PERCEPTIONS OF AND WILLINGNESS TO PAY FOR HEXANAL TECHNOLOGY AMONG SMALLHOLDER BANANA FARMERS IN MERU COUNTY, KENYA

By

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DECLARATION

This thesis is my original work and has not been presented for award for a degree in any other academic institution.

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This thesis is dedicated to my loving parents Mr & Mrs. Kahwai, my sisters Jacinta, Ann and Roselyne Kahwai, my niece Lateysha Wanjiku, and my grandmother Jane Kariuki.

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This study was part of the 'Enhanced preservation of fruits using nanotechnology' project that aimed at testing the efficacy of Hexanal technology in reducing post-harvest losses in banana, mango and pawpaw fruits.

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ABBREVIATIONS AND ACRONYMS

CVM- Contingent Valuation Method

EFF- Enhanced Freshness Formulation

FAO- Food and Agriculture Organization of the United Nations

HCD- Horticultural Crops Directorate

HCDA- Horticultural Crops Development Authority

IFPRI- International Food Policy Research Institute

IITA- International Institute of Tropical Agriculture

KAVES- Kenya Agricultural Value Chain Enterprises

KNBS- Kenya National Bureau of Statistics

NGO- Non- Governmental Organization

PCA- Principal Component Analysis

SPSS- Statistical Package for Social Scientists

WTP- Willingness to pay

ABSTRACT

About 40-50% of horticultural produce meant for consumption is lost along the value chain in Sub-Saharan Africa due to post-harvest losses. This greatly reduces food availability and leads to increased food prices thereby increasing food insecurity in Africa. Promotion of technologies to reduce these post-harvest losses is therefore necessary in improving food security. Hexanal technology, which is an organic compound, has been identified as an important intervention as it is able to prolong shelf life of perishable farm produce such as bananas thereby providing farmers with more time to access markets and/or get better prices. In order to inform the commercialization decisions of the technology, it is important that farmers' perceptions and willingness to pay (WTP) for the technology are studied. This thesis assessed farmers' perceptions of and their willingness to pay for Hexanal technology to prolong fruits' shelf life among banana farmers in Meru County. In addition, the study also assessed the socioeconomic and other factors conditioning farmers' perceptions and their willingness to pay for the Hexanal technology.

Methodologically, data used for analysis was generated from a sample of 130 households from South Imenti Sub-county, Meru County. The sample was selected using purposive and systematic random sampling from a sampling frame obtained from banana farmer groups in the study area. Data was obtained through face-to-face interviews with the household heads or their spouses using semi-structured questionnaires. Principal Component Analysis (PCA) was conducted in order to reduce the many and correlated variables to distinct perceptions while the Contingent Valuation Method (CVM) was employed to measure the WTP. Data was analyzed separately for farmers who were 'aware' and 'not aware' of the technology. From the PCA three components were extracted namely; 'effectiveness' which described the potential for Hexanal to reduce post-harvest losses as well as increasing incomes,

‘acceptability’ which explained social acceptance of the technology to the farmers and ‘environmental Safety’ of the technology.

Results indicate that both groups of farmers had positive perceptions on the Hexanal technology and its application. Farmers aware of the technology perceived it to be able to reduce post- harvest losses leading to increased incomes. They also noted that the technology was socially acceptable. However, farmers not aware of the technology perceived Hexanal as difficult to use as they emphasized that they would require the assistance of an extension officer. Perception scores were regressed against explanatory variables using Ordinary Least Squares between the sub-samples. Perceptions scores between the sub-samples were influenced by different sets of variables such as sex of household head, distance to input shop, age and annual household income among others. Results from the CVM approach show that farmers were willing to pay to use the Hexanal technology, the mean WTP value per 0.25L of Hexanal being Ksh 466.67 for farmers aware of the technology and Ksh.331.86 for farmers not aware of the technology. This is a clear indication that access to information on the use and benefits of Hexanal technology increases the amounts households are willing to pay for it in order to reduce their post-harvest losses. Results indicate that a higher initial bid, farmers with larger land size as well as farmers with positive perceptions on social acceptability of Hexanal had a higher WTP for Hexanal. The major key policy implication from the study is that, it is important that stakeholders invest more in dissemination of information on the technology to increase its awareness especially among farmers currently not aware of the technology. This will enhance positive perceptions about Hexanal that will increase its adoption. Future studies should focus on the cost benefit analysis of adopting Hexanal.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Huge Post-harvest losses of between 40-50% impact negatively on the global food and nutritional security, the environment as well as the economic development (FAO, 2014). Globally, the specific causes of food losses differ from country to country as they depend on the prevailing socio-economic and ecological conditions (FAO, 2014). Across the food categories, fruits and vegetables are more susceptible to food loss and waste globally. According to literature, these losses are estimated at 66% based on total weight (FAO 2011; Lipinski et al. 2013). This is due to their very short postharvest shelf life which makes them highly perishable (Kader, 2002).

Post-harvest loss is defined as the measurable qualitative and quantitative food loss within the postharvest system (de Lucia and Assennato, 1994). The postharvest system is comprised of interconnected activities ranging from time of harvest through product processing and marketing to the food preparation and final decision by the consumer to consume or discard the food. The definition is consistent with Grolleaud (2002) who described postharvest losses as quantifiable reduction in foodstuffs affecting both the produce quality and quantity.

These losses are categorized as either quantitative or qualitative and may occur at any stage within the postharvest system. Quantitative losses affect the weight or volume of produce while qualitative losses lead to altered physical attributes of the produce which consumers find appealing (Hodges et al., 2010). Improper handling that causes bio deterioration by microorganisms, birds or rodents and insects are the main causes of both the qualitative and quantitative losses. These losses are a major cause of economic losses as fresh produce fail

either to reach the markets or reach in deteriorated state reducing consumer acceptability (Hodges et al., 2011; Kader, 2005) thereby fetching very low prices.

In Kenya, the fruit sub-sector is very important due to its tremendous contribution to the economy. In 2016, the sub-sector contributed KSh. 57 billion which accounted for 27% Kenya's value of horticultural produce (HCD 2016). Bananas (*Musa spp*) were ranked first in terms of production with 1.24 Million tons being produced under 63,074Ha of land which was an increase from the 60,743Ha in 2015. The production was reported to be worth KSh18.1 billion accounting for 31.6% of the total fruits' production in the Country (HCD 2016). The increased production has been attributed to the shift from backyard to commercial farming of bananas as a pro-poor agro-enterprise (Muchui et al. 2010; Miriti et al. 2013). The major banana producing regions in Kenya together with their percentage contribution are; Meru (19%), Kirinyaga (14%), Embu (12%), Taita Taveta (9%), Muranga (7%), Kisii (6%), Tharaka Nithi (6%) and Bungoma (5%) (KAVES, 2017). The most preferred banana variety currently at 23% is the Cavendish (both the Dwarf and Giant).

The banana enterprise is highly commercialized in Kenya as farmers sell 86% of their output (KAVES 2017). Commercialization of bananas especially in Central and Eastern regions can be attributed to the decline in traditional cash crops such as coffee as well as the recent success in the introduction of high yielding tissue culture banana which include; GrandNian, Williams, Chinese Cavendish and Giant and Dwarf Cavendish varieties (Wambugu & Kiome 2001; Karembu 2007). The market for banana is also rapidly expanding due to the growing demand for fresh juice processing and increasing health concerns (USAID, 2015).

Despite the increased importance of the fruits sub-sector, most farmers are not gaining from the ready market due to the huge losses occasioned by poor post-harvest handling and on-season glut of fruits in the market. This is because banana is a delicate and perishable fruit

(Muchui et al. 2010). The high-post harvest losses reduce the availability of the fruit in the supply chain as well as farmers' incomes since they are forced to sell their produce at farm gate prices. Reducing these losses is very important as bananas are of huge economic importance to all value chain actors and essential for human nutrition as they are a source of vitamins, fibers, phytonutrients and minerals. Moreover, reducing these losses can enhance achievement of food security which is one of the United Nation (UN) Sustainable Development Goals (SDGs).

1.2 Hexanal

Hexanal, a nanotechnology formulation of a naturally occurring compound ($C_6H_{12}O$) is one of the technologies identified as having potential to reduce post-harvest losses of fresh produce. Hexanal is found in traces in some plants such as beans, cucumbers and grasses. In grasses, the compound is responsible for the odor produced when grass is mowed (Misran, 2013). Use of Hexanal, which is a relatively new technology, has been found to be effective in prolonging the shelf life of some temperate fruits like peaches, apples, sweet cherries and strawberries (Sharma et al., 2010). In pears, Hexanal has been found to have mild antifungal effect leading to delayed emergence of underlying post-harvest infections associated with Penicillium species (Fan et al., 2006). In the United States, Hexanal is already approved by the Food and Drugs Authority (FDA) as a safe food additive (US Patent No. 6, 514, 914; 7, 198, 81). In the approval, it is termed as a green flavor that is safe to use in processed plants-based foods as it does not remain in treated tissues 48 hours after treatment (http:/www.accessdata.fda.gov/). Furthermore, in the human body it is oxidized after 48 hours to hexanoic acid which is further oxidized to water and carbon (IV) oxide during the respiration process (Kruse et al., 2006).

Hexanal is insoluble in water and to increase its solubility a formulation is made known as the Enhanced Freshness Formulation (EFF) that contains Tween 20, ethanol and distilled water. Hexanal works by inhibiting the enzymes that are responsible for the breakdown of cell membranes in the fruit's ripening process (Paliyath and Subramanian, 2008). According to Miller (2010), Hexanal aims at prolonging fruits' shelf life thereby reducing post-harvest losses. Results from studies in Kenya between 2014 and 2018 on bananas and papaya showed that Hexanal prolonged the time the fruits remained on the tree when applied as a pre-harvest spray by 12 to 18 days based on peel color changes. In addition, it prolonged the storage shelf life when applied as a dip on mature green fruits by 9 days (Hutchinson et al., 2018; Yumbya et al., 2018).

With Hexanal technology, farmers will not have to harvest all their fruits at the same time, and this will give them ample time to find better markets thereby reducing post-harvest risks and increasing their incomes. A study by the Rockefeller Foundation (2015) recommends that it is important to stimulate demand and supply of alternative technologies among farmers that are aimed at reducing post-harvest losses of fresh farm produce such as bananas. This will ensure the achievement of sustainable development target number 12.3, to reduce post-harvest losses by half by the year 2030. Increased adoption of Hexanal technology will be beneficial to banana farmers as delaying the ripening of their harvest will reduce post-harvest losses incurred during peak seasons. Currently Hexanal is not yet in commercial use in Kenya as it is awaiting registration by Kenya Plant Health Inspectorate Service (Kephis) before its' introduction to the Kenyan market.

1.3 Statement of the research problem

In developing countries, 20-25% of fruits and vegetables produced are lost due to poor post-harvest handling (Mashav, 2010). In India, 25-40% of fruits are estimated to be lost from

harvesting to the consumption stage as a result of poor post- harvest handling techniques (India Ministry of Agriculture, 2013). Statistics on horticultural post-harvest losses in Kenya vary depending on authors. The International Institute of Tropical Agriculture (IITA) estimates post-harvest losses to be 50% (2010), while Kitinoja and Cantwell (2010) put them at 18- 45%. The main cause being poor post-harvest handling and storage (Mashau et al., 2012).

Currently, some of the affordable technologies available and recommended to reduce post-harvest losses in developing countries are Integrated Pest Management (IPM), value addition into banana juice or flour, sun drying, charcoal/brick coolers and solar-powered refrigeration to preserve freshness. Others include mechanical refrigeration, hypobaric storage and controlled atmospheres that are mainly used in the developed countries. In addition, 1-methylcyclopropene (1-MCP) has been found to be effective in prolonging shelf life of some climacteric fruits such as mangoes (Ambuko et al., 2013) and avocado (Meyers et al., 2011). Despite its effectiveness, its use in bananas has been limited due to its undesirable effects on the fruit's quality such as colour change, blotchy ripening, and softening. Except for the adiabatic cooling, most of these technologies are beyond the reach of small- scale farmers in developing countries (Woldemariam et al., 2014). It is therefore necessary to complement existing technologies with affordable alternatives that will enhance banana shelf life without compromising the fruit's quality (Yumbya et al., 2018). This will ensure improved farmers' welfare through increased incomes.

Past studies have demonstrated that farmers are willing to pay for new technologies and improved services that are likely to reduce farm produce losses, increase productivity and gain them access to better markets (Uddin et al., 2014; Muchiri et al., 2012; Migwi et al.,

2012; De Groote et al., 2008; Adetonal et al., 2007). However such a study has not been conducted for Hexanal in Kenya.

Prolonging the shelf life of bananas gives farmers time to look for better markets and sell their fruits at premium prices. However, despite the already documented effectiveness of Hexanal to reduce post-harvest losses, there is very little information on farmers' awareness and perceptions of Hexanal efficiency. In addition, the actual price farmers would be willing to pay for the technology in Kenya is not known. This study makes an attempt to fill the knowledge gaps taking the case of banana production and marketing in Meru County.

1.4 General Objective

The general objective of the study was to determine farmers' perceptions of and willingness to pay for Hexanal technology for reduction of post-harvest losses among banana farmers in Meru County, Kenya

1.5 Specific objectives

1. To assess farmers' perceptions on the use of Hexanal technology in reducing post-harvest losses in bananas.
2. To determine the factors influencing farmers' perceptions on the use of Hexanal technology
3. To estimate how much farmers are willing to pay (WTP) for the use of Hexanal technology in reducing post-harvest losses.
4. To assess factors influencing willingness to pay for Hexanal technology

1.6 Hypotheses

1. Farmers have positive perceptions towards Hexanal technology

2. Institutional factors, knowledge and socio-economic factors influence farmers perceptions
3. Farmers are willing to pay the expected set price for Hexanal technology.
4. Socio-economic factors and perceptions on Hexanal influence willingness to pay for Hexanal

1.7 Justification

Information generated from the study will be important to technology developers and retailers in the commercialization of the product. This is because if the farmers are willing to adopt and pay for the product, then the commercial viability and up scaling of Hexanal will be justified. Furthermore, estimates of the maximum amount farmers are willing to pay will help in pricing mechanisms for the product.

Results from perceptions on attributes of the technology will provide insights to manufacturers of the product and the private sector who are expected to be part of the commercialization process. They will be able to better understand the attitudes of their target consumers concerning Hexanal and their willingness to use/ adopt hence their demand for the product.

Project partners will also benefit from the study as estimates from WTP will inform on the ability of farmers to meet the cost of Hexanal and provide insights into whether government intervention will be necessary, and in what form. As such, WTP estimates will also provide policy makers with sufficient information needed for the investment decisions of promotion of Hexanal

Increased adoption of Hexanal technology will be very beneficial to banana farmers as delaying the ripening of their harvest will reduce post-harvest losses incurred which results in

reduced incomes from banana production. Additionally, farmers will also be able to obtain premium prices for their produce in the markets as a result of glut reduction during peak seasons. Reduction of these post-harvest losses will contribute in the achievement of the sustainable development goal number two that aims to end hunger, achieve food security and improved food nutrition as well as promote sustainable agriculture. Further, it will be instrumental in contributing towards the achievement of Kenya's vision 2030 by addressing the food security pillar in the big four agenda.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Theoretical background of economic valuation of new agricultural technologies

Valid estimates of WTP are considered very essential in agribusiness when developing optimal pricing strategies for new markets (Balderjahn, 2003). Monroe (2003), Nagle et al. (2002), and Simon (1992) argue that such estimates and perceptions of value by consumers help to model demand functions and to predict market responses arising from price changes. With the increased development of new agricultural technologies, it has become crucial to estimate their values especially due to the current shift towards producer/ consumer demand driven marketplaces (Lusk et al., 2004). Use of consumers' willingness to pay has been gaining popularity among economists and market researchers as a standard approach to value goods and services for which market- based prices are non- existent (Chandrasekaran et al., 2009). With the aim of informing agribusiness decisions on adoption and commercialization of new products, the number of willingness to pay studies is increasing.

Willingness to pay is the economic value attached to a good by an individual under certain conditions (Yang et al., 2007). For environmental services, it refers to the maximum amount of money an individual is willing to give up to increase the quantity or quality of an ecosystem good or service (Agudelo, 2001). Therefore, WTP estimates are considered as measures of maximum utility derived from use of a good or service or benefit of the good to an individual. However, according to Lusk and Hudson (2004), estimates from WTP studies often have different uses based on the issue being addressed. In the case of informing environmental policies, estimates obtained are mean WTP and aggregate welfare changes of parties involved. On the other hand, to inform business pricing decisions, the emphasis is placed on deriving estimates that are useful in deriving compensated market demands for

novel products. This makes WTP estimates useful in estimating the revenue-maximizing price for goods and services (Foreit et al., 2004). Further, application of WTP to agribusiness not only makes elicitation incentive- compatible but also makes it possible and easier to attribute private costs and benefits to the good or service being studied.

Surveys on WTP are important to businesses as they are used to find out the maximum amount of money an individual is willing to pay, amount of revenue likely to be generated by the price as well as the characteristics of intended consumers of a certain product and those who will pay and not pay any price. Furthermore, they are useful in deriving deviation between the stated WTP and actual WTP.

2.2 Willingness to pay elicitation and measurement methods

The basis of conducting a WTP study is to find out the maximum monetary value attached to goods or services at any given time by individuals (Department for International Development [DFID], 1997; Wedgwood and Sansom, 2003), which is a prediction of how much consumers are likely to pay towards maintaining the good or service (Boadu, 1993). Also, it estimates the capacity of a given social group to pay for a hypothetical good or program (Quevedo et al., 2009). There are various approaches used to elicit WTP. Wedgewood and Sansom (2003) grouped them into three major ways which are;

a) Observing set market prices people pay for goods,

b) Observing individual expenditures of money, time and labor used to obtain goods or avoid their loss, i.e the travel cost method and

c) Asking people directly what they are willing to pay for a good or change in policy in future.

