EX-ANTE ECONOMIC IMPACT ANALYSIS OF MARUCA RESISTANT Bt COWPEA IN KADUNA AND SOKOTO STATES, NIGERIA

BY

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A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF DOCTOR OF PHILOSOPHY DEGREE IN AGRICULTURAL ECONOMICS

DEPARTMENT OF AGRICULTURAL ECONOMICS AND RURAL SOCIOLOGY, FACULTY OF AGRICULTURE,
AHMADU BELLO UNIVERSITY, ZARIA

JULY, 2015

DECLARATION

I hereby declare that the work in this dissertation titled **"Ex Ante Economic Impact Analysis of Maruca Resistant Bt Cowpea in Kaduna and Sokoto States, Nigeria"** has been written by me and is a record of my research work. No part of this work has been presented in any previous application for another degree or diploma at any Institution. All borrowed ideas have been duly acknowledged in the text and a list of references provided.

_____ _____

Musa Isa Abubakar **Date**
Student

CERTIFICATION

This dissertation titled **"Ex Ante Economic Impact Analysis of Maruca Resistant Bt Cowpea in Kaduna and Sokoto States, Nigeria"** by Musa Isa **Abubakar** meets the regulations governing the award of the degree of Doctor of Philosophy of the Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This dissertation is dedicated to my late parents and in memory of my late wife Mrs Aminat Yemisi Abubakar.

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ABSTRACT

The broad objective of this study was to conduct an ex ante economic impact of maruca Bt cowpea in Kaduna and Sokoto states, Nigeria. The specific objectives of the study were to examine consumers' awareness/perceptions and preferences regarding Bt cowpea, to determine how much consumers were willing to pay for Bt cowpea quality attributes, to determine the effect of socio-economic characteristics of consumers on willingness to pay for the Bt cowpea, to predict the potential market share of transgenic Bt cowpea, and to measure the aggregate welfare net benefit of introducing the new Bt cowpea in the marketplace of the study areas. Using multi-stage random sampling technique, 12 Local Government Areas, 12 urban and 12 rural markets were randomly sampled from six Agricultural Development Project (ADP) Zones, in Kaduna and Sokoto states, Nigeria. A random sample of 208 consumers was selected from the cowpea consumer population. Data collected were analyzed using descriptive statistics, conditional and mixed logit discrete choice models. The descriptive combined result show that 19.71% of the respondents said they were aware of the new Bt cowpea, implying that consumer awareness of Bt cowpea was low in the study area. The result further revealed that about 20.19% respondents had little perceived knowledge of Bt cowpea in the study area. The results also indicated that 6.25% of the respondents exhibited ethical concerns while 2.2% perceived risks of toxic, 19.23% perceived that Bt cowpea has no disadvantages and 8.17% perceived the risks of environment in the study area. The conditional logit pooled results revealed that the respondents preferred cowpea large grain size and placed a relatively high level of importance on safety attribute of Bt cowpea in the study area. Results further showed that consumers were willing to pay premium or higher prices on cowpea large grain size (₦92.90) and safety attributes (₦186.77) in the study area. The age of consumers had a positive sign (0.002) and significant effect on willingness to pay for cowpea attributes at 5% level in the study area. Furthermore, the results of predicted market share indicated that the potential market share of Bt cowpea was low (40%) compared to conventional cowpea (60%) in the study area. Results from welfare analysis indicated that consumers would experience positive welfare net benefit of ₦242 billion in urban and ₦395 billion per year in rural areas, respectively, in the study area. This implies that Bt cowpea commercialization would have a significant impact on consumers' welfare in both rural and urban areas at 1% and 5% levels, respectively. The mixed logit pooled results revealed that the price coefficient showed the expected negative sign (-0.08) and was statistically significant at 5% level and distributed log normal. The coefficient of cowpea large grain size was normally distributed with an estimated mean of 0.742 and estimated standard deviation of 1.457. In other words, two third of the consumers had positive preference while one third had negative preference for cowpea large grain size. It was concluded that the mixed logit provided better representation of consumers' preferences or choice situation and give more information than conditional logit model. The study recommended the need for policy on decision-making to incorporate a few regulatory steps on safety into the regulatory approval and to assess the safety of Bt cowpea to be introduced. It is also recommended that research should ensure that insert resistant is not broken down.

CHAPTER ONE

INTRODUCTION

1.0 Background to the Study

Nigeria is the world's largest producer and consumer of cowpea (Mishilli et al., 2007). It is estimated that due to cowpea consumption, Nigeria has more than 400,000 metric tons (MT) in deficit. In West and Central Africa, cowpea production has been estimated to be over 3.5 million metric tons (MT) annually in the last decade. Cowpea production in Nigeria has been estimated at 3.332 million tons per annum, but it is faced with many constraints/challenges including insect pests, diseases, drought and poor soil (Institute for Agricultural Research, 2012).

Farmers have identified maruca insect pest as major problem in cowpea production in many African countries including Nigeria (African Agricultural Technology Foundation, 2008). Cowpea (Vigna unguiculata) is one of the crops targeted for improvement using biotechnology to overcome some challenges in Nigeria. Most of the cowpea varieties are susceptible to the cowpea borer (Maruca spp.), which is highly implicated in cowpea production losses. The cowpea pod borer reduces cowpea yields from 50-70% or even up to 80% in severe infestations (Machuka, 2002). Cowpea grain yields can potentially be doubled when pod bugs are controlled. They can be controlled with insecticides, but these pesticides are either unavailable or not affordable by West African small holder farmers. Also, when insecticides are applied in West Africa, illiterate farmers often misuse them resulting in serious health and environmental problems (Saket et al., 2004).

To manage the cowpea pod borer problem, cowpea varieties have been engineered to produce a protein that is toxic to Maruca vitrata using biotechnology and genetic engineering techniques. Because there is no resistant source in the available germplasm of cowpea, biotechnology had to be applied to overcome this problem using genetic engineering techniques whereby a gene from different crop species was taken and inserted into the cowpea genome to confer the resistance to the Maruca spp. The benefits of overcoming the major constraints/challenges in cowpea production through genetic improvement will include healthier environment, reduced health risks, reduced production costs, more income to farmers, and better product (IAR, 2012). In addition, the merits of biotech crops include pest resistance, herbicide tolerance, disease resistance, drought tolerance/salinity, pharmaceuticals and nutrition (Open Forum on Agricultural Biotechnology, 2009).

Early genetically modified traits (that is herbicide tolerance, insect resistance) were obtained by transferring genes across species, largely from soil bacteria. This transgenic nature of genetically modified organisms (GMOs) has been one dimension of consumer resistance to genetic modification raising biodiversity, environmental, ethical, safety, and health concerns and has been a factor in the larger controversy surrounding genetic modification (Colson and Hoffman, 2011).

Maruca resistant Bt cowpea varieties have been developed by international research consortium through public-private partnership using biotechnology to address insect resistant trait using antibiotic markers with no specific "product - enhancing nutritional attributes," or new value – added traits (such as vitamin A or C, beta-carotene and antioxidant) that directly benefit consumers. Bt cowpea gets its name from the soil

bacteria (Bacillus thuringiensis), which is the organism used for the introduction of Bt gene into cowpea genome to give it the potential to produce proteins that are toxic to certain insects, but have no negative effects on humans. The Bt cowpea technology would be similar to that used to develop Bt maize, Bt potato and Bt cotton which are widely used around the world (Gbegbelegbe et al., 2010).

Bt cowpea is currently in research stage with Confined Field Testing (CFT), and is not yet available in the marketplace. The confined field trials and containment project were established in 2009 at the Institute for Agricultural Research (IAR), Samaru, Zaria, in Nigeria with the expected terminal date in 2014. Thereafter on-farm trials of Bt seeds would be conducted at the farmers' fields. Bt cowpea seeds are expected on the market around the year 2017 subject to approvals from regulatory agencies, the identification of effective and stable maruca resistant lines, and efficient transfer of the resistance to traditional varieties through conventional breeding (IAR, 2012; OFAB, 2012).

Genetically modified (GM) crops are popular in many regions of the world, but their deployment in Africa is hindered by safety concerns and regulatory issues, although the continent is in dire need of boosting its food production. (Kimenju and De groote, 2007). The world population by the year 2050 is predicted to double, making food security a significant concern for the next 30 years (Hiroshi et al., 2002). Genetically modified crops are the most promising solution for augmenting agricultural production and productivity to solve the food shortage in the future, if properly implemented in current farming techniques (Herrera – Estrella, 2000). This is only possible if consumer reactions toward genetically modified crops are positive. If not, the dilemma of feeding the world will become a difficult task indeed (Cuellar, 2004). Hence, the majority of

agricultural scientists anticipate great benefits from biotechnology in the coming decades to help meet Nigeria's future needs for food and fiber.

Formulating genetically modified crops requires heavy investment in research and development. A number of factors have combined to stimulate interest and investment in agricultural biotechnology by farmers, processors and consumers. These include changing needs and preferences of consumers which have created opportunities and markets for new products. Other factors include an expanded interest in food safety, labeling, nutrition, and value-added enhanced qualities, which also create opportunities for agricultural biotechnology expansion (Mclennon, 2002).

To date, the previous ex ante economic study on Bt cowpea by Gbegbelegbe et al. (2010) had estimated the impact of the new Bt cowpea on both cowpea growers and consumers, and they have often been limited to the problem of market failure and uncertainty in the economic state of the seed sectors given price, yield and income risks. The present study relates to the previous study on Bt cowpea in predicting the net impact of the new Bt cowpea technology on cowpea consumers. Unlike the previous study, this study specifically focuses mainly on understanding how consumers evaluate the Bt cowpea attributes before investment is made in moving the new Bt cowpea through regulatory approval to commercialization.

1.1 Problem Statement

The Federal Government of Nigeria is considering whether or not to commercialize transgenic maruca resistant Bt cowpea around the year 2017as reported by African Agricultural Technology Foundation (AATF, 2009). Previous research has shown that

one of the problems of introducing GM crops in some parts of the world is the principal objections to GM crops including Bt crops and the food products made from them, concern about possible harm to human health, damage to the environment and 'unnatural' status of the technology (Angus Reid, 2000). There are also fears about damage to non-target species by insect-resistant crops and inadvertent creation of new viruses (Nuffield council on Bioethics, 1999). According to Sophia and Powell (2000) consumers around the world have a negative view about g GM foods and perceive the issue as one where the risks outweigh the benefits.

Saket *et al*. (2004) reported that little is known of the potential consumer response to Bt cowpea in Nigeria. One of the problems that may arise is that consumers may be scared that conventional cowpea varieties are likely to be contaminated by Deoxyribo- Nucleic Acid (DNA) from transgenic Bt cowpea. Genetic contamination of conventional cowpea varieties is a concern because according to Mishilli *et al*. (2009) cowpeas are big business and the most important indigenous grain legume in West and Central Africa, and provide high protein food for family consumption.

Gbegbelegbe *et al*. (2010) reported that consumer reaction to Genetically Modified (GM) food in Africa has not been well studied. In view of this, AATF (2009) pointed the need to ensure smooth progress in developing a transgenic Bt cowpea and safeguards against potential technology backlash as has been demonstrated in some parts of the world such as Argentina where some consumers have reacted negatively to products from genetically modified grains and oilseeds from certain markets.

The international infrastructure for seed movement has gaps and distortions that carry some risks of harming developing countries including Nigeria by discouraging

commercially fair bioprospecting (legal field crop transfer), and by facilitating the so-called biopiracy (the unauthorized and uncompensated) removal from developing to developed countries for experimental use with a view to commercial development. Neither approach necessarily involves GM crops and confined to private companies. Obtaining crops from small farmers in developing countries, patenting genes of agronomic interest and attempting to restrict the use of such crops, is not only widely agreed as unethical but raises a special problem because Nigeria has not developed legislation and expertise restricting the export of biological samples and to control biopiracy (Nuffield Council on Bioethics, 1999).

One of the technologies which could generate economic growth and better living standards in Africa is biotechnology, but political issues have slowed down the use of this option. Genetically Modified (GM) crops in Africa has become a political issue in part because little is known about the potential producer and consumer benefits (Gbegbelegbe *et al*., 2010). For politicians, GM crops occasionally threatened difficulties with ECOWAS trade or pose problems for African Union biosafety regulations, but the regulation of research and release into the environment of new plant strains was not politically contentious. Also, awareness about the field of biotechnology is low even within the policy makers in Nigeria who still do not seem to appreciate the impact science and technology can make in developing nations (OFAB, 2009). Policy makers are further confronted with contradictory sources of information on GM crops while scientific facts are often mixed with social, ethical and political considerations (African Union, 2006). This information environment could have a direct impact on consumers' perspectives and valuations for GM foods in Africa. In addition to lack of accurate information on GM benefits to African populations, GM cowpea cultivars are

likely to be introduced in a region characterized by serious consumers' perceived potential risks of ethical and health concerns about GM crops.

In view of these problems, there is need to conduct a careful *ex ante* economic impact analysis to predict the economic impact and consequences of introducing the new Bt cowpea in order to provide guidance in solving this public policy problem. This study is therefore intended to provide answers to the following research questions:

i. What are consumers' awareness/perceptions and preferences regarding Bt cowpea in the study area?
ii. How much consumers would be willing to pay to consume the new Bt cowpea in the study area?
iii. What is the effect of socio-economic characteristics of consumers on willingness to pay for the Bt cowpea in the survey area?
iv. What is the predicted market share of the new transgenic Bt cowpea in the study area?
v. What is the expected aggregate welfare net benefit of introducing the new Bt cowpea in the marketplace?

1.2 Objectives of the Study

The broad objective of the study was to conduct an ex ante economic impact analysis of maruca resistant Bt cowpea in Kaduna and Sokoto States, Nigeria. The specific objectives are aimed to:

i. examine consumers' awareness/perceptions and preferences regarding Bt cowpea in the study area;

ii. determine how much consumers are willing to pay for Bt cowpea quality attributes;
iii. determine the effect of socio-economic characteristics of consumers on willingness to pay for the Bt cowpea in the survey area;
iv. predict the market share of transgenic Bt cowpea in the study area; and
v. measure the expected aggregate welfare net benefit of introducing the new Bt cowpea in the marketplace.

1.3 Hypotheses

The objectives of the study were achieved by testing the following hypotheses:

i. There is no significant difference in consumers' awareness of Bt cowpea across the two states.
ii. Introducing Bt cowpea would have negative impact on consumers' welfare across the two surveyed states.
iii. Socio-economic characteristics of consumers would have negative effect on willingness to pay for the new Bt cowpea attributes in the study area.

1.4 Justification for the Study

This study addresses the potential net welfare benefit of releasing Bt cowpea in the marketplace and how much cowpea consumers would be willingness to pay for its attributes in the study area. For example, the ex ante economic impact studies of transgenic Bt cowpea conducted in West Africa particularly in the Republic of Benin revealed that the welfare gain that introduction of Bt cowpea would bring to cowpea growers far outweigh the loss to consumers so that the society in Republic of Benin would, on aggregate experience higher net welfare gain (Gbegbelegbe *et al*., 2010). A

baseline study for impact assessment of high quality of insect resistant Bt cowpea showed that the expected gross benefits from Bt cowpea in Niger Republic for both producers and consumers with the introduction of Bt would be US$3 billion per year while gross benefits from Bt cowpea suggests that producers and consumers in Nigeria would experience a welfare gain of about US$5.1billion once Bt cowpea is available in Nigerian rural markets. Furthermore, the study indicated a gross welfare gain of about US$3.3 billion for all urban consumers in Nigeria once Bt cowpea is available in Nigerian urban markets.

The preliminary baseline results further revealed that there was high willingness to pay (WTP) for Bt cowpea seed by farmers. Furthermore, both cowpea growers and consumers were willing to pay a premium price for Bt cowpea as an alternative to harmful cotton pesticides in the West African region. It can be seen that the impact of Bt cowpea on consumer and producers' welfare justifies the need for this study.

Information on ex ante economic impact of Bt cowpea is expected to benefit cowpea farmers to increase their income, and may require less pesticides in cowpea production while marketers would use willingness to pay estimates as important tool in marketing decision. Also, policy makers' would be guided by the information generated in this study in making well-informed decisions regarding the release of the new product in the marketplace.

1.6 Limitation of the Study

This study conducted ex ante impact analysis of Bt cowpea among consumers in only two states, namely, Kaduna and Sokoto States, Nigeria. The perceptions and preferences of these respondents regarding Bt cowpea may not be the same for other States. Also,

most respondents were less - educated and somewhat knowledgeable about the new Bt cowpea coupled with the non-provision of any potential risks and benefits information about Bt cowpea, this has influenced the respondents' assessment of the potential risks and benefits of Bt cowpea and tend to change their valuation of cowpea attributes. A major limitation of the study was in asking subjects hypothetical valuation questions without the use of "cheap talk" script to determine its effect on consumer willingness to pay. "Cheap talk" script is a recent approach or method that has been proposed to eliminate the potential bias in hypothetical valuation questions when no money payment is required or no real money payment is made in hypothetical market. In the absence of "cheap talk" script, the potential for 'hypothetical bias' in willingness to pay estimates may be large (a tendency for people to overstate their willingness to pay for goods in a hypothetical situation). This study did not use cheap talk in consumer valuation because when the respondents were asked if they could read the "cheap talk" information they said that they will not take time to read and assimilate lengthy cheap talk information in the comfort of their own home.

Despite these limitations, t*he study showed that the expected net welfare benefit had positive and significant impact on cowpea consumers in the study area. Hence,* the value of ex ante prediction in this study indicated that it *contains important knowledge about welfare effects of Bt cowpea on cowpea consumers that could guide policy makers in making informed decisions on releasing the new Bt cowpea in the year 2017.*

CHAPTER TWO

LITERATURE REVIEW

2.1 *Concept of Ex-ante Analysis*

Myrdal (1940) was the first to introduce an important innovation in a distinction between calculations ex ante, and calculations ex-post in his published work on monetary equilibrium at Stockholm University, Sweden. According to him the concept of ex-ante is built on the question of anticipations, calculations, and plans driving the dynamic process forward. Furthermore, calculations ex ante consider expectation, which can be compared with the ex post calculations or realized benefit and/or costs. The author attempted to solve the question of how does a disparity in the saving-investment equation develop into an ex post balance? The findings of his work showed that ex post, savings always equals investment, which agrees in this respect with that of Keynes General theory, but ex ante, they may not be equal. However, Myrdal (1940) clearly warns that there can be no doubt that it is correct to introduce expectations into economic analysis, but in so far as it makes the analysis more realistic, it can also introduce much vagueness into the final results, and prevents the economist from looking very far ahead.

According to (United Nations Development Programme, 2007) ex ante impact analysis is conducted before the actual measure is taken so that the analyst wants to know what the problem is, what kind of solutions exist, whether the solution can actually achieve the objective. In a word, it refers to knowing what you are doing before you start doing it. The international literature uses terms like impact assessment, impact analysis or impact evaluation. The impact assessment areas include economic, environmental, social, fiscal, and impact on consumers, which can help provide information, data and

analysis to support the assessment of intended and unintended impacts of future policies. The choice of the techniques and methods of impact analysis will depend on the availability of data, time and local capacity while the analytical framework involved in the analysis vary. The main techniques in impact assessment include cost-benefit analysis, integrated impact analysis, socio-economic impact analysis, social and private profitability analysis, welfare analysis, policy analysis, risk assessment, threshold analysis, and sensitivity or uncertainty analysis, however, the impact analysis should be based on standardized methodology(using both quantitative and qualitative indicators, information and methods from a range of discipline) in order to become a reliable and effective aid to policy making.

Gomez-Barbero and Rodriguez-Cerezo (2006) reported that ex ante evaluations deal with forecasting the economic impact of GM crops, at farm or aggregate level, before they are actually adopted. Evaluations of this kind have a strong modeling component and a number of parameters have to be estimated in ex ante studies. Various ex ante studies on the economic impact of GM crops were conducted in developed and developing countries. But there are few of such ex ante studies on GM crops in Africa. In spite of the existing scientific evidence on the economic impacts of GM crops in the developed and developing world, it was reported that there is no single model for a good impact analysis. Also, there is variability of theoretical economic frameworks, methodologies, variables, hypotheses in ex ante studies.

