Acceptance, perceptions and willingness to pay for Quality Protein Maize (QPM) by rural consumers in Tanzania

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DECLARATION

I Christine Gacheri Kiria, student number 29615217, declare that the thesis, which I hereby submit for the degree of MSc (Agric) Agricultural Economics at the University of Pretoria, is my original work and that it has not been presented before any another academic forum for assessment. All information that has been used from other peoples' work has been referenced accordingly.

Signature: Christine Kiria

Date: 15th December 2010

DEDICATION

To my loving fiancé Simon Chege, my dear parents Mr. John Kiria and Mrs. Mary Kiria and my brothers Charles Koome and Henry Muthomi, you are simply the best!

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ABSTRACT

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Malnutrition remains a persistent and increasing problem in Sub-Saharan Africa (SSA). Food production has not kept pace with population growth, and many people have poor access to adequate, nutritious diet. In many areas of the developing world, maize is a vital staple and a main source of dietary protein. In Eastern and Southern Africa, maize is the basic food for the subsistence farmers. Per capita consumption of maize in Malawi, Zambia and Zimbabwe is 100 kg per year, while in Tanzania, per capita consumption is estimated at 73 kg per year. Unfortunately, the nutritional value of conventional maize is poor, partly due to the low biological value of its protein. To ensure sufficient protein intake, conventional maize should therefore be consumed with complementary protein sources, such

as legumes or animal proteins. The complementary proteins sources however, tend to be expensive, or take a lot of time and fuel to cook, for instance beans.

The main aim of this study was to evaluate the sensory characteristics and consumer acceptance of quality protein maize (QPM) in rural Tanzania. QPM is a maize cultivar which has almost double the amount of tryptophan and lysine. QPM has been adopted in several countries of SSA, but very few studies have been undertaken on its acceptance by consumers. In Tanzania, no study has been undertaken to elicit consumers' acceptability for this maize variety. The sensory characteristics of food products affect consumers' immediate consumption gratification. This study makes a unique contribution to the literature by exploring the roles that sensory evaluation and nutritional information play in shaping consumers' QPM flour purchasing behaviour through economic experiments in rural Tanzania.

A triangle test was undertaken to find out whether there is a difference between QPM and conventional maize. Additionally, a rural household survey was undertaken which collected consumers' demographic, farming and individual characteristics. This was done using structured questionnaires administered by trained enumerators. Moreover, modified home use sensory testing and central location sensory testing were also undertaken to determine sensory characteristics of QPM and conventional maize. Stiff porridge, a major maize product in East and South Africa, was used to undertake this experiment. Finally, acceptability of QPM was tested using experimental auctions with the Becker-DeGroot-Marschak (BDM) procedure, and maize flour was used to undertake this experiment.

The sensory evaluation findings of the study indicated that consumer characteristics of QPM stiff porridge were highly appreciated than those of conventional maize stiff porridge. This was observed both in the modified home use testing and central location testing. Likewise, consumers were willing to pay more for QPM than for conventional maize in all evaluation criteria used. Triangle test showed a significant difference between QPM and conventional maize. Sensory evaluation however needs to be repeated with other QPM varieties to

ensure that it is not only a specific QPM variety that has favourable consumer characteristics.

This study further revealed that providing QPM nutritional information to consumers increases their willingness to pay for QPM. Subjects who were provided with QPM nutritional information had higher WTP for QPM than those who were not. This shows that creating awareness of the nutritional contents, especially of the new varieties, would increase the appreciation by consumers hence help in fighting malnutrition in SSA. Providing QPM nutritional information, on the other hand, decreased consumers' WTP for conventional maize. This was unexpected because the information provided only concerned QPM. The study recommends that another study be carried out to find out the cause of decrease in WTP for conventional maize when QPM nutritional information is provided.

This study clearly reveals that QPM is acceptable by rural consumers in Tanzania. This information can help policy makers in Africa to better understand consumers' food behaviour and make initiatives to improve diet and health, which can be important in reducing malnutrition in Sub Saharan Africa.

Key words: Malnutrition, QPM, Consumer acceptance, Sensory testing, Tanzania

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LIST OF ACRONYMS

Acronyms	Meaning
ASARECA	Association for Strengthening Agricultural Research in Africa
DALYs	Disability-Adjusted Life-Years
FAO	Food and Agriculture Organisation
FARA	Forum for Agricultural Research in Africa
GM	Genetically modified
NSCA	National Sample Census of Agriculture
O2	*Opaque-2* Maize
PHDR	Poverty and Human Development Report
QPM	Quality Protein maize
QPMD	Quality Protein Maize Dissemination
SARI	Selian Agricultural Research Institute
SPSS	Statistical Package for Social Scientists
SSA	Sub-Saharan Africa
TDHS	Tanzania Demographic Health Survey
UNICEF	United Nations Children's Fund
USA	Unites States of America
WHO	World Health Organisation
WTP	Willingness to Pay

CHAPTER 1: INTRODUCTION

1.1 BACKGROUND

1.1.1 Malnutrition

Malnutrition is a condition principally caused by lack of appropriate nutrition, and mainly arises when a person's body is receiving insufficient nutrients. This may be as a result of insufficient diet, unbalanced diet, absorption problems or digestive difficulties (John, 2007:1). The United Nations Children's Fund (UNICEF) further defines malnutrition as a broad term commonly used as an alternative to under-nutrition[1]. People are malnourished if their diet does not provide adequate calories, protein and micronutrients for growth and maintenance, or if they are unable to fully utilize the food they eat due to illness (under-nutrition) (UNICEF, 2006).

Sufficient micronutrients in the daily diet are one of the prerequisites for human health (Caballero, 2003:77). However, most of the countries within Sub-Saharan Africa (SSA) experience a reduction in dietary diversity among the consumers, which is a fundamental determinant of malnutrition, especially among children, expectant women and the aged (Johns & Eyzaguirre, 2007:2). Humans require at least 49 nutrients to meet their metabolic needs, inadequate consumption of any one of which results in adverse metabolic disturbances and in turn sickness, poor health, impaired development in children, and large economic costs to society (Branca & Ferrari, 2002:10; Ramakrishnan, Manjrekar, Rivera, Gonzales-Cossio & Martorell, 1999:105).

Childhood under-nutrition is among the most serious health issues facing developing countries (Branca & Ferrari, 2002:11), and is associated with mortality, morbidity and reduced labour productivity (Black, Allen, Bhutta, Caulfield, De Onis, Ezzati, Mathers & Rivera, 2008:243). Under-nutrition is estimated to directly cause 53% of child deaths globally (Habicht, 2008:1749). Across the developing world, 178 million or 32% of children under five years are stunted and 112 million or 20%

[1] The definition of under-nutrition is given in Appendix A together with definitions of other key terms in this paper

of the children under five years are underweight (Black *et al.*, 2008:245). Severe protein-energy malnutrition in children manifests as *marasmus*, which mainly affects children below one year of age (Ngichabe, 2002:361). On the other hand, severe protein malnutrition manifests as *kwashiorkor*, but it may coexist with marasmus, and mostly appears during weaning. In some instances, both kwashiorkor and marasmus are characterised by diarrhoea, stunting, wasting and discolouration and sparseness of the hair, even though all these characteristics may not be present in all cases (Ngichabe, 2002:361).

Malnutrition continues to be a growing problem in most developing countries, such as Tanzania (John, 2007:1). Prevalence of malnutrition in Tanzania has been attributed to the high levels of poverty in rural areas of the country, in which 87% of the population depend on agriculture for their livelihood. Indicators of malnutrition among the children under five years include stunted growth, underweight and wasting (PHDR, 2009). Rural children experience higher levels of stunted growth (41%) than urban children (26%), and a higher percentage of rural children (23%) than urban children (17%) are underweight (Table 1:1).

Table 1.1: Indicators of malnutrition in children under five years in Tanzania, urban-rural, 2004/05

	Stunting (height-for-age)	Underweight (weight -for-age)	Wasting (weight-for-height)
2004/05 mainland	38.00%	21.92%	2.90%
Urban	26.00%	17.30%	2.90%
Rural	40.91%	23.01%	2.90%

Source: TDHS (2006)

1.1.2 Malnutrition remediation strategies

Four strategies are commonly used to address nutrient deficiencies, namely dietary intervention, fortification, supplementation and biofortification.

1.1.2.1 Dietary diversification

In order to achieve a well-fed and food-secure household it is vital to improve what people eat, in terms of variety, quality, and quantity (ILSI & FAO, 1997:2). Under dietary diversification, consumers are encouraged to modify their eating behaviours, and by eating a wide variety of foods with different nutrients they increase the levels of those that are necessary in the diet. Dietary diversification is undertaken mainly on types of food already available to the population, with modifications only to a consumer's choice of foods. Moreover, solutions to micronutrient malnutrition go hand-in-hand with ensuring food security, especially at the household level (Campos-Bowers & Wittenmyer, 2007:2).

In most tropical countries the diversity of indigenous crops and wild plant and animal species available, in addition to providing essential nutrients, provides broad benefits to health (Frei & Becker, 2004:1594). In some cases, traditional food cultures such as the red palm oil, fish, meat and leafy green food complex of West Africa are noted for delivering excellent nutritional quality (including vitamin A) at low cost and in a culturally acceptable way (Smith, 1998). For example, daily requirements for vitamin A are contained in small portions of foods such as carrot, mango, liver, pumpkin, sweet potato or dark green leafy vegetables.

Dietary diversification has been successful in reducing malnutrition and micronutrient deficiency in some places. In South Africa, increased consumption of foods rich in vitamin A, and awareness creation of the problem in the affected areas, has helped to reduce vitamin A deficiency among children (Faber, Phungula, Venter, Dhansay & Spinnler Banad´e, 2002:1050).

For high income consumers, developing the nutritional value of staple food crops has been of less concern since they have access to improved nutrition through dietary diversification (Morris & Sands, 2006:1079). In the case of rural consumers however, food diversification strategy is inhibited by resources available to the households and seasonality of vegetables and fruits. In Kenya, vitamin A intake among preschool children from low income rural households considerably differed between post-harvest and lean months (Kigutha, van Staveren, Veerman & Hautvast, 1995:693). Dietary diversity has also been identified as a difficult and an

expensive strategy to maintain on a large scale (Unnevehr, Pray & Paarlberg, 2007:127).

Whereas ensuring access to a balanced diet would be the best solution to curb micronutrient deficiency, it is not always an attainable one in developing countries since the poor people are deficient in purchasing power (Meenakshi, Johnson, Manyong, De Groote, Javelosa, Yanggen, Naher, Gonzalez, Garcia & Meng, 2009:66). Therefore, other methods have been used to curb the problem of malnutrition.

1.1.2.2 Fortification

Food fortification is the practice of deliberately increasing the content of essential micronutrients in a food to improve the nutritional quality of the food supply and to provide a public health benefit with minimal risk to health (WHO & FAO., 2006:24). Fortification of staple foods can be used as a measure of addressing malnutrition since it is socially acceptable, and does not require active participation of consumers or any change in buying, cooking or eating habits (Nestel, 1993:3). Moreover, food fortification can be introduced quickly and the benefits are readily visible. In most cases, it does not affect the organoleptic properties of food products (Bauernfeind & Arroyave, 1986:370).

Food fortification has been used effectively to raise micronutrient levels in large populations. For example, iodine fortification of salt was introduced in the United States of America (USA) in the 1920s, since when it has been seen to prevent iodine deficiency in many developing and developed countries (Miller, 2004:5). Moreover, fortification of sugar in Latin America contributed significantly to the control of vitamin A deficiency (IVACG, 2003:8). In South Africa, maize meal fortification is mandatory (the regulation R7634 dated 7 April 2003 on fortification of certain foodstuffs as guided by the Foodstuffs, Cosmetics and Disinfectants Act, Act no 54 1972). In the Philippines, several foods fortified with different micronutrients are available in the consumer market, which include rice fortified with iron (Florentino & Pedro, 1995:4), margarine, wheat flour, sugar and cooking oil fortified with vitamin A (Marero, Florentino, Aguinaldo, Capanzana & Saises, 1997:3; NCP, 1999:1; Solon, 1998:155).

Food fortification as a measure of addressing micronutrient malnutrition has several challenges. Firstly, people who consume locally produced, unprocessed food are unlikely to benefit from food fortification since it relies on centrally processed and marketed food vehicles (National Nutritional Council, 1994:5). This remains the case among the majority of the African countries' rural consumers, who mill small batches of staple grains at local hammer mills to get their weekly supply of maize meal. Therefore, to address the micronutrient malnutrition problem among such population groups through fortification becomes a major challenge (Underwood, 1999:4). Secondly, food fortification mainly relies on broadly distributed, industrially processed food items, which are usually unaffordable to the world's poor consumers living on less than two dollars per day, and much less those who live on less than one dollar per day (Mayer, Pfeiffer & Beyer, 2008:167). Thirdly, fortified foods are accessible to both target and non-target groups. This usually is not the most economical way to reach the target group, however if the cost of fortification was to be passed to the target group only then their purchasing patterns would adversely change (INACG., 1981). Fourthly, food fortification has additional costs for food manufacturers, which trickles down to the consumer, making it more expensive (Arroyave, 1987:88). Finally, for an individual to benefit from nutrients in the fortified food, the food must be consumed on a regular basis, preferably during most meals (Food and Agriculture Organization, 1996). This, however, remains a challenge for rural consumers in developing countries.

1.1.2.3 Supplementation

Supplementation is the term used to describe the provision of relatively large doses of micronutrients, in the form of capsules, syrups or pills (Meenakshi *et al.*, 2009:65). These are periodically administered to people to reduce micronutrient deficiency. For example, vitamin A capsules administered to pre-school children twice a year. Through supplementation, individuals can attain an optimal amount of a specific nutrient in a highly absorbable form. Supplementation is often the fastest way to control micronutrient deficiency in individuals or population groups that have been identified as being deficient (WHO & FAO, 2006:13).

Supplementation can be effective on a large scale, for instance as supported by successful eradication of vitamin A deficiency in Vietnam and Indonesia (Underwood, 1999:4). These successes were partly due to regular and broad supplementation coverage. However, where supplementation is used as a long-term solution, deficiencies may reoccur in times of economic or political crisis, indicating that supplementation efforts may be subject to the effects of social instability (Underwood, 1999:4).

Vitamin A supplementation programmes carried out in 103 priority countries showed that coverage stagnated at 58%, with high annual fluctuations (UNICEF, 2007). Moreover, a 'Nutritional Anaemia Control Programme' in India, which has been in operation since 1970, has shown very little impact because of underfunding, logistical problems, mismanagement and poor compliance (Vijayaraghavan, 2002:74). Another disadvantage of supplementation is that it is not cost-effective. The results of a review of the literature estimating the global cost of vitamin A supplementation revealed that the cost of one vitamin A capsule was $US 0.10. However, logistics and distribution cost made the cost of the capsule more expensive, at one dollar (Neidecker-Gonzales, Nestel & Bouis, 2007:310).

1.1.2.4 Biofortification

Biofortification is the development of food crops rich in bio-available micronutrients, either through conventional breeding or genetic modification (Johns & Eyzaguirre, 2007:2). This is done by reducing levels of anti-nutrients in staple foods that slow down the bioavailability and absorption of nutrients, by increasing levels of substances that promote nutrient absorption and bioavailability and increasing nutrient content in food plants through selective plant breeding (Campos-Bowers & Wittenmyer, 2007:3). Plant breeding takes the benefit of the natural genetic assortment of crops, which is genetically crossing different varieties of a crop to develop new cultivars with higher levels of desired nutrients. These new varieties can be disseminated to farmers in areas where nutrient-dense crops could address problems of nutrient deficiency and malnutrition (Zapata-Caldas, Hyman, Pachón, Monserrate & Varela, 2009:2). Biofortification particularly targets rural areas where home production and consumption of staple

food crops are significant and consumption of the marketed surplus is likely to remain in the community (Johns & Eyzaguirre, 2007:3).

Cereals are the most important staple crops in both developing and developed countries and are a particularly important source of vitamins, minerals and rare amino acids (Poletti, Wilhelm & Christof, 2004:162). However, cereals, in general, contain low levels of micronutrients, many of which are lost during processing into food or feed. Therefore, they have in many cases been the target vehicle for biofortification. Maize is an important staple food for many people in Sub-Saharan Africa, Latin America, and parts of Asia (N.R.C, 1988). In many African countries, especially East and Southern Africa, maize is the basic food for most people. For instance, in Malawi, Zambia and Zimbabwe, per capita consumption of maize is 100 kilograms per year (NRC, 1988:5). Populations in the developing world are more in need of cereal biofortification since several million people derive their protein and calorie requirements from maize. Maize accounts for about 15 - 56% of the total daily calories in diets of people in about 25 developing countries, particularly in Africa where animal protein is scarce and expensive, and consequently unavailable to a vast sector of the population (N.R.C, 1988). The utilizable protein content in maize is limited by low levels of certain amino acids, particularly lysine, and to a lesser extent tryptophan (Lauderdale, 2000:3). Therefore, in areas or amongst populations where diets consist largely of maize, protein deficiencies can occur.

Recent studies conducted with human subjects under a controlled setting show that biofortification can have an impact on private health. Quality protein maize (QPM), a biofortified crop, has been seen to have positive results towards malnutrition. QPM are conventionally bred varieties that contain the *opaque-2* gene which roughly doubles the available protein in maize due to higher levels of the essential amino acids lysine and tryptophan (Vasal, 2000:446). A study conducted in Peru with 10 malnourished children showed that the measurement of growth kilocalories per gram of weight gain, weight for age change, height for age change and fat-fold change were similar to those for milk (Graham, Lembcke & Morales, 1990:88). This shows that the high quality of protein of high-lysine maize is very close to that of milk protein. Modern QPM varieties are currently being

actively disseminated, particularly in Sub-Saharan Africa (Krivanek, De Groote, Gunaratna, Diallo & Friesen, 2007:318)

A nine-month feeding experiment in the Philippines showed that frequent consumption of rice containing an extra 2.6 parts per million (ppm) of iron was efficient in improving body iron stores among iron-deficient women (Haas, Beard, Murray-Kolb, Del Mundo, Felix & Gregorio, 2005:2824). In addition, the results from a study in Philippines showed that "Golden rice" could improve the vitamin A status of deficient food consumers, especially women and children in developing countries (Zimmermann & Qaim, 2004:149). Another piece of research done in India showed that biofortification of wheat and rice could decrease the disease burden allied to deficiency of iron (Stein, Meenakshi, Qaim, Nestel, Sachdev & Bhutta, 2008:1799). In South Africa, a feeding trial with school children showed that consumption of orange-fleshed sweet potato, high in beta-carotene, led to improvements in their vitamin A status (Van Jaarsveld, Faber, Tanumihardjo, Nestel, Lombard & Spinnler Benade, 2005:1083). Similar results were obtained in a community setting in Mozambique (Low, Arimond, Osman, Cunguara, Zano & Tschirley, 2007:1322).

The success of biofortification depends on many factors, including the degree to which biofortified staples are adopted by farmers and accepted by consumers, and its cost-effectiveness (Unnevehr *et al.*, 2007:128). A number of studies have documented the relative cost-effectiveness of biofortification. For instance, in India, saving one DALY through vitamin A fortification costs $US 84 to $US 98, whereas through vitamin A supplementation, it costs $US 134 to $US 599 and through biofortified "Golden Rice" , which is engineered to contain a Vitamin A precursor, it costs only between $US 3.40 to $US 35, significantly less than either of the other interventions (Stein, Qaim, Meenakshi, Nestel, Sachdev & Bhutta, 2006:4; Unnevehr *et al.*, 2007:127).

1.1.3 Importance of maize in Tanzania

Maize is the most important staple food crop grown in Tanzania, with an estimated consumption per capita of 73 kilograms per year (Minot, 2010:1). Other staples include cassava, sorghum, rice, wheat, millet, sweet potatoes and bananas

(Ministry of Agriculture and Cooperatives, 2001). Over 80% of the population depend on maize as a food crop as well as a cash crop. Moreover, maize is the most widely grown crop in Tanzania, produced by 4.5 million farm households which represent about 82% of all Tanzanian farmers. Most of the maize (85%) is produced by small-scale farmers, the rest (15%) by public and private large scale farmers (Moshi, 1997:3-4). Most maize produced (85%) is consumed at the household level, and the surplus is bought by other farmers within and outside the region, or by urban dwellers (Natai, 2001). Figure 1:1 summarises the different crop categories in Tanzania and the areas planted for each.

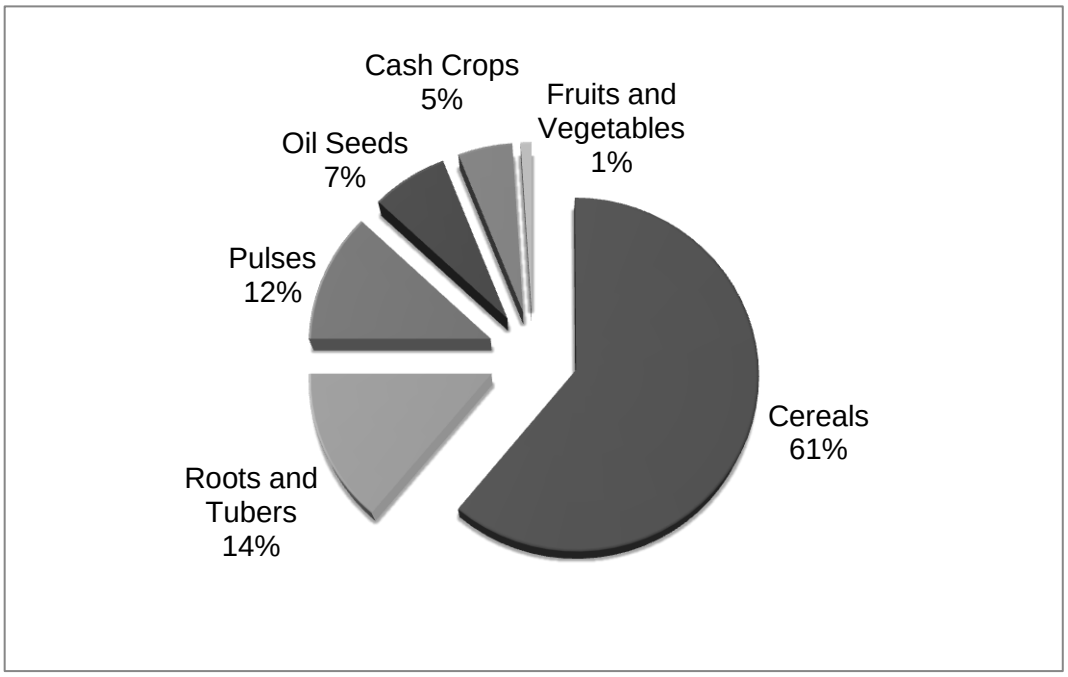

Figure 1.1: Category of crops and percentage of total area planted (ha) in Tanzania
Source: Tanzania National Bureau of Statistics, (2006)

Cereals, which consist of maize, paddy, sorghum, bulrush and finger millet, wheat and barley, are the major agricultural crops grown in Tanzania (61%), followed by roots and tubers (14%), pulses (12%), and fruits and vegetables (1%).

In 2006, the total maize production in Tanzania was 2,617,115 tonnes, which represented 74% of total cereal production (Tanzania National Bureau of Statistics, 2006). Maize is grown on more than 45% of the total national cultivated area and 72% of the area planted with cereals (Government of Tanzania, 2006:2)

Among the major staple food crops, maize and cassava are the most important staple foods in Tanzania (Table 1:2, below). The consumption of maize (73 kg per capita) is about half that of cassava (157 kg per capita). However, because maize has greater caloric density than cassava it is a more important source of calories (33%) compared to cassava (15%). Other important staples are rice (8%), wheat (4%) and sorghum (4%).

Table 1.2: Importance of staple foods in diet of Tanzania

Commodity	**Quantity Consumed** (kg/person/year)	**Daily caloric intake** (kcal/person/day)	**Share of caloric intake** (percent)
Maize	73	655	33
Cassava	157	298	15
Rice	16	154	8
Wheat	10	79	4
Sorghum	9	79	4
Other		730	35
Total		1,917	100

Source: Food and Agriculture Organization, (2009)

The importance of the different staple foods in Tanzania depends greatly on the income levels of the people and on their location. For instance, sorghum and cassava are more important in the diets of low-income households and in the rural areas, mainly in their production zones where they are subsistence crops (Minot, 2010:9). In contrast, wheat and rice consumption are among the most important staple crops in the diets of high-income consumers in the urban areas. This is to a certain extent due to their being more expensive sources of calories than cassava, sorghum and maize. Maize, however, is in an intermediate position, being an important staple crop in both rural and urban areas (Minot, 2010:9).

Maize is used to prepare staple foods both in the urban and rural areas of Tanzania. Stiff porridge prepared from maize (*ugali* in Swahili) is the most common meal eaten by the Tanzanians (Mazengo, Simell, Lukmanji, Shirima & Karvetti, 1997:314), followed by *kande*, which is prepared from boiled maize grain from which the seed coat has been removed. Some of the rural consumers mix

maize with peas or pulses to prepare *kande*. However, if consumers do not have any peas or pulses and cannot afford to buy them they prepare *kande* purely from maize grain (Koizumi, 2007:6).

Within the rural population, very few consumers buy maize flour for stiff porridge preparation, but rather mill their maize in their local hammer mills (Mazengo *et al.*, 1997:316). According to the findings of Mazengo *et al. (*1997:16), consumption of milk, meat and other high-protein foods in Tanzania is minimal in rural areas. The mean daily protein intake is highest among the urban 12-year old females when values are expressed as proportions of total energy. Lowest protein intakes were recorded in rural females aged 65-74 years.

1.1.4 Quality protein maize (QPM)

As mentioned above, maize is a major cereal crop both for human consumption and animal feed in developed and developing countries. Where animal protein is scarce and expensive the consumers overly depend on maize for their daily protein uptake. However, protein from conventional maize has poor nutritional value especially for monogastric animals, including humans. Conventional maize has limited content of essential amino acids such as tryptophan, lysine and threonine, which makes it a poor source of protein (Bressani, 1991:807). Therefore, to ensure a healthy diet, consumption must be complimented by alternative protein sources, such as legumes or animal protein. Due to this limitation of the conventional maize, scientists have collectively devoted time and effort to the breeding of *opaque-2* maize, which was later upgraded to quality protein maize (QPM).

QPM is a conventionally bred maize variety which has roughly double the available protein of normal maize, due to higher levels of the essential amino acids, lysine and tryptophan (Vasal, 2000:446). Research on QPM has been ongoing for several decades. In the early 1960s, at Purdue University, it was discovered that *opaque-2* endosperm had 69% more lysine than the normal maize endosperm (Mertz, Bates & Nelson, 1964:279).The *opaque-2* mutants altered the amino acid profile and composition of maize endosperm protein, which results in doubling the lysine and tryptophan levels. However, the mutation also had several

undesirable effects on the maize, including lower yields, and a soft and chalky kernel which left the maize susceptible to disease and pest damage both in the field and during storage, as well as changing the taste (Vasal, 2000:446). Moreover, the gene controlling for high protein levels is recessive, and hence protein levels could be reduced if new seeds were not purchased every two or three seasons, or if proper seed selection was not carried out. These factors made QPM unattractive for farmers to produce (Lauderdale, 2000:2).

These setbacks stimulated many years of subsequent research at the International Maize and Wheat Improvement Centre (CIMMYT). The research resulted in maize varieties that retained the *opaque-2* mutation and the quality protein trait, but lacked the accompanying unfavourable agronomic characteristics of a soft endosperm (National Research Council, 1988), and they were collectively referred to as “quality protein maize” (QPM).

QPM has extra improved nutritional benefits over conventional maize. Apart from increased levels of lysine, it has reduced levels of the leucine amino acid. A lower leucine level is considered an advantage because it results in a more balanced leucine-isoleucine ratio, which in turn helps liberate more tryptophan (Vasal, 2000:447), and improves absorption of carotene and potassium (Graham, Placko & Mclean, 1980:1071). Due to the increased concentration of tryptophan, QPM has a higher concentration of niacin (B3). These changes in amino acids composition increase the total amount of protein that can be obtained from QPM, without requiring the ingestion of other foods (the percentage of lysine and tryptophan that is in QPM and the conventional maize is summarised in Table 1:3. Lysine levels in QPM average about 4% of the total protein in the QPM flour, compared to about 2% of the total protein in the conventional maize flour. Likewise, the amount of tryptophan in QPM is higher than that found in conventional maize. QPM tryptophan levels average about 0.8% of the total protein in QPM, compared to about 0.4% of the total protein found in conventional maize.

Table 1.3: Tryptophan and lysine levels as a percentage of total protein in whole grain flour of QPM and conventional maize.