The first two are categorized under *revealed preference* approach as they focus on behavior toward a good while the third under *stated preference* approach as it focuses on the value attached to a hypothetical good (Devicienti et al., 2004). Stated preferences method uses a simulated market to elicit WTP and WTA value for products not currently existing in the market or changes in the provision of services hence, making it the most appropriate approach for use on non-use values of a good (Boyle, 2003).

Stated preference approaches uses; - direct surveys and indirect surveys. Indirect surveys include the conjoint and discrete choice analysis while the direct surveys include the expert judgments and customer surveys. With the direct surveys, respondents are asked to directly state the maximum amount they are willing to pay for a hypothetical product while in indirect surveys; different products are ranked, and respondents asked to select a preference from which WTP is derived (Breidert et al., 2006). The techniques widely used in stated preferences are choice experiments and contingent valuation method (CVM) methods. The Contingent Valuation Method (CVM) uses direct customer survey to determine the maximum monetary value of goods and services for which there exists no real market price (Mitchell & Carson, 1989). It mainly involves describing a hypothetical good to be valued, and respondents are directly asked to reply with the maximum amount they would pay (Yussif, 2017). However, it is limited by being sensitive to biases arising from survey design and implementation (Adamowicz et al., 1998).

Each of these valuation methods has its own strengths, weaknesses and limitations in estimating WTP. Whereas stated preference (SP) methods have the capacity to estimate both the use and non- use values of proposed goods, services and policies (Carson et la., 2001), revealed preference methods are inadequate in capturing non- use values of resources and hence limited to only use values of goods (Young, 2005). The major limitation of CVM is

that its estimates are based on the stated and not actual WTP. However, for the scope of this study, it is sufficient to evaluate the pricing of new technologies.

CVM elicitation methods have already been used in past studies to estimate values of both private and public goods. They include; open-ended CV format, bidding game, the payment card, the discrete choice (take-it-or-leave it) and the dichotomous question with follow up. Open-ended questions were frequently used during earlier applications of CVM. However, respondents found it hard to answer the payment questions resulting in many missing values for WTP which has made the method less popular. Bidding approach begins by providing an initial price or bid to a respondent and raising or lowering it at intervals until a point where the individual declines to pay (Randall *et al*., 1974). The final price becomes the maximum WTP for the respondent. The approach, however, is characterized by a starting bias which may affect the final WTP as it is systematically related to the initial price or bid. Furthermore, the approach tends to be tiresome to the respondent which may cause them to agree or disagree with an aim to end the interview. Alternatively, payment card approach may be used whereby possible values of WTP are listed on cards and the respondent requested to pick the price on the card that represents their WTP. Cameron and Huppert (1988) interpreted the chosen price as the lower bound WTP while the higher bound being the next highest price on the card. There have been concerns about respondents limiting their WTP to prices on the cards, but research by Rowe et al. (1996) found out that as long as prices listed on cards are not truncated from above, estimates will not be biased.

The dichotomous choice approach aims to mimic regular market behaviour. It uses a bid value which is varied across respondents. The dichotomous choice payment question enquires if a respondent would pay a certain price which is the bid to obtain a good. The responses to a dichotomous question are only two which are "yes" or "no" (single-bounded). However, one

limitation of this approach is that estimates obtained do not reflect direct WTP but mean WTP. To increase the accuracy of the estimates from the dichotomous choice question, researchers have introduced follow up questions (Hanemann et al., 1991; Pearce and Ecezdemiroglu, 2002). The follow-up bid level should be greater than initial level if the previous answer were "yes" and lower if the answer was "no" (double- bounded). A second follow up question may be asked (Alberini *et al*., 1997) although not necessary as evidence from Monte Carlo simulations proved that answers from the first follow up question provided sufficient statistical efficiency gains in estimating mean WTP (Cooper and Hanemann, 1994; Cooper et al., 1999).

CVM is preferred to other methods due to its ability to capture both use and non- use values of goods and services. Additionally, it is also very flexible as the researcher can create a hypothetical market for varieties of both public and private goods (Guo et al., 2006). Contingent valuation is the most suitable method for this study which requires creating a hypothetical scenario to elicit the maximum WTP for Hexanal technology which is a novel product in the market. There have been concerns about hypothetical biases resulting from the differences between respondent's stated WTP and their actual WTP making the method unreliable (Guo et al., 2006; Niringiye and Omortor, 2010). However, Calkins et al. (2002) and Whittington (2002) ascertain that hypothetical biases can be controlled through proper designing and execution of the contingent valuation methodology.

2.3 Past studies on WTP for new agricultural technologies in developing countries

Adetonah et al. (2007) assessed farmers' awareness and perceptions on cotton pests in Benin on both conventional and organic cotton farmers and found out that farmers' perceptions were that levels of damage from Helicoverpa increased each year due to the increasing resistance and decreasing efficacy of chemical pesticides used. However, even after the introduction of

a new biopesticide to control for Helicoverpa, the premium prices farmers were willing to pay for it remained low for both categories of farmers with conventional farmers offering a lower price than organic farmers. The result was similar to those of De Groote et al. (1998) who assessed WTP for a biological control of grasshoppers and locust in both Mali and Niger and demonstrated farmers' WTP as small but not negligible (De Groote et al., 1999).

Uddin et al. (2014) assessed farmers' willingness to pay for agricultural extension services in Bangladesh using contingent valuation and observed that 81.11% of farmers were willing to pay while 18.89% were not willing to pay. For those willing to pay they proposed an amount of 54 BDT which is equivalent to 0.65 US Dollars per visit. However, according to the extension officers, farmers willing to pay did not have the ability of paying more than 20 BDT (0.24$).

Muchiri et al. (2012) used CVM approach to elicit the WTP for integrated pest management in mangoes in Kenya using a predetermined seasonal cost of KES 1100 per acre. The study found out that 66% of farmers were willing to pay the seasonal cost. Furthermore, analysis revealed the mean WTP was KES1700 higher than seasonal cost which was a good indicator of increased potential for adoption of the product.

In studying WTP for Aflasafe KE01 in Kenya which is a biological control product for aflatoxins in maize, Migwi et al. (2012) used CVM approach and results indicated that farmers were willing to pay for the Aflasafe with the aim of producing maize free of aflatoxin. The maximum WTP estimates derived for Aflasafe KE01 was KES250/kg, KES490/kg and KES510/kg for three regions which were more than the amount charged for the same product in Nigeria which is KES130/kg.

2.4 Post- harvest technologies to reduce losses in fruits

Post-harvest losses of fruits are both qualitative and quantitative in nature and mainly occur between harvest and consumption. To minimise the losses, it is important the biological and environmental factors involved in post-harvest deterioration are understood, and appropriate technologies used to maintain the safety and quality of agricultural commodities (Kader, 2005). Research in India on mangoes, found out that post-harvest loss during storage varied with different varieties. Totapari mango showed 36% losses, Neelam 22%, Deshari 17% and Bavgana Palli 20% (Dhyani et al., 2013). Over the years a variety of technologies have been developed to reduce postharvest losses through germplasm manipulation and storage technologies. They include; introducing varieties with longer shelf life potentials, reducing sun exposure after harvesting, only harvesting after proper maturity, cooling to lower temperatures which are safer for storing, protecting fruits from physical damage and drying. An example of storage technology has been the reusable plastic containers and bags that act as a barrier for reducing water loss and as a means of improving quality of produce by protecting it from physical damage (Horticulture Innovation Lab, 2014). Other options for proper packing to reduce the physical damage that has been in use include; corrugated polypropylene or fibre board boxes, woven sacks, shrink wrapping and stretch films. Selectivity Permeable plastic films have widened the scope of proper packaging of fruits due to their ability to modify the carbon dioxide, oxygen temperature and humidity levels (Dhyani et al., 2013).

To cater for the needs of the local farmers in developing countries, affordable cold storage structures and sun driers have been constructed which has helped reduce post-harvest losses after harvest and improve quality of produce. In Bangladesh, the Horticulture Innovation Lab and the International Potato Center have assisted local farmers to construct small-scale cool

storage facilities for vegetables and potatoes that use a regular and relatively inexpensive air conditioner that is controlled by a small electronic controller called a CoolBot. This has been instrumental in reducing post-harvest losses. Other technologies currently being used are chimney dryers, root cellars and earth bags which store and preserve food. (Horticulture Innovation Lab, 2014). Also, for short-term storage of horticultural produce, the Indian Agricultural Research Institute in New Delhi has developed a zero- energy cool chamber which is based on evaporative cooling system (Dhyani et al., 2013).

Due to lack of storage facilities at farm levels, most fruit farmers are forced to sell their mangoes after harvest which causes a glut in the market translating into major losses to farmers (FAO, 2003). Additionally, the seasonality causes low supply to factories during off peaks making them operate below capacity (Ambuko, 2017). To ensure year-round supply of mangoes, there has been success in stimulating flowering of the trees during offseason using hormone or chemical treatments which include; paclobutrazol, ethephon, potassium nitrate, calcium nitrate and pruning which is a cultural practice (Yeshitela et al., 2006; Wilkie et al., 2008; Davenport, 2009).

Quantities of ethylene produced by fresh produce regulate the rates of fruit ripening and presence of high ethylene concentration causes high rates of fruit spoilage. Since high temperature increases rates of ethylene production, it has been recommended to lower holding temperatures to reduce physiological effects caused by ethylene. This is because low temperatures reduce metabolic activities in fruits as well as making ethylene present ineffective. Furthermore, a lower concentration of oxygen has been shown to limit the functioning of ethylene while high concentrations of carbon dioxide reverse ethylene effects by reducing fruits respiration rates. Therefore, during ripening of fruits, it is essential that ethylene concentration is maintained at a minimum to slow the rate of ripening and enhance

shelf life (Dhyani et al., 2013). Since ethylene is responsible for regulating postharvest of many fruits, its modulation through ethylene synthesis has been shown to be effective in improving the quality of fruits. For example in the case of Charentais melons where research showed that through biotechnology its' shelf life greatly improved (Horticulture Innovation Lab, 2014).

In addition to the storage, packing and flowering stimulating chemical technologies, there has been major progress in developing biotechnology hormones meant to prolong the shelf life of various fruits through; sprays, protective treatments and disinfection and irradiation.

2.4.1 Pre-harvest sprays

Spraying Thompson seed less grapes with a pre-harvest spray of 0.6% calcium chloride 10-20 days before harvest was found to improve its shelf life and reduced its physiological losses in weight. Application of 20ppm of GA before harvest has shown to delay ripening thereby improving the shelf life of mangoes and guava while improving colour development in citrus. Topsin- M of a concentration of 0.1% or Bavistin of the same concentration sprayed on mangoes before harvest helped in controlling for stem- end rot and anthracnose in mangoes. Moreover, Topsin- M at 0.05% concentration has been found effective for reducing post-harvest losses in mangoes by delaying ripening (Ministry of Agriculture, India 2013).

In enhancing fruits shelf life such as pears and apples, 1- MCP (1-methyl cyclopropene) has been used successfully as it also maintained the fruits' firmness. However, it was found to be ineffective when used at low temperatures (Watkins, 2006). This necessitated the need to develop a more effective technology that could be used at both room temperatures and cooler conditions. Studies on the effectiveness of Hexanal have demonstrated that the technology enhances shelf- life, reduces post- harvest decays and disorders in fruits such as strawberries,

mango, guava, tomato and sweet cherries respectively (El Kayal et al., 2017; Anusuyaet al., 2016; Gill et al., 2015; Cheema et al., 2014; Sharma et al., 2010).

Field tests in Asia have indicated that spraying mangoes with Hexanal at very low concentrations of 0.02% twice during growing seasons prolongs the fruit on the tree for an extra three weeks compared to those not sprayed (Subramanian et al., 2014). Additionally, after harvest, treatment with Hexanal was found to double the shelf life of mangoes in storage up to 17 days at room temperature and 26 days in cooler storage conditions (Subramanian et al., 2014). Prolonging mangoes shelf life helped stabilized prices as more produce was able to reach the markets in good condition.

2.4.2 Protective treatments and disinfection

Waxing, chemicals and fungicides can also be used to reduce post-harvest losses. They include; Bavistin and Topsin at 0.1% concentration which has been effective in controlling of disease in mangoes during storage. An aqueous emulsion of CIPC @ 50mg/kg sprayed on stored potatoes completely inhibited sprouting for 4-5 months. In cases where cool storage facilities are lacking coating fruits with a protective skin wax have been effective in increasing the storage life of fresh produce even at ambient temperatures.

2.4.3 Irradiation

Irradiation is not only useful in preserving meat and dairy products but also very effective in reducing spoilage of horticultural produce by increasing their shelf life. Studies at Bhabha Atomic Research Centre (BARC) have indicated that minimal doses of irradiation at mature but unripe stages delay the rates of ripening and senescence of bananas, mangoes, and other fruits.

2.5 Perceptions and adoption of new agricultural technologies

The development of technologies has immense benefits in agriculture as they increase efficiency through the competitive use of factors of production, thereby creating more opportunities for the farmers (Gurel, 1998). However, developing a technology is not enough as it is only useful if governments, markets or even society adopts it (Bechdol, 2012). Adoption of these new technologies have been proven to be influenced by the subjective perceptions of the farmers towards new technologies (Adesina and Baidu-Forson, 1995). Incorporating farmers' perceptions complements the socio-demographic and institutional factors affecting the WTP for Hexanal technology. In addition, studying perceptions provides technology developers with appropriate information necessary in yielding more targeting technologies.

Analysis of adoption rates of several postharvest technologies found that ease of use of a particular technology increases chances of adoption as well as sustainability of its use in the long term. Besides, farmers were more likely to adopt an improved local technology as they perceived it to fit into the already existing value chain and marketing system, unlike a completely new technology that requires big changes in using them. Profitability from the use of technology plays a key role in ensuring sustainable use in the local setting as well (Kitinoja, 2013). De Groote et al. (2008) while determining WTP for a herbicide used for Striga control in western Kenya noted that poor maize farmers were willing to use the herbicide as they perceived it to be effective in addressing their needs.

Information is very important in creating awareness of new technologies. A report by Kitinoja (2010) indicated that farmers in South Asia and Sub- Saharan Africa (SSA) were keen on getting access to information on improved local post-harvest practices and simple tools that were easy to use at village level and that could reduce losses thereby increasing

their farm incomes. Membership to farmer groups is one of the avenues used in availing information to the farmers' which positively influences the adoption of new technologies. According to Nkamleu (2007), membership in group activities provides farmers with wide range of positive information and ideas that are likely to change their attitude towards new technologies.

In general, adoption and WTP for new technologies is usually a function of a farmer's perceptions, knowledge, intention and attitude towards the technology (Aryal et al., 2009; Ulimwengu and Sanyal, 2011). An assumption in literature is that WTP is also a function of a farmer's ability to pay for the product (Donaldson, 1999).

2.6 Theoretical frameworks

2.6.1 Theoretical framework for perceptions

Hexanal is a novel product not yet in the market and hence its acceptance and adoption rates by the fruit farmers cannot be explicitly observed. Therefore, adoption decisions can only be contingent upon the stated perceptions of farmers on Hexanal technology. The first objective is based on the theory of planned behavior (TPB) as it provides consistent theoretical basis for evaluating acceptance of a non- market good or performing a particular behavior (Davis, 1989). According to Kalafatis et al. (1991), behavioral intention results from attitudes towards a behavior, that is an outcome of the perceived behavioral control (PBC) and subjective norm. Perceived behavioral control is defined as the perceptions people have regarding the ease or difficulty of performing a certain behavior (Ajzen, 1991). It determines both intention and behavior (Kalafatis et al., 1991) as individuals perceive the performance of a good or service in question depending on its capability to meet their needs.

In the case of this study, use of Hexanal will be based on the perceived benefits of using the technology to prolong the freshness of their fruits. On the other hand, Mueller (2004) defined

subjective norm as the decision to adopt or reject a good or service in question. The decision is influenced by normative beliefs of people a respondent highly regards and their views on whether to perform or not perform the behavior (Kalafatis et al., 1991). The two components PBC and subjective norm are then determined by the control and referent beliefs whereby the control beliefs is when a respondent feels they have necessary resources and opportunities needed to perform a behavior as well as past experiences of others (Ajzen, 1991). Based on the Theory of Planned Behavior, fruit farmers are more likely to accept to use Hexanal to prolong the freshness of their fruits, only if they believe its use will results in reduced post-harvest losses. Their decisions will be influenced by views of people they value and beliefs on availability of resources and opportunities required.

2.6.2 Theoretical framework for willingness to pay

During the introduction of a new product in the market, the proponents are more interested in the production costs and consumer demand of the new technology. This is because these are the main considerations in the pricing of products and adoption by consumers. Estimating production costs is never a challenge unlike assessing the consumer demands for new products whose market prices are not yet set. This necessitates the need to create a hypothetical market scenario which is similar to real markets to enable economists assess consumer demands for new products (Lusk and Hudson, 2004) as well as their perceptions.

The second objective was anchored on the random utility theory which is based on the hypothesis that individuals are rational decision makers whose aim is to maximize utility relative to choices available. According to the theory, an individual will always select the alternative that maximizes his or her utility. Utility assigned to each alternative is determined by several measurable attributes or characteristics. Hanemann and Kanninen (1996) noted that survey responses from CVM are economically meaningful, as they are comprised of a

utility maximizing response to a survey questions hence being consistent with the utility maximization economic model.

Since utility maximization is subject to a budget constraint, a consumer can only choose a good that maximizes his/her utility but not above his / her budget as his/her demand will be constrained. With measurement of a good's quality being represented by q a rational individual will always choose the level of market good represented by xm that maximizes their utility forming a Marshallian demand curve, xm (p,y,q); whereby (p is the current market price of the good and y is the individual's income). Therefore, WTP estimates are useful in agribusiness as they identify positions on the demand curve beyond which returns on investments are positive (Hudson and Hite, 2002).

CHAPTER THREE

3.0 METHODOLOGY

3.1 Conceptual framework

To ensure farmers are benefiting from the high demand of the fruits in the country it is important technologies aimed at reducing the losses are promoted among farmers. Hexanal is one of the technologies identified as a key intervention to reducing these losses.

