.3)	20 (33.3)	
	Tertiary Edu.	3 (6.2)	3 (25)	6 (10)	
Total		48 (100)	12 (100)	60 (100)	

Note. N = 60; *p < 0.05.

4.2.4.2.3.4 All retailers' demographics and waxed fruit quality expectations

Extended shelf life (ESL) was the most preferred (20) quality attribute expected of waxed fruits (Table 4.2.4.2.3d). Females outnumbered males by 3:1 out of 20 retailers who opted for ESL. 95% of them were aged between 31-50 yrs and they were either married or had experienced marriage before. All 20 retailers who chose ESL had at least 1 ward (dependant) and had all attained as high as a secondary education level. However there was no significant association between all retailers' demographic characteristics and quality expectations of waxed cucumber fruits.

Table 4.2.4.2.3d Cross tabulation analysis of all retailers' demographics and waxed fruit quality expectations

Demographic Variable		Waxed fruit quality expectations						X^2
		IT't/Fm *f* (%)	IAp/Gl *f* (%)	ISC *f* (%)	ESL *f* (%)	RSP *f* (%)	Total *f* (%)	
Gender	Male	0 (0)	6 (40)	3 (20)	5 (25)	2 (40)	16 (26.7)	4.006
	Female	5 (100)	9 (60)	12 (80)	15 (75)	3 (60)	44 (73.3)	
Age	21-30	1 (20)	0 (0)	1 (6.7)	1 (5)	1 (20)	4 (6.7)	8.615
	31-40	2 (40)	11 (73.3)	5 (33.3)	9 (45)	2 (40)	29 (48.3)	
	41-50	2 (50)	4 (26.7)	9 (60)	10 (50)	2 (40)	27 (45)	
Marital status	Single	1 (20)	1 (6.7)	1 (6.7)	1 (5)	1 (20)	5 (8.3)	5.807
	Married	3 (60)	9 (60)	9 (60)	11 (55)	3 60v	35 (58.3)	
	Divorced	1 (20)	3 (20)	5 (33.3)	6 (30)	1 (20)	16 (26.7)	
	Widowed	0 (0)	2 (13.3)	0 (0)	2 (10)	0 (0)	4 (6.7)	
No. of dependants	0	0 (0)	1 (6.7)	0 (0)	0 (0)	0 (0)	1(1.7)	9.141
	1	2 (40)	3 (20)	6 (40)	5 (25)	3 (60)	19 (31.7)	
	2	2 (40)	5 (33.3)	3 (20)	5 (25)	1 (20)	16 (26.7)	
	3	0 (0)	3 (20)	3 (20)	4 (20)	0 (0)	10 (16.7)	
	4	1 (20)	3 (20)	3 (20)	6 (30)	1 (20)	14 (23.2)	
Educational level	No formal Edu.	1 (20)	5 (33.3)	7 (46.7)	8 (40)	1 (20)	22 (36.7)	6.873
	Basic Edu.	1 (20)	4 (26.7)	1 (6.7)	5 (25)	1 (20)	12 (20)	
	Sec. Sch. Edu.	2 40v	4 (26.7)	5 (33.3)	7 (35)	2 (40)	20 (33.3)	
	Tertiary	1 (20)	2 (13.3)	2 (13.3)	0 (0)	1 (20)	6 (10)	
Total		5 (100)	15 (100)	15 (100)	20 (100)	5 (100)	60 (100)	

Note. N = 60; *p < 0.05. IT't/Fm is improved fruit texture / firmness; IAp/Gl is improves appearance / Glossiness, ISC is improves fruit skin colour; ESL is extend shelf life; RSP is reduced spoilage

4.3 Effect of the different waxing materials on the physico-chemical and organoleptic quality attributes of cucumber fruits

4.3.1 Effects of different wax treatments on the weight loss (WL) of cucumber stored at different storage conditions

It is observed that generally weight loss (%) increased with days of storage. Fruits with synthetic wax (SW) wax treatment recorded the highest % WL of 17.6% at day 4 whilst coconut oil-shea butter combination (COSB) recorded the lowest value of 8.3% when stored at room temperature and relative humidity (Figure 4.3.1a). There was a significant difference among wax treatments over the storage period. Cold storage conditions also recorded similar observations (Figure 4.3.1b,) however the % WL was much lower in absolute terms than room storage conditions (Appendix).

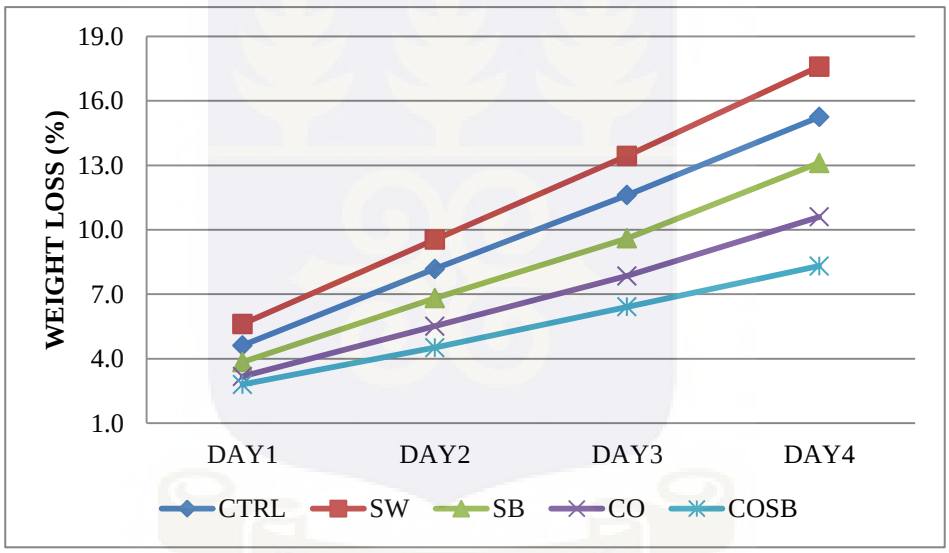

Figure 4.3.1a Effects of different wax treatments on the weight loss (WL) of cucumber stored at room temperature

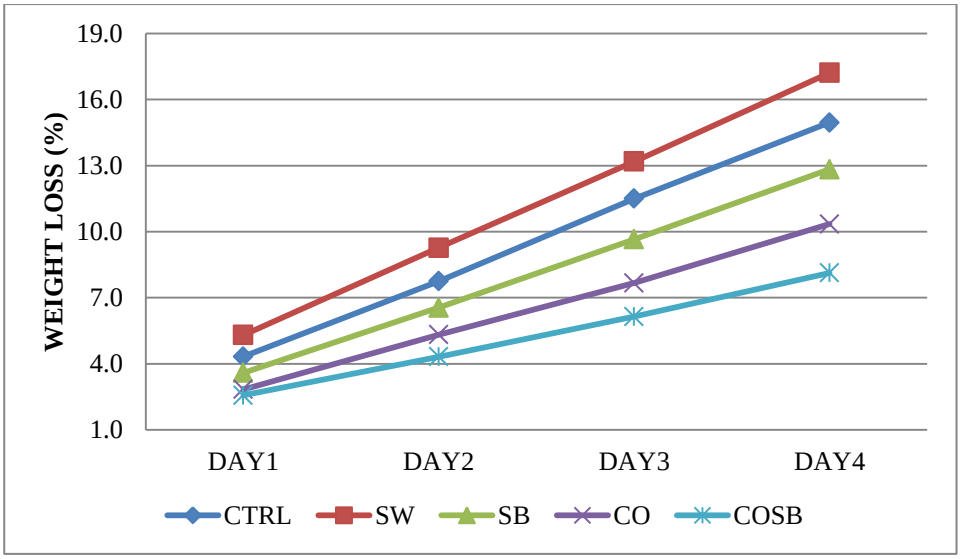

Figure 4.3.1b Effects of different wax treatments on the weight loss (WL) of cucumber stored in cold condition

4.3.2 Effects of different wax treatments on the total soluble sugars (TSS) of cucumber stored at different storage conditions

The amount of total soluble sugars (TSS) in the fruits increased over the storage period across both storage conditions. SW and CTRL treatments developed higher TSS values faster than SB, CO and COSB. However TSS of SN and CTRL at room temperature started dropping after Day 3 and Day 4 respectively whilst for the other treatments TSS increased steadily. Figure 4.3.2a shows that CTRL, SW and SB treatments were similar but significantly different from CO and COSB treatments under room temperature storage. However for cold storage COSB and CO are similar but different from SB, SW and CTRL (Figure 4.3.2b).