Parameter	QPM	Conventional maize
Lysine	2.7-4.5% (average 4.0%)	1.6-2.6% (average 2.0%)
Tryptophan	0.5-1.1% (average 0.8%)	0.2-0.5% (average0.4%)

Source: Moro, Habben, Hamaker & Larkins, (1996:1653)

Over the years, several studies have documented the effect of QPM on the nutritional status of children and monogastric animals in many maize-consuming areas. A study by Bressani (1991:807) showed that children and adults eating QPM had considerably higher nitrogen retention than those who ate conventional maize, thus showing that QPM protein is more bio-available. A meta-analysis of nine studies with children showed a 12% increase in the rate of growth in weight as a result of consumption of QPM, compared to conventional maize, and a 9% increase in the rate of growth in height in infants and young children with mild to moderate under-nutrition from areas where maize is an important crop in their diet (Gunaratna, De Groote , Nestel, Pixley & McCabe, 2010:205). One of the studies included in the meta-analysis, which was carried out in Ghana, indicated that children fed on QPM porridge were healthier, had reduced stunting and had better growth enhancing potential than those fed on porridge from conventional maize (Akuamoa-Boateng, 2002). QPM has the potential to improve nutritional status of vulnerable groups whose main staple is maize and who cannot afford foods rich in protein to supplement the diet.

Studies have also been made of QPM in the diet of monogastric animals, with one of the earliest feeding experiments on *opaque-2* conducted on the growth of rats. Six male rats were fed on a diet containing 90% *opaque-2* maize for 28 days, and they attained an average weight gain of 97 grams, while those fed on conventional hybrid maize attained an average gain of 27 grams (Mertz, Veron, Bates & Nelson, 1965:1741). The feeding effectiveness showed by *opaque-2* in rats provided a basis on which to assume that *opaque-2* protein would be equally superior to conventional maize protein if used in the diet of humans or

monogastric animals. This has been substantiated by several experiments carried out on human beings and pigs fed on *opaque-2* maize. Pig feeding studies conducted in Colombia (1974), El Salvador (1999), Ghana (1994) and Guatemala (2000) showed a growth rate advantage for sibling pigs raised solely on quality protein maize versus sibling pigs raised solely on conventional maize. Those raised solely on QPM gained weight at almost double the rate of those raised solely on normal maize, with no extra protein supplements. In addition, it was observed that if an equal quantity of QPM was substituted for normal maize in pig feeds it would uphold the amino acid balance and hence decrease the use of synthetic lysine (Burgoon, Hansen, Knabe & Bockholt, 1992:813).

QPM has been adopted in several countries of SSA. By the year 2006, 17 countries had commercial QPM seed available in their markets (Krivanek *et al.*, 2007:318), including Kenya, Tanzania, Ethiopia, Uganda, Ghana, Benin, Cote d'Ivoire, Cameroon, Burkina Faso and Guinea. QPM was introduced in Uganda in 2000, in Tanzania in 2001 and in Kenya and Ethiopia in 2003, through the Quality Protein Maize Dissemination project (QPMD), undertaken by CIMMYT. The results of a survey on the QPMD project showed that farmers appreciated QPM varieties both for their field characteristics, including yield, and post-harvest characteristics, notably good cooking qualities (De Groote , Gunaratna, Kebebe, Lyimo, Ouma, Kyazze & Friesen, 2009:35-37). The same survey showed that QPM was appreciated in Tanzania because of its better processing, cooking and taste properties. In target areas of QPMD, awareness of QPM went up by 65% between 2003 and 2007. Currently, two QPM hybrid varieties (Lishe H1 and Lishe H2) and one QPM open pollinated variety (Lishe K1) exist in Tanzania. These were all released in 2001 (ASARECA, 2010).

1.2 PROBLEM STATEMENT

Modern technology in agricultural production is widely considered as having great potential to contribute towards food security and to deal with malnutrition in the world. However, there has been consumer resistance in some of the technologies, such as genetic modification, especially in Europe and Japan (Gaskell, Allansdottir, Allum, Corchero, Fischler, Hampel, Jackson, Kronberger, Mejlgaard, Revuelta, Schreiner, Stares, Torgersen H. & Wagner, 2006:69; Zhang, Bai,

Huang, Hallman, Pray & Aquino, 2004:2). This shows that consumer acceptance would be a major issue in development of new technologies and only consumers would be the final judges of emerging technologies in agricultural production (Christopha, Bruhnb & Roosen, 2008:61).

Because dietary behaviour and choices are generally directed towards foods, not nutrients, nutrient content alone is unlikely to be sufficient reason to expect their acceptance (Johns & Eyzaguirre, 2007:15). In some cases, the biofortification of a variety may alter aspects such as its cooking, storage or sensory (taste, odour, colour, texture) qualities, all of which affect its acceptance (Johns & Eyzaguirre, 2007:17). Even though QPM has improved levels of lysine and tryptophan amino acids, its colour can be white or yellow, like conventional maize. Despite the long history of QPM and the anecdotal evidence, consumer acceptability of QPM in East and Southern Africa has not been studied, therefore there arose a need for a study that would produce this information. A literature search on the leading electronic journal databases, including *Google Scholar*, *Science Direct*, *Emerald* and *EBSCOHost* did not show any published papers on consumer preference for QPM products by the rural consumers in East and Southern Africa. Therefore, this study would be groundbreaking in this field and would be vital in filling the current research gap.

1.3 IMPORTANCE AND BENEFITS OF THE STUDY

This study will reveal important information on acceptability of QPM by rural consumers in Tanzania. Information was obtained on consumers' willingness to pay (WTP) for QPM flour, and their level of acceptance of QPM stiff porridge. This is regarded as important to both agricultural and food industries in Tanzania and can bring benefits to many stakeholders in these industries, including:

- Large and small scale maize producers could utilise the information to make decisions on whether or not to produce QPM, depending on consumer acceptance. This would enable them to become consumer-driven producers.

- Food processors could use the information to decide whether or not to introduce QPM products to the market, depending on the acceptability of the technology by the consumers.
- Food traders and retailers could use this information to make a decision on whether or not to stock QPM products.
- The Tanzanian and other SSA governments could use this information to make informed decisions regarding programmes to reduce malnutrition in their countries, especially among the population groups that mostly depend on cereals as the main diet.
- The research can also assist the organisations undertaking QPM projects in countries within Eastern and Central Africa, (Kenya, Tanzania, Ethiopia, Uganda and Democratic Republic of Congo), to comprehend the challenges facing QPM acceptability by consumers as they move to the next phases of their projects. Such projects include Dissemination of New Agricultural Technologies in Africa **(**DONATA**)** and Quality Protein Maize Dissemination (QPMD) projects.

1.4 HYPOTHESES

Three hypotheses are tested in this study:

Hypothesis 1: Rural consumers in Tanzania will prefer the sensory characteristics of QPM stiff porridge to conventional maize stiff porridge.

This hypothesis is informed by findings of previous studies which have revealed that consumers either preferred the sensory characteristics of QPM varieties to those of conventional maize or equally liked them. A sensory evaluation study undertaken in Ghana on four QPM varieties and two conventional maize varieties (using *kenkey* and *tuo zafi* food preparations), revealed that the QPM maize samples had acceptable attributes for appearance, consistency and taste. However, one of the QPM varieties (Dadaba) had the highest scores for appearance, smoothness and taste. In addition, the taste of QPM hybrids was

preferred to the taste of the local maize variety (Ahenkora, Twumasi-Afriyie & Obeng-Antwi, 1999:357). In another study in Nigeria, sensory evaluation of QPM and two conventional maize varieties was undertaken by a panel of 20 untrained nursing mothers, and it was found that QPM soft porridge was the most preferred for flavour. Moreover, soft porridge prepared from QPM compared favourably with that prepared from conventional maize varieties for colour, texture and overall acceptability (Martins, Jideani, Yusuf, & Tahir, 2010:325).

In the current study, stiff porridge, a major maize product consumed in East and South Africa, was used to undertake sensory evaluation. Sensory evaluation of QPM has not previously been tested using this food preparation. Owing to the previous results from Ghana and Nigeria, it was therefore hypothesised in this study that rural consumers in Tanzania would prefer the sensory characteristics of QPM stiff porridge to conventional maize stiff porridge.

Hypothesis 2: Rural consumers in Tanzania will be willing to pay a higher price for QPM flour than for conventional maize flour.

Consumers are usually interested in nutritionally enhanced food or food products. There is evidence that consumers are willing to pay a premium for nutritionally enhanced staple foods compared to foods without any nutritional enhancement. For example, a study carried out in Beijing showed that consumers were willing to pay a premium of 38% for genetically modified (GM) rice with higher levels of vitamins as compared to conventional rice (Li, Curtis, McCluskey, & Wahl, 2002:148). In another study carried out in Kenya, consumers were willing to pay a premium of 24% for maize meal fortified with minerals and vitamins (De Groote, Kimenju & Morawetz, 2010a:9-13). Therefore, it was hypothesized in the current study that consumers would be willing to pay a higher price for QPM flour, compared to conventional maize flour, since QPM flour is nutritionally enhanced with protein.

Hypothesis 3: Providing rural consumers in Tanzania with nutritional information on QPM will increase their WTP for QPM flour compared to conventional maize flour.

This hypothesis is informed by previous findings that show nutritional information has an influence on consumer acceptance of food products. For example, studies undertaken in Zambia and Ghana on consumer acceptance of orange maize revealed that nutritional information translated into improved acceptance and willingness to pay for the orange maize (De Groote, Tomlins, Haleegoah, Awool, Frimpong, Banerji, Chowdury & Meenakshi, 2010b:12; Meenakshi, Banerji, Manyong, Tomlins, Hamukwala, Zulu & Mungoma, 2010:29).

1.5 RESEARCH OBJECTIVES

The aim of this study was to measure the level of acceptance, perceptions and magnitude of willingness to pay (WTP) for quality protein maize (maize which has high quality protein) and white conventional maize by rural consumers in the northern region of Tanzania. The study was undertaken as part of a regional study covering four countries, the specific objectives of which were:

- To study the difference between stiff porridge made from QPM and conventional maize in blind testing in a laboratory using triangle test.
- To determine consumers' acceptance of QPM through sensory evaluation of stiff porridge in central location, as well as modified home use testing.
- To estimate consumers' willingness to pay for QPM flour as compared to conventional maize flour using experimental auctions.
- To determine whether provision of relevant product information has any effect on the magnitude of consumers' willingness to pay for the maize flour
- To determine whether sensory characteristics of stiff porridge affect the consumers' willingness to pay for maize flour

1.6 OVERVIEW OF RESEARCH METHODOLOGY AND DATA

This study used primary data collected through qualitative and quantitative methods. To achieve the objectives of the study, four methods were employed in the data collection. First, 30 employees of the Selian Agricultural Research Institute (SARI) were gathered at a central location where they undertook the

triangle test and sensory evaluation. Information on individual characteristics, such as age, employment status and marital status was also collected.

Second, a household survey was undertaken with 209 rural consumers in the northern region of Tanzania. Structured questionnaires were used in the data collection. The instruments were pre-tested prior to data collection in the sampled population. Data on demographic characteristics of the household, family income in the past year, farming activities, and maize consumption was collected. The respondents were mainly head of the household or spouse, to ensure that those who participated were those who influenced or partook in purchasing of household food.

Third, modified home use sensory testing (HUT) on QPM and conventional maize stiff porridge was undertaken with rural consumers and, finally, the same consumers who undertook the modified HUT carried out willingness to pay (WTP) experiments with the Becker-DeGroot-Marschak (BDM) mechanism. Half of those who participated in the WTP experiment were provided with QPM nutritional information. The information was provided both in the morning and in the afternoon to avoid time-of-day effect, as it was found in Ghana that consumers' WTP is lower in the afternoon than in the morning (De Groote *et al.,* 2010b:12)

Sensory evaluation data[2] was analysed using an ordinal regression model with fixed effects. This model was chosen because consumers' scores are measured on an ordered categorical scale, and therefore need to be analysed as such. The analysis was undertaken using SPSS statistical software. The WTP data was analysed using random effects model in STATA statistical software.

1.7 ORGANISATION OF THE THESIS

This dissertation comprises six chapters. After this introductory chapter, the second chapter discusses the literature review of sensory evaluation and the different value elicitation methods. Chapter three discusses the research design

[2] Although 'data' is a Latin plural of datum, it may also be used grammatically as an uncountable singular, as is the case in this paper.

and methodology of the survey. This comprises the area of study, the sampling process a detailed description of the entire research process, as well as the models used in the analysis of the different data sets. Chapter four presents the findings from the survey in terms of the demographic profile, triangle testing and sensory evaluation. Chapter five reports the findings of the BDM experiment to elicit consumers' WTP. Chapters six and seven presents a detailed discussion of the main findings, conclusions and recommendations derived from the survey.

The definitions of key terms used in this study are presented in Appendix A. Appendix B shows a picture of a respondent undertaking sensory testing at the central location. Appendix C presents the QPM farmer-consumer survey questionnaire used in data collection. Appendix D shows the survey instrument used to collect data using modified home use sensory testing. Appendix E shows the instrument used to collect data at the central location using central location sensory testing. Appendix F shows the instrument used to collect data using experimental auction method, and finally Appendix G presents the QPM nutritional information given to respondents.

CHAPTER 2: A REVIEW OF LITERATURE ON SENSORY EVALUATION OF STAPLE FOOD COMMODITIES

2.1 INTRODUCTION

In the study of consumer preference for new agricultural products, it is vital that preference and appreciation by rural consumers is studied, because they are the producers and at the same time consumers of the agricultural products. Social scientists often apply methods such as sensory evaluation and willingness to pay (WTP), using value elicitation methods to evaluate consumer preference for agricultural products.

This chapter reviews the literature on sensory evaluation so as to elicit consumer preference for QPM. First, sensory evaluation methods are discussed, highlighting their advantages and disadvantages. This is followed by factors that affect sensory evaluation of products, sensory evaluation methods and a discussion of studies conducted on sensory evaluation globally. Finally, a summary of the chapter is given. A discussion of consumer willingness to pay using value elicitation methods will be discussed in Chapter three.

2.2 SENSORY EVALUATION

Sensory evaluation can be defined as a multidisciplinary science that uses human panellists and their senses of light, smell, touch, taste and hearing to measure the sensory characteristics and acceptability of food products (Watts, Ylimaki, Jeffery & Elias, 1989:12). Three methods are mainly used to carry out sensory testing, namely laboratory testing, central location testing (CLT) and home use testing (HUT) (Meilgaard, Civile & Carr, 2007:263).

Laboratory tests consist of carrying out sensory testing in a room where temperatures and light are controlled. Colour and other visual aspects that may not be fully under control though a prototype can be masked so that subjects can concentrate on the differences in flavour or texture under investigation. An advantage with this methodology is that product preparation and presentation can

be carefully controlled. Moreover, instances where there is a difference in the colour of products being tested, but not one of the factors to be tested, the colour of the products can be masked so that the subjects wholly concentrate on the other factors (Meilgaard *et al.*, 2007:263).. A major disadvantage of this method however is that the standardized preparation procedures and product handling protocols might not necessarily mimic consumer behaviour and experience at home (Meilgaard *et al.*, 2007:263). In addition, if employees of a company are used to test products of the same company it may influence bias in the sensory evaluation results

In CLT, potential purchasers of a product are assembled in one central place, for instance a school, church or hall. The products are prepared out of sight and served on uniform plates uniquely labelled. The potential purchasers are then asked to evaluate the products and state their level of likeness. An advantage with this methodology is that any misunderstandings can easily be cleared up since all respondents are gathered together. In addition, conditions are favourable for a high return of responses from a large sample size (Meilgaard *et al.*, 2007:264). In this method, however, the product is usually tested under conditions that are artificial in comparison to normal use at home or in parties or in restaurants (Meilgaard *et al.*, 2007:264). In addition, the number of questions that can be asked during a CLT experiment may be limited, which further reduces the information obtainable from the study (Meilgaard *et al.*, 2007:264).

HUT on the other hand represents the ultimate in consumer research, where the product is prepared and tested under its natural conditions of use. Unlike CLT, where a product is prepared by one person and tasted by several people, in HUT every household prepares the product according to their normal way, and the respondents have repeated use of the product before they can make the evaluation. When two products are being evaluated the households are given one product first, which they use for four to seven days. Its corresponding score sheet is completed, after which the second product is supplied and tasted. (Meilgaard *et al.*, 2007:265). This is done to give the consumers time to repetitively use the product and give their level of acceptance based on stabilised use rather than first impression alone (Meilgaard *et al.*, 2007:265). The repeated use of the product in

HUT, however, makes the sensory evaluation process very expensive and time-consuming. In addition, since the consumers are given the test product to prepare and evaluate on their own, it is likely to be consumed with other foods or products.

Table 2.1: The advantages and disadvantages of sensory evaluation methods

Method	Advantage	Disadvantage
Laboratory test	➢ Product preparation and presentation can be carefully controlled ➢ Colour and other visual aspects can easily be masked if not part of factors to be tested ➢ Employees can be contacted on short notice to participate	➢ Standardized preparation procedures and product handling protocols does not mimic consumer behaviour and experience at home ➢ If employees of a company are used to test the same company's products, it may result in bias
Central location testing (CLT)	➢ Product preparation and presentation can be carefully controlled ➢ Conditions are favourable for a high return of responses from a large sample size	➢ Since product is tested under artificial conditions, it does not mimic consumer behaviour ➢ Number of questions that can be asked are limited ➢ Can be expensive and tedious to gather respondents
Home use testing (HUT)	➢ Product is prepared and tested under natural conditions of use ➢ Information regarding preference between products will be based on repeated use of the products ➢ More information can be collected because there is more time	➢ Repeated use of products makes this method expensive and time-consuming ➢ If respondents are not frequently reminded about the experiment, they may forget to undertake it ➢ Test product is likely to be consumed with other foods or products, hence producing a large variability across the sampled consumers

Source: Meilgaard *et al.,* (2007:263-265)

The variability from other foods or products used with the test product may produce a large variability across the sampled consumers (Meilgaard *et al.*, 2007:265). Table 2.1 presents a summary of the three sensory evaluation methods with their advantages and disadvantages.

People eat to live and can be influenced by other individuals, professional groups and organisations. Undertaking sensory evaluation of foods reveals their different characteristics, which may determine whether a product is accepted or rejected by consumers. Several other factors affect consumer choice of products.

2.2.1 Factors that influence food preference and acceptability

Intake of food is a result of choice behaviour of individual consumers who consume particular products. Whether or not a new product is accepted by consumers depends on many factors interacting to influence a person's decision to purchase or to consume a food. These considerations may be physiological, psychological, cultural, sensory, nutritional, economical, social or practical. Sensory aspects may form an equally complex picture in which aroma, flavour, taste and texture attributes interact (Conner, 1994:167). The factors that influence food intake fall into under three main categories: food characteristics, individual characteristics or economic and social environment characteristics (Shepherd, 1999:810) as shown in Figure 2.2.

2.2.1.1 Food characteristics

What makes food acceptable to the consumer is one of the fundamental questions being asked by the food industry and food marketers. If established products are to maintain their market position and new ones are to succeed, it is essential that food scientists, technologists and marketers know more precisely what the consumer wants, not merely in general terms but in terms of the chemical and physical parameters of such products (Land, 1983:16).

Consumers use a combination of extrinsic and intrinsic product attributes to identify the most suitable products for specific end-use. The intrinsic attributes, such as the physical and chemical composition of food, are perceived by an individual as sensory attributes (appearance, aroma, texture and taste).

Consumers identify food as acceptable by using sense of smell, sight, taste, and feeling by mouth and hand during consumption. Chemical compounds, such as the amount of proteins or carbohydrates a food contains may affect the consumer's acceptance of the product (Shepherd, 1985:10). A study undertaken by Stranieri, Baldi and Banterle (2010:23) showed that consumers have high interest in the nutrition attributes of food products, with 84% of the interviewees considering these attributes as very important for choice of food products. Flavour was equally considered important for choice of food products, with 87% of the interviewees considering it as a very important attribute.

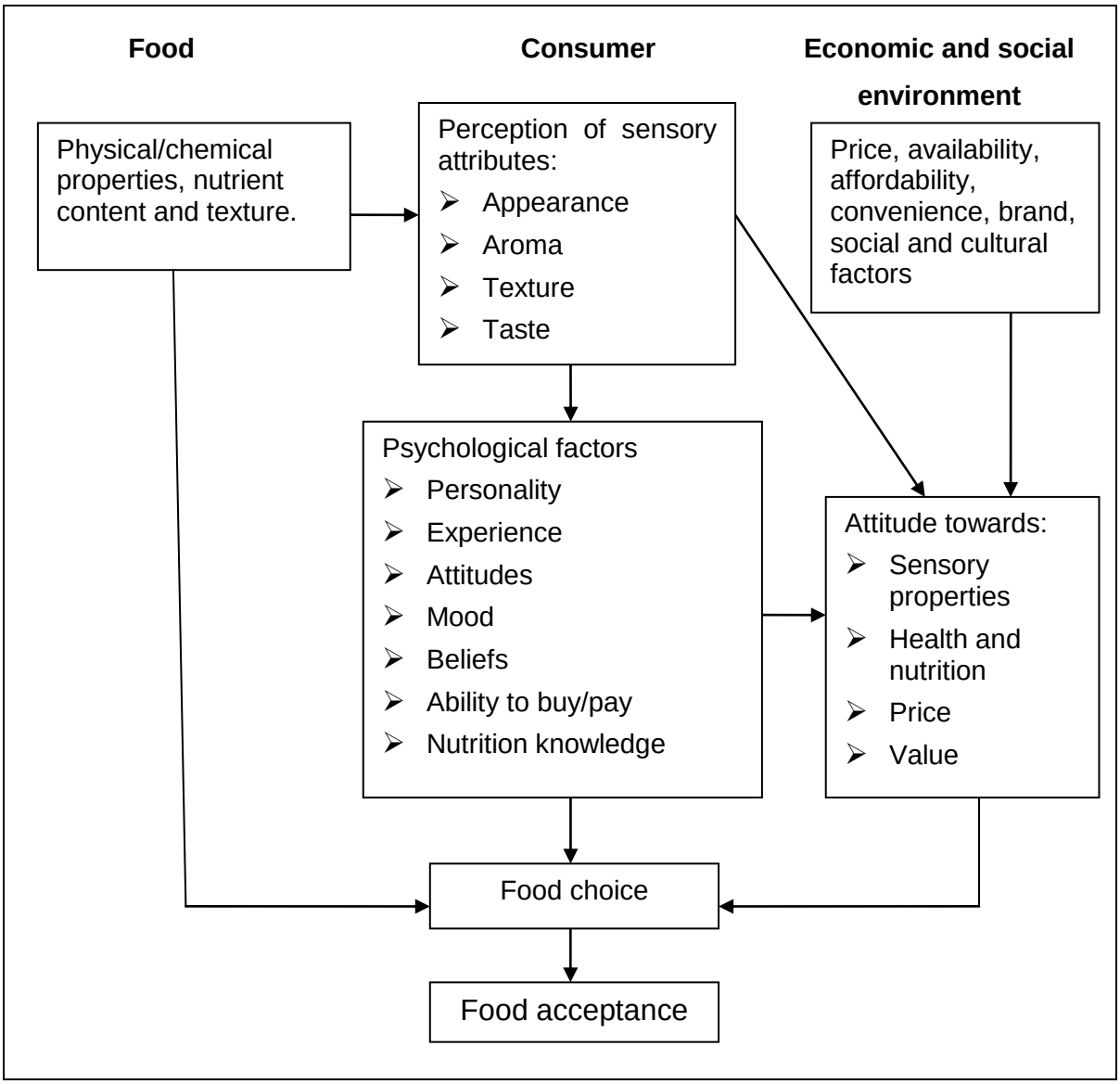

Figure 2.1: Factors affecting food choice and intake (adapted from Shepherd, 1985:10)

According to Lawless & Heymann (1998:812), properties that appeal to sight and feel include coarse, medium-coarse and fine texture. If these properties meet consumers' expectations this may lead to consumer acceptance of the product. Moreover, the image of the product and packaging could have a great influence on product acceptance by consumers.

2.2.1.2 Consumer characteristics

Consumer characteristics are much studied in consumer behaviour, which is an important component of marketing strategy. By understanding it the marketer is able to anticipate and react to it in the market place. According to Peter and Olson (1993:9) consumer behaviour is the study of individuals, groups, or organizations and the processes they use to select, secure, use, evaluate and dispose of products, services, experiences, or ideas to satisfy needs, as well as the impacts that these processes have on the consumer and society. Studying consumer behaviour helps understand the decision-making process, which entails five stages as shown in Figure 2.2.

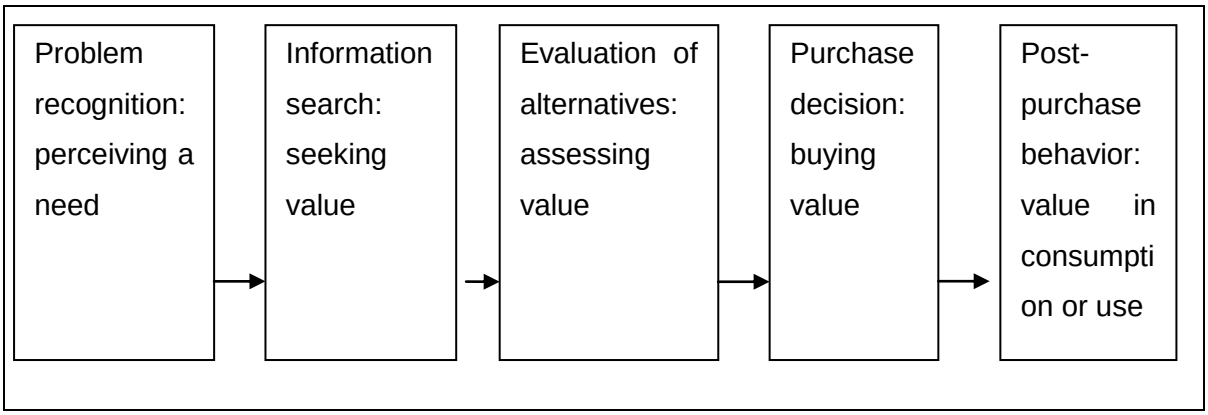

Figure 2.2: Consumer decision making process (adapted from Schiffman & Kanuk, 1994:566-580)

The consumer decision-making process starts with problem recognition. A consumer recognises that a problem exists and sees the need for searching for a solution, for example malnutrition in SSA. In the second stage, the consumer begins to search for information needed in decision-making, which could include information regarding possible foods that can help reduce malnutrition (including QPM), their prices, the product attributes (including sensory attributes), quality

attributes and product availability (Padberg, Ritson & Albisu, 1997:263). Sensory information is vital in making marketing decisions. In marketing of a new product, data is needed about product preferences, product optimization and consumer acceptance. Consumers can decide to consume or not to consume a specific type of food depending on their perceptions of sensory attributes of that food or on other psychological factors (Land, 1983:18).

In market research, there is a realization that consumers' choice of product to purchase depends on their experiences, and that actual buying depends on consuming. This therefore calls for better understanding of consumers' sensory preference of different products (Parson & Maclaran, 2009:45). The perception that a consumer has of sensory attributes of food, such as appearance, aroma, texture and taste, is the determining factor as to whether he or she will choose it (Shepherd & Sparks, 1994:205). For instance, a consumer may decide to consume or not to consume QPM stiff porridge depending on its sensory attributes.

Sensory quality is one of the major factors that affect consumers' perception of a product, which in turn affects their purchase behaviour. By performing an experiment on cheese tasting, Grunert, Lahteenmaki, Ueland and Astrom (2004:105) verified that a positive tasting experience helped improve European consumers' acceptance of genetically modified organisms in food production. Brennan and Kuri (2002:65) contended that it was widely accepted that consumers' acceptance of food is mainly based on their sensory perception, and once people have developed a preference for a product in this way it is very unlikely they will change it. Thus, sensory characteristics have a great influence on sustaining consumers' repeated purchases.

Different sensory variables are used by marketers in the study of food acceptability (Land, 1983:20). First, a marketer would want to know whether consumers can detect any sensory difference between an existing food product and the new food product, such as the sensory difference between stiff porridge prepared from QPM and that prepared from conventional maize. Second, the marketer would be interested in knowing the intensity of the difference between the two products. Here, he wants to know how much of a particular attribute is

present in the two food products, which is done by scaling. Finally, he will be interested in knowing the level of acceptance of the new product by the consumers.

After the consumers gather all the necessary information regarding the products, they move to the third stage of decision-making, i.e. evaluation of alternatives. Here, the consumer evaluates all the necessary alternatives at hand. For example, if trying to solve malnutrition problem caused by protein deficiency the consumer would evaluate all sources of protein available, including QPM. Here, beliefs regarding different types of food may lead to formation of attitude about them, which could consequently influence the purchase decision of the consumer, for example over QPM or conventional maize. The final stage of the consumer decision-making is the valuation of consumption, on whether it leads to satisfaction or dissatisfaction. If the consumer is satisfied this could lead to a positive attitude towards that product, conversely if not satisfied it could lead to a negative attitude (Padberg *et al.,* 1997:268-275).