However, in promoting its adoption it is important farmers' perceptions are well understood. These perceptions and WTP among banana farmers are hypothesized to be influenced by institutional factors, farm characteristics, external support services, infrastructure, socio-demographics factors of the farmers as well as knowledge on existence of Hexanal (Figure 3.1). CVM approach was used to obtain the WTP of Hexanal. The study focused on the relationships between farmers' perceptions on the attributes of Hexanal on the one hand and the WTP/adoption for Hexanal on the other.

Institutional factors such as advertisement, labelling and packaging of Hexanal would influence farmer's knowledge of the technology (Singh et al., 2008) thereby influencing their perceptions. The perceptions towards attributes of Hexanal will influence farmer's WTP for agricultural innovations (Adesina and Baidu-Forson, 1995; Aryal et al., 2009; Ulimwengu and Sanyal, 2011). The socio-demographic characteristics of the farmer such as education, gender, age and household size are important factors hypothesized to influence decisions on adopting modern agricultural innovation (Feder et al., 1985)

Therefore, if farmers have positive perceptions regarding some of the attributes of the technology, this will increase chances of its adoption and hence farmers will be willing to pay more to acquire the technology. Increased use of the technology is hypothesized to reduce

post- harvest losses in bananas, reduce glut of the fruits in the market during peak season, thereby giving famers more time to look for better markets hence increasing their incomes as well as ensuring constant supply of quality bananas in the market.

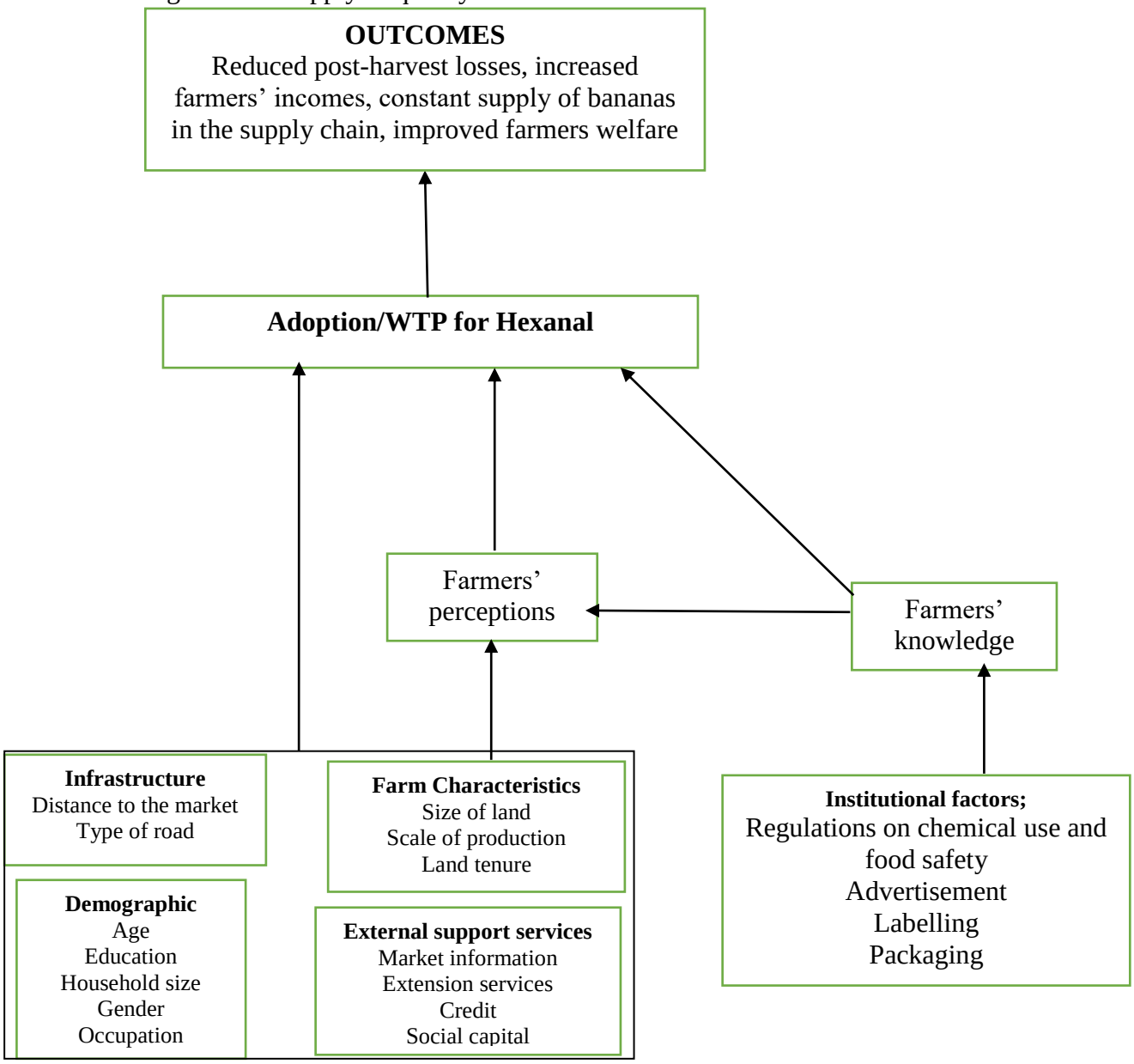

Figure 3.1: Conceptual framework illustrating the interactions among factors hypothesized to influence farmers' perceptions and WTP for Hexanal

Source: Author's conceptualization

3.2 Study area

3.2.1 Meru County

Meru County, which is approximately 225km northwest of Nairobi, is located on the eastern part of Mount Kenya covering an area of 6,936sq km. The county borders four other counties namely; Laikipia to the west, Tharaka-Nithi to the South West, Isiolo to the North and Nyeri to the South West. The area lies between altitudes of 300 and 5199 meters above the sea level. Climate is cool and warm with annual average temperatures ranging between 8˚C in cold seasons and 32˚C in hot seasons. The average annual rainfall received in the region is 1250mm (KNBS, 2015).

Agriculture is the main economic activity in the County with tea, coffee and bananas being the main cash crops produced. Additionally, dairy and fish farming is also practiced mainly for local consumption. To promote agriculture in the drier parts of the sub-county such as Mitunguu, farmers are practicing irrigated agriculture. In 2014, 9,715tonnes of bananas were produced from the County which was an increase from 6884tonnes in 2013 (KNBS, 2015). Tourism is also a major economic activity as the County has several tourist attraction sites such as the; Lewa Conservancy, Meru Museum, Meru National Parks and Mt. Kenya National Park. Despite the region being cosmopolitan, majority of the people are Meru-speaking.

Meru County is comprised of nine sub-counties and the current study was based in South Imenti sub-County (Figure 3.2) which is comprised six wards namely; Mitunguu, Igoji East, Igoji West, Abogeta East, Abogeta West and Nkuene.

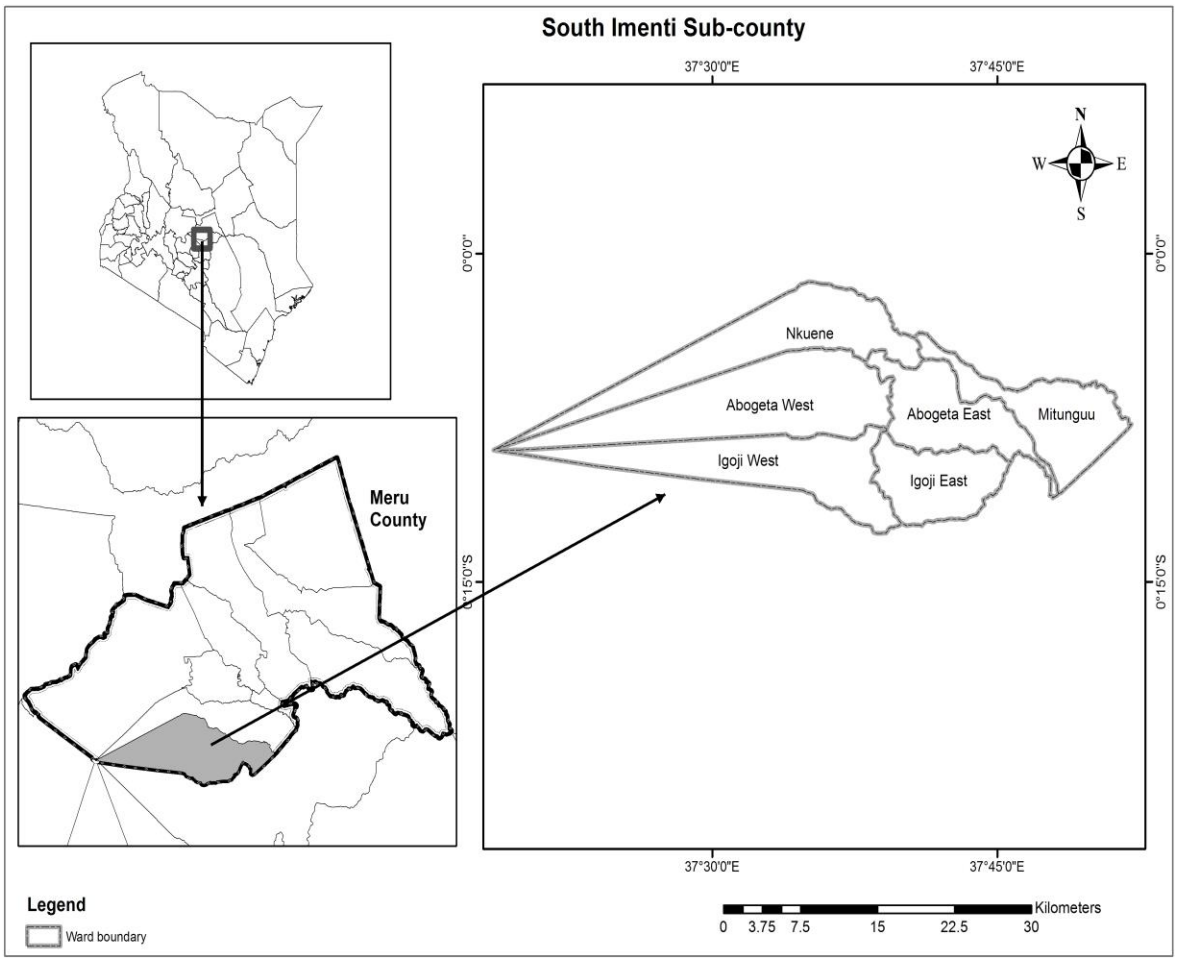

Figure 3.2: Map showing study areas in Imenti South Sub- County

Source: IEBC

The sub– County which covers an area of 739sq km is the most developed in Meru with a good and vast road network that facilitates transport of inputs and produce to markets. Some of the roads present are the Mate road and Meru- Marimba- Chogoria road. According to the 2009 household survey, population was at 179,604 (KNBS, 2009).

South- Imenti sub- County was purposively chosen for this study because it is the leading producer of bananas in Meru County and among the highest banana producing regions in Kenya. Bananas produced in the region are not only for own consumption as there have been increased commercialization resulting from the introduction of tissue culture technology in the area (Nyabaro et al., 2018). Due to the high production of bananas and lack of proper

post-harvest handling techniques, the region is characterized by high post-harvest losses of bananas. The Sub-County was selected as the region where Hexanal field trials have been taking place since 2015 (Yumbya et al. 2018).

3.3 Methods and procedure

3.3.1 Research design

The research was quantitative in nature with household data being collected using semi-structured questionnaires. The University of Nairobi had earlier done a study on Hexanal in 2016. The current survey was therefore conducting a second follow up survey on the same respondents. In the current study, the respondents were categorized in two groups comprising of the treatment and control group. The treatment group (Aware) attended a dissemination workshop where they were trained on the use and benefits of Hexanal technology in February 2018 while the control group (Not Aware) on the other hand comprised of farmers that did not attend the dissemination workshop and were not aware of the existence of Hexanal technology. This research design was important in comparing the differences in perceptions and willingness to pay for Hexanal technology between the two groups. Furthermore, it was instrumental in assessing the role of extension in enhancing positive perceptions as well as adoption of Hexanal technology.

3.3.2 Sample size and sampling procedure

The baseline study used a multistage sampling procedure in selecting respondents. In the first stage, Meru County was purposively selected based on empirical evidence as the region with the highest volume of bananas in terms of production and marketing (Mbogoh et al., 2003; Miriti et al., 2014). The second stage involved mapping out banana producer groups in the area from which a sampling frame comprising banana producers in South Imenti Sub-County

was created. Systematic random sampling was used in the third stage to select every 10th producer from the list. Due to time and resource constraints, the sampling procedure resulted in 160 banana producers being selected for interviewing. However, by the time of this study in the month of April 2018, only 130 farmers who comprised of 52 treatment farmers and 78 control farmers were interviewed. This is because some farmers had either relocated to other areas or were not interested in taking part in the current study.

3.4 Data types

This study used cross- sectional data from interviews conducted by enumerators to the household decision makers in South Imenti Sub-County. Data needed was characterized into; socio-economic characteristics of the household head, perceptions on Hexanal technology and maximum amount farmers are willing to pay for Hexanal technology.

Specifically data collected on socio-economic characteristics included; demographic data such as age, education, household size, sex and main occupation of the household head. Data on external support services included; access to extension services, access to credit and social capital of the household head. Data on farm characteristics such as size of land, type of land tenure and scale of banana production was also collected as well as, data on infrastructure such as distance to the market and type of road.

3.5 Data collection methods

Primary data was collected by the use of a semi-structured questionnaire which contained both open ended and closed questions. The questionnaire was designed to collect all relevant information needed for the study and was therefore deemed adequate and reliable. Prior to data collection, the questionnaire was pretested and revised based on feedback from the pre-

test thereby ensuring it was effective in capturing required data. Trained enumerators who used Swahili or local dialect for accuracy interviewed household heads or their spouses.

The questionnaire used comprised of an introductory section and provided means to collect respondent's socio-demographic characteristics. It also included a detailed segment explaining the use of Hexanal technology, its attributes and market price if it was to be introduced into the market. The questionnaire also included a hypothetical scenario needed to accommodate the elicitation of farmers' willingness to pay for the Hexanal technology.

3.5.1 Contingent valuation method for WTP

The study used Contingent Valuation Method which is one of the stated preference (SP) approach used to elicit the maximum amounts farmers were willing to pay for Hexanal technology. The method is termed as contingent because the product or service being researched on is hypothetical and is currently not available in the market but provided by the researcher (Whittington, 1998). CVM uses different techniques such as bidding games, open or closed ended questions, single or double bound dichotomous questions with follow-up, and payment cards (Umberger et al., 2002).

The choice of elicitation technique to use depends on the nature of good to be valued as well as the resources available for survey (King, 2007). Iterative bidding game technique was the most appropriate technique to elicit maximum WTP for Hexanal. This is because it is capable of measuring hypothetical responses of respondents presented with hypothetical scenarios. Bid amounts obtained from the iterative bidding do not reflect costs implications but represent the respondents' perceptions of value of the product or service (Randall, 1974). In this case, respondents were assigned a specific initial bid and were required to answer with a 'yes' or 'no'. The enumerator increased the bid amount if the previous response was 'yes' until they obtained a negative response and reduced the initial bid amount if the previous response was 'no' up to a point a positive response was obtained and the highest amount the

respondent was WTP was recorded (Boyle et al. 1985). The individual responses obtained were then aggregated, and used to generate the mean WTP for Hexanal technology.

3.5.2 Willingness to pay elicitation format and bidding process

Data was obtained on the WTP amounts for both groups of farmers who are aware as well as those not aware of the Hexanal technology. Farmers who were already aware of the technology were given a brief reminder of the attributes of the technology, how to use the technology as well as its' benefits as they had already attended a dissemination workshop on the same. As for the case of farmers who were not aware of the technology, a hypothetical scenario was provided in order to enable the elicitation of the maximum WTP amount from the farmers. Information on mix ratios of Hexanal was explained of diluting 0.25litres of Hexanal with 12.5litres of water. It was explained to them that the solution would be enough to spray 125 bunches of bananas or dip as many fruits until the solution is completely used. The hypothetical scenario was designed as follows; *"banana production supports many farmers economically in Kenya. However, lack of access to proper post-harvest handling techniques contributes to great losses of up to 40% each year. There is an organic pre-harvest dip and spray known as Hexanal technology {which is an Enhanced Freshness Formulation (EFF)} that is capable of prolonging fruit shelf life by 21days on the trees and 17 days in storage (at room temperature) to 26 days in cold storage. Field trials carried out in Kenya show it is very effective in prolonging shelf life in mangoes and bananas while causing no harmful effects on humans. The product is currently not available in the market but considering the costs of importation it would cost Ksh.400 per 0.25Litres. If the product was introduced in the market and you were required to pay for it, would you be willing to pay for it? Would you be willing to pay Ksh400 per 0.25L?"*

Iterative bidding was then used to elicit the maximum WTP. First, the enumerator explained to the respondent that they would have to pay cash for the product or purchase it through credit from an agro-dealer and repay later after harvesting. A bid of ± Ksh50 was used whereby if the answer was "yes" to the initial amount of Ksh400 an increment of the bid amount was added until the respondent said "no". In case the respondent responded "no" to the first amount an equal decrement of the bid used until the respondent revealed the amount they are willing to pay by answering with a "yes". The revealed amount was recorded as the maximum amount farmers are WTP. The base price of Ksh400 of the Hexanal technology was obtained from the aggregation of the components' current market value/prices used to formulate Hexanal.

3.5.3 Collection of data on perceptions

In this study, data on farmers' perceptions was obtained through a Likert scale whereby (1=strongly disagree, 2=disagree, 3=neutral, 4=agree and 5=strongly agree) based on different attributes of hexanal which included; product design, ease of use, delivery mode, the efficacy of the Hexanal, support services related to Hexanal, sustainability aspects and socio-cultural compatibility of Hexanal. Questions for the likert scale were informed by group discussions during dissemination workshops. The discussions mainly focused on the current status of post-harvest losses of fruits in Kenya, relevant requirements needed in introducing Hexanal in Kenyan markets as well as effective ways of ensuring successful uptake of the Hexanal technology among fruit farmers.