Ex ante analyses are necessary to estimate the economic impact of novel products on producers and consumers. According to Gbegbelegbe and Lowenberg-DeBoer (2008) the ex ante assessment of a new technology is undertaken with non-market valuation

methods which can be divided into observed data-based and perception-based methods. The observed-data based methods use budgets, regression, mathematical programming and simulation, whereas the perception-based methods include contingent valuation, choice-based conjoint analysis, and experimental methods. Hedonic price, travel cost, and replacement cost methods are also categorized as non-market valuation methods, but they cannot be used to undertake ex ante analyses because they all imply that the non-marketed goods/services must exist and must be consumed. These three methods also involve using market prices to estimate the value of non-marketed factors. Similarly, on-farm trials which also provide observations for perception-based analysis can also be used for ex ante analyses, but only when non-marketed products exist. Findings imply that the preferred observed data-based method to estimate the ex ante impact of a new technology on the welfare of farm household is a combination of simulation and mathematical programming. The preferred perception-based method for estimating ex ante impact on the welfare of an economic agent is represented by experimental methods. Findings also imply that observed data-based methods and more specifically mathematical programming are more popular for estimating the ex ante farm-level impact of a new technology. On the other hand, perception-based methods are more popular for estimating the economic impact of a novel product for consumers.

2.1.1 Biotechnology and its Applications in Agriculture

There are many definitions of biotechnology but the Convention on Biological Diversity (CBD) defines biotechnology as any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use. This definition of biotechnology covers many of the tools and techniques that are commonplace in agriculture and food production, which considers

only the new deoxyribonucleic acid (DNA) techniques, molecular biology and reproductive technological applications, and covers a range of different technologies such as gene manipulation and gene transfer, DNA typing and cloning of plants and animals. The application of biotechnology to make, modify or improve on a product has led to the development of sector called agricultural biotechnology. The importance of agricultural biotechnology due to the increased adoption of bioengineered varieties by farmers in developing countries over the past few years has shown that they can benefit at least as much, if not more than, their industrialized counterparts (Open Forum for Agricultural Biotechnology, 2009).

Therefore, it can be seen that biotechnology is a novel discipline that is involved with the integration of scientific and engineering skills to achieve enhanced technological applications. It is concerned with the practical application of organisms or their components for the benefit of mankind. Unlike single scientific disciplines, biotechnology draws upon an array of relevant field including biology (genetics), biochemistry, food science, food technology and engineering, mechanical engineering, chemical engineering, biochemistry engineering and microbiology. Modern biotechnology comprises three main branches including genetic engineering, cell and tissue culture techniques, bioconversion and enzyme technology. Genetic engineering is almost erroneously regarded as biotechnology itself. However, genetic engineering is the modification of specific genetic information by the transfer of isolated genes between individuals of similar or different species, in order to improve an organism through breeding. Genetic engineering involves a number of steps including identification of desired gene, isolation of the gene, search for gene transfer mechanisms, investigation of the expression of the transferred gene in the receptor

organism. Cell and tissues culture engineering is that branch of biotechnology that involves the *in vitro* culture and growth or reproduction of isolated cells or tissue parts in suitable germ-free nutritive media. Also, bioconversion and enzyme technology is the branch of biotechnology that is based on the use of micro-organisms or their enzymes referred to convert substances from one form to other much more valuable varieties as in the fermentation industry. The micro-organisms or enzymes referred to as biocatalyst can be utilized as free cells (or enzymes) or are attached to carriers and are said to be immobilized, which have been reported to enhance the processes better. By enzymes technology, it is also easy to increase the quantity and/or quality of a product (OFAB, 2009).

Today many people in the developing world, including Nigeria, do not have access to sufficient food to meet their needs, primarily because of poverty and unemployment. Malnutrition plays a significant role in half of the nearly million deaths each year of children under five in developing countries (OFAB, 2009). In addition to lack of food, deficiencies in micro-nutrient (especially vitamin A, iodine and iron) are widespread. Furthermore, changes in the pattern of global climatic and alterations in the use of land will exacerbate the problems of regional production and demands for food. Dramatic advances are required in food production, distribution and access if Nigeria is going to address these needs. Some of these advances will occur from non-biotechnologies, but others will certainly come from the advantages offered by biotechnology. It is important to increase yield on land that is already intensively cultivated.

Nigeria is the advocate of biotechnology in West and Central Africa, where there is political support for biotechnology. The Nigerian government approved the biotechnology policy in April, 2001 and believes in the opportunities offered by

biotechnology to empower the farmers through increased productivity, thereby alleviating poverty and creating wealth ultimately economically empowering them (OFAB, 2009). Very recently, all governmental members of the Economic Community of West African States (ECOWAS) agreed to use biotechnology to boost crop yields in their respective countries (African Union, 2006). Nigeria adopted Biotechnology policy in 2001 as an alternative tool for sustainable and improved food production that will ensure food security, environmental sustainability, industrial growth and improved health care delivery for her populace. The establishment of the national biotechnology development agency (NABDA) in 2001 is to further actualize the vision of Nigeria in its Biotechnology policy. Prior to 2007, genetically modified organisms (GMOs) policies by African governments were very mixed, with some governments being opened to genetically modified organisms (GMOs) contrary to others.

In Africa, agricultural biotechnology holds great potentials in addressing the issue of food security in the face of population growth among others. In 2001-2002 governments of several southern Africa countries refused donations of U.S. maize because the U.S. could not guarantee the absence of genetically modified organisms in the product. Within Network for Genetic Improvement for Cowpea in Africa there has been a debate about the awareness of African consumers about genetically modified products. Some said that African consumers were largely unaware of what GM means (Saket et al, 2004). Genetically modified crops in Africa have become a political issue in part because little is known about the potential producer and consumer benefits (Gbegbelegbe et al, 2010). Notwithstanding the potential contributions of biotechnology in addressing issues of food security and poverty reduction, there is still an on-going debate which ranges from issues of ethics, safety, intellectual property, costs and

*access, and regulatory issues (*Open Forum on Agricultural Biotechnology, 2009; *Enoch et al, 2011).*

Biotechnology provides powerful tools for the sustainable development of agriculture, fisheries and forestry, as well as the food industry. When appropriately integrated with other technologies for the production of food, agricultural products and services, biotechnology can be of significant assistance in meeting the needs of an expanding and increasingly urbanized population in the next millennium. Biotechnology also offers hope of improving not only nutritional benefits of many foods also quality and quantity (OFAB, 2009).

2.1.2 Biosafety regulation

Biosafety is a term used to describe efforts to reduce and eliminate the potential risks resulting from modern biotechnology, genetically modified organisms (GMOs) and products thereof. Biosafety is therefore, intended to minimize or eliminate the possible harmful effects of modern biotechnology on the environment, biodiversity and human health using laws and guidelines (OFAB, 2009). The goals of biosafety are to determine in advance when hazards to human health and natural systems will result if any particular GMO is released into the environment; anticipate when a given GMO or any of its product(s) will be harmful if it becomes part of human food; discern whether a GMO will actually yield the benefits it was designed to provide; and make as certain as possible that hazards will not arise when GMOs are transported, intentionally or intentionally, between different ecosystems and countries (OFAB, 2009).

The issue of biosafety regulation in Africa is rapidly gaining momentum as more African countries are embracing GMOs. Nearly all African countries have signed and ratified the Cartagena protocol on Biosafety and also developed their bills and some are

already passed into laws. South Africa already has a biosafety law and is currently growing and consuming genetically modified (GM) corn and cotton. Kenya also recently passed a biosafety law and is currently carrying out GM potato field trials. Egypt also has a biosafety law. Mali and Burkina Faso, in West Africa, also have biosafety laws and Burkina Faso is presently carrying out GM cotton confined field trials/commercial release. The African Union has developed a model for biosafety law to assist member states develop their biosafety laws which was made reference to in the development of the draft Nigeria National Biosafety Bill. In addition, The Economic Community of West African States (ECOWAS) commission is currently developing a common Biosafety regulation in line with National Biosafety laws/regulations for the sub-region. This is due to the fact that Africa has embraced modern biotechnology and more also West African states have common borders and free trade that may be very difficult to monitor (OFAB, 2009).

Modern biotechnology regulation in Nigeria started in the early 1990s as researchers in biotechnology became competent in modern biotechnology research and also when the need for precaution in the development of modern biotechnology became glaring globally. The development of biosafety legal regime in Nigeria has followed an evolutionary pattern, with each successive step being an improvement on the preceding level, while taking cognizance of the country's national and international obligations in the field of biosafety. Nigeria is currently having the 1994 and 2001 Biosafety Guidelines, developed the Draft Nigeria National Biosafety Bill (OFAB, 2009).

Furthermore, Nigeria has already passed the Biosafety bill into law in the year 2015.The Biosafety Bill covers all modern biotechnology activities including GMOs and other products of modern biotechnology and all germplasms. It defines modules of practice of modern biotechnology and the handling of its products (GMOs) to ensure safety to the

environment and human health. The Biosafety bill is therefore intended to guide different segments of society in contributing to safe application of modern biotechnology. It defines offences and penalty for the violation of the act and covers socio-economic consideration in risk assessment.

Some of the major issues of biosafety regulation in Nigeria include risk assessment, substantial equivalence, risk management, precautionary principle/approach, benefit analysis, and products labeling. Bisosafety regulation in Nigeria is to regulate application and approval of GMOs for confined field testing, import, placing in the market, contained use or products thereof, ethical and socio-economic considerations, packaging, labeling, storage, transport, handling of laboratory practices in relation to GMOs or products thereof, standards of risk assessment, fees, waste from genetic engineering techniques, and contingency plan to manage emergency/unintentional releases. Nigeria need to regulate GMOs in order to harness the potentials modern biotechnology has to offer in the field of improved food production, medicine/health, industrial growth and environmental protection, allay the fear of the populace on the socio-economic consequences of modern biotechnology, especially among the small scale farming systems that are prevalent in Nigeria. Also, there is currently a lot of concern regarding the possible toxicity and allerginicity of food products derived from GMOs. There is, therefore, the need to minimize risks to human beings. The need to regulate GMOs is also due to concerns on the environmental consequences of the release of GMOs into the environment, in particular the effect on biological diversity (OFAB, 2009).

2.1.3 Genetically Modified (GM) Foods

Genetically modified foods (GM foods, or biotech foods) are foods derived from genetically modified organisms (GMOs). The GMOs have had specific changes introduced into their Deoxyribonucleic Acid (DNA) by genetic engineering (GE) techniques. Commercial sale of genetically modified foods began in 1994, when Calgene first marketed its *Flavr savr* delayed ripening tomato. Typically, genetically modified foods are transgenic plant products like Soybean, Corn, Canola, Rice, and Cotton seed oil. These may have been engineered for faster growth, resistance to pathogens, production of extra nutrients, or any other beneficial purpose. Genetically modified livestock have also been experimentally developed, although as of July 2010 none are currently on the market (Clive, 1997).

2.1.4 Experience of some African countries growing Bt crops

South Africa is the only country in Africa to have commercialized genetically modified or biotech crops. It is ranked number eight in the world with a total biotech crop hectare of 1.8 million hectares in 2007, a 30% increase over the 1.4 million hectares in 2006. Biotech maize, cotton and soybean are grown in South Africa and the area under cultivation has increased every single year since the first introduction in 1998. The major increase in 2007 was in Bt maize, notably most of it in white maize use for food, which now occupies two-thirds of the total white maize area of 1.7 million hectares. Both small and resource-poor farmers and large farmers grow biotech crops, which have earned their trust and confidence. The Bt cotton grown in Kwazulu Natal region is mainly grown by women subsistence farmers. A woman cotton farmer from the Makathini Flats, Kwazulu-Natal Province, increased her yield with Bt cotton from three bales per hectare to eight bales per hectare, earning her a net income of Rand 38,400 (US$5,730). South Africa is estimated to have enhanced farm income from biotech

maize, soybean and cotton by US$156million in the period 1998-2006, with benefits for 2006 alone estimated at US$67million (OFAB, 2009).

In Kenya, the state of biotechnology can be categorized into traditional and modern techniques and applications. Traditional techniques are the most widely applied tools but the country is slowly moving into advanced modern applications. Traditional applications include fermentation, bio-fertilizers and tissue culture. Modern applications comprise of molecular markers, novel vaccines, diagnostic tools and genetic engineering. Kenya has come a long way in overcoming considerable challenges in regard to modern biotechnology transfer and applications for improvement in production of food and cash crops, especially for small-scale resource-poor farmers who form the large proportion of the farming community.

In Kenya, approval for and research trials of genetically modified organisms (GMOs) move swiftly, a major factor to the successes in agricultural biotechnology applications in the region. Apart from Bt cotton, Kenya is currently experimenting with transgenic sweet potato and Bt maize. These were the first and second genetically modified crops to be approved respectively. Recently genetically modified cassava was approved for trials. Like most of Africa, application of biotechnology in Kenya is needs-based. A major priority in Kenya is for high yielding-drought tolerant crop varieties to boost food production in the arid and semi-arid regions that occupy 71% of the country. The demand for tree seedlings reach 14 million per year whereas the country could only supply 3 million, a clear indication of the practical need for tissue-culture and clonal techniques to curb deforestation and boost re-forestation using various indigenous species threatened with extinction (OFAB, 2009).

2.2 Consumers' Valuation of Bio-fortified/Genetically Modified Foods in Some African Countries

In Uganda, a study was conducted by Chowdhury *et al.* (2009) to provide potential answer to the question: Are consumers in developing countries willing to pay (WTP) more for micronutrient, dense bio-fortified foods. The paper attempts to address this question by using a choice experiment with the real product to quantify the magnitude of the premium or discount in consumers' willingness to pay that may be associated with it. The experiment was conducted in Uganda, a key target country for the dissemination of orange sweet potato. The results suggest that in the absence of nutritional information, there is no difference between white and orange varieties in consumers' willingness to pay, but there is a discount for yellow sweet potato (which does not have any beta-carotene). The provision of nutritional information does translate into substantial premium for the orange varieties, indicating that an information campaign may be important in driving market acceptance of the new product. With knowledge of nutritional value, there is a substantial premium for deep orange potato varieties relative to white, which is also significant, unlike the case when no information was provided. Given the developing country setting of the study, the premia for the nutrition information appear high, especially considering the relatively limited purchasing power of most study participants, and the salience of this staple food in average budgets in countries such as Uganda. This suggests that nutritional messages and social marketing may be relevant for the promotion of orange sweet potatoes in the market to ensure that traders have an incentive to demand and sell the biofortified varieties. The study concluded that the impact of nutritional information on consumers' willingness to pay is substantial.

Enoch *et al*. (2011) analyzed consumers' perceptions and institutional awareness and trust toward genetically modified regulation in Uganda. In their study, an explanatory factor analysis was conducted to identify the perceptions toward genetic modification. The identified factors were used in a cluster analysis that grouped consumers into segments of genetically modified skepticism, government trust, health, safety concern, and food and environmental safety concern. Results were based on a study conducted among 421 banana-consuming households between July and August, 2007. Results showed a high willingness to purchase genetically modified banana among consumers. Socio-economic characteristics differed significantly across segments. Consumer Characteristics and perception factors influence consumers' willingness to purchase genetically modified banana. The institutional awareness and trust varied significantly across segments as well.

2.2.1 Consumers' valuation of genetically modified food in developed countries

Lusk *et al.* (2003) estimated consumer willingness to pay for beef in France, Germany, the United Kingdom, and the United States. Their analysis uses a variety of quality variables, including whether the cattle were fed genetically modified corn. Results suggest European consumers place a much higher value on beef from cattle that have not been fed genetically modified corn compared to their consumer counterparts in the United States. Yet, in a study of the discrepancy between European public opinion and consumer purchase behavior with regard to genetically modified food products, Noussair *et al.* (2002) found that consumers were typically unaware of the labeling indicating genetically modified content.

Using a dichotomous contingent valuation method, Jill *et al.* (2003) conducted a survey of 400 consumers at the Seikatsu Club consumer cooperative (Seikyou), a grocery store-like setting, in Matsumoto City, Japan, during 2001. The survey solicited information

regarding respondents' attitudes about the environment and food safety, and their self-reported knowledge and perceptions about biotechnology. Findings showed the discount needed for Japanese- Seikyou consumers to purchase genetically modified food products is positively affected (i.e. a greater discount is required) by higher levels of self-reported risk perceptions toward genetically modified food, higher levels of concern about food safety and environment, higher self-reported knowledge about biotechnology, education levels, and income. Interestingly, gender does not significantly affect the discount needed for genetically modified food.

Baker and Burnham (2001) investigated United States consumers' acceptance of genetically modified corn flakes, and reported that 30% of those surveyed based their purchasing decision on genetically modified content. Their findings showed that cognitive variables (opinions, beliefs, knowledge) have a great influence on consumer preferences. The level of risk aversion, knowledge about genetic modification, and opinion about genetic modification were highly significant in explaining the purchasing decision. Earlier studies investigating the relationship between consumer characteristics and food safety concerns have generally found that socio-demographic variables (such as education and income) perform poorly as explanatory variables for purchasing decisions regarding genetically modified food products. The exception is that women, in general, are more concerned with food safety.

A small number of surveyed studies have assessed consumer perceptions about food safety and biotechnology in developed societies, including the United States and Japan. Jussaume and Judson (1992) studied the effects of sociological characteristics on consumer attitudes toward food safety. Using responses to mail surveys in Seattle, Washington, and kobe, Japan, they examined differences between consumers in the two countries. Residents of Kobe were found to be significantly more concerned about food

safety than residents in Seattle. For both countries, households more likely to care about food safety issues are those with children under the age of 18, who belong to consumer cooperatives, and with relatively high incomes.

Using telephone surveys conducted in Japan and the United States in 1995, Hoban (1995) studied consumer awareness and acceptance of biotechnology and willingness to purchase genetically modified foods. Despite the recent controversy over the use of biotechnology, Hoban observed increasing acceptance of genetic modification for food production by Japanese and U.S. consumers between 1995 and 1998, and increasing numbers of consumers who are willing to buy genetically modified foods in both countries. He concludes that the use of biotechnology does not negatively affect consumers' willingness to purchase those foods. However, Hoban cautions that consumer awareness and understanding of biotechnology is still relatively low in Japan compared with the United States.

2.3 Stated Preference Valuation Methods

Stated preference (SP) techniques involve asking the same individuals to state their preferences to hypothetical questions (Train, 1998; Louviere *et al*., 2000). The literature suggests at least three compelling reasons for the interest in stated preference data: First, to estimate demand for new products. This is one of the reasons favoring stated preference techniques as it is based on hypothetical choices that can be precisely specified in advance using a design, which allows straightforward identification of all effects of interest. This is in contrast to revealed preference (RP) data, which cannot be controlled *a priori* so that model identification cannot be guaranteed. Second, stated preference methods allow large quantities of relevant data to be collected at moderate

cost. It is however, observed that , in the case of cowpea revealed preference data in West African selected cities of Nigeria, Ghana, and Cameroon by Mishilli *et al*. (2007) were usually collected in multi year period, being time consuming and expensive. Third, stated preference data provides information on current preferences and how these are likely to respond to a proposed change in resource allocation.

2.3.1 Cheap talk studies

Cheap talk refers to process of explaining hypothetical bias to individuals prior to asking a valuation question. There is extensive literature on the presence and extent of bias involved in valuations elicited from hypothetical scenarios, especially in the literature on natural resources (Frykblom, 1997). A large body of literature suggests willingness-to-pay is overstated in hypothetical valuation questions as compared to when actual payment is required. One way to mitigate hypothetical bias is to use so called "cheap talk" scripts, as proposed by Cummings and Taylor (1999) and subsequently used by List (2001a), and Lusk (2003), among others. Recently, "cheap talk" has been proposed to eliminate the potential bias in hypothetical valuation questions.

Cummings and Taylor (1999) were the first to report on the potential of cheap talk to reduce or eliminate hypothetical bias with student participants in a laboratory setting. Their cheap talk script contained three primary sections with: (a) an explanation of hypothetical bias, (b) a discussion of why hypothetical bias might exist, and (c) a request to avoid hypothetical bias in a subsequent valuation question. In their experiments, participants voted by referenda on contribution to a public good. Four different public goods were utilized in the experimental design and different subjects

participated in real, hypothetical, and hypothetical with cheap talk referenda. The public goods varied by what was being delivered, where delivery was taking place, and the degree of the good delivered in relation to the amount of the contribution.

The results of experiments conducted by Cummings and Taylor (1999) can be summarized as follows: (a) hypothetical valuations without cheap talk were typically greater than when real payment was required, (b) hypothetical valuations with cheap talk were equal to real valuations in *every* treatment and (c) cheap did not introduce a downward bias in valuations that was coincidentally equal to hypothetical bias as evidenced by the fact that cheap talk did not decrease valuations when hypothetical, non-cheap talk valuations were already equivalent to real valuations. That is, cheap talk lowered WTP when the propensity for hypothetical bias existed and left WTP unaffected in cases hypothetical bias did not exist. Results are robust across all referenda and variations in the cheap talk script.