Sensory evaluation is increasingly being applied within the field of agricultural economics, as shown by publications and presentations in many of the agricultural economics journals and conferences respectively. Examples were of sensory evaluation studies were those of Hu, McCluskey and Durham (2005:1-27) in the USA to evaluate consumers' WTP for Washington apples with respect to their sensory attributes; by Vermeulen (2005:1-188) in South Africa to evaluate consumer perceptions of genetically modified maize; by Xue, Mainville, You and Nayga, Jr. (2009:1-43) on pasture-fed beef and the extent sensory characteristics could influence consumers' choices and WTP; and by Meenakshi *et al.,* (2010:1-43) to evaluate consumer acceptance of provitamin A orange maize in rural Zambia. Some of these studies undertaken globally will be discussed in detail in Section 2.2.3.

Besides the product's sensory attributes, consumer behaviour can also be influenced by the psychological factors, including personality, beliefs (e.g. regarding QPM), ability to purchase, previous experience of the product, nutritional knowledge (e.g. of quality protein in the QPM), values and attitude (Shepherd, 1985:10). These affect the consumers' attitudes towards sensory properties, price,

health and nutrition and value of the product, which further affect food choice and acceptability.

2.2.1.3 Economic and social environment characteristics

The economic and social environment represents the external influences of food acceptability, which include the price of the product, ability to pay for it, its availability, information and knowledge about it, and social, cultural and ecological resources (Cardello, 1994:275; Shepherd & Sparks, 1994:212). A culture is a pattern of knowledge, value, attitude, traditions and believes that are learned and passed on from generation to generation (Johns & Kuhnlein, 1990:19). Culture is thought to be a major determinant of food choice, because values, beliefs and traditions are believed to be among the main factors influencing preference, mode of food preparation, serving and nutritional status (Cox & Anderson, 2004:147).

In addition, the price of a product and the consumer's ability to pay for it highly affects acceptability. People with high income often have a wide range of foods from which to choose. Conversely, people with low income have a limited selection, and mostly depend on low-cost foods, mainly cereals, to supply most of their nutrient requirements (Furst, Connors, Bisogni, Sobal & Falk, 1996:254).

Understanding consumer choice of products based on food, consumer and economic and social environment characteristics is therefore vital to a marketer, who gets to understand the importance of sensory attributes of a product and the perceptions of the consumers about the product's attributes. Additionally, the market gets to understand that acceptability of any product may be highly influenced by the consumers' perceptions about the product, their sensory preferences and the psychological, economic and social environment factors.

2.2.2 Types of sensory testing

When carrying out a sensory evaluation test, Watts et al. (1989:110) distinguished three types of sensory testing: preference tests, acceptance test and hedonic tests. Preference tests allow a consumer to express a choice between samples, based on preference for one sample over the others. A panel should consist of at least 50 panellists to ensure that the statistical power of the test is not reduced.

Acceptance tests are used to determine the degree of consumer acceptance for a product. In this case, ranking tests and paired comparison tests are used to estimate product acceptance. Panellists are asked to rank coded samples for acceptance in order from the least acceptable to the most acceptable.

Hedonic tests measure the degree of liking for the product, or which are preferred. Category scales (hedonic scales) ranging from 'like extremely', through 'neither like nor dislike' to 'dislike extremely', with varying number of categories, are used (Lawless & Heymann, 1998:440).

2.2.3 Past studies on sensory testing globally

Studying consumption characteristics of new varieties is a relatively new area in adoption research in Africa. Initially, most of the research attention was on support of agronomic characteristics of new varieties. Recently, however, studies have been undertaken on consumer acceptance of the new varieties in Africa. Some of the studies undertaken in different countries, including Africa, are discussed below in order to present an overview of consumer perception and attitude towards the new varieties.

A study undertaken in USA used central location sensory testing to evaluate acceptance of corn chips by urban consumers. Eight types of commercial corn chips were evaluated by 305 adult using a seven-point category scale. The study revealed that the purchase of the corn chips was highly driven by the degree of liking of them, and by their sensory attributes, which included the corn flavour, saltiness and greasiness. Health issues related to the consumers' attitudes towards the level of fat in the diet came second in the order of importance of factors that they considered when choosing the corn chips (Tepper & Trail, 1998:270).

In Tanzania, sensory testing was undertaken with 94 school children and 59 mothers with preschool children. The main objective was to evaluate the flavour profile and consumer acceptability of four sweet potato cultivars that differed in *β*-carotene content. Two cultivars were of orange fleshed sweet potatoes (OFSPs), and the other two of pale-fleshed sweet potatoes (PFSPs). To evaluate consumer

acceptability, the children and parents undertook sensory evaluation of cooked sweet potatoes at a central place, and scored their acceptability using a category scale. The study revealed that OFSPs and PFSPs have distinct differences in sensory profile. In addition, the former were more acceptable than the traditional cultivars used in that study (Tomlins, Ndunguru, Stambul, Joshua, Ngendello, Rwiza, Amour, Ramadhani, Kapande & Westby, 2007:2440). Mothers, however, ranked OFSPs higher than did the preschool children, which was found encouraging for the new sweet potato variety (OFSP), since evidence suggests that if mothers find a food acceptable they are more likely to feed it to their children (Skinner, Carruth, Wendy & Ziegler, 2000:1643).

In Ghana, a study was undertaken by 300 consumers in three urban centres using a central location sensory evaluation method. The main objective was to evaluate consumer acceptance and affordability of prototype parboiled rice (PPR) in relation to three local samples and a high-value imported one. This study revealed that the new rice variety (PPR) was very acceptable among the urban consumers of Ghana, and it had a similar flavour profile to high-value imported parboiled rice (Tomlins, Manful, Gayin, Kudjawu & Tamakloe, 2007:1567-1574).

In South Africa, a study was undertaken with 51 rural consumers using a central location sensory evaluation method. The main objective was to determine the level of acceptability and perceptions of traditionally prepared maize meal porridge, from commercially produced white maize meal (fortified and unfortified maize meal); local white non-genetically modified and local white genetically modified maize meals; and local white maize meal and yellow maize meal. This study revealed that there was no significant difference between GM and non-GM maize meal in terms of aroma, appearance, texture and taste (Ngqaka, 2008:53). However, a study carried out on urban consumers in South African showed that when they are informed about presence of GM maize in a maize stiff porridge sample, the “Anti-GM” cluster revealed a sensory preference for the non-GM maize stiff porridge. On the contrary, the “Pro-GM” cluster and the “Pro-GM consumer benefit” cluster revealed a sensory preference for the GM maize stiff porridge over the non-GM maize stiff porridge. (Vermeulen, 2005:147-148). This

showed that the sensory experience of the maize porridge consumers were consistent with their perceptions and attitudes towards GM foods.

In Mozambique, a study on consumer acceptance of provitamin A-biofortified maize was undertaken in a market place, with 201 urban consumers participating in the sensory evaluation of maize meal stiff porridge. The results indicated that the biofortified maize was acceptable to many consumers in Maputo, and they were willing to trade local white maize meal for meal from the biofortified maize (Stevens & Winter-Nelson, 2008:346). Moreover, it was revealed that the consumers most likely to suffer from vitamin A deficiency were those most likely to accept the trade for orange maize meal. These are households who do not consume animal products frequently and those with young children.

In Zambia, a study on acceptability of pro-vitamin A orange maize was undertaken using both home use sensory evaluation and central location sensory evaluation methods. The main objective was to determine the consumer acceptance of biofortified maize in rural Zambia (Meenakshi *et al.*, 2010:12-16). For the home use testing, 279 households participated and each household was given two kilograms of biofortified maize flour and two kilograms of conventional maize flour to prepare stiff porridge and evaluate the sensory characteristics. For the central location testing, 208 rural consumers participated in the sensory evaluation of stiff porridge. This study revealed that orange maize was liked by the rural consumers in Zambia and the negative perception of yellow maize did not affect the acceptability of orange maize. Moreover, the study showed similar findings from home use testing and central location testing. This suggests that giving consumers more time to evaluate the product at home is probably not particularly critical, and the exposure time of 30 minutes in central-location testing seems to be sufficient for consumers to form an opinion about the product. In addition, the way that the product was prepared, that is, consistently by one person for central location testing or variedly by individual consumers in home use testing, did not appear to influence the outcome.

Other studies have been undertaken on sensory evaluation of different food products. Table 2.2 presents a summary of some of the studies undertaken globally. The table combines a summary of studies discussed in Section 2.2.2 with

other studies, while highlighting the authors, area of focus, methods applied and the main results of the study.

Table 2.2: A summary of sensory evaluation studies relating to staple food commodities

Authors and year	Focus	Methods applied	Main results
Tepper &Trail (1998)	Acceptability of corn chips by urban consumers in United States	Central location testing	➢ Purchase of corn chips is highly driven by degree of liking of the corn chips and their sensory attribute
Tomlins, *et al.,* (2007)	Flavour profile and consumer acceptability of orange-fleshed sweet potatoes (OFSP) and pale-fleshed sweet potatoes (PFSP) in Tanzania	Central location testing	➢ OFSP and PFSP have distinct differences in sensory profiles ➢ OFSP is more acceptable in Tanzania than PFSP
Tomlins, *et al.,* (2007)	Consumer acceptance and affordability of prototype parboiled rice (PPR) in urban Ghana	Central location testing	➢ The new rice variety (PPR) is acceptable by urban consumers in Ghana, and it has similar flavour profile to the high-value imported parboiled rice
Mkanda *et al.,* 2007	Consumer preference, sensory and physicochemical properties of dry beans in South Africa	Laboratory testing	➢ Sensory characteristics such as sweet taste, cooked-bean flavour, soft and mushy texture, are the beans' attributes that are most accepted by South Africa consumers
Stevens &Winter-Nelson (2008)	Acceptability of provitamin A-biofortified orange maize by urban consumers in Mozambique	Central location testing	➢ The biofortified maize is more acceptable than the conventional maize to consumers in Maputo
Meenakshi *et al.,* 2010	Acceptability of provitamin A-biofortified orange maize in rural Zambia	Central location testing and home use testing	➢ Orange maize is liked by rural consumers in Zambia ➢ The negative perception of yellow maize does not affect the acceptability of orange maize ➢ Central location and home use testing had similar results

2.3 SUMMARY

Before introducing a new product into the market, sensory evaluation could be applied as an important tool for studying product characteristics and consumers' evaluation and acceptance. This chapter provides the theoretical basis for testing the first hypothesis of this study, that rural consumers in Tanzania will prefer the sensory characteristics of QPM stiff porridge to conventional maize stiff porridge.

To study sensory characteristics of products, three methods are mainly used in the consumer panel sensory evaluation: laboratory test, central location and home use sensory testing methods. Several studies have been undertaken globally using these methods. Laboratory and central location tests are simple to undertake and take a short time because the subjects are brought together and experiments are undertaken in groups. Moreover, product preparation and presentation can be controlled. These methods might not result in a true reflection of consumer behaviour because product evaluation is done in artificial conditions. Since home use sensory testing has been seen to better predict consumers' behaviour, as participants prepare the product themselves, this study will employ home use sensory evaluation. A disadvantage with this method, however, is that it is expensive to implement. In Tanzania, few studies have been undertaken on sensory evaluation of new varieties, but no study has been conducted on consumer preference for QPM varieties.

Sensory evaluation is an important methodology currently used by agricultural economists to evaluate sensory characteristics of new agricultural products being introduced in the market. Sensory information is vital in making marketing decisions. In marketing of a new product, data is needed on product preferences and consumer acceptance. Consumers can decide to consume or not to consume specific type of food depending on their perceptions of sensory attributes of that food or don other psychological factors. This can eventually have an impact on the consumers' WTP for those products. Therefore, it is vital that the marketer knows the consumers' perceptions about the sensory characteristic of the products before introducing a new product onto the market.

CHAPTER 3: A REVIEW OF LITERATURE ON VALUE ELICITATION METHODS APPLIED TO CONSUMERS' FOOD CHOICES

3.1 INTRODUCTION

Value elicitation methods are used to study consumer appreciation of new food products. People reveal their relative values when they choose to spend extra money in purchasing one good relative to another. The economic value of this choice is characterised by determining the amount a consumer is willing to pay (WTP) for a product, or the rate at which he or she is willing to trade one product for another. To determine consumers' WTP for a product, or willingness to trade one good for another, different value elicitation methods are used.

This chapter covers the different value elicitation methods. First, the hypothetical value elicitation methods are discussed, with their advantages and disadvantages. Then, the non-hypothetical value elicitation methods are discussed, also highlighting their advantages and disadvantages. A discussion on experimental auctions, a non-hypothetical value elicitation method follows. Afterwards, studies undertaken globally using experimental auction are discussed and, finally, a summary of the chapter is given.

3.2 VALUE ELICITATION

There are a number of value estimation methods available, each with its merits and drawbacks. The following subsections outline the different ones, with some discussion of their relative advantages and disadvantages. Elicitation methods are divided into two categories: hypothetical and non-hypothetical.

3.2.1 Hypothetical value elicitation

Various hypothetical valuation methods are used today, but contingent valuation (CV) and conjoint analysis (CA) are the most widely used. CV is mostly used to find out how consumers evaluate goods and services not found in the market. A

new product is described and participants are asked how much they would hypothetically be willing-to-pay (WTP) for the good, or whether they would purchase it at a certain price level. In this context, WTP refers to the maximum amount of money a consumer would be willing to pay for the new product. Since different consumers have different WTP, the distribution is estimated through open-ended or closed-ended questions (Lusk & Hudson, 2004:156), and the format can either be single-bound, where only one bid is presented, or double-bound, where two bid values are tested, by an initial bid and a follow-up bid (Hanemann, Loomis & Kanninen, 1991:1258). CV has been widely used to assess consumer demand for novel products and attributes.

CV has some advantages over other value elicitation techniques (Gregory & Furby, 1987:176). First, it is cheap to undertake because the procedure is purely hypothetical, hence no need to obtain a supply of the experimental products. Second, variations in survey questioning can be used for easy comparison of contingent market characteristics. Third, since the procedure is hypothetical, information about quality, quantity and consumption of the product can be easily changed for any situation, and at low cost.

On the other hand, CV has several disadvantages (Gregory & Furby, 1987:276; Murphy, Allen, Stevens & Weatherhead, 2005:316). First, because CV is hypothetical in nature, in both the payment for and provision of the product in question, CV method can result in hypothetical bias, with responses that are significantly greater than actual payments. Second, responses in CV are sensitive to question formulation, which creates problems with standardization across studies. Third, due to the hypothetical nature of the questions, the participants may view their responses as inconsequential. As a result, they do not have any incentive to report private values truthfully in a hypothetical exercise. Fourth, in CV, assumptions must be made about the form of a representative utility function and the distribution of errors in the random utility model for yes/no responses to be meaningfully used (Hanemann, 1984:334). Fifth, the CV method is likely to result in other forms of bias, such as: strategic and protest bias, design bias, availability bias and compliance bias (Melichar & Ščasný, 2004:46).

Conjoint analysis (CA), the second hypothetical value elicitation method, is one by which a respondent is asked to state a preference between one group of product attributes at a given price or costs and another at a different price or costs (UN, EC, IMF, OECD & WB, 2003:19). Numerous approaches of CA can be used, such as contingent ranking, choice experiments, paired comparison, contingent conjoint ranking or diverse similar techniques using choices, ranks or matches (Hanemann & Kanninen, 1996:82).

CA offers some advantages to the marketing researcher, as it is a relatively cheap data collection procedure, and since it is hypothetical the researcher does not need to acquire the experimental products. In addition, CA is a relatively simple methodology for data collection, and since it combines different product attributes, it measures the importance individuals attach to them, hence enabling the marketing researcher to identify the most important attributes in a product that deliver the highest level of utility to consumers (Malhotra, 1996:709).

Despite the several advantages of CA, this hypothetical methodology comes with several disadvantages. Like CV, CA is a hypothetical data collection procedure, hence it can result to hypothetical bias. Second, designing CA studies can be complex, and if a study is poorly designed, it may result in over-valuation of preference variables and undervaluation of concrete variables. Third, this method of data collection is difficult to use for product positioning research, because there is no procedure for converting perceptions about actual features to perceptions about a reduced set of underlying features. Moreover, it may become difficult for respondents to articulate attitudes towards new categories of products that are not present (Marder, 1999:4).

One of the main issues surrounding the credibility of a value elicitation technique is that of incentive compatibility. A mechanism is said to be incentive compatible or demand revealing when the participants' best strategy is to truthfully reveal their value for the product in question (Lusk, Feldkamp & Schroeder, 2004:391). In addition, the hypothetical bias of the hypothetical value elicitation mechanism, i.e. that individuals respond differently when responding to hypothetical questions than when confronted with real payment, is a big disadvantage to these methodologies. Because many valuation questions involve asking hypothetical questions where

incentives may not be properly aligned, this issue is an important consideration. A large body of research has confirmed that when using hypothetical value elicitation methods, consumers may not behave in an economically rational way, and the hypothetical questioning routinely elicits inflated values (Cummings, Harrison & Rutstrom, 1995:263; Fox, Shogren, Hayes & Kliebenstein, 1998:458; Neill, Cummings, Ganderton, Harrison & McGuckin, 1994:148). Consumers frequently say they are willing to pay more than they actually would pay in a non-hypothetical setting. A meta-analysis of 29 studies containing 58 valuations revealed that average subjects overstated their preferences by a factor of about three in hypothetical settings (List & Gallet, 2001:246). Similar results have been observed by other authors (Cummings *et al.*, 1995:264; Fox *et al.*, 1998:458; List, 2001:1502).

Therefore, it is vital to employ value elicitation methods that truly reveal consumer preferences, instead of simply asking for stated preferences. To determine revealed preferences, consumers must be observed making purchase decisions with real money and real products as they would in a retail setting. When the hypothetical nature of valuation is removed, consumers have an incentive to judiciously spend their money, especially if the auction is incentive compatible (Feldkamp, Schroeder & Lusk, 2005:3). Consumers use money to buy products daily and are fully aware of their value. They know the consequences of paying too much for a product, as well as the lost opportunity of not purchasing at a lower price. Consequently, when presented with an opportunity to buy with cash, consumers carefully weigh costs and benefits, instead of just guessing at what they would pay. The methodologies that utilize real money to reveal consumer preferences are the non-hypothetical value elicitation methods, where real products are exchanged for real money.

3.2.2 Non-hypothetical value elicitation

Non-hypothetical value elicitation methods have a distinct advantage over studying purchase decisions with field data, because they allow a consumer's limit price to be measured directly (Nalley, Hudson & Parkhurst, 2004:4). It is advantageous to use a non-hypothetical value elicitation method as opposed to a hypothetical one because the participant deals with real goods and market

discipline is established (Hayes, Shogren & Kliebenstien, 1996:369). One such method that utilizes real money and real products to reveal consumer preference for a commodity is experimental auction.

3.3 EXPERIMENTAL AUCTIONS

In the recent research, experimental methods have gained acceptance as a valuable tool in market research. Experimental auctions are generally conducted in one of two ways. First, consumers can be provided with an endowed good (usually a pre-existing substitute) and then asked to bid to exchange it for a novel one (Lusk, Fox, Schroeder, Mintert & Koohmaraie, 2001b:541). In this case, the auction elicits demand for the novel good relative to a pre-existing substitute. The advantage of the endowment approach is that it forces subjects to focus on the auction, because they will leave the experiment with at least one good regardless of their actions. The disadvantage of the approach is a potential problem with the "endowment effect," where subjects place greater value on a good simply because they possess it (Kahneman, Knetsch & Thaler, 1990:1338).

Second, consumers can bid directly on several competing goods and a random drawing can be used to determine which one is binding, so that demand for a single unit can be elicited (List & Shogren, 1998:196; Lusk *et al.*, 2004:393). In this case, several methods are used to elicit consumers' WTP, but only those that are incentive compatible should be used for applied purposes.

3.3.1 Methods used to solicit consumers' WTP

Willingness-to-pay (WTP) is the maximum price that a consumer is prepared to meet to acquire a good or a service. While market price and WTP are not the same, the latter does form the upper bound on a market price an individual will pay for a good. The WTP concept is important to benefit-cost analysis, welfare economics, consumer study and efficiency criteria directly (Nalley *et al.*, 2004:9). Eight auction mechanisms have been used to elicit consumers' WTP: Ascending-bid second price, Vickrey second price, random n^{th} price, first price, fifth price, English, Becker-DeGroot-Marschak (BDM) and combinatorial private-collective auctions. Among these, the English auction, the nth price auction, the Becker–

DeGroot–Marschak mechanism, and the random nth price auction are said to be incentive compatible (Lusk, Daniel, Lusk & Mark, 2001a:42; Shogren, Fox, Hayes & Kliebenstein, 1994:1090).

In English auction, an auctioneer opens the auction at a relatively low price and the competitors offer ascending bids (signalling their willingness to stay in the auction as the prices increase). The auction ends when only one participant is willing to pay the current price and the individual wins the auction and pays the last price offered (Coppinger, Smith & Titus, 1980:3; Vickrey, 1961:10).

The random n^{th} price and the Vickrey or second price auctions are known as sealed-bids. All bidders simultaneously submit sealed bids, and the highest bidder wins. The winner or winners can either pay the second highest bid submitted (Vickrey or second-price auction), or a randomly assigned bid out of all bids (random n^{th} price auction). There is one winner in the second-price auction and (n-1) winners in the n^{th} price auction. The market price in the case of Vickrey or second-price auction is the second highest bid, whereas for the random n^{th} price auction it is the n^{th} bid (Shogren, Margolis, Koo & List, 2001:410; Vickrey, 1961:10).

The Becker-DeGroot-Marschak (BDM) mechanism compares individually submitted bids for a good with a random number or price that is drawn from a pre-specified distribution. Individuals with bids greater than the randomly drawn price win the auction and purchase a unit of the good at the randomly drawn price. The winners in this case are all participants with a bid equal to or greater than a randomly drawn price, and the market price is the randomly drawn price (Becker, DeGroot & Marschak, 1964:227; Irwin, McClelland, McKee, Schulze & Norden, 1998:274).

Random n^{th} price, English, Vickrey or second price and BDM are theoretically incentive compatible auctions (Lusk *et al.*, 2004:391), that is an individual's main strategy is to bid in such a manner that the WTP is truthfully revealed. In incentive compatible methods, there is no gain from strategic bidding because the market price is independent of a participant's bid. In the case of the BDM mechanism, the market price is defined as a randomly drawn number from a pre-specified

distribution, whereas for random n^{th} price and the Vickrey methods, it is the n^{th} price. Participants who bid less than their true value reduce their chances of winning the auctioned good at a potentially profitable price. On the other hand, by submitting a bid more than their true value, auction participants have a greater probability of winning, but paying a price that is in excess of what they are willing to pay to obtain the good. Therefore, in most cases bidders will not benefit but lose by not expressing their true value in an incentive compatible auction. Hence, it follows that bidders in an incentive compatible auction will always express their true WTP, leading to generation of accurate data required by the researcher (Nalley *et al.*, 2004:8). The BDM method has been successfully used to estimate maize consumers' WTP in Kenya before (De Groote, Kimenju & Morawetz, 2010a:4).

Among the four incentive compatible mechanisms discussed (the English auction, the second-price auction, the random *n*th price auction, and the BDM mechanism), BDM is different from the others. First, the bids of individual participants in the BDM auction are not compared to one another, but to a randomly generated number. If the bid offered is higher than the random number, the bidder purchases the good at a price equal to the random number drawn (the random price), as long as it is equal to or lower than their own offer (the bid price) (Becker *et al.*, 1964:228). Second, although BDM auctions in groups are possible and have been reported (Monchuk, Rousu, Shogren, Nonnemaker & Kosa, 2007:96), the BDM approach can be executed individually, which may be more convenient for researchers. Comparing BDM and Vickrey second-price auction mechanisms, the former has been found more efficient and faster to implement (De Groote *et al.*, 2010a:4).

There are several advantages of using incentive compatible experimental auctions to elicit consumers' WTP for products. According to Lusk and Hudson (2004:158), some of these include:

- Experimental auctions provide a convenient way to determine each consumer's WTP, because every consumer submits a bid which, in theory, is equal to their value for the good. This precludes the need to make parametric assumptions about the shape of the market demand curve.

- Subjects can integrate feedback from the experimental market into their bids as it would be the case in an actual market setting.

- Experimental auctions entail the exchange of real money and real goods with properly aligned incentives.

- If the experimental auction is an incentive compatible auction and the participants are aware, they will reveal their true WTP for the products because there is no gain from strategic bidding in such mechanisms.

- Since the WTP dependent variable is continuous in nature, modelling determinants of WTP becomes straightforward.

- There is a wealth of literature on auctions that can assist the researcher in designing appropriate experiments.

On the other hand, experimental auctions have some disadvantages (Becker *et al.*, 1964:228; Rutstr¨om, 1998:431):

- Application of experimental auctions are often limited to private goods, for which actual values can be estimated in a market-based experiment.

- Since it is a non-hypothetical method, the experimental goods have to be acquired, and the subjects given money to enable them to participate in the experiment. This makes experimental auctions more expensive to undertake than the hypothetical methods.

- In case the experimental auctions are conducted in a laboratory setting, the experiments become much more expensive because the subjects have to be paid a participation fee to attend. This drawback however is mitigated by undertaking the auctions in the field or at the subjects' homes, where a participation fee may not need to be paid.

Having discussed the merits and demerits of the different value elicitation methods, a summary is made for the reader to better understand each method's advantages and disadvantages (Table 3.1). From hypothetical methods, only advantages and disadvantages of conjoint analysis and contingent valuation

methods are summarised in this table, because they are the commonly used hypothetical methods. From non-hypothetical group, merits and demerits of experimental auctions will be discussed, because this is the method that was used in this study.

Table 3.1: A summary of advantages and disadvantages of various value elicitation methods

Method	Advantages	Disadvantages
Contingent valuation (CV)	➢ It is cheap to undertake because the procedure is purely hypothetical ➢ Variations in survey questioning can be used for easy comparison of contingent market characteristics ➢ Information about quality, quantity and consumption of the product can be easily changed for any situation	➢ It can result in hypothetical bias ➢ Responses are sensitive to question formulation, which creates problems with standardization across studies ➢ Individuals do not have any incentive to truthfully report private values ➢ Assumptions must be made about the form of a representative utility function ➢ CV method is likely to result to other forms of biases such as: strategic and protest bias, design bias, availability bias and compliance bias
Conjoint analysis (CA)	➢ It is a relatively cheap data collection procedure ➢ CA enables the researcher to identify the most important attributes in a product that deliver the highest level of utility to consumers	➢ It is a hypothetical methodology hence may result to hypothetical bias ➢ Designing CA studies can be complex, and if a study is poorly designed, it may result to over-valuation of some variables and undervaluing of others ➢ CA is difficult to use for product positioning research ➢ It may become difficult for respondents to articulate attitudes towards new categories of products that are not present ➢ Requires use of assumptions

Method	Advantages	Disadvantages
Experimental auctions	➢ Each consumer's WTP is determined ➢ Subjects can integrate feedback from the experimental market into their bids ➢ Experimental auctions entail the exchange of real money and real goods with properly aligned incentives ➢ In an incentive compatible auction participants reveal their true WTP for the products ➢ Modelling determinants of WTP is straight forward ➢ There is a wealth of literature on auctions that can assist the researcher in designing appropriate experiments	➢ Application of experimental auctions is often limited to goods for which actual values can be estimated in a market-based experiment ➢ It is an expensive methodology to undertake compared to the hypothetical methods ➢ Undertaking the auctions in a laboratory setting makes the experiment more expensive because the subjects have to be paid a participation fee to attend the laboratory sessions. This drawback however is mitigated by undertaking the auctions in the field or at the subjects' homes, where a participation fee may not need to be paid.

Source: Becker *et al.*, (1964:228); Gregory & Furby, (1987:176-276); Hanemann, *et al.*, (1991:1258); Lusk & Hudson, (2004:156-158); Marder, (1999:4); Murphy, *et al.,* (2005:316); Rutstr¨om, (1998:431)

3.3.2 A review of studies undertaken using incentive compatible experimental auctions globally

Several studies have been undertaken globally using experimental auctions to elicit consumers' WTP for different goods. The background and main findings of some of these studies are discussed, highlighting the different methods used in each study.