3.6 Data analysis

Primary data collected on socio-demographic characteristics, perceptions, willingness to pay amounts for Hexanal and factors likely to influence farmers' perceptions and WTP were all analyzed using econometric softwares Statistical Package for Social Scientists (SPSS) version

20 and STATA version 14. SPSS was used for data entry and cleaning. Data was first cleaned to ensure there were no outliers and minimum amount of data was met on each sub-sample to conduct factor analysis. In addition, SPSS was also used to conduct Principal Component Analysis (PCA) model. STATA version 14 was used to generate descriptive statistics as well as estimate the mean amounts farmers are willing to pay for the Hexanal technology. Ordinary Least Squares (OLS) and tobit model were used in STATA to analyze the significant levels of some of the hypothesized variables likely to influence farmers' perceptions and willingness to pay respectively.

The explanatory variables were presented in both qualitative and quantitative form. Qualitative variables were in form of dummy variables. Ordinary Least Squares (OLS) method was used to test the null hypothesis that explanatory variables had no influence on the perception scores while the tobit regression was used to test the null hypothesis that the explanatory variables had no significant influence on the maximum WTP for Hexanal technology. P-values were used in determining whether to reject the null hypothesis or not per each independent variable as it is the lowest significance level at which a null hypothesis can be rejected (Gujarati, 2004). The levels used were at 1% ($p<0.01$), 5% ($p<0.05$) and 10% ($p<0.1$) which indicate highly significant, moderately significant and weakly significant respectively.

3.6.1 Principal component analysis (PCA)

Farmers' perceptions on Hexanal were generated through Principal Component Analysis (PCA). Principal Component Analysis is one of the methods of conducting factor analysis. Bartholomew et al., (2011) explained factor analysis as a method operating under the concept of reducing measured and observed variables with common variance to few factors while

retaining original information. The common factors obtained are unique to each of the observed variable (Harman, 1976; Kim and Mueller,1978; Tabachnick and Fidell,2007).

Through PCA, maximum variance was extracted from the data within each factor thereby reducing large data sets in to fewer factors known as principal components (Tabachnick & Fidell, 2007). PCA therefore is a suitable approach used in conducting factor analysis (Rao, 1964) by way of data reduction (Costello & Osborne, 2005). Since components obtained are ambiguous, they were rotated for better interpretation. The main aim of rotation is to try and have each variable load on as few components as possible while at the same time maximizing the number of the high loadings on each variable (Rummel, 1970). The structure aims at having each component explain a defined cluster of related variables for simple interpretation (Cattell, 1973). Varimax which is one of the methods of orthogonal rotation, was used as it assumes uncorrelated nature of the components (DeCoster, 1998; Rummel, 1970). In addition, varimax was used in order to minimize the number of variables with high loadings on each component while making small loadings much smaller. The signs of the loadings do not affect interpretation of the component loadings magnitude as the signs only indicate the direction of the correlation (Kline, 1994). In determining number of principal components to retain, Kaiser's criterion was used as a rule of thumb. This criterion recommends that all components with eigenvalue of greater than 1 are retained (Kaiser, 1960). Only three components with eigenvalues >1 were retained per sub-sample and component loadings less than 0.4 were dropped and not considered in explaining the principal components.

3.6.2 Empirical model to assess farmers' perceptions

The first principal component is computed as follows;

$$PC_n = f(a_{ni}X_i, \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots . a_{1k}X_k) \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots . . 1$$

When the number of extracted principal components is more than 1, each principal component is a continuous variable comprising of the values of the variables as well as their respective component loading. The relationship therefore becomes an additive one where the value of nth principle component is obtained through addition of the products as illustrated in the following equation;

$$PC_n = f(a_{11}X_1 + a_{12}X_2 +, \dots \dots \dots \dots \dots \dots . a_{1k}X_k) \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots . .2$$

Whereby PC_n which is the nth principal component is a function of linear weighted combination of original variables $a_{1k}X_k$. Where a_{1k} which is the coefficient is equal to the eigenvector of the covariance matrix between the variables (Rao, 1964; Lwayo and Obi, 2012) and X_k is the value of the kth variable. The ordering of the principal components is in such a way that the first principal component will always be the one accounting for the largest amount of variation in the initial variation. The second component accounts for maximum variance not accounted by the first component while remaining uncorrelated to it. The third accounts for maximum variance not accounted for by the first and the second components and so forth (Rao, 1964). All the principal components remain completely uncorrelated with each other.

Using PCA in analyzing ordinal data such as the Likert scale data is acceptable especially if the objective is to obtain general clusters of variables to be used for exploratory purposes as long as the correlations among variables are less than 0.6 (Kim and Muellar, 1987). Factor analysis has been used in previous studies to assess perceptions for instance Abebaw et al. (2006) used PCA to assess risk perceptions in coffee production in Ethiopia and Ssebaggala et al. (2017) who assessed farmers’ perceptions of rice post-harvest losses in Uganda.

There were sixteen variables analyzed through PCA and they include; “post- harvest losses of fruits is a great challenge”, “Hexanal can contribute to reduction of post-harvest losses in fruits”, “use of Hexanal will lead to increased incomes to fruit farmers”, “pricing of Hexanal is crucial in adoption decisions”, “Hexanal is a safe product on human health”, “Hexanal is not a foreign material”, “Hexanal is safe to other micro-organisms in the environment”, “Hexanal is capable of reducing post-harvest losses”, “distribution of Hexanal should be left to private sector”, “government agency should be involved in distribution of Hexanal”, “more awareness on Hexanal is necessary to reduce fruit glut in the market”, “Hexanal is easy to use”, “it is necessary to train more farmers on Hexanal in order to increase demand”, “counterfeiting of Hexanal can be a serious problem”, “Hexanal does not go against any cultural belief” and “Hexanal use on fruits will not lead to any environmental pollution”

Farmers’ responses were then subjected to PCA to obtain few and uncorrelated variables known as principal components that retained much of the variation in the data (Jolliffe, 2002). Variables that did not contribute to a minimum factor structure and did not meet a factor loading of 0.5 and above were eliminated.

To ensure for sampling adequacy the Kaiser-Meyer-Olkin (KMO) measure was considered whereby it was greater than 0.5 in both cases which is the recommended threshold (Everitt & Hothorn, 2011). This is an indication that data is adequate for PCA analysis and principal components yielded are reliable (Field, 2013). Principal components were generated using the Barletts method whereby Barlett’s test of sphericity yielded significant results at 1% level ($p<0.01$) of significance for both groups. Since there was no correlation among the principal components obtained, varimax rotation was used and only components with factor loadings values greater than 0.4 were retained (Stevens, 2002).

3.6.3 Empirical model to assess factors influencing perception scores for Hexanal technology

The socio-demographic variables hypothesized to influence the perceptions scores were estimated using the Ordinary Least Squares (OLS) that is theoretically presented in equation 3 (Greene, 2002);

$y=X\beta+\varepsilon$..... (3)

which specifies a linear relationship between the dependent and independent variables as follows;

$y_i = x_i\beta_1 + x_i\beta_2 + \cdots + x_i\beta_k + \varepsilon_i$ ..... (4)

Whereby y_i is the dependent variable which is the perceptions scores obtained for Hexanal technology while $x_i,...,x_k$ are the independent or explanatory variables. $B_1.....\beta_k$ are the coefficients and ε is a random disturbance term. The observed value of y_i is the sum of two parts, a deterministic part and a random part, ε_{iA}.

Since there were three categories of perceptions extracted from PCA, similar regressions were run using identical sets of independent variables for each group of farmers (treatment and control).

The estimating equations are as follows;

'Effectiveness' $(Y_1^*)=\beta_0+\beta_1 AGE+\beta_2 INC+\beta_3 GND+\beta_4 EDU+\beta_5 CRDTACC+\beta_6 LANDTENURE+\beta_7$GRPMBRSHP$+\beta_8 MRTSTAT+\beta_9 EXTACC+\beta_{10} HHSIZE+\beta_{11} DISTMKT+\varepsilon_i$ .....(5)

'Acceptability' $(Y_2^*)=\beta_0+\beta_1 AGE+\beta_2 INC+\beta_3 GND+\beta_4 EDU+\beta_5 CRDTACC+\beta_6 LANDTENURE+\beta_7$GRPMBRSHP$+\beta_8 MRTSTAT+\beta_9 EXTACC+\beta_{10} HHSIZE+\beta_{11} DISTMKT+\varepsilon_i$ .....(6)

'Environmental.safe' $(Y_3^*) = \beta_0 + \beta_1 AGE + \beta_2 INC + \beta_3 GND + \beta_4 EDU + \beta_5 CRDTACC + \beta_6 LAND\ TENURE + \beta_7 GRPMBRSHP + \beta_8 MRTSTAT + \beta_9 EXTACC + \beta_{10} HHSIZE + \beta_{11} DISTMKT + \varepsilon_i$ ..(7)

Whereby the following variables were hypothesized to influence the perception scores.

Table 1: Description of hypothesized factors for perceptions

Variable	Description	Unit of measurement	Expected sign
AGE	Number of years of the HHH	Continuous	-/+
SEX	Sex of the HHH (Male – 1, Female – 0)	Dummy	+/-
EDU	Number of years of formal schooling	Continuous	+
GRPMBRSHP	Is the farmer a member of a group either formal or informal (Yes-1, Otherwise-0)	Dummy	+
CRDTACC	Has the farmer obtained credit in the last 12 months (Yes-1, Otherwise-0)	Dummy	+
EXTACC	Has the farmer had any contact with an extension officer in the last 12 months (Yes-1, Otherwise-0)	Dummy	+
INC	Annual household income in Kenyan shillings (KSH)	Continuous	+
LANDTENURE	Type of land tenure (Yes-1, Otherwise-0)	Dummy	-
DISTCOLL	Distance to banana collection center in Km	Continuous	-
HHSIZE	Number of household members	Continuous	+/-
MRTSTAT	Marital status of HHH(Yes-1, Otherwise-0)	Dummy	+
GRPDUR	Duration to group membership	Continuous	+
DISTMKT	Distance to nearest market in Km	Continuous	-
INC_BANANA	Income received from banana sales	Continuous	+

The model was found to be appropriate due to the nature of dependent variable (perception scores) which were continuous variables.

3.6.4 Diagnostic tests

The primary data was screened for existence of multicollinearity and heteroscedasticity. Multicollinearity tests the degree of correlation (collinearity) among the variables while heteroscedasticity explains the relationship between the error terms across the variables.

Multicollinearity

Multicollinearity is the existence of linear relationships among the independent variables in a model (Koutsoyannis, 1973). The problem arises when related variables are included in an econometric model and limits the estimation of separate influence of individual independent variable on the dependent variable. Presence of multicollinearity in a model results in high standard errors of coefficients, high values of R-squared despite the individual estimates being insignificant as well as incorrect signs of coefficients (Gujarati, 2003).

The study used Variance inflation factor (VIF) to check for multicollinearity. According to Greene (2002), variables with a VIF of greater than five are considered to have high multicollinearity.

Heteroscedasticity

Ordinary Least Squares (OLS) assumes constant variance of the error terms (Homoscedastic) across the observations (Greene, 2007). However, the assumption can be violated leading to variation in the error term variance (Heteroscedasticity) which results in large standard errors and small t-values causing the researcher to fail to reject the null hypothesis erroneously. Variables were tested for Heteroscedasticity using the Breusch-Pagan test that tests the null hypothesis of constant variance of the error terms across the variables.

According to Table 1, age was expected to influence perception scores on the attributes of Hexanal either negatively or positively. Age can be used as a proxy for farming experience. Older farmers have more experience in farming and hence they are able to appreciate the innovations more compared to younger farmers. On the other hand, younger farmers tend to be more risk loving which enhances their appreciation of new technologies especially if they perceive them to solve their problems.

Education in terms of years completed in formal schooling was hypothesized to have a positive influence on perceptions. Farmers that are more educated are more capable of synthesizing new information hence making better informed decisions (Ntshangase et al., 2018). The variable income is a proxy of the capital available for use in banana production. Total annual income was calculated from all their livelihood activities. It was hypothesized that households with higher household incomes would be more likely to have positive perceptions towards new technologies compared to the ones with lower incomes.

Membership to a group and access to extension access variables were hypothesized to positively influence perception scores. Both variables are important in provision of important information to farmers thereby enhancing positive perceptions on new agricultural technologies. Therefore, farmers who were members of a group or had access to extension services were more likely to have positive perceptions Hexanal compared to those with no access to any form of information.

Ownership to title deed to one's land was hypothesized to negatively influence perceptions. Farmers who own title to their lands are more protective of their lands. Therefore, they are more likely to be against the use of foreign materials on their land compared to farmers who farm on leased or temporarily owned lands.

3.6.5 Empirical model to assess WTP and factors influencing WTP for Hexanal technology

In the case of choice discrete response format as is the case in this study, it is assumed a farmer is interested in reducing post- harvest losses of his fruits. Therefore his/her corresponding indirect utility function would depend on; q which is the novel product to be valued, p, prices of market goods, z which is the farmer's characteristics, y representing the farmer's income and ε representing some stochastic components of preferences of the farmer which are unobservable to the researcher and hence treated as random (Hanemann,1984). Therefore, the farmer will be faced with the following indirect utility function $V(q^o, p, y, z, \varepsilon)$ (Hanemann and Kanninen, 1996). With introduction of Hexanal technology, a farmer is confronted with the opportunity of prolonging freshness of his/her fruits which will require a change from using product q^o which is the traditional post-harvest handling techniques to q^1, which is the Hexanal technology that has proved to be effective in prolonging shelf life of mangoes, bananas and pawpaw in Kenya. Hexanal technology is more effective and has greater benefits to the farmer than traditional techniques hence $q^1 > q^o$. It is assumed the farmer perceives the change as an improvement in terms of incomes from the reduced losses and hence his/her indirect utility is as follows;

$$V(q^1, p, y, z, \varepsilon) \geq V(q^o, p, y, z, \varepsilon); \quad (8)$$

However, when the farmer is informed that the change would cost Ksh A the farmer would only be willing to pay (by replying "yes") the amount only if;

$$V(q^1, p, y\text{-}A, z, \varepsilon) \geq V(q^o, p, y, z, \varepsilon); \quad (9)$$

and "no" otherwise (Martinez, 1991), as his/her main objective is to maximize utility.

According to Cook (2011) the maximum amount a farmer is willing to pay for a change from q^o *to* q^1 can be expressed using the compensating variation measure whereby C satisfies;

$$V(p.\ q^1, y\text{-}C, z, \varepsilon) = V(p.\ q^o, y, z, \varepsilon) \quad (10)$$

Thus, C=C ($p, q^1\ q^o, y, z, \varepsilon$) is a farmer's maximum WTP for the change. If the stated price in the bid question is lower than the above WTP a farmer will answer "yes" and "no" otherwise and hence;

$$\text{Max WTP=C=C}\ (p, q^1\ q^o, y, z, \varepsilon) \geq A \quad (11)$$

Adoption of the Hexanal technology is perceived as a farmer's way of improving the quality and freshness of his/her fruits by changing post-harvest handling techniques from q^o *to* q^1. Alternatively, the WTP for the change in this case is expressed as;

$$\text{WTP}=\pi\ (q^1, p, w) - (q^o, p, w) \quad (12)$$

Whereby w is the vector of input prices, and p is the vector of output prices, which yields the following indirect restricted profit function $\pi\ (p, w, g)$. In reference to equation (12) above, WTP is the amount of profit the farmer would be ready to forego to obtain the Hexanal technology q^1 rather than using traditional techniques q^o. The farmer is likely to adopt the novel product which is the Hexanal technology if he/she perceives it to provide higher utility. WTP in this case was evaluated using averaging the 'Yes' individual bid responses which resulted in the mean amount WTP in Ksh.

A two- limit tobit model was used to assess the factors influencing willingness to pay for Hexanal with LogWTP as the dependent variable. Tobit model was found to be superior to OLS and probit models due to the nature of the dependent variable which was scaled between 2 and 3. WTP was censored from above and below due to the presence of outliers within the

data. Tobit model uses the maximum likelihood estimation that directly estimates σ and β̃ (Fieldman, 2012).

Theoretically, the model is presented as follows (Greene, 2003);

$$Y^{*} = X\beta + \varepsilon \quad (13)$$

Where Y^{*} is the latent (hidden) variable that is unobservable, β is the vector for some unknown coefficients, X is the vector for independent variables while ε is the error term which is assumed to be independently distributed with a mean of zero and a variance of σ^2.

Two similar regressions for both treatment and control groups were run using identical sets of independent variables. The estimating equations are as follows;

$$\boldsymbol{WTP(Y^{*}treatment)} = \beta_0 + \beta_1 AGE + \beta_2 INC + \beta_3 SEX + \beta_4 EDU + \beta_5 CRDTACC + \beta_6 LANDSIZE + \beta_7 GRPMBRSHP + \beta_8 PERCACCEPT + \beta_9 INITIALBID + \beta_{10} OCCP + \beta_{11} DISTMKT + \varepsilon_i \ldots..(14)$$

$$\boldsymbol{WTP(Y^{*}control)} = \beta_0 + \beta_1 AGE + \beta_2 INC + \beta_3 SEX + \beta_4 EDU + \beta_5 CRDTACC + \beta_6 LANDSIZE + \beta_7 GRPMBRSHP + \beta_8 PERCACCEPT + \beta_9 INITIALBID + \beta_{10} OCCP + \beta_{11} DISTMKT + \varepsilon_i \ldots\ldots\ldots(15)$$

Table 2 shows the description and expected signs of the variables that were used in assessing factors influencing willingness to pay for Hexanal. Age of the farmer has been shown to negatively influence the adoption of new technologies (Walker and Davies, 2013; Muhammad et al., 2015). Several studies have found out that younger farmers are more receptive towards innovations and hence more likely to adopt new agricultural technologies compared to older farmers (Abdulai and Huffman, 2005; Elemasho et al., 2017; Jabil and Abdu, 2012; Koundouri et al., 2006).