In a follow-up study, List (2001a) employed the use of cheap talk in a study of sports cards valuation in a field setting. Rather than utilizing a referendum voting format, List (2001a) used a 2^{nd} price auction to elicit hypothetical, hypothetical with cheap talk, and real valuations. For inexperienced card traders, List (2001a) confirmed the results in Cummings and Taylor (1999) who found that cheap talk valuations were indistinguishable from real valuations, which were lower than hypothetical valuations. However, cheap talk failed to reduce hypothetical bias for experienced card dealers. List (2001a) concluded that experienced subjects might have been less susceptible to the external prompting of a cheap talk script they had developed hard-and-fast rules and valuation strategies which were not easily changed. Additionally, experienced card

traders may have believed they were very familiar with market conditions and therefore discounted the cheap talk information.

Lusk (2003) explored the effect of cheap talk on consumer willingness to pay for golden rice in a mass mail survey using a conventional value elicitation technique. In July 2001, 4900 surveys were mailed to a random sample of consumers in the fourth largest rice producing Mississippi State in the United States. Four hundred and seventy-eight surveys were returned because of undeliverable addresses and 632 completed surveys were returned resulting in a 14% response rate. Lusk (2003) removed all partially completed surveys from the data set, which reduced the final number of observations to 574. Results indicate that cheap talk was effective at reducing willingness to pay (WTP) for most survey participants; however, consistent with previous research, cheap talk did not reduce WTP for knowledgeable consumers. In general, results suggest that cheap talk significantly reduced WTP for consumers unknowledgeable about golden rice and genetic engineering. The study concluded that the advent of cheap talk may alleviate the concern that in non-market valuation people behave differently in hypothetical and non-hypothetical settings. Also, the study of cheap talk is still in its infancy and the conditions in which cheap talk is effective at reducing hypothetical bias are not fully known.

Chowdhury *et al*. (2009) examined whether a "cheap talk" script is effective in mitigating hypothetical bias or reminds respondents that hypothetical scenarios are to be treated as if they are real in Uganda. The results showed that there is a substantial hypothetical bias in both the willingness to pay (WTP) and the marginal WTP, for the new orange sweet potato varieties; while "cheap talk" may mitigate this bias, it does not

eliminate it. The results suggest that although the use of cheap talk script does result in a reduction of the magnitude of WTP, the bias remains substantial. This finding is of interest because, unlike most other cheap talk scripts, such as those used by Cummings and Taylor (1999) and List (2001a) which explicitly indicate the direction of bias, the cheap talk script used by Chowdhury *et al*. (2009) was deliberately neutral in its wording. The study concluded that the introduction of cheap talk script does result in a significant reduction in valuations even when the script does not mention the direction of possible bias. However, the estimated WTP and marginal WTP are higher than those obtained in the real treatment, suggesting that while the bias is reduced, it is not eliminated and, indeed, remains substantial.

Gbegbelegbe *et al*. (2010) used a questionnaire survey combining cheap talk with choice experiment in *ex ante* analysis of Bt cowpea in Republic of Benin, Cotonou. According to Gbegbelegbe *et al*. (2010) cheap talk consists in explaining hypothetical bias to respondents so as to reduce its occurrence during the market simulation, and hypothetical bias occurs when the simulated market does seem familiar and believable to respondents. The choice experiment involves a simulation of a market scenario very similar to the one that respondents are exposed to in their transactions involving cowpea. In this experiment, the respondent is invited to imagine that he/she is in front of a seller in a market to buy cowpea. The seller then provides advantages/disadvantages of conventional and Bt cowpea prior to offering these products at given prices to the client. During the market simulation, respondents are informed about the advantages and disadvantages, including health risks, of Bt cowpea, prior to making purchase choices.

2.3.2 Concept of willingness to pay

According to Lusk (2003) willingness to pay is the amount of money taken from income that makes a consumer indifferent. Choong (2007) pointed that one of the ways in which the consumer preference can be evaluated is by acquiring the maximum amount that may be contributed by the individual to equalize a utility change. This is known as consumer's "Willingness-to-Pay".

Several studies have used willingness to pay estimates to elicit consumer preference for a new product or food quality attributes, and this measure is becoming an important tool for marketing decision (Alfines *et al*., 2006; Lusk and Hudson, 2004). A person's value for a good can be viewed from two perspectives, willingness to pay to purchase the good or willingness to accept to sell the good. The appropriate value measure to use depends on whether the person owns the perceived property rights to the good. Most of the literature on willingness to pay for product attributes focus on choice experiment (CE) and experimental auction (EA).

In this study, CE is the elicitation method that will be utilized due to its some desired theoretical properties and its practical relevance in the current case. CEs are consistent with random utility theory and Lancaster's theory of consumer demand (Adamowicz *et al*. 1998; *Alfnes et al., 2006).* In addition, CEs can be designed to resemble actual purchasing scenarios where more than one product attributes can be simultaneously evaluated (Lusk and Schroeder, 2004). *Despite of its advantage, the CEs has some drawbacks associated with,* namely the hypothetical nature of the survey and the construction of statistical design of choice questions (Lusk and Norwood, 2005). Because of this, the findings from the survey might suffer of hypothetical bias, resulting in a difference between the true preferences and the elicited preference. However, *this*

situation is not extremely significant, as statistical differences between hypothetical and non - hypothetical responses in a CE can be in general small (Lusk and Hudson, 2004).

Naico and Lusk (2010) estimated the parameters of the indirect, attribute-based utility function, which can be used to calculate the willingness to pay (WTP) for specific sweet potato attributes, and to estimate the market share for different options of sweet potatoes. After the parameters are estimated, then willingness to pay for k^{th} attribute is calculated using the negative ratio of the estimated parameter over the product of the marginal utility of income and the price variable. The study indicated that willingness to pay for orange versus white potatoes is about 21 MT and willingness to pay for high versus low dry matter content is about 35 MT. the results suggest that dry matter content is a key factor driving consumer acceptance.

2.4 Economic Welfare Measures

2.4.1 Marshallian Measures of Welfare

Marshall based his concept of consumer surplus (CS) on the diminishing marginal utility of a commodity, emphasizing that a consumer derives surplus utility from being able to buy a commodity at a particular price. But since, utility is not directly observable; Marshall needed a money measurement of welfare change that could be uniquely related to utility changes. He defined CS as "the excess of the price he would be willing to pay rather than go without the thing, over that which he actually does pay". As a measure of this revealed willingness to pay in terms of money, Marshall used the triangular area under the demand curve and above the rectangle to represent the actual money expenditure of the consumer.

The classical tool for measuring welfare changes is consumer surplus, which is the total benefit from the consumption of a product net of the total cost of purchasing it. When consumer's preferences can be represented by a quasi linear utility function, consumer surplus is an exact measure of welfare change. When utility is quasi linear, the compensating variation (CV) equals equivalent variation (EV) and both are equal to the consumer surplus integral. Hence, consumer surplus is an exact measure of compensating variation and equivalent variation only when the utility function is quasi linear. However, even when utility is not quasi linear, consumer surplus may be a reasonable approximation to more exact measures (Varian, 1992). Therefore, an unambiguous conversion of the surplus change into utility change can be made only when the slope of the utility function is constant (That is, when the marginal utility of income (MUI) , which is the conversion unit between money and utility is constant).

2.4.2 Hicksian measures of welfare

To overcome the very restrictive assumption concerning the constancy of the marginal utility of income, Hicks introduced four measures of the change in a consumer's welfare from an actual or proposed price change: compensating variation, compensating surplus, equivalent variation, and equivalent surplus. Substantial agreement exists that these represent the correct quantities to be measured. However, compensating variation and equivalent variation are only two measures that allow the consumer freedom of choice in responding to changing economic conditions.

Compensating variation is a measure of utility change introduced by Hicks. It refers to the amount of additional money an agent would need to reach its initial utility after a change in prices, or a change in product quality, or the introduction of new products. Compensating variation can be used to find the effect of a price change on an agent's

net welfare. Also, compensating variation reflects new prices and the old utility level. In other words, it is the amount of compensation, paid or received, that will allow consumers in their initial welfare positions after the change in price if they are constrained at the new price to buy the quantity that they would have bought at that price without compensation.

Equivalent variation is a closely related measure of welfare change that uses old prices and the new utility level. It measures the amount of money a consumer would pay to avoid a price change, before it happens. When the good is neither normal nor inferior, or when there are no income effects for the good then Equivalent variation = Compensating variation = consumer surplus. Thus, equivalent variation is the amount of compensation, paid or received, that will leave consumers their subsequent welfare positions without the price change if they are free to buy any quantity of the commodity at the old price (Stephen and Dixit, 1988).

2.5 Theoretical Framework

Utility is the conceptual basis for measuring consumer demand in economic theory. Demand theory has traditionally been based on the fundamental precept that a product or a service generates utility (Faye *et al.*, 2004). The traditional neoclassical consumer theory assumes consumers' utility is a function of the quantity of goods consumed. Recent research on new approach to consumer theory by Lancaster (1966) has focused instead on the utility consumers derive from quality attributes of products, and posits that consumers make a discrete choice of one of a finite set of discrete bundle of attributes. This new framework poses challenge to develop demand specifications based on discrete choice modeling (Chang, 2009).Since developed by McFadden (1974), the

random utility model (RUM) has been the dominant theoretical framework for studying consumer behavior in discrete choice contexts (Louviere *et al.*, 2000).

This present study used the random utility model in order to estimate the parameters of the indirect, attribute-based utility function, V_{ij} (systematic utility), that can be used to estimate willingness to pay for specific cowpea quality attributes and to calculate the market share for each different options of Bt and conventional cowpea varieties. The study used the random utility framework (RUT) developed by McFadden (1974) in the analysis because according to (Chang, 2009) the random utility model (RUM) represents the integration of consumer behavior and randomness, and specifies utility in terms of deterministic and random influences, making it ideally suited for the econometric analysis of choice. Researchers have considered more carefully the appropriate sources and form of random variation in individual models of discrete choice. Furthermore, (Greene, 1997) pointed that the *random utility model* of discrete choice provides the most general platform for the analysis of discrete choice.

According to Morrison (2009) the central idea of random utility theory (RUT) is that the probability of choosing one product alternative over another depends on the magnitude of the utility of each alternative, and the utility of each alternative depends on its attributes.

Following Louviere et al. (2000), the assumptions that can be made in random utility maximization are;

i. Assume each individual defines utility in terms of attributes via a common functional form

ii. Assume each utility value can be partitioned into two components: a systematic component or representative utility, and a random error component

iii. The utility parameter, initially assumed to be constant across individuals

Following the random utility framework introduced by McFadden (1974), it is assumed that individual *i*'s indirect utility from consuming Bt cowpea option j is:

$$U_{ij} = V_{ij} + \varepsilon_{ij} \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where U_{ij} ,is the i[th] consumer's utility of choosing option j, V_{ij} is the systematic portion of the utility function determined by attributes of the alternative j and potentially individual-specific characteristics, and ε_{ij} is a stochastic element, which represent unobserved idiosyncrasies of taste. Consumers are assumed to choose the Bt cowpea alternative that provides the highest utility.

2.5.1 Discrete choice modeling

Discrete choice models describe decision makers' choices among alternatives and these models are usually derived under an assumption of utility-maximizing behavior by the decision maker (Train, 1998). The simple discrete choice models include the behavioral models namely, conditional logit (CL) and mixed logit (mlogit) models.

Conditional logit describes a model in which the choices are described by the attributes of the choice not by the characteristics of the individuals. In this study, conditional logit was used to estimate the random utility model. The conditional logit is based on the assumption that the error term, ε_{ij} is independently and identically distributed with the extreme value distribution. The conditional logit also assumes that all individuals share

the same parameters for all individuals, which indicates that individuals have the same preferences for quality attributes.

Maximum Likelihood estimation (MLE) procedure was used to estimate the parameters in the systematic utility by maximizing the following log-likelihood function. The log-likelihood function will be maximized as:

$$LogL = \sum_{i=1}^{N} \sum_{c=1}^{12} \sum_{j=1}^{3} D_{ijc} \ln (P_{ij}) \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Where the probability of choice P_{ij} is D_{ijc} is a dummy variable taking the value of 1 if option j was selected by individual i in choice set c and 0 otherwise.

The probability of choosing a particular product alternative among the alternatives available will be modeled statistically using discrete choice models.

$$prob(V_{ij+} \varepsilon_{ij} \geq V_{ik} + \varepsilon_{ik} \, ; for \; all \; k \neq j) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

Where J is the choice set for respondent i, i.e., Ji = {option 1, option 2, option 3, etc.}

If the, ε_{ij}, are independently and identically distributed across the J alternatives and N individuals with a type I extreme value distribution (e.g., F (ε_{ij}) =exp (-exp (-ε_{ij})))

Because data were collected from people in different locations, it is of interest to determine whether the parameters vary by such factors. When making such comparisons, however, it is important to control for possible differences in error variance, which are confounded with the parameter estimates in discrete choice models.

A mixed logit cannot explain causes of any observed heterogeneity in individual preferences because each parameter value varies stochastically around its mean. One

way to address this limitation is to consider differences in preferences due to demographic and other characteristics of respondents. However, in discrete-choice models, researchers cannot directly include these characteristics in econometric models because they remain the same across all alternatives, whereas only attributes of the goods under evaluation vary across alternatives. Therefore, individual's characteristics must interact with the choice attributes or with the alternative-specific constants (Hanley *et al*, 2001).

There are two alternative interpretations of the results in logit model. First, it can be interpreted in terms of random coefficients by looking at a normal logit model by allowing each variable's coefficient to vary and allow correlation among the coefficients. Second, the model can be interpreted as error component and the model has fixed parameters but a more complicated error structure than logit. According to Train (2000) random coefficients and error component interpretations are formally equivalent. Under the random coefficients interpretation the parameter is a vector of coefficients, which can be decomposed into the mean and standard deviation while the distribution of the coefficients was specified.

This study considers various interaction terms between choice attributes and individual demographic characteristics such as age, income, gender, and education in order to determine if they have significant effect on willingness to pay.

2.6 Review of studies on Consumers' Awareness of Biotechnology/Genetically Modified Foods

Saket *et al*. (2004) analyzed and reported the results of a "person-on-the-street" survey of 200 consumers in northern Nigeria in early 2003 concerning consumer awareness of and acceptance of biotechnology. The study used descriptive statistics and binary logit tools of analyses. The preliminary summary statistics results showed that almost ninety

percent of the respondents were aware of genetic modification terminology. About 40% reported first becoming aware of the term on international radio broadcasts of the British Broadcasting Company (BBC), Voice of American (VOA) or Deutsche Welle (DW) radio, all of which have Hausa language broadcasts in the region. About 27% said the second most common source was from friends, neighbors and other social contacts while 18% reported that they heard about genetic modification through internationally distributed English language television programs from the Cable News Network (CNN) and the Discovery Channel. About 6% mentioned other sources of information including print media while another 6% mentioned extension, and 3.5% cited local radio, respectively. International radio was a more important information source for the respondents who reported aware; whereas television was a more important information source for the respondents who reported being unaware of genetically modified technology in the study area.

Given the debate concerning the level of awareness of African consumers about genetically modified technology, Saket *et al*. (2004) explored the socio-economic characteristics of those respondents who identified they were aware or unaware of genetic modification terminology. The study revealed that respondents who indicated awareness of this terminology were more likely to be younger, compared with the respondents who were not aware. Almost 60% of the respondents who indicated "Aware" were under the age of 40 while not quite 48% of the respondents who indicated "Unaware" were under the age of 40 years. Respondents who reported being aware of the genetic modification technology had more education than those who reported unaware.

The binary logit results suggest that ethical concern and international radio as source of information were important factors in whether consumers approve of genetically modified technology. In spite of the preliminary nature of the survey it was concluded that there is reason to believe that there was a high level of awareness of genetically modified technology among African consumers.

The Angus Reid (1999) world poll conducted in 8 countries (Australia, Brazil, Canada, France, Germany, Japan, United Kingdom and the United States) during late November and early December of 1999 examined public awareness regarding genetically modified foods. The results showed that to a large extent the public is aware of genetically modified foods. The Angus Reid group has charted a significant increase in the issue in Canada since September 1999 when only 64% of Canadians said they had heard or read anything about genetically modified foods. By December, 1999, that had increased to 78 percent, coinciding with the launch of Greenpeace campaign in Canada and subsequent increase in negative media coverage.

Results from a more recent Angus Reid World Poll (Angus Reid, 2000) indicate that consumer awareness is fairly high on a global scale with understanding being the greatest in Germany, Australia and the United Kingdom. In North America, 65 percent of Americans and 79 percent Canadians are aware of the issue but understanding remains low. Further, on the global scale, more than four in ten consumers (ranging from 44 percent to 58 percent) said that they only have "little" understanding about genetically modified foods. The results also show that consumers want to learn more about genetically modified foods, especially the technology of genetic modification, with 54 percent of Americans and 68 percent of Canadians expressing a willingness to learn more about genetically modified foods.

2.6.1 Review of studies on consumers' perception of bt cowpea/biotechnology

An ex ante socio-economic study conducted by Gbegbelegbe *et al*. (2010) found that farmers viewed Bt cowpea as way to improve cowpea yield in a safer way while the consumers also viewed Bt cowpea as a safer source of food compared to conventional cowpea. The results of the study imply that the population is accepting of genetically modified cowpea in the Republic of Benin.

Public perceptions of biotechnology have received extensive attention in most western countries (Fleising, 1991; Albretcht, 1992; Powell, 1998). There have been several surveys on public perceptions of biotechnology (Russell *et al*., 1987; Hoban, 1990; Miller, 1992; Hallman and Metcafe, 1994; National Science Foundation, 2000).

Earlier in the year 2000, the Angus Reid World Poll surveyed adult consumers on genetically modified foods in Australia, Brazil, Canada, France, Germany, Japan, United Kingdom, and United States (Angus Reid, 2000). Results from this international survey indicated that consumers around the world have a negative view about genetically modified foods and perceive the issue as one where the risks outweigh the benefits. Also, the context in which the consumers view the technology is more of a health and safety issue rather than progress in science and technology (Angus Reid, 2000).

Among the eight countries polled, the trend towards genetically modified foods was seen most negatively in Japan (82%), followed by Germany (73%) and France (71%). In North America, 51 percent Americans and 59 percent Canadians hold negative views about the technology and these figures have increased from 45 percent in both the United States and Canada in 1998. Over half of the consumers surveyed in Japan,

France, Germany, Australia, and Canada view the issue in a health and safety context, followed by 44 percent of Americans and 39 percent of consumers in United Kingdom. Only in Brazil, where awareness of the issue is the lowest, it is seen largely as a science and technology issue (61%).

Risk communication research has shown that consumers view risk very differently from scientists (Fischhoff, 1989). Therefore, to communicate effectively with non-technical citizens about food safety issues, scientists need to understand how consumers understand risks, While, most scientists define risks in rather narrow, quantitative terms (Groth, 1991), the public has a broader notion of what to be worried about and issues like control, benefit, familiarity and trust all enter the public mindset (Sophia and Powell, 2000).

Most consumers are wary of the perceived uncertainty that exists with agricultural biotechnology. According to the Angus Reid World Poll (Angus Reid, 2000), when consumers were asked about perceived risks associated with genetically modified foods, 31 percent of consumers cited food safety and health concerns. An equal proportion (30%) also said they were concerned about unknown impact and experimental nature of genetically modified foods.

A study conducted by Benjamin *et al*. (2004) examined the role of product benefits and potential risks in consumer acceptance of genetically modified foods in United States. The study analyzed consumer willingness to consume three meat products that confer specific benefits with an inherent risk. The meat products were from animals fed genetically modified corn or soybeans, genetically modified beef with less fat and cholesterol, and genetically modified meat products that prevent food poisoning. The

results indicated that respondents who were provided both the product benefit and risk information were less likely to consume the three genetically modified meat products than those who were only provided the product benefit information. Results also suggest that males were consistently more likely to consume the three meat products than females. Also, the results showed that those who take time to read food labels were also consistently less likely to consume the three meat products. Differences in social or political values (that is, conservative or liberal) and trust in private and public entities were not significant factors affecting consumers' willingness to accept genetically modified foods.

2.6.2 Review of studies on consumers' knowledge of genetically modified foods

Survey-based studies on public perceptions of biotechnology have found evidence that respondents' knowledge of science (relating to biotechnology) is related to their acceptance of transgenic technology. A study by Benjamin *et al*. (2004) explored the issue and included consumers' objective knowledge as an independent variable in their empirical model. According to Benjamin *et al*. (2004) objective knowledge measure was obtained by asking the survey participants to correctly answer a set of 11 questions.