BDM mechanism was used in a study undertaken in the mid-western USA, the main objective of which was to elicit consumers' WTP for tender steak. The study was undertaken with individual shoppers at three urban retail grocery stores and two types of stake were used: red (guaranteed tender) and blue (probably tough. The experiment was undertaken in two sessions. In the first session, consumers

were not told that the samples differed in tenderness, but that they were expected to assess this on their own. To begin the experiment, consumers were given a 12 oz. blue stake and asked which type of steak they preferred, red or blue. If they indicated that they preferred the blue they were told to take the 12 oz blue stake with them and the experiment was terminated. If they indicated that they preferred the red steak they were shown 12 oz. of red steak and asked to indicate the most they would be willing to pay to exchange their blue steak for the 12 oz. Red steak. During the second session of the experiment, the two types of steak were known as "*guaranteed tender*" and *"probably tough".* In this case, the participants knew the difference in tenderness of the two types of steak (Lusk *et al.*, 2001b:544). Results of this study showed that even though majority of the respondents preferred the tender stake, many were not willing to pay more to exchange their tough stake for a tender one.

At the Ohio State University, Second-price Vickrey auction method was used in a study, the main objective of which was to elicit the willingness to pay for a new orange juice processed with the pulsed electric field (PEF) processing technology, and also to find out whether the product tasting altered the consumers' WTP (Chern, Kaneko & Tarakcioglu, 2003:9). A total of 27 students participated in bidding for four types of orange juice: unprocessed/fresh juice, PEF-processed juice, pasteurized juice but not-from-concentrate and pasteurized juice from concentrate. This study showed that consumers were willing to pay higher for unprocessed and PEF juices than the rest juices. The bids for the preferred juices were consistently higher than the other two. When the participants were asked to taste the juices and then bid for the orange juices again, the mean bid price for PEF juice declined substantially. A 17% drop in the WTP for the new juice was recorded. Respondents indicated that they did not like the taste of the new orange juice, showing that if they like the taste of a product their WTP would be higher than if they did not.

BDM mechanism was used to determine consumer WTP for differentiated beef steak quality attributes, a study undertaken in Manhattan (Feldkamp *et al.*, 2005:5). Twenty seven research subjects participated in the experiment to determine WTP for five different types of steak: *Generic* steak, *Natural* steak,

Guaranteed Tender steak, USDA *Choice* steak and *Certified Angus Beef* (CAB) steak. Results showed that consumers were willing to pay premiums for *natural* steak, with 18% WTP at least $US 1.50/steak more. This showed that there was a market for natural steaks in Kansas.

In Canada, a study was taken to elicit consumer WTP for food traceability information. Participants were given a beef (or ham) sandwich, and had an opportunity to bid to exchange their sandwich for one with additional verifiable characteristics. Four alternative sandwiches were used in the auction: animal welfare assurance, meat that was traceable to the farm of origin, extra food safety assurance and a sandwich that combined all the three attributes. Vickrey second-price auction procedure was used to measure WTP for the different types of products. Participants were requested to bid the amount they would be willing to pay to exchange their regular sandwich for each auction one. This study revealed that consumers were not willing to pay as much for traceability information only, as they were for quality verification information with respect to the credence attributes. Consumers prefer products that have both traceability information and positive quality assurance (Hobbs, Bailey, Dickinson & Hangiri, 2005:56).

In Kenya, the BDM individual auction mechanism was used with rural consumers to estimate WTP for food quality, considering yellow versus fortified maize meal. The consumers were presented with three types of maize meal: plain white, plain yellow and fortified white, then requested to bid for the different one (De Groote *et al.*, 2010a:4). This study revealed that Kenyan maize consumers are greatly interested in nutritionally enhanced maize. Consumers were willing to pay a premium of 24% for maize fortified with minerals and vitamins. In addition, consumers from one of the study zones where yellow maize is most commonly preferred, showed higher preference for the yellow plain maize meal than white plain maize meal and were even willing to pay a premium of 4.9% for the yellow plain maize meal.

A summary of these global studies undertaken on sensory evaluation are presented in Table 3.2. The table shows the authors, focus of the study, methods applied in the data collection and the main results.

Table 3.2: A summary of some incentive compatible experimental auctions studies

Authors and year	Focus	Methods applied	Main results
Lusk *et al.,* 2001b	WTP for tender steak by urban consumers in USA	BDM	➢ Even though majority of the respondents preferred tender stake, they were not willing to pay more to exchange tough steak for tender one
Chern *et al.,* 2003	WTP for new orange juice processed with Pulsed Electric Field (PEF) processing technology by urban consumers in Ohio State University	Vickrey second-price auction	➢ Before tasting, consumers are willing to pay higher for unprocessed PEF juices than for other types of juices ➢ After tasting, the WTP for PEF decreased substantially because consumers did not like its taste
Feldkamp *et al.,* 2005	WTP for differentiated beef steak quality attributes by consumers in Manhattan	BDM	➢ Consumers are willing to pay premiums for natural steak than for other steak attributes
Hobbs *et al.,* 2005	WTP for food traceability information by consumers in Canada	Vickrey second-price auction	➢ Consumers are willing to pay more for quality verification information with respect to credence attributes that they are WTP for traceability information
De Groote *et al.,* 2010	Willing to pay for food quality, considering yellow versus fortified maize meal, by rural consumers in Kenya	BDM	➢ Consumers are willing to pay a premium for maize fortified with minerals and vitamins

3.4 SUMMARY

This chapter provides the theoretical basis for testing the second and third hypotheses of this study stating that rural consumers in Tanzania will be willing to pay a higher price for QPM flour than for conventional maize flour and that the provision of nutritional information on QPM will increase their WTP for QPM flour compared to conventional maize flour.

When a new product is introduced onto the market, it is important that its acceptance by consumers is known. This will help in applying the right marketing strategies for the new product. To know consumer acceptance for products, value elicitation studies are undertaken. These can either be hypothetical or non-hypothetical methods. Research, however, has shown that hypothetical methods come with several disadvantages, among them the hypothetical bias and that the methods may not be demand-revealing. Therefore, non-hypothetical methods, and specifically those that are incentive compatible, have been seen more reliable in eliciting consumers' WTP for different products. Experimental auctions have been widely applied to determine consumer WTP for new products. Even though these methods are more expensive to undertake than the hypothetical ones, they give more accurate data. It is for this reason there that this study will employ experimental auctions method, specifically BDM procedure, to elicit consumer WTP for QPM.

CHAPTER 4: RESEARCH DESIGN AND METHODOLOGY

4.1 INTRODUCTION

This chapter presents the detailed research methodology that was applied in this study. The study was executed based on four research methods: central location testing, use of household questionnaires, modified home use sensory evaluation and individual experimental auction, in order to achieve the project objectives.

4.2 RESEARCH DESIGN

A flow diagram of the overall research design used in this study is shown in Figure 4.1. As evident from this figure, four methods of data collection were used to collect primary data for the study.

First, sensory evaluation of QPM and conventional maize was carried out in a central location testing (CLT) with 30 employees of the Selian Agricultural Research Institute (SARI). Information on their individual characteristics was first collected, followed by sensory evaluation and triangle test.

The second method used was a household survey, where personal interviews were carried out with 209 rural consumers from three districts (Hai, Karatu and Babati) of the northern region of Tanzania. Data on farming activities, family income for the past year, demographic characteristics of the household, asset ownership, dietary information and maize consumption details for the households were collected.

Third, modified home use sensory testing (HUT) on QPM and conventional maize stiff porridge was conducted by the rural consumers. They evaluated QPM and conventional maize and stated their level of liking of the two types of maize. Due to financial constraints, only 120 of the 209 respondents who undertook the household survey undertook this experiment.

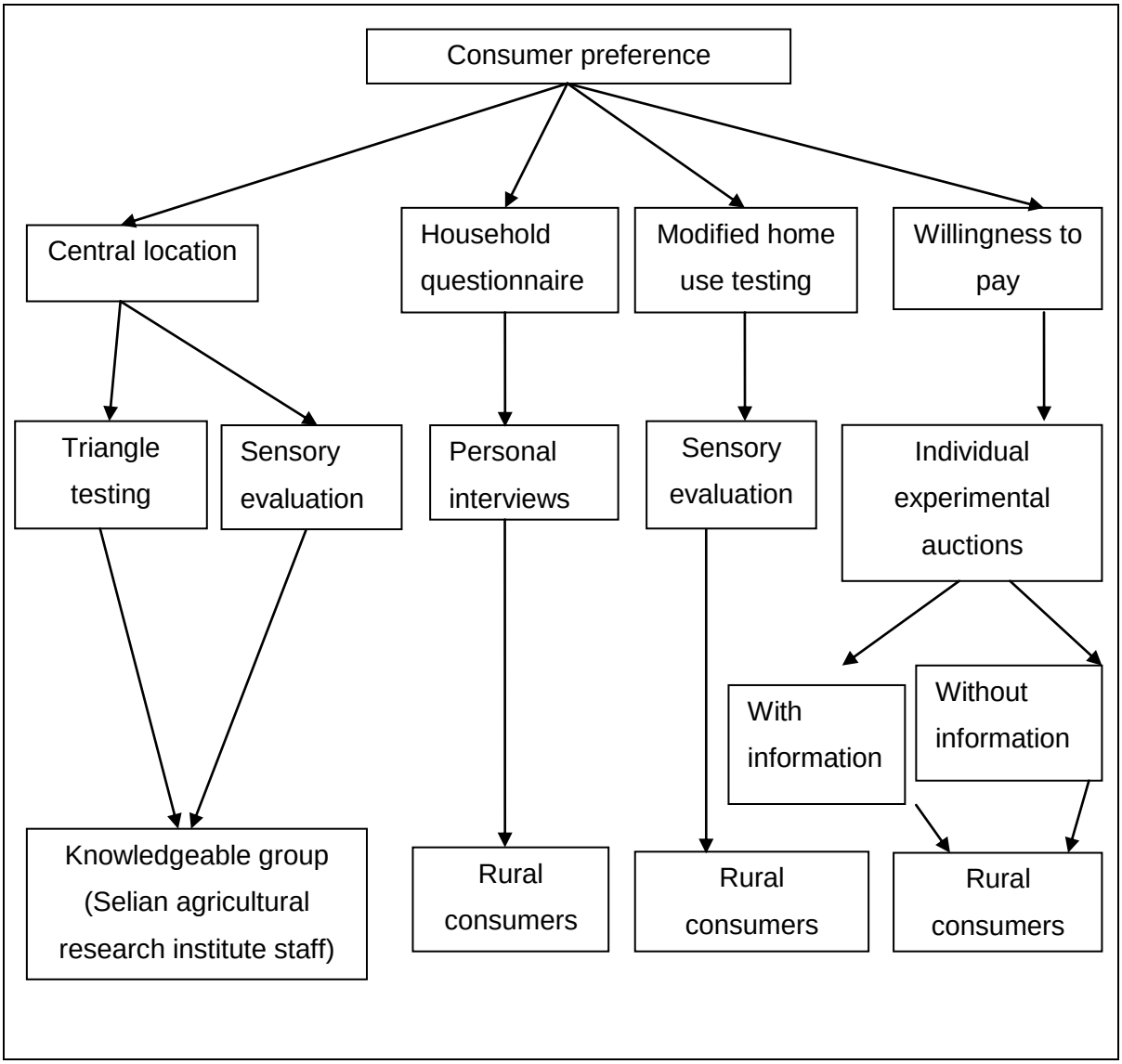

Figure 4.1: Flow diagram of overall research design

Finally, rural consumers' WTP for QPM flour was tested through individual experimental auctions using BDM method. All the 120 consumers who participated in the modified HUT also undertook this experiment. Out of these, half were provided with QPM nutrition information before undertaking the WTP experiment and the others not. Data collection for those provided with nutritional information started with the household identification questions, followed by modified home use sensory testing, followed by questions from the household questionnaire on awareness of QPM. Afterwards, the QPM nutrition information was provided to the respondents, then individual experimental auction took place, and finally the

remaining questions on the household questionnaire were administered. Respondents who did not receive QPM nutritional information had a different flow of events. The household identification questions were first administered followed by sensory evaluation, then by the individual experimental auction, and finally the rest of the household questionnaire. Administering of the household questionnaire and carrying out of the experiments was done by enumerators who were trained, using tools specially developed and tested for this purpose.

4.3 GEOGRAPHICAL AREAS

Northern Tanzania is an important maize growing area that accounts for 10% of the total national production of the cereal, and is one of the nation's maize surplus areas (Nkonya, Xavery, Akoonay, Mwangi, Anandajayasekeram, Verkuijl & Moshi, 1998:6). Three agro-ecological zones are present in the northern region:, namely the high rainfall zone, which receives about 1,200 to 1,500 mm of rainfall per year, the moderate rainfall zone, which receive about 800 to 1,200 mm per year, and the low rainfall zone, which receives about 500 to 800 mm per year (Nkonya, Xavery, Akoonay, Mwangi, Anandajayasekeram, Verkuijl & Moshi, 1998:6)..

Figure 4.2 shows Tanzania with the three districts of study shaded. Hai district is one of the six districts of the Kilimanjaro Region of Tanzania, bordered to the north by Kenya, to the South and West by the Arusha Region, and to the east by the Moshi Rural and Rombo Districts. Babati district is one of the districts of Manyara Region, 172km south of Arusha, bordered to the north by the Arusha Region, to the south east by the Simanjiro District, to the south by the Dodoma Region, to the South West by the Hanang District, and to the North West by the Mbulu District. A part of Babati district is in high rainfall zone, but the largest part of the district fall in the moderate rainfall zone which is the most important zone for maize production in Tanzania (Nkonya *et al.,* 1998:2). Karatu, one of the five districts in Arusha Region, is bordered by the Ngorongoro District to the north, the Shinyanga Region to the west, the Monduli District to the east, and the Manyara Region to the south and southeast. According to the 2002 Tanzania National Census, the population of Karatu district was 178 434, Babati 303 013 and Hai 259 958.

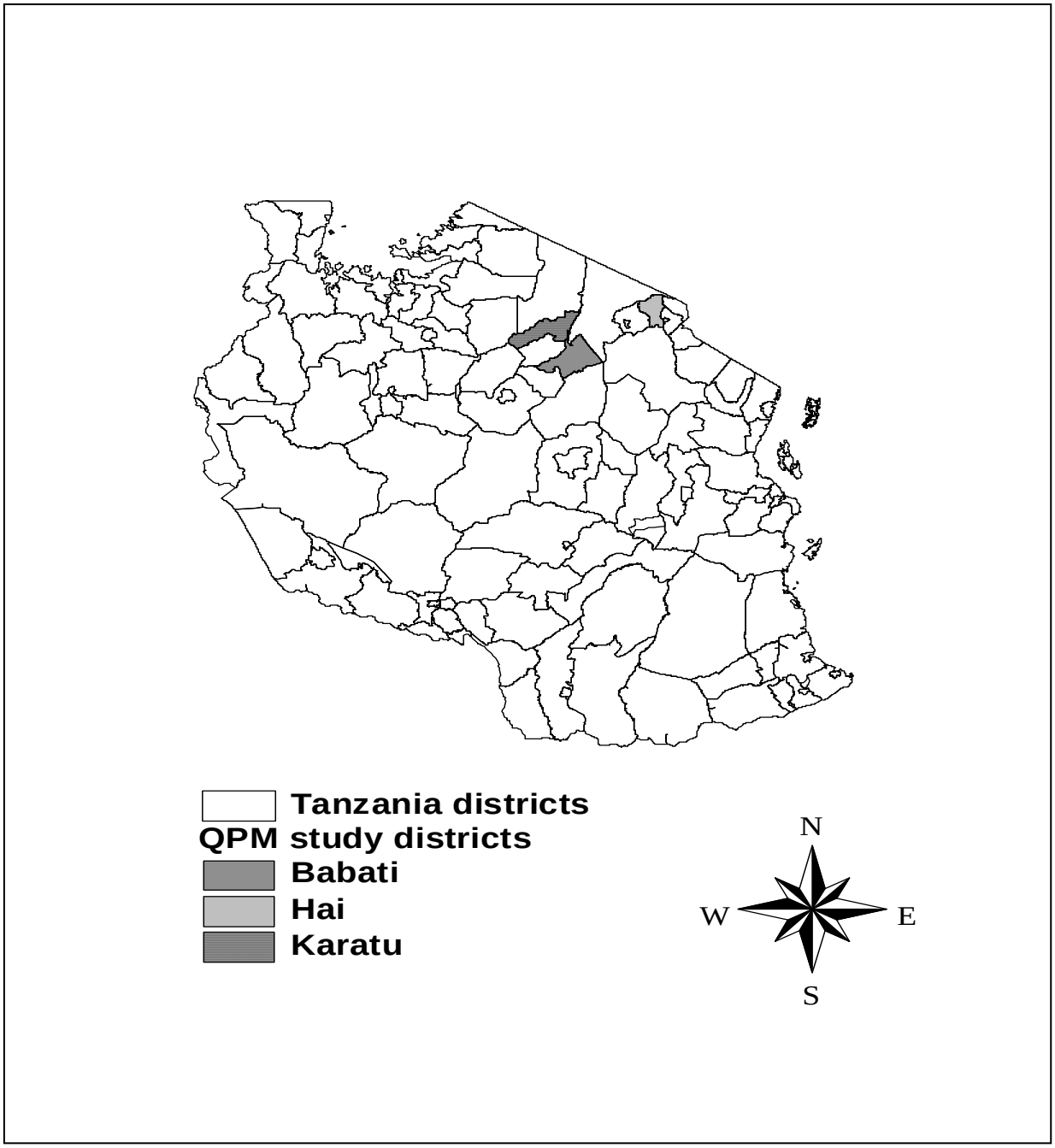

Figure 4.2: Tanzania districts

Source: Tanzania National Bureau of Statistics, (2006)

4.4 CONCEPTUAL FRAMEWORK FOR THE STUDY

A number of aspects comprise the conceptual framework for this study. First, consumer choice and utility theory will be discussed to get to understand more how consumers behave when it comes to attaining utility from goods consumed. Then, the theoretical model of the study will be discussed.

4.4.1 Consumer choice and utility theory

The theory of rational choice behaviour asserts that a decision-maker can rank possible alternatives in order of preference, and will always choose from these the option which he or she considers most desirable, given taste and the relevant constraints placed on the decision-making (Domencich & McFadden, 1975:34). If a consumer is approached with two products, the theory of rational behaviour assumes that there is completeness in preference, that is, there are three possibilities in the preference relation: either product A is preferred to product B, or product B is preferred to product A, or both product A and B are equally attractive (Nicholson, 2005:69). Consumers rank their preferences in order of possible situations from the least desirable to the most desirable. These rankings are said to be in order of level of utility that the consumer derives from each product (Nicholson, 2005:71). If a consumer prefers product A to product B, then it means that the level of utility derived from product A exceeds that from product B.

Where a consumer is given a chance to evaluate the sensory characteristics of a product, perceiving these does not necessarily mean that he or she will or will not choose to consume it. Rather, it is an individual's liking of specific attributes in a particular product that will be the determining factor. Among factors that affect consumer choice for food, the amount of chemicals it contains, such as protein or carbohydrate, are one of them. Others include marketing and economic variables, as well as social, cultural, religious and demographic factors (Shepherd, 1999:807).

4.4.2 Theoretical model

In most of the market surveys, opinion polls and consumer acceptance tests, ordinal responses are common, where for example in consumer acceptance tests consumers are asked to "rate" their perceived likeness for a product (Coe, 2002:47). The rating is done in terms of scores on an ordered but arbitrary scale, for example, a 5-point hedonic scale, form *1=very bad*, to *5=very good*. At all times, a selection of 5 is higher and better than a selection of 4, while 4 is higher and better than 3 and so on. A product rated 4 however is not necessarily twice as well liked as a product rated 2. Also, the intervals between each rating are not

necessarily exactly the same. However, Meilgaard *et al.* (2007:55) observe that panellists should be encouraged to treat all intervals between categories as equal.

In ordinal regression models it is assumed that scores represent ordered segments of a utility distribution. Respondents score a sensory characteristic in a particular ordered category, driven by a latent, unobserved variable *u*, which represents utility. In our case where one is studying consumer preference for maize varieties, the variable *u* indicates a general appreciation of the maize variety. Instead of this latent variable *u*, one observes the scores *y*, a variable that falls in one of J ordered categories, in this case from 1 (*very poor*) to 5 (*very good*). The latent variable corresponds to the consumer's preference for the maize variety. Higher levels of *u* mean that the consumer's preference for the maize variety is higher than when the levels of *u* are lower. If *u* is at some cut-off which we label k_1, the respondent chooses the answer "*very bad*". If *u* is k_4, then the answer is "*good*" and the cut-off goes up to k_{j-1} (Train, 2009:160). This is represented using the general formula:

$$y=j \quad \text{if } k_{j-1} <= u \qquad (1)$$

In this study of consumer evaluation for stiff porridge, the values of y will be determined as follows:

$$y=1 \quad \text{if } u<k_4$$

$$y=2 \quad \text{if } k_4 \leq u<k_3$$

$$y=3 \quad \text{if } k_3 \leq u<k_2$$

$$y=4 \quad \text{if } k_2 \leq u<k_1$$

$$y=5 \quad \text{if } k_1 \leq u. \qquad (2)$$

Since the latent variable *u* is a continuous variable from negative infinity to positive infinity, regression technique can be used. The value of *y* that the consumer chooses is influenced by observable and non-observable factors. Hence, *u* can be decomposed into observed and unobserved components, as follows (Train, 2009:161):

$$u_i = \boldsymbol{\beta}' x_i + \varepsilon_i \qquad (3)$$

All the observed components will be represented by ***β'***x, and will consist of factors such as level of income of the consumer and gender. On the other hand, the unobserved factors will be represented by the error term, $\boldsymbol{\varepsilon_i}$, and these will be considered distributed logistically. The cumulative density function of the standard logistic distribution is given by:

$$f(\varepsilon) = \frac{\exp(\varepsilon)}{1+\exp(\varepsilon)} \qquad (4)$$

The distribution of the unobserved factors determines the probability of the possible value of *y*, such that the probability of *y* having the value of one is derived as follows:

$$\begin{aligned} \mathrm{P}(y=1) &= \mathrm{P}(\mu < k_4) \\ &= \mathrm{P}(\boldsymbol{\beta}'\mathrm{x} + \varepsilon < k_4) \\ &= \mathrm{P}(\varepsilon < k_4 - \boldsymbol{\beta}'\mathrm{x}) \\ &= \frac{e^{k_4 - \beta' x}}{1+e^{k_4 - \beta' x}} \end{aligned} \qquad (5)$$

whereas the probability of y having the value of two is derived as follows:

$$\begin{aligned} \mathrm{P}(y=2) &= \mathrm{P}(k_4 < \mu < k_3) \\ &= \mathrm{P}(k_4 < \boldsymbol{\beta}'\mathrm{x} + \varepsilon < k_3) \\ &= \mathrm{P}(k_4 - \boldsymbol{\beta}'\mathrm{x} < \varepsilon < k_3 - \boldsymbol{\beta}'\mathrm{x}) \\ &= \mathrm{P}(\varepsilon < k_3 - \boldsymbol{\beta}'\mathrm{x}) - \mathrm{P}(\varepsilon < k_4 - \boldsymbol{\beta}'\mathrm{x}) \\ &= \frac{e^{k_3 - \beta' x}}{1+e^{k_3 - \beta' x}} - \frac{e^{k_4 - \beta' x}}{1+e^{k_4 - \beta' x}} \end{aligned} \qquad (6)$$

and so forth (Train, 2009:162).

The coefficients quantify the effect of the explanatory variable on consumers' preference. However, the interpretation of the coefficient is quite cumbersome in the above formulation, but much easier if the odds of the cumulative probabilities are considered. To calculate the odds of the cumulative probabilities, the cumulative probability of a score *j* is first calculated, which is defined as a probability of a score to be less than or equal to *j*, and it can be derived from logistic cumulative distribution function as follows:

$$P(y \leq j) = \frac{e^{k_j - \beta' x}}{1+e^{k_j - \beta' x}} P(y \leq j) = \frac{e^{k_j - \beta' x}}{1+e^{k_j - \beta' x}} \qquad (7)$$

Secondly, the odds of an event occurring is estimated as the probability that the event occurs (success) divided by the probability that the event does not occur (failure) (Agresti, 1996:75). Mathematically, this is calculated as:

$$\text{Odds} = \frac{\text{prob(q)}}{1-\text{prob(q)}} \qquad (8)$$

In the case of ordered response models, for example the case of consumers' preference of a product, the odds of highest score to occur (score=5) will be calculated as follows:

$$\textbf{Odds}\,(\mathbf{y=5}) = \frac{\textbf{prob}(\mathbf{y=5})}{\mathbf{1-prob}(\mathbf{y=5})} \qquad (9)$$

Lastly, the cumulative odds ratio is equal to the odds that a score *y* falls at or below a certain level of *j*.

$$\text{Cumulative odds} = \frac{\text{prob}(y \leq j)}{1-\text{prob}(y \leq j)}$$

This is calculated as follows:

$$\frac{\text{Prob}(y \leq j)}{1-\text{Prob}(y \leq j)} = \frac{\left[e^{k_j - \beta' x} \Big/ 1+e^{k_j - \beta' x} \right]}{\left[1-\left(e^{k_j - \beta' x} \Big/ 1+e^{k_j - \beta' x} \right) \right]}$$

$$= \left(e^{k_j - \boldsymbol{\beta}' x} \Big/ 1 + e^{k_j - \boldsymbol{\beta}' x} \right) \times \left(1 + e^{k_j - \boldsymbol{\beta}' x} \Big/ 1 \right)$$

$$= e^{k_j - \boldsymbol{\beta}' x} \qquad (10)$$

Taking the natural logarithm on both sides, the log of cumulative odd ratio is found to be a linear function of the independent variables:

$$\ln \left(\frac{\text{Prob}(y \leq j)}{1 - \text{Prob}(y \leq j)} \right) = ln \left(e^{k_j - \boldsymbol{\beta}' x} \right)$$

$$= k_j - \boldsymbol{\beta}' x \qquad (11)$$

The effect of a change in variables $\boldsymbol{x}$ can be calculated from equation 11 above. For example, when $\boldsymbol{x}$ changes from $\boldsymbol{x_3}$ to $\boldsymbol{x_4}$ the effect of the change can be calculated as follows:

$$ln \left(\frac{\left[P(y \leq j | X = x_4) \Big/ 1 - P(y \leq j | X = x_4) \right]}{\left[P(y \leq j | X = x_3) \Big/ 1 - P(y \leq j | X = x_3) \right]} \right)$$

$$= \boldsymbol{\beta}' x_4 - x_3 \qquad (12)$$

This odds ratio is independent of *J*, and the odds in favour of a low score ($y \leq j$) versus a high score ($y > j$) are in the same proportion for two diverse x values, whatever the value of *j*. Hence, the model is known as 'proportional odds' model (McCullagh, 1980:110). The coefficient $\boldsymbol{\beta}$ can be interpreted as the change in the log of odds ratio for a unit change in the explanatory variable $\boldsymbol{x}$. If the independent variable *x* is a binary variable, such as maize variety when only two maize varieties are present, the interpretation of the coefficient $\boldsymbol{\beta}$ becomes different. In such a case, $\boldsymbol{\beta}$ will represent the change in the log odds, which is mathematically explained as the log of the ratio of the odds of that variety having a high score

rather than a low score to the odds of control variety having a high score rather than low. This ratio is called the log odds ratio. The exponential of the log odds ratio ($e^{\beta i}$) represents the odds that one technology is rated higher over the same odds for another technology (Bellon, Adaro, Becerril & Mindek, 2006:116).

4.5 SAMPLING

A total of 209 rural consumers from Hai, Babati and Karatu districts in the northern zone of Tanzania were interviewed, and a household questionnaire was administered by specially trained enumerators. These respondents were randomly selected from the 150 QPM villages and 150 control villages sampled in an earlier survey (QPMD survey) in 2003, using a stratified two-stage sampling procedure. The two strata used were areas with and without access to QPMD extension activities. The primary sampling units were villages, the lowest administrative unit, randomly sampled with probability proportional to size measured in number of households. Secondary sampling unit were households, where ten households were randomly selected within each village. All the 300 respondents in the QPMD project could not be taken into this survey due to financial constraints.

From the 209 rural consumers who were interviewed in the household questionnaire, 120 were randomly selected and these undertook the modified HUT and WTP experiments. All the households that participated in the modified HUT also participated in the WTP experiment.

All the respondents were either head of the household or the spouse. This was to ensure that people who participated in the survey were mainly those who influence or partake in purchasing household food.

4.6 DETAILED DESCRIPTION OF RESEARCH COMPONENTS

The remaining part of this chapter will present a detailed discussion of the four methods applied in this study.