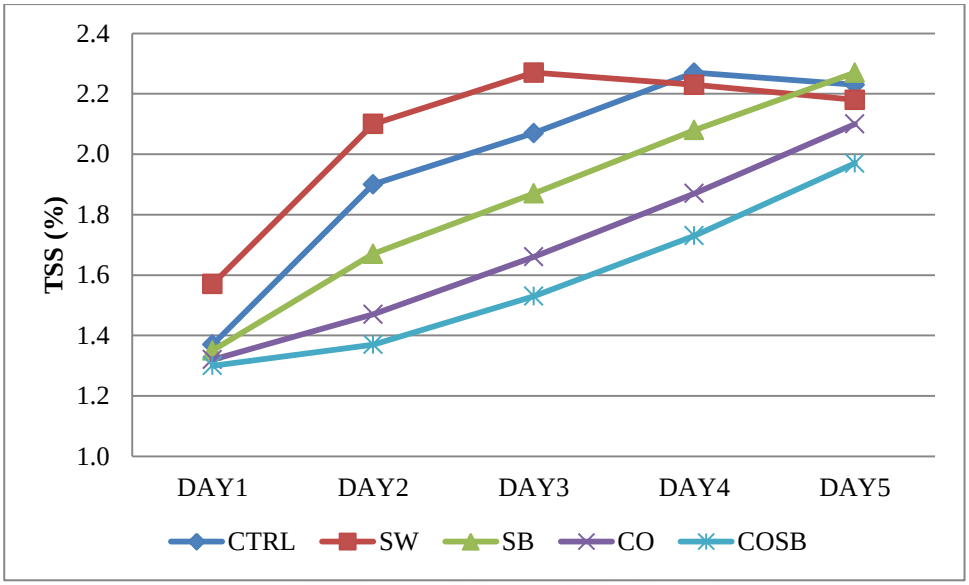

Figure 4.3.2a Effects of different wax treatments on the total soluble sugars (TSS) of cucumber stored in room condition

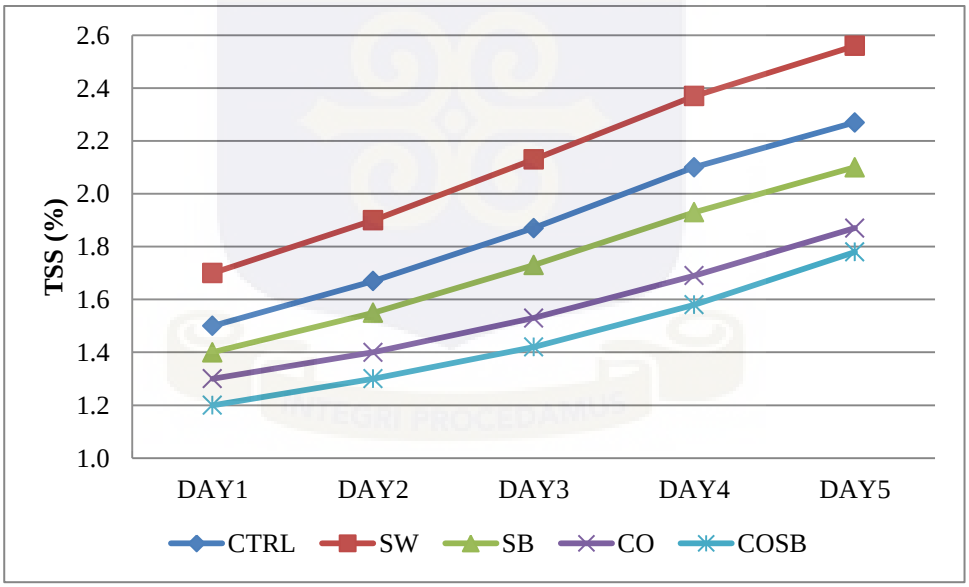

Figure 4.3.2b Effects of different wax treatments on the total soluble sugars (TSS) of cucumber stored in cold condition

4.3.3 Effects of different wax treatments on the pH of cucumber stored at different storage conditions

Figures 4.3.3a and 4.3.3b show the pH performance of waxed fruits under two storage conditions over a period of 5 days. From the graphs SW and COSB had the highest and lowest pH values respectively over the period. Treatments and days of storage were significant except DAY 1. pH of CTRL was not significantly different from SW but was different significantly from SB, CO and COSB statistically (Figure 4.3.3a). CTRL and SW treatments were similar as well as SB, CO and COSB under both storage conditions. With the exception of DAY 1, days, treatments, storage conditions and interaction of treatment and days were significant (Appendix).

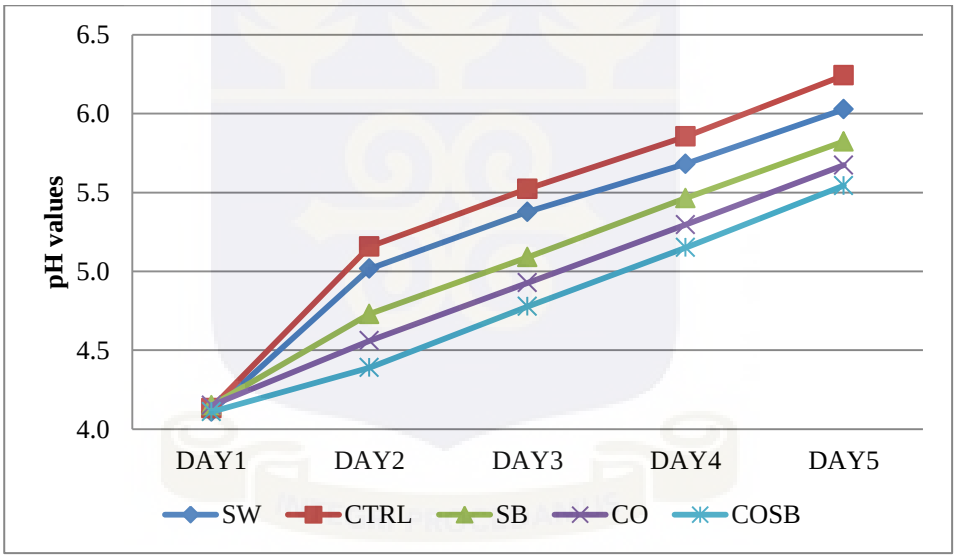

Figure 4.3.3a Effects of different wax treatments on the pH of cucumber stored in room condition

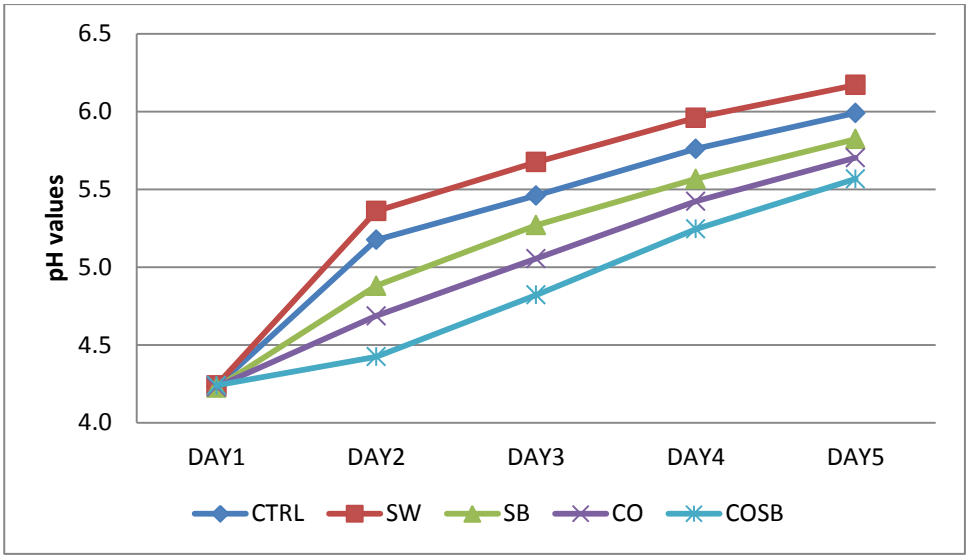

Figure 4.3.3b Effects of different wax treatments on the pH of cucumber stored in cold condition

4.3.4 Effects of different wax treatments on the total titratable acidity (TTA) of cucumber stored at different storage conditions

Total titratable acidity (TTA) of the fruits declined with storage period. However SW had the lowest TTA value (1.07cm^3) and COSB had the highest of 1.59cm^3 at DAY 5. There was no significant difference between CTRL and SW, and SB, CO and COSB treatments under room conditions likewise treatments CTRL, SW and SB, and COSB, CO and SB under cold storage. Days, treatment, storage condition and their interactions were all significantly different (Appendix).

