PERCEPTIONS OF ENHANCED FRESHNESS FORMULATION TECHNOLOGIES AND ADOPTION DECISIONS AMONG SMALLHOLDER BANANA FARMERS IN MOROGORO, TANZANIA

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A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN AGRICULTURAL AND APPLIED ECONOMICS OF SOKOINE UNIVERSITY OF AGRICULTURE. MOROGORO, TANZANIA.

2017

ABSTRACT

This study identifies the perceptions and adoption decisions of Enhanced Freshness Formulation (EFF) technologies among potentially banana growers in Morogoro, Tanzania. The study establishes whether men and women are likely to have equal preferences in adoption of new technologies and explores whether women who are able and those who are unable to adopt technologies face similar adoption challenges. The present study revealed that, potential adopters of EFF technologies seem to attach more weight to uniform ripening, colour intensity (attractiveness), and freshness followed by easiness of formulation and application, then minimum adverse health and environmental effects. This study also found that the adoption prospect was lower among female than male adopters, although its overall impact on the adoption rate was low. Moreover, the findings indicated limited adoption prospect of the technologies among female growers perceiving EFF as labour insensitive technologies. The study established higher adoption prospect among growers whose banana are at early stages of maturity. Continued efforts to address a priori the challenges that can potentially undermine the adoption, easing the use of technologies, and targeting growers whose fruits are at early stages of maturity, as ideal means to enhance the adoption during the introduction phase. The present study recommends the EFF package to mainly focus on preferred fruit attributes, especially easy formulation and application and minimum health and environmental effects. Future studies should focus on impacts of specific formulation of the EFF on the adoption prospect.

DECLARATION

I, MOSES PETER SUBERT, do hereby declare to the Senate of Sokoine University of Agriculture that, this dissertation is my own work done within the period of registration and that it has neither been submitted nor being concurrently submitted in any other institution.

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(Supervisor)

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ACKNOWLEDGEMENTS

It is my pleasure to express my sincere thanks to the Almighty God for his love and care that enabled me to overcome all the challenges during the study period. My extended appreciation should go to Professor Kilima for his patience, helpful guidance and support throughout my study. I am also deeply indebted to IDRC and project team members in Tanzania, Professors Maulid W. Mwatawala, Theodosy Msogoya, and Dr. Hosea Mtui for all their valuable contribution and advice. I would like to extend my sincere thanks to CMAAE and IDRC for funding my coursework and research, respectively. Special thanks are also extended to my friends who supported me in different ways to successfully complete my study at SUA.

Finally, my most sincere gratitude goes to my family; in a special way, to my beloved late mother Gladys, who departed during the course of my study. May her soul rest in eternal peace, Amen. Sincere thanks are also due to my uncle families, my brothers Johannes, Emmanuel and Haroun, and my sister Martha, and my girlfriend Neema, who were my greatest strength and support. They believed in me, shared my dream, prayed for me and fortified me with the necessary spiritual support to successfully complete my study. It has not been possible to get enough space to thank everyone I am indebted to. I extend my sincere thanks and acknowledgements to you all. “Aksanteni sana”.

DEDICATION

This research work is highly dedicated to the Almighty God who gives me strength, patience, and grace to do and manage the ambitions; to my late mother Gladys, who brought me up and gave me the value of education and success.

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LIST OF ABBREVIATIONS

EFF	Enhanced Freshness Formulation
FAO	Food and Agriculture Organization
MT	Metric Tonne
UNCST	Uganda National Council for Science and Technology

CHAPTER ONE

1.0 BACKGROUND INFORMATION

1.1 Introduction

Tanzania has huge potential to produce banana owing to her favourable climate. The country is the fourth major producer of banana in Africa producing about 3.7 million MT annually (Kilimo Trust, 2012). Its year-round harvest makes it one of the most important and reliable source of food and income. Thus, banana is crucial for food security and poverty alleviation among smallholder farmers (UNCST, 2007; Odame, 2010).

Despite its economic importance, smallholder growers in Tanzania and many other African countries have not fully exploited the market potential for banana fruits owing to their inability to control factors that determine storage-life and final fruit quality (Tadesse 1991; Olorunda, 2000; Hailu, *et al*., 2014). Some of the farmers tend to harvest immature fruits that are subject to shrivelling and mechanical damage leading to inferior flavour when ripe. These farmers have limited access to technologies that allow fruits to reach their best eating-quality by allowing the ripening process to end while the fruits are on the plant. The use of improved technologies has been pioneered by governments in order to increase agricultural productivity, reduce losses, and promote quality of food as well as livelihood security (FAO, 2011). Until recently, the choice and use of technologies among farmers is largely determined by the need to increase production, profits and productivity.
Nevertheless, differences between males and females in the adoption of new technologies have long been recognized in farming communities. While the existing literature reveals varied and context specific reasons for such differences there is evidence that female tend to adopt new agricultural technologies at a lower rate than male farmers (Doss, 2001; Tiruneh *et al*., 2001; Bourdillon *et al*., 2002; Phiri *et al*., 2004; Kakooza *et al*., 2005; Jagger and Pender, 2006; Thapa, 2009; World Bank and IFPRI, 2010; Peterman *et al*.,

2010; FAO, 2011). Consequently, there has been a growing interest to identify means to enhance the adoption of agricultural technology innovations among both male and female smallholder farmers in many places including Africa. This renewed interest has motivated the development of specific guidelines and user-tailored toolkits for streamlining gender in agricultural development initiatives. These guidelines and toolkits are important references to guide current and future agricultural interventions but are based on specific case studies, experiences and lessons that may not apply to all types of technologies and circumstances of potential adopters. To effectively overcome gender based barriers to technology adoption, there is a need for context specific studies that examine how the adoption decisions are made and identify factors underlying this process.