4.6.1 Central location testing

4.6.1.1 Data gathering

Central location testing (CLT) was undertaken by 30 employees of the Selian Agricultural Research Institute (SARI). These undertook both triangle test and central location sensory evaluation. A triangle test is used to determine sensory differences between two products (Meilgaard *et al.*, 2007:65), a method first explained to the respondents before each was given three uniquely labelled samples of stiff porridge. They were informed that two of the samples were the same, and their task was to identify the odd one out. The respondents were allowed to use any method of sensory evaluation, (tasting, smelling, and checking the hand/mouth texture or any method that they wish). The respondents did not know what type of maize the stiff porridge was made from. All the samples were similar, and only the labels differentiated them. Every consumer evaluated and filled in the sheet provided. The researcher was present for any questions or clarifications. Figure 4:3 shows a respondent undertaking the triangle test.

For the central location sensory evaluation, both QPM (Lishe K1 variety) and conventional maize were bought, milled, and the maize flour was packed and labelled “triangle” or “circle”. This was done to enable the person preparing the stiff porridges to know the type of flour used in their preparation. These symbols did not have a particular connotation in the areas of data collection and were considered better than numbers to avoid influencing judgement of the respondents (Watts *et al.*, 1989:120).

The two types of maize flour were given to one woman who was well conversant with preparation of stiff porridge. She prepared the stiff porridges from a kitchen in the institute and presented them in the institute’s hall, where the experiment was undertaken. The stiff porridge was served in plates labelled “triangle” or “circle”, and the respondents were requested to evaluate both, one at a time, for aroma, appearance, texture in the hand (hand feel), texture in the mouth (mouth feel), taste and overall evaluation. A nine-level hedonic scale was used, from 1=*extremely bad*, to 9=*extremely good*. The respondents did not know what type of maize the stiff porridges were prepared from.

The order of the products was random. Respondents were given mineral water to drink between evaluations to clear their palette. They were also requested to wash their hands before the experiment and after sensory testing of the first sample to ensure texture results were not influenced.

Figure 4.3: A respondent undertaking triangle test

The figure in appendix A shows a respondent undertaking central location sensory testing. Every consumer evaluated and filled in the sheet provided. The researcher was present for any questions or clarifications.

4.6.1.2 Data analysis

Data from the central location sensory evaluation were analysed using SPSS 15 and the paired sample t-test method was used for the analysis. To analyse the data from the triangle testing, the number of correctly identified odd sample were counted, and this was checked against a table of critical numbers for interpretation.

4.6.2 Household survey

4.6.2.1 Data gathering

A household survey was carried out using structured questionnaires, which were administered by trained enumerators. The household questionnaires applied both quantitative and qualitative approaches to collect different types of information from the consumers. Information on QPM production, consumption and consumers' perception about QPM was collected. In addition, characteristics of the consumers were collected, such as demographic characteristics, level of adoption of the QPM technology, level of knowledge of QPM, QPM adoption levels for three years and use QPM grain. A total of 209 rural consumers were interviewed and in each household, either the household head or the spouse was interviewed.

4.6.2.2 Data analysis

The household survey provided demographic characteristic variables, wealth indicator variables and variables indicating the different regions. These were included in the ordinal regression model of the modified home use sensory evaluation and the random effects model of the WTP for analysis.

4.6.3 Modified home use sensory evaluation

4.6.3.1 Theoretical basis of method

As discussed in Section 2.5 on the literature review of sensory testing, the available literature explains home use sensory testing as a method where respondents use a product repeatedly under natural condition of use before evaluating it (Meilgaard *et al.*, 2007:264). However, a study in Zambia on sensory evaluation of provitamin A orange maize, where home use testing method was applied, showed that giving consumers more time to evaluate the product was not critical. Rather, the exposure time of 30 minutes, as that given in central location testing, is sufficient for a consumer to form an opinion about the product (Meenakshi *et al.*, 2010:21). Furthermore, the repeated use of product in HUT makes the sensory evaluation process very expensive and time-consuming

(Meilgaard *et al.*, 2007:264). For this study therefore, HUT was carried out in one day, hence called 'modified home use sensory testing'. As with CLT, both QPM (Lishe K1 variety) and conventional maize were bought, milled, and the maize flour was packed and labelled "triangle" or "circle".

4.6.3.2 Data gathering

Each respondent was given one kilogram of "triangle" and one kilogram of "circle", and requested to prepare the two types of stiff porridge separately. Afterwards, they undertook sensory evaluation of the two stiff porridges, one after the other. They were requested to give their response based on the texture in the hand (hand feel), texture in the mouth (mouth feel), taste and overall evaluation using a five-level hedonic test, where 1=*very bad*, to 5=*very good*. The order in which the respondents made the evaluation was randomised.

The respondents were requested to drink water before starting the experiment and after tasting the first stiff porridge before tasting the second stiff porridge. This was done to clean their palette. Likewise, they were requested to wash their hands before starting the experiment and after sensory evaluation of the first stiff porridge. This was to ensure that texture in the hand result was not affected. The evaluation scorecards were filled by trained enumerators, specially trained for that purpose.

Figure 4.4 shows a rural consumer undertaking the modified home use sensory testing with the help of a trained enumerator.

Figure 4.4: A respondent undertaking sensory testing at his home

4.6.3.3 Data analysis

Consumers' scores are measured on an ordered categorical scale, hence the ordinal regression model was chosen for analysis of this data. The ordinal regression estimates the log odds ratio. When consumers score two products, for example QPM and conventional maize, the odds ratio is the ratio of the odds of one maize variety receiving a higher score over the odds that the other maize variety receives a higher score. The odds ratio can be calculated as the antilog of the estimated coefficient, the log odds ratio, and indicates how one product was evaluated compared to another one (Meullenet, Xiong & Findlay, 2007:130-131).

When the same consumer is asked to evaluate different products, these evaluations are likely to be correlated. To avoid that the error terms in the model

are correlated, fixed or random effects can be included (Green, 2008:200). Therefore, data from the modified HUT was analyzed using SPSS 15, and ordinal regression model with fixed effects was used.

Since consumer evaluation provides categorical data, a vector ***x*** is used with a binary variable for each product. The basic model becomes:

$$\ln\left(\frac{\text{Prob}(Y_i \leq j)}{1-\text{Prob}(Y_i \leq j)}\right) = k_j + \boldsymbol{\beta}' \boldsymbol{x} \qquad (13)$$

The dependent variable Y_i is the overall evaluation rating of both QPM and conventional maize by consumer *i*, using a score from 1 (*very poor*) to 5 (*very good*), while the explanatory variable consists of three binary variables, to capture, the difference in the type of maize, (QPM or conventional maize) (**x**), difference in gender (**s**) and difference in sites (**f**).

To determine whether technology is more appreciated by the wealthy, wealth indicators such as land and livestock ownership were also included. These factors were combined in a vector **z**.

The new model is shown below:

$$\ln\left[\frac{P(Y \leq j)}{1 - P(Y \leq j)}\right] = k_j + \boldsymbol{\beta}'\boldsymbol{s} + \boldsymbol{\sigma}'\boldsymbol{x} + \boldsymbol{\gamma}'\boldsymbol{f} + \boldsymbol{\alpha}'\boldsymbol{z} + \boldsymbol{x}'\boldsymbol{A}_{\boldsymbol{sx}}\boldsymbol{z} \qquad (14)$$

The coefficient $\boldsymbol{\beta}'$ is interpreted as the log odds ratio of a factor (for example women) for both QPM and conventional maize varieties. The matrix A_{sx} has a row for the QPM maize variety in vector ***x***, and a column for women variable in vector ***s*** and every element represents a cross effect of female respondents for the specific maize variety (QPM). To analyse the effect of age of respondents to acceptance of QPM, a cross effects dummy variable was introduced, representing respondents' age and maize variety. Similar calculations were made for Hai and Babati districts (Karatu district was the base). Level of wealth of respondents was also considered as one of the variables of the regression model, where livestock and land ownership were used to represent wealth.

4.6.4 Experimental auction

4.6.4.1 Theoretical basis of method

For this study, Becker-DeGroot-Marschak (BDM) individual auction mechanism was used to solicit consumers' WTP for QPM flour. The BDM mechanism is individual and can therefore be combined with the modified HUT, which would be difficult with group type experimental auctions (Becker *et al.*, 1964:227). Moreover, BDM is an incentive compatible mechanism. The BDM auction elicits important values of individuals one at a time. Because there is no requirement to gather a large audience, individuals may participate in the auction at their leisure. This trait is helpful in consumer research, as subjects may not finish the tests at the same time (Watts *et al.*, 1989:120).

4.6.4.2 Data gathering

All 120 respondents who took part in the modified home use sensory testing also took part in experimental auction of rewards using the BDM method. To analyse if nutritional information affects consumers' WTP, half of the respondents were provided with QPM nutritional information, and the others not. The information was read to each respondent by trained enumerators so all received the same information. Both QPM and conventional maize flour were packed in one kilogram packets and labelled either "QPM" or "conventional". For the respondents not receiving the nutritional information, their maize flour was labelled either 'triangle" or "circle". Before the enumerators started the auction process, they first explained the BDM process to the respondent. The respondents were also informed that the best strategy was to bid exactly what it was worth to them to obtain the maize flour.

The maize flour auction was preceded by a test round using cup cakes to ensure that all the respondents understood the BDM procedure. A participation fee for the test round of TShs 200 ($US 0.15) was given to each respondent. If the respondent won the cake auction, he or she retained the cake and paid the random price, and retained the change if any. If a consumer lost in the cake auction, the researcher kept the cake, and the consumer kept the money. After the

researcher confirmed that the respondents had completely understood the BDM method, they proceeded to the maize flour auction.

Respondents not presented with QPM nutritional information were shown the two packets of maize flour and told that the one labelled “triangle” contained the same flour used to prepare stiff porridge labelled “triangle”, and the package labelled “circle” was the flour used to prepare stiff porridge labelled “circle”. Next, they were asked to state their WTP for each type of maize flour, one at a time, and the enumerators wrote them down. Each consumer was requested to pick a random price from a box containing several prices, randomly drawn from a distribution with a mean equal or close to the current price for maize flour, and a reasonable standard deviation. Their bids were compared to this random price. If the consumer’s bid was higher than or equal to the random number, he or she won the auction, and bought the maize flour at the random number drawn (the random price). However, if the consumer’s bid was lower than the randomly picked price, he or she lost the auction, retained the money and the enumerator retained the maize flour.

Respondents who received nutritional information were also first provided with explanations of the BDM process, and informed that the best strategy was to bid exactly what it was worth to them to obtain the maize flour. This was followed by the cake auction to ensure that they understood the BDM process. Next, the QPM nutritional information was read to them, followed by the maize flour auction using BDM method.

4.6.4.3 Data analysis

Data from the individual experimental auction was analyzed using SPSS 15. The average bids for QPM and conventional maize flour were compared using paired-samples t-test method and the mean differences between the bids were also taken. In addition, a random effects model was run using STATA 19, which was used to estimate consumers’ WTP. Consumer WTP for particular products is driven by their appreciation of particular characteristics of that product. When *I* consumers are asked to bid on *J* products with *P* characteristics, the WTP y_{ij}, of

consumer *i* for product *j*, can be regressed on the vector x_j, which represents value of *P* characteristics of product *J*:

$$Y_{ij} = \alpha + \sigma' x_j + v_{ij}, \qquad 15$$

where v_{ij} is the error term for consumer *i*'s WTP for product *j.*

The dependent variables in this model are the sensory characteristics (taste, mouth feel and hand feel) that consumers evaluated earlier in the sensory test. These characteristics vary for the two maize varieties used QPM and conventional maize). Since the data comes from consumers' WTP for the products, and hence introduces correlation in the error terms, there arises a need to include a disturbance term *ui* for each consumer (Green, 2008:201).

$$Y_{ij} = \alpha + \sigma' x_j + u_i + v_{ij}. \qquad 16$$

Since the consumers were randomly selected from a large population, the individual disturbance term *ui* is also assumed to have a random distribution. The two terms are considered in the generalized least squares estimation, a model referred to as random effects approach (Green, 2008:201). One of the main assumptions for unbiased estimate is that (*ui)* are uncorrelated with the explaining variables.

WTP for different products can vary among consumers. This can be analysed by including a vector f_i of *K* consumer characteristics (De Groote *et al.*, 2010a:6). The consumer characteristics in this case will include variables such as age, gender and years of formal education. Further, since consumer characteristics, for example level of income, could affect the consumers' WTP for the different products, a matrix A (dimensions K x P) of cross effects is also included.

WTP for different products could also vary according to change in locations. To analyse this, a vector d_i is included in the model. Only two districts were added, the third district being the base. To analyze WTP for different products in the different districts, a matrix B of cross effects is included.

Providing QPM nutritional information could affect consumer WTP for the different products. A vector z_j is included in the model for the analysis. In addition, to analyse the WTP for the different products with the nutritional information, a matrix C of cross effects is introduced. Providing the nutritional information could also have an influence on the WTP for the different products as the location change. On the other hand, to find out effects of information on consumer WTP in different regions, a matrix D of cross effects is introduced. The general model with product characteristics, consumer characteristics, the different locations, information variable, cross effects and individual disturbance term becomes

$$Y_{ij} = \alpha + \sigma' x_j + \beta' f_i + \gamma' d_i + \rho' z_j + x'_j A f_i + x'_j B d_i + x_j' C z_j + d'_j D z_j + u_i + v_{ij}$$

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4.7 SUMMARY

This chapter provided a detailed descriptive of the methodological process applied in the study, research design, a discussion of area of study and the sampling design. Four methods were used in data collections for the study: central location testing, a household survey, modified home use sensory testing and individual experimental auctions. At the central location, 30 subjects participated in the triangle test, a test of difference. In addition, the same subjects undertook sensory evaluation of QPM and conventional maize stiff porridge, which were presented randomly, and uniquely labelled. This was done to elicit consumer's acceptability of QPM stiff porridge, compared to that made from conventional maize.

The household survey, modified home use sensory testing and individual experimental auctions were undertaken by rural consumers from Babati, Hai and Karatu districts of the Northern region of Tanzania. For household survey, 209 respondents were interviewed using structured questionnaires which were administered by trained enumerators. This survey collected data such as the consumers' demographic characteristics, farming activities, maize consumption and ownership of assets.

For the modified home use sensory testing and individual experimental auctions, a total of 120 respondents were randomly selected from those who participated in

the household survey. They undertook sensory evaluation of two types of stiff porridge, one after the other in a random order. Afterwards, the same subjects undertook WTP for QPM and conventional maize flour using BDM mechanism. Half the number of those who participated in the WTP experiment were provided with QPM nutritional information. This study was undertaken between January and February 2010.

Data collected from the CLT was analysed using descriptive statistics. From the modified HUT, data was analysed using ordinal regression model with fixed effects in addition to the descriptive statistics. Consumer scores are ordinal in nature, hence this model was chosen. WTP data on the other hand was analysed using random effects model.

CHAPTER 5: RESULTS AND DISCUSSIONS OF SOCIO-ECONOMIC PROFILES, TRIANGLE TEST AND SENSORY EVALUATION

5.1 INTRODUCTION

As discussed in Section 2.2.1, sensory evaluation is an important factor in studying consumer behaviour, especially when a new product is being introduced in to the market. Through sensory evaluation, the marketer is able to identify the specific sensory characteristics that consumers prefer in a product. Moreover, the product characteristics, consumer characteristics and economic and socio-environmental characteristics together determine whether or not a product is accepted.

This chapter presents a discussion of the results obtained through triangle test, central location and modified home use sensory evaluation and the socio-economic profile of the consumers. The chapter has five sections. The first section presents the demographic characteristics of the research subjects for the different research components. The second section presents a discussion on awareness and adoption of QPM in the area of study. This is important to this study because the subjects, who are rural maize consumers, are also producers, therefore important to understand their QPM adoption awareness levels. The third section gives a detailed discussion of the results of triangle test, followed by a discussion of central location and home use sensory evaluation. Finally, a summary of the chapter is presented.

5.2 SAMPLE DEMOGRAPHICS

5.2.1 Central location sensory testing and triangle test

Central location sensory evaluation and triangle test data were collected from 30 SARI employees, of whom 12 were women and 18 men. Their ages ranged from

18 to 56 years, with a mean age of 42 years. Their number of years in formal school ranged from 7 to 24, with a mean of 15 years (Table 5.1).

Table 5.1: Age and education level of the respondents at the central location

	N	Minimum	Maximum	Mean	Std. Deviation
Age of the respondent in years	30	18.00	56.00	42.32	10.40
Years in formal education	30	7.00	24.00	15.10	4.91

5.2.2 Modified home use sensory testing and WTP

A total of 120 rural consumers from Babati, Karatu and Hai district participated in the modified HUT and WTP experiments. Of these consumers, 44% were women, 56% men and their average age was 49 years (Table 5:2).

Table 5.2: Consumer demographic characteristics by district

Characteristic	Babati (n=36)		Hai (n=48)		Karatu (n=36)		Overall (n=120)	
	Mean	Std dev.	Mean	Std dev.	Mean	Std dev.	Mean	Std dev.
Female (%)	41.67	0.50	43.75	0.50	47.22	0.51	44.17	0.50
Age (Years)	44.22	8.82	52.35	10.08	48.06	13.53	48.63	11.33
Years in formal education	6.19	2.24	7.79	2.10	6.31	2.41	6.87	2.53
Non-Agricultural income received in 2009 ($US)[+]	351.89	633.82	1,139.85	2,973.44	317.99	535.19	657.90	1,962.48

[+] Income values indicated are nominal incomes

The average non-agricultural income received by all the households in the previous year was $US 657, but substantially higher in Hai ($US 1140) than in Babati ($US 352) and Karatu ($US 318). A household budget survey undertaken in Tanzania in 2001 showed that non-agricultural income per capita per year was

around $US 91. The same survey showed that the average size of rural households in Tanzania was approximately six people (Government of Tanzania, 2002:3). Therefore, this indicates that the average non-agricultural income per household was around $US 546. The figures arrived at in this study shows that the average non agricultural income for all households was slightly above the 2001 figures. This could have been caused by increased diversification in sources of income in Tanzania, with a continued shift from farming to other activities. This was noted in the 2006/2007 budget household survey (Government of Tanzania, 2008).

Out of an average 1.8 ha of land cultivated during the 2008/2009 main season, 1.5 ha was under maize (Table 5.3). The respondents in Babati had the highest average land cultivated (2.3 ha) and land under maize (1.9 ha) compared to Hai and Karatu districts. In one year, each household produces about 3.3 tons of maize, of which 54% is consumed. Respondents in Babati have the highest maize production per year (4.5 tons) compared to Hai (2.6 tons) and Karatu (3.1 tons). Babati district is in the moderate rainfall zone, which is the most important zone for maize production in Tanzania. Past study has shown that this district is one of the important maize producing districts in Tanzania, and at times a surplus producer which feeds the deficit districts (Nkonya *et al.,* 1998:2). This therefore explains the large area of land under maize in Babati, and the high production compared to other districts of study.

Table 5.3: Consumer farming characteristics by district

Characteristic	Babati (n=36)		Hai (n=48)		Karatu (n=36)		Overall (n=120)	
	Mean	Std dev.	Mean	Std dev.	Mean	Std dev.	Mean	Std dev.
Total land cultivated (ha)	2.28	2.29	1.36	1.82	1.87	1.51	1.79	1.91
Land under maize (ha)	1.93	2.02	1.14	1.73	1.58	1.31	1.51	1.73
Maize production in one year (tons)	4.50	4.09	2.59	2.30	3.08	2.39	3.31	3.06
Proportion of maize consumed in one year (%)	49.88	24.84	55.05	25.57	58.03	31.24	54.39	27.15

5.3 QPM AWARENESS AND ADOPTION LEVELS

Before discussing consumer acceptance of QPM in Tanzania, it is necessary first to look at the awareness levels of QPM in the three districts of study. Since rural consumers are producers and consumers at the same time, it is also important to understand the adoption levels of QPM in the area of study.

As expected, awareness of QPM is highest in the project areas. All respondents from the project areas in Babati district were aware of QPM, 92% in Hai district were aware of QPM and 75% from Karatu (Figure 5.1). Among the control household, QPM awareness is highest in Babati district (58%). The high QPM awareness in Babati district is attributed to QPM promotional activities which were carried out in the district by SARI. In this district, more consumers learnt about QPM from SARI than consumers in Karatu and Hai districts. Also, the government's agricultural extension officers from Babati district were more vigorous in promoting QPM than those in Hai and Karatu districts. This was seen from the high responses received from the consumers on their source of QPM awareness. In Hai district, QPM was being promoted by World Vision, and SARI.

No non-governmental organizations were however involved with promoting QPM in Karatu, and SARI's presence was minimal.

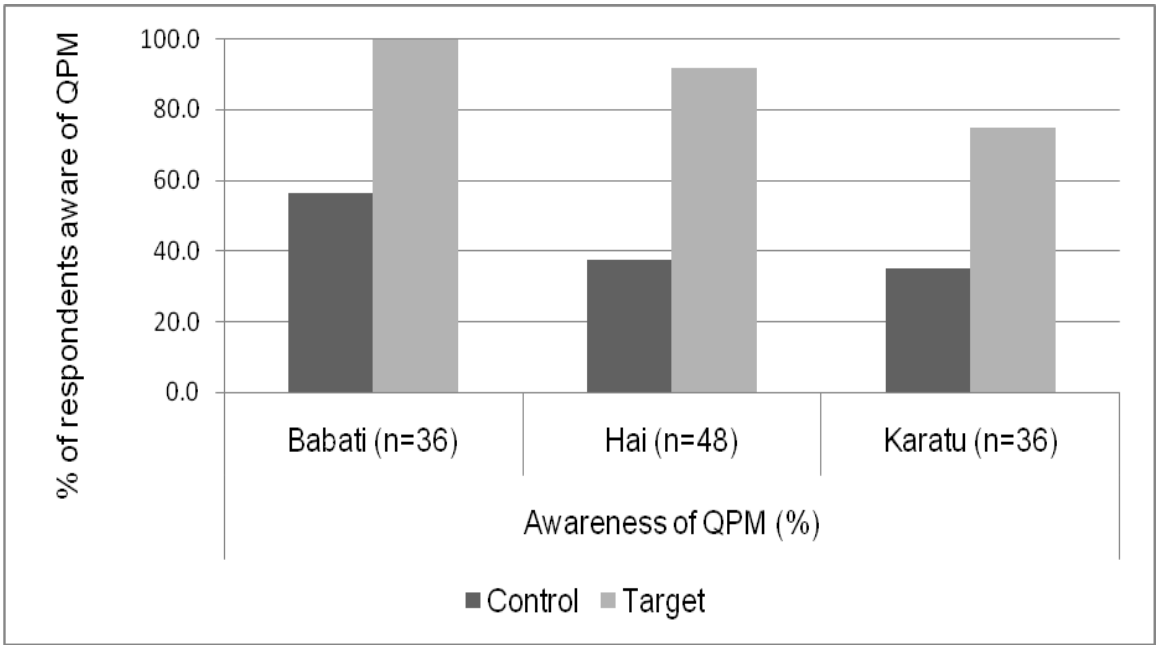

Figure 5.1: QPM awareness by sample type and district

Mainly, adoption of QPM in the three districts of study depended on whether or not the QPM seed was available. During the household survey the respondents were asked whether they had ever planted QPM and then stopped planting at some point. Those who indicated a positive response to this question were asked why. The majority of these respondents indicated that the main problem was seed availability. In addition, since some QPM varieties such as Lishe K1 and conventional maize have no physical difference, farmers could not purchase QPM seed from their fellow farmers unless a farmer was identified as a QPM producer, as it was found out in Hai district.

In Hai district, there was an increase in the number of QPM adopters from 2008 to 2009, both in the target and control households (Figure 5.2). This was attributed to availability of QPM seed that was provided by SARI, a seed company and selected farmers who produced QPM seed and sold to the farmers. Besides, the extension officers in this area offered training to the farmers on QPM and its benefits. The reduction in adoption levels of QPM in Babati and Karatu districts was as a result of unavailability of QPM seed in the two districts.

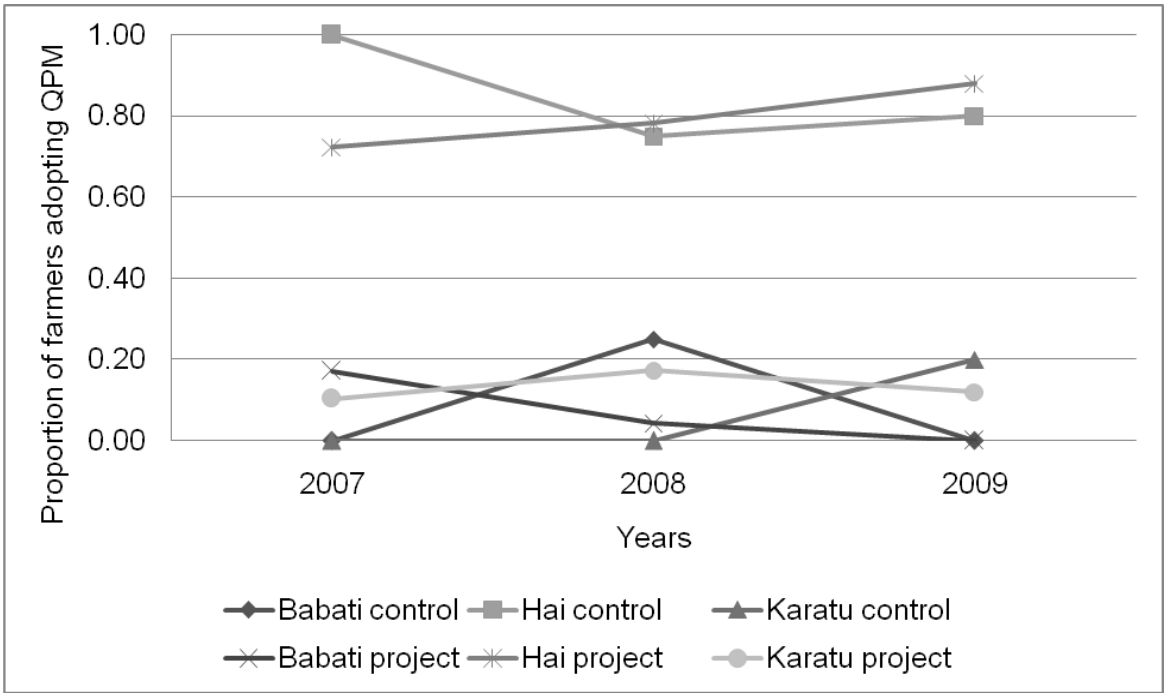

Figure 5.2: Adoption and disadoption of QPM by sample type and district

5.4 TRIANGLE TEST RESULTS

Out of the 30 respondents who participated in the triangle testing, 21 correctly identified the odd sample. The table of critical number of correct responses in a triangle test provides numbers that are compared with the number of correctly identified odd sample, depending on the number of respondents. The assumption of "*no difference*" is rejected if the number of correct responses is greater than or equal to the tabled value.

For this sample size, the tabled critical number is 19 (for a significance of 1%). Since the number of the correctly identified odd samples (21) is greater than the critical number (19), the assumption of "no difference" is rejected, and it is concluded that there is a significant difference between QPM and conventional maize, at 1% level of significance.

5.5 SENSORY EVALUATION RESULTS

Results of central location sensory testing and modified HUT will be presented in this section. For modified HUT, results from both the descriptive analysis and model analysis will be presented.

5.5.1 Central location sensory testing results

As noted in Chapter 4, the attributes tested in the central location sensory testing were aroma, appearance, taste, texture in the hand, texture in the mouth and overall evaluation, which were evaluation on a nine-level hedonic scale: 1 = *extremely bad* to 9 = *extremely good/excellent*. Consumers were requested to taste and evaluate two types of stiff porridge, which were labelled “triangle” or “circle”. The consumers did not know the difference between the samples. This was done to ensure that the evaluation results were not biased.

The mean scores of QPM were consistently higher than those of conventional maize for aroma, taste, texture in the mouth and texture in the hand, and therefore more appreciated than conventional maize (pair-wise t-test) (Table 5.4). Evaluation of QPM and conventional maize stiff porridge based on the taste criteria produced the largest mean difference (1.4), compared to other criteria used in this evaluation. The difference in appearance of QPM stiff porridge and conventional maize stiff porridge was however not significance. This was not surprising since white maize grains were used both for QPM and conventional maize.

The differences in the mean evaluation of QPM and conventional stiff porridge according to the different evaluation criteria can be well seen in Figure 5.3.