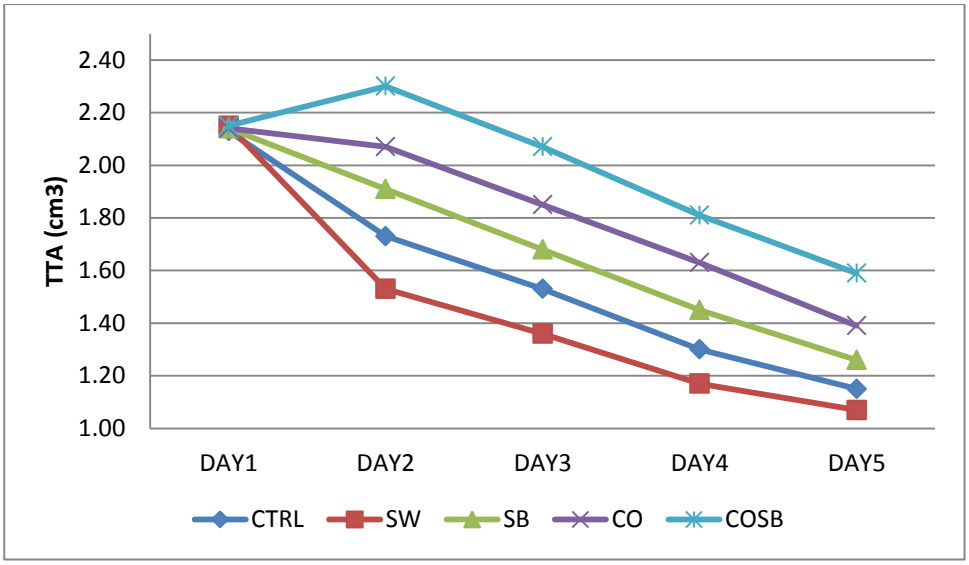

Figure 4.3.4a Effects of different wax treatments on the total titratable acidity (TTA) of cucumber stored in room condition

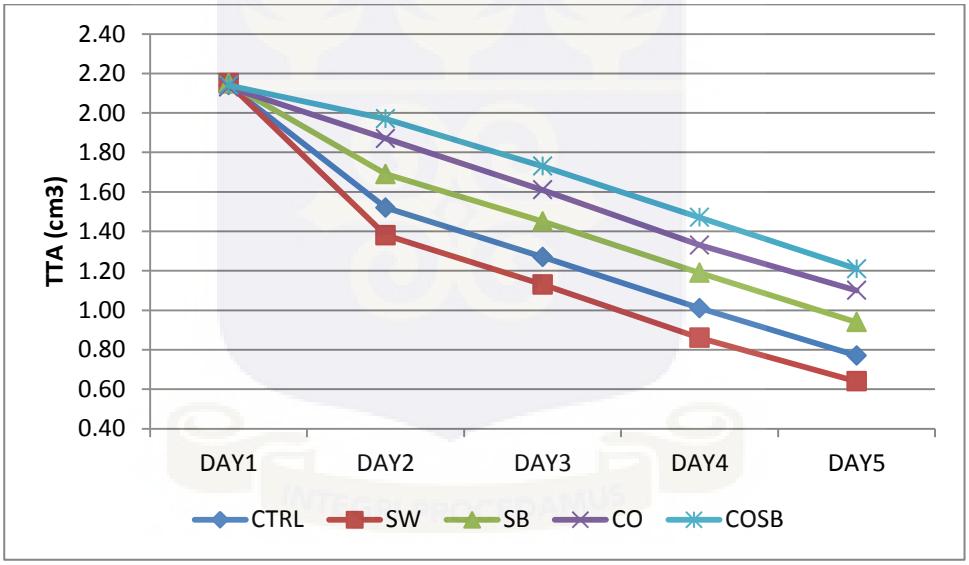

Figure 4.3.4b Effects of different wax treatments on the total titratable acidity (TTA) of cucumber stored in cold condition

4.3.5 Effects of different wax treatments on shelf life (SL) of cucumber stored at different storage conditions

Storage condition affected the shelf life of fruits. The waxed materials maintained the shelf life of fruits with the exception of SW as compared with the control treatment.

Under room storage conditions, fruits coated with SB, CO and COSB wax recorded a shelf life of 12, 13 and 14 days whilst Ctrl and SW recorded 10 and 7 days respectively. There was no significant difference between CO and COSB treatments under this storage condition. However there was substantial difference among Ctrl, SW and CO treatments statistically. A similar observation was recorded in fruits stored in cold storage conditions. However cold storage conditions recorded higher storage days of 19, 19, 18, 14 and 16 days for COSB, CO, SB, SW and Ctrl treatments in that order. There is a significant difference between the shelf life of waxed fruits stored under room condition and those stored in cold storage (Appendix).

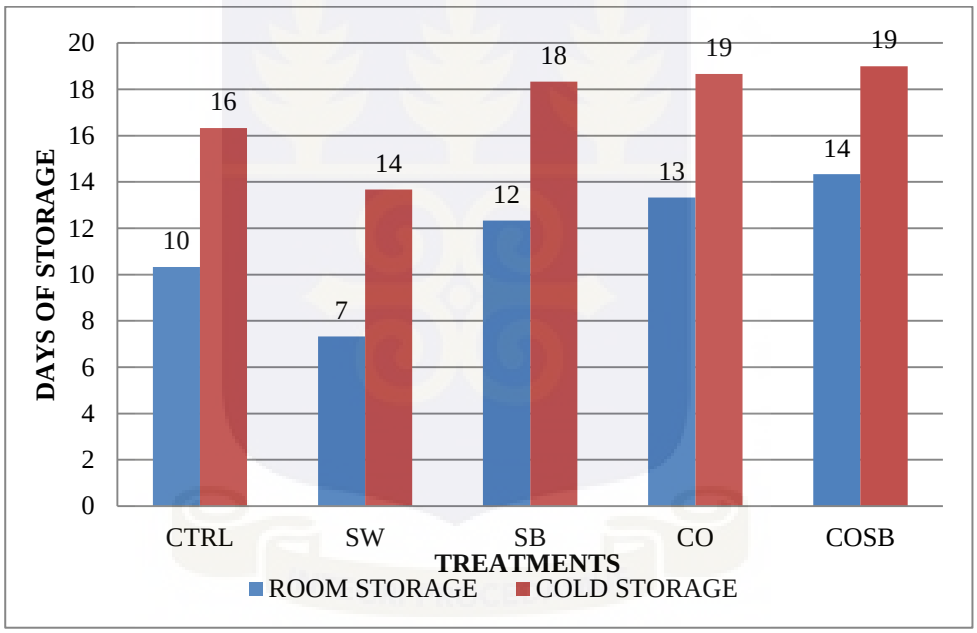

Figure 4.3.5 Effects of different wax treatments on shelf life of cucumber stored in different temperature

4.3.6 Effects of different wax treatments on fruit firmness (FF) of cucumber stored at different storage conditions

Fruit firmness could not be measured due to instrumental failure. As at the time of data collecting the instrument was still not available.