Consumers are overconfident because they think they know more than they actually do (Alba and Hutchinson, 2000). The impact of knowledge on decision making, and the measurement of this variable, has long been a subject in marketing literature. Brucks (1985) described three categories of consumer class knowledge used in consumer behavior research, namely, (a) subjective knowledge, is an individual's perception of how much he/she knows; (b) objective knowledge, is a measure of what an individual actually knows; and (c) prior experience, is the amount of purchasing or usage

experience the consumer has with the product. However, according to Brucks, experience-based measures of knowledge are less directly linked to behavior.

Differences in objective and subjective knowledge occur when people do not accurately perceive how much or how little they actually know. Jacoby (1974) noted that it is "not what is provided by the source, but how this information is perceived and affects the receiver (or class of receivers) which should be the preliminary and the major focus of the entire public policy issue".

There appears to be significant disagreement on the impact of knowledge on consumer acceptance of biotechnology, however, much of this disagreement can be explained when considering the type of knowledge used in each study.

Gaskell *et al*. (1999) measured objective knowledge and found that textbook knowledge (as measured by a score on a true/false 'textbook" items on general knowledge about foods and genes, enzymes, etc.) was significantly higher in Europe than in the United States. The study concluded from this that levels of knowledge did not explain the more positive attitudes in the United States towards genetically modified foods. In contrast, however, Hoban (1998) also measured objective knowledge and found that U.S. consumers were better able to accurately answer true/false questions than European consumers. Chern *et al*. (2003) tested knowledge with true/false questions. Although the authors questioned differences in these ratings by country (comparing the United States, Norway, Japan, and Taiwan) in levels of objective knowledge, they appear to have combined measures of subjective and objective knowledge into one variable in their final estimation of willingness to accept thereby making it hard to understand the conclusions.

A few studies have found significant positive relationships between subjective knowledge and willingness to accept genetically modified foods. Boccaletti and Moro (2000) measured subjective knowledge in Italy using a four-point self-rated scale and found that knowledge played "an important role in purchasing decisions regarding products exhibiting a lower use of pesticides and organoleptic properties".

A study conducted by House *et al*. (2004) on the impacts of objective and subjective knowledge on consumer demand for genetically modified foods in the United States and the European union found that perceived (subjective) knowledge was negatively associated with the amount of information acquired by consumers making food purchase decisions, and measured knowledge (score on quiz) was unrelated to information acquisition.

2.6.3 Review of empirical ex-ante studies

A baseline study of insect resistant Bt cowpea was commissioned by the African Agricultural Technology Foundation in the year 2008 to assess the regional impact of Bt cowpea through *ex-ante* analysis prior to the introduction of Bt cowpea in west Africa. The theoretical models used to analyze data in the study included two basic models, one for modeling the representative farm household for optimal decision making and a second one for the representative consumer perceptions and willingness to pay and consume Bt cowpea products. Preliminary results showed that there is high willingness to pay (WTP) for Bt cowpea seed by farmers. Urban consumers in regional markets believe that Bt cowpea may be safer than conventional cowpea treated with chemicals. Given the potential of reducing health hazards by lowering the use of synthetic pesticides, both farmers and consumers are WTP a premium price for Bt cowpea as an

alternative to harmful cotton pesticides. The study concluded that majority of producers and rural consumers are not aware of GM food or GMO products.

A study conducted by Gbegbelegbe *et al*. (2010) used choice experiment (CE) or choice-based conjoint protocol combined with cheap talk to estimate the *ex ante* economic impact of Bt cowpea (GM crop) on producers and consumers in Benin, Niger, and northern Nigeria. The experiment involves the simulation of a market transaction very similar to the one respondents are exposed to in the open air markets where they usually buy cowpea. During the market simulation, respondents are informed about the advantages and disadvantages, including health risks, prior to making purchase choices. The study used the household theoretical model to capture the problem of the typical family in West Africa. Also stratified random sampling was used to sample cowpea growers, rural and urban consumers in the major cowpea producing agro-ecological zones in Benin, Niger republic and northern Nigeria, respectively. The authors applied expected utility theory and estimated exponential demand functions using the Seemingly Unrelated Regression (SUR) analysis. The study demonstrates that regression data need to satisfy the assumptions underlying regression techniques to provide credible results. The results from the study suggest that cowpea growers and consumers in Benin and northern Nigeria prefer Bt to conventional cowpea because they believe that with Bt cowpea, they would be able to avoid the health hazards related to chemical insecticide misuse. More specifically, the results imply that social welfare in all of Benin, Niger and northern Nigeria would increase by at least US$512 million per year with the introduction of Bt cowpea, given the yield, price and income risks faced by economic agents in the region and given that seed sectors are operating smoothly. Such welfare increase translates into about US$7.14 per capita annually in the

region. With inefficiencies in seed sectors, the estimated social welfare increase in the region would be about US$90million per year or about US$1.6 per capita annually. The study concluded that seed sector inefficiencies could substantially decrease the benefits from Bt cowpea in west Africa.

Boughton *et al*. (2009) conducted an *ex ante* analysis of the private and social profitability of the introduction of Bt cotton for a major cotton producing area of northern Mozambique. Multivariate regression model was used to quantify the relationship between pest control and yield loss at farm level as a basis for estimating the expected yield gain from the introduction of Bt cotton. The study analyzed on –farm profitability of Bt cotton using partial budget analysis. The determinants of yield were modeled with a Cobb-Douglas specification in terms of the dependent and continuous independent variables. The results revealed that partial budget analysis of technical packages with and without Bt cotton seed indicates a strong divergence between private (negative) and social (positive) profitability. The Mozambique case indicates that effective bio-safety and legal frameworks may be a necessary but not sufficient condition for Bt cotton technology adoption and poverty reduction. Policy changes to align private and social profitability of cotton production with Bt seed, as well as complimentary improvements in crop management, especially timely planting and weed control, are also necessary for Bt technology to change the fortunes of Mozambican cotton growers. With improved policy and technology in place the adoption of Bt cotton varieties could result in a sizeable reduction in poverty as measured by the predicted change in squared poverty gap.

Doupe and Lembery (2002) used budget analysis to estimate the impact of genetically modified (GM) species on two Australian fish production systems. Their analysis dealt with random character of fish growth rate, prices and fish survival rates by undertaking sensitivity analysis with a range of values for these three variables. The conclusions by Doupe and Lembery are unlikely to be accurate since fish growth rate; prices and survival vary simultaneously in the real world but are varied one after the other in the sensitivity analysis. According to Gbegbelegbe and Lowenberg- DeBoer (2008) the impact of one factor cannot be accurately estimated with the model used by Doupe and Lymbery (2002). Typically budget analysis uses sensitivity testing to examine risk, but the interpretation of the results is highly subjective. It is difficult to incorporate probabilities and utility information (that is, risk aversion levels) into budget sensitivity testing. If there are many observations on the results of using a technology, it may be possible to budget out benefits for each observation and estimate distributions which can be compared using stochastic dominance rules. The advantage of budget analysis is that it can quickly provide credible and useful results with sparse data and modest expertise. However, the method lacks credibility with client when the analysis involves risk or a large variety of input-output combinations (Gbegbegbelegbe and Lowenberg-DeBoer, 2008).

A study by Preckel (2003) used mathematical programming to estimate how an adverse consumer reaction to genetically modified (GM) grain could affect Unites States (U.S) agricultural production sector. The authors derive a detailed mathematical model which supposedly captures the processes linking the production and uses of grains from the perspective of U.S grain farmers. Then, a model was used to determine optimal production decisions under the status quo as well as under a decrease in the demand for

U.S GM grains. The study validated the model by showing that optimal production decisions under the status quo resemble collected sparse data which reflect production activities in U.S agricultural sector in 1998. The study concluded that GM grains would be shifted from export to domestic uses if U.S. trading partners were reluctant to accept GM grains.

After reviewing the literature, it was discovered that the empirical ex ante studies in Africa had made little effort to use choice experiment to examine household behavior and estimated the ex ante economic impact of Bt cowpea on cowpea growers and consumers using expected utility theoretical framework based on the economic state of the seed sectors given price and income risks. For example, income earnings can go up or down and for most consumers future incomes are uncertain. Also, if a person delay buying a product in the market for consumption will risk price increases that could make such purchases less affordable. Typically expected utility is an average of the utility associated with each outcome, with the associated probabilities serving as weights. The advantage of using expected utility is to measure payoff or value associated with a possible outcome in terms of utility rather than monetary terms. The expected utility requires two pieces of information such as a utility value for each outcome form the utility function and the probability of each outcome. Also, consumers make decisions in which there is uncertainty about the future.

However, the previous ex ante studies on Bt cowpea are relatively quiet on discrete choices that consumers among a set of specific alternatives. This study provides the departure point from the previous ex ante studies on Bt cowpea by analyzing discrete consumer choices, rather than modeling choice behavior under uncertainty about the

future. According to Train (2009) researchers use discrete choice methods to examine the choices that consumers, households, firms, and other agents make. For example, in forecasting for a new transit system the discrete choice models predicted quite well, far more accurately than the procedures used by consultants of a new rail system, called Bay Area Rapid Transit (BART) who had not used discrete choice models.

CHAPTER THREE

METHODOLOGY

3.1 Description of the Study Area

The study was conducted in Kaduna and Sokoto States, Nigeria. The study areas are situated in northern Nigeria, an area of limited rainfall (Norman, 1975). Kaduna State lies between latitudes 09^0 2' and 11^0 32' north of the equator and longitudes 06^0 15' and 80^0 50' east of prime meridian. The climate varies from the North to the Southern part of the states. The vegetation is divided into the Northern Guinea Savanna in the South while the mean annual temperature varies between 24^0C and 27^0C (Banta, 2011).

Agricultural production in Kaduna State is carried out predominantly by small-scale farmers whose labor, capital and management originate mostly from the household. The cropping system in the state is dominated by mixed cropping, although sole cropping system is also practiced. The main crops grown are: cowpea, groundnut, soya bean, maize, sorghum, yam and vegetables (Abdul Rahman, 2001). Mixed cropping is shown in this area to be under indigenous technological conditions, which is a rational strategy both in terms of profit maximization and risk minimization. Sorghum, cotton and groundnuts are grown as sole crops while the main crop mixtures are cotton/cowpeas, cotton/ cowpeas/ sweet potatoes, and millet/sorghum/groundnuts/ cowpeas (Norman, 1975).

Both Kaduna and Sokoto States have high concentration of cowpea farmers. Cowpea has great potential to increase production and farmers income in the study area (Mohammed and Mohammed, 2014). However, one of the constraints facing cowpea growers in the study area is the use of cowpea storage methods which are prone to

losses of grains and poses health risks to consumers. Dogondaji (2000) in a study of cowpea storage losses in Sokoto State found that cowpea farmers store about 85% of the cowpea produced for future sales and consumption and unfortunately 13% was lost in storage. It was also observed that cowpea was mostly stored in threshed form and through the use of chemicals or pesticides.

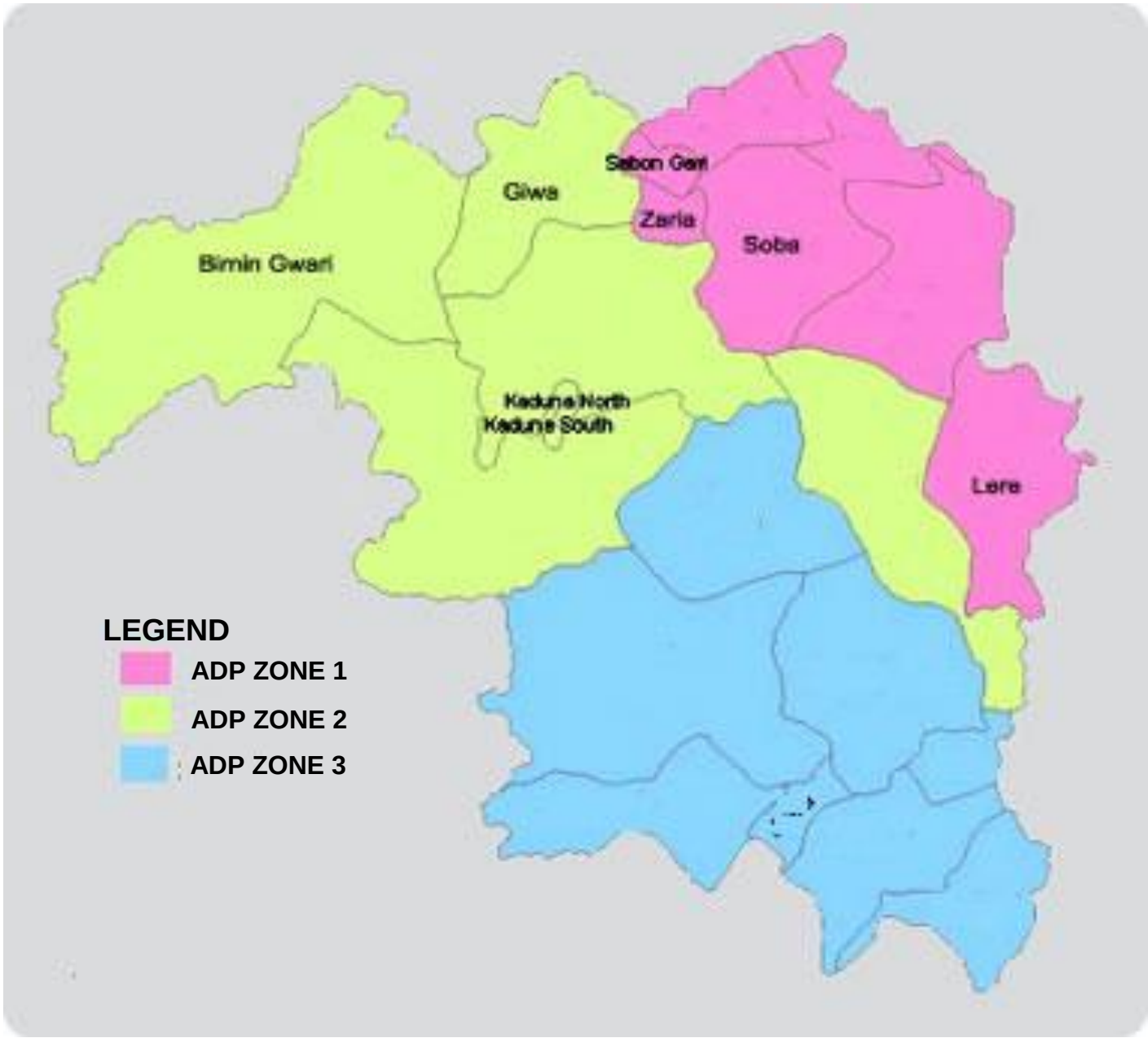


Figure 1: Map of Kaduna state showing the study Areas

The State covers a total land area of 46,053 square kilometers (17,781 square miles). According to the national population census statistics of 2006, Kaduna state has a total population of about 6,066,562 people with a density of 130 per square kilometers, which is about 340 per square miles.

Sokoto State on the other hand, is located within the Sudan Savanna zone in the North western part of Nigeria, and lies within longitudes 3^0 and 6^0 E and latitudes 8^0 and 13^0 N (Obiora, 2014). Sokoto has a semi-arid climatic condition, characterized with low rainfall varying widely in amount from year to year (500m-1300mm) and a long dry season. Diurnal and seasonal temperature fluctuations are very wide. Maximum temperature of 41^0 C is attained in April while minimum temperature of 13.2^0 C occurs in January. Humidity is very low during most parts of the year and solar radiation is relatively high due to dry atmosphere and clear skies (Obiora, 2014).

The State is also divided into 23 Local Government Areas (LGAs) as shown in Figure 2. The state has a total land area of 25,973 square kilometers (10,028 square miles). Sokoto state has a total population of 4,244,399 people with a density of 170 per square kilometers, which is about 440 per square miles. Sokoto state is essentially an agrarian state with traditional mode of production predominating and more than 90 percent of the population engaged in subsistence farming. The main crops produced in the state are cowpea millet, guinea corn, maize, rice, wheat, cassava, potatoes, groundnut, cotton, sugarcane, and tobacco. Fruits and vegetables grown in the state include oranges, mangoes, cashew, bananas, lettuce, onions, spinach, okra, cabbage, pawpaw and guava (Obiora, 2014).

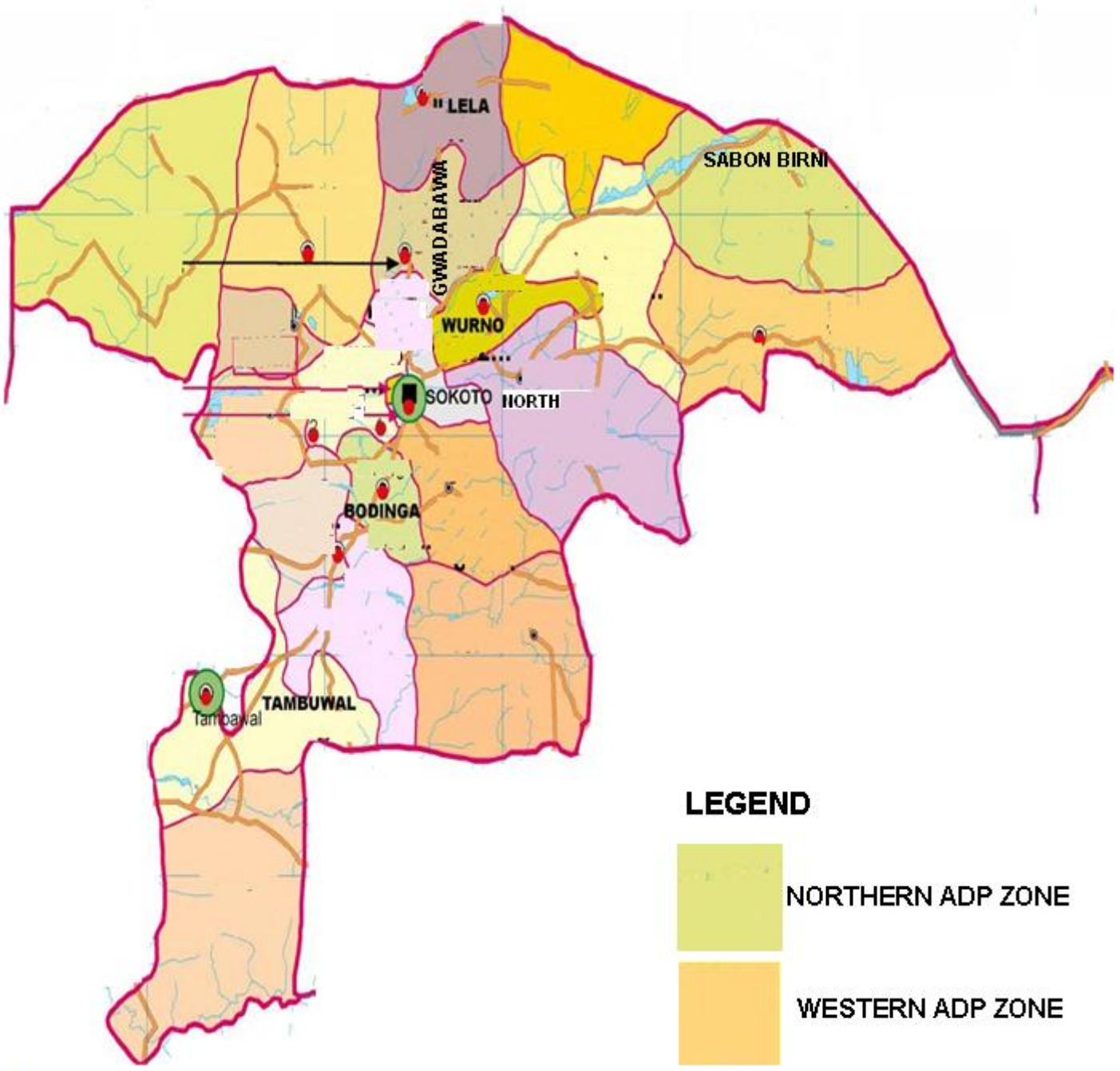


Figure 2: Map of Sokoto State showing the study areas

The study used multistage random sampling procedure for the selection of secondary sampling units (local government areas and markets). In the first stage, a random selection of LGAs was made in each Agricultural Development Zone (ADP). Three ADP zones were selected in Kaduna state while two zones were selected in Sokoto state. The selection of different number of ADP zones per state is based on the number of zones. In the second stage, a random selection of markets was made in each LGA.

The random selection of the LGAs and the markets was carried out from the available sampling frame compiled by the ADPs in each state.