Table 2: Description of hypothesized factors for WTP

Variable	Meaning	Unit of measurement	Expected sign
AGE	Number of years of the HHH	Continuous	-
SEX	Sex of the HHH (Male – 1, Female – 0)	Dummy	+/-
EDU	Number of years of formal schooling	Continuous	+
GRPMBRSHP	Is the farmer a member of a group either formal or informal (Yes-1, Otherwise-0)	Dummy	+
CRDTACC	Has the farmer obtained credit in the last 12 months (Yes-1, Otherwise-0)	Dummy	+
INC	Annual household income in Kenyan shillings (KSH)	Continuous	+
INITIALBID	Initial bid amount (KSH)	Continuous	-
PERCACCEPT	Perception on social acceptability of Hexanal	Continuous	+
LANDSIZE	Total size of land (Acres)	Continuous	+
DISTMKT	Distance to nearest market in Km	Continuous	-
INC_BANANA	Income received from banana sales	Continuous	+
OCCP	Main occupation of HHH (Farming-1, Otherwise-0)	Dummy	+

Access to credit and extension services positively influences the adoption of new agricultural technologies (Abdulai and Huffman, 2005). Access to extension services provide farmers with knowledge and necessary skills thereby increasing the adoption rates/ WTP for new technologies. In addition, access to credit services provides framers with required resources to purchase inputs when required thereby increasing adoption/WTP for innovations and hence the positive relationship.

Education in terms of years of formal schooling has been shown to positively influence the adoption of new technologies. Elemasho et al. (2017) while studying determinants of adoption of post- harvest technologies found out that the more educated a respondent was, the higher chances for them to adopt a post-harvest technology. The results concurred with those of Yusuf and Fakayode, (2012) who found out that low literacy levels among farmers reduced the effective use of post-harvest technologies that led to low adoption of innovations. Therefore, as literacy levels increase adoption/WTP for innovations is expected to increase.

Household size, which is a key socio-economic indicator of labor in African homesteads has been found to influence both positively and negatively the adoption/WTP for innovations. According to Jabil and Abdu, (2012) household size negatively influenced adoption rates of post-harvest technologies. Households with more members have supply to adequate labor needed for post-harvest activities thereby reducing the demand for such innovation. On the other hand, Muhammad et al. (2015) in his study for WTP for organic foods found out that household size positively influenced the WTP for the organic foods. The assumption was that larger households had more resources compared with smaller households hence their ability to pay more. However, the findings are in contradiction with the African setting whereby having large households may not necessarily guarantee more resources.

Sex of the household head has been found to negatively influence the WTP such as in the case of Steur et al. (2012) who found out that female rice consumers were willing to pay more for Genetically Modified rice compared to their male counterparts. However, this contrast with findings from Doss and Morris (2000) who found out that women have lower adoption rate of improved technologies compared to men as they are more resource and time constrained (Pender and Gebremedhin, 2007).

The initial bid amount was hypothesized to influence the maximum WTP value negatively (Wattage and Simon, 2008). This is based on an economic theory whereby increase in price reduces the demand of the product. It is an assumption in CVM approach that it is a representation of an actual market setting and hence increasing the bid amount will result in reduced demand for the product.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1Household Characteristics

4.1.1 Social-economic characteristics of sampled households

Descriptive results shown on Table 3 indicate that the average years of the households is 61 years with further analysis indicating only 18% of the respondents are below the age of 45 years. Majority (78%) of the respondents reported to practicing farming as their main economic activity of which they have been involved in for an average of 31 years. Given the average age and experience in farming, this is an indication that it is older people mainly practicing banana production.

Further results showed that the average household size was 3.4 indicating that Meru county households comprised of small families or had some family members living away from home. However, the results concur with the Kenya national household survey in 2015/2016 that found an average of four persons per household nationally (KIHBS, 2018). The study found that 84% of the households sampled were male- headed which is consistent with the African setting of males being the main decision makers in a household. The proportion of married respondents was 79%.

The mean land size in the study area was 2.9 acres which concurs with Miriti et al. (2014) who found out that banana production in Meru County is practiced by small- scale farmers owning less than 5 acres of land.

Table 3: Socio-economic characteristics of sampled households

Variable	Min	Max	Mean (SD)
Household characteristics			
Household size	1	6	3.36(1.36)
Age	25	90	60.6(14.4)
Farmingexperience	0	70	30.98(15.67)
Education	0	18	9.04(3.6)
INC_banana	1400	720000	121536(115159)
INC	23760	1979000	333793(279737)
Maritalstatus	0	1	0.79(0.41)
Sex	0	1	0.84(0.37)
Occupation	0	1	0.78(0.41)
INC_source	0	1	0.11(0.31)
Farm characteristics			
Landsize	1	40	2.9(4.02)
Landtenure	0	1	0.72(0.45)
Infrastructure			
Distinputshop	0	20	0.92(2.02)
Distcollectioncenter	0	11	2.5(2.6)
External support services			
Creditaccess	0	1	0.14(0.35)
Grpmembership	0	1	0.59(0.49)
Grpduration	0	50	7.47(10.84)
Extensionaccess	0	1	0.23(0.42)
Percptacceptability	-1.59	2.49	5.04(0.99)

Source: Survey data, 2018; (SD)- Standard Deviation.

The study area is characterized by medium literacy levels with the mean level of the education of the household head being 9 years of formal schooling. With the lack of attainment of secondary education among the respondents, one can say that most households are not capable of synthesizing new information thereby not able to appreciate new technologies.

Results from the study indicate that the average distance travelled by households to the nearest banana collection center is 2.5km. These results are consistent with Mbuthia et al.

(2018) who found out that households in Meru County travelled an average of 3.3km to the nearest markets. Despite the households travelling for relatively short distance, majority (84%) of the respondents reported to using poor feeder roads (Seasonal marram roads) which were impassable during rainy seasons. The results affirm findings from previous studies on the poor state of roads in the rural parts of Kenya (Mbuthia, 2003; Wambugu, 2005; Mwithirwa, 2010 and Miriti, 2011). According to Mwithirwa (2010), 95% of traders interviewed reported to using poorly maintained feeder roads to the major markets, while Miriti (2011) found out those bad rural roads were the highest ranked constraint facing banana marketing in Meru County. The slippery roads have been reported to be the main cause of the high transport costs and rise in accidents on the roads which in turn compromises the prices fetched from banana sales (Mbuthia et al. 2018).

Participation in formal or informal groups was found to be high with 59% of the respondents in Meru County belonging to a group. Out of those belonging to a group, 85% cited market access as their main reason for joining. According to respondents, belonging to banana cooperatives enhanced their bargaining power enabling them sell their produce at higher prices as well as availing them with production information.

Contact with extension officers was very low with only 23% of the respondents citing to have had contact with an extension officer in the last 12 months. Government extension services were found to be the most common form of extension with 41% of respondents having received extension services from a government officer while only 28% from Non-Governmental Organizations (NGOs) personnel. The main extension service provided by the extension personnel was on product handling (43%) which could be explained by the nature of banana which is a perishable product and prices obtained largely depends on its quality in the market. Only 14% of the respondents in the study area accessed credit with 22% citing

high costs of obtaining credit as a reason they had not accessed credit and 14% citing lack of collateral required to obtain credit. The findings are consistent with Miriti et al. (2014) who found that only 10% of the respondents interviewed in South Imenti accessed credit. According to Nyabaro et al. (2018), the low access to credit was attributed to lack of collateral and guarantors required by financial institutions in order to obtain credit.

4.2 Perceptions of Hexanal technology and its application

4.2.1 Perceptions of the control group

The Kaiser -Meyer –Olkin (KMO) which is the measure of sampling adequacy for the control group was 0.632, which was above 0.5 threshold requiring performance of a factor analysis. Using PCA, three principal components were extracted as shown in Table 4 and they accounted for 64% of the total proportion of variance explained. The principal components were labelled: ‘Effectiveness’, ‘Acceptability’ and ‘Environmental Safety’ respectively according to the factors with the highest loadings. The first component accounted for 23% of the total variance while the second accounted for 22% of the variance not accounted for by the first while the third accounted for 18% of total variance not accounted for by the first two components. Five variables were excluded from the analysis, as they did not attain a 0.5 KMO measure.

Table 4: Factor loadings on farmers perceptions

Variable	Effectiveness		Acceptability		Environmental Safety	
	Treatment	**Control**	**Treatment**	**Control**	**Treatment**	**Control**
Glut of fruits in the market is a serious challenge in production and marketing of bananas	**0.937**	**0.899**				
Post- harvest losses in banana production is a major marketing challenge	**0.877**	**0.881**				
Hexanal technology will offer solutions by increasing incomes from banana production	**0.853**	**0.761**	-0.406			
Hexanal technology is socially acceptable	**0.754**		**0.824**	**0.678**		
Education on use of Hexanal technology is necessary			**0.505**	**0.654**		
Government Agency should be involved in distribution of Hexanal technology				**-0.638**	**0.679**	
Hexanal technology will offer solutions to post-harvest losses in bananas				**-0.630**		
Hexanal technology cannot cause any environmental pollution			**0.645**	**0.608**		0.407
Possibility of counterfeiting Hexanal			**-0.736**	**-0.558**		
Hexanal technology is safe to micro-organisms					**0.776**	**0.905**
Hexanal technology is not a foreign material			0.429		**0.572**	**0.878**
Variance Explained (%)	28.48	23.43	20.92	22.58	13.36	18.15
	Treatment			Control		
Proportion of variance explained	0.6275			0.6416		
Kaiser -Meyer -Olkin Measure of sampling adequacy (MSA)	0.633			0.632		
Bartlett's Test of Sphericity; Approximate Chi-Square (df)	241.085(55)***			359.101(55)***		

PCA results with Varimax rotation. Source: Survey data, 2018

For the first component ‘Effectiveness’, three variables loaded strongly. Households who were not aware of Hexanal technology strongly agreed that one of the challenges they are facing in terms of production and marketing of bananas were glut of the produce in the market during peak seasons. They also perceived the high post- harvest losses as a hindrance to marketing as most of their produce fail to reach the market or if it does, not in good quality. This prevents them from accessing better markets where they could sell their produce at premium prices and increase their incomes. After explaining to them the benefits of Hexanal, they noted that the technology could be very beneficial to them as it its’ use would lead to increased incomes from bananas. This is a positive perception that is likely to enhance adoption of the technology.

Six variables loaded strongly on the second perception on ‘Acceptability’. Households perceived Hexanal as a socially acceptable technology but thought that more efforts were needed in creating more awareness about the technology. This is an indication that respondents were not confident that they would be able to use it without the assistance of an extension officer. However, respondents did not believe that this technology would be able to offer them real solutions to their post-harvest problem. This is a negative perception towards the technology that can be enhanced through increased awareness about its use and benefits. households did not think it was necessary for the Government agency to be involved in the distribution of the technology, as they did not perceive counterfeiting of the technology a problem. This could only mean households in this region have trust with their input provision system. In addition, households are positive that Hexanal is a safe product and they are not worried about it causing any environmental pollution which is a positive perception about the technology.

Perception on ‘Environmental safety’ was explained by two variables whereby control farmers were positive that Hexanal technology was a safe product that was safe to use in the presence of other microorganisms. In addition, they did not regard the technology as a foreign material, which is a positive perception about the technology.

4.2.2 Perceptions of the treatment group

The treatment group had a KMO measure of 0.633, which was above 0.5 thresholds. Three principal components were extracted which accounted for 62% of the total proportion of variance explained. The components were labelled: ‘Effectiveness’, ‘Acceptability’ and ‘Environmental safety’. The first component accounted for 28% of the total variance while the second accounted for 20% total variance not accounted for by the first while the third accounted for 13% of total variance not accounted for by the first two components. Five variables were removed as they failed to meet the minimum threshold of 0.5 required to conduct a PCA,

Loadings on the perception ‘Effectiveness’ were similar to the loadings on the control group. Treatment households just like the control perceived glut in the market and high post-harvest losses as the main challenges in production and marketing of their bananas. They also agreed that with the introduction of Hexanal technology, post- harvest losses could reduce which would result in increased incomes. They also perceived Hexanal technology as a socially acceptable technology. The perception was a positive one that is very instrumental in increasing the uptake of the technology.

Perception on ‘Acceptability’ was best explained by four main variables. Households aware of the technology strongly agreed that Hexanal technology was socially acceptable and they would not find it hard to integrate it into their lives. They however noted that it was necessary to increase awareness on the technology as that would boost farmers’ confidence as they used

it. Households did not perceive possibility of counterfeiting the technology a problem meaning they are confident of the input delivery system in place. Households also had positive perceptions about the technology and they did not have any concerns on Hexanal technology causing any environmental pollution.

Treatment households perceived Hexanal technology as 'environmentally safe' as they strongly believed that the technology was a safe product to other organisms in the environment. In addition, they did not think the technology was a chemical (foreign material) which is a positive perception among the household trained on the use of the technology. They also thought it was necessary that a government agency be involved in the distribution of Hexanal as they believed that would help in controlling the quality and pricing of the technology as well as providing adequate knowledge on the use of the technology. A government agency has been involved in conducting field trials on farms of some of the respondents as well as creating awareness and providing trainings on the use of the technology, which has created trust between the government agency and the respondents in provision of the technology.

4.3 Determinants of perceptions on the use of Hexanal

Output from regression analysis of perception scores against key variables hypothesized to influence each perception is as shown in Table 5. Non- identical sets of explanatory variables were used in the regressions across the sub- samples of the both control and treatment group to explain determinants of each perception. Different variables were found to explain different perceptions on use of Hexanal between the two sub- samples. This is an indication that each dimension of farmers' perception on use of Hexanal varies, as the perceptions cannot all be predicted by the same set of independent variables between the two groups of respondents.

Table 5: Determinants of perceptions on use of Hexanal

Variable	Effectiveness		Acceptability		Environmental safety	
	Control	**Treatment**	**Control**	**Treatment**	**Control**	**Treatment**
AGE	-0.004(0.007)	-0.009(0.010)	-0.019(0.009)**	-0.020(0.013)		
SEX	0.719(0.329)**	-0.651(0.266)**	0.327(0.341)	0.692(0.409)*	0.397(0.342)	0.614(0.353)*
EDUC	-0.377(0.139)	0.265(0.228)	0.037(0.032)	0.006(0.034)	-0.291(0.247)	0.082(0.239)
HHSIZE			-0.119(0.077)	0.028(0.093)		
MRTSTAT	-0.147(0.302)	0.587(0.176)***				
LANDTENURE	0.523(0.281)*	0.772(0.465)*	0.039(0.267)	0.841(0.338)**	0.039(0.256)	-0.779(0.277)***
EXTACC	-0.291(0.346)	-0.205(0.341)			0.264(0.395)	-0.265(0.263)
CRDTACC			0.807(0.282)***	0.703(0.409)*		
GRPDUR			0.015(0.007)*	0.028(0.012)**		
GRPMBRSHP	0.398(0.218)*	0.459(0.372)			0.209(0.230)	-0.145(0.283)
DISTMKT			0.038(0.022)*	-0.086(0.038)**	0.012(0.048)	-0.328(0.086)***
DISTCOLL	-0.038(0.038)	0.087(0.053)				
LogINC					-0.412(0.144)***	-0.161(0.069)**
INC			-1.27(3.93)***	-2.41(5.50)***		
INC_BANANA	2.4(1.03)	6.79(7.45)				
CONSTANT	-0.354(0.559)	-0.497(0.600)	1.104(0.719)	0.363(0.935)	4.787(1.719)***	2.482(0.853)***
F-statistics	1.95*	2.00*	3.86***	4.34***	1.94*	4.32***
R^2	0.1687	0.2482	0.2471	0.3719	0.1642	0.4126
Adj R^2	0.0587	0.0871	0.146	0.234	0.0794	0.317

Note: *, **, *** implies statistically significant at 10%, 5% and 1% respectively. Figures in parentheses are standard errors

Source: Survey data, 2018.

The low adjusted R^2 of below 0.50 obtained from the regressions are usual in Ordinary Least Squares (OLS) regressions especially when based on cross-sectional data (Greene, 2000). In addition, Nunes (2002) notes that low R^2 is always good news in perception studies.This is because obtaining a high R^2 would be an indication that perceptions are only influenced by respondent's characteristics thereby indicating that the perceptions per se will be conveying redundant information. The significant F- statistics are an indication that we reject null hypothesis in the cases where coefficients in each estimated equation is zero. This provides evidence that the model is significant and has significant explanatory powers.

4.3.1 Determinants of perceptions among the treatment group

According to the results, perception on 'Effectiveness' was influenced by three independent variables namely sex, marital status and ownership of a title deed to land under banana production. There was the expected either negative or positive relationship between sex and perceptions and in this case, sex of the household head negatively influenced perception on effectiveness of Hexanal ($p<0.05$) while marital status and ownership to title deed positively influenced the perception scores at ($p<0.01$) and ($p<0.1$) respectively as hypothesized.

This means that male respondents had negative perceptions on 'Effectiveness' of the Hexanal and they did not believe Hexanal would be an effective solution to their post- harvest problem. Married household heads on the other hand had positive perceptions regarding the effectiveness of the technology. This findings concur with Dauda et al. (2014) who found out that married people were more likely to have positive perceptions towards new technology as they viewed them as a way of increasing their incomes which is important in meeting their social obligations (families). Ownership to title deeds which is an indication of resource endowment is likely to improve perception scores on 'Effectiveness' as households can use the land for long-term production.

The second perception on ‘Acceptability’ was influenced by six factors. Sex of respondent, ownership of title deed, credit access and duration to a group all positively influenced the perception at ($p<0.1$), ($p<0.05$), ($p<0.1$) and ($p<0.05$) respectively, while distance to the input shop and annual income of the household negatively influenced the perception scores at ($p<0.05$) and ($p<0.01$) respectively. Male household heads who owned the title deed to their lands and had accessed credit services in the last twelve months perceived the technology as socially acceptable. The results indicate that personal land ownership that is majorly owned by men in most African societies enhances acceptability of new agricultural technologies. This could be attributed to the security of tenure as households can invest in their lands on long-term basis. In addition, increasing the number of years of a household’s membership to a group has also been shown to enhance acceptability. This is because membership to groups is a form of social capital and when household heads meet and interact, they can share information on agricultural innovations.