4.3.7 Effects of different wax treatments on fruit skin colour (SC) of cucumber stored at different storage conditions

Fruit skin colour has been reported to have a positive relationship with shelf life of fruits and vegetables (Wills *et al.*, (2007), Badu, (2004) and Abbott, (1999)). Inferring from the results of shelf life (Figure 4.3.1), skin colour development would be faster with control treatments and result in shorter shelf life period. Hence SW and COSB treatments would have the highest and lowest skin colour values. Deducing again from shelf life graphs, COSB, CO and SB treatments would be expected not to be different from each other but significantly different from SW and CTRL treatments. Yet again since treatment and storage condition were significantly different in shelf life, it can also be inferred that a similar trend would occur under fruit skin colour analysis.

4.4 Consumer acceptability of cucumber fruits treated with the different waxing materials

This section examines the acceptability or otherwise of cucumber fruits treated with different wax materials after 7 days of storage. Respondents were asked to assess coded samples of the waxed cucumber fruits placed before them individually and to score the waxed fruit as they perceived it. Scores were summed and converted to percentages. Consumers accessed the waxed fruits based on their skin colour, attractiveness / glossiness, fruit firmness, smell / aroma and overall acceptability. Plates 4.4a and 4.4b show some waxed cucumber fruits taken immediately after waxing and 7 days after waxing.

Plate 4.4a Waxed cucumber fruits at Day 0

Plate 4.4.b Waxed cucumber fruits at Day 7

The panellists ranked fruits treated with SB, CO and COSB as been bright and very bright whilst the CTRL and SW were dull in colour. With respect to attractiveness the panellists scored COSB, CO and SB coated fruits as been extremely glossy whilst the CTRL and SW were judged to be not glossy and slightly glossy respectively. COSB, CO and SB coated fruits were judged to be very firm and extremely firm respectively whilst CTRL and SW coated fruits were both ranked as been slightly firm. The

panellist indicated “no aroma” for fruits coated with CTRL and SW whilst SB, CO and COSB recorded “pleasant” and “very pleasant” aroma. SB, CO and COSB coated fruits were like very much than the other treatments. Skin colour, attractiveness, fruit firmness, smell / aroma and overall acceptability of waxed fruits were very significant at 7 days of storage. There was a significant difference among treatments concerning skin colour after the storage period. Consumers scored COSB and CO treatments to be the same but significantly different from SB, SW and CTRL treatments. However CTRL and SW were not significantly different. In terms of attractiveness, consumers scored SB, CO and COSB as been alike and different from SW and Ctrl treatments. CTRL and SW treatments were alike but different from SB, CO and COSB when consumers scored waxed fruits based on the fruit firmness. Smell / aroma scored a similar response as skin colour except that SB and CO are alike. Considering the treatments overall acceptability, COSB, CO and SB were not significantly different but dissimilar with SW and CTRL (Table 4.4a).

Table 4.4a Consumer acceptability of cucumber fruits treated with the different waxing materials at 7 days of storage

Treatment	Skin Colour	Attractiveness	Fruit Firmness	Smell / Aroma	Overall Acceptance
CTRL	2.9a	1.0a	2.2a	2.8b	2.8b
SW	3.0ab	1.9b	2.5a	2.5a	2.4a
SB	3.8c	4.6c	4.8b	4.4c	4.4c
CO	4.6d	4.6c	4.4c	4.6cd	4.4c
COSB	4.5d	4.8c	4.4c	4.8d	4.6c
Fprob (0.05)	<0.001	<0.001	<0.001	<0.001	<0.001

Means sharing same letters within columns are not significantly different from each other at LSD 0.05%.

CTRL = Control, **SW** = Synthetic wax, **SB** = Shea butter wax, **CO** = Coconut oil, **COSB** = Coconut oil+shea butter

CHAPTER FIVE

5.0 DISCUSSION

5.1 Introduction

In the previous chapter the results of the study were presented. The trend or relationship among the different parameters or segments of the study was established. However in this section the researcher suggests explanation or possible reasons for the trend or relationship for the different segments of the results. These possible explanations or reasons are compared with relevant or related works to affirm or otherwise disprove the generalised previous findings from similar works. The discussions follow the objectives and results of the study.

5.2 Knowledge and perceptions about fruit waxes, particularly waxed cucumber fruits among retailers and consumers in Accra.

Results from the previous chapter concerning the knowledge and perceptions of respondents towards fruit waxes particularly cucumber fruits, are discussed and possible reasons or causes for these findings are suggested.

5.2.1 Demographics of respondents

5.2.1.1 Demographic characteristics of consumers

From the results of all consumers interviewed females formed the majority and were at a ratio of 5:1 to males. However the ratio was higher open markets shoppers than supermarkets. The domination of female consumers may be due to the traditional role women in West Africa and Ghana in particular, play in households. Laforge *et al.*, (1994) and Obosu-Mensah, (1999) confirmed this by reporting that women handle 60 -

90% of domestic farm produce (vegetables, fruits, etc.) from point of origin to consumption and they also consume more fruits than males.

Majority of consumers interviewed (95%) were aged between 21-50 yrs which fall within the economically active age ground (15-49 yrs) by Ghana Living Standard Survey (GLSS 6, 2012). However open market consumers were much younger with the highest age of 40 years whereas supermarket consumers were much older with some elder citizens (50-60 years). Open markets appeal more to the youth than the elderly and this can be attributed to the competitive prices, bargaining options and travel convenience that they provide.

Majority of consumers interviewed were either married or single. More married persons preferred to shop in supermarkets than in open markets. On the contrary, more single persons preferred shopping in open markets for fruits and vegetables than supermarkets. This could be attributed to the fact that married persons had more responsibilities and less time to spend in shopping. Again the convenience of one-stop shopping is also an added benefit to consumers who were married.

Most consumers had at least 1 person who depends on them for their livelihood. The majority of consumers from open markets have no dependents whereas their counterparts from supermarkets had 2. This concurs with the findings of Ghana Demographic and Health Survey (GDHS, 2008) which reported the dependency ratio of Accra was 2.5.

Majority of all consumers have had some form of formal education with only 3% who had no formal education. Supermarket consumers had secondary education as their minimum education level attained. Majority of open market consumers have had up to basic education. Meng *et al.*, (2014) reported similar findings which suggested that more educated people prefer to shop in supermarkets.

5.2.1.2 Demographic characteristics of retailers

Females are the major players in the retailing of cucumber in Accra. They represented 73.3% whilst males represented 23.7%. However in supermarkets, males outnumbered females by 46%. The managerial roles mainly played by males could be attributed to this as well as the dominance of females in petty trading. This is in line with Obosu-Mensah, (1999).

All retailers interviewed were aged between 21-50 years. Most of the retailers aged between 31-50 years were within the economically active age group described by GLSS 6 in 2012. However the lowest age group of 21-30 years recorded respondents of less than 8% for both markets.

58.3% of all retailers were married and they constitute the majority. Supermarket retailers were either married or single whilst those of the open markets had some of their respondents being single, divorced, widowed or married. All supermarkets retailers were either married or single whilst 60% of retailers in open markets had similar status. Similar finding was reported by Johnson and Yawson, (2000) with street food-vendors in Accra. They reported that 62% of the vendors were married, 21% single, 7% widowed and 8% divorced.

All retailers from the supermarkets had at most 2 wards whereas all those from open markets had at least 1 dependant. The number of dependency could be attributed to the marital status and the fact that majority of the retailers were either married or divorced. This is in line with GDHS (2008) which put the dependency ratio of Accra to 2.5.

The educational level of supermarket retailers is very high with the minimum being secondary education. However the majority of open market retailers have no formal education. 63.3% of all retailers interviewed have had at least a basic education whilst 36.7% have no formal education. The high educational status of supermarket retailers

can be attributed to the high entry requirement by the owners of these supermarkets since all of them are privately owned. Similar findings were reported by Johnson and Yawson, (2000) where 52% and 36% of street food-vendors had basic education and no formal education respectively.

5.2.2 Experiences and purchase decisions of respondents

5.2.2.1 Experiences and purchase decisions of consumers

From the results obtained from the survey, it can be deduced the consumers did go shopping weekly, forth nightly and monthly. However the majority of consumers did their shopping on weekly basis irrespective of the market location. Most consumers may be active in some other economic activity and may have very little time to do their shopping. Also weekly shopping can be attributed to the lack of storage facilities and technology to store large produce at a time. Meng *et al.*, (2014) reported similar findings among food venders in Accra.