Table 5.4: Pair wise evaluation of QPM and conventional maize stiff porridge during central location sensory testing

Evaluation criteria	Statistics	QPM	CV	Mean difference	P-value	
Overall evaluation	Mean	7.60	6.47	1.13	0.001	***
	Std.dev	0.89	1.33	1.70		
Aroma	Mean	7.23	6.37	0.90	0.001	***
	Std.dev	0.77	0.96	1.25		
Taste	Mean	7.67	6.27	1.40	0.001	***
	Std.dev	1.12	1.48	2.01		
Hand feel	Mean	7.40	6.87	0.50	0.03	**
	Std.dev	0.89	1.07	1.28		
Mouth feel	Mean	7.63	6.30	1.30	0.001	***
	Std.dev	1.10	1.29	1.92		
Appearance	Mean	7.27	6.93	0.33	0.152	
	Std.dev	0.69	1.17	1.24		

N = 30

Meaning of scores: 1=extremely bad to 9=extremely good

*** = Statistically significant at 1%; ** = Statistically significant at 5%; * = Statistically significant at 10%

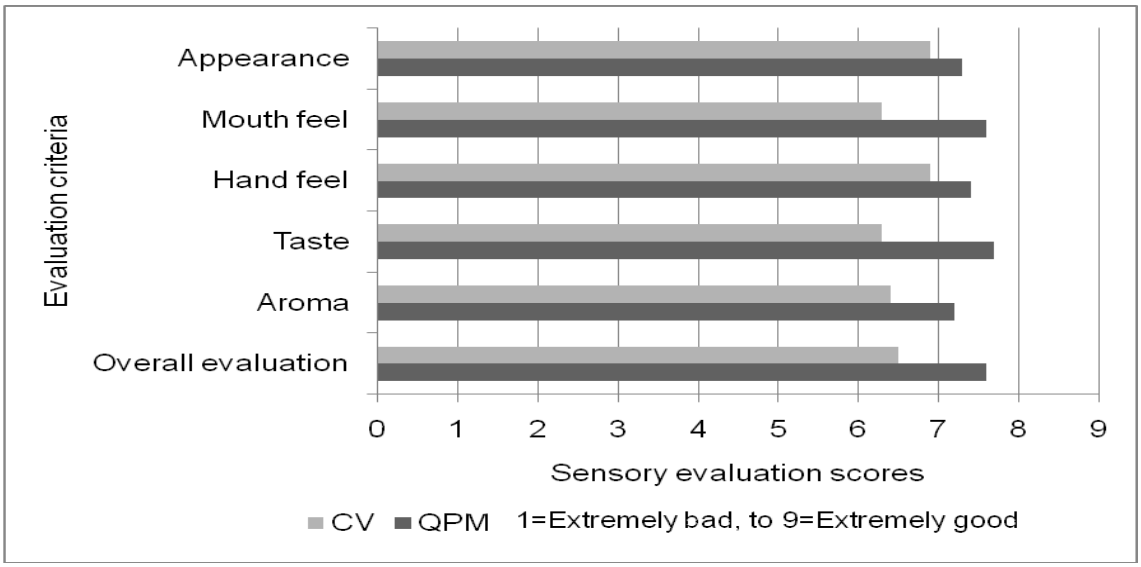

Figure 5.3: Mean evaluations for QPM and conventional maize stiff porridge during central location sensory testing

5.5.2 Modified home use sensory testing results

As noted in Chapter 4, the attributes tested for modified home use sensory testing were taste, texture in the hand, texture in the mouth and overall evaluation. Scores used were five-level hedonic test, from 1 = *very bad* to 5 = *very good*. Scores below 3 signify some level of dislike of an attribute, whereas scores above 3 signify some level of liking of the attribute. In this experiment, neither the consumers nor the enumerators knew the difference between the stiff porridge samples. This was to ensure that the evaluation results were not biased.

As evident from Table 5.5, QPM was ranked higher than conventional maize in all evaluation criteria. This shows that the consumers perceived QPM to have better sensory characteristics than conventional maize.

When considering taste, QPM received a particularly higher rating. Of all the participants, 58% perceived QPM to have a '*very good*' taste, while only 1.7% rated conventional maize stiff porridge as having a '*very good'* taste. In the sensory evaluation sheet, both subjects in the CLT and the rural consumers provided comments regarding tastes of both QPM and conventional maize stiff porridge. The comments received on QPM indicated that the QPM stiff porridge had a sweet taste which the consumers liked more than the conventional maize stiff porridge. Therefore, this difference in sweetness of the two types of stiff porridge could be attributed to the high preference of the taste of QPM stiff porridge.

Interestingly, during the modified home use sensory testing, none of the maize varieties were rated as *very poor*, as can be seen from Table 5.5, where none of the consumers perceived any varieties as '*bad*'. This could have been because maize is a staple crop, widely consumed by most people in the area of study.

Based on hand feel, QPM stiff porridge was perceived to have better texture in the hand than conventional maize stiff porridge. About 21% of the respondents recorded QPM as having *very good* hand feel, whereas only 0.8% perceived conventional maize stiff porridge to have a *very good* hand feel. Moreover, QPM was perceived to have better mouth feel than conventional maize. About 35% of

the respondents recorded QPM stiff porridge as having *very good* mouth feel, and only 3.3% perceived conventional maize to have *very good* mouth feel.

Looking at the overall evaluation of QPM and conventional maize, 61% of the respondents scored QPM stiff porridge as *very good*, whereas only 5% of the respondents perceived conventional maize to have *very good* overall sensory characteristics. Instead, most respondents (58%) reported conventional maize to have fair overall sensory characteristics. This further concurs with the results of CLT, that QPM was perceived to have better sensory characteristics than conventional maize.

Table 5.5: Cross tabulation of scores received during home use sensory evaluation of QPM and conventional (CV) stiff porridge (in percentage)

Score	Overall		Hand feel		Mouth feel		Taste	
	CV (%)	QPM (%)	CV (%)	QPM (%)	CV (%)	QPM (%)	CV (%)	QPM (%)
Bad	0.00	0.00	0.00	0.00	3.33	0.00	0.83	0.00
Fair	57.50	6.67	65.83	12.50	52.50	10.00	50.00	10.00
Good	37.50	32.50	33.33	66.67	40.83	55.00	47.50	31.67
Very good	5.00	60.83	0.83	20.83	3.33	35.00	1.67	58.33

Given the high share of respondents who showed high preference for QPM above conventional maize stiff porridge (Table 5.5), a t-test analysis was carried out to determine whether there was a difference in the mean evaluations of QPM and conventional maize stiff porridge, and whether the differences were significant (Table 5.6). Clearly, QPM was evaluated higher than conventional maize stiff porridge in all evaluation criteria. The mean differences in evaluation of QPM and conventional maize stiff porridge were all significant at 1%. Overall, out of a score of 5, QPM stiff porridge was scored 4.5 whereas conventional maize stiff porridge was scored 3.5. These results are in line with the results of central location sensory testing. Among the evaluation criteria used (taste, hand feel and mouth feel), the largest mean difference between QPM and conventional maize was realised in the taste, as was the case in the CLT (Table 5.4). Out of a score of 5,

QPM had a mean score of 4.5 on taste, whereas conventional maize stiff porridge had a mean score of 3.5, giving a significant mean of 1.0.

Table 5.6: Pair wise evaluation of QPM and conventional maize stiff porridge during modified home use sensory testing

Evaluation criteria	Statistics	QPM	CV	Mean difference	P-value	
Overall evaluation	Mean	4.54	3.48	1.07	0.000	***
	Std.dev	0.62	0.59	0.93	-	
Taste	Mean	4.48	3.50	0.98	0.000	***
	Std.dev	0.67	0.55	0.96	-	
Hand feel	Mean	4.08	3.35	0.73	0.000	***
	Std.dev	0.57	0.50	0.82	-	
Mouth feel	Mean	4.25	3.44	0.81	0.000	***
	Std.dev	0.63	0.62	0.95	-	

N =120

Meaning of score: 1=very bad, to 5=very good

*** = statistically significant at 1%; ** = statistically significant at 5% ; * = statistically significant at 10%

5.5.2.1 Ordinal regression model

Data on modified HUT was further analysed using ordinal regression model with fixed effects. Both main effects and cross effects of different variables were included in the model.

The estimation of both main effects and cross effects of different variables (Table 5.7) showed that QPM is evaluated better than conventional maize during the HUT. The log odds ratio of QPM was 4.5, which translated to an odds ratio of 90 when the exponent was taken. Therefore, it means the odds of QPM variety being rated higher than odds of conventional maize variety are 90:1.

To analyse the effect of consumer characteristics, gender and age were used in the ordinal regression model. The main effect for female participants had a significant coefficient or log odds ratio of 9.55, meaning that female respondents

were almost 14,045 times more likely to give a higher rating for overall evaluation of both types of stiff porridge than men. The cross effect between QPM and female was significant, but negative, estimated at -1.50. Taking the exponent resulted in an odds ratio of 0.20, indicating that female respondents appreciated QPM higher than conventional maize, but not as highly as did the men.

The main effect of age had a significant log odds ratio of 0.24, and an odds ratio of 1:30. This means that older people gave higher sensory evaluation scores than the younger ones. The cross effect of age with QPM, however, is not significant, indicating that appreciation of QPM does not change with age.

To find out whether wealthier consumers have different preferences for maize varieties from the poor consumers, livestock and land ownership variables were introduced in the model, with their cross effects. The estimated coefficient of livestock ownership was significant and negative, indicating that both QPM and conventional maize varieties would be rated lower by consumers with more livestock. The cross effects of livestock and QPM were not significant, hence indicating that there is no relationship between livestock ownership and acceptance of QPM variety. Land ownership, another wealth indicator, was not found to have a significant effect on the consumers' appreciation of the different maize varieties. When a cross effect between QPM and land ownership was introduced into the model, the estimated coefficient was also not significant, showing further that there is no relationship between land ownership and appreciation for QPM.

Table 5.7: Estimates of the ordinal regression of sensory evaluation during modified home use sensory testing

	Variables	Coefficient	Std.error	
Threshold (overall=3.00)		15.86	7.79	**
Threshold (overall=4.00)		19.61	7.85	**
Main effects	QPM	4.50	1.86	**
	Age	0.24	0.13	*
	Women	9.55	4.03	**
	Land ownership (ha)	1.14	1.58	
	Livestock ownership (number)	-0.18	0.10	*
	Babati district	6.26	3.27	*
	Hai district	5.89	5.72	
Cross effects	QPM x age	0.01	0.03	
	QPM x women	-1.50	0.76	**
	QPM x livestock	0.02	0.02	
	QPM x land ownership	-0.15	0.16	
	QPM x Babati	-0.26	0.89	
	QPM x Hai	2.04	0.94	**
Model	Pseudo R-Squared (McFadden)	0.50		
	Pearson - (Chi-Square)	485.13		***
	N	120		

*** = statistically significant at 1%; ** = statistically significant at 5% ;* = statistically significant at 10%

The log odds ratio of respondents in Babati was positive and significant (6.26), meaning they (both men and women) are likely to appreciate both QPM and conventional maize varieties more than respondents in other district. A cross effect between QPM and Babati was not significant. The coefficient of Hai was not significant, but its cross effect with QPM was positive and significant. The log odds ratio of QPM was Hai is 2.04 higher than other districts. Therefore, appreciation of QPM in Hai is (2.04+4.5) =6.54.

Thus, the ordinal regression results revealed that QPM stiff porridge is appreciated more highly than conventional maize stiff porridge, which concurs with the results from central location sensory testing and the t-tests on modified home use sensory testing. This information is important to governments in SSA, food processors, retailers and traders. This will be discussed in more detail in Chapter Seven.

5.6 SUMMARY

This chapter provided results of the sensory evaluation and triangle testing. Demographic profiles were also presented, both for participants of the CLT and modified HUT participants. In both CLT and modified HUT, participants were adults of 18 years and above, and number of women and men who participated in the experiments was almost equal. Results of this chapter reveal that there is a significant difference between QPM and conventional maize. This was clearly seen from the triangle test results and also the sensory evaluation tests of the two maize varieties. From both CLT and modified HUT, it is evident that QPM stiff porridge is more appreciated that conventional maize stiff porridge in Tanzania. Most importantly, the taste of QPM variety used in this study is very distinct from that of conventional maize. On the other hand, there was no difference in appearance between QPM and conventional maize varieties used in this study.

In both central location and modified home use tests, neither the consumers nor enumerators knew the difference between the stiff porridge samples. The sensory evaluations done were blind tests. This was done to eliminate bias on the sensory evaluations, which would have come as a result of pre-perceptions on QPM by enumerators and/ or respondents.

CHAPTER 6: RESULTS AND DISCUSSION OF EXPERIMENTAL AUCTION

6.1 INTRODUCTION

This chapter provides results of WTP for QPM and conventional maize flour by the rural consumers in Tanzania. As discussed in Chapter Four, half of the rural consumers who participated in the experimental auction were provided with the QPM nutritional information; and the packets in which the maize flour was packaged were labelled “QPM” or “conventional”. Therefore, they knew which maize flour was QPM and which was conventional. On the other hand, those not provided with the nutritional information were unaware of the difference in the types of maize flour. Their packets were labelled “triangle” or “circle”. The results are first presented in the simplest form, the descriptive statistics. Afterwards, results of the random effect model are presented, followed by the QPM nutritional effect results.

6.2 DESCRIPTIVE RESULTS

In total, the rural consumers in the three districts were generally willing to pay more for one kilogram of QPM flour than for the same quantity of conventional maize flour. The mean WTP for QPM in the three districts was $US 0.38, whereas that of conventional maize was $US 0.30. This gives a mean difference of $US 0.08 between the average consumers' WTP for QPM and conventional maize flour, which was significant at 1%. In terms of premium, it shows that the rural consumers were willing to pay a 26.67% premium for QPM above conventional maize flour (Table 6.1).

Among the three districts, consumers in Karatu district had the largest mean difference between their WTP for QPM and conventional maize flour ($US 0.11), which translates to 39% premium for one kilogram of QPM maize flour above the same quantity of conventional maize. Those in Babati district registered the smallest mean difference between their WTP for QPM and conventional maize

flour ($US 0.07) and Hai registered a mean difference of $US 0.09. The variations in the consumers' WTP for QPM and conventional maize flour across districts could be due to different poverty levels across districts, although this was not studied.

Table 6.1: Average bid for QPM and conventional maize flour ($US) by district

		Average bids for different maize varieties					
District	Statistics	QPM	CV	Mean difference	P-value		Premiums for QPM (%)
Babati (n=36)	Mean	0.37	0.30	0.07	0.001	***	23.33
	Std. Dev	0.07	0.08	0.1	-		
Hai (n=48)	Mean	0.39	0.30	0.09	0.000	***	30.00
	Std. Dev	0.07	0.08	0.08	-		
Karatu (n=36)	Mean	0.39	0.28	0.11	0.000	***	39.29
	Std. Dev	0.05	0.08	0.07	-		
Total (n=120)	Mean	0.38	0.30	0.08	0.000	***	26.67
	Std. Dev	0.06	0.08	0.09	-		

*** = statistically significant at 1%; ** = statistically significant at 5%;
* = statistically significant at 10%

6.3 RANDOM EFFECTS REGRESSION MODEL

The results of the random effects model are consistent with findings in Table 6:1. WTP for QPM flour is higher than that of conventional maize flour, a finding supported by the significant and positive coefficient of QPM variable (110.81) in Table 6.2. Analysis of the age of the respondents showed that older people have higher WTP for both QPM and conventional maize flour.

Estimating cross effects of the different regions and WTP shows a negative and significant coefficient of Babati cross effect (Table 6.2). This means that

consumers in Babati district were willing to pay less for QPM flour than their counterparts in Karatu and Hai. This concurs with results presented in Table 6.1, where mean WTP for QPM in Babati ($US 0.37) was lower than that of Karatu ($US 0.39) and Hai. The coefficient of cross effects of QPM and Hai district was also negative but insignificant. As indicated earlier, the variations in the consumers' WTP across districts could be due to different poverty levels across districts, although this was not studied.

As expected, sensory evaluation of stiff porridge was found to have a positive effect on WTP for maize flour. A correlation between sensory testing of stiff porridge and WTP for maize flour produced a positive Pearson Correlation coefficient (0.48) which was significant at 1% level of significance. According to a study by Melton,. Huffman, Shogren, and Fox (1996), appearance and taste experience are important when predicting consumer perceptions and WTP for food. The effect of sensory attributes on consumer food behaviour has previously been identified. For instance, Cherns *et al.* (2003) showed that after tasting the orange juices, consumers were willing to pay higher for the fresh orange juice than they were willing to pay for the same juice before tasting it. On the other hand, consumers willingness to pay for the new PEF orange juice declined by 17% after tasting, because the consumers did not like the taste.

Table 6.2: Estimates of WTP for QPM and conventional maize flour from experimental auctions using random effects model

Group	Variable	Coefficient	Standard error	P-Value	
Main effects	Constant	348.66	51.01	0.000	***
	Hai	-3.23	29.80	0.914	
	Babati	26.92	31.01	0.385	
	QPM	110.81	21.76	0.000	***
	Livestock ownership (number)	-0.29	0.54	0.594	
	Land ownership (ha)	1.06	3.72	0.775	
	Income	0.00	0.00	0.200	
	Male respondents	-1.29	15.37	0.933	
	Age	1.54	0.73	0.036	**
	Years of formal education	-1.71	3.68	0.641	
Cross effects	QPM x Hai	-23.29	25.13	0.354	
	QPM x Babati	-60.19	26.47	0.023	**
	QPM x income	0.00	0.00	0.890	
Information effect	Information provided	-62.18	28.39	0.029	**
	Hai x information	36.92	35.33	0.296	
	Babati x information	25.73	37.67	0.495	
	QPM x information	58.03	20.64	0.005	***
Model	R2, within	0.55			
	R2, overall	0.33			
	σu	54.59			
	σe	79.50			
	ρ (fraction of variance due to ui)	0.32			
	Number of observations	240			
	Number of respondents	120			

*** = statistically significant at 1%; ** = statistically significant at 5%;* = statistically significant at 10%

6.4 EFFECT OF INFORMATION

This section provides results of the experimental auction separately, both for those who were provided with QPM nutritional information and those who were not. Further, the effect of QPM nutrition information on consumers' WTP for maize flour is discussed.

From the random effects regression model (Table 6.2), the binary information variable had a significant and negative coefficient, which shows that providing QPM nutritional information decreases consumers' WTP for conventional maize flour. However, a cross effects of QPM and information variables produced a positive and significant coefficient (58), meaning that providing QPM nutritional information to consumers increased their WTP for QPM flour. It could be argued that facing a choice between two types of products, one with more nutrients than the other, consumers could be willing to purchase the product with more nutrients because they will derive more utility from it. Furthermore, if they have to purchase the product with the lower nutritional value, then they could possibly not be willing to buy it at the same price than the alternative as it will not give them equal satisfaction.Average bids for QPM and conventional maize flour were compared using paired t-tests, separately for consumers who received information and those who did not. The provision of QPM nutritional information clearly increased the WTP for QPM maize flour (Table 6:3). On the other hand, WTP for conventional maize was decreased, which was unexpected because the information provided only concerned QPM. This however is consistent with a study undertaken in another location (De Groote, *et al.,* (2010b). The decrease in WTP for conventional maize was higher than the increase in WTP for QPM flour, hence leading to a negative coefficient on information variable as was noted in the random effects model (Table 6.2). Provision of information also led to an increase in the difference between WTP for QPM and conventional maize flour (Table 6.3). This difference could be attributed to the nutritional information effect. These results reveal that nutritional knowledge can be an influential factor in consumer WTP for food products. Furthermore, the QPM nutritional information provided was extensive and it made consumers aware of almost all the benefits of QPM. To

promote the marketability of QPM therefore, awareness of its nutrient value should first be increased among the consumers.

It is important that another study be undertaken to find out the cause of decrease in WTP for conventional maize when QPM nutritional information is provided. This could be done by having follow-up questions after the experimental auctions.

Table 6.3: Average bids for QPM and conventional maize ($US) and information effect

Average bids for different maize varieties and information effect											
		With information (n=66)					Without information (n=54)				
District	Statistics	QPM	CV	Mean difference	P-values		QPM	CV	Mean difference	P-values	
Babati	Mean	0.37	0.30	0.07	0.000	***	0.36	0.31	0.05	0.018	**
	Std. Dev.	0.07	0.08	0.09	-		0.08	0.08	0.11	-	
Hai	Mean	0.40	0.28	0.12	0.000	***	0.37	0.32	0.06	0.000	***
	Std. Dev.	0.06	0.07	0.06	-		0.07	0.09	0.08	-	
Karatu	Mean	0.39	0.26	0.13	0.000	***	0.38	0.30	0.08	0.000	***
	Std. Dev.	0.05	0.08	0.07	-		0.06	0.07	0.07	-	
Total	Mean	0.39	0.28	0.11	0.000	***	0.37	0.31	0.06	0.000	***
	Std. Dev.	0.06	0.08	0.08	-		0.07	0.08	0.09	-	

*** = statistically significant at 1%; ** = statistically significant at 5%;

* = statistically significant at 10%

The differences in consumer WTP for QPM and conventional maize flour in the three districts of study can be well observed in Figure 6.1. In all districts, bids for QPM were consistently higher than those of conventional maize, both for those who received information and those who did not, and all were significant.

Further, the rural consumers appreciated QPM more than conventional maize, with or without information. The appreciation here could be attributable to the sensory characteristics of the two maize varieties.

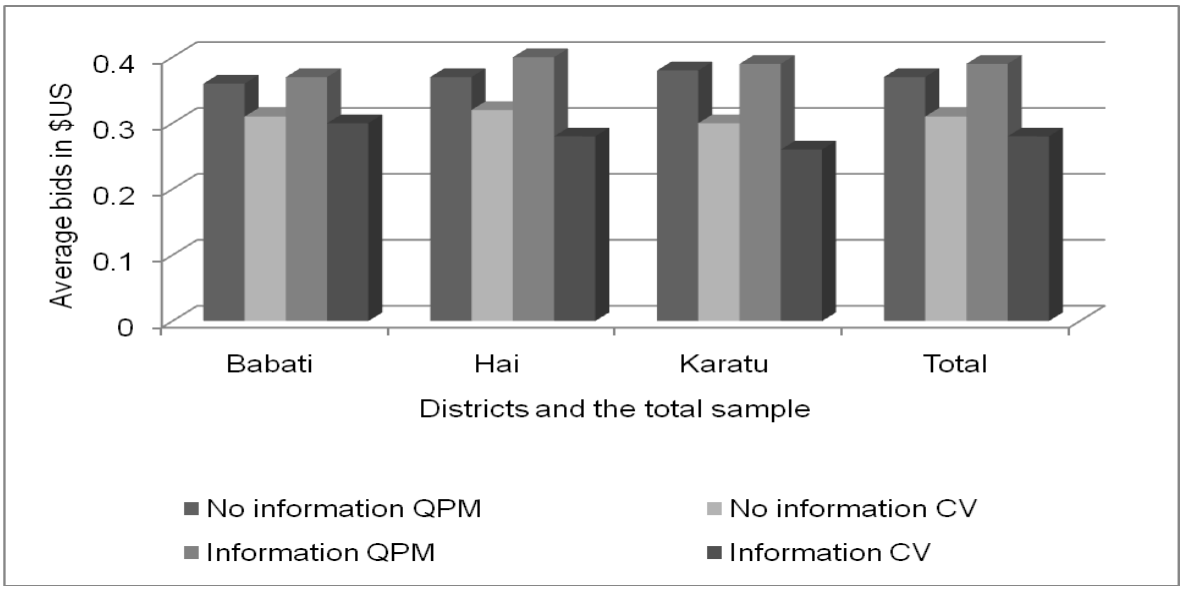

Figure 6.1: Differences in WTP for QPM and conventional maize flour with information and without information

The results of WTP experiment reveal important information which can be very useful in marketing of QPM. Since consumers are WTP more for QPM, food retailers and traders can stock QPM products, and if the consumers are aware of the nutritional value of the products, they will be willing to pay for them, even if they are priced higher than the conventional products. Importance of information is revealed in this section. When consumers know the difference in the food products and the importance of the nutritional contents of the products, they are willing to pay more for the product that is nutritionally enhanced. Therefore, the governments in SSA should spend more time in raising awareness of the different nutritionally enhanced food products, including QPM, which can be important in eradicating malnutrition in the region.

6.5 SUMMARY

This chapter provided the results of consumer willingness to pay for QPM maize flour against conventional maize flour. Descriptive statistics and random effects model show that QPM is more appreciated than conventional maize flour. From the three districts of study, the mean difference between rural consumers' WTP for QPM against conventional maize flour is $US 0.08, and it was significant at 1% level of significance. In terms of premium, consumers in all districts are willing to pay an average premium of 26.67% for one kilogram of QPM flour above one kilogram of conventional maize flour.

As revealed in other studies, this study also showed that sensory evaluation has an effect on consumer WTP. If consumers like the sensory attributes of a product, they will be willing to pay more for it, and let for the less preferred. Further analysis in this study revealed the effect of QPM nutritional information to consumers' WTP. Providing the nutritional information increased consumers' WTP for QPM flour and reduced their WTP for conventional maize flour. The results revealed in this chapter are important for marketing of QPM varieties.

CHAPTER 7: CONCLUSIONS AND RECOMMENDATIONS

7.1 INTRODUCTION

As noted in Chapter one, QPM is a maize cultivar developed through selective breeding, with significantly higher levels of the essential amino acids tryptophan and lysine compared to conventional maize. Products such as QPM could have significant potential in contributing to combating malnutrition in African countries.

The overall objective of the study was to determine the acceptance and magnitude of willingness to pay for QPM, as a novel staple food product, by the rural consumers in the northern region of Tanzania. In order to address this objective, a combination of research techniques were applied, more specifically sensory evaluation techniques as well as an experimental auction technique.

The first step involved a 'blind' central location triangle test, conducted to investigate consumers' perceived ability to distinguish between stiff porridge made from QPM and that from conventional maize. It was argued that the presence of difference between the two types of maize (QPM and conventional maize), could explain differences in their sensory characteristics and WTP.

The second step involved a central location consumer panel sensory evaluation of QPM and conventional maize stiff porridge (undertaken by the same group of consumers involved in the previous procedure) to investigate the consumers' acceptance of QPM. Thirdly, sensory evaluation was also undertaken by rural consumers at their homes by applying a modified home use sensory evaluation method, to determine their acceptance of QPM. During both central location sensory evaluation and modified home use sensory evaluation, the consumers were unaware of the difference in type of maize used in preparation of the stiff porridge.

In the fourth step in the research process, simulated individual experimental auctions (the BDM method specifically) were undertaken by the rural consumers to estimate their willingness to pay for QPM flour compared to conventional maize

flour. Finally, to find out whether provision of relevant product nutritional information had any effect on the magnitude of consumers' WTP for the maize flour, half who participated in the WTP experiments were provided with QPM nutritional information, while the others were not.

7.2 MAIN FINDINGS

Within this section the main findings of this study are discussed in line with the three hypotheses formulated at the onset of the research.

The results of the 'blind' central location triangle test undertaken on QPM and conventional maize stiff porridge revealed that 70% of consumers could tell the difference between QPM and conventional maize stiff porridge, indicating the result that there is a significant difference between QPM and conventional maize at 1% level of significance. Furthermore, on average, this consumer panel indicated significantly higher scores ($p<0.01$) in terms of the overall sensory profile, aroma, taste and mouth feel of QPM stiff porridge than for conventional maize stiff porridge (evaluated 'blind'). Results of the central location sensory testing revealed that there was no difference between appearance of QPM stiff porridge and conventional maize stiff porridge. Such an outcome was expected because QPM and conventional maize varieties used in preparation of the stiff porridge were both white.

The results of the modified home use sensory evaluation showed that QPM was ranked significantly higher than conventional maize in all evaluation criteria, again confirming consumers' perception that QPM has better sensory characteristics than conventional maize (evaluated on a 'blind' basis). These results clearly proved the first hypothesis of the study as true, as the targeted rural consumers in Tanzania significantly preferred the sensory characteristics of QPM stiff porridge to conventional maize stiff porridge. The consumer sensory evaluation results of this study are in line with one of the first acceptability studies on *opaque-2* maize conducted in 1970 in Colombia using two varieties in different foods, where *opaque-2* maize preparations showed good acceptability (Pardo, Mora, Paez, De Orstruss & De la Cruz-Villata, 1972:565). It also reflects the results of other

previous studies mentioned in this thesis, such as those of Ahenkora *et al*. (1999:357) and Martins, *et al.* (2010:325).

Consumers' perceptions of the sensory qualities of QPM could have significant implications for the QPM's market penetration and nutritional implications. From a nutritional impact perspective, these sensory evaluation results are of significant importance to the governments in SSA as a malnutrition reduction strategy. Increased consumption of QPM by both urban and rural consumers could potentially reduce malnutrition in SSA. Therefore, the governments should increase awareness of QPM among consumers in the region, and also ensure availability of seed and other products. From a commercial perspective, food processors could incorporate QPM in manufacturing different maize products for example maize flour and samp. At the same time, food retailers and traders can stock QPM products because consumers could be willing to purchase them, judging from their positive sensory perceptions towards QPM. However, this goes hand-in-hand with awareness of the products by the consumers, since they have to be informed of the availability, characteristics and benefits of the QPM products. This can be done through media or other means of communication, such as passing the information to rural consumers during farmers' meetings.