However, households living far away from the input shops as well as households earning a higher annual income did not think the technology would be socially acceptable. This could be attributed to the high costs incurred in searching for input information in the case of those living far off from the input shops while households with higher incomes have diverse means of earning income as well as having access to diverse ways of reducing post-harvest losses they are already using.

Perception on whether Hexanal is ‘Environmental safe’ was influenced by four variables namely; sex of the household head, whether the household head own a title deed for the land, distance to input shop and the annual total income. Sex of the household head positively influenced the perception scores ($p<0.1$) which means male- headed households perceived Hexanal technology as an environmentally safe product to use in their farms without causing

any harm to other micro-organisms. Ownership of a title deed however negatively influenced the perception scores ($p<0.01$). Household heads who owned title deeds to their land did not perceive this technology as environmentally safe to use on their crops. Distance to input shop was also found to negatively influence the perception scores ($p<0.01$). Households living far distances from input shops did not think Hexanal technology could be environmentally safe for use on their farms which could be attributed to lack of information and assurance from other farmers as most meetings and discussions are held around the market areas. In addition, total annual income negatively influenced the perception scores ($p<0.05$). This is an indication that households earning higher incomes had negative perceptions on the 'environmental safety' of the technology. This can be explained by the household's ability to have access to markets on time thereby reducing their losses, which leads to the high incomes and are therefore not receptive towards innovations. Alternatively, households with high incomes may be involved in other farm or non-farm activities and therefore do not suffer from high post-harvest losses hence lack incentive to use Hexanal.

4.3.2 Determinants of perceptions among the control group

Among the control farmers who did not attend the dissemination workshop on use of Hexanal technology, perception on 'effectiveness' was positively influenced by three variables namely sex ($P<0.05$), ownership of a title deed ($p<0.1$) and group membership ($p<0.1$). Male household heads owning title deeds to their lands as well as those belonging to groups perceived the technology as being effective in reducing post-harvest losses. This is an indication that they believed Hexanal technology would be an opportunity to increase incomes from the banana production. Having ownership of one's title deed gives a household confidence to invest in new technologies and especially for long- term production and hence the positive perception. Group membership increases a household heads' knowledge and confidence on new technologies thereby enhancing the positive perception on 'effectiveness'.

Perception on ‘acceptability’ was influenced by five factors whereby age of household head and annual total income of a household negatively influenced the perception scores at ($p<0.05$) and ($p<0.01$) respectively. However, credit access and duration in group membership and distance to input shops positively influenced the perception scores at ($p<0.01$), ($p<0.1$) and ($p<0.1$) respectively. The results are an indication that older household heads and households with higher annual earnings did not perceive the technology as socially acceptable which could reduce the uptake of the technology among the farmers. These findings concur with Elemasho et al. (2017) who stated that older people are more likely to be rigid towards the adoption of innovations as they are termed to be more risk averse, compared to younger people. However, households with access to financial services as well those households belonging to groups both formal and informal in nature for many years perceived Hexanal as a socially acceptable technology; this are positive factors and means of increasing the uptake of the technology among the farmers.

The third perception on the ‘environmental safety’ of the technology use on the farms was only influenced by the annual total income which negatively influenced the perception scores ($p<0.01$). Households earning higher annual income did not perceive Hexanal as an environmentally safe product to be used on their farms. This is attributable to the fact that financially stable households have diverse means of earning income and are not over reliant on banana production that enhance their resilience on post- harvest losses. Alternatively, such households could be having access to guaranteed markets which reduces their losses and in which case they earn high incomes from thereby lacking incentives to invest in Hexanal.

4.4 Households Willingness to pay for Hexanal

4.4.1 Estimation of mean WTP for both treatment and control groups

The results show that both groups of households in Meru County are willing to pay positive amounts for the Hexanal technology as shown on Table 6. The minimum amounts households were willing to pay for Hexanal was Ksh.100 for both treatment and control households respectively. Treatment group had a higher mean WTP of Ksh 466.47 compared to control group of sh.331.86. The mode for both groups was Ksh.400.

Table 6: WTP estimates (ksh/0.25L of Hexanal)

Household Category	Valid n	Mean	SD	Min	Max	Mode	Median	t-value
Meru (treatment)	78	466.47	203.7	100	1000	400	400	
Meru (control)	52	331.86	126.27	100	600	400	325	
								-4.6518* **

In addition to the earlier hypothesis, It was also hypothesized there would be no difference in the mean amounts households are willing to pay between the treatment and control groups. However, results from t-test testing the hypothesis of equal WTP amounts was rejected at 1% level of significance ($p<0.01$). The mean WTP amount for households who attended the dissemination workshop is statistically higher than for those who never attended. Specifically, treatment group was willing to pay Ksh. 134.61 more than those ones not aware of the technology. Therefore, the results are an indication that access to information on existence of a new technology increases the acceptance and WTP amounts for the technology. In addition, the mean WTP for treatment households is also higher than the initial bid value which is an indication of undervaluation of the Hexanal technology which can happen in cases where prices for non-market goods are set with little or no consideration for farmers' preferences (Seck, 2016). For both groups of samples, the median WTP was found to be lower than the mean WTP amounts for Hexanal. The findings are consistent with

literature whereby, Chen and Jim (2012) used CVM approach to study the WTP for ecotourism development in Hong Kong and found out that the median WTP was 16% lower than the mean WTP.

4.2.2 Factors influencing WTP for Hexanal

Identical sets of independent variables were used in the tobit regression model for both control and treatment groups of farmers. Results from Table 7 indicate that LR chi2 statistic for both groups were significant at 1% level of significance ($p<0.01$) which is an indication variables included in this regression significantly contribute to the changes in the maximum amount households are willing to pay for Hexanal. The Pseudo R2 was 53.13 and 24.35 for control and treatment group respectively. The values indicate that independent variables included in this model could explain 53.13% and 24.35% variation in the maximum WTP respectively.

Among the explanatory variables, the initial bid amount positively influenced ($p<0.01$) the maximum WTP for both groups of households. This is an indication that increasing the bid amount results in increased mean WTP for Hexanal. However, based on the economic theory by Wattage & Simon (2008) increasing the bid amounts through iterative bidding approaches such as in this case, demand for the product increases thereby increasing prices. The findings are an indication that households in Meru County believed the initial bid amount to be the true value of the technology and based their maximum WTP on the amount. Additionally, the findings could be indicative of the likelihood of occurrence of a starting point bias that could explain the high influence of the initial bid on the WTP amounts.

Table 7: Factors influencing WTP for Hexanal

	Sample (n=130)			
Variable	**Control**		**Treatment**	
LogMaxWTP (Ksh.)	**Coefficient**	**SE**	**Coefficient**	**SE**
INITIALBID	0.224	0.037***	0.349	0.043***
AGE	-0.003	0.002**	0.002	0.002
SEX	0.034	0.078	-0.292	0.094***
OCCP	-0.041	0.046	-0.145	0.056**
MRTSTAT	0.023	0.078	0.104	0.086
EDUC	-0.005	0.006	-0.005	0.007
DISTMKT	-0.005	0.007	0.002	0.009
LANDSIZE	0.00	0.004	0.026	0.015*
INC	-2.01e	8.16e**	1.16e-07	8.64e-08
PERCEFFECTIVE	-0.025	0.019	-0.011	0.199
PERCACCEPT	0.036	0.019*	0.019	0.021
PERCSAFE	-0.008	0.019	0.007	0.019
GRPMBRSHP	0.049	0.039	-0.066	0.042
CONSTANT	2.62	0.122***	2.557	0.140***
Log Pseudo likelihood		26.99		27.42
LR chi2 (13)		54.99***		57.18***
Pseudo R2		53.13		24.35

Note*, **, *** implies statistically significant at 10%, 5% and 1% respectively. Source: Survey data, 2018

Age of the household head negatively influenced ($p<0.0\ 5$) the mean WTP amounts among control farmers. The results are an indication that older farmers not aware of the technology were willing to pay lesser amounts for Hexanal compared to younger farmers. These findings are consistent with Walker & Davies (2013) and Muhammad et al. (2015) who also found out that farmers' age negatively influenced adoption of agricultural innovations. Several studies have also found out that younger farmers are more receptive towards innovations and hence more likely to adopt new agricultural technologies compared to older farmers who are considered more risk averse (Abdulai & Huffman, 2005; Koundouri et al. 2006; Jabil & Abdu 2012; Elemasho et al. 2017.)

Sex of the household head (being male) was found to negatively influence the mean WTP amounts among the treatment farmers ($p<0.01$). This means the mean WTP amounts were less for male farmers compared to female farmers. The findings contrast Boucher et al. (2008) and Fletschner et al. (2010) who found out that women tend to be more risk averse in acceptance of new technologies compared to the men as they perceive them to be more risky which may cause them to be less likely to adopt innovations such as Hexanal technology. According to a study by Nyabaro et al. (2018) on gendered analysis of banana value chain in Meru County, the research found out that women dominated the retail marketing channel. The findings explain why the WTP for Hexanal is higher for women compared to men as women view Hexanal as a way of increasing incomes from their sales.

The explanatory variable 'main occupation of the household head' negatively influenced WTP amount ($p<0.05$) among the treatment farmers. Farmers who practice farming as their main occupation had reduced WTP amounts compared to farmers engaging in other non-farm activities. This could have been contributed by them being skeptical about the technology and viewed it as a chemical that could be harmful to consumers thereby threatening their main

source of livelihood. On the other hand, farmers involved in other activities viewed Hexanal a solution to save time-spent on farm activities and looking for markets, which increased the demand of Hexanal among them.

Land size which was measured in acres positively influenced ($p<0.1$) the WTP amounts among control households. Households with larger farm sizes were willing to pay higher amounts for Hexanal to reduce post-harvest losses due to their high production of bananas. A larger land size under banana production meant increased output which required good post-harvest handling to avoid losses. This led to the increased demand for the technology among farmers already aware of the benefits of Hexanal.

The variable income (total annual household income) had a negative influence ($p<0.05$) on the WTP amounts among control households. Households earning a higher annual income were willing to pay lesser amounts for Hexanal. Income can be used as a proxy for a household's ability to invest in alternative methods to reduce post- harvest losses or gain better access to markets. In addition, such households have diverse means of earning income and are not over reliant on banana production.

The perception on social acceptance of the technology positively influenced the maximum WTP ($p<0.1$) among the control households. Households that perceived Hexanal to be a socially acceptable were willing to pay higher amounts for it. This is because they viewed the technology as a product which they would be able to incorporate as one of their post-harvest management practices. The findings concur with Steur et al. (2010) who found out that consumers' perceptions influenced their maximum WTP for Genetically Modified Rice.

CHAPTER FIVE

5.0 CONCLUSION AND POLICY RECOMMENDATIONS

5.1 Conclusions

The objective of the study was to assess the perceptions of and willingness to pay for Hexanal (EFF) technology as a post-harvest reduction technology in banana production between households aware and those not aware of the technology in Meru County, Kenya. The determinants of those perceptions as well as of the willingness to pay were also assessed. The households perceptions extracted for both groups of farmers were classified into; "Effectiveness of Hexanal", "Social acceptance of the technology" and "Environmental Safety of Hexanal".

Both groups of farmers had positive perceptions on some attributes of the technology. Despite both groups, agreeing that Hexanal was a socially acceptable technology the factor loadings on the treatment group of households was higher than the control group. The control group did not think Hexanal was capable of offering solutions to the post-harvest losses in banana, which could have been contributed by lack of prior information on Hexanal. The control group strongly believed that more education was necessary on the use Hexanal as it was a new product to them. Based on the results we failed to reject the first hypothesis and concluded that farmers have positive perceptions on some of the attributes of Hexanal technology.

Further, results from regressions statistics indicate that determinants of these perceptions vary between the sub- samples as well as the type of perception. Determinants of perception scores included land tenure, farmer characteristics, infrastructure and access to credit services. The

null hypothesis stating socio-demographic, institutional and farm characteristics have no effect on the perception scores was therefore rejected in favor of the alternative.

Further results from the study indicated that households in Meru County were willing to pay certain prices for the Hexanal technology to prolong banana fruit's shelf-life thereby increasing their incomes. Despite the maximum WTP values being hypothetical, values for the households aware of Hexanal technology were higher compared to the base price which is an indication of positive willingness to pay among banana producing households. The results concur with the hypothesis that banana farmers are willing to pay some price for the Hexanal technology and we therefore fail to reject the hypothesis.

Determinants of the WTP between the two groups were assessed and different factors were found to influence the amount households were willing to pay for the technology. Generally factors that positively influenced WTP included; initial bid amount, land size and perception on social acceptability of Hexanal. On the other hand, age, sex of the household head, main occupation, and income were found to negatively influence WTP amounts. Since the results showed significant influence of factors on the WTP values, we reject the null hypothesis in favor of the alternative. The null hypothesis stated that socio-economic, perceptions and institutional factors have no influence on the amounts farmers are willing to pay for Hexanal.

5.2Policy recommendations

Results from the study showed that banana farmers have positive perceptions concerning some of the attributes of Hexanal technology. Perceptions obtained were grouped into; effectiveness, acceptance and environmental safety. From the results on perceptions, treatment households who attended the dissemination workshop were more confident about the use and benefits of Hexanal technology as well as its social acceptance. Therefore, to facilitate the acceptance of the technology, more information needs to be availed by the product developers using dissemination workshops targeting control farmers on the use and benefits of incorporating Hexanal as one of their postharvest reduction strategies. This will boost households' confidence in using the technology. To increase the uptake of the technology it is necessary for stakeholders to take note of the different influences of perception scores and invest in the ones that would enhance positive perceptions on 'effectiveness', 'acceptability' and 'environmental safety' attributes of Hexanal. Therefore, stakeholders need to increase extension contact and especially among the older farmers who had negative perceptions on the effectiveness and social acceptability of the technology to enhance its uptake. Since land size positively influenced perception on effectiveness it is important benefits of Hexanal technology be emphasized to farmers with large pieces of land as that would enable them increase their production without fear of post-harvest losses.

There is also need for promotion of the technology by extension agents targeting households living far off from input shops in order to improve their perceptions on the social acceptability of the technology as well as its environmental safety attribute. Both the national and county government should also come up with initiatives to improve the terms of credit access in the study area in order to enable farmers have access to capital needed in the uptake

of new technologies such as Hexanal thereby reducing their losses and increasing their incomes.

Based on results from the second objective, households are willing to pay positive amounts for Hexanal technology. This provides sufficient basis for scaling up and commercializing the technology as well as providing guidelines on the pricing mechanisms to the technology developers. However, for enhanced adoption, stakeholders should provide sufficient information in order to increase perception scores on social acceptability of the technology as it was found to positively influence the WTP.

The product developers should also ensure the pricing of the technology takes into account the households' characteristics such as age, sex, main occupation, land size, income, and perceptions among others as they were found to influence amounts farmers are willing to pay. Farmer's age negatively influenced WTP among farmers not aware of the technology. There is therefore need for product developers to conduct more dissemination workshops in order to demonstrate the effectiveness of the technology especially among younger household heads to enhance their confidence in its effectiveness.

5.3 Suggestion for further research

The study assessed the perceptions of banana farmers using PCA and their WTP for Hexanal using the CVM approach. Future studies should focus on cost benefit analysis (CBA) of adopting Hexanal. Information obtained will be useful to product developers and other stakeholders in informing their decisions on the efficiency and effectiveness of the technology to the banana farmers.

REFERENCES

Abdulai, A., and Huffman, W. E. (2005). The diffusion of new agricultural technologies; The case of crossbred-cow technology in Tanzania. *American Journal of Agricultural Economics*, 87(3), 645-659. doi:10.1111/j.1467-8276.2005.00753.x

Abebaw, D., Muller K.H., and Mburu, J. (2006). Understanding the perceived importance of risk for coffee growers: empirical evidence from Ethiopia. *Quarterly journal of International Agriculture* ,45(3), 253-267.

Adesina, A. A., and Baidu-Forson, J. (1995). Farmers' perceptions and adoption of new agricultural technology; evidence from analysis in Burkina Faso and Guinea, West Africa. *Agricultural economics*, *13*(1), 1-9.

Alhassan, N. J., Samuel, A. D., Franklin, N. M., and Isaac, G. K. (2016). Commercializing innovations from agricultural research in Northern Ghana and farmers` willingness to pay. *African Journal of Business Management*, *10*(7),140-150. doi:10.5897/ajbm2016.8004

Ambuko, J., Sekozawa, Y., Sugaya, S., and Gemma, H. (2013). A comparative evaluation of postharvest quality attributes of two banana (Musa spp) varieties as affected by preharvest production conditions. *Journal of Agricultural Science, 5*(3), 170.

Ambuko, J., Kemunto, N., Hutchinson, M., and Owino, W. (2017). Comparison of the Postharvest Characteristics of Mango Fruits Produced under Contrasting Agro-Ecological Conditions and Harvested at Different Maturity Stages. *Journal of Agricultural Science, 9*(8), 181. doi:10.5539/jas.v9n8p181

Anusuya, P., Nagaraj, R., Janavi, G. J., Subramanian, K. S., Paliyath, G., and Subramanian, J. (2016). Pre-harvest sprays of Hexanal formulation for extending retention and shelf-life of mango (Mangifera indica L.) fruits. *Scientia horticulturae*, *211*, 231-240.