Fruits and vegetables were the major commodities consumers bought when they went shopping. However open market consumers often bought more vegetables than fruits and vegetables combined. With respect to cucumber, the majority of consumers did weekly shopping whilst monthly shoppers were the least.

Although all consumers did not know which particular variety of cucumber they purchase, they however bought either local or imported types provided the fruits meet their quality expectations of fruit skin colour, fruit size, glossiness, fruit shape and texture/firmness in that order of preference. Supermarket consumers preferred skin colour, fruit size, texture/firmness, fruit shape and glossiness also in that order. Consumers based their quality preference on fruit skin colour and size because these

attributes were the major external indicators of fruit quality. Kanellis *et al*., (1988) and Kader and Rolle, (2004) reported similar findings with cucumber and other fruits.

5.2.2.2 Experiences and purchase decisions of retailers

Majority of retailers interviewed had more than 4 yrs of work experience in cucumber retailing in Accra. All open market retailers had over 4 years of experience whilst only 90% of those in the supermarkets have similar work experience. Open market trading started over 50 years ago whilst the concept of supermarkets started in Accra fairly recently possible in the early 20th century. The findings concur with that of Johnson and Yawson, (2000) and Meng *et al*., (2014).

All retailers sold vegetables whilst some supermarket retailers (10%) sold fruits in addition. They also displayed mixed cucumber varieties which had been acquired from both local and imported markets. The vegetable production in Accra is below the demand and hence the imports to make up the difference in quantity demanded.

Fruits size, shape, texture/firmness, glossiness and skin colour were the external physical quality attributes expected of cucumber fruits by all retailers. However supermarket retailers ranked skin colour, glossiness and firmness/texture over fruit size and shape. Contrarily, open market retailers ranked skin colour, fruit size, glossiness, fruit shape and texture/firmness in that order.

5.2.3 Respondents perception about wax and waxed fruits

5.2.3.1 Consumers' perception about wax and waxed fruits

All consumers were not aware that fruits and vegetables can be waxed and they also claimed that they had neither bought nor used waxed produce before. This lack of knowledge about the preservation technology of using edible coatings and films could

be due the very low commercialisation of this technology although research and regulatory institutions are aware of such a technology.

Most consumers were very willing to buy and use waxed produce. Supermarket consumers were more willing (70%) to wax usage than open market consumers (68%). The high affirmative response could be due to the positive health and economic benefits statement of waxed produce received by respondents. Similar responses were reported by Lawless *et al.,* (2012) with consumers of nutraceuticals-rich juice product. However those who responded negatively could be due to social influences and the fear of uncertainty. Some even indicated their quality expectations of waxed fruits. Blanchard *et al.*, (2009), Kvaavik *et al.*, (2005) and Prättälä *et al.*, (2007) reported similar findings in previous works.

Consumers expected waxed fruits to have improved skin colour, appearance/glossiness, texture/firmness, extended shelf life and reduced spoilage. Supermarket consumers ranked improved skin colour, appearance and texture/firmness as the 3 most important quality expected whilst open market consumers expected their waxed cucumber fruits to have improved skin colour, appearance/glossiness and extended shelf life. This finding is in line with Olivas *et al.*, (2007) and Kays and Paull, (2004).

5.2.3.2 Retailers' perception about wax and waxed fruits

All retailers were not aware that fruits and vegetables can be preserved using edible wax coatings and films. They also claimed they neither purchase nor displayed waxed produce. However some waxed fruits were observed on display in one supermarket. Although this retailer was not aware, the waxed fruits were sold without any objections from their customers. When confronted, the retailer requested training and education about wax so as to equip him to differentiate between unwaxed and waxed produce.

With respect to willingness to purchase and retail waxed produce majority of all retailers indicated willingness provided the waxed produce met some quality and economic requirements. Again social influence could possible explain the negative responses from the minority (Wan *et al.*, 2007).

Some quality expectations of waxed cucumber fruit include extended shelf life, improve skin colour, appearance/glossiness, texture/firmness and reduced spoilage. Extended shelf life was ranked highest by open market retailers whilst improved skin colour was ranked highest for supermarket retailers. The inadequate storage facility of open market retailers and the temperature sensitive nature of the fruit to high temperature can be the main reasons for which open market retailers expected their waxed cucumbers to have extended shelf life. Similar findings were recorded by Kays and Paull (2004), Batu (2004) and Ubani and Suleiman (2008) with harvested fruits, tomatoes and garden eggs respectively.

5.2.4 Cross tabulation analysis of respondents' demographics and study variables

5.2.4.1 Cross tabulation analysis of consumers' demographics and study variables

5.2.4.1.1 Cross tabulation analysis of open market consumers' demographics and study variables

Skin colour was the most preferred quality attribute expected of cucumber fruit by consumers of open markets. More females opted for this attribute than males. This may be due to the fact that more females were involved in fruit and vegetable shopping than males. However there was no direct association with gender and fruit quality expectations. Those who opted for skin colour were mostly young people aged between 21-30 yrs. However there was no significant association or influence between age and fruit quality expectations. More married people prefer skin colour than single and

divorced with open market consumers. Consumers with 3 wards were the least who ranked skin colour as the most important quality attribute of cucumber fruit. Consumers with basic education were the most with respect to educational level who ranked skin colour as the most. However, there was no significant association between fruit quality expectation and educational level, number of dependents and marital status of open market consumers.

Irrespective of the demographic characteristics, open market consumers were not aware that edible coatings and films can be used as preservation method. However female consumers aged between 31-40 yrs, who were married with no wards with basic education were the most ignorant of the use of edible coatings as compared with consumers with other attributes. This is contrary to the findings of Sonti, *et al., (*2003) who found that 93.5% and 74.5% of respondents were aware of edible coatings on apples and cucumber respectively.

More married females aged between 31-40 yrs were more willing to use wax than other consumers. Consumers with 2 wards with basic education were more willing to use waxed produce. There was a strong relationship between marital status, number of dependents and educational level of open market consumers to willingness to wax. This is in line with Prättälä et *al.*, (2007) who concluded that married people consume more fruits and vegetables in Finland. State of Plate (2010) reported similar results among US fruit and vegetable consumers.

Improved skin colour was the most preferred quality attribute of waxed cucumber fruit. Majority of married females with ages between 31-40 yrs opted for improved skin colour. Those with basic education with 2 dependents preferred this quality attribute more with respect to number of dependents and educational level. However there was

no significant relationship between demographic characteristics of open market consumers and waxed cucumber fruit quality attribute expectations.

5.2.4.1.2 Cross tabulation analysis of supermarket consumers' demographics and study variables

Supermarket consumers ranked skin colour as the most important quality attribute that inform their purchase decision. Again married females aged between 31-40 yrs were the most who associated themselves with fruit skin colour. With respect to number of dependents and educational level, those with 2 wards and tertiary education were the majority in favour of skin colour. Demographic characteristics of consumers however had no relationship with fruit quality expectations in cucumber.

All consumers were not aware that edible coatings and films can be used to preserve fruits and vegetables. Irrespective of the demographics there was a general unawareness of wax usage among consumers.

With respect to the general willingness to buy and utilise waxed produce, married or divorced females aged between 31-40 yrs with 1 ward and who had had tertiary education were most willing. Their decision could be influenced by the health benefit statements received by the respondents. Social influence and fears of uncertainty could also be the underlining reasons for the negative response.

Improved skin colour was ranked as the most expected quality of waxed cucumber fruits. Again married females whose ages ranged between 31-50 yrs with 1 ward and had a minimum of tertiary education were the majority who decided on improved skin colour. There was no association between demographic characteristics and waxed fruits quality expectations of consumers.

5.2.4.1.3 Cross tabulation analysis of all consumers' demographics and study variables

Skin colour was the most ranked quality attribute that influence the purchase decisions of all consumers. Married females with 2 wards, aged between 31-40 yrs and with basic education were the majority of consumers who picked skin colour as most important. Demographics and fruit quality expectations did not show any association among them. Irrespective of the demographics, the unawareness level of waxed usage as a preservation method remained the same. However majority of them were willing to use waxed produce. More females who were married with 2 dependents and aged between 31-40 yrs with tertiary education were more willing than the others. Gender, age, marital status, number of dependents and educational level all have a positive association with willingness to wax. This is in conformity with Sonti, (2003) findings. There was no association however between demographics and waxed fruit quality expectations. Married females with at least 1 ward, tertiary educated and aged between 31-40 yrs were the majority who ranked improved skin colour as the most preferred waxed fruit quality expected.