1.2 Problem Statement and Justification

Limited access to shelf-life extension, poor postharvest losses control techniques and associated risks have compelled farmers to use traditional methods (Kilimo Trust, 2012). The most significant problem facing banana producers is staggered ripening, hence farmers fail to synchronize ripening and sales decisions. Occasionally farmers succumb to the pressure of disposing fruits over a short period of time at giveaway prices upon ripening when buyers are few, hence incurring economic losses. These farmers would be better-off if they adopt the "Enhanced Freshness Formulation (EFF)" technologies that can enhance fruit maturity, prolong the shelf-life to reduce losses, promote entry to high-quality (niche) markets and enhance gains for the actors in the fruits industry (Paliyath *et al*., 2008; De Kock *et al*., 2012; Hailu, *et al*., 2014).

While farmers stand to gain from such technologies, there are uncertainties with regard to perception and gender issues especially limited abilities of women to influence decisions to adopt technologies including EFF (De Kock *et al*., 2012; IFAD 2008). In developing countries, technology adoption is undermined by gender-related constraints and unequal access to productive resources and opportunities (World Bank, FAO and IFAD 2008; FAO 2011). Also, it is noted that women tend to adopt improved technologies at a lower rate compared to men (Doss and Morris, 2001). For fruit growers, these challenges are translated to overall lower households' welfare in terms of earnings, nutrition and food security.

However, perceptions and gender are among the key determinant for adoption, but little is known about the overall perceptions of the agricultural technologies and gender differences in the adoption prospect of the banana industry. Understanding farmer's perception and gender differences in the adoption process is important for promoters of EFF to foresee real adoption challenges and identify a priori effective means for overcoming the challenges. This study identifies factors that can potentially affect women's decisions to adopt EFF technologies in Tanzania.

Results from this study could help researchers, the government and policy makers to re-structure and modify the packages of and promotion strategies for such technologies to meet desires of small holder farmers.

1.3 Study Objectives and Hypotheses

1.3.1 Overall objective

To assess the perceptions in adoption of Enhanced Freshness Formulation (EFF) technologies among smallholder banana farmers.

1.3.2 Specific Objectives

i. To determine the variation in farmers' perception in adoption of EFF technologies as post-harvest losses control options,

ii. To assess whether men and women are equally likely to adopt EFF technologies, and

iii. To explore whether women who are able and those who are unable to influence adoption decisions face similar socio-economic and demographic adoption challenges.

1.3.3 Research question for objective 1, and Hypotheses for objective 2 and 3

i. What are farmers' perceptions towards Enhanced Freshness Formulation technologies adoption?

ii. There is no difference between men's and women's prospect to adopt EFF technologies,

iii. There is no difference in socio-economic and demographic adoption challenges between women who are able and those who are unable to influence adoption decisions.

1.4 Organization of the Dissertation

This dissertation comprises five chapters. Chapter one presents the study background, problem statement and justification of the study, the overall and specific objectives, and study hypotheses. The second chapter covers the literature review relevant to the study topic which include, empirical studies, conceptualization of the study and gender related issues towards adoption of new technologies. The following chapter covers the methodology, while the forth chapter presents the study findings and discussion. Chapter five presents the conclusion and recommendations.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Gender and Decision to Adopt Agricultural Technology

The actual adoption and use of any new agricultural technology is primarily determined by farmers' decisions to adopt it. This decision is normally made along gender lines and should be examined to establish whether men and women stand equal chances to adopt such technologies and under what circumstances.

Literature shows that there are differences in men's and women's decision to adopt and use agricultural technologies. One of the fundamental difference is with respect to their risk attitude where women are considered to be more risk averse than men and thus less likely to adopt new technologies when introduced for the first time (FAO, 2014). Also there are notable differences in access to knowledge, critical support services and agricultural assets as men tend to have a competitive edge over women (Ndiritu *et al*., 2014). Moreover, factors such as unequal division of labour can make women more liable to performing household's chores and agricultural activities and reduce their time to learn about new technologies (Meinzen-Dick *et al.*, 2010; Satyavathi *et al*, 2010; Ogunlela *et al.*, 2009). This heavy workload and unequal access to resources can potentially limit women's adoption of both labour and capital intensive agricultural technologies (Satyavathi *et al.*, 2010; Baba *et al.*, 2015; Doss, 2001). The differential impacts of these factors on men's and women's decisions to adopt and use agricultural technologies have been widely studied and are well documented in the existing literature. A significant literature on the subject is based on the assumption that members of households' pool resources and make joint decisions (Ndiritu *et al.*, 2014).

However, some scholars recognize that men and women are expected to make different decisions owing to power imbalances and inequalities that exist within households and between men and women (FAO, 2014; World Bank and IFPRI 2010). Some analysts argue that the view that households pool resources and make joint decision could tempt researchers to target heads of households as interviewees during surveys (*Ibid*). Consequently, the information collected is likely to be biased because women's opinions may not be adequately captured. To overcome this bias, new ways are needed to account for men's and women's decision making at the household level. The bias could be reduced through solicitation of detailed information so as account for power dynamics and pin-point factors that can make some family members more likely to adopt new technologies than others.

In view of this focus, household's headship and decision making should be treated as separate aspects during the data collection and analysis because the head of a household may not necessarily be the main decision maker. This separation allows for examination of the decision making processes in both female- and male-headed households. This study adopted the proposed perspective to examine whether men and women are equally likely to adopt EFF technologies and identify specific factors underlying the adoption prospect among women adopters. Studies that have sorely assessed differences in the adoption of agricultural technologies among female adopters have generally been rare (Ndiritu *et al.*, 2014; FAO, 2014; World Bank and IFPRI 2010).

2.2 Division of Labour in Agriculture

Generally, many African countries face unequal division of labour in agriculture. The division of labour is based on patriarchal norms that tend to increase women workload on farm and family responsibilities (Mehra and Rojas 2008). The division may be in type of the farming activities performed on the farm or crop type grown by men and women (Ezumah *et al*., 1995).