Another significant result from this study is the high score on taste of QPM stiff porridge received from the sensory evaluation. From the CLT, taste of QPM stiff porridge was scored much higher than that of conventional maize stiff porridge. Moreover, in the cross tabulation of scores received from modified HUT, the results revealed that the respondents preferred the taste of QPM much more than that of conventional maize stiff porridge. This was attributed to the sweet taste of QPM. During the sensory evaluation tests, consumers indicated that QPM stiff porridge had a sweet taste, which conventional maize stiff porridge lacks. Past studies have shown that a liking for sweetness is considered an innate human trait, present from birth (Steiner, 1977). The sweet sensory characteristic of this QPM variety could be used by marketers in marketing QPM. For instance, marketers could prepare some QPM products, such as cakes, and give them to maize flour or cakes buyers in the supermarkets, so that they can taste the cakes

before buying the maize flour. This could influence buyers to choose QPM flour over conventional maize flour.

It is critical to note that both the central location and modified home use sensory evaluation were blind tests. This was done to ensure that there was no bias in the scores given by the consumers during sensory evaluation of the stiff porridge. If the consumers knew the maize varieties that were used to prepare the different types of stiff porridge, it would have had an influence on their scores. For instance, if consumers had a negative attitude towards QPM, then they would evaluate it lower than conventional maize stiff porridge, regardless of its sensory characteristics. However, since the impact of consumers' preformed perceptions on product acceptance cannot be ignored, future research should also re-evaluate their sensory evaluation of QPM on a non-blind basis.

The second hypothesis tested in this study was that rural consumers in Tanzania are willing to pay a higher price for QPM flour than for conventional maize flour. This hypothesis was also confirmed as true by the results of this study. The WTP experiment revealed that, on average, rural consumers in Tanzania were willing to pay a premium of 26.67% for QPM flour. Analysis by district showed that consumers in Karatu were willing to pay the highest premium for QPM (39.29%) compared to consumers in Hai and Babati district. Those in Babati were willing to pay the least premium for QPM (23.33%). The variations in the amount of premium the consumers were willing to pay for QPM across districts could be the result of difference in poverty levels across districts, although this was not studied.

Results of the simulated individual auctions reveal important information to food processors, retailers and traders. Since consumers are willing to pay premiums for QPM flour, it is an indication that if the retailers and traders stocked QPM products, consumers would buy them, even if they were priced higher than products from conventional maize. Currently, the few traders selling QPM grains and QPM flour do so at the same price as the conventional maize grains and conventional maize flour. However, if the marketers invested more in differentiating QPM products from conventional maize products, for example through packaging, and advertising QPM products so that people become aware

of them, there is a possibility that consumers could be willing to buy them even if they were priced higher than conventional maize product.

Both the results of sensory evaluation and experimental auctions reveal important information to processors. Since consumers prefer QPM products to conventional maize products, processors can manufacture QPM products to be distributed by the wholesalers and retailers. At all times, however, consumers need to be aware of the different food products in the market and the different nutrition enhancement, if any.

This study also hypothesised that providing rural consumers in Tanzania with nutritional information on QPM would increase their WTP for QPM flour compared to conventional maize flour. The results proved this hypothesis as true. From this study, it was shown that providing QPM nutritional information translated to a greater acceptance for QPM. The mean difference between WTP for QPM and conventional maize flour when nutritional information was provided was $US 0.11 (significant at 1% level), while without nutritional information, the mean difference between WTP for QPM and conventional maize flour was only $US 0.06 (significant at 1% level). The main effect of information from the random effects regression model, however, showed that information decreased consumers' WTP for maize flour generally. When descriptive statistics were calculated on WTP for QPM and conventional maize amongst respondents who received information and those who did not, separately, the results showed that provision of QPM nutritional information led to consumers decreasing their WTP for conventional maize, and increasing their WTP for QPM. The decrease in WTP for conventional maize was however higher than the increase in WTP for QPM flour, hence leading to a negative information coefficient in the random effects model. The decrease in WTP for conventional maize was unexpected because the information provided only concerned QPM. The effect of nutritional information in this study showed a trend similar to that found in a study undertaken in Zambia, where provision of orange maize nutritional information translated into a greater acceptance for orange variety and a lower acceptance of white maize (Meenakshi *et al.,* 2010).

Sensory evaluation of stiff porridge positively affected the WTP for maize flour, which was expected because sensory attributes of food are consistently reported

as a major influence on food choice (Shepherd, 1999:808; Steiner, 1977). Since consumers preferred sensory characteristics of QPM over conventional maize, which eventually led to high WTP for QPM, the marketers could use the QPM favourable sensory characteristics to penetrate the market. To do this, they could apply several marketing strategies, for instance offering free samples of QPM flour to consumers who enter a supermarket to buy maize flour. This could give consumers a chance to use the QPM flour at their homes and evaluate its sensory characteristics, which could potentially lead to purchases due to its favourable taste.

7.3 LIMITATIONS OF THE STUDY AND RECOMMENDATIONS FOR FUTURE RESEARCH

A number of limitations and areas of future research were identified during this study.

Due to financial constraints, the study only covered the Northern zone of Tanzania, and only a total of 120 rural consumers were sampled from three districts to determine preference and WTP for QPM in Tanzania. This implies that the results are not representative of all the rural consumers in Tanzania, since only one zone was covered. Moreover, the sample size of 120 respondents is relatively small for a consumer survey representing preference and WTP for QPM by the rural consumers in Tanzania. Therefore, this kind of research needs to be extended in other zones in Tanzania, especially where QPM has been introduced, and a larger sample size considered.

Another limitation is the sample size of 30 consumers who participated in the triangle test. Even though the results showed that there was a significant difference between QPM and conventional maize, the test was close (there was only a small difference between the critical number and the actual number correctly identified). Given the significant difference observed between QPM and conventional maize from sensory evaluation, there would have been a wider gap between the critical number and the actual number of correctly identified had a wider sample been used. Therefore, a larger sample size, greater than 30, is recommended for triangle test.

For this study, only one dish was prepared (stiff porridge) from the two types of maize. But stiff porridge is not the only form in which maize is consumed in East Africa. There are other dishes which are common in the same region but follow a different preparation method. These include *kande* from Tanzania, and *Githeri* and *Samp* from Kenya. All these are prepared using whole grains. A study needs to be undertaken using some of these methods of preparation to see if QPM will be appreciated the same way as stiff porridge.

Another limitation of this study is that sensory characteristics for QPM were only tested on one variety (Lishe K1). The positive organoleptic characteristics derived from this study are different from the results arrived at in a study undertaken in Ghana, where QPM was claimed to have a sticky dough (Ahenkora, Twumasi-Afriyie & Obeng-Antwi, 1999:357). Therefore, there arises a need for research on sensory evaluation using other QPM varieties other than Lishe K1, to ensure that it is not only this specific QPM variety that has favourable consumer characteristics.

7.4 CONCLUDING REMARKS

The findings of this study show that there is a significant difference between QPM and conventional maize stiff porridge from a consumer perspective. The statistical significant difference was observed in the triangle test.

Results from both central location and modified HUT indicate that rural maize consumers in Tanzania prefer stiff porridge made from QPM to that which is made from conventional maize. Since the conventional maize is the standard for acceptability in local dishes prepared from maize, and sensory results reveal that this QPM variety was equally acceptable to consumers, it means that QPM could be incorporated into preparation of traditional foods, hence improving their nutritional value.

Consumers are willing to pay a premium for QPM compared to conventional maize flour. In addition, sensory appreciation translated into a substantial economic appreciation, estimation of utility and an increase in WTP. This shows that if QPM flour were introduced in the market at a higher price than conventional maize flour,

consumers would purchase it. The favourable sensory characteristics of QPM revealed by this study would lead to a repurchase of the QPM by the consumers.

As expected, providing QPM nutritional information to consumers was found to increase their WTP for it. However, this led to a decrease in the WTP for conventional maize. This shows that consumers are concerned about the nutritional value of maize flour and they will be willing to spend more for the nutritionally enhanced maize flour, and less for the maize flour without any nutrition enhancement.

Improving the nutritional quality of maize varieties by enhancing the amino acid profile through breeding is an example of an important nutrition objective in an agricultural research programme. Having seen that QPM is appreciated by consumers, it is important that people be informed about this type of maize. Breeding nutritionally enhanced food could make a considerable contribution in malnutrition problems, especially in SSA.

Both sensory evaluation and experimental auctions provided important information for the marketers of QPM products. Taste of QPM can be used as a market penetration strategy by QPM marketers. Since the sensory evaluation revealed that consumers in Tanzania prefer taste of QPM stiff porridge compared to taste of conventional maize stiff porridge, marketers can pack small samples of maize flour and give them to people buying maize flour in supermarket so that they try it at home. This could give people a chance to taste QPM, which could lead to purchase and repurchase of QPM flour and other products. Marketers could also increase awareness of QPM by advertising in the media or even informing farmers about QPM during farmers' meetings. All these strategies could potentially increase consumption of QPM, and in turn help fight malnutrition in SSA.

In order to increase adoption and subsequently increase consumption of QPM in SSA, QPM seed has to be available to farmers. Problem of seed availability was noted in the areas of study, which led to reduction of adoption levels of QPM among some of the respondents who had adopted the technology. Such projects should therefore work on seed value chains in addition to breeding and promotion. In this way, farmers would not fall into being disadopters due to lack of seed.

An agronomic challenge for QPM is the size of the maize grain. Some of the QPM varieties have grains which are smaller in size compared to most of the conventional maize hybrids. This may pose a challenge to QPM adoption, especially to farmers who grow it purposely for sale. As was noted during the study, it is common for buyers to use a certain quantity (for instance a gunny bag) instead of weight. In such a case, sellers of QPM that has smaller grains would lose because more grain would be needed to fill the bag than for conventional maize of ordinary grain size. This may discourage farmers from growing QPM.

This study observes that modified HUT is a convenient and less expensive methodology for testing consumer preference for products. Since it is carried out at the homes of the respondents, it mimics the actual occurrence of food preparation at their homes. In addition, undertaking sensory evaluations in one day ensures that there is no confusion in the stiff porridge and their attributes. Also, the enumerator was present to guide on the progress of the evaluation.

In conclusion, a combination of sensory evaluation testing and consumer preference is an important tool in consumer study, especially for new varieties in agriculture. These two methodologies aid in understanding the consumer's perceived sensory characteristics of the new variety, and at the same time enable the researcher to explore the consumer's willingness to pay for the same product thus linking the revealed preferences to their predicted economic behaviour in terms of product price boundaries.

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APPENDICES

Appendix A: Definition of key terms

The following key terms are applicable for the purpose of this study:

Anti-GM are consumers who have strong preference for non-genetically modified (GM) maize meal and are against maize meal containing genetically modified maize, especially when the maize is genetically modified for the farmers' benefit (Vermeulen, 2005:91) (see section 2.2.2).

Bioavailability is defined as the amount of a nutrient that is potentially available for assimilation from food by the body and once absorbed, it is utilizable for metabolic processes (Welch & Graham, 2004:355) (see section 1.1.2.4).

Height for age is an expression of height in relation to age which gives a measure of nutritional status. It gives a picture of the past nutritional history of a person (Waterlow, 1972:566) (see section 1.1.1).

Kwashiorkor is defined as an acute form of childhood protein malnutrition, which is characterized by edema, irritability, anorexia and ulcerating dermatoses (Liu, Howard, Mancini, Weston & Paller, 2001:632) (see section 1.1.1).

Marasmus is a form of serious protein-energy malnutrition (PEM) characterized by energy deficiency (UNICEF, 1981:9) (see section 1.1.1).

Micronutrients are nutrients required by humans throughout their life, in small quantities to orchestrate a whole range of physiological functions, but which the human body itself cannot produce (UNICEF, 2008:59) (see section 1.1.1)

Pro-GM are consumers who have an overall positive attitude towards maize meal manufactured from GM maize, especially if consumers and farmers are receiving the benefits of genetic modification (Vermeulen, 2005:95) (see section 2.2.2).

Pro-GM consumer benefit cluster are consumers with strongest preference for maize meal manufactured from maize that was genetically modified to benefit consumers (Vermeulen, 2005:94) (see section 2.2.2).

Quality protein maize describes a range of conventionally bred maize cultivars which have an increased content of limiting amino acids (lysine and tryptophan) compared to conventional maize (Krivanek *et al.*, 2007:312) (see section 1.1.4).

Stunting refers to insufficient height for age indicating chronic under-nutrition (PHDR, 2009:58) (see section 1.1.1).

Under-nutrition is the insufficient nutrient intake or the inability of the body to absorb nutrients, and it can be subdivided into micronutrient under-nutrition or protein energy malnutrition (PEM) (West & Caballero, 2001:220). Micronutrient under-nutrition consists of deficiencies in essential vitamins, minerals and amino acids, whereas PEM consists of a continued dietary deficiency mainly characterised by energy and protein deficiencies (see section 1.1.1).

Underweight is the insufficient weight for age which could be a result of both stunting and wasting (PHDR, 2009:58) (see section 1.1.1).

Wasting is insufficient weight for height, an indicator of acute under-nutrition (PHDR, 2009:58) (see section 1.1.1).

Weight for age is an expression of weight in relation to age which gives a measure of nutritional status (Waterlow, 1972:565) (see section 1.1.1).

Weight for height is an expression of weight in relation to height which gives a measure of nutritional status, and it is independent of age. Weight for height is an index of current nutritional status (Waterlow, 1972:566) (see section 1.1.1).

Appendix B: Figure of a respondent undertaking sensory testing at the central location

Appendix C: Quality Protein Maize (QPM) farmer-consumer survey Questionnaire – Tanzania

Introduction: *Dear Sir/Madam. In order to provide guidance to governments and the private sector in Kenya and Tanzania on consumption and consumer acceptability of different types of maize, a student from Kenya in collaboration with CIMMYT and SARI have engaged in a survey to investigate consumers' purchasing and consumption habits. This is in follow-up to a previous survey conducted by SARI in 2007. Your kind assistance to complete the questionnaire that follows will be much appreciated. Your responses will be added to more than 200 others from households in Hai, Karatu and Babati districts. All information that you will provide will be kept confidential. If you have any questions or concerns about this study, you may contact CIMMYT scientist: Dr Hugo De Groote – h.degroote@cgiar.org.*

SECTION 1: IDENTIFICATION

(Enumerators to fill in the names, supervisors to provide the codes)

Respondent Name first name: _____ Last name _____

Household head first name: _____Last name _____

Date of Interview: (Dd/Mm/Year) **SURDATE** ____/_____/_____

IDENTIFYING VARIABLES:

Country Name: _____ **COCODE**: _____
Admin 1 (District):_____ **ADMIN1**: _____
Admin 2 (Division/County/PA):_____ **ADMIN2**: _____
Admin 3 (Ward/Sub-County):_____ **ADMIN3**: _____
Admin 5 (Village/Local Council 1):_____ **ADMIN5**: _____
Is the Village/Local Council Control or Target? (1=Control; 2=Target) **SAMPLE**:_____

GPS

GPS Longitude (E) _____Decimal Degrees (Format: _ ___ Dd.Ddddd)
GPS Latitude (N) _____Decimal Degrees (Format: ____Dd.Ddddd)
GPS Altitude _____Meters above the sea level

Supervisor first name:_____ Last name _____ **SUPCODE**_____
Enumerator first name: _____Last name _____ **ENCODE**_____
Date checked: (Dd/Mm/Year) **CHDATE** ____/____/_____

Data entry:

Date entered: (Dd/Mm/Yr) **ENTDATE** ____/____/_____
Entered by: First name:_____ Last name _____**DECODE**_____

SECTION 2: HOUSEHOLD DEMOGRAPHIC CHARACTERISTICS

a) Household Characteristics

1. Please ask the following questions relating to the household

		Full Names	Year of birth	Gender 1=male 2= female	Marital status *(See codes below)*	Relationship to head *(See codes below)*	Years in formal education	Years resident in the area	Year started own farming
		fname	ybirth	gender	mstat	rshead	yeduc	yresde	yfarm
Respondent	**1**								
Household head	**2**								
Spouse(to head)	**3**								

Marital Status: 1=married; 2=single; 3=widowed; 4=divorced; 5=separated; 6=other(specify) _____)

Relationship to head: 1= head ; 2= spouse ; 3= own child; 4= step child ; 5= parent(m/f) ; 6= brother /sister ; 7= nephew /niece ; 8= son/daughter-in-law ; 9= grandchild ; 10=other relative ; 11= worker ; 12=brother /sister-in-law ; 13=parent-in-law; 14= unrelated

b) Household Size

2. What is the size of your family including mother and father?

Range of ages for family		Family size according to gender		
FSZRANG		FEMALE	MALE	TOTAL
No of persons **0-4 years**	**1.**			
No of persons **5-14 years**	**2.**			
No of persons **15-64 years**	**3.**			
No of persons **>64 years**	**4.**			

SECTION3: HOUSEHOLD PRODUCTION

c) Farm characteristics

3. Asset endowments of the households (indicate numbers and values).

Asset Type	Asset	Number	Total current value in Tshs.
ASSGRP	ASSTYP	ASSNO	TASSVL
Livestock	1.Cattle (improved oxen)		
	2.Cattle (Local oxen)		
	3.Cattle (improved dairy)		
	4.Cattle (local cows)		

	5.Goats		
	6.Sheep		
	7.Chicken,ducks and other		
	8.Pigs		
	9.Donkeys		
	10.Other(specify)_____		
Machinery and equipment	11.Ox ploughs		
	12.Wheelbarrows		
	13.Hoes		
	14.Pitch fork		
Transport	15.Bicycles		
	16.Tractors		
	17.Motorcycle		
	18.Car or truck		
Household goods	19.Radio		
	20.Television		
	21.Telephone		
	22.) Mobile		

FARM SIZES AND LAND USE

4. **Farm size** (excluding buildings and the compound), **Main season 2009**.

a) Land owned in acres: **LOWN**_____

b) Land rented out in acres **LRENTO**_____

c) Land rented in, in acres: **LRENTIN**_____

d) Land borrowed out in acres: **LGIVE** _____

e) Land borrowed in, in acres: **LBORR**_____

f) Total available land (in acres): = (a –b + c - d + e) **LTOTAL**_____

5. **Land Use** in the **main season 2009**

g) Total Cultivated land in acres: **LTCULT**_____

h) Fallow land in acres: **LFALL**_____

i) Pastures in acres: **LPAST**_____

j) Land under trees in acres: **LTREE**_____

k) Total land use: = (g+ h + i+ j) **LUSET**_____

6. **Total area** that had Crop production short season 2008/2009 (acres)? **LSHORT**_____

c) CROP PRODUCTION

7. Do you produce maize (1=Yes; 0=No) **MPROD**_____
8. a. If yes, how much maize do you produce **on average** per year, both main and short seasons, in a normal year (in 100 kg grain Bags)?

   MBAGS_____

   b. What **percentage** is **sold**? (In %) **PSOLD**_____
   c. What **Percentage** is **consumed**? (In %) **PCONS**_____

9. Is maize **important** in your daily diet? **MIMPT**_____

   (0=No; 1=Low importance; 2=medium importance; 3= high importance)

10. Area planted to maize **main season, 2009**.

Variety Grown	**Source of seed**[1] *(See codes below)*	**Area Planted (acres)**
VARGRWN	**SOURCE**	**SEEDAREA**
LISHE		
Local variety		
Other Improved Varieties		
1.		
2.		
3.		
4.		

1= recycled (own saved seed), 2= stockiest, 3= farmer exchange, 4= grain from market or shop, 5= local seed markets, 6= research (such as SARI), 7= Agricultural extension service, 8= seed companies, 9= NGOs/development project, 10= other (specify_____

11. Complete the table below for the major crops that you planted during the **main season** 2009. (*Instruction*: Capture Cash crops, fruits and bananas for the whole year in this table).

Group	Crop		Area (acres)	Number of fruit trees	Intercropped? (1=Yes 0=No)	Production		Qty sold		Selling price of largest qty (Tsh/ unit)
						Qty	Unit **(codes below)**	Qty	Unit **(codes below)**	
crgrp	crop		area	ftree	inter	pqty	punit	sqty	sunit	sprice
Cereals	QPM-Lishe	1								
	Maize-other	2								
	Maize-	3								
	Sorghum	4								
	Millet	5								
	Rice	6								
	Wheat	7								
	Barley	8								
	Other specify	9								
Legumes	Beans	10								
	Soybean	11								
	Cowpea	12								
	groundnuts	13								
	Pigeon	14								
	Other specify	15								
Tubers & Roots	Cassava	16								
	Irish potato	17								
	Sweet	18								
	Yam	19								
	Other specify	20								
Cash crops	Coffee	21								
	Sunflower	22								
	Other specify	23								
Vegetables	Pepper	24								
	Kale (Sukuma	25								
	Mchicha	26								
	Other specify									
Fruits	mangoes	27								
	pawpaw	28								
	Avocado									
	Other specify	29								
Bananas	Bananas	30								

Unit code
1=100 kg bag; 11=50kg bag; 2=kgs; 5=bunches; 7=25 kg bag; 8=10 kg bag; 9=debe; 10=sado (4kg tin)

b. Complete the table below for the major crops that you planted during the **short season 2008/2009.**

Group	Crop		Area (acres)	Intercropped? (1=Yes 0=No)	Production		Qty sold		Selling price of largest qty (Tsh/ unit)
					Qty	Unit **(codes below)**	Qty	Unit **(codes below)**	
crgrp	**Crop**		**area**	**inter**	**pqty**	**punit**	**sqty**	**sunit**	**sprice**
Cereals	QPM-LISHE	1							
	Maize-other improved	2							
	Maize-local	3							
	Sorghum	4							
	Millet	5							
	Rice	6							
	Other specify	7							
Legumes (check other common legumes)	Beans	8							
	Soybean	9							
	Cowpea	10							
	groundnuts	11							
	Other specify	12							
Tubers & Roots	Cassava	13							
	Irish potato	14							
	Sweet	15							
	Yam	16							
	Other specify	17							
Vegetables add other specify	Pepper	22							
	Kale (Sukuma	23							
	Other specify	24							

Unit code
1=100 kg bag; 11=50kg bag; 2=kgs; 5=Bunches; 7=25 kg bag; 8=10 kg bag; 9=debe; 10=

D) MAIZE PRODUCTION

12. Maize grain production and area covered since 2007 (Total Main and short season per year)

year		maize variety	area (acres)	production	
		qpm (lishe)=1		quantity	units (codes below)
mzyr		mzvar	mzarea	mzqty	Unit
2007	1				
2008	1				
2009	1				
		Conventional=2			
2007	2				
	2				
2008	2				
	2				
2009	2				
	2				

Unit code

1=100 kg bag; 11=50kg bag; 2=kgs; 5=numbers; 7=25 kg bag; 8=10 kg bag; 9=debe; 10=sado (4kg

E) PRODUCTION COSTS FOR MAIZE.

13. **a. What is the area in acres for** the largest maize field **(**main season 2009**)? LRGMFILD**_____

b. Is this field maize a mono crop or inter crop? (1=mono crop; 2=inter crop) **CROPSYS**_____

14. Cost on **maize production** incurred **(on the largest maize field)** - **Main season 2009.**

Variable costs (on the largest maize field) - **Prior to harvesting**				
Variable costs		**Quantity**	**Unit** *(codes*	**Cost per unit**
Seed	Vitem	Vqty	Vunit	Vcost
LISHE	**1**			
Other improved variety (name)	**2**			
Local variety	**3**			
Fertilizer costs				
a. DAP	**4**			
b. Amm. Sulphate	**5**			
c. Mijingu	**6**			
d. Urea	**7**			
e. Manure	**8**			
Pesticides				
a.	**9**			
Others specify_____	**10**			

1=kg; 2=2kg bag; 3=25kg bag; 4=50kg bag; 5=grams; 6=litres; 7=sado; 8=debe; 9=ox carts;

15. How much did you pay to carry out the following field operations during 2009 **main** season **on the largest maize field?**

Field Operation		**Total cost (TShs)**
Factv		**Actcost**
Land clearing	**1**	
First land preparation	**2**	
Second land preparation	**3**	
Planting	**4**	
1st fertilizer application	**5**	
1st weeding	**6**	
2nd weeding	**7**	
3rd weeding	**8**	
2nd Fertilizer application	**9**	
Harvesting	**10**	
Transporting to Home	**11**	

SECTION 4: NON-AGRICULTURAL INCOME

16. Over the **last 12 months** has any one in your household operated any of the following non-agricultural enterprises?

Activity		**Any household who member undertook this activity?** (1= yes; 0= no)	Number of people who undertook the activity	Total income **last month (TShs)**	**Total income last 12 months (Tshs)**
NAACTIV		**ANY**	**PEOPACT**	**INCLMNTH**	**INCYR**
Casual laborer	**1**				
Brick making	**2**				
Firewood &charcoal selling	**3**				
	4				
Salaried employment	**5**				
Business income	**6**				
Rental income	**7**				
Remittance	**8**				
Pension payment	**9**				
Other (specify) _____)	**10**				
Other (specify) _____)	**11**				

Importance of Criteria in Selecting Maize Variety

17. Please indicate the importance of following criteria in selecting a maize variety, using following scale**: 0 = not important, 1 = somewhat important, 2 = important, 3 = very important**

Type	Criteria		Score *0 = Not important;* *1 = Somewhat important,* *2 = Important,* *3 = Very important*
SELTYPE	**SELCRIT**		**SELSCORE**
Field	Germination	1	
	Plant vigor	2	
	Resistance to drought	3	
	Resistance to field pests	4	
	Resistance to disease	5	
	Early maturity	6	
	Yield	7	
	Field Other (specify): _____	8	
	Field Other (specify): _____	8	
Cob/Grain	Cob size	10	
	Number of rows on the cob	11	
	Good cover of the tip	12	
	Grain size	13	
	Grain colour	14	
	Grain weight	15	
	Cob Other (specify):	16	
	Cob Other (specify):	16	
Cooking qualities	Good Pounding ability *(amount of flour obtained out of a given amount of grain)*	18	
	Water absorption capacity *(amount of flour need to make stiff porridge with a certain amount of water)*	19	
	General cooking qualities	20	
	Taste of green maize, roasted	21	
	Taste of boiled	22	
	Cooking Other (specify): _____	23	
	Cooking Other (specify): _____	23	
Post Harvest	Marketability	25	

	Resistance to storage pests	26	
	Post-H Other sp_____	27	

SECTION 5: MAIZE AND MAIZE MEAL CONSUMPTION

18. How important to you are the following in choosing the **maize for milling** into maize flour or when buying maize flour? ***(0 = not important, 1 = somewhat important, 2 = important, 3 = very important)***

Choice factors		***Level of importance*** *0 = not important;* *1 = somewhat important;* *2 = important* *3 = very important*
CONFACTOR		**CONSCORE**
Taste	**1**	
Price	**2**	
Variety	**3**	
Color	**4**	
Smell	**5**	
Freshness	**6**	
Texture	**7**	
Nutritional value	**8**	
Packaging	**9**	
Other (specify)_____	**10**	

19. Which types of food do you eat most of the time during the following meals:

1. Breakfast
   a. _____ (most common)(composition): _____)
   b. _____ (second)(composition): _____)
   c. _____ (third)(composition): _____)
2. Lunch
   a._____(most common)(composition):_____)
   b. _____ (second)(composition): _____)
   c. _____ (third)(composition):_____)
3. Dinner
   a._____ (most common)(composition): _____)
   b. _____ (second)(composition): _____)
   c. _____ (third)(composition): _____)

(*Specify the composition, at least the first time encountered, in particular which cereals*

20. If you have school-going children, does the local school have a school feeding program?

(1=yes; 2=no; 3=no child attends).

a. Primary school _____ b. Secondary school _____

21. If yes to either of the above, what does the family contribute per term per child?

primary:

crop_____ amount_____ kg

crop_____ amount_____ kg

secondary:

crop_____ amount_____ kg

crop_____ amount_____ kg

SECTION 6: NUTRITION AND DIETARY DIVERSITY

22. a. Did the household consume the following groups of food items **yesterday and over the last one month**?