Atreya, K. (2007). Farmers' willingness to pay for community integrated pest management training in Nepal. *Agriculture and Human Values, 24*(3), 399-409. doi:10.1007/s10460-007-9063-3

Blomquist, G. C., Blumenschein, K., and Johannesson, M. (2008). Eliciting Willingness to Pay Without Bias Using Follow-Up Certainty Statements; Comparisons Between Probably/Definitely and a 10-Point Certainty Scale. *SSRN Electronic Journal*. doi:10.2139/ssrn.993509

Blumenschein, K., Blomquist, G. C., Johannesson, M., Horn, N., and Freeman, P. (2007). Eliciting Willingness to Pay Without Bias; Evidence from a Field Experiment. *The Economic Journal, 118,*(525), 114-137. doi:10.1111/j.1468-0297.2007.02106.x

Boucher S, Carter M., and Guirkinger, C. (2008). Risk rationing and wealth effects in credit markets; theory and implication for agricultural development. *American Journal of Agricultural Economics* 90, (2), 409-423.

Boyle, K. J., Welsh, M. P., and Bishop, R. C. (1988). Validation of empirical measures of welfare change: Comment. *Land Economics, 64*(1), 94-98.

Brown, J. E. and Dunn, P. K. (2011). Comparison of Tobit, Linear, and Poisson-Gamma Regression Models: An Application of Time Use Data. *Sociological Methods and Research,* 40(3):511–535.

Buschena, D. E., Anderson, T. L., and Leonard, J. L. (2001). Valuing Non-Marketed Goods: The Case of Elk Permit Lotteries. *Journal of Environmental Economics and Management, 41*(1), 33-43. doi:10.1006/jeem.2000.1129

Caroline Mugure, M. (2012). *Economic Assessment of Losses Due to Fruit Fly Infestation in Mango and the Willingness to Pay for an Integrated Pest Management Package in Embu District, Kenya* (No. 243461). Collaborative Masters Program in Agricultural and Applied Economics.

Carpio, C. E., and Isengildina-Massa, O. (2009). Consumer willingness to pay for locally grown products: the case of South Carolina. *Agribusiness*, *25*(3),412-426. doi:10.1002/agr.20210

Cheema, A., Padmanabhan, P., Amer, A., Parry, M. J., Lim, L. T., Subramanian, J., and Paliyath, G. (2018). Postharvest hexanal vapor treatment delays ripening and enhances shelf life of greenhouse grown sweet bell pepper. (*Capsicum annum L.). Postharvest Biology and Technology* 136; 80-89.

Cheema, A., Padmanabhan, P., Subramanian, J., Blom, T., and Paliyath, G. (2014). Improving quality of greenhouse tomatoes (*Solanum Lycopersicum*) by pre and post-harvest applications of HexanalHexanal containing formulations. *Postharvest Biology and Technology* 95;13-19

Chen, W. Y., and Jim, C.Y. (2012). Contingent valuation of ecotourism development in country parks in the urban shadow. *International Journal of Sustainable Development & World Ecology* 19(1): 45–53.

County Government of Meru, (2016). County government of Meru annual development plan 2017/2018. Meru.go.ke/lib.php? com=114&&res_id=618. Last accessed May 17, 2018

Dong, H., Kouyate, B., Cairns, J., and Sauerborn, R. (2003). A comparison of the reliability of the take-it-or-leave-it and the bidding game approaches to estimating willingness-to-pay in a rural population in West Africa. *Social Science & Medicine*, *56*(10), 2181-2189. doi:10.1016/s0277-9536(02)00234-4

Dumont, M., Orsat, V., and Raghavan, V. (2016). Reducing Postharvest Losses. *Emerging Technologies for Promoting Food Security*, 135-156. doi:10.1016/b978-1-78242-335-5.00007-x Woodhead Publishing

El Kayal, W., El-Sharkawy, I., Dowling-Osborne, C., Paliyath, G., Sullivan, J.A., and Subramanian, J. (2017). Effect of Hexanal in enhancing shelf life and regulation of membrane associated genes in strawberry. *Can. J. Plant. Sci*. http://dx.doi.org/10. 1139/CJPS-2016-0351.

Elemasho, M. K., Alfred, S. D. Y., Aneke, C. C., Chugali, A. J. C., and Ajiboye, O. (2017). Farmers' perception of adoption of postharvest technologies of selected food crops in rivers state, Nigeria. *International Journal of Agricultural Research, Innovation and Technology*, *7*(2), 22-26.

Elemasho, M.K., Alfred, S.D.Y., Aneke, C.C., Chugali A.J.C and Ajiboye O (2017) 'Factors influencing adoption of post-harvest technologies of selected food crops in River State, Nigeria,' *International journal of Agricultural Economics and Extension* 5(5), 295-301

FAO. 2011. Global food losses and food waste- Extent, causes and prevention. Rome

Field, A. (2013) *Discovering Statistics using IBM SPSS Statistics* Vol. 4th ed., Sage London

Fletschner, D., Anderson, C., and Cullen, A. (2010). Are women as likely to take risks and compete? Behavioural findings from Central Vietnam. *Journal of Development Studies* 30(1); 1-26.

Gogo, E. O., Opiyo, A. M., Ulrichs, C., and Huyskens-Keil, S. (2017). Nutritional and economic postharvest loss analysis of African indigenous leafy vegetables along the supply chain in Kenya. *Postharvest Biology and Technology*, 130,39-47

Greene, W. H. (2003). *Econometric Analysis*. Fifth edition. New Jersey, Prentice Hall

Greene, W.H. (2000) *Econometrics Analysis* 4th ed., Prentice Hall International, Inc., Englewood Cliffs, NJ, USA.

Hodges, R.J., Buzby, J.C., and Bennet, B (2010). Postharvest losses and waste in developed and less developed countries: opportunities to improve resource use. *The journal of Agricultural science,*149, 37-45

Horticultural Crops Development Authority (HCDA). (2014) Horticultural Data Validation Report, HCDA, Nairobi.

Horticultural Crops Directorate (HCD). (2016). Validated Report. 2015-2016.

Hubbell, B. J., Marra, M. C., and Carlson, G. A. (2000). Estimating the Demand for a New Technology: Bt Cotton and Insecticide Policies. *American Journal of Agricultural Economics*, *82*(1), 118-132. doi:10.1111/0002-9092.00010

Jolliffe, I. T. (2002). *Principal Component Analysis*. *Springer Series in Statistics.* 2, Springer, New York

Kader AA, 2005. Increasing food availability by reducing postharvest losses of fresh produce. *Acta Horticulturae,* 682 (5); 2168–2175.

Kader AA, 2010. Handling horticultural perishables in developing countries versus developed Countries. *Acta Horticulturae,* 877 (6); 121–126.

Kader, A. A. (2004, June). Increasing food availability by reducing postharvest losses of fresh produce. In *V International Postharvest Symposium 682* (2169-2176).

Kader, A. A., and Rolle, R. S. (2004). The role of post-harvest management in assuring the quality and safety of horticultural produce. *Food and Agriculture Organization, 152*

KAVES, 2017. Highlights of banana market survey. Kenya Agricultural Value Chain Enterprise Project.

Kiaya, V. (2014). Post-harvest losses and strategies to reduce them. *Technical Paper on Postharvest Losses, Action Contre la Faim (ACF).*

Kimenju, S.C,, and De Groote, H. (2007). Consumer willingness to pay for genetically modified food in Kenya. *Agricultural Economics* 38(1); 35-46. doi:10.1111/j.1574-0862.2007.00279.x

Kiprop, J., Mulungu, K., Kibet, N., and Macharia, A., (2017). Determinants of Smallholder Farmers' Willingness to Pay for Irrigation Water in Kerio Valley Basin, Kenya. *Journal of Sustainable Development* 10(2); 135.

Kitinoja, L., and Barrett, D. M. (2015). Extension of small-scale postharvest horticulture technologies—A model training and services center. *Agriculture*, *5*(3), 441-455.

Koundouri, P., Nauges, C., and Tzouvelekas, V. (2006). Technology adoption under production uncertainty: Theory and application to irrigation technology. *American Journal Of Agricultural Economics* 88; 657-670.

Kpadé, C. P., Mensah, E. R., Fok, M., and Ndjeunga, J. (2016). Cotton farmers' willingness to pay for pest management services in northern Benin. *Agricultural Economics*, *48*(1), 105-114. doi:10.1111/agec.12298

Kuwornu, J. K., JNR, A. B. N., Egyir, I. S., Onumah, E. E., and Gebrezgabher, S. (2017). Willingness to pay for excreta pellet fertilizer: Empirical evidence from Ghana. *Acta agriculturae Slovenica*, *109*(2), 315-323.

Lipinski, B., Hanson, C., Lomax, J., Kitinoja, L., Waite, R., and Searching, T. (2013). Reducing food loss and waste. *World Resources Institute*, Working Paper

MacKenzie, J.O., Elford, E.M., Subramanian, J., Brandt, R.W., Stone, K.E. and Sullivan, J.A., (2018). Performance of five haskap (Lonicera caerulea L.) cultivars and the effect of Hexanal on postharvest quality. *Canadian Journal of Plant Science*, 98,(2), 432-443.

Maloba, S., Ambuko, J., Hutchinson, M., and Owino, W. (2017). Off-Season Flower Induction in Mango Fruits Using Ethephon and Potassium Nitrate. *Journal of Agricultural Science, 9*(9), 158. doi:10.5539/jas.v9n9p158

Mamba, S.F. (2016). Factors Influencing Perception of Climate Variability and Change among Smallholder Farmers in Swaziland. *Indian Journal of Nutrition,* 3, (2), 138

Marechera, G. and Ndwiga, J. (2015). Estimation of the potential adoption of Aflasafe among smallholder maize farmers in lower Eastern Kenya. *African Journal of Agricultural and Resource Economics* 10 (1), 72-85

Mbuthia, S.W., Kayi, C and Wambugu, S.K. (2018). Constraints to profitable participation in Agri-food value chains: A case of small scale banana farmers in Meru County, Kenya. *International journal of scientific and research publication*, 8, (7), 66-75

Migwi, B.G. (2016). Assessment of Farmers' perceptions of And Willingness to Pay for Aflasafe Ke01, a biological control for aflatoxins in Kenya. Masters thesis, Department of Agricultural Economics, University of Nairobi, Kenya.

Ministry of Agriculture, India (2013). *Post- Harvest profile of mango.*

Ministry of Agriculture, Kenya, (2010). *Technology on Reducing Post Harvest Losses and Maintaining Quality of Fruits and Vegetables in Kenya*.

Miriti, L., Wamue., Masiga, C., Miruka, M., and Maina, I. (2014). Gender concerns in banana production and marketing: their impacts on resource poor households in Imenti south district, Kenya. *African Journal of Horticultural Science* 7, 36-52

Misran, A., Padmanabhan, P., Sullivan, J.A., Khanizadeh, S., and Paliyath, G. (2015). Composition of phenolics and volatiles in strawberry cultivars and influence of preharvest hexanal treatment on their profiles. *Canadian journal of plant science,* 95(1), 115-126.

Muchui, M. N., Gatamba, E.K., Kamau, M.W., Thuranira, D.M., Miruka, M., Wasilwa, L., Gitau, D., and Gitau, C. (2013). Enhancing small scale banana production through the farmer field school in Eastern Kenya

Muchui, M. N., Njoroge, C. K., Kahangi, E. M and Onyango, C. A. (2010). Determinants of maturity indices of Tissue Cultured Bananas (Musa spp.) 'Williams' and 'Grande Naine'. *Acta Horticulturae* 879, 425-430

Muhammad, S., Fathelrahman, E., and Ullah, R. U. (2015). Factors affecting consumers' Willingness to Pay for certified organic food products in United Arab Emirates. *Journal of Food Distribution Research* 46(1), 37-45.

Namyenya, A. (2014). Farmers' willingness to pay for irrigation water: The case of Doho rice irrigation scheme in Eastern Uganda.

Nunes, P.A.L.D. (2002). Using factor analysis to identify consumer preferences for the protection of a natural area in Portugal. *European Journal of Operational Research* 140, 499-516

Nyabaro, V., Mburu, J., and Hutchinson, M. (2018). Factors Influencing gendered intra-household allocation of land and capital assets in banana (*Musa* spp.) production: The case of Meru County, Kenya. *Tropical Agriculture* 95, (1), 134-150

Opara, L.U. (2006). A new era in postharvest technology. *International Journal of Postharvest Technology and Innovation*, 1, (1), 1.

Owens, N. N. (1997). *Farmer willingness to pay for herbicide safety characteristics*.

Paliyath, G., and Murr, D. P. (2007). Compositions for the preservation of fruits and vegetables. Google Scholar

Porat, R., Lichter, A., Terry, L.A., Harker, R., and Buzby, J. (2018). Postharvest losses of fruit and vegetables during retail and in consumers' homes: Quantifications, causes, and means of prevention,' *Postharvest biology and technology*, 139, 135-149

Qaim, M., and De Janvry., A. (2003). Genetically Modified Crops, Corporate Pricing Strategies, and Farmers' Adoption: The Case of Bt Cotton in Argentina. *American Journal of Agricultural Economics*, *85*(4), 814-828. doi:10.1111/1467-8276.00490

Romanazzi, G., Sanzani, S.M., Bi, Y., Tian, S., Martínez, P.G., and Alkan, N (2016). Induced resistance to control postharvest decay of fruit and vegetables, *Postharvest Biology and Technology*, 122, 82-94.

Roy, S., Saran, S., and Kitinoja, L., (2011). Bael (Aegle marmelos (L.) Corr. Serr.). *Postharvest Biology and Technology of Tropical and Subtropical Fruits*, 186-216e. doi:10.1533/9780857092762.186

Seck A, (2016). A dichotomous choice contingent valuation of the Parc Zoologique de Hann in Dakar. *African Journal of Agricultural and Resource Economics* 11 (3), 226-238

Sekhar, C., Selvarajan, M., Pounraj, A. and Praghadeeswaran, M. (2013). Production and Export of Mango in India: A Paradigm to the Developing Nations. *American International Journal of Research in Humanities, Arts and Social Sciences, 13(337): 78-84.*

Sharma, A. (2004). Post-harvest processing of fruits and vegetables by ionizing radiation. In *Production Practices and Quality Assessment of Food Crops* 261-265. Springer, Dordrecht.

Sharma, M., Jacob, J.K., Subramanian, J., and Paliyath, G. (2010). Hexanal and 1–MCP treatments for enhancing the shelf-life and quality of sweet cherry (Prunus avium L.). *Scientia Horticulturae,* 125, 239-247.

Ssebaggala, G.L., Kibwika, P., Kyazze, F.B., and Karubanga, G. (2017). Farmers' perceptions of rice postharvest losses in Eastern Uganda. *Journal of Agricultural Extension*, 21, (2), 30-43.

Steur, HD., Gellynck, X., Storozhenko, S., Liqun, G., Lambert, W., Straeten, D.V and Viaene, J. (2010). Willingness-to-accept and purchase geneticaly modified rice with high folate content in Shanxi province, China. *Appetite* 54,118-125.

Stevens, J. (2002) Applied Multivariate Statistics for the Social Sciences, 4th ed., Mahwah, NJ: Lawrence Erlbaum Associates.

Sustainable Development Goals, 2015. Available at https://sustainabledevelopment.un.org/topics/sustainabledevelopmentgoals (Accessed 26 February 2019)

Twyman, J., Useche, P., and Deere, C. D. (2015). Gendered perceptions of land ownership and agricultural decision-making in Ecuador: Who are the farm managers? *Land Economics*, 91(3), 479-500.

Uddin, E., Gao, Q., and Mamun-Ur-Rashid, M. (2014). Crop Farmers' Willingness to Pay for Agricultural Extension Services in Bangladesh: Cases of Selected Villages in Two Important Agro-ecological Zones. *The Journal of Agricultural Education and Extension*, *22*(1), 43-60. doi:10.1080/1389224x.2014.971826

Ulimwengu, J., and Sanyal, P. (2011). Joint estimation of farmers' stated willingness to pay for agricultural services. *International Food Policy Research Institute Discussion Paper*, *1070*.

Venkatachalam, L. (2004). The contingent valuation method: a review. *Environmental Impact Assessment Review*, *24*(1), 89-124. doi:10.1016/s0195-9255(03)00138-0

Voelckner, F. (2006). An empirical comparison of methods for measuring consumers' willingness to pay. *Marketing Letters*, *17*(2), 137-149. doi:10.1007/s11002-006-5147-x

Walker, S., and Davies, B. (2013). Farmer perceptions of aflatoxins: Implications for intervention in Kenya. Washington, D.C: *International Food Policy Research Institute (IFPRI).*

Wambugu, F., and Kiome, R. M. (2001). The benefits of biotechnology for small-scale banana Producers in Kenya. ISAAA briefs, no. 22. Ithaca, NY: International Service for the Acquisition of Agri-biotech Applications.

Watkins, C.B. (2006). 1-Methylcyclopropene (1-MCP) based technologies for storage and shelf life extension. *International Journal of Postharvest Technology and Innovation,* 1(1), 62-68

Woldemariam, H .W., and Abera, B. D (2014). Development and evaluation of low cost evaporative cooling systems to minimize post-harvest losses of tomatoes (Roma vf) around Woreta, Ethiopia. *International Journal of Postharvest Technology and Innovation,* 4, (1), 69-80

Yadav, R. K., Goyal, and Singh, S. (2017). *Post- Harvest Technology of Horticultural Crops.* (Unpublished). https://doi.org/10.13140/rg.2.2.28507.98089

Yumbya, P.M., Hutchinson M.J., Ambuko, J., Owino W.M., Sullivan A., Paliyath G and Subramanian J (2018). Efficacy of Hexanal application on the post-harvest shelf life and quality of banana fruits (*Musa acuminata*) in Kenya. *Tropical Agriculture,* 95,(1), 14-35

Yussif, K., Obeng, F., and Ansah, I. (2017). Farmers' Willingness to Pay for Private Irrigation Supply in Nandom District, Ghana. *Ghana Journal of Development Studies*, *14*(1), 39. doi:10.4314/gjds.v14i1

APPENDICES

Annex 1 Questionnaire

Canadian International Development Agency

Agence canadienne de développement international

IDRC International Development Research Centre

CRDI Centre de recherches pour le développement international

ENHANCED PRESERVATION OF FRUITS IN KENYA

Fruit Production Survey

INTERVIEW SCHEDULE FOR FARMERS

The University of Nairobi in collaboration with KARLO is interested in conducting research on farmers' perceptions and willingness to pay for EFF technology in reducing post- harvest losses in bananas and mangoes. Results from the study will enable the involved stakeholders understand product's demand among farmers that will inform commercialization decisions of the product. Information from the study is meant for academic and research purposes only and your responses will be treated with confidentiality. The interview will approximately take an hour of your time and your participation is highly appreciated.