The distinction between crops is sometimes not very clear; some analysts classify high yielding varieties to be men's crop and low yielding (local) varieties to be women's crop (Doss 1999). Nevertheless, division of labour by tasks is considered, usually men clear the farms and climb trees for collecting fruits while women are responsible for weeding, post-harvest management and marketing (Whitehead, *et al*., 2002). However, gradually the distinction between men's and women's tasks is becoming quite unclear; some tasks that are done exclusively by men are likely being performed by women. The ownership and management of banana can vary across locations and cultural settings. This variation has important ramifications for the adoption of EFF technologies. There is a need to understand perceptions of potential adopters of EFF technologies. It is also important to understand how physical practices such as formulation and application of hexanal compounds can affect the adoption of EFF technologies in the project sites.

2.3 Enhanced Freshness Formulation Technology

Enhanced Freshness Formulation (EFF) is an application of Nano-technology through spraying or dipping fruits with a natural compound called hexanal. Hexanal tends to slow down ripening and retain fruits' freshness and nutrients for a longer time. The current EFF formulation and composition combine numerous active ingredients that can potentially reduce fruits' deterioration via multiple mechanisms (Paliyath *et al.,* 2008). Composition can be applied at a stage of fruit maturation through pre-harvest spray and post-harvest dip practices (Cheema *et al*., 2014).

The application of these technologies is considered vital in enhancing fruit quality and prolonging shelf life. These twin benefits can allow farmers to sell fruits in niche and high value markets and reduce postharvest losses that are estimated to be as high as 30% (Paliyath *et al*., 2008; Hailu, *et al*., 2014). These changes may also mean that farmers make more money from prolonged sale of fruits. Trials in Sri Lanka and India have shown that EFF technologies can reduce postharvest losses by extending the shelf life up to 21 days for mangoes and banana (Paliyath *et al*., 2008). There is global evidence in favour of the efficacy of the EFF technologies in addressing the problems for the case of apple, banana, mango and strawberries (Paliyath *et al.*, 2008; De Kock *et al*., 2012).

The EFF technologies are currently being introduced in Tanzania for direct evaluation at a farm. There is good prospect that some of these technologies will be recommended for up-scaling to growers of fruits such as banana, mango and oranges. However, the EFF technologies cannot result into pro-poor, sustainable and inclusive growth in Tanzania if preference and the rate of adoption is lower for some groups of fruit growers than others. An understanding of these differences in the adoption of EFF technologies is crucial for the discovery of complementary measures that can be adopted to improve upon the design of the packages and implementation strategies to ensure the realization of desired development outcomes and impacts.

2.4 Adoption of EFF Technologies

Like any other technology, the adoption of the EFF technologies is bound to follow the five stages of technology adoption theory where potential adopters become aware of the technologies, establish whether such technologies are relevant to their unique circumstances, then decide whether to adopt or reject before they actually acquire relevant knowledge and skills for effective use (Yoh *et al*., 2003). The theory reveals awareness creation as the first stage of the technology adoption. However, men and women in the same household are likely to be linked to different social networks because factors that shape their network linkages are not the same (Gotschi *et al.,* 2008; FAO, 2014; Kassie *et al*., 2013; Di Falco and Bulte, 2011; Pandolfelli *et al.*, 2008; Doss *et al*., 2003). Consequently, their perceptions of cost and benefits associated with the adoption and use of new agricultural technologies are different.

Also men's and women's desire to adopt agricultural technologies is likely to be influenced by several factors including: 1) differences in access to and control over resources such as land, other assets and financial resources (Bryant and Pini, 2006; Doss and Morris 2001) and; 2) socio-economic characteristics and other households' specific dynamics such as power relations and social and family obligations (Haque *et al*., 2010; FAO, 2014). The roles and responsibilities that women and men assume in agricultural systems and power relations at household level have important ramifications for their decision to adopt agricultural technologies. In households where men are more powerful than women, the ability of female-members to influence decisions is normally restricted. Moreover, if women are liable to perform both family and agricultural activities; they are less likely to have time to learn about the technologies. Consequently, they will be less informed about the technologies and disadvantaged to adopt the technologies (Doss, 2001).

Additionally, preferences for crops have also been reported to have differential impact on men's and women decision to adopt agricultural technologies. In many agrarian communities in Africa, women tend to disassociate with decisions that lead to adoption of technologies that will only affect the production of cash crops. In these communities, cash crops are perceived to be men's crops. Women are instead interested with crops that ensure steady supply of food for family members and the shelf life of these crops (Badstue 2006; Bellon *et al*., 2003).

Overall, literature on technology adoption reveals a wide range of factors that can potentially affect men’s and women’s decisions differently. The EFF technologies are relatively complex technologies and new to potential adopters in Tanzania. In view of the fundamental differences in men’s and women’s decision making, it is reasonable to expect that there will be remarkable differences in their preferences and decisions to adopt the technologies. It is important to empirically assess how the factors hypothesized to influence the adoption of agricultural technologies relate directly to men’s and women’s decisions to adopt the EFF technologies in areas where the technologies are being demonstrated to fruit growers in Tanzania. Moreover, it is also important to assess differences in technology adoption among women themselves.

2.5 Review of Analytical Techniques

Various methods have been used to determine the perception and adoption. Likert scale and econometric modelling entailing the use of principal components, principal factor analysis and structural equation models using confirmatory factor analysis have been used to analyze farmers’ perceptions toward new agricultural innovations. However, principal factor analysis has been more frequently used, and for this study is chosen owing to its ability to model complex systems in linear relationships (Batista-Foguet and Coenders, 2000; Nabifo, 2003; Ajayi, 2007; Hiroyuki, 2007). For this study,

Choices of agricultural technologies are normally modelled using the random utility model (RUM) because there is no direct measure of the amount of utility a person gain from making a particular choice. Decision to adopt a given set of agricultural technologies have been frequently estimated using Tobit or Logit models (Nkuba *et al*., 2011; Senkondo *et* *al*., 2011; Kilima *et al*., 2010). However, unlike Tobit, the Logit has been more preferred, and for present study is also chosen due to its flexibility and robustness as it normally gives better results when there is a mix of categorical and continuous variables (Kirui and Njiraini, 2013). Also this model can handle both traditional indicators and technology-specific attributes that are preferred by potential users.