In the random selection of primary sampling unit (individual cowpea consumers), the study followed the procedure employed by Lusk and Schroeder (2004); and, Lusk and Naico (2010). Within a location, subjects were randomly selected from several local marketplaces to ensure a representative sample of the general cowpea consumer population. The local market committee and raw cowpea traders/sellers were requested for permission to contact and interact with individuals that mostly buy cowpea for home use or personal consumption for participation in the survey. Random sample of consumers were selected to evaluate quality attributes of Bt cowpea in the selected markets. Participants were informed about their rights to accept or decline the interview, and it was made known that no one would face consequences for his or her unavailability or unwillingness to participate. Random samples of 208 respondents were selected as presented in Table 3.1.

Table 3.1: Sample Size for the Study

State	Target population	ADP Zones	LGAs selected	Sample size
Kaduna State	Individual beans shoppers	Maigana	Zaria	24
			Giwa	18
			Sabon Gari	13
		Lere	Saminaka	20
		B/Gwari	Chikun	20
			Kaduna south	
Sokoto State	Individual beans shoppers	Northern Zone	Wurno	20
			Sokoto North	24
			Gwadabawa	25
		Western Zone	Tambuwal	20
			Sabon Birni	12
			Bodinga	12
Total		**5**	**12**	**208**

3.2 *Data Collection*

Data were collected by the researcher and assisted by trained enumerators in September/October, 2013 in Zaria, Giwa, Sabon Gari, Chikun and Kaduna South Local Government Areas of Kaduna State as well as in Wurno, Sokoto North, Gwadabawa, Tambuwal, Sabon Birni and Bodinga Local Government Areas of Sokoto State using choice experiment (CE) designed questionnaires. The designed questions were asked in a CE to elicit preferences of consumers on Bt and conventional cowpea. The experimental design of the CE comprises of three options, namely Bt and conventional cowpea, and "none" option. The full factorial design was initially constructed to obtain 144 possible combinations of the attributes while orthogonal fractional factorial was later designed to reduce the number of combinations to 12. *In a CE, people make a* series of repeated choices between different products defined by multiple attributes. In

this CE, Bt cowpea was described by key attributes such as price, safety, color, grain size and insect damage. These attributes are potentially applicable in explaining choices between wide ranges of cowpea products in order to estimate consumer preferences.

This survey used interviews and literature review in collection of data which centre on identification of appropriate attributes of Bt cowpea such as price, color, safety from insecticide misuse, grain size, Genetically Modified Organisms (GMO) and insect damage. Information on consumers' awareness / perception regarding Bt cowpea was collected. Awareness is the first stage consumers go through in the process of adopting a new product. Initially, the consumer must become aware of the new product. A new product is a good, service or idea that is perceived by some potential customers as new (Kotler and Armstrong, 2008). This study examined consumer awareness for the new Bt cowpea because genetic transformation of cowpea with *Bacillus thuringiensis (Bt)* genes to control pod boring insects has many advantages, but little is known about the potential consumer response on genetically modified (GM) products in Nigeria. Hence, awareness was investigated to better understand potential consumer response to Bt cowpea in the study area. Information on socio-economic characteristics such as age, gender, education and income were collected.

3.3 Analytical Techniques

The tools used for data analysis to achieve the objectives of the study are: descriptive statistics, conditional logit and mixed logit models, willingness to pay and compensating variation.

3.3.1 Conditional Logit (CL)

The conditional logit describes a model in which the choices are described by the attributes of the choice. It is a model designed to explain the choice of food products based on attributes of the choice itself NOT by the characteristics of individuals that make the choices. Conditional logit (CL) model is the easiest, simplest and the most widely used discrete choice model. Its popularity is due to the fact that the formula for the choice probabilities takes a closed form and is readily interpretable.

The CL model is derived under the assumption that each unobserved factor is independently identically distributed (iid) extreme value and can be expressed as follows:

$$\Pr(Y_i = j) = \pi_{ij} = \frac{\exp(x_i \beta_j)}{\sum_{J=1}^{K} \exp(x_i \beta_k)} \quad \ldots\ldots\ldots\ldots (1)$$

Where,

Pr = the probability that a consumer chooses alternative j,

exp=exponential function

B= the marginal utility parameter. The parameter is fixed, or is the same for everyone and is not a random parameter.

$Y_{i,=}$ the choice dependent variable between several discrete outcomes that takes one of the values from 1 to J (total number of categories),

J= options chosen by consumers such as Bt cowpea, conventional cowpea, none

$\times_i$= the vector of observed explanatory variables such as price, color, grain size for observation i

i=1……n individual consumers

The major limitations of conditional logit include no correlation in utility over alternatives giving rise to the Independence of Irrelevant Alternatives (IIA) property, and assume the marginal utility parameters are fixed over decision makers.

Assuming that the representative utility is linear in parameters, the functional form of the utility function in the conditional logit model may be specified as:

$$\boldsymbol{Vnj = \alpha_j + \beta\chi_{ni} + \varepsilon ni} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textbf{(2)}$$

With

εni ~ iid extreme value and identically zero, so that there is no correlation in utility over alternatives.

Where,

Vnj = Representative utility, which is usually specified to be linear in parameters

α = Alternative specific constant, which is the utility provided by a particular alternative or option that is not explained by variation in attributes. If there are j choice alternatives only J-1 alternative specific constants can be estimated.

n = nth attribute value for choice alternative j

i = consumer i

j = choice alternative

X_{ni} = is the attributes of choice which vary across choices

β = Marginal utility parmater to be estimated and is fixed over decision makers

εni = Unobserved portion of utility

3.3.2 Mixed logit

Mixed logit is a fully general statistical model for examining discrete choices and a highly flexible model that can approximate any random utility model to any degree of

accuracy (McFadden and Train, 2000). The mixed logit assume that the parameter in the model varies over decision makers and unobserved portion of utility can be correlated over alternatives, and exhibit heterogeneous preferences. Because of the concern for bias in the violations of behavioral assumptions in conditional logit (CL), it can be extended to the mixed logit (mlogit) considering respondent heterogeneity.

The mixed logit allows the parameters of attributes to vary across population and relaxes the Independence of Irrelevant Alternatives (IIA) assumption. It obviates the three limitations of standard logit by allowing random taste variation, unrestricted substitution patterns, and correlation in unobserved factors over time. It should be noted that in a logit model, each variable takes a different value in each alternative. Unlike CL, simulation was performed in mixed logit using one thousand random *halton* sequence draws for each sampled consumers, and mean and standard deviation for each attribute were reported.

In mixed logit model, the estimated mean and standard deviation statistics of the random coefficients provides important information on a share of the population that places positive value on the cowpea attributes and the share that places negative value. The mean and standard deviation obtained from the mixed logit were used to determine market share above and below zero for each attribute. The share of the respondents was computed using the mean divided by the standard deviation, which is assumed to follow the standard normal (Z) distribution. The formulae namely, Normsdist(Z) and 1-Normsdist(Z) were used to compute market share above and below zero, respectively.

Mixed logit model can be expressed as follows:

$$P_{ni} = \int L_{ni(\beta)} f(\beta) d\beta \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where ,

P_{ni} = the probabity of individual n choosing option I

$Lni(\beta) = \frac{e^{V_{in(\beta)}}}{\sum_{j=1}^{J} e^{V_{in(\beta)}}}$, which is he logit probability evaluated at random parameters

$\boldsymbol{\beta}$s, which are different for each person (i.e, each decision maker)

$f(\beta)$ = density function, which is a function of parameters βs that represent the mean b and covariance W of βs in the population. Using maximum likelihood estimation framework, the mean and covariance are considered fixed and were estimated on a sample of consumers drawn from the population.

$V_{in(\beta)}$ = the observed portion of the utility, which is linear in parameters

$d\beta$ = integration over β

n = individual consumers

i = consumer i

For the mixed logit model, the utility specification is:

$$\boldsymbol{Uni} = \boldsymbol{\beta_n \chi_{ni} + \varepsilon ni} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

With

εni ~ iid extreme value. With nonzero error component, utility is correlated over alternatives giving rise to no IIA

$$\boldsymbol{\beta_n} \sim f(\boldsymbol{\beta_n} / \boldsymbol{\theta})$$

This specification is generalized by allowing $\boldsymbol{\beta_n}$ to be random.

Where,

Θ are the parameters of the distribution over the population, such as the mean and covariance of $\boldsymbol{\beta_n}$.

$\boldsymbol{\beta_n}$ = random parameter and not known. It allows the slope of utility (i.e, marginal utility) to be random. The coefficient or random parameter can be decomposed into mean and standard deviation

3.3.3 Willingness to pay

Willingness- to- Pay (WTP) was computed as the ratio of each coefficient to the negative of price coefficient to achieve objective 3. The WTP provide economically meaningful information and was calculated using the following formula:

$$WTP = \frac{\beta}{-Price} \quad \text{..... (5)}$$

Where,

WTP = willingness to pay

β = Coefficient

j = Choice alternatives or options

P = Price coefficient

3.3.4 Potential market share

The study predicted the potential market share of the new Bt cowpea relative to conventional cowpea using the estimated coefficients from the conditional logit (CL) model. There is no formula for the predicted market share but the average probability is the predicted share for an alternative. The probabilities were calculated and predicted

the market share (i.e average probability) for all the alternatives using simulation for each draw in the bootstrapped samples to achieve objective 4.

3.3.5 Expected welfare net benefit

To estimate the consumer welfare effects of introducing Bt cowpea, the methods outlined in Hanemann (1999) and Moorey (1999) were followed. In particular, they show that compensating variation (CV) can be calculated as:

$$CV = -\frac{1}{\alpha}\left[\ln\sum_{j=1}^{2}\exp(V_j^0) - \ln\sum_{j=1}^{3}\exp(V_j^1)\right], \qquad \text{..... (6)}$$

Where,

V_j^0, represents the utility of option *j* in the initial condition when only conventional cowpea is available for sale (the other option is the choice not to purchase – i.e., choose "none.")

V_j^1, is utility in the situation where both Bt and conventional cowpea are available for sale. Thus, the CV equation calculates the consumer benefit (in Naira per choice occasion) from having an additional choice option.

α represents marginal utility of income, which is negative of the negative price coefficient.

Welfare estimates were calculated under the assumption that the average price of cowpea is ₦250/kg (Exchange rate: US$1= ₦155). Numbers in brackets are 95% confidence interval calculated using Krinsky-Robb bootstrapping method. The aggregate welfare benefit was estimated using representative indirect utility function, options presented in the survey and consumer choices. Specifically, the expected welfare was computed as the utility consumers gained by moving them from one world

where they have to make only one choice for option of conventional cowpea to another world where they would make two choices for options of conventional and Bt cowpea.

3.4 Statistical Inference

3.4.1 Parametric bootstrapping

Confidence intervals (CI) for both WTP and market share were obtained using the parametric bootstrapping method developed by Krinsky-Robb (1986). The method is based on taking a large number of draws from a multivariate normal distribution with means or averages given by the estimated coefficients and the variance given by the covariance – matrix.

The CI is to create an interval estimate for the population parameter instead of working with a point estimate. Descriptive statistics was used to get the desired confidence interval, which was used to test for significance of the willingness to pay estimates and predicted market shares.

Standard deviations of willingness to pay (WTP) were derived by generating a distribution of 1,000 WTP estimates using the parametric bootstrapping method proposed by Krinsky and Robb (1986). More specifically, 1000 observations were drawn from multivariate normal distributions created using the coefficient estimates, the variance – covariance matrices from each of the econometric models. The WTP and predicted market share were computed for each draw.

The likelihood ratio was used to test for preference homogeneity and equality of parameters in the conditional logit model. Chi square test was used to test for significant

difference in consumers' awareness and perceived risks/benefits and location (Kaduna and Sokoto states) while t test was used to test for significant difference between the age, gender, education and income of consumers and location.

3.5 Attribute-based Utility Function

Each participant indicated which of the three choices (Bt, conventional cowpea, "None") they most preferred in each of the 12 CE questions. It is assumed that choices between Bt and conventional cowpea are driven by an attribute-based utility function, which is specified as follows:

$$V_{ij} = \alpha PR_j + \beta_1 WH_j + \beta_2 BR_j + \beta_3 SA_j + \beta_4 SL_j + \beta_5 GMO_j + \beta_6 IND_j + \beta_7 Bt_j + \beta_8 Con_j \quad (7)$$

Where, PR_j is the price for alternative j, WH_j is the dummy variable equals to 1 if the alternative j has white color, BR_j is the dummy variable equals to 1 if the alternative j has brown color, SA_j is the dummy variable equals to 1 if the alternative possesses safety, SL_j is the dummy variable equals to 1 if the alternative has large grain size, GMO_j is the dummy variable if the alternative has GMO, IND_j is the dummy variable equals to 1 if the alternative has insect damage, Bt_j is the dummy variable equals to 1 if the alternative is the Bt cowpea, and Con_j is the dummy variable equals to 1 if the alternative is the conventional cowpea, α is the marginal utility of income (or marginal disutility of price), and β_k are marginal utilities to be estimated.

3.5.1 Operational definition and a priori sign of the study variables

i. It was hypothesized that price will have the expected negative relationship with probability of choosing an attribute of Bt cowpea. Price refers to the retail price of conventional cowpea (N/kg). Price attribute was chosen based on economic theory and past studies on genetically modified foods. The price was measured

as the prevailing market retail price while the average price and standard deviation of conventional cowpea prices was computed to infer the price of Bt cowpea and then checked for price variability.

ii. Safety can logically take a positive sign if it is desired by consumers. Safety attribute refers to the safety from pesticides misuse in cowpea. Safety is a qualitative factor varied at two levels or categories. The rationale for selecting safety attribute is because residues from several chemical pesticides in cowpea have been linked to death and other human health hazards such as food poisoning in West Africa including Nigeria.

iii. Cowpea color can take a positive sign among Nigerian consumers. Color refers to the visual appearance of the cowpea grains such as white, red and brown cowpea color.

iv. Heard was a dummy variable used as a proxy for awareness (1 if consumers heard of Bt cowpea; or 0 if otherwise).

v. Consumers' view was generated as dummy variable that represent perception (1 if consumers hold some negative view about Bt cowpea, or 0 if otherwise)

vi. It was hypothesized that age had a positive sign when interacted with price. Age was measured in numerical years. The effect of age on willingness to pay was analyzed to examine whether the effect of age on willingness to pay is different across States and combined, and how the age groups tend to value cowpea attributes in the study area. To conduct the analysis, dummy variables for three age groups were generated (Young Age =1 if a respondent is in 20 or 30 years, otherwise Young Age = 0; Middle age =1 if a respondent is in 31-59 years, otherwise middle age = 0; Old Age = 1 if a respondent is over 60 years, otherwise Old Age = 0). Then, interaction of Young Age dummy variable with

price was included in the original conditional logit model, estimates the model and calculated willingness to pay for each cowpea attribute. The price variable was used for the interaction in order to provide a monetary valuation of the variation in other attributes. The willingness to pay for the age of consumers in 20 or 30years with price interaction relative to the age group over 60 years was estimated.

vii. Gender was a dummy variable that represent the sex of individuals (1 if male; or 0 if otherwise). It was hypothesized that gender had a positive sign when interacted with price. The effect of gender on willingness to pay was analyzed to examine whether the effect of gender on willingness to pay is different across states and combined, and how the gender groups tend to value cowpea attributes in the surveyed area. Dummy variables for gender was generated as (gender =1 if a respondent is female, otherwise gender = 0).

viii. Education refers to acquisition of knowledge through formal or informal means. It was a dummy variable that represent the level of education (1 if primary education; 0 otherwise). The hypothesized sign for education was positive. Dummy variable for education was generated as (formal education = 1 if a respondent had attained western education, otherwise formal education = 0).Education level was categorized as formal on the basis of the western education attained such as primary, secondary and university while informal education include the Quranic or Arabic and Islamic education attained by the respondents in the study area.

ix. Dummy variables for two income groups were generated as (low income =1 if a respondent's annual income is less than or equal to ₦19, 999 otherwise low income = 0; middle income =1 if a respondent's annual income is between ₦

20,000- ₦100, 000, otherwise middle income = 0). Two dummy variables of low and medium income were generated because according to 2010 gross national income (GNI) per capita, calculated using World Bank Atlas method, Nigeria was a lower-middle income country. Thus, consumers are expected to belong to the lower and middle income groups in the study area. Annual Income refers to the annual income of the individuals and was measured at the interval level of measurement. The unit of annual income is in money (Nigerian naira). Positive sign was expected when income was interacted with price.

x. Perception is the process by which people select, organize and interpret sensory information of sight, hearing, smell, touch and taste to form a meaningful picture of the world (Kotler and Armstrong, 2008). Consumers' perceived knowledge is an individual's perception of how much he/she knows about Bt cowpea. The study used consumers' subjective knowledge rather than their objective knowledge because the respondents were not better able to accurately answer tested true/false questions about Bt cowpea and genetically modified foods. To ascertain consumers' subjective level of knowledge, respondents were asked whether they had heard of Bt cowpea and how knowledgeable they were about the new Bt cowpea. Awareness and perceived knowledge are quite different terms.

xi. Consumers' negative views about transgenic Bt cowpea were mostly based on the ethics of Bt cowpea genetic modification. The relevance of analyzing consumers' negative views about transgenic Bt cowpea was to obtain measures of degree of acceptance of transgenic Bt cowpea based on the assumption t on the belief about consumers' abilities to report degrees of acceptance in the study area.

The development of genetically modified plant technology raises to kinds of issues, namely the scientific and the ethical. Although it may be scientifically possible to introduce the new Bt cowpea for commercial planting, it does not follow that it would be ethically right to do so. Ethics comes into play in situations where humans are manipulating with natures genetic makeup. Consumers may be scared that genetically modified including Bt crops are hazardous, but it is assumed that existing natural strains are safe (Cuellar, 2004). The study expressed consumers negative views as measures of degrees of acceptance of Bt cowpea by rating scale (0 – 6) with 0 as do not know and 6 as ethical.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Consumer Awareness of Bt Cowpea

The analysis of consumers' awareness for Bt cowpea according to states and combined data is presented in Table 4.1. The combined result showed that 19.71% of the respondents said they had heard about the new Bt cowpea before this survey. The result implies that consumer awareness of Bt cowpea was low in the study area. This suggests that there was low consumer response potential about Bt cowpea in the study area. A possible explanation for this might be the Bt cowpea project has not made a strong effort to make adequate sensitization or use the media, radio mostly, for communicating the project message to the communities. Another explanation may be due to lack of public information and awareness creation on Bt cowpea in the study area. This finding is in agreement with OFAB (2009) who pointed that in general a poor awareness of biotechnology remains high in all regions throughout the world.

The result in Table 4.1 further revealed that only 12.20% of the respondents said they were aware of Bt cowpea in Kaduna State while majority (87.80%) of the respondents were aware of Bt cowpea in Sokoto State. The results imply that consumers' awareness of Bt cowpea was higher in Sokoto state than in Kaduna state. The huge gap in consumer's awareness of Bt cowpea of about 75.6% might be attributed to the perceived knowledge of respondents where respondents in Sokoto State had perceived how much they heard about Bt cowpea more than respondents in Kaduna State. Another possible explanation could be respondents were more likely to be informed about Bt cowpea in Sokoto State than respondents in Kaduna State.

Table 4.1: Distribution of Respondents According to their Awareness of Bt Cowpea in the States

	States					
	Sokoto		Kaduna		Combined	
Awareness	**Frequency**	**Percentage**	**Frequency**	**Percentage**	**Frequency**	**Percentage**
Not Aware	103	61.68	64	38.32	167	80.29
Aware	5	12.20	36	87.80	41	19.71
Total	**108**	**51.92**	**100**	**48.08**	**208**	**100.00**

4.2 Consumers' Perception of Bt Cowpea

The analysis of consumers' perceived knowledge of Bt cowpea is presented in Table 4.2. The combined result showed that none of the respondents indicated that they were very knowledgeable about Bt cowpea. Some 20.19% indicated that they were somewhat knowledgeable, and 79.81% claimed that they had no knowledge about the new Bt cowpea in the study area.

The result in Table 4.2 further revealed that only 9.52% of the respondents said they were somewhat knowledgeable about Bt cowpea in Kaduna State, whereas majority (90.48%) were somewhat knowledgeable about the new product in Sokoto State.

Table 4.2: Distribution of Respondents According to their Perceived Knowledge of Bt Cowpea in the States

Knowledge Of Bt cowpea	States				Combined	
	Kaduna		Sokoto			
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Very knowledgeable	0	0	0	0	0	0
Somewhat knowledgeable	4	9.52	38	90.48	42	20.19
No knowledge	104	62.65	62	37.35	166	79.81
Total	**108**	**51.92**	**100**	**48.08**	**208**	**100.00**

4.2.1 Consumers' negative views about transgenic Bt cowpea

The analysis of consumers' negative views about the transgenic Bt cowpea in the study area is presented in Table 4.3. The combined results revealed that 2.4% of the respondents viewed transgenic Bt cowpea negatively as somewhat ethical whereas, 3.37% of the respondents viewed it as ethical while 16.83% of the respondents viewed Bt cowpea as unethical. Some of the respondents' said they had negative ethical views about Bt cowpea based on moral and religious reasons while others said it was based on their concerns over ethics of genetic modification of Bt cowpea. This finding is consistent with Saket *et al*. (2004) who found that Nigerian consumers had expressed serious negative ethical and health concerns about Bt cowpea especially in some parts of northern Nigeria.