5.2.4.2 Cross tabulation analysis of retailers' demographics and study variables

5.2.4.2.1 Cross tabulation analysis of open market retailers' demographics and study variables

Although there was no significant relationship between demographics of retailers and fruit quality expectations, females who were married, aged between 31-40 yrs, had 1 and 3 wards with no formal education were those who decided on fruit skin colour the most when purchasing cucumber fruits.

Again irrespective of the demographics, all retailers were not aware that fruits and vegetables can be preserved using edible coatings and films.

The majority of respondents indicated willingness to use or purchase waxed produce. Social influences with health and economic benefits could have been the reasons for their choice. Gender and educational level had no significant relationship with willingness to wax however age, marital status and number of dependents had a significant association with willingness to wax usage.

There was no significant association for retailers' demographics and quality expectations of waxed cucumber fruits although married females between the ages of 31-50 yrs with 4 relations and no formal education preferred waxed fruits to have extended shelf life. Sonti, (2003) reported similar findings.

5.2.4.2.2 Cross tabulation analysis of supermarket retailers' demographics and study variables

Although fruit skin colour was the most quality that influence purchase decision, there was no significant association between demographics and fruit quality expectations. However all married males who opted for this quality were between the ages of 41 and 50 yrs, had 2 dependents and had attained tertiary education.

Again there was no relationship between retailers' demographics and wax awareness. Although married females aged between 31-50 yrs with 1 ward and had attained tertiary education were the most of the non-aware retailers interviewed in Accra.

Even though the majority of retailers were willing to wax their produce, there was no significant relationship between retailer's demographics and willingness to wax fruits.

Improved skin colour was the most ranked quality attribute expected of waxed cucumber fruits. However there was no meaningful relationship between waxed fruit quality expectations and demographic characteristics of retailers.

5.2.4.2.3 Cross tabulation analysis of all retailers' demographics and study variables

With respect to the quality attribute expected of cucumber fruits, skin colour was ranked the highest at purchase. Again there was no meaningful relationship between demographics and fruit quality expectations. However married females aged between 31-50 yrs with either 1 or 2 relations and had attained secondary education were the majority who make purchase decision based on skin colour.

The usage of edible coatings and films as preservation method was unfamiliar with all retailers. This could be due to the lack of commercialisation of this technology in Accra. This explains why irrespective of the demographic characteristics there was no change with regards to wax and waxed produce awareness among all retailers interviewed in Accra.

Majority of all retailers were however very willing to wax their produce after receiving the health and economic benefit information on edible coatings and films. Those willing to accept waxed produce were married females aged between 31-40 yrs with 1 dependent and had attained secondary education. Age, marital status and number of dependents had a significant association with retailers' willingness to use wax technology. However gender and educational level were not significant with willingness to the usage of this noble technology.

Extended shelf life was ranked highest as the most imported quality attribute expected of waxed fruits. Again there was no relationship associated with demographics and quality expectations of waxed fruits although married females aged between 41-50 yrs with 4 dependents and no formal education were more in favour of extended shelf life of waxed fruits.

5.3 Effect of the different waxing materials on the physico-chemical and organoleptic quality attributes of cucumber fruits

5.3.1 Effects of different wax treatments on the weight loss (WL) of cucumber stored at different storage conditions

There was a general increase in weight loss (%) over storage period. The general loss of weight over the period can be attributed to the natural physiological process of respiration and evapotranspiration. However control and synthetically waxed fruits lost more weight (over 16% more than the highest weight loss of shea butter (SB) at Day 4) during the storage period than SB, coconut oil (CO) and coconut oil-shea butter combination (COSB) treatments. The natural waxy coat of fruits was unable to offer adequate protection against water loss and high respiration. However the improvised synthetic wax rather removed (by dissolving and evaporating) the natural wax of the fruits exposing them to more respiration, evaporation and evapotranspiration. The improvised synthetic wax although may have the active ingredient of vegetable glycerine in most commercial food waxes, lacks the complementary substances which would enhance its protective properties. This may account for the poor performance of the improvised synthetic wax. The local wax materials provided a semi permeable membrane around the fruit restricting the loss of moisture and hence maintaining the weight of the fruits over the storage period. The sharp rise in cumulative weight loss could be as a result of the high temperature and low relative humidity storage conditions created during the experimental setup. Coating with local waxes was the most effective treatment for retarding weight loss of harvested cucumber compared to the control and synthetic wax; similar results were also reported by Chien *et al.*, (2007) with chitosan coatings on mango slice, Tapia *et al.*, (2007) with alginate and gellan-based edible films for probiotic coatings on fresh-cut fruits and Olivas *et al.*, (2003)

with edible coatings composed of methylcellulose, stearic acid, and additives to preserve quality of pear wedges.

5.3.2 Effects of different wax treatments on the total soluble sugars (TSS) of cucumber stored at different storage conditions

There was a gradual increase in the TSS value over the storage period. This may be due to the breakdown of carbohydrates and proteins, partial hydrolysis of proteins and decomposition of glycosides into subunits during respiration and ripening. For the control and improvised synthetic waxed fruits, TSS values started declining during the latter stages of storage. This may be due to the advancement in ripening. However fruits coated with local wax had delayed formation of total soluble sugars. The local wax coatings formed a modified atmosphere around the fruits reducing respiration and evapotranspiration hence delayed the formation of simple sugars in the fruits and maintained the quality. Again low temperature and high relative humidity during the storage period could have contributed to low TSS value in fruits. Togrul and Arslan (2004) recorded similar results with mandarins.

5.3.3 Effects of different wax treatments on the pH of cucumber stored at different storage conditions

The increase in pH value during storage period may be due to break-up of acids during respiration and ripening into simpler acids like citric acid and malic acid. The pH values of coated fruits were lower than control and improvised synthetically waxed fruits. This may be as a result of the wax effect reducing respiration and ripening. However the improvised synthetic wax had higher pH vales than the control and this may be due to depletion effect of the natural wax coating. Again cold temperature

storage conditions had lower pH values than ambient storage. Cold temperature storage reduced the rate of respiration, maturation and ripening better than ambient temperature storage. This increasing trend is backed by (Johnson, (2000) and Forney *et al*., (2012) who indicated that the pH values of fruit flesh increased with the onset of maturation till ripening.

5.3.4 Effects of different wax treatments on the titratable acidity (TTA) of cucumber stored at different storage conditions

The titratable acidity content in the fruits decreased as the storage period advanced. The decrease in TTA can be attributed to the breakup of carbonic acids into simpler acids during respiration, ripening and senescence. Local wax coated fruits maintained their TTA content than control and synthetic wax coated fruits during the storage period. This can be attributed to the modified environmental effect around the fruits which delayed respiration and ripening. Cold temperature storage also contributed by reducing moisture loss, respiration and ripening. Abbasi *et al*., (2011) and Harker *et al*., (2008) observed similar trends with mangoes and pears respectively.

5.3.5 Effects of different wax treatments on shelf life (SL) of cucumber stored at different storage conditions

Wax material extended the shelf life of cucumber fruits both at ambient room and low temperature storage. Fruits waxed with SB, CO and COSB recorded extended shelf life of 2, 3 and 4 days under room storage and extended shelf life of 2, 3 and 3 days in cold storage better than their respective control (CTRL) fruits. This could be due to the effect of the wax material which created a microclimate around the fruit surface which decreased the oxygen content and increased the carbon dioxide content. This

microclimate regulated or reduced the product's respiration rate, deterioration and hence increased the postharvest life. This confirms similar findings by Kays and Paull (2004), Batu (2004) and Ubani and Suleiman, 2008 that waxed fruits extended shelf life than uncoated fruits even under different storage conditions.