2.6 Conceptual Framework

2.6.1 Objective 1

According to Baraghani (2007), potential users of a new technology receive and evaluate information based on their perception variables that are bound to vary across adopters based on their unique farm, farmer and market characteristics (Figure 1). Following Baraghani (2007), the present study assumes that farmers who are potential users/adopters of EFF technologies will screen technologies according to key perception variables that are broadly classified into relative advantage, complexity, profitability and risk concerns. In the context of this study fruit growers may consider the potential of EFF technologies to bring about uniform ripening, enhance colour intensity along with fruit longevity, endurance and freshness as key parameters under relative advantages as these parameters may potentially increase fruit value in the market place. Under complexity, farmers may consider attributes such as ease of formulation, application, availability and affordability as key parameters. It is expected that EFF technologies that are perceived difficult to formulate, apply, access and afford will not be widely adopted by smallholder farmers. Smallholder farmers may perceive technologies to be more profitable if are associated with increased sales, market share and consumer's appeal while their risk concerns may be rooted in potential adverse health and environmental effects (Bisanda *et al*., 1996). A mechanism through which these perception variables interact and affect the adoption of new technologies is depicted in Figure 1.

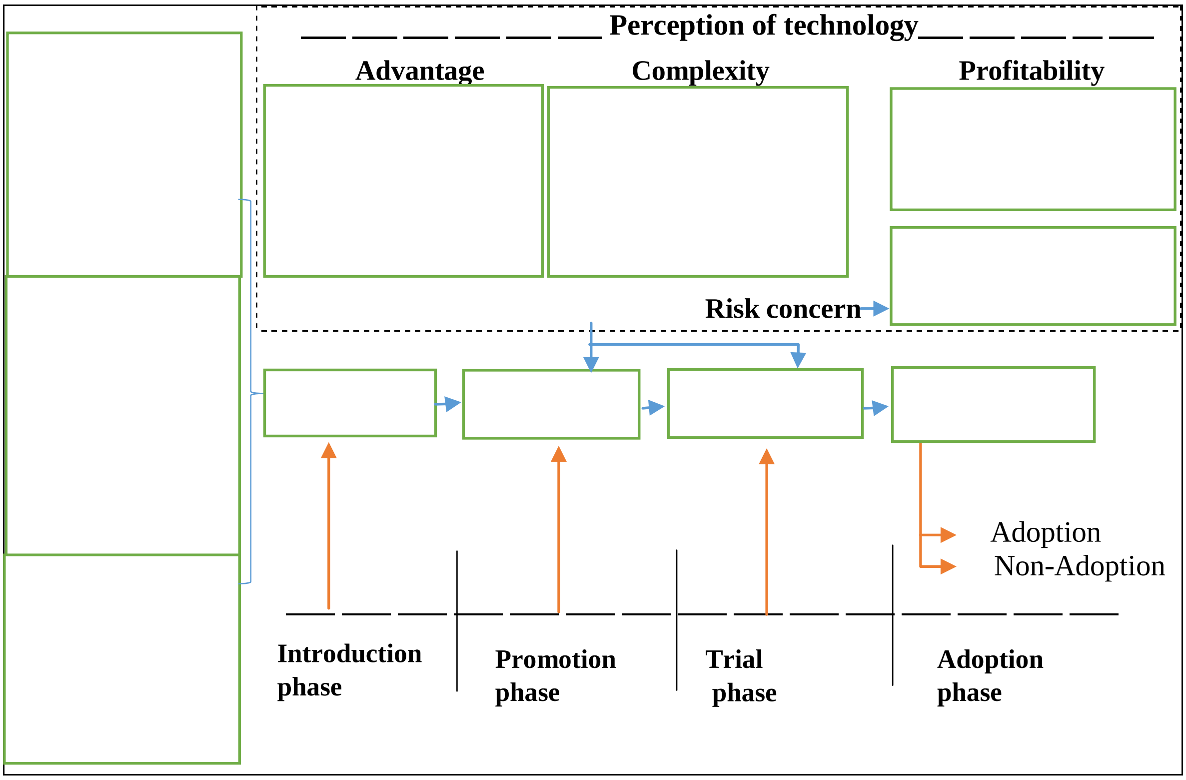


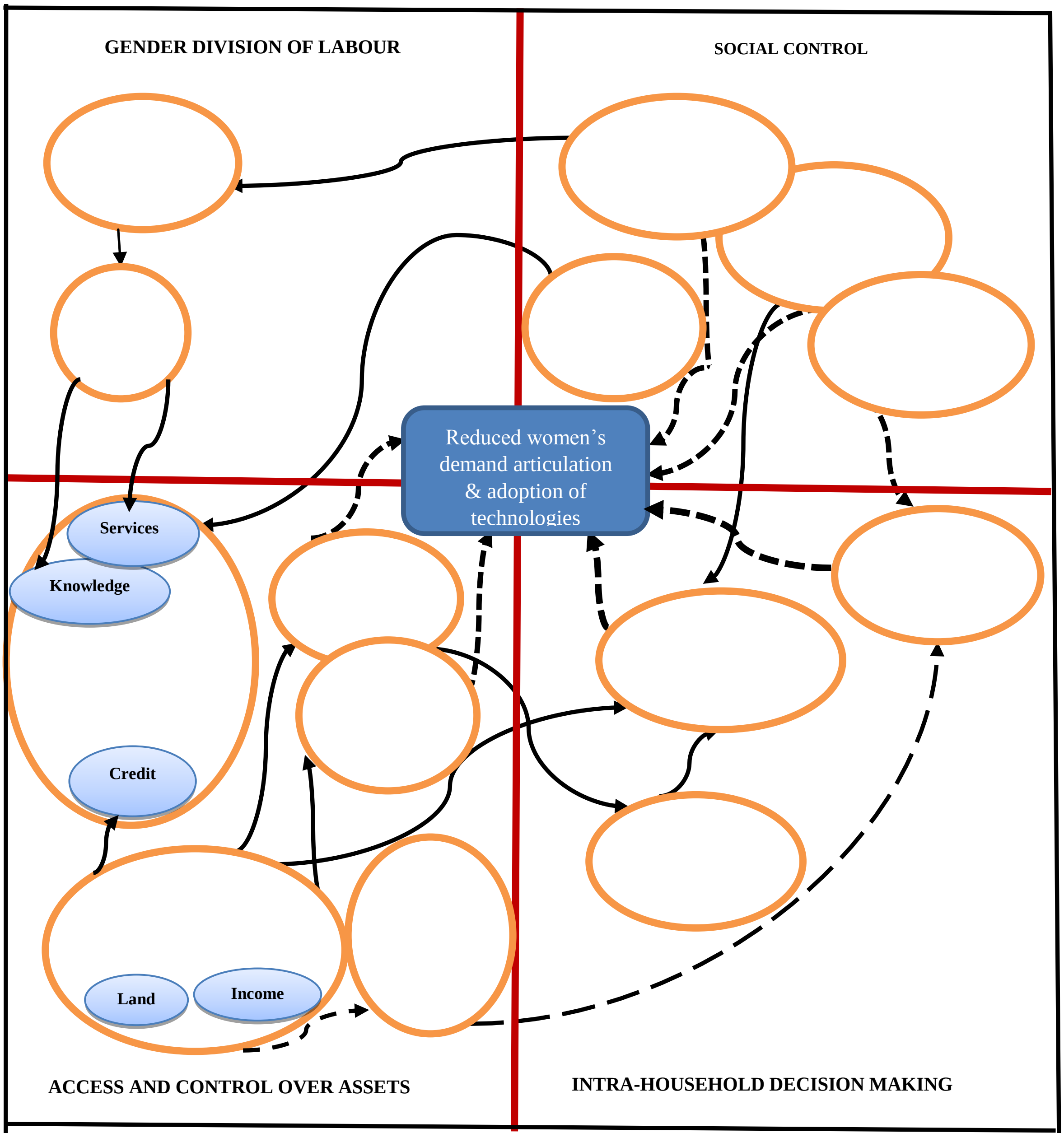
Figure 1: Conceptual framework for farmers' adoption of EFF technologies adoption

Source: Adapted (with modified) from Baraghani (2007)

2.6.2 Objectives 2 and 3

The decision to adopt agricultural technologies is an inherently complex process that is primarily under the influence of social and cultural factors that define norms. The socially "defined" and "accepted" norms are likely to affect men and women differently (Figure 2). In a setting where the norms expose women to more social obligations such as farm and family roles, the net effect will be raising women's burden and reducing their time for accessing critical information on agricultural production and business development. This setting may indirectly undermine women access to agricultural support services as there could also be preferential targeting in favour of household heads, who in many African societies tend to be men. Moreover, the norms could also be against women's independence and voicing concerns. The combined effect of these cultural hindrances is to undermine women's demand for- and the adoption of agricultural technologies. If the norms also allow men to have better access to and greater control over resources than women, women will have limited ownership of resources and less control over the resources and income. The ultimate effect is to reduce women's prospect to adopt the technologies.