Results across the States in Table 4.3 further revealed that majority (100%) of respondents in Sokoto State perceived that Bt cowpea was ethical while 60% negatively viewed the transgenic Bt cowpea as somewhat ethical.

The interpretation of ethics indicated that it is a negative construct for likelihood of acceptance of transgenic Bt cowpea technology in the study area. However, it is difficult to know how to interpret ethical and somewhat ethical rating scale measures of acceptance of transgenic Bt cowpea because there is no theory available to enable the interpretation of a difference between a rating on ethical and a rating of somewhat ethical. But it can be seen tin Table 4.3 there was ordinal information in the data of consumer negative views which can be used to transform the ratings into implied rankings and interpret them. Therefore, ethical concern was interpreted as greater than somewhat ethical in implied ranking.

Table 4.3: Distribution of Respondents According to their Negative Views about Transgenic Bt Cowpea in the States

	State				**Combined**	
	Kaduna		**Sokoto**			
Perception of Bt cowpea	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Ethical	0	0	7	100	7	3.37
Somewhat Ethical	2	40	3	60	5	2.40
Neutral	0	0	25	100	25	12.02
Somewhat unethical	0	0	8	100	8	3.85
Unethical	6	17.14	29	82.86	35	16.83
Don't know	100	78.14	28	21.88	128	61.54
Total	**108**	**51.92**	**100**	**48.08**	**208**	**100**

4.2.2 Consumers' risk perception of Bt cowpea

Consumers' risk perception is not just a perception of inherent dangers of the new Bt cowpea technology; the actions taken by those who use and regulate the technology also ultimately determine risk. Analysis of consumers' perceived risks associated with Bt cowpea is presented in Table 4.4. The combined results revealed that about 8.17% of the respondents indicated that they had the perceived risk on environmental concern, 19.23% of respondents cited no disadvantages or potential risks while majority (53.37%) of respondents indicated that they were unsure about the perceived risks of Bt cowpea. The likely reason for this might be because the respondents did not understand the question they were asked to answer on risk perception during the survey. However, respondents were informed about the advantages and disadvantages of Bt cowpea prior to making purchase choices of attributes of Bt cowpea. Results in Table 4.4 also indicated that majority (83.78%) of the respondents in Kaduna State said they were unsure about perceived risks of Bt cowpea while majority (88.89%) of respondents in Sokoto State reported the perceived risk of gene mutation because even the new Bt cowpea is not yet in marketplace they perceived this risk on the Bt cowpea attributes rather than on the new product *per se*. A possible explanation for the high percentage of respondents perceiving the risk of gene mutation in Sokoto State might be attributed to their greater awareness and high perceived knowledge about the attributes of the new Bt cowpea technology.

Table 4.4: Distribution of Respondents According to their Perceived Risks of Bt Cowpea in the States

Perceived risks	States				Combined	
	Kaduna		Sokoto			
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Safety of pesticides	1	20	4	80	5	2.4
Toxic	1	16.67	5	83.33	6	2.88
Ethics	2	15.38	11	84.62	13	6.25
Quality of beans (worse)	3	42.86	4	57.14	7	3.37
Gene mutation	1	11.11	8	88.89	9	4.33
Environmental concern	2	11.76	15	88.24	17	8.17
No Disadvantages	5	12.50	35	87.50	40	19.23
Unsure	93	83.78	18	16.22	101	53.37
Total	**108**	**51.92**	**100**	**48.08**	**208**	**100**

4.2.3 Consumers' perceived potential benefit of Bt cowpea

The analysis of consumers' perceived potential benefit of maruca resistant Bt cowpea in the surveyed states is presented in Table 4.5. The rationale for this analysis given the earlier findings was to ask the respondents what they would say about the perceived benefits of Bt cowpea, identify areas they believed the perceived benefits involved so as provide meaningful information to the government and regulatory authorities to ensure that the Bt cowpea that would be introduced has ingredients of consumers' perceived benefits. The combined result in Table 4.5 showed that 2.40% said that they expected Bt cowpea to provide no advantages, 7.21% of the respondents said they perceived the potential benefit of safer Bt cowpea while 27.4% said they perceived potential benefit of

improved nutritional value of Bt cowpea in the study area. This is not surprising because according to (Cuellar, 2004) normally positive attitudes towards genetically modified foods in developing nations come from the availability and nutritional content of food. The combined result in Table 4.5 further revealed that majority (44.71%) of the respondents reported that they were unsure of any perceived potential benefits of Bt cowpea or advantages of the technology in the study area. This may possibly be attributed to their lack of understanding the question on advantages of Bt cowpea. Another possible explanation may likely be due to their being less educated which possibly affected their assessment of the potential benefits of the new Bt cowpea in the study area.

Results further showed that majority (90.91%) of the respondents in Kaduna state said they considered quality of bean as potential benefits of Bt cowpea, while majority of respondents (87.72%) in Sokoto state said that they perceived the potential benefit of improved nutritional value. A possible explanation for this was that the respondents had not been informed about the potential benefits of the new Bt cowpea.

Table 4.5: Distribution of Respondents According to their Perceived Benefits of Bt Cowpea in the States

	States				Combined	
	Kaduna		Sokoto			
Perceived benefits	**Frequency**	**Percentage**	**Frequency**	**Percentage**	**Frequency**	**Percentage**
Improved nutritional value	7	12.28	50	87.72	57	27.4
Quality of beans (better)	10	90.91	1	09.09	11	5.29
Less pesticide required	7	38.89	11	61.11	18	8.65
Higher cowpea yields	5	55.56	4	44.44	9	4.33
Safer product	4	26.67	11	73.33	15	7.21
No advantages	1	20	4	80	5	2.40
Unsure	74	79.57	19	20.43	93	44.71
Total	108	51.92	100	48.08	208	100

4.3 Consumer Preferences for Bt Cowpea Attributes from Conditional Logit Analysis

Table 4.6 present the results from the econometric estimation of consumer preferences for cowpea attributes using conditional logit analysis with discrete choice as the dependent variable. The results in Table 4.6 in both the pooled and States revealed that the price coefficients showed the expected negative signs and were statistically significant at 5% level, meaning that options with lower prices were more likely to be chosen by cowpea consumers as compared to options with higher prices. This implies a negative relationship between the price and demand for cowpea attributes. From the

pooled data, it can be interpreted that one unit increase in price was associated with 0.005unit decreases in utility.

The coefficient for cowpea large grain size (0.464) relative to small grain size was positive and statistically significant at 5% level both in the study areas meaning that in general consumers preferred cowpea large grain size than small sized cowpea grains in the study area.. A one unit increase in cowpea large grain size is associated with 0.464 unit increase in utility. This finding is in agreement with Faye *et al*. (2004), Langyintuo *et al*. (2004) and Mishilli *et al*. (2007) who found that most consumers prefer cowpea large grain size in Ghana, Cameroon and Senegal, respectively.

Safety from pesticides misuse in cowpea is the most important attribute to the consumers as indicated by the relative size of its coefficient (0.886), meaning that consumers placed a relatively high level of importance on safety attribute of Bt cowpea in the study area. This implies that consumers' level of utility decrease by 0.886 units as the safety attribute increases by 1 unit. A possible explanation for this could be the respondents' believe that pesticides misuse in cowpea may be harmful to human health.

The coefficient for insect damage (-0.361) relative to no insect damage was negative, indicating that consumers were more likely to purchase preferred cowpea without insect damage as compared to cowpea with insect damage. A possible explanation for this is that consumers seem more sensitive to insect damage in their purchasing decisions. The relevance of this finding indicated that consumers would be willing to buy or were more likely to buy Bt cowpea enhanced through biotechnology if protected from insect damage.

The coefficient for white colored (0.094) relative to red colored cowpea was positive both in Kaduna and Sokoto States indicating that in general, consumers in the surveyed areas preferred white colored cowpea. This finding is in agreement with Mishilli *et al.* (2007) who found that cowpea consumers in the surveyed Monday market in Borno State, Dawanau market in Kano State, and Iddo market in Lagos state, Nigeria seem to prefer white grain cowpea to other colored grains. Also, their study found that white skin colored cowpeas was positive and statistically significant in these surveyed markets in Nigeria. However, the coefficient for brown colored (-0.083) compared to red colored cowpea was negative, implying that the sampled consumers preferred red colored cowpea.

The coefficient for genetically modified organism (GMO) yes (0.182) relative to no GMO was positive and statistically significant at 5% level indicating that the respondents preferred cowpea with GMO in the study area. A likely reason for this was that they believe that cowpea with GMO can protect it against maruca insect damage.

The coefficient for Bt cowpea (1.788) relative to "none" option is positive and significant at 5% level. This indicates that consumers preferred Bt cowpea relative to "none" option both in the combined data as well as in Kaduna and Sokoto States. This means that at the average levels used in the choice experiment design, respondents were more likely to choose Bt cowpea than "none" option. This result is attributed to the importance of safety. That is, for options with high levels of safety attribute, people frequently selected Bt cowpea option, resulting in a positive coefficients across the states and location. This finding is in agreement with Gbegbelegbe *et al*. (2010) who found that in an ex ante baseline study cowpea growers and consumers in Republic of Benin, Niger and northern Nigeria preferred Bt to conventional cowpea because they

believe that with Bt cowpea they will be able to avoid the health hazards related to chemical insecticide misuse.

Similarly, the coefficient for conventional cowpea (1.854) relative to none option is significant at 5% level indicating that the respondents preferred conventional cowpea than a 'none' option. In general, the result indicates that quality attributes are very important in West African food markets including Nigeria.

The combined conditional logit results in Table 4.6 also indicated that the price coefficient (-0.005) had the expected negative sign and was significant at 5% level in the study area. The result further revealed that price coefficient (-0.009) for Kaduna State was negative and statistically significant at 1% and 5% level, respectively. This finding is in agreement with Gbegbelegbe *et al*. (2010) who found the negative relationship between price and quantity demanded of Bt cowpea seeds in Republic of Benin.

The combined results also revealed that the coefficients for safety (0.952) and cowpea large grain size (0.474) were positive and significant at 5% levels, respectively, indicating that consumers in the study area preferred safer cowpea and cowpea large grain size attributes. The coefficients for white color (0.0309) and Bt cowpea (1.603) were positive and significant at 1% and 5% levels, respectively, in Kaduna state, while the coefficient for insect damage was negative (-0.216) and statistically significant in Sokoto state. This implies that consumers in Kaduna preferred white color and Bt cowpea, while consumers in the surveyed Local Government Areas of Sokoto state significantly discounted cowpea with insect damage.

More important than the absolute magnitude of these coefficients is the relative comparison of the coefficients for Bt cowpea and conventional cowpea. The results in Table 4.6 suggest that holding constant other factors, safety attribute was highly preferred relative to no safety by consumers in the study areas. Thus, the results indicated that, holding other factors constant, consuming safer cowpea rather than no safety increases utility.

Table 4.6: Conditional Logit Estimates of Consumer Preferences for Cowpea Attributes across States

Independent variables	**States**		
	Kaduna	**Sokoto**	**Combined**
Price	-0.009***	-0.002**	-0.005**
	(0.001)	(0.001)	(0.001)
Wc vs Rc	0.309*	-0.003	0.098
	(0.132)	(0.108)	(0.080)
Bc vs Rc	-0.096	-0.092	-0.076
	(0.119)	(0.104)	(0.074)
Safety(yes vs no)	1.811***	0.404***	0.952**
	(0.153)	(0.107)	(0.083)
Large Size(large vs small)	0.659***	0.482***	0.474**
	(0.179)	(0.135)	(0.102)
GMO(yes vs no)	0.254**	0.031	0.143**
	(0.077)	(0.072)	(0.051)
Insect Damage(yes vs no)	0.126	-0.504***	-0.216**
			(0.072)

	(0.111)	(0.101)	
Bt vs none	1.603***	1.693***	1.667**
	(0.195)	(0.179)	(0.129)
Conven vs none	2.128***	1.451***	1.767**
	(0.193)	(0.180)	(0.130)
Log likelihood at zero	-1450.168	-1463.352	-2913.520
Log likelihood at convergence	-1006.442	-1247.896	-2357.21
Pseudo R^2	0.30	0.14	0.193
N	108	100	208

Numbers in parentheses are standard errors, *** = significant at 10% level, ** =,significant at 5% level, * = significant at 1% level, Wc = white color, Bc= brown color

4.4 Consumers' Willingness to Pay for Bt Cowpea Attributes

The analysis of the aggregate consumers' willingness to pay for Bt cowpea attributes is presented in Table 4.7. It was hypothesized that consumers would be willing to pay more for attributes of Bt cowpea compared to conventional cowpea. The combined results were in support of this hypothesis. The combined result revealed that consumers in the study areas would be willing to pay (₦ 186.77) significantly more for safer Bt cowpea varieties relative to no safety. The willingness to pay (WTP) for safety attribute was positive across the States and combined result, indicating that the respondents valued safety attribute more than no safety.

The combined result also revealed that consumers would be willing to pay (₦ 92.90) as premium price for large grain size relative to small grain size. This finding agrees with Mishilli *et al*., (2007) who found that cowpea consumers in Ghana, Mali, and Nigeria were willing to pay premium (higher) price for large cowpea grains.

The result in Table 4.7 further revealed that only consumers in Kaduna State would be willing to pay significantly more for genetically modified organism (GMO) cowpea attribute. The willingness to pay for insect damage was negative in all models, implying that consumers significantly would discount cowpea with insect damage, but the discount rate was significantly higher in Sokoto as compared to Kaduna States. This is most likely due to the fact that the consumers in Sokoto State may likely be agents as consumers as well as producers. Also the result indicated that consumers in both Kaduna and Sokoto States would be willing to pay significantly higher for conventional cowpea relative to Bt cowpea, holding other attributes constant.

Table 4.7: Willingness-to-pay for Cowpea Attributes by States

Willingness to Pay (WTP) for Cowpea Attributes	States		Combined
	Kaduna	**Sokoto**	
white color vs red	34.68	-1.50	19.16
color	[3.70, 62.38]	[-2.15, -0.81]	[-11.61, 49.13]
Brown color vs red	-10.74	-39.96	-14.93
color	[-38.27, 13.28]	[-130.21, 48.43]	[-41.48, 11.48]
Safety vs no Safety	202.98	174.55	186.77
	[169.46, 235.52]	[82.31, 263.65]	[152.93, 219.52]
large grain size vs	73.89	208.18	92.90
small size	[33.92, 113]	[116.18, 297.51]	[73.43, 111.64]
GMO vs no GMO	8.45	13.32	28.13
	[11.05, 44.14]	[-48.49, 78.64]	[8.81, 47.02]
Insect damage vs	14.10	-217.75	-42.44
no insect damage	[-11.0, 38.07]	[-301.42, -132.16]	[-30.76, 24.73]
Bt cowpea vs none	179.67	731.65	327.02
	[139.10, 221.28]	[576.26, 879.52]	[275.87, 379.07]
Conventional vs	238.44	627.09	346.77
none	[197.73, 278.86]	[470.6, 783.37]	[299.58, 396.54]
White color vs	45.42	38.46	34.09
Brown color	[20.98, 71.37]	[-49.87, 129.07]	[6.96, 62.21]
Bt cowpea vs			
Conventional	-58.76	104.56	-19.75
cowpea	[-73.38, -40.96]	[50.71, 160.7]	[-38.19, -0.94]

WTP values are calculated from the coefficients in the models in Table 8 , and the values are measured in Naira (250 ₦/Kg)
Numbers in brackets are 95% confidence interval calculated using the Krinsky-Robb bootstrapping method

4.5 Socio-economic Characteristics of Respondents

4.5.1 Age distribution

Table 4.8 presents frequency distribution of respondents according to age in the study area. Results from combined data indicated that the average age was 37.88 years and majority (30.77%) of respondents was in the age group of 28-38 years in the study area. This implies that most of the responses were obtained from the age group of 28-38 years in the study area. This finding is consistent with Saket *et al*. (2004) who found that the young-aged groups accounted for the most responses on consumer acceptance of GMO cowpea in some parts of northern Nigeria. The result further indicated that majority (66.67%) of the respondents in Kaduna State were in the age group of 72-82 years while most (58.33%) of the respondents in Sokoto State were in the age category of 61-71 years, respectively.

Table 4.8: Distribution of Respondents by Age in the States

	States				**Combined**	
	Kaduna		**Sokoto**			
Age (years)	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
17-27	27	49.09	28	50.91	55	26.44
28-38	38	59.36	26	40.63	64	30.77
39-49	22	46.81	25	53.19	47	22.6
50-60	13	52	12	48	25	12.02
61-71	5	41.67	7	58.33	12	5.77
72-82	2	66.67	1	33.33	3	1.44
83-93	1	50	1	50	2	0.96
Total	**108**	**51.92**	**100**	**48.08**	**208**	**100**

4.5.2 Gender distribution

Analysis of gender in the states is presented in Table 4.9. The combined result revealed that there was equal proportion of males (50%) and females (50%) that accounted for most of the responses in the study area. Results in Table 4.9 further revealed that majority (59.62%) of the respondents were females in Kaduna State while 55.77% of respondents were males in Sokoto State. This means that women accounted for most of the responses in cowpea shopping in Kaduna State possibly because of the culture and nature of the society that allow women equal opportunity with men in the surveyed area. However, men accounted for most of the responses in Sokoto State possibly because of the religious factor that put women in purdah and not having equal opportunity with men in the surveyed area.

Table 4.9: Distribution of Respondents according by Gender in the States

	States				**Combined**	
	Kaduna		**Sokoto**			
Gender	**Frequency**	**Percentage**	**Frequency**	**Percentage**	**Frequency**	**Percentage**
Male	46	44.23	58	55.77	104	50
Female	62	59.62	42	40.38	104	50
Total	**108**	**51.92**	**100**	**48.08**	**208**	**100**

4.5.3 Educational level of respondents

The analysis of educational level of respondents in the states is presented in Table 4.10. Combined results indicated that majority (34.62%) of the respondents had completed primary education in the study area. This implies that primary educated respondents accounted for most responses in the study area. This means that most

of the respondents that accounted for the responses had the ability to read, write and communicate at the primary education level in the study area. This is followed by respondents with some secondary school (27.78%) and informal school (20.9%). The findings in this study is consistent with Saket *et al*. (2004) who reported that majority (94%) of consumers that were aware of Bt cowpea had primary education in the metropolitan towns of Gombe, Bauchi and Kano States, northern Nigeria. However, the finding is not in agreement with Edem *et al*. (2011) who reported a low literacy level in primary education in Nigeria. Also, the finding is not consistent with Australian Council for Educational Research (ACER, 2013) who found literacy level of urban or city students to be higher than that of students in rural schools in Nigeria.

The results also revealed that majority (54.17%) of the respondents in kaduna State had completed primary school, while 65.52% of the respondents had informal education. Also, majority (45.83%) of respondents in Sokoto State had completed primary school (34.48%) while 78.57% of the respondents had informal education in the study area. The chi-square as shown in the bottom of Table 4.10 revealed that there is significant difference between location and education level of respondents.

Table 4.10: Distribution of Respondents by Educational level in the States

	States				Combined	
	Kaduna		Sokoto			
Education Level	**Frequency**	**Percentage**	**Frequency**	**Percentage**	**Frequency**	**Percentage**
Completed Primary	39	54.17	33	45.83	72	34.62
Some Secondary school	38	65.52	20	34.48	58	27.88
Post secondary school	22	61.11	14	38.89	36	17.31
Informal school	9	21.43	33	78.57	42	20.9
Total	**108**	**51.92**	**100**	**48.08**	**208**	**100**

4.5.4 Annual income of respondents

The analysis of annual income of respondents in the states is presented in Table 4.11 Combined results showed that majority (28.37%) of respondents had annual income of less than ₦19, 999. Results across state show that majority (74.58%) of respondents in Kaduna State had annual income of less than ₦19, 999, whereas 78% of respondents in Sokoto State had annual income between ₦20, 000 and ₦ 39,999. This indicated that most of the respondents had low income in the study area. The annual income of respondents comes from different potential sources. The respondents said they had their annual income from business and civil service, farming and trading.