5.4 Consumer acceptability of cucumber fruits that have been treated with the different waxing materials

There was a general acceptance of fruits coated with local wax than the control and improvised synthetic waxed fruits during the storage period. Fruits with local wax improved the physical properties of the fruits by making them brighter, extremely glossy and very firm, and impacted a pleasant aroma better than those with no or improvised synthetic wax coatings. These added benefits resulted in the overall likeness of fruits coated with local wax. The results suggested that local waxes (SB, CO and COSB) can be successfully used as edible coatings instead of the synthetic wax. The findings are in agreement with Han *et al.*, 2005 and Nanda *et al.*, 2001 who concluded that coated fruits (strawberry and pomegranate) maintained their physical characteristics (skin colour, appearance, fruit firmness and aroma) hence got better scores than uncoated fruits during sensory evaluation.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

This research concludes that retailers and consumers of cucumber in Accra were dominated by females irrespective of the market location. They were aged between 31-40 years, married with 1 or 2 wards and who had had no formal education and tertiary education respectively. With respect to experience and purchase decision of respondents, most consumers did weekly shopping for their fruits and vegetables during which cucumber fruits were purchased. They however were not particular about the varieties and the source of the fruits they purchased but explained that fruit skin colour was the most important quality attribute that informed their purchase decisions. Most retailers in the study area had more than 9 years working experience in retailing. They sold cucumber with other vegetables. They mostly acquired mixed varieties from local and imported sources, and based their purchase decision mostly on fruit skin colour.

All retailers and consumers of fruits and vegetables in Accra were not aware of edible coatings and films as a preservation technology. They had neither purchased nor used any waxed produce to the best of their knowledge. However majority of them were very willing to purchase and use waxed fruits after they had been informed of the benefits of waxing, although some raised some concerns regarding its safety and use. Whilst most consumers willing to wax cucumber expected the resultant fruits to have improved skin colour, retailers preferred extended shelf life over other quality expectations.

There was no association between demographic characteristics and fruit quality expectations, wax awareness and quality expectations of waxed fruits for both

respondents. However there was a significant association between willingness to wax and demographic characteristics of all respondents. Married females of open market consumers aged between 31-40 years with 2 dependants and who had had basic education were more willing to purchase and use waxed produce whereas their counterpart retailers were aged between 31-40 years, married and with 1 dependant.

Coconut oil, shea butter oil and their combination proved to be the best wax material over the control and synthetic wax in maintaining pH, TTA, weight loss and extended shelf life of cucumber fruits. CO and COSB treatments were the most preferred and accepted by the panellists in terms of skin colour, appearance, texture and overall acceptability.

6.2 Recommendations

The use of edible coatings and films (ECs and EFs) is a noble, cost effective, low capital and technology requirements, and safe preservation method for fruits and vegetables. However the awareness and commercialisation of such as a technology is yet to be appreciated and utilised by major stakeholders (consumers and retailers) in the fruit and vegetable value chain in Accra, Ghana.

For this reason it is recommended that all stakeholders in this value chain be educated on the composition, advantages and applications of ECs and EFs as a preservation method to reduce postharvest losses, extend their shelf life and appeal of cucumber fruits as well as increase revenue. This can be accomplished through focused group discussions with consumer and retailer associations and public civic education by research and regulatory institutions. Advertisements should be targeted at stakeholders particularly married females aged between 31-50 yrs with at least a dependant and formal basic education or training.

Since most retailers and consumers of fruits and vegetables in Accra were very willing to adopt and consume produce with ECs and EFs, further work should be conducted using other locally available edible vegetable oils (groundnut oil, palm and palm kernel oil, soy oil, etc.) and starches (cassava, corn, rice or sorghum) as wax materials. Again this study can be carried practically using actual real market conditions (open market and supermarkets). Profit and cost benefit analysis should also be conducted to provide further and better understanding of the effects of demographic characteristics on the respondents' responses and the cost effectiveness of this technology to facilitate easy commercialisation of this technology.

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APPENDIXES

Appendix1: Consumers' Questionnaire

UNIVERSITY OF GHANA, CROP SCIENCE DEPARTMENT, LEGON.

Topic: **"Effectiveness and efficacy of different waxing materials on the quality of cucumber fruit stored under different source conditions."**

Questionnaire No: …….. Date: ……

Respondents Name: …… Contact No: ……

Location: ……

I am a student in the University of Ghana pursuing a Master of Philosophy Degree in Postharvest Technology. This questionnaire is meant to collect information for research purposes as part of the requirement for a master of philosophy degree. I would therefore be very grateful if you could willingly partake in this interview with the assurance that information obtained will be treated as confidential and be used solely for academic purposes. Thank you for participating.

Section A: Socioeconomic Characteristics of Consumers

Please tick one answer only.

1. Gender: Male ☐ Female ☐
2. Age: < 20 ☐ 21 -30 ☐ 31 – 40 ☐ 41- 50 ☐ 51- 60 ☐ > 60 ☐
3. Marital status: Single ☐ Married ☐ Divorced ☐ Widowed ☐ Widower ☐
4. No. of dependants: 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ >5 ☐
5. Level of education: No formal education ☐ Basic Education ☐ Secondary Education ☐ Tertiary Education ☐

Section B: Purchase Decision of Consumers

6. How often do you shop here? Daily ☐ Weekly ☐ Forth Nightly ☐ Monthly ☐ Quarterly ☐
7. What do you often buy? Fruits ☐ Vegetables ☐ Fruits and vegetables ☐ Tubers ☐ Others ☐

8. Do you also buy cucumber? Yes ☐ No ☐
9. How often do you buy cucumber? Daily ☐ Weekly ☐ Forth Nightly ☐ Monthly ☐ Quarterly ☐
10. Which cucumber variety (ies) do you buy? Ashley ☐ Poinsett ☐ Don't know ☐
11. Aside price, which of these qualities of cucumber affect your decision to buy. Please rank with 1 being lowest score and 5 being highest score.

Quality	Score				
Fruit size					
Fruit shape					
Texture / Firmness					
Appearance / Glossiness					
Skin colour					

12. Aside price, which of these qualities in your opinion is the most important thing you look out for when buying cucumber? Fruit size ☐ Fruit shape ☐ Texture/ Firmness ☐ Appearance/ Glossiness ☐ Skin colour ☐

Section C: Consumers Perception on waxed Fruits.

13. Are you aware that fruits can be waxed? Yes ☐ No ☐
14. If yes, please explain how you got to know? ……
15. Have you ever bought waxed fruits before? Yes ☐ No ☐
16. Have you ever bought waxed cucumber fruits before? Yes ☐ No ☐
17. If no, would you try buying and consuming waxed fruits? Yes ☐ No ☐
18. Please give reasons for your choice of answer? ……
19. If yes, how did you treat the waxed before consuming cucumber fruit?

Washed wax off ☐ Peeled off the skin ☐

20. Below is a list of some of the benefits of waxing on fruits, please rank which of these you would prefer with 1 being lowest score and 5 being highest score?

Benefits	Score				
Improves Texture / Firmness					
Improves Appearance / Glossiness					
Improves Skin Colour					
Extends Shelf Life					
Reduces Spoilage					

21. Please indicate which of these benefits of waxing fruits is most important to you? Improves texture / firmness ☐ Improves appearance / glossiness ☐ Improves skin colour ☐ Extends shelf life ☐ Reduces spoilage ☐

Thank you.

Appendix 2: Retailers' Questionnaire

UNIVERSITY OF GHANA, CROP SCIENCE DEPARTMENT, LEGON.

Topic: **"Effectiveness and efficacy of different waxing materials on the quality of cucumber fruit stored under different source conditions."**

Questionnaire No: …… Date: ……
Respondents Name: …… Contact No: ……
Location: ……

I am a student in the University of Ghana pursuing a Master of Philosophy Degree in Postharvest Technology. This questionnaire is meant to collect information for research purposes as part of the requirement for a master of philosophy degree. I would therefore be very grateful if you could willingly partake in this interview with the assurance that information obtained will be treated as confidential and be used solely for academic purposes. Thank you for participating.

Section A: Socioeconomic Characteristics of Retailers

Please tick one answer only.