The severity of effects of norms that are against women's independence and voicing concerns is also likely to vary among women as they have different levels of exposure to resources and knowledge and skills on agricultural technologies. While acknowledging potential differences in technology adoption between men and women it is important to assess such differences among female adopters.



HHs means households

Key to cause and effect relationships:

Dashed arrows represent reducing (-ve) effect

Solid arrows represent increasing (+ve) effect

Figure 2: Gender Perspective on Effects of Norms and other Cultural Factors on Adoption of Technology

CHAPTER THREE

3.0 METHOD

3.1 Descriptive Statistics

Descriptive statists involving the use of frequencies and mean were used to describe the sample according to variables used in logistic regression. The intent was to disaggregate the proportions of potential adopters according to such variables. Data for this and other analyses were collected in 2015 from a random sample of 96 banana growers. The respondents were proportionately drawn based on the sampled population from two project locations in Morogoro districts (Mvomero and Morogoro rural), Tanzania. The survey entailed the use of structured questionnaire that solicited information on various parameters of banana farming including farmers' socio-economic and demographic characteristics along with their levels of involvement in planning and performing different activities as well as access to and control of assets and other resources at household level.

3.2 Objective One

To address the first objective, perception of potential adopters with respect to 14 fruit attribute variables were clustered under four perception variables, measured using a five point Likert scale (Appendix 1) and analysed using principal factor analysis. The rationale was to summarize data into factors that explain the perception of farmers and determine their correlations with the attributes. The factor analysis was preferred in this analysis as it overcomes the maintained hypothesis that the communality is always equal to 1, which is generally perceived to invalid under some circumstances **(**PAD 705 Handout**).**

3.3 Objective Two

To address the second objective, a *z*-test that is similar to the single-group *t*-test was adopted to test for the difference between two proportions whether there was no difference in preferences between men's and women's prospect to adopt/use EFF technologies in the project area. The null hypothesis assumed equal preferences between proportions of male and female adopters. The test statistic was computed as:

$$\boldsymbol{z} = \frac{\boldsymbol{p} - \boldsymbol{\pi}}{\sqrt{\frac{\boldsymbol{\pi}(1-\boldsymbol{\pi})}{\boldsymbol{n}}}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots .. (1)$$

Where, $\boldsymbol{p}$ is the proportion of women that preferred the use of technologies and were able to influence the adoption decisions, $\boldsymbol{\pi}$ is the null hypothesis value signifying the expected proportion if there is no difference in preferences between the proportions of men and women with such attributes, and $\boldsymbol{n}$ is the sample size.