Table 4.11: Distribution of Respondents by Income in the States

	States				Combined	
	Kaduna		Sokoto			
Annual Income (₦)	**Frequency**	**Percentage**	**Frequency**	**Percentage**	**Frequency**	**Percentage**
Less than 19,999	44	74.58	15	25.42	59	28.37
20,000 – 39,999	11	22	39	78	50	24.04
40,000 – 59,999	14	46.67	16	53.33	30	14.32
60,000 – 79,999	5	31.25	11	68.75	16	7.69
80,000 – 99,999	17	70.83	7	29.17	24	11.54
More than 100,000	17	58.62	12	41.38	29	13.94
Total	**108**	**51.92**	**100**	**48.08**	**208**	**100**

4.6 Effect of Socio-Economic Characteristics on Consumers' Willingness to Pay (WTP)

4.6.1 Effect of age on willingness to pay

The analysis of the effect of age on willingness to pay across the States is presented in Table 4.12. The combined result in Table 4.12 showed that price coefficient was statistically significant at 1% level and showed the expected negative sign. The negative sign (-0.006) for the price coefficient indicated that the level of consumers' utility decreases as the price of cowpea attributes increases.

The combined result in Table 4.12 further revealed that the coefficient for the interaction variable of consumers' Age category between 20-30 years and price

had a positive sign (0.25) and was statistically significant at 1% level, implying that the estimated coefficient of this interaction was significantly different from the age of individuals over 60 years. The results also indicated that the willingness to pay estimate of ₦0.25 for the interaction variable was positive, implying that the estimated willingness to pay for respondents' age between 20 – 30 years was higher relative to the age of respondents over 60 years. This indicated that the individuals within the age of 20-30 years were more likely to value the attributes of the new Bt cowpea as compared to the respondents over 60 years of age in the study area. A possible explanation for this is that the consumers between the age of 20-30 years may have different tastes and preference patterns for cowpea attributes compared to the individuals with age of over 60 years in the study area. Another possible explanation is that the consumers in their 20-30 years were likely greater awareness and acceptance of Bt cowpea and viewed the Bt technology as novel than the individuals with over 60 years of age.

The results also revealed that age dummy variable of 20-30 years category had positive effect on willingness to pay for white colored cowpea, safety, cowpea large grain size and genetically modified organism (GMO) attributes, meaning that individual consumers within the age category of 20-30 years tend to value these attributes and more willing to pay maximum amount of money out of their income regarding white colored, safer, and large grain size cowpea attributes. However, age dummy variable of 20-30 years category had negative effect on willingness to pay for brown colored cowpea and insect damage attributes, meaning that the individuals within the age group of 20-30 years were less willing to pay for brown colored cowpea and insect damage attributes in the study area.

The interpretation of the results in Table 4.12 indicated that respondents in the age category of 20 - 30 years tend to value white colored cowpea at ₦15.41 more than consumers with over 60 years of age. Also, the respondents in the age group of 20-30 years tend to value safety attribute at ₦152.98 more than consumers with over 60 years of age. Furthermore, individuals within the age category of 20-30 years tend to value cowpea large grain size at ₦76 more than respondents with over 60 years of age. This imply that respondents in the age group of 20-30 years tend to value safety and large grain size attributes more than white colored cowpea as compared to the respondents in the age group of over 60 years of age in the study area.

The results in Table 4.12 further showed that respondents in the age category of 20 - 30 years tend to value brown colored cowpea at ₦ -12.33 less than respondents with over 60 years of age. Also, the respondents within 20 - 30 years of age tend to value insect damage at ₦ -35.02 less than consumers with over 60 years age in the study area. Also, when respondents in the age category of 20-30 years evaluated white versus brown colored cowpea attributes they tend to value white color at ₦27.74 more than consumers with over 60 years of age in the study area. The results further showed that when respondents in the 20-30 years age category evaluated Bt versus conventional cowpea they tend to value Bt cowpea at ₦ -16.15, meaning that they were willing to pay less amount of money for Bt cowpea than conventional cowpea in the study area. The respondents said they were less willing to pay for Bt cowpea because their perceived potential risks of Bt cowpea tend to outweigh their perceived potential benefit about the new Bt cowpea in the study area.

Furthermore, the effect of age on willingness to pay across states is also shown in Table 4.12. The price interaction with age coefficient is positive and significant for consumers in Kaduna, indicating that the willingness to pay for consumers within age category of 20-30 years was significantly higher than the willingness to pay for respondents with over 60 years age. The calculated t-value of 2.17 which was greater than 0 .84 revealed that there was no significant difference between the effects of age on willingness to pay across states and combined data.

	States					
	Kaduna		**Sokoto**		**Combined**	
	Coefficients	**WTP**	**Coefficients**	**WTP**	**Coefficients**	**WTP**
Price	-0.011**		-0.003**		-0.006*	
White	0.305*	27.83	-0.004	-1.33	0.096	15.41
Brown	-0.098	-8.92	-0.093	-31.14	-0.007	-12.33
Safety	1.811**	165.33	0.404**	135.92	0.951**	152.98
Large Size	0.658**	60.06	0.481**	161.97	0.473**	76.00
GMO	0.253**	23.09	0.030	10.25	0.143**	22.95
Insect damage	0.123	11.20	-0.504	-169.81	-0.218**	-35.02
Bt cowpea	1.622**	148.08	1.696**	571.00	1.674**	269.23
Conventional cowpea	2.147**	195.96	1.454**	489.48	1.775**	285.38
Price: 20-30 years age	0.003*	0.24	0.001	0.33	0.002*	0.25
White versus		36.76		29.81		27.74

Brown			
Bt versus Conventional cowpea	-47.88	81.51	-16.15

Table 4.12: Effect of Age on Willingness to Pay across States
* = statistically significant at 1% level, ** = statistically significant at 5% level

4.6.2 Effect of gender on willingness to pay

The analysis of the effect of gender on willingness to pay across States and combined is presented in Table 4.13. The combined results in Table 4.13 showed that the price coefficient was statistically significant at 5% level and showed the expected negative sign. The negative sign (-0.005) for the price coefficient indicated that the level of consumers' utility decreases by 0.005 unit as the price of cowpea attributes increases by 1 unit, meaning that cowpea attributes with lower prices were more likely to be purchased by the respondents in the study area. . The combined result in Table 4.13 further revealed that the coefficient for Price: female interaction had positive sign but was not statistically significant, implying that the estimated coefficient for females was not significantly different from that of males in the study area

The combined results in Table 4.13 further revealed that female consumers were mostly willing to pay a maximum amount on safety (₦174.67) and cowpea large grain size attributes (₦86.82), respectively, in the study area. This implies that female consumers tend to value safety attribute at ₦174.67 more than the male respondents. This finding is similar to the results of Baker (1999) and Byrne *et al*.

(1999) who found that women tended to be more concerned with food safety than men in United States of America.

The results in Table 4.13 further revealed that female respondents tend to value cowpea large grain size at ₦86.82 more than the males in the study area. The effect of gender on willingness to pay across the two States showed that the coefficient for price interaction with female consumers in Sokoto State was positive and significant at 1% level, indicating that the willingness to pay for female consumers was significantly higher than the willingness to pay for male consumers.

Table 4.13: Effect of Gender on Willingness to Pay Across States

	States					
	Kaduna		**Sokoto**		**Combined**	
	Coefficients	**WTP**	**Coefficients**	**WTP**	**Coefficients**	**WTP**
Price	-0.009**		-0.003**		-0.005**	
White	0.309*	34.54	-0.006	-1.88	0.097	17.79
Brown	-0.096	-10.69	-0.093	-31.63	-0.06	-13.99
Safety	1.811**	202.17	0.404**	137.27	0.952**	174.67
Large Size	0.659**	73.59	0.481**	163.50	0.473**	86.82
GMO	0.254*	28.34	0.030	10.15	0.143**	26.24
Insect damage	0.126	14.04	-0.506**	-171.85	-0.217**	-39.82
Bt cowpea	1.603**	178.95	1.702**	578.58	1.670**	306.45
Conventional cowpea	2.128**	237.48	1.460**	496.19	1.770**	324.89

Price: Female	0.000	0.01	0.002*	0.58	0.001	0.18
White versus Brown		45.23		29.74		27.74
Bt versus Conventional cowpea		-58.53		82.39		-18.43

* = significant at 1% level, ** = significant at 5% level

4.6.3 Effect of education on consumers' willingness to pay

The analysis of the effect of education on consumers' willingness to pay is presented in Table 4.14. The combined results in Table 4.14 indicated that the willingness to pay for the interaction coefficient of Price: Education variables had negative sign (₦ -0.02) but were not statistically significant, implying that the estimated coefficient of the interaction variable was not significantly different from that of consumers that had informal education. The negative sign on the estimated willingness to pay (-0.02) indicated that the willingness to pay for formally educated respondents was lower than that of informally educated consumers. This implies that formally educated respondents were less likely willing to pay maximum amount of money as compared to informally educated consumers in the study area. A likely reason may be that formally educated consumers were better able to perceive the potential risks and benefits of the Bt technology than informally educated respondents in the study area.

The combined result in Table 4.14 further revealed that when respondents evaluated cowpea white color versus brown color attributes, the formally educated respondents tend to value cowpea white color attribute at ₦ 34.67 more than informally educated consumers in the study area. The result in Table 4.14 also

indicated that when consumers evaluated Bt cowpea versus conventional cowpea, the formally educated respondents tend to value Bt cowpea at ₦ -20.09 less than informally educated respondents in the study area. The result further showed that formally educated respondents tend to value safety attribute at ₦189.02 more than the informally educated consumers. The result in Table 4.14 also showed that the formally educated consumers tend to value cowpea large grain size at ₦94.49 more than the informally educated individuals in the study area.

The effect of education on the willingness to pay across states is also shown in Table 4.14. Results revealed that the coefficient for price interaction with education was positive in Kaduna State (0.09) and Sokoto State (0.02), but not statistically significant, respectively. This implies that the willingness to pay for formally educated consumers was not significantly different from the willingness to pay of informally educated consumers across the States.

Table 4.14: Effect of Education on Willingness to Pay across States and combined

	States					
	Kaduna		**Sokoto**		**Combined**	
	Coefficients	**WTP**	**Coefficients**	**WTP**	**Coefficients**	**WTP**
Price	-0.010**		-0.002*		-0.005**	
White	0.310*	31.91	-0.004	-1.54	0.098	19.47
Brown	-0.096	-9.85	-0.092	-40.44	-0.076	-15.20
Safety	1.812**	186.67	0.404**	176.61	0.952**	189.92
Large Size	0.659**	67.92	0.482**	210.63	0.474**	94.49

GMO	0.254**	26.14	0.031	13.49	0.143**	28.61
Insect damage	0.126	12.97	-0.504**	-220.33	-0.216**	-43.17
Bt cowpea	1.604**	165.24	1.693**	740.27	1.667**	332.59
Conventional cowpea	2.128**	219.26	1.451**	634.46	1.768**	352.68
Price: Education	0.001	0.09	0.000	0.02	0.000	-0.02
White versus Brown		41.76		38.90		34.67
Bt versus Conventional cowpea		-54.02		105.82		-20.09

* = significant at 1% level, ** = significant at 5% level

4.6.4 Effect of consumers' income on willingness to pay

The analysis of the effect of income on consumers' willingness to pay is presented in Table 4.15. The results showed that the willingness to pay for the interaction coefficient (Price: Income) had positive sign (₦0.04) but was not statistically significant. The positive sign on income in Table 4.15 imply that demand for cowpea attributes varies directly with income which suggests that cowpea is a normal product.

The result in Table 4.15 showed that that middle income respondents having annual income between ₦ 20,000- ₦ 100,000) were more likely willing to pay as compared to low income respondents having annual income below or equal to ₦19, 000 in the study area. This finding is not in agreement with House *et al*. (2004) that income of U.S. consumers had significant effect on willingness to

accept genetically modified foods. House *et al*. (2004) reported that low income consumers (respondents with income levels below US$40,000 were more likely than those with incomes above US$100,000 to have a higher acceptance level of genetically modified foods.

The effect of income on the willingness to pay across States is also presented in Table 4.15. The coefficients for price interaction with income in conditional logit model were positive and not statistically significant, indicating that the willingness to pay for consumers with lower income was not significantly different from the willingness to pay for consumers with middle income.

Table 4.15: Effect of Income on Willingness to Pay across States and Combined

	States				Combined	
	Kaduna		Sokoto			
	Coefficients	**WTP**	**Coefficients**	**WTP**	**Coefficients**	**WTP**
Price	-0.010**		-0.002*		-0.005**	
White	0.308*	29.45	-0.003	-1.41	0.098	18.65
Brown	-0.096	-9.18	-0.092	-37.39	-0.076	-14.32
Safety	1.811**	173.04	0.404**	163.49	0.952**	181.76
Large Size	0.658**	62.88	0.482**	194.89	0.473**	90.40
GMO	0.253**	24.19	0.031	12.42	0.143**	27.37
Insect damage	0.124	11.88	-0.504**	-203.94	-0.216**	-41.32
Bt cowpea	1.608**	153.58	1.694**	685.40	1.667**	318.29
Conventional cowpea	2.132**	203.70	1.452**	587.45	1.768**	337.51
Price: Income	0.002	0.16	0.001	0.20	0.000	0.04
White versus Brown		38.64		35.98		-196.2
Bt versus Conventional cowpea		-50.12		97.95		-19.22

* = significant at 1% level, ** = significant at 5% level

4.7 Predicted Market Share for Cowpea Attributes in the Study Area

The analysis of the predicted market share for cowpea attributes across state is presented in Table 4.16. Confidence interval at 95% significant level of each cowpea attributes using the parametric bootstrapping techniques was also reported. The combined results showed that the new Bt cowpea had a low predicted market share of 0.438 compared to the conventional cowpea (0.484). The results in Table 4.16 also revealed that the market share for Bt cowpea was statistically significant at 5% level regardless of the States. The result suggests that Bt cowpea can garner a majority market share if they possess similar large size grain quality attribute relative to the more conventional cowpea varieties. The results in Table 4.16 further revealed that the predicted market share for Bt cowpea was significantly lower in both Kaduna (0.36) and Sokoto States (0.39) than that of conventional cowpea (0.60, 0.68), respectively, indicating that Bt cowpea had a significant low potential market penetration across the two states.

Table 4.16: Predicted Market Share (%) for Cowpea Attributes across States and Combined

	States		
	Kaduna	**Sokoto**	**Combined**
Bt cowpea	0.36[a]	0.39	0.438
Confidence interval	[0.34, 0.40][b]	[0.33, 0.49]	[0.427, 0.495]
Conventional cowpea	0.60	0.68	0.484
Confidence Interval	[0.59, 0.65]	[0.40, 0.77]	[0.587, 0.710]

[a] The market shares were calculated under the assumption that the average price of cowpea is ₦250/kg

[b] Numbers in brackets are 95% confidence interval calculated using Krinsky-Robb bootstrapping method

4.8 Expected Aggregate Welfare Net Benefit of Introducing the New Bt Cowpea in the Marketplace

Welfare analysis of expected aggregate net benefit of introducing the new Bt cowpea in the marketplace per choice occasion as well as the aggregate total benefit by treatment and location and state are respectively presented in Table 4.17. The results revealed that releasing Bt cowpea in the marketplace would have a significant higher net benefit on consumers at 5% level. This finding is in agreement with Gbegbelegbe *et al*. (2010) who reported that the welfare gain of US $51.9 million that Bt cowpea would bring to producers far outweigh the welfare loss of US $ 1.5 million to consumers, so that the society in republic of Benin would, on aggregate experience a net welfare gain of about US $ 50.36 million.

The aggregate benefits and confidence intervals were reported in Table 4.17 at 95% significant level by States. Results in Table 4.17 further showed that the aggregate benefit of releasing Bt cowpea in the marketplace on consumers was estimated to be ₦242 billion per year and was not statistically significant The study suggests that releasing Bt cowpea in the marketplace would improve the welfare of cowpea consumers in the study area.

Moreover, Table 4.17 revealed that the aggregate welfare benefit for both Kaduna and Sokoto States were estimated to be ₦10 billion and ₦45 billion, respectively and were statistically significant at 5% levels. However, the aggregate welfare benefit for consumers in Sokoto State was higher than that of Kaduna State.

Table 4.17: Estimated Benefit of Introducing Bt Cowpea into the Market Place across Location and States (N/Choice made)

Items	**States**		**Aggregate**
	Kaduna	**Sokoto**	
Benefit per choice made (Naira)	₦49.96	₦297.61	₦96.20
population in year 2010	6066562	4,244,399	70,007,683.60
Valuation Questions	12	12	12
Options chosen	3	3	3
Net Benefit (N/year)	₦10,913,250,227	₦45,474,665,914	₦242,471,844,397.38
Confidence Interval	[1,599,037,701,12,404,061,485]	[14,026,180,252,115,375,872,683]	[18,774,403,213.72, 135,794,666,298.18]

4.9 Mixed Logit Analysis

The analysis of mixed logit is presented in Table 4.18. The combined result in Table 4.18 revealed that the price coefficient showed the expected negative sign (-0.08) and was statistically significant at 5% level. This indicated that as the price of an attribute falls (and the prices of other attributes remain the same) the probability of that attributes being chosen increases.

The combined results in Table 4.18 showed that the coefficient of white color attribute is normally distributed with mean (0.050) and standard deviation (1.681). This indicated that about 49% of the respondents were estimated to dislike white colored attribute. The result means that slightly more than half of cowpea consumers (51%) preferred white colored attribute and the other half dislike white color in the study area.

The coefficient of cowpea large grain size in Table 4.18 was normally distributed with an estimated mean of 0.742 and estimated standard deviation of 1.457, meaning that 70% of the distribution is above zero and 30% below. This implies that two third of the consumers had positive preference while one third had negative preference for large grain size. Finally, the coefficient of insect damage was also normally distributed with an estimated mean of -0.464 and estimated standard deviation of -1.208, indicating that 36 percent of the distribution was above zero and 64 percent below. This means that 36 percent of consumers preferred cowpea with insect damage, while 64 percent avoided cowpea with insect damage.

The standard deviation for white color, large grain size, and insect damage were also statistically significant, meaning that these coefficients do vary in the population.

Individual results for the states were also reported as shown in Table 4.18. The price coefficient was negative (-0.018) as expected, and significant at 5% level in kaduna State. Also, the coefficient was negative (-0.006) as expected, and significant in Sokoto State. This implies an inverse relationship between price and attribute-based demand.

Coefficients for safety (4.625) and large grain size (2.064) in Table 4.18 were positive and significant at 5% level across the two states, indicating that consumers preferred safer cowpea and large grain size attributes. The coefficient for brown cowpea relative to red cowpea was negative and significant, implying that red cowpea was more preferred than brown cowpea in Kaduna State. The coefficient for insect damage was negative and significant, indicating that consumers in Sokoto State significantly pay lower price (discount) cowpea with insect damage. Thus, in Kaduna State, the standard deviation for brown cowpea relative to red cowpea, safety and large grain size were significant, while in Sokoto State, the standard deviation for white cowpea relative to red cowpea and insect damage were statistically significant. This indicated that these attributes do vary within the population thereby expressing preference heterogeneity for these attributes.

The willingness to pay for safety (₦256.95) and large grain size (₦114.66) in Kaduna State using the mixed logit in Table 4.18 were higher than the WTP for safety (₦202.98) and large grain size (₦73.89) using the conditional logit in Table 4.6. Similarly, the WTP for the attributes of safety (₦138) and large grain size (₦124) in Sokoto using the mixed logit were lower than the WTP for safety (₦174.55) and large grain size (₦208.18) using the conditional logit. Therefore, the mixed logit tend to over predict the WTP in some cases whereas the conditional logit also tend to over predicts in other cases. Thus, in Kaduna State , safety attribute had a mean 4.625 and standard

deviation of 2.608 and large grain size had a mean 2.064 and standard deviation of 4.331. This means that 96.18% of consumers preferred to have safer cowpea while 3.82% consumers avoided safe cowpea. Also the result in Table 4.18 indicated that large grain size was preferred by 68.32% of consumers and avoided by 31.68% in the study area. In Sokoto State, safety had a mean of 0.828 and a standard deviation of 0.532, while large grain size had a mean of 0.744 and standard deviation 0.699. This means that 94.02% of consumers in Sokoto State preferred safer cowpea while 5.98% shunned it; while large grain size is preferred by 85.64% of consumers and avoided by 14.36% of them.

The value or importance that consumers place on each attribute of the alternative varies, in general, over decision makers. For instance, in the combined result in Table 4.18, consumers were probably more concerned about the safety (1.681), large grain size (0.742) attributes, relative to other attributes like genetically modified organism (0.252), and probably less concerned on cowpea with insect damage (-0.464) in the study area. However, consumers in Kaduna State were probably less concerned about brown colored cowpea (-1.099), and more concerned about safety (4.625) and large grain size (2.064), relative to other attributes, than consumers in Sokoto State.