Group		**Consumption in hh over the last 24 hours (1=Yes, 0 =No)**	**Consumption over the last one month (1=Yes, 0 =No)**
FGROUP		**CONS24**	**CONSMNTH**
Cereals	**1**		
Tubers 1 (Vit A, orange)	**2**		
Tubers II	**3**		
Vegetables I (dark green leafy	**4**		
Vegetables II (other)	**5**		
Fruits I (high in Vit. A)	**6**		
Fruits II (low in Vit A)	**7**		
Meat	**8**		
Eggs	**9**		
Fish	**10**		
Legumes	**11**		
Dairy products	**12**		
Fats and oils	**13**		
Sugars and Honey	**14**		
Other (condiments, coffee, tea)	**15**		

SECTION 7: QPM (LISHE)

KNOWLEDGE

23. Have you ever heard of proteins? (1=Yes, 0=No)(***If no go to Qn.24)*****PROTN** _____

b. If yes, do you know what the major sources of proteins are? (1=YES, 0=No)

PROTSRC_____

24. List the major sources of proteins that you know?

PROTSRC1._____

PROTSRC 2._____

PROTSRC 3._____

PROTSRC 4._____

25. a. (If QPM (LISHE) was not mentioned earlier as one of maize varieties); Are you aware of its existence? (1=Yes; 0=No) (***if no go to question 45)***

QPMEXT_____

b. Where did you hear/ read from?

QPMSRC _____

26. a. Do you know what it means? (1=yes; 0=No) **QPMMEN**_____

b.If yes, what does it mean?

QPMN_____

27. What are the major **advantages** of QPM (LISHE) to **human beings**? (If don't know put **-9**)

ADVHB1._____

ADVHB 2._____

ADVHB 3._____

28. What are the major **advantages** of QPM (LISHE) to **livestock**?

ADVL1._____

ADVL 2._____

ADVL 3._____

29. Have you ever **planted** QPM (LISHE) variety in your farm? (1=Yes, 0=No)(If No, skip to 36) **QPMPLT**_____

30. Which **year** did you **first** plant on the farm? **YRFRST**_____

31. How did it **perform** in the **field**? **QPMFLD**_____

(1= very poor; 2=poor; 3=fair; 4=good; 5=very good)

32. Where did you get the first QPM (LISHE) seed you planted?

QPMSD_____

*1= extension; 2=Research centre; 3=farmers/neighbours; 4=Input stockist; 5=NGO or projects; 6=cooperatives or unions; 7=private seed producer; 8= other(specify):*_____

QPM (LISHE) grain production and area covered since 2005 (both seasons)

33. Enter details in the table below

Year	Main season Harvest			Short season Harvest		
	Area(acres)	Production	Unit ***(Code below)***	Area(acres)	Production	Unit ***(Code below)***
MZYR	**SHACRE**	**SHPROD**	**MNPUNT**	**MHACRE**	**MHPROD**	**SHTPUNT**
2005						
2006						
2007						
2008						
2009						

Unit code
1=100 kg bag; 11=50kg bag; 2=kgs; 7=25 kg bag; 8=10 kg bag; 9=debe; 10=sado (4kg tin)

34. Do you plan to plant QPM (LISHE) in the next season or next year?

QPMPLAN_____

(1=Yes, 0=No)

35. Did you grow QPM (LISHE) in the past, but discontinued it;

QPMDISC_____ (1=Yes, 0=No)

36. If you ever planted QPM (LISHE), but has discontinued, what were the reasons (more than one possibility)? *See codes below*

RSNDIS1_____

RSNDIS2_____

RSNDIS3_____

RSNDIS4_____

1. Seed not locally available; 2. Seed expensive; 3. Poor in field characteristics (e.g. low yield, vulnerability to

disease, etc); 4. Poor in post harvest characteristics (e.g. storage, taste, flour colour, etc); 5. Expensive in fertilizer/pesticides use; *6. No market* *7. All grain was consumed, no seed kept; 8. Other (specify):* _____

37. What is the main use of the QPM (LISHE) that you produce?

QPMUSE_____

(1= For home consumption; 2= for sale; 3=others specify_____)

38. Have you ever eaten QPM (LISHE)? (1= Yes; 0=No)

QPMEAT_____

39. (If yes) Do you eat QPM (LISHE) regularly? (1=Yes; 0= No)

QPMREG_____

40. How often do you eat it?

QPMEAT_____

(1=every day; 2=once a week; 3=once a month; 4=one a year; 5=other _____)

41. If you don't eat it regularly, what is the main reason?

QPMNOT_____

SECTION 8: APPRECIATION OF QPM (LISHE) AND REGULAR VARIETIES

(Enumerator instruction: First evaluate the conventional variety, then Lishe)

42. Evaluate your favourite conventional varieties (Name: _____and the QPM (LISHE) variety, (**LISHE**) using the criteria given. Score each criterion using codes:

1=very poor; 2=poor; 3=fair; 4=good; 5=very good.

Type	**Criteria**		**Conventional maize varieties Scores** *1=very poor 2=poor 3=fair 4=good 5=very good*	**QPM (LISHE) Scores** *1=very poor 2=poor 3=fair 4=good 5=very good*	**Remarks**
APRTYPE	**APRCRIT**		**APRCSCO**	**APRQPSCORE**	**APREMAK**
Field	Germination	**1**			
	Plant vigor	**2**			
	Resistance to drought	**3**			
	Resistance to field pests	**4**			
	Resistance to disease	**6**			
	Early maturity	**7**			
	Yield	**8**			
Cob/Grain	Cob size	**9**			

	Number of rows on the	**10**			
	Good cover of the tip	**11**			
	Grain size	**12**			
	Grain colour	**13**			
	Grain weight	**14**			
Cooking qualities	Pounding ability	**15**			
	Water absorption capacity	**16**			
	Taste of green maize,	**17**			
	Taste of green maize,	**18**			
	Taste of dry maize cooked	**19**			
	General cooking qualities	**20**			
	Other specify_____	**21**			
Marketability	Marketability	**22**			
	Resistance to storage	**23**			
	Other specify_____	**24**			
Overall evaluation		**25**			

SECTION 9: PARTICIPATION IN QPM (LISHE) PROMOTION

43. Have you ever **participated in QPM (LISHE)** transfer/promotion activities? (1=Yes; 0=No) **QPMPRO**_____

44. List the transfer/promotion activities in which you participated and the number of times (in the year 2008 and 2009)

Activity		Number of times in 2008 (for none, write 0)	Number of times in 2009 (for none, write 0)
PROMACT		**PRTIME08**	**PRTIME09**
Field days/farmers assessment	**1**		
On farm trials/demonstrations	**2**		
Surveys	**3**		
PRAs	**4**		
Seminars/meetings/workshops	**5**		
Sensory evaluations	**6**		
Others(specify)_____	**7**		

45. a. Have you received any QPM (LISHE) **promotional materials**? (1=Yes; 0=No)

QPMAT_____

b.If yes, describe: (1=leaflet; 2=T-shirt; 3=cap)

PROMAT_____

46. a. Have you ever seen a **poster promoting QPM (LISHE)**?(1=yes; 0=No)

QPMPOST_____

b. If yes, where? **POSTLOC** _____

SECTION 10: INFRASTRUCTURE ACCESS QUESTIONS

47. What is the distance (in kilometres) from your home to the nearest:

a. Tarmac Road	**DTMRDKM**_____
b. All weather (motorable) road	**DMTRDKM**_____
c. District town (Headquarters)	**DIST_KM**_____
d. Market centre	**MKT_KM**_____
e. School (either private or public)	**SCH_KM**_____
f. Clinic (either private or public)	**CLNIC_KM**_____
g. Tap water supply	**H20_KM**_____
h. Extension office	**DEXTN_KM**_____
i. Maize Research station	**DRESEACH**_____

48. a Have you **ever consulted** extension agent? (1=Yes, 0=No)

DEVAG_____

b.If yes, how **many times** did you consult the extension agent during the **last 12 months?**

TIMDEV_____

49. Where do you **mostly sell** your maize?

PRODSAL_____

(1= at farm gate; 2=at near markets; 3= Others specify_____)

50. How **far** from the place of residence to the **selling point (in Km)**?

KMSAL_____

51. a. Are there programs that promote maize production in this area?

PROPROM_____

(1= Yes); 0 = No

b. If yes above, list names of two main programs.

PROG1_____

PROG2_____

52. a. How do you access agricultural extension information on maize production?

1. NGOs

2. *NAADS*
3. *Local extension/ veterinary officers*
4. *Farmer groups and associations*
5. *National Agricultural Research Centres(e.g., NARO,SARI)*
6. *Stockists*
7. *Radio*
8. *Newspaper*
9. *Television*
10. *Others (specify)*_____

b. What kind of information do you access?
   1. ----------
   2. ----------
   3. ----------

c. What kind of information would you have liked to access?
   1. ----------
   2. ----------
   3. ----------

53. Do you belong to farming group (1 = Yes;0 = No) **FGRP**_____

54. Do you have access to agricultural credit? (1= Yes; 0= No)**ACESCRD**_____

55. What are the **two main sources of agricultural credit** that exist in your district?

1. ----------

2. ----------

(b) Have you **ever received credit** from any of **these sources**? (1=Yes, 0= No)**RCRDT**_____

(c) If **no** to (b) above, **why**?

1. ----------

2. ----------

(d) What are the **3 main general constraints** to the **use** of improved maize varieties such as **LISHE?**

1. ----------

2. ----------

3. ----------

56. (a) Do you have Striga in your maize garden? (1= Yes 0= No)**STRIG**_____

(b) If yes, what proportion of your land has been invaded by Striga (%)? **STRIGPR** _____

SECTION 11: HOUSEHOLD WELFARE

Type of dwelling (from enumerator's observation).

57. (a) Type of walls (main house): **MNWALL**_____

1. Wood and mud 2. Mud/bricks 3. Concrete bricks 4. Stones/blocks; 5. Wood; 6. Other (specify _____)

(b) Type of roof (main house): **MNROOF**_____

1. Grass thatched 2. Iron Sheets 3. Tiles 4. Wood covered with mud or dung 5. Other (specify _____)

(c) Type of toilet used by the household most of the time: **MNTOIL**_____

1. Traditional pit 2. Improved pit latrine 3. Flush/ modern toilet 4. Community owned latrine 5. None (bush); 6. Other (specify _____)

THANK YOU FOR YOUR PARTICIPATION!

Appendix D: Modified home use sensory testing questionnaire for stiff porridge "triangle" and "circle" in Tanzania.

SECTION 1: IDENTIFICATION

Date of experiment: (Dd/Mm/Year) **SURDATE** ____/_____/_____
Starting time (Hrs and minutes in 24 hr clock) **STIMEHU** _____:_____

1. **Respondent** first name: _____Last name _____ **RESPID**_____
2**. Enumerator first name**: _____ Last name_____ **ENCODEH**____
3. Admin 1 (District) _____ **ADMIN1**_____

Data entry:
Date entered: (Dd/Mm/Yr) **ENTDATE** ____/____/____
Entered by: First name: _____ Last name _____ **DECODE**_____

SECTION 2: SENSORY TESTING

Instructions: You are required to prepare stiff porridge and taste according to the order given to you below. Afterwards, please evaluate the two stiff porridges differently according to:

1. Texture in the hand (Hand-feel)
2. Texture in the mouth (Mouth-feel)
3. Taste
4. Overall evaluation.

(50% will be required to start with stiff porridge ..△..... and 50% will be required to start with stiff porridge ...○....)

Please give a genuine opinion about your sensory evaluation of the stiff porridge in terms of how good each is, and use a rating of 1 to 5 for each evaluation to mean:

1=very bad; 2=bad; 3=fair; 4=good; 5=very good;

A. Sensory evaluation of the stiff porridge

DIMENSION	RATING SCALE	STIFF PORRIDGE VARIETIES (*tick only one*)
Texture in the hand (Hand-feel) Break a piece of the cooked stiff porridge and rub it gently between the middle fingers and the thumb to feel the texture/touch.	1=very bad	
	2=bad	
	3=fair	
	4=good	
	5=very good	

DIMENSION	RATING SCALE	STIFF PORRIDGE VARIETIES (*tick only one*)
Texture in the mouth (mouth-feel) Put a piece of cooked stiff porridge in your mouth and feel the grittiness when chewed and swallowed.	1=very bad	
	2=bad	
	3=fair	
	4=good	
	5=very good	

DIMENSION	RATING SCALE	STIFF PORRIDGE VARIETIES (*Tick only one*)
Taste/flavour Swallow the chewed stiff porridge and evaluate its overall taste/flavour when swallowing**.**	1=very bad	
	2=bad	
	3=fair	
	4=good	
	5=very good	

DIMENSION	RATING SCALE	STIFF PORRIDGE VARIETIES (*Tick only one*)
Overall evaluation Evaluate the overall stiff porridge.	1=very bad	
	2=bad	
	3=fair	

	4=good	
	5=very good	

B. Sensory evaluation of the stiff porridge

DIMENSION	RATING SCALE	STIFF PORRIDGE VARIETIES (*Tick only one)*
Texture in the hand (Hand-feel) Break a piece of the cooked stiff porridge and rub it gently between the middle fingers and the thumb to feel the texture/ touch.	1=very bad	
	2=bad	
	3=fair	
	4=good	
	5=very good	

DIMENSION	RATING SCALE	STIFF PORRIDGE VARIETIES (*Tick only one)*
Texture in the mouth (mouth-feel) Put a piece of cooked stiff porridge in your mouth and feel the grittiness when chewed and swallowed.	1=very bad	
	2=bad	
	3=fair	
	4=good	
	5=very good	

DIMENSION	RATING SCALE	STIFF PORRIDGE VARIETIES (*Tick only one)*
Taste/flavour Swallow the chewed stiff porridge and evaluate its overall taste/flavour when swallowing**.**	1=very bad	
	2=bad	
	3=fair	
	4=good	
	5=very good	

DIMENSION	RATING SCALE	STIFF PORRIDGE VARIETIES (*Tick only one*) ◯
Overall evaluation Evaluate the overall stiff porridge.	1=very bad	
	2=bad	
	3=fair	
	4=good	
	5=very good	

Finishing time (Hrs and minutes in 24 hr clock) **FTIMEHU_____: _____**

THANK YOU FOR YOUR PARTICIPATION!

Appendix E: Central location sensory testing questionnaire for stiff porridge "triangle" and "circle" in Tanzania

Introduction: Dear Sir/Madam, we are researchers in agriculture and we would like to lead you as we undertake some few experiments on stiff porridge.

SECTION 1: IDENTIFICATION

(Enumerators to fill in the names, supervisors to provide the codes)

Date of experiment: (Dd/Mm/Year) **SURDATE** ____/_____/_____

Starting time (Hrs and minutes in 24 hr clock) **STIME** _____:_____

1. Respondent first name: _____Last name _____ RESPID _____

a) Identifying Variables:

Country: _____ **COCODE**: _____
Admin 1 (District):_____ **ADMIN1**: _____
Admin 2 (Division/County/PA):_____ **ADMIN2**: _____

Admin 3 (Ward/Sub-County):_____ **ADMIN3**: _____
Admin 5 (Village/Local Council 1):_____ **ADMIN5**: _____

Supervisor first name: _____Last name_____ **SUPCODE**_____
Date checked: (Dd/Mm/Year) **CHDATE** ____/____/____

Data entry:

Date entered: (Dd/Mm/Yr) **ENTDATE** ____/____/____
Entered by: First name: _____ Last name _____ **DECODE**_____

2. **Sex** of the respondent (1= Female, 2=Male) **REGEND**_____
3. **Marital status** of the respondent? **MSATRES**_____
(1=married; 2=single; 3= windowed; 4= divorced; 5=separated; 6=other (specify)_____)
4. **Age** of the respondent (in years)? **AGERES**_____
5. **Level of education** acquired by respondent (Number of years in formal education)?
EDUCRES_____

6. What is your employment status? **OCCUP**_____
1=work on family farm; 2=salaried employment in private sector, govt, NGO; 3=casual laborer; 4= self employed business (not farm); 5=Not employed; 6= Other specify_____

Part A: Sensory Testing

Instructions: In front of you, you will find two plates of stiff porridge and a bottle of water. You will be required to do the sensory evaluation of the two stiff porridge according to the order given to you (50% will be required to start with stiff porridge ..△.. and 50% will be required to start with stiff porridge .....◯

Please evaluate the stiff porridge in terms of:

1. Appearance
2. Texture in the hand (Hand-feel)
3. Aroma (smell)
4. Texture in the mouth (Mouth-feel) and
5. Taste.
6. Overall evaluation

You are required to evaluate the stiff porridge in terms of how good each is, and use a rating of 1 to 9 for each evaluation to mean:

- 1=Extremely bad
- 2=Very bad
- 3= Bad
- 4= Moderately bad
- 5=fair
- 6= Moderately good
- 7= Good
- 8=Very good
- 9=Extremely good/excellent

Give a genuine opinion about your sensory evaluation of the stiff porridge. **Before you start** the tasting, **rinse your mouth using the water provided**, and also **drink some water to clean your palate**.
Also, **after you finish evaluating the first stiff porridge, and before you start evaluating the second stiff porridge**, rinse your mouth and drink some water.

A. Sensory evaluation of stiff porridge △

DIMENSION	RATING SCALE	STIFF PORRIDGE VARIETIES (*Tick only one)* △
Aroma (Smell) Take short sniffs of the stiff porridge as soon as you uncover the porridge.	1=extremely bad	
	2=very bad	
	3= bad	
	4= moderately bad	
	5=fair	
	6=moderately good	
	7=good	
	8=very good	
	9=excellent/extremely good	

DIMENSION	RATING SCALE	STIFF PORRIDGE VARIETIES (*Tick only one)* △
Appearance (Impression of the colour)	1=extremely bad	
	2=very bad	
	3= bad	
	4= moderately bad	
	5=fair	
	6=moderately good	
	7=good	
	8=very good	
	9=excellent/extremely good	

DIMENSION	RATING SCALE	STIFF PORRIDGE VARIETIES (*Tick only one)* △
Texture in the hand (Hand-feel) Break a piece of the cooked stiff porridge and rub it gently between the middle fingers and the thumb to feel the texture/	1=extremely bad	
	2=very bad	
	3= bad	
	4= moderately bad	
	5=fair	
	6=moderately good	
	7=good	

touch.	8=very good	
	9=excellent/extremely good	

DIMENSION	RATING SCALE	STIFF PORRIDGE VARIETIES (*Tick only one*) △
Texture in the mouth (mouth-feel) Put a piece of cooked stiff porridge in your mouth and feel the grittiness when chewed and swallowed.	1=extremely bad	
	2=very bad	
	3= bad	
	4= moderately bad	
	5=fair	
	6=moderately good	
	7=good	
	8=very good	
	9=excellent/extremely good	

DIMENSION	RATING SCALE	STIFF PORRIDGE VARIETIES (*Tick only one*) △
Taste/flavour Swallow the chewed stiff porridge and evaluate its overall taste/flavour when swallowing**.**	1=extremely bad	
	2=very bad	
	3= bad	
	4= moderately bad	
	5=fair	
	6=moderately good	
	7=good	
	8=very good	
	9=excellent/extremely good	

DIMENSION	RATING SCALE	STIFF PORRIDGE VARIETIES (*Tick only one*) △
Overall evaluation Evaluate the overall stiff porridge.	1=extremely bad	
	2=very bad	
	3= bad	
	4= moderately bad	

	5=fair	
	6=moderately good	
	7=good	
	8=very good	
	9=excellent/extremely good	

Comment: _____

B) Sensory evaluation of stiff porridge ◯.

Please rinse your mouth using the water provided, and also drink some water, before you start this new session of tasting.

DIMENSION	**RATING SCALE**	**STIFF PORRIDGE VARIETIES (*Tick only one*)** ◯
Aroma (Smell) Take short sniffs of the stiff porridge as soon as you uncover the porridge.	1=extremely bad	
	2=very bad	
	3= bad	
	4= moderately bad	
	5=fair	
	6=moderately good	
	7=good	
	8=very good	
	9=excellent/extremely good	

DIMENSION	**RATING SCALE**	**STIFF PORRIDGE VARIETIES (*Tick only one*)** ◯
Appearance (Impression of the colour)	1=extremely bad	
	2=very bad	
	3= bad	
	4= moderately bad	
	5=fair	
	6=moderately good	
	7=good	
	8=very good	
	9=excellent/extremely good	

DIMENSION	RATING SCALE	STIFF PORRIDGE VARIETIES (*Tick only one*) ◯
Texture in the hand (Hand-feel) Break a piece of the cooked stiff porridge and rub it gently between the middle fingers and the thumb to feel the texture/touch.	1=extremely bad	
	2=very bad	
	3= bad	
	4= moderately bad	
	5=fair	
	6=moderately good	
	7=good	
	8=very good	
	9=excellent/extremely good	

DIMENSION	RATING SCALE	STIFF PORRIDGE VARIETIES (*Tick only one*) ◯
Texture in the mouth (mouth-feel) Put a piece of cooked stiff porridge in your mouth and feel the grittiness when chewed and swallowed.	1=extremely bad	
	2=very bad	
	3= bad	
	4= moderately bad	
	5=fair	
	6=moderately good	
	7=good	
	8=very good	
	9=excellent/extremely good	

DIMENSION	RATING SCALE	STIFF PORRIDGE VARIETIES (*Tick only one*) ◯
Taste/flavour Swallow the chewed stiff porridge and evaluate its overall taste/flavour when swallowing**.**	1=extremely bad	
	2=very bad	
	3= bad	
	4= moderately bad	
	5=fair	
	6=moderately good	
	7=good	
	8=very good	
	9=excellent/extremely good	

DIMENSION	RATING SCALE	STIFF PORRIDGE VARIETIES (*Tick only one*) ◯
Overall evaluation Evaluate the overall stiff porridge.	1=extremely bad	
	2=very bad	
	3= bad	
	4= moderately bad	
	5=fair	
	6=moderately good	
	7=good	
	8=very good	
	9=excellent/extremely good	

Comment _____

C. Triangle test:

Among the three types of stiff porridge given below, **two are the same** and one is the odd one out. Please taste the three stiff porridges, each at a time, and fill below **the odd one out**. Definitely one is the odd one out. So, if no difference is apparent, you must guess.
After tasting the two types of stiff porridge and before tasting the next, please rinse your mouth (using the water provided) and also drink some water to completely clean your palate.

Type of samples: Stiff porridge
Order of tasting: Sample 1._____
Sample 2._____
Sample 3._____

Which is the odd one out? _____

Finishing time (Hrs and minutes in 24 hr clock) **FTIME**_____**:** _____

THANK YOU FOR YOUR PARTICIPATION!!

Appendix F: Experimental auction questionnaire

A. EXPERIMENTAL AUCTION (WITHOUT INFORMATION)

1. Respondent first name _____ Last name _____ **RESNOWTP**_____
2. **Enumerator first name**: _____ Last name_____ **ENCODE**_____
3. **Starting time (Hrs and minutes in 24 hr clock)STNOWTP** _____:_____

Instructions to bidders:

In this section we want to know how you value different products that will be presented to you. We will undertake an auction and for this purpose we will give you money for you to be able to participate. The money is yours and is to help you buy the product in case you win the auction. Note that these two types of maize flour are the same that you tasted earlier in form of stiff porridge. The maize flour is given the same label as the stiff porridge that you tasted for the respective stiff porridge that the flour made (maize flour △ made stiff porridge △ and maize flour ◯ made stiff porridge ◯).

This is how the auction will be operated **(*Explain the BDM auction as below)*:**

- I will show you 2 different types of maize flour, one at a time and ask you how much you can pay to have each product,
- I will ask you to bid for each maize flour and write your two bids down,
- I will then ask you to pick a random number to determine the binding round among the two bids you made,
- You will then pick another random number to determine the winning price (for the product in the binding round),
- If the bid you set is higher than or equal to the randomly picked winning price, you win the auction and you have to buy the product at the price of the random number you picked (remember money will have been provided to you to facilitate this exchange),
- If the bid you set is lower than the winning price, you have not won the auction, hence you just keep the money and get no maize flour,
- You will be required to bid for the two maize flour (one at a time) based on the sensory tasting of their respective stiff porridge that you did earlier.

- Kindly note that it will be to your own benefit that your bid is the true amount that you are willing to pay for the maize flour/cake. In this kind of auction, if you give a lower/higher bid than your true value, you are the one who ends up losing.
- We will start with cakes before we come to maize-meal auction so that you can get familiar with the method.

a) Test Round with cakes

Bid 1: _____ (TShs)
Bid 2: _____ (TShs)
Binding round: _____
Winning price: _____ (TShs)
Whether has won the test auction or not_____ (Y/N)

b) Maize meal Auction

(Enumerator Note: To randomize, 50% will start with circle and 50% with triangle. So please follow the order of auction given by the researcher.)

Order of auction products _____ ***(To be filled by researcher)***
Bid 1: _____ (TShs)
Bid 2: _____ (TShs)
Binding round: _____
Winning price: _____ (TShs)
Whether has won the maize auction _____ (Y/N)

Finishing time (Hrs and minutes in 24 hr clock) **FTNOWTP_____: _____**

B. EXPERIMENTAL AUCTION (WITH INFORMATION)

1. Respondent first name_____ Last name_____ **RESNOWTP_____**
2. Enumerator first name: _____ Last name_____ **ENCODE____**
3. Starting time (Hrs and minutes in 24 hr clock) **STNOWTP** _____:_____

Instructions to bidders:

In this section we want to know how you value different products that will be presented to you. We will have two types of maize flour; one is made from QPM and the other is made from conventional maize **(Give the specific conventional maize according to area----------).** QPM flour is labelled “QPM” and flour from conventional maize is labelled “CONVENTIONAL” These are the two types of stiff porridge that you tasted earlier. The stiff porridge that was labelled ◯ was made from the maize flour now labelled “CONVENTIONAL” and the one that was labelled △ was made from the maize flour now labelled “QPM”. We will undertake an auction and for this purpose we will give you money for you to be able to participate. The money is yours and is to help you buy

the product in case you win the auction. This is how the auction will be operated (Explain the BDM auction as below):

- I will show you the QPM and CONVENTIONAL maize flour, one at a time and ask you how much you can pay to have each flour,
- I will ask you to bid for each maize flour and I will write your two bids down,
- I will then ask you to pick a random number to determine the binding round among the two bids you made,
- You will then pick another random number from a distribution to determine the winning price (for the product in the binding round),
- If the bid you set is higher than or equal to the randomly picked winning price, you win the auction and you have to buy the flour at the price of the random number you picked (remember money will have been provided to you to facilitate this exchange),
- If the bid you set is lower than the winning price, you have not won the auction, hence you just keep the money and get no maize flour,
- Kindly note that it will be to your own benefit that your bid is the true amount that you are willing to pay for the maize flour/cake. In this kind of auction, if you give a lower/higher bid than your true value, you are the one who ends up losing.
- We will start with cakes before we come to maize-flour auction so that you can get familiar with the method.

a) Test Round with cakes

Bid 1: _____ (TShs)
Bid 2: _____ (TShs)
Binding round: _____
Winning price: _____ (TShs)
Whether has won the test auction or not_____ (Y/N)

b) Maize meal Auction

***(Enumerator Note: To randomize, 50% will start with circle and 50% with triangle. So please follow the order of auction given by the researcher.*)**
Order of auction products _____ ***(To be filled by researcher)***
Bid 1: _____ (TShs)
Bid 2: _____ (TShs)
Binding round: _____
Winning price: _____ (TShs)
Whether has won the maize auction _____ (Y/N)

Finishing time (Hrs and minutes in 24 hr clock) **FTINWTP_____: _____**

Appendix G: QPM nutritional information given to rural consumers

- Proteins and amino acids
    - Proteins are the building blocks of the body
    - Proteins are made from amino acids,
    - and not all proteins are of the same quality: some proteins are of lower quality because they have low levels of essential amino acids
    - For example:
        - protein from animal sources such as milk, meat and eggs are of excellent quality,
        - Protein from cereals (maize, wheat) is of poor quality.
        - If eaten by itself, only 40% of the protein in maize can be used to build protein for the human body.
        - Therefore, maize should be eaten with foods rich in quality proteins such as legumes or eggs to supply the missing portion.
        - Protein from legumes (beans, etc.) is of intermediate quality.
- Maize
    - Maize protein is low in quality because it is lacking lysine and tryptophan, two of the essential amino acids. It has to be eaten with protein that is high in those amino acids, for example legumes such as beans.
- QPM
    - Since many people do not have good access to alternative protein sources, , breeders have developed maize varieties with double amounts of these amino acids,
    - These varieties are called Quality Protein Maize or QPM.
    - Even if eaten by itself, 80% of the protein of QPM can now be used to build proteins for the human or animal body.
    - Pigs fed on QPM only, will therefore grow twice as fast as pigs fed on conventional maize only.
    - Animals and humans are not usually fed on maize only, though. Still, if non-

QPM maize is the major source of protein in a person's diet, his/her diet is likely to be deficient in high quality protein and specifically the amino acid lysine and tryptophan. In those circumstances, the person will grow faster on QPM than on conventional maize.

- QPM in Tanzania
    - In Tanzania, 3 QPM varieties have now been released: Lishe K1 an OPV, Lishe H1 and H2, hybrids. The three varieties were released in the year 2001.