3.4 Objective Three

The third objective of the study was tested using the conventional random utility model for binary choices. The choice model was fitted as logit to associate the categories of female adopters (y) with specific independent variables (Table 1). The null hypothesis assumed no difference in socio-economic and demographic variables between female adopters. The analytical model was specified as:

$$\text{Prob}\,(\boldsymbol{y} = 1 | \boldsymbol{x}) = \Lambda(\boldsymbol{x\beta}) = \frac{\exp(\boldsymbol{x\beta})}{1 + \exp(\boldsymbol{x\beta})} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots .. (2)$$

Where Λ stands for the cumulative standard logistic distribution function while $\boldsymbol{x}$ and $\boldsymbol{\beta}$ are vectors of independent variables and parameters to be estimated, respectively.

In the empirical model, the dependent variable is an indicator of whether a woman in a particular household was able to influence the adoption decision of EFF technologies. This was captured by indicating who within the household decides on the use of EFF technologies. Independent variables included in the empirical model were those identified in contemporary literature to influence farmer's decision to adopt agricultural technologies (Akudugu *et al*., 2012, Gabre-Madhin and Haggblade, 200; Kariyasa and Dewi, 2011; Mohamed and Temu, 2008; Ouma *et al*., 2002; Reardon *et al*., 2007). These variables included both socio-economic characteristics of farmers along with those measuring farmers' subjective perception of the EFF technology (Table 1).

Table 1: Factors influencing farmers' decision making

Variable	Description	Expected effect
Yi=Adoption decision	Coded as 1 if the main decision maker was a woman and able to influence adoption decision of EFF technologies, 0 if she was unable to influence adoption decision;	
X_1 =Age	Coded as 1 if the age of the main decision maker was above 35 years, 0 otherwise;	+/-
X_2 =Income share	Coded as 1 if household's share of income from agriculture was greater than 60%, 0 otherwise;	+
X_3 =Fruit status	Coded as 1 if fruits were about to be harvested, 0 otherwise;	-
X_4 =Savings	Coded as 1 if the decision maker saved money, 0 otherwise;	+
X_5 =Labour intensity	Coded as 1 if the technology was perceived to be labour intensive, zero otherwise;	-
X_6 =Experience	Coded as 1 if the main decision maker was experienced in fruit production; 0 otherwise;	+
X_7 =School aged kids	Codes as 1 if the main decision maker had school aged kids; 0 otherwise and;	+
X_8 =Plot owned	Size of plot owned in acreage.	+

Farmers' perception of labour intensity of the EFF technologies was perceived to be an important measure of differences in preferences for labour intensive technologies among female adopters. According to the background information and conceptual framework of this study, women tend to disassociate with decisions leading to adoption of labour intensive technologies as their workload is normally heavy (Berti *et al*., 2004). Farmer's age was included as measure of potential differences in risk attitude and experience between female farmers who were in different age groups. Literature reveals that when risk aversion predominates, older farmers might be less willing to adopt new technologies than younger farmers (Alexander and Van Mellor, 2005). However, long term experience among old farmers implies that they are likely to have accumulated knowledge and practical skills over time to facilitate quicker adoption than young farmers (Kariyasa and Dewi, 2011).

The status of the farmed fruit was included as a predictor of stage of plant growth where farmers are more likely to contemplate adopting the EFF technologies. It was expected that fruit growers would be more willing to adopt the technologies for the first time when time to maturity allowed them to both improve fruit quality (value) and prolong the harvesting period so as to hedge against price risk. In practical terms, farmers with significant proportion of banana at this stage can potentially serve as a pool of first adopters. Saving behaviour was included as measure of farmer's ability to finance the adoption of the technologies and was expected to have positive effect on the adoption decision. Farmer's share of agricultural income was considered appropriate measure of lucrativeness of farming business and was expected to have positive effect on the decision to adopt EFF. Having school age kids was included as a measure of parents' devotion to keep their children in school (Kingdon, 2005). It was expected that, decision maker who care more about the education of their kids will engage in decision making and adopt technologies that improve earnings as they desire to meet the cost of education. Plot ownership was included as a measure of farmers' resource base for agricultural production and was considered to be positively associated with the decision to adopt agricultural technologies.

It is worth noting that selection bias could be encountered during the estimation of the logit model if female adopters that were willing to adopt and able to influence the adoption decisions had characteristics that were remarkably different from those who were willing to adopt but unable to influence the decisions. To fully account for this potential problem, the authors adopted Heckman's two-stage estimator which is the most widely used approach to control for selection bias (Heckman, 1976; Kabunga, 2012).

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Descriptive Analysis Results

Descriptive analysis suggests that many of the female banana growers who were willing and able to influence the decision to adopt EFF technologies along with those who were willing but unable to influence the decisions were above 35 years. Moreover, a majority were those who were able to save money and did not perceive EFF as labour intensive technologies. Also a relatively big number of these decision makers were those whose banana were about to be harvested, with share of income from agriculture above 60% although they were less experienced on banana production (Table 2).

Table 2: Descriptive statistics

Variables in percentage (%)		Proportion of Women	
		Willing and able to influence adoption decision	**Willing but not able to influence adoption decision**
Adopter category		58	42
Age category	< 35 years	4.2	6.3
	≥ 35 years	52.7	36.8
Income share	< 60%	11.6	10.5
	≥ 60%	45.3	32.6
Fruit status	Not about to be harvested	15.8	5.3
	Harvested	41.0	37.9
Saving	NO	24.2	21.1
	YES	32.6	22.1
Labour intensity	NO	50.5	33.7
	YES	6.3	9.5
Fruit production	NO	33.7	29.5
Experience	YES	23.1	13.7
School aged kids	Mean	2.3	2
Plot owned (acreage)	Mean	1.03	0.8

Source: Field survey data, 2015

Overall, the proportions presented in Table 2 suggest that women who were willing and able to influence decisions to adopt the EFF technologies might share similar characterises such as education and income levels. This assumption was tested using parameters generated from the logit model using the Heckman's two-stage estimator to control for self-selection bias and is reported in section 4.4 (Table 5).