Table 4.18: Mixed Logit Results of Choice of Attributes on Bt Cowpea

		States				Combined	
		Kaduna		Sokoto			
Independent variable	**Parameter**	**coefficients**	**SE**	**Coefficients**	**SE**	**Coefficients**	**SE**
Price		-.018**	0.005	-0.006**	0.002	-0.08**	0.002
White color versus Red color	Mean of coefficient	-0.183	0.355	0.087	0.220	0.050	0.129
	Standard deviation	1.337	1.051	2.817**	1.037	1.681**	0.676
Brown color versus Red color	Mean of coefficient	-.099**	0.374	-0.136	0.180	-0.082	0.121
	Standard deviation	3.727**	0.951	0.044	2.574	0.286	0.571
Safety Yes (yes versus No)	Mean of coefficient	4.625**	1.067	0.828***	0.245	1.353**	0.271
	Standard deviation	2.608**	0.931	0.532	1.033	-0.045	1.172
Large size (large versus small)	Mean of coefficient	2.064**	0.680	0.744**	0.253	0.742**	0.216
	Standard deviation	4.331**	0.881	-0.699	0.777	1.457**	0.350
GMO Yes(Yes versus No)	Mean of coefficient	0.172	0.223	0.244	0.150	0.252*	0.096
	Standard deviation	-0.526	1.848	-0.001	1.694	0.051	1.167
Insect Damage Yes(Yes versus No)	Mean of coefficient	0.090	0.323	-0.925***	0.216	-0.464*	0.149
	Standard deviation	-0.040	1.401	2.179***	0.530	-1.208**	0.373
Bt cowpea versus None	Mean of coefficient	3.531	0.712	2.603***	0.435	2.224**	0.305
Conventional cowpea versus None	Mean of coefficient	4.704	0.847	2.228***	0.399	2.288**	0.297
Log-likelihood at convergence		-978.69		-1234.9z		-2341.8	

Market share was computed as Mean divided by standard deviation and this number is the standard Z distribution and its probability can be found by looking at Z table, ** significant at 5% level, SE=standard errors

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

A new cowpea, called *Bacillus thurigiensis* (Bt) cowpea has been developed in laboratory in Australia under public-private partnership using biotechnology and genetic engineering techniques through national and international research consortium. Bt cowpea is a new technology and cowpea genetic transformation is expected to address insect resistance and control pod boring maruca insects in cowpea production. Presently, the new Bt cowpea is not yet available in the marketplace in Africa but the Federal Government of Nigeria is considering whether or not to introduce the new Bt cowpea seeds around the year 2017 to enhance cowpea yields and food security as well as require the ability to regulate the management of genetically modified plants in the country and food safety just as developed countries do. The broad objective of this study was to conduct an ex ante economic impact analysis of Bt cowpea in Kaduna and Sokoto States, Nigeria. The specific objectives of the study were to examine consumers' awareness, perceptions(perceived knowledge, potential risks and benefits), and preferences regarding Bt cowpea in the study area, determine how much consumers are willing to pay for Bt cowpea attributes, determine the effect of socio-economic characteristics of consumers on willingness to pay, predict the potential market share of Bt cowpea, and measure the expected aggregate welfare net benefit of introducing the new Bt cowpea in the marketplace in the study area.

The study used multi stage random sampling technique and collected primary data in a conjoint choice experiment on 208 cowpea consumers before Bt cowpea commercialization using designed questionnaires administered by the researcher and

assisted by well-trained enumerators of Institute of agricultural research and the Agricultural Development Project (ADP) in the study area. Six attributes were considered for the choices in the design, including price, color, safety, grain size, genetically modified organism (GMO), and insect damage. The socio-economic characteristics of the consumers were also collected, including age, gender, education, and annual income.

Conditional and mixed logit discrete choice statistical models were used to predict the choice of cowpea attributes that the sampled consumers would make once Bt cowpea became available in the marketplace. The combined result revealed that the percentage of consumer awareness was low (19.71%) in the study area. Consumers in Sokoto State were more aware (87.80%) about the new Bt cowpea compared to their Kaduna State (12.20%) counterparts. The combined result further showed that consumers perceived that they were somewhat knowledgeable (20.19%) about Bt cowpea in the study area. This implies that the respondents had little perceived knowledge about the new Bt cowpea. In addition, the combined result showed that most respondents (61.54%) said they don't know about their perceptions regarding Bt cowpea while about 16.83% said it is unethical, 12.20% were neutral, 3.85% of the respondents perceived that it is somewhat unethical and 3.37% had ethical concerns about Bt cowpea in the study area. These perceptions were from the opinions of the respondents since they never have perfect information regarding the new Bt cowpea in the study area.

Furthermore, the results showed that all age groups were represented in the sample. Results from the combined data indicated that majority (30.77%) of the respondents' age fall between 29-39 years, implying that the young - aged groups accounted for most

of the responses in the study area. The results further showed that most respondents (58.33%) in Sokoto State were in the 60-69 age group while majority (66.67%) of the respondents in Kaduna State were in the 69-79 age category, respectively. The combined results revealed that there was an equal proportion (50%) of women and 50% of men that accounted for most of the responses in cowpea shopping in the study area. The result across the States indicated that majority (59.62%) of the respondents in Kaduna State were females, whereas majority (55.77%) of the respondents in Sokoto State that accounted for most of the responses were males. The combined results further revealed that majority (34.62%) of the respondents had completed primary education and most of the consumers (28.37%) had annual income of less than ₦19, 999 in the study area.

The combined results on the effect of socioeconomics characteristics of consumers' willingness to pay (WTP) indicated that age of respondents had positive (0.002) and significant effect on willingness to pay at 1% level, in the study area. The results further indicated that consumers between the 20-30 years of age were likely more willing to pay for cowpea attributes such as safety at ₦152.98 , white color at ₦15.41, large grain size at ₦76 and genetically modified organisms ₦22.95 more than consumers in the age category of over 60 years. Also, the results revealed that consumers' annual income had positive (0.04) effect on willingness to pay but was not statistically significant. The result also indicated that middle income consumers were likely to pay more for safety at ₦181.76 and cowpea large grain size at ₦90.40 as the most important attributes more than low income consumers in the study area. Furthermore, the formally educated consumers tend to value safety at ₦ 189.92 and cowpea large grain size at ₦94.49 as most important attributes more than the informally educated respondents. The results

further showed that female consumers were likely more willing to pay maximum prices on safety and cowpea large grain size as the most important attributes more than their male counterparts in the study area.

The combined results from conditional logit on consumers' willingness to pay indicated that the respondents were more willing to pay for safety (₦186.77) and large grain size (₦92.90) as the most important attributes of cowpea in the study area. The combined results on predicted market share revealed that Bt cowpea had a low potential market share (43.8%) compared to conventional cowpea (48.4%). The predicted share for Bt cowpea was much lower (36%) in Kaduna State compared to conventional cowpea (60%) than for Bt cowpea (39%) in Sokoto State. However, the predicted market shares for Bt cowpea in urban (43.5%) and rural (43.75) locations were much lower than the shares for Bt cowpea in the combined States, respectively.

The estimated aggregate benefit of releasing Bt cowpea in the market was also calculated. The results also revealed that introducing Bt cowpea would have a significant and positive impact on consumers' welfare of about ₦242 billion per year, respectively, in the study area.

Finally, combined results from the mixed logit model showed a significant and positive value on safety (1.353), cowpea large grain size (0.742) at 5% levels, respectively, and a negative and significant value on cowpea with no insect damage (-0.464) at 1% level. The results imply that the mixed logit estimates the extent to which consumers differ in their preferences for cowpea attributes. However, results across the states indicated that the value on the attributes of safety (4.625) was positive and significant at 5% level,

cowpea large grain size (2.064) at 5% level, and red color (-0.183), relative to other attributes, was much higher in Kaduna state than in Sokoto state.

5.2 Conclusion

The study concluded that consumers' awareness for Bt cowpea was low compared to conventional cowpea, and respondents had perceived ethical concerns about the new transgenic Bt cowpea. The study also concluded that consumers within the 20-30 years of age were more likely willing to pay for Bt cowpea than cowpea consumers over 60 years of age.. In addition, the study concluded that consumers in the study area were willing to pay significantly more for safer cowpea varieties, and for cowpea large grain size attributes. Also they were willing to pay significantly more for genetically modified (GM) cowpea. Thus, releasing Bt cowpea in the marketplace would have a significant higher net benefit on cowpea consumers in the study area. The study also concluded that Bt cowpea attributes can garner a majority market share if they possess similar grain size quality relative to the more conventional cowpea varieties. Finally, the study concluded that the mixed logit is a better model in analysis of consumers' preferences or choice situation and give more information than conditional logit model.

5.3 Contribution to Knowledge

1. This study calculated welfare effects of introducing the new Bt cowpea from empirically estimated parameters of conditional logit model to allow for monetary measurement of welfare change. The expected welfare indicated a positive and significant impact of about ₦242 billion per year in the study area.

2. Consumer preferences were represented by an indirect attribute-based utility function, which gives the maximum utility level obtainable on safety and cowpea large grain size attributes with a given set of retail cowpea prices and income of consumers. Prediction of attribute preferences from mixed logit showed that Safety attribute had a positive estimated value of 1.353 while cowpea large grain size had 0.742, which were statistically significant at 5% levels, respectively.
3. The study considered interaction between price attribute and individual socio-economic characteristics such as age, gender, education and annual income and examined whether willingness to pay (WTP) differ across socio-economic groups with differing levels of price preference. Using age to differentiate WTP or value showed that people in the age group of 20-30 years appear to have statistically significant effect on WTP for Bt cowpea more than people in the age category of above 60 years in the study area.

5.4 Policy Recommendations

Because many dimensions to agricultural biotechnology need to be considered to adequately inform public policy, which is made more difficult by the fact that agricultural biotechnology encompasses many issues addressed in very different ways, the following genetically modified organisms (GMOs) regulatory future policy measures were recommended:

i. There is need for public enlightenment on Bt cowpea to increase potential consumer response and acceptance of Bt cowpea before it is released in the marketplace in the study area.
ii. The study revealed that consumers had exhibited concerns on the ethics of genetic modification of Bt cowpea and perceived the risks of toxicity about the

new Bt cowpea in the study area. Thus, there is need for public enlightenment on the regulatory authorities to understand these negative concerns more fully and to take them into account before moving Bt cowpea from regulatory approval commercialization.

iii. The study revealed that both in Kaduna and Sokoto States consumers placed a relatively high level of importance on safety attribute of Bt cowpea and thus, there is the need to incorporate a few regulatory steps on safety into the regulatory approval as well as assess the safety of Bt cowpea to be introduced in the study area.

iv. The study also showed that consumers significantly discounted cowpea with insect damage in the study area. Therefore, before Bt cowpea is introduced in the marketplace, it is recommended that research should ensure to modify and protect the new Bt cowpea from insect damage.

v. The study revealed that cowpea large grain size and safety attributes were the most valued by consumers in the study area. There is need for crop breeders to keep improve cowpea large grain size when introducing new varieties of Bt cowpea in the study area.

vi. The study indicated that introducing Bt cowpea in the marketplace would have a significant higher net welfare benefit on cowpea consumers in the study area. Therefore, there is need for the Federal Government of Nigeria and regulatory authorities to ensure that introducing the new Bt cowpea promote consumer welfare in the study area.

5.5 Suggestions for Further Research

This study analyzed the economic impact of Bt cowpea in Kaduna and Sokoto States, Nigeria. Areas recommended for future research are as follows:

i. Future research in this area might focus on investigating the relationship between knowledge level of subjects on Bt cowpea and the effectiveness of "cheap talk" information.

ii. Consumer perceptions about trust in information sources and government might be analyzed in the future to determine the acceptance of Bt cowpea.

iii. Factors that influence consumer views about Bt cowpea might be analyzed in a study of consumer's reactions to commercialization of Bt cowpea in the future.

iv. Sensory acceptability test might be conducted to enable consumers to taste the real Bt cowpea that they would be asked to value in the future.

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APPENDIX I

QUESTIONNAIRE

A. Genetically Modified Knowledge and Awareness of Bt cowpea

1) Have you ever read or heard of maruca resistant Bt cowpea or Bt technology in Sokoto or Kaduna State prior to this survey?
   a) Yes, I have read or heard about Bt cowpea
   b) No, I have read or heard anything about Bt cowpea

If your answer to question 1 was (a), please answer questions 2 through 5. Otherwise go to question 6.

2) If yes, please what does Bt technology or cowpea meant?
   a) Changing the nature of food
   b) Something to do with science
   c) Changing genes
   d) Human involvement in changing food
   e) Playing around with genes
   f) Playing around with nature
   g) Something to do with longer lasting qualities

3) If yes, please identify the source of your information on Bt cowpea
   a) Institute for Agricultural research (IAR) Zaria
   b) Open Forum on Agricultural biotechnology
   c) African Agricultural technology Foundation
   d) National Biotechnology Development Agency
   e) Nigerian Television Authority
   f) Radio
   g) People talking about Bt cowpea
   h) Others (Please specify)

4) How knowledgeable you are about genetically modified (GM) food, Bt cowpea or biotechnology?
   a) Very knowledgeable
   b) Somewhat knowledgeable
   c) Not informed

5) If you are very knowledgeable, please indicate whether the following statements are true or false or don't know
   a) Ordinary cowpea [beans] do not contain genes, whereas maruca resistant Bt cowpea do

b) If people eat genetically modified cowpea, their genes could also become modified
c) It is impossible to transfer genes originating from soil bacteria into cowpea plants

6) Perception of Consumers on Bt Cowpea

7) What is your view or feeling about the new Bt cowpea varieties?
a) Ethical
b) Somewhat ethical
c) Neutral
d) Somewhat unethical
e) Unethical
f) Don't know

8) Overall, what would you say are the main risks or disadvantages of maruca resistant cowpea?

a) Food safety/health concerns/allergies
b) Toxic
c) Ethics
d) Quality of beans [worse]
e) Gene Mutation
f) Environmental concern
g) No disadvantages
h) Unsure
i) Other (please specify

9) Do you prefer cowpea that is produced in Nigeria?
a) Yes
b) No

Consumers view about biotechnology/Maruca resistant Bt cowpea

10) What is your overall feeling about use of biotechnology in crops like cowpea?
a) Very positive
b) Somewhat positive
c) Neutral
d) Very negative
e) Don't know

11) If very negative, can you please mention the issues that matter most to you about cowpea genetic modification

a) Ethical concern
b) Health concern
c) Improved nutrition
d) Safety
e) Environmental impact
f) Yield increase
g) Insecticide use
h) Useful
i) Risky
j) Morally acceptable
k) Others (please specify)

Perceived benefits of Bt cowpea genetic modification

12) Overall, what would you say are the main benefits or advantages of Bt cowpea

a) Improved nutritional value
b) Quality of Beans [better]
c) Less pesticide required
d) Higher cowpea yields
e) Safer product
f) No advantages
g) Unsure
h) Other (Please specify)

13) Would you like to consume GMO Cowpea?
a) Yes
b) No

Choice Experiment (CE) Questions:

14) Please tick the cowpea option that you are most likely to consume given the attributes in the table below

Attributes	Bt cowpea	Conventional cowpea	None Neither option is preferred
Price (N/kg)	150	250	
Color	White	Red	
Safety	Yes	No	
Grain size	Small	Large	
GMO	No	Yes	
Insect damage	Yes	Yes	
I would choose	[ ]	[ ]	[ ]

15) Please tick the cowpea option that you are most likely to consume given the attributes in the table below:

Attributes	Bt cowpea	Conventional cowpea	None Neither option is preferred
Price(N/kg)	250	200	
Color	Red	White	
Safety	No	Yes	
Grain size	Large	Large	
GMO	Yes	Yes	
Insect damage	Yes	No	
I would choose	[ ]	[ ]	[ ]

16) Please tick the cowpea option that you are most likely to consume given the attributes in the table below

Attributes	Bt cowpea	Conventional cowpea	None Neither option is preferred
Price (N/kg)	150	250	
Color	Brown	White	
Safety	Yes	No	
Grain size	Small	Small	
GMO	Yes	No	
Insect damage	No	No	
I would choose	[ ]	[ ]	[ ]

17) Please tick the cowpea option that you are most likely to consume given the attributes below:

Attributes	Bt cowpea	Conventional cowpea	None Neither option is preferred
Price (N/kg)	150	200	
Color	White	Brown	
Safety	No	No	
Grain size	Large	Large	
GMO	Yes	No	
Insect damage	Yes	No	
I would choose	[ ]	[ ]	[ ]

18) Please tick the cowpea option that you are most likely to consume given the attributes below

Attributes	Bt cowpea	Conventional cowpea	None Neither option is preferred
Price (N/kg)	150	150	
Color	Red	Red	
Safety	No	No	
Grain size	Large	Large	
GMO	No	No	
Insect damage	No	No	
I would choose	[ ]	[ ]	[ ]

19) Please tick the cowpea option that you are most likely to consume given the attributes below

Attributes	Bt cowpea	Conventional cowpea	None Neither option is preferred
Price (N/kg)	200	250	
Color	Brown	Red	
Safety	No	Yes	
Grain size	Large	Small	
GMO	No	Yes	
Insect damage	No	No	
I would choose	[ ]	[ ]	[ ]

20) Please tick the cowpea option that you are most likely to consume given the attributes below

Attributes	Bt cowpea	Conventional cowpea	None Neither option is preferred
Price (N/kg)	200	200	
Color	Brown	Red	
Safety	No	Yes	
Grain size	Small	Small	
GMO	Yes	No	
Insect damage	Yes	Yes	
I would choose	[ ]	[ ]	[ ]

21) Please tick the cowpea option that you are most likely to consume given the attributes in the table below

Attributes	Bt cowpea	Conventional cowpea	None Neither option is preferred
Price (N/kg)	250	150	
Color	Brown	Brown	
Safety	Yes	Yes	
Grain size	Large	Small	
GMO	No	Yes	
Insect damage	Yes	No	
I would choose	[ ]	[ ]	[ ]

22) Please tick the cowpea option that you are most likely to consume given the attributes in the table below

Attributes	Bt cowpea	Conventional cowpea	None Neither option is preferred
Price (N/kg)	200	250	
Color	White	Brown	
Safety	Yes	Yes	
Grain size	Large	Large	
GMO	Yes	No	
Insect damage	No	Yes	
I would choose	[ ]	[ ]	[ ]

23) Please tick the cowpea option that you are most likely to consume given the attributes in the table below

Attributes	Bt cowpea	Conventional cowpea	None Neither option is preferred
Price (N/kg)	200	150	
Color	Red	White	
Safety	Yes	No	
Grain size	Small	Large	
GMO	No	Yes	
Insect damage	Yes	Yes	
I would choose	[ ]	[ ]	[ ]

24) Please tick the cowpea option that you are most likely to consume given the attributes in the table below

Attributes	Bt cowpea	Conventional cowpea	None Neither option is preferred
Price (N/kg)	250	150	
Color	Red	White	
Safety	Yes	Yes	
Grain size	Small	Small	
GMO	Yes	No	
Insect damage	No	Yes	
I would choose	[ ]	[ ]	[ ]

25) Please tick the cowpea option that you are most likely to consume given the attributes in the table below

Attributes	Bt cowpea	Conventional cowpea	None Neither option is preferred
Price (N/kg)	250	200	
Color	White	Brown	
Safety	No	No	
Grain size	Small	Small	
GMO	No	Yes	
Insect damage	No	Yes	
I would choose	[ ]	[ ]	[ ]

Socio-Economic Characteristics Data

27) Age…… 2) Gender: Male [ ] Female [ ]

28)Marital Status a) Single [ ] b) Married [ ] c) Widowed [ ] d) Divorced [ ]

29) What is your level of Education?

a) Completed Primary School
b) Some Secondary School
c) University
d) Informal
e) Others (please specify)……

30) How often do you purchase beans?

31) Daily [ ] b) Once a week [ ] c) twice a week [ ] d) thrice a week[ ] e) Once a month [ ]

32) How often do you consume beans?

a) Daily [ ] b) Once a week [ ] c) twice a week[ ] d) thrice a week[ ] e) Once a month [ ]

33) Would you continue to consume beans even if price is increasing?

a) Yes [ ] b) No [ ]

34) Which of the following better represents your annual income?

a) <19,999 Naira [ ]
b) 20,000 – 39,999 [ ]
c) 40,000 -59,999 [ ]
d) 60,000 – 79,999 [ ]
e) 80,000 – 99,999 [ ]
f) >100,000 [ ]