1. Gender: Male ☐ Female ☐
2. Age: < 20☐ 21-30☐ 31–40☐ 4-50 ☐ 51- 60☐ > 60 ☐
3. Marital status: Single☐ Married ☐ Divorced ☐ Widowed☐ Widower☐
4. No. of dependants: 0☐ 1☐ 2☐ 3☐ 4☐ 5☐ >5☐
5. Level of education: No formal education☐ Basic Education☐ Secondary Education ☐ Tertiary Education ☐

Section B: Purchase Decision of Retailers

6. How long have you been working in this business?<1☐1-3☐ 4-6☐ 7-9☐ >9 ☐
7. Aside cucumber, what other commodities do you sell? Please tick as many as possible. Lettuce ☐ Cabbage☐ Onion☐ Pepper☐ Fruits☐ Spices ☐ Roots and tubers ☐ Grains ☐
8. What variety (ies) of cucumber do you sell here? Ashley☐ Poinsett☐ Mixed ☐ Don't know☐
9. Where do you get the cucumber you sell? From: Own farms☐ Local farmers ☐ Local market ☐ Imports☐

10. Aside price, which of these qualities of cucumber affect your decision to buy. Please rank with 1 being lowest score and 5 being highest score.

Quality	Score				
Fruit Size					
Fruit Shape					
Texture / Firmness					
Appearance / Glossiness					
Skin Colour					

11. Aside price, which of these qualities in your opinion is the most important thing you look out for when buying cucumber? Fruit size ☐ Fruit shape ☐ Texture/ Firmness ☐ Appearance/ Glossiness ☐ Skin Colour ☐

Section C: Retailers' Perception on Waxed Fruits.

12. Are you aware that fruits can be waxed? Yes ☐ No ☐
13. If yes, please explain how you got to know? …….
14. Have you ever bought waxed fruits before? Yes ☐ No ☐
15. Do you wax your fruits before selling? Yes No ☐ ☐
16. If no, would you wax your commodities (fruits and vegetables)? Yes ☐ No ☐
17. Please give reasons for your choice of answer? ……
18. If yes, do you remember the type of wax used? Yes ☐ No ☐
19. If yes, please list the type of wax? ……..……..
20. Below is a list of some of the benefits of waxing on fruits, please rank which of these you would prefer with 1 being lowest score and 5 being highest score?

Benefits	Score				
Improves Texture / Firmness					
Improves Appearance / Glossiness					
Improves Skin Colour					
Extends Shelf Life					
Reduces Spoilage					

21. Please indicate which of these benefits of waxing fruits is most important to you?

Improves texture / firmness ☐ Improves appearance / glossiness ☐
Improves skin colour ☐ Extends shelf life ☐ Reduces spoilage ☐

Thank you.

Appendix 3: Analysis of variance table for weight loss (WL %) of waxed cucumber stored at different storage conditions.

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Trt	4	549.6763	137.4191	1329.65	<.001
Days	3	1338.9815	446.3272	4318.61	<.001
StrgCond	1	1.6560	1.6560	16.02	<.001
Trt*Days	12	86.7436	7.2286	69.94	<.001
Trt*StrgCond	4	0.0450	0.0112	0.11	0.979
Days*StrgCond	3	0.1039	0.0346	0.34	0.800
Trt*Days*StrgCond	12	0.1825	0.0152	0.15	1.000
Residual	80	8.2680	0.1033		
Total	119	1985.6569			

Appendix 4: Analysis of variance table for total soluble solids (TSS) of waxed cucumber stored at different storage conditions.

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Trt	4	5.079356	1.269839	1106.13	<.001
Days	4	9.805403	2.451351	2135.32	<.001
StrgCond	1	0.073041	0.073041	63.62	<.001
Trt*Days	16	1.361224	0.085076	74.11	<.001
Trt*StrgCond	4	0.168929	0.042232	36.79	<.001
Days*StrgCond	4	0.544949	0.136237	118.67	<.001
Trt*Days*StrgCond	16	0.365664	0.022854	19.91	<.001
Residual	100	0.114800	0.001148		
Total	149	17.513366			

Appendix 5: Analysis of variance table for pH of waxed cucumber stored at different storage conditions.

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Trt	4	6.867878	1.716970	248.47	<.001
Days	4	50.035200	12.508800	1810.24	<.001
StrgCond	1	0.225583	0.225583	32.65	<.001
Trt*Days	16	1.923012	0.120188	17.39	<.001
Trt*StrgCond	4	0.025140	0.006285	0.91	0.462
Days*StrgCond	4	0.079771	0.019943	2.89	0.026
Trt*Days*StrgCond	16	0.171934	0.010746	1.56	0.096
Residual	100	0.691004	0.006910		
Total	149	60.019523			

Appendix 6: Analysis of variance table for total titratable acid (TTA) of waxed cucumber stored at different storage conditions.

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Trt	4	4.7285027	1.1821257	1436.94	<.001
Days	4	19.8049827	4.9512457	6018.53	<.001
StrgCond	1	1.7930667	1.7930667	2179.58	<.001
Trt*Days	16	1.3014907	0.0813432	98.88	<.001
Trt*StrgCond	4	0.0576867	0.0144217	17.53	<.001
Days*StrgCond	4	0.5807667	0.1451917	176.49	<.001
Trt*Days*StrgCond	16	0.0789467	0.0049342	6.00	<.001
Residual	100	0.0822667	0.0008227		
Total	149	28.4277093			

Appendix 7: Analysis of variance table for shelf life (SL) of waxed cucumber stored at different storage conditions.

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Trt	4	149.4667	37.3667	93.42	<.001
StrgCond	1	240.8333	240.8333	602.08	<.001
Trt*StrgCond	4	2.6667	0.6667	1.67	0.197
Residual	20	8.0000	0.4000		
Total	29	400.9667			

Appendix 8: Analysis of variance table for consumer acceptability of waxed cucumber based on Skin Colour after 7days.

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Trt	4	77.1600	19.2900	36.71	<.001
Residual	145	76.2000	0.5255		
Total	149	153.3600			

Appendix 9: Analysis of variance table for consumer acceptability of waxed cucumber based on Attractiveness after 7days.

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Trt	4	385.4400	96.3600	412.16	<.001
Residual	145	33.9000	0.2338		
Total	149	419.3400			

Appendix 10: Analysis of variance table for consumer acceptability of waxed cucumber based on Fruit firmness after 7days.

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Trt	4	176.1600	44.0400	115.06	<.001
Residual	145	55.5000	0.3828		
Total	149	231.6600			

Appendix 11: Analysis of variance table for consumer acceptability of waxed cucumber based on Smell / Aroma after 7days.

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Trt	4	140.6400	35.1600	135.95	<.001
Residual	145	37.5000	0.2586		
Total	149	178.1400			

Appendix 12: Analysis of variance table for consumer overall acceptability of waxed cucumber after 7days of storage.

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Trt	4	128.6400	32.1600	90.37	<.001
Residual	145	51.6000	0.3559		
Total	149	180.2400			

APPENDIX 13: SENSORY QUESTIONNAIRE

UNIVERSITY OF GHANA, CROP SCIENCE DEPARTMENT, LEGON.

Topic: **"EFFECTIVENESS AND EFFICACY OF DIFFERENT WAXING MATERIALS ON CUCUCMBER FRUITS STORED IN DIFFERENT MARKET CONDITIONS."**

Name: …… Gender: …… Sample Code: …….
Contact: …….. Date: …….. Replication No.: …….

You will be receiving coded samples of cucumber fruits treated with different edible wax materials. Please pass your individual judgement based on the keeping and sensory quality of the fruits careful observation and examination. Please register your judgement based on the scores provided in the table below. **THANK YOU.**

Score	**Skin Colour**	**Attractiveness**	**Fruit Firmness**	**Smell / Aroma**	**Overall Acceptability**
1	Extremely dull	Not glossy	Not Firm	Very unpleasant	Dislike very much
2	Very dull	Slightly glossy	Slightly firm	Unpleasant	Dislike
3	Dull	Glossy	Firm	No smell	Like
4	Bright	Very glossy	Very firm	Pleasant	Like very much
5	Very bright	Extremely glossy	Extremely firm	Very pleasant	Like extremely
Please indicate your score or judgement by ticking or writing your score in appropriate column.					
1					
2					
3					
4					
5					