4.2 Farmers' Perception of EFF Technologies

Prior to estimations, tests for sampling adequacy and internal consistency of the perception variables were performed. These tests result (appendices 2 and 3) validated the use of principal factor analysis due to high level of correlations (0.7482) and internal consistency (0.8122). In subsequent analysis, only factors with eigenvalues greater than 1 were considered in subsequent analysis (appendix 4).

According to the empirical results, three factors with eigenvalues above 1 were identified and selected for further analysis. These factors jointly explained farmer's perceptions by 91.3% with 55.5%, 20.2% and 15.6% and were explained by factors 1, 2 and 3; respectively (Table 3).

Table 3: Principal factor analysis results

Factor	**Eigenvalue**	**Difference**	**Proportion**	**Cumulative**
Factor1	**5.62337**	3.58172	**0.5552**	0.5552
Factor2	**2.04164**	0.46229	**0.2016**	0.7568
Factor3	**1.57935**	1.01277	**0.1559**	**0.9127**
Factor4	0.56658	0.15343	0.0559	0.9687
Factor5	0.41315	0.15007	0.0408	1.0095
Factor6	0.26308	0.16475	0.0260	1.0354
Factor7	0.09833	0.01052	0.0097	1.0452
Factor8	0.08780	0.07416	0.0087	1.0538
Factor9	0.01364	0.05653	0.0013	1.0552
Factor10	-0.04289	0.03022	-0.0042	1.0509
Factor11	-0.07311	0.04580	-0.0072	1.0437
Factor12	-0.11891	0.02896	-0.0117	1.0320
Factor13	-0.14787	0.02813	-0.0146	1.0174
Factor14	-0.17600	..	-0.0174	1.0000

LR test: independent vs. saturated: $chi^2(91)$ = 988.70 Prob. > chi^2 = 0.0000
Number of observations = 94; number of Factor = 3; Trace = 14; Rho = 1.0000

Source Field survey data, 2015

Correlation results for the three factors (Table 4) indicated that, the first principal factor is correlated with the three original attributes under relative advantage. This means that principal factor 1 increases with the increase of uniform ripening, colour intensity and freshness. The second principal factor was identified to be correlated with two attributes under complexity whereas the last principal factor was correlated with two attributed under risk concerns.

Table 4: Correlation results of the three Factors

Variable	Factor 1	Factor 2	Factor 3
Inducing uniform ripening	**0.6186**	0.3065	0.0018
Enhancing colour intensity	**0.8629**	0.1404	0.0265
Enhancing fruit freshness	**0.7900**	0.1300	0.0268
Enhancing shelf life/longevity	0.4412	0.2494	0.0308
Enhancing endurance	0.4412	0.2686	0.0113
Enhancing consumer appeal	0.4658	0.2406	-0.0993
Ensuring stable supply	0.4594	-0.0268	-0.1203
Enhancing market access	0.2323	0.1960	-0.0687
Associated with adverse health effects	0.0557	-0.0646	**0.9288**
Associated with adverse environmental effect	-0.0369	0.0281	**0.9268**
Easy of formulation	0.1822	**0.8800**	-0.0509
Easy of application	0.1676	**0.8711**	-0.0089
Affordability	0.0116	0.3653	0.1913
Availability to potential users	0.0470	0.0470	0.0781

Source Field survey data, 2015

Results in Table 4 show that 7 out 14 attributes hypothesized to influence adoptions seem to be more important in explaining the variation (90.2%) in perceptions among adopters. The potential of EFF technologies to bring about uniform ripening, enhance colour intensity and freshness that were clustered under relative advantage explained most of the variation. Technologies that are easy to formulate and apply clustered under complexity were the second most important in explaining the variation. Technologies that are associated with least adverse health and environmental effect were the least important in explaining the variation.

4.4 Differences in Decision to Adopt EFF Technologies

The test on whether there was no difference in preferences between men's and women's prospect to adopt/use EFF technologies rejected the null hypothesis that there was equal adoption prospect between the two categories. The test revealed a significant difference in preferences between the proportion of men and women who were able and willing to adopt the EFF technologies ($p<0.01$). Overall there were more men than women who were willing and able to influence the adoption decision. These findings affirmed the general view that men are more likely to adopt new agricultural technologies than women and are consistent with findings from other studies conducted in Sub-Saharan Africa (Doss, 2001; Ndiritu *et al*., 2014). While there are global reasons to account for these differences, poor access to support services and lack of relevant knowledge and experience were the main reasons to just the observed difference in the study area.

The results presented in Table 5 identified age ($p<0.05$), perception of labour intensity of the EFF technologies ($p<0.05$) and status of banana fruit ($p<0.05$) as variables that influenced the likelihood of female growers to influence the adoption decision. The likelihood of influencing the adoption decision was estimated to be 0.28 lower among farmers who were above 35 years than those below this age. Similarly, the likelihood of influencing such a decision was estimated to decrease by 0.31 and 0.26 when a female decision maker perceived EFF as labour intensive technologies and had banana fruits that were being harvested.