UNIVERSITY OF NAIROBI 2018

PERCEPTIONS OF AND WILLINGNESS TO PAY FOR HEXANAL TECHNOLOGY AMONG SMALLHOLDER MANGO AND BANANA FARMERS IN MACHAKOS AND MERU COUNTIES, KENYA.

Questionnaire for farmer households

County:		Sub-County	
Division		Location	
Sub Location		Village:	

Date of the Interview:

Name of the Interviewer:

Time Start:
Time Stop:

I. Basic Information about the Banana/Mango Growing Farmers

I. Name of the Respondent _____

Phone Number : _____

II Gender: 1. Female ☐ 2.Male ☐

III Relationship to the Household head: 1. Head ☐ 2. Spouse ☐ 3. Daughter ☐ 4. Son ☐ V. 5. Other(specify) ☐

V. Category of farmer according to farm size

1.MF ☐ 2.SF ☐ 3.MMF ☐ 3.LF ☐ Specify:

MF- Marginal farmer owning less than one acre of land; SF- Small farmer owning 1 to 2.5 acres of land

MMF- Medium farmer owning 2.6 to 5.0 acres of land; LF- Large farmer owning more than 5 acres of land

II. Background of the Household Members:

1	2	3	4	5	6	7	8	9	10	11

Sl. No.	Name of the household Member	Relationship to the Household head 1=head 2=spouse 3=daughter 4=son 5= other	Sex (Code)	Age (Completed years)	Marital status (*Code*)	Years of education	Primary Occupation (code)	Duration of Occupation	Group Membership	Duration in the group(in years)
1										
2										
3										
4										
5										
6										

4: Sex
Female.....1
Male…..2

6: Marital status
Unmarried …….1
Married…… ….2
Widow/widower...……3
Separated/divorced….4

8: Occupation:
Cultivation (crop farming) 1
Agri. labour.....2
Non-agri. labour.....3
Petty business.....4
Business (other than petty business) 5
Private Job 6
Government job 7
Livestock rearing 8
Mixed farming ……9
Student ……10
Other (specify) .....….11

10. Group Membership
No Group……0
Self-Help Group ….. 1
Farmers' club…….2
SACCO……3
Merry go round ….4

Title deed: Legal property right of land. Note: H-Husband; W-Wife

c) Do you have title deed for land owned? (Ownership by title deed here means the legal right to sell and dispose the land without consultation)

1. Yes 0. No

d) If you sold this land, would you have to share any of the sale proceeds with your spouse?

1. Yes 0. No

III. Labour Costs

ii.

	Permanent House: A permanent house is one, which has walls and roof made of the following material (Wall material: Burnt bricks, stones (packed with lime or cement), cement concrete, etc. Roof Material: Tiles, GCI (Galvanised Corrugated Iron) sheets, asbestos cement sheet, RBC, (Reinforced Brick Concrete), RCC (Reinforced Cement Concrete) and timber etc. Semi permanent House: The walls and/or roof of which are made of material other than those mentioned above, such as un-burnt bricks, timber, bamboos, mud, grass, reeds, thatch, loosely packed stones, etc. Others: The houses, which are not covered by the types mentioned above, are to be treated as of 'others.

iii. Possession of Farm Land

How many parcels of land do you own? _____

Total farm Land possessed_____ acres

1	2	3	4	5	6	7		9
Sl. No.	Type of land	In Acres						
		Owned	Leased in' land	Leased out' land	Forest land/ others without Title deed	Total Operational Area		1= Rain fed Or 2= Irrigated
						H	W	HW
1	Area under annual crops							
2	Area under perennial crops			82				
3	Others, specify							

Do you hire labour? l=Yes 0 = No

b) If yes, how many people hired in the last 7 days?_____ (mandays)

c) At what cost per person ksh. _____

IV. What are your major production constraints? (At least five)

1	2	3	4
Sl. No.	Constraints	Rank the Constraints According to Priority	Suggest the MAIN possible solution
1	Non availability of quality seedlings		
2	Lack of irrigation facilities during summer months during establishment		
3	Access to credit		
4	Incidence of pests		
5	Disease Infestation		
6	Non availability of inputs(pesticides, fungicides, growth regulators etc.) at right time		
7	Lack of institutional support such as policy, Infrastructure –(Specify)		
8	Non availability of suitable harvesting tools to reduce losses by bruising		
9	Scarcity of labourers to carryout farm operations		
10	Wind during flowering seasons		
11	High cost of institutional credit to meet working expenses		
12	Practical applicability of the recommended packages of practices		

V. Method of selling banana at the farm level

1	2	3	4	5	6	7
Sl. No.	Market Functionary	Quantity (bunches) /Year	Price/bunch	Value (KSH.)	Nature of Packaging Material	Cost of the Packaging Material per year
1	Wholesaler /broker					
2	Retailer					
3	Commission Agent					
4	Processor					
5	Exporter					
6	Consumers					
7	Cooperative					
8	Others					

Activities you do to extend your fruits shelf life?

VI. Marketing Constraints (at least five)

1	2	3	4
Sl. No.	Constraints	Rank the Constraints According to Priority	Suggest MAIN for way improvement
1	Cartel among traders		
2	Un remunerative/ low price		
3	Lack of institutional support in establishing local and export market		
4	Complicated institutional procedures to facilitate export of fruits to overseas market		
5	Non availability of adequate numbers of processing units near the production catchments		

6	Lack of cold storage facilities to enhance the shelf life		
7	Meagre marketable surplus		
8	Lack of market intelligence and information		
9	Distance to the market		
10	Logistical support and services		
11	Market Access		

VII. Level of Awareness about the Knowledge on Good Agricultural and Management Practices

1	2	3
Sl. No.	Awareness	Responses
1	Integrated pest and disease management	
2	Precision farming (Need based application of inputs)	
3	Time lag between chemical spray and harvest of fruits	
4	Safe handling and application of chemicals	
5	Organic farming of Banana/Pawpaw/mangoes	
6	Harvesting fruits at physiological maturity	
7	Food safety norms (pesticide residue, mycotoxins etc.)	
8	Value addition technologies	
9	Potential market for raw and processed banana/mango products	
10	Eco-friendly waste management and recycling	

(1 = Very much aware; 2= Moderate awareness, 3= Not aware at all

VIII. Group Membership details and related costs

Are you a member of a banana production and marketing group? Yes No ☐ if n☐ip to (e)

If Yes, state the year of joining _____ and the registration fee (Ksh)_____

What is the main reason for joining

What services does the group offer?

Services	Code(yes=1, no-0)
Access to credit	
Marketing of commodity/ provision of Market information	
Product bulking	
Input acquisition	
Extension services	

Does the groups/organization include both men and women? 1. Yes 0. No

Give the main reason for not joining the group.

IX. Access to credit (both formal and informal)

Have you ever used credit for growing and marketing bananas/mangoes? 1=Yes 2=No (*if No, go to f)*	Major Source of credit (Codes)	Major form of credit (codes)	Amount	Interest (rate (%)

Major source of credit			Major form of credit
1 = Government fund/agency e.g. AFC 2 = Buyers 3 = Commercial bank 4=Shylocks	5 = Donor / NGO/MFI's 6 = Groups (farmer groups, ROSCAS) 7= Relatives/friends	8= input dealers 9=Other joint(specify codes)_____ 10 = Other Specify_____	1=Money 2=Material(s) and/or inputs 3=Other (specify)

If No (*question a*), why haven't you obtained credit? (Rank codes) [_] [_] [_] [_]

1=Not needing any loan 2= No collateral as required	3. Not a member of the (Microfinance institution (MFI)	4. High cost to obtain the loan/credit 5. Other (specify)_____

X: Market Access Details

What is the distance to the nearest main market centre from the farm? (Kms)_____

How do you transport the bananas/mangoes to the market? 1. Car 2. Motorbike. 3. Bicycle 4. Foot 5. Other(specify)

What is the type of road from the farm to that main market? [___] (codes)

Road type codes	
1=All seasons tarmac,	3=Seasonal murram road,
2=All seasons murram road	4=other (specify)

What is the distance to the Banana/mango collection centre from the farm? (Kms)_____.

How far is your farm from the nearest input shop in walking (hrs)? _____

What is the distance from your farm to the nearest health centre (Kms)?_____

What is the cost of transporting produce to the most important market centre (specify means of transport) (Ksh)?_____

XI: Access to Extension Services

Did you receive extension contact for bananas/mangoes for the last one year? 1=Yes 2=No	If yes, who was the provider? *(Codes) RANK.*	What types of services were provided? *(codes)*

Extension services provider		Types of services provided	
1 = Government	4= Input dealers	1=Product handling	5=Record keeping
2 = NGO/donor	5= Farmer group	2=Pest management	6=Field hygiene
3= Local traders	6=Co-operative society	3=Soil and water use	7= others (specify_____
	7 = Other specify	4=chemical handling	

XII: Income and Expenditure

d) Is banana/mango production your only source of income 1= yes 0= No

If no, fill the table below on other sources of income

Source of income	Amount p.a	Income mainly managed by H, W or HW
Bananas/mangoes		
Other horticultural crops		
Other farm crops		
Livestock and livestock products (e.g. milk)		
Other farm activities (e.g. bee keeping, brew making, charcoal burning etc)		
Wages/ salaries/ non-farm, pension and business activities		
Remittances/ gifts from absent family members and other external income		
Other sources, specify:		

e) Do you receive any regular source of income, either from working inside or outside of the household (exclude income received from spouse) 1. Yes 0. No

f) If yes, are you free to spend this on household expenditures? 1. Yes 0. No

estimate your annual expenditure for the following p.a;

Food Ksh_____	Medicare Ksh_____	Purchase of assets _____
Clothing Ksh_____	Entertainment Ksh_____	Savings _____
School fees Ksh_____	Donations Kshs_____	Other(specify).Kshs_____

XIII: FARMERS AWARENESS AND PERCEPTIONS OF EFF

a) Have you ever heard of an organic product being used to prolong shelf life of mature green fruits?

1. Yes 2. No

b) If yes, what is the name of product? _____

c) From whom did you hear it first? _____

*If from organization specify the type/ name of organization.

Code 1= Organization 2= Friends 3= Relatives

d) Are you aware of EFF introduced by the University of Nairobi? 1. Yes 2. No

* If respondent is not aware, enumerator should fully explain on EFF.

e) Did you attend the EFF dissemination workshop held by the University of Nairobi in your area in February 2018? 1. Yes 2. No

g) Please give your opinion on your perception of EFF to reduce post- harvest losses on a scale of 1 to 5 (whereby 1= strongly disagree, 5=strongly agree). (Tick one box)

Statement	1=Strongly disagree	2=Disagree	3=Unsure	4=Agree	5=Strongly agree
Economic Aspect					
Do you consider glut of fruits (excess supply than is demanded)in the market a challenge in production and marketing of bananas and EFF can contribute to its reduction.					
The most serious challenge to marketing bananas/mangoes is post- harvest losses and EFF can contribute to its reduction					
Do you think using EFF will lead to increased farm income from banana/mango production?					
Do you think the pricing of EFF will affect your decision to adopt the product?					
a) Basic Product Design					
Do you think EFF is a safe product to use on fruits and will not have any harmful effects on human health?					
Do you think EFF is a foreign material and should not be used on fruit farms?					
Do you think EFF is capable of causing harm to other beneficial micro-organisms on the fruit trees and environment?					

Do you think EFF will offer real solutions to reducing post-harvest losses in fruits by prolonging fruits' freshness?					
b) Delivery characteristics					
Do you think the distribution of EFF should be left to the private sector for effectiveness?					
Do you think University of Nairobi should be involved in the distribution of EFF?					
Do you think it is necessary to create more awareness on the fruit glut in the market and use of EFF to reduce the glut and enhance market access.					
c) Ease of Use					
Do you think you will face challenges in the application of EFF and you will require assistance from extension officers?					
Do you think more efforts are required to create more awareness of EFF in order to increase demand for the product among fruit farmers?					
Do you think counterfeiting of the product can be a serious problem leading to increased post- harvest losses?					
d) social- cultural and environmental compatibility					
Do you think use of EFF on fruits will go against any cultural belief?					
Do you think using EFF on bananas/mangoes will lead to any environmental pollution?					

XIV. ELICITATION OF WILLINGNESS TO PAY FOR HEXANAL/ EFF

Questions below to be answered by treatment farmers only (farmers who have heard of it before the study/ attended the dissemination workshops)

(The farmers should first be reminded of the dissemination workshops on the use of Hexanal.

a) Would you be willing to use Hexanal on your bananas/mangoes? 1. Yes 2. No

If NO, why? _____

b) If YES in (Q a), If the product was to be introduced in the market and you were to purchase it, would you be willing to pay for it? 1. Yes 2. No

* Enumerator should explain that 0.25litres of EFF diluted with 12.5litres of water and is enough to spray 125 banana bunches/ 31(local) to 62(dwarf) mango trees or to dip as many fruits until the solution is completely used.

c) If yes, would you be willing to pay Ks400 for Ksh0.25 per litre of Hexanal to increase shelf life of major fruits? 1. Yes 2. No

If for the bid in QC is YES, increase the price by Ksh50 until you reach the highest bid he/she is willing to pay. Record the highest bid _____

If for the bid in QC is NO, decrease the price by Ksh50 until you reach the lowest bid he/she is willing to pay. Record the lowest bid _____

Questions below to be answered by control farmers (who are not aware of Hexanal before the study)

A hypothetical scenario for eliciting WTP for the EFF to reduce post- harvest losses

d) Banana/mango production supports many farmers economically in Kenya. However lack of availability of proper post- harvest handling techniques contributes to great losses of up to 40% each year from lack of access to better markets. There is an organic pre-harvest dip and spray known as Hexanal formulation (EFF) that is capable of prolonging fruit shelf life by 21days on the trees and 17 days in storage (at room temperature) to 26 days in cold storage. Field trials carried out in Asia and Kenya show it is very effective in prolonging shelf life in mangoes and bananas while causing no harmful effects on humans. The product is currently not available in the market but considering the costs of importation it would cost Ksh400 per 0.25Litres.

* Enumerator should explain that 0.25litres of EFF diluted with 12.5litres of water is enough to spray 125 banana bunches/ 31(local) to 62(dwarf) mango trees or to dip as many fruits till the solution is completely used.

e) If the product was to be introduced in the market and you were to purchase it in cash or through credit, would you be willing to pay Ksh400 per 0.25litre of EFF to prolong the shelf life of your fruits?

1. Yes 2. No

f) If for the bid in QE is YES, increase the price by Ksh50 until you reach the highest bid he/she is willing to pay. Record the highest bid _____

g) If for the bid in QE is NO, decrease the price by Ksh50 until you reach the lowest bid he/she is willing to pay. Record the lowest bid _____

END

(Please remember to thank the farmer genuinely)

Interviewer's Remark

Annex 2: Variance Inflation Factors and tests for heteroscedasticity

2.1 VIF and test for heteroscedasticity for farmers' WTP for Hexanal

Variable	**VIF**	**1/VIF**
Gender	4.7	0.212977
Marital status	4.16	0.240317
Age	2.21	0.453253
Main occupation	2.12	0.471523
Land size	1.6	0.624686
Education	1.45	0.689508
Income	1.44	0.695135
Perception on effectiveness of Hexanal	1.41	0.710787
Perception on social acceptance of Hexanal	1.21	0.826211
Perception on environmental safety	1.3	0.712065
Distancemkt	1.21	0.826772
Group membership	1.39	0.717847
initialBidamount	1.16	0.864962
Mean VIF	**2**	

Breusch-Pagan /Cook Weisbergtest for heteroskedasticity
$\chi^2(1)=5.82$
prob> $\chi^2=0.0158$

2.2 VIF and test for heteroscedasticity for determinants of perception on Effectiveness

Variable	**VIF**	**1/VIF**
Gender	3.96	0.252714
Maritalstatus	3.91	0.255692
LogAge	3.57	0.279881
Farmer experience	3.22	0.310695
LogLandsize	1.54	0.647947
LogHousehouldsize	1.54	0.651215
Ownership of title deed	1.43	0.700077
Education	1.37	0.729090
Distance to banana collection center	1.18	0.849298
Mean VIF	**2.41**	

Breusch-Pagan /Cook Weisbergtest for heteroskedasticity
$\chi^2(1)=74.57$
prob> $\chi^2=0.0000$

2.3 VIF and test for heteroscedasticity for determinants of perception on Acceptability

Variable	**VIF**	**1/VIF**
Landisze	1.66	0.603799
LogAge	1.62	0.616983
Access to credit	1.51	0.660890
Ownership of title deed	1.50	0.666157
Distance to banana collection centre	1.24	0.803371
Membership to Group	1.20	0.833942
Distance to input shop	1.20	0.835393
Total income	1.15	0.869380
Market transport costs	1.13	0.884824
Mean VIF	**1.36**	

Breusch-Pagan /Cook Weisbergtest for heteroskedasticity
$\chi^2(1)= 8.09$
prob> $\chi^2=0.0044$

2.4 VIF and test for heteroscedasticity for determinants of perception on Environmental Safety

Variable	**VIF**	**1/VIF**
Gender	1.36	0.734919
Access to extension services	1.27	0.787427
LogTotal income	1.27	0.790176
Membership to group	1.25	0.800415
Ownership of title deed	1.14	0.874406
Distance to input shop	1.10	0.911422
Education of household head	1.07	0.932942
Mean VIF	**1.21**	

Breusch-Pagan /Cook Weisbergtest for heteroskedasticity

$\chi^2(1)= 0.92$

prob> χ^2=0.3380