Table 5: Coefficients and marginal effect of the heckman model

Variable	Coeff.	Std. Err	Z	P>|z|	$\partial y / \partial x$
Age category	-0.2834304	0.1223285	-2.32	0.021	-0.2834304
Plot owned	0.0183775	0.0313878	0.59	0.558	0.0183775
Fruit production Exp.	0.1564057	0.1038564	1.51	0.132	0.1564057
Labour intensity Tech	-0.3073283	0.1383306	-2.22	0.026	-0.3073283
Income share	0.0220222	0.0978859	0.22	0.822	-0.3073283
Fruit status	-0.2660025	0.1128297	-2.36	0.018	-0.2660025
Constant	0.7792018	0.157149	4.96	0.000	-
Select					
Savings	0.6109085	0.4258966	1.43	0.151	0
School Age	0.0186276	0.1034318	0.18	0.857	0
Constant	0.9837314	0.1758729	5,59	0.000	
/athrho	-14.61675	210.1222	-0.07	0.945	
/insigma	-0.7597216	0.0731329	-10.39	0.000	
Rho	-1	1.69e-10			
Sigma	.4677967	.0342113			
lambda	-.4677967	.0342113			
LR test of indep. Eqns. (rho = 0) : chi2 (1) = 5.21 Pro > chi2 = 0.02224					
Wald chi^2(6)= 11.89; prob. > chi^2 =0.0645; log pseudo likelihood= -61.72727					

Source Field survey data, 2015

Findings in Table 5 imply that female growers in the study area who were young (<35 years) and willing and able to influence the adoption decisions, were more likely to adopt the EFF technologies than older growers with similar characteristics. Literature associates the higher adoption rate among younger decision makers to their willingness to try new things and their higher ability to learn and acquire new skills (Alexander and Van Mellor, 2005). However, the proportion of young female farmers was generally small (about 11%) implying less impact on the overall adoption rate.

The findings also revealed low adoption prospect among females that were willing and able to influence the adoption decision but perceived EFF as labour intensive technologies. Female growers in the study area were accustomed to agricultural technologies involving the use of labour intensive equipment's such as knapsack sprayers that were widely used to spray agro-chemicals. This experience might have caused them to perceiving the EFF technologies being similar to other labour intensive technologies that existed in their communities. About 16% of the decision makers felt that the technologies were labour intensive. Previous studies have also established that women are less likely to adopt technologies that raise their total labour burden and intensity (Berti *et al.*, 2004; Doss, 2001).

Furthermore, the findings suggest that decision makers whose fruit were just about to be harvested were less likely to adopt the EFF technologies than those whose fruits were at earlier stages of maturity. Time to fruit maturity served as measure of time available for decision makers to adopt the practice and allow the realization of sufficient gains/benefits. The adoption of EFF technologies when fruits were maturing might not accord growers sufficient time to reap benefits through prolonged sale. According to statistics presented in Table 2, a majority of the decision makers (about 79%) who were willing to adopt the technologies were those whose fruits were at early stages of maturing. It is worth noting that selective treatment of the banana fruits with EFF formulations at this stage could allow them to delay the maturity, albeit among some banana trees, thereby prolonging the sale of fruits and hedging against low prices that are normally offered when the supply is high.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Summary

The overall objective of this study was to assess the perceptions of adoption of EFF technologies among smallholder banana farmers in Morogoro, Tanzania. The specific objectives were to determine the variation in farmers' perception in adoption of EFF technologies as post-harvest losses control options, assess whether men and women are equally likely to adopt EFF technologies, and explore whether women who are able and those who are unable to influence adoption decisions face similar socio-economic and demographic adoption challenges.

5.2 Conclusion

Based on the results above, descriptive analysis suggests that majority farmers were able to save money. Potential adopters of EFF technologies seem to attach more weight of perceptions to uniform ripening, colour intensity (attractiveness) and freshness followed by easy of formulation and application then minimum adverse health and environmental effects. The study found that the adoption prospect is likely to be lower among female than male adopters. The study also found higher adoption prospect of the EFF technologies among young female growers of banana although its overall impact on the adoption rate was low owing to limited participation of young farmers in banana production. Moreover, the findings revealed limited adoption prospect of the technologies among female growers perceiving EFF as labour insensitive technologies. The study also established higher adoption prospect among growers whose banana were at early stages of maturity. The implication is that efforts to promote the adoption of these technologies should primarily focus on these growers as early adopters.

5.3 Recommendations

Based on the findings the following recommendations are suggested;

a) Continued efforts are required to address a priori challenges that can potentially undermined the adoption, especially unequal access to agricultural support services and knowledge.

b) Easing the formulation and application of the technologies are required to potentially make the technologies more appealing to women growers and accelerate the adoption among female adopters.

c) Promoters of EFF are required to mainly focus on preferred fruit attributes, especially easy formulation and application and minimum health and environmental effects.

d) Future studies should focus on impacts of specific formulation of the EFF on the adoption prospects.

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APPENDICES

Appendix 1: Table of Likert scale construct

S/N	Construct *(just put the tick to your opinion level)*	Very less(1)	Less (2)	Medium (3)	High (4)	Very high (5)
	How important is…..					
1.	….EFF technology that maintains uniformity during ripening					
2.	….EFF technology that enhances colour intensity					
3.	….EFF technology that enhances freshness of the fruits					
4.	….EFF technology that enhances longevity/shelf life					
5.	….EFF technology that enhances fruits to withstand damages (endurance)					
6.	….EFF technology that enhances consumer appeal					
7.	….EFF technology that ensures stable supply of fruits					
8.	….EFF technology that enhances market access					
9.	….EFF technology that is associated with adverse health impacts on producers and consumers					
10.	….EFF technology that is associated with negative environmental effects					
11.	….EFF technology that is easy to formulate					
12.	….EFF technology that is easy apply					
13.	….EFF technology that is affordable					
14.	….EFF technology that is readily available to potential users					

Appendix 2: The Kaiser-Mayer-Olkin measure of sampling adequacy.

Attributes	KMO
Enhancing uniform ripening	0.8533
Enhancing colour intensity	0.7551
Enhancing fruit freshness	0.7999
Enhancing shelf life/longevity	0.7478
Enhancing endurance	0.8215
Enhancing consumer appeal	0.8367
Ensuring stable supply	0.8631
Enhancing market access	0.7800
Possibility of adverse health	0.3987
Possibility of harm to environment	0.4039
Easy of formulation	0.7501
Easy of application	0.7651
Affordability	0.7353
Availability to potential users	0.7723

Appendix 3: Cronbach's alpha results

Average interitem covariance	0.1478493
Number of items in the scale	14
Scale reliability coefficient	0.8122

Appendix 4: Scree plot showing the cutoff point of eigenvalues