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Abstract: The purpose of this study was to evaluate the sensory characteristics and consumer acceptability of quality protein maize (QPM) in rural Tanzania. Due to the malnutrition problem facing consumers in developing countries, QPM which has almost double the amount of tryptophan and lysine, has been identified as a possible solution to this problem. To know whether consumers will accept QPM, it is vital that its sensory attributes and consumer acceptance tests are carried out. Sensory characteristics were determined using home use testing and central location methods by use of stiff porridge. Three districts were visited and 120 consumers participated in home use testing, whereas 30 respondents participated in the central location testing. At the central location, triangle test was also undertaken to find out if a difference exists between QPM and conventional maize. Additionally, acceptability of QPM was tested using BDM method. Consumer characteristics of QPM were highly appreciated for stiff porridge, a major maize product in East Africa. This was observed both in home use and sensory 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.

Key words: QPM; consumer acceptability; sensory evaluation; malnutrition; Tanzania.

INTRODUCTION

Sufficient micronutrients in the daily diet are one of the prerequisites for human health (Caballero, 2003). However, due to food insecurity in most of the countries within Sub-Saharan Africa (SSA), there has been a reduction in dietary diversity among the consumers, which is a fundamental determinant of malnutrition especially among the children, expectant women and the elderly (Johns & Eyzaguirre, 2007). Micronutrients deficiency affects more than 40% of the world's population(Tucker, 2003). In Tanzania, in 2004, 38% of children under the age of five suffered from malnutrition (TDHS, 2006). Protein deficiency remains an important dietary problem, particularly among the children and the elderly, due to the low quality of protein that is often consumed when animal products are not a part of the diet (Krivanek *et al.*, 2007).

Maize is a vital staple and a main source of dietary protein in many areas of the developing world. In many African countries, especially East and southern Africa, maize is the basic food

for the subsistence farmers. In Malawi, Zambia and Zimbabwe, per capita consumption of maize is 100 kg per year (NRC, 1988), while in Tanzania, per capita consumption is estimated at 73 kg per year (Food and Agriculture Organization, 2009). In Tanzania, maize is the most important staple food crop with other staples including cassava, sorghum, rice, wheat, millet, sweet potatoes and bananas (Ministry of Agriculture and Cooperatives, 2001). Over 80% of the national population depends on maize as a food crop as well as a cash crop (Moshi, 1997). 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, and the rest (15%) is produced by public and private large scale farmers. Most maize produced (85%) is consumed at the household level, and the surplus is bought by other farmers within and outside the region and by urban dwellers (Moshi, 1997). Conventional maize is poor in protein quality due to deficiencies in lysine and tryptophan, two amino acids essential in the diets of humans and monogastric animals (Lauderdale, 2000). The deficient amino acids can be supplemented by animal protein such as meat, milk, eggs or fish, pulses or commercially produced synthetic amino acids. Most rural households, however are too poor to consume animal source protein on a regular basis, (NRC, 1988).

Four main methods are commonly used to address the micro nutrient deficiencies: dietary diversification, supplementation, fortification and biofortification (Campos-Bowers & Wittenmyer, 2007). Biofortification is the development of food crops rich in bio-available micronutrients, either through conventional breeding or genetic modification (Johns & Eyzaguirre, 2007). This method does not rely on food processing or the milling process to incorporate micronutrients into the diet (Bouis, 1996), and repeat purchases are not necessary (Johns & Eyzaguirre, 2007). Therefore, 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.

Biofortification is a promising strategy to address the underlying cause of under nutrition, households' poor access to nutritious food (Johns & Eyzaguirre, 2007). Furthermore, recent studies conducted with human subjects under a controlled setting show that biofortification can have an impact on public health. For instance, a school children feeding trial in South Africa showed that consumption of orange-fleshed sweet potato, high in beta-carotene, led to

improvements in their vitamin A status (Van Jaarsveld *et al.*, 2005). Likewise, a 9-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 *et al.*, 2005). A similar result was also obtained in a community setting in Mozambique (Low *et al.*, 2007).

Quality protein maize (QPM), another biofortified crop, 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). A study conducted in Peru with 10 malnourished children showed that the measurement of growth-kilocalories per gram of weight gain, weight per age change, height per age change and fat-fold change were similar to those for milk (Graham *et al.*, 1990). 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 *et al.*, 2007). However, anecdotal evidence suggests that the opaque 2 gene has an effect on organoleptic characteristics, especially making the dough more sticky (Ahenkora *et al.*, 1999).

Therefore, consumer studies are needed to study the sensory qualities of QPM and estimate consumers' willingness to pay (WTP) for QPM products. Consumer acceptance can be a major issue in development of new technologies, as has been shown with consumer resistance to genetically modified products in Europe and Japan (Chern *et al.*, 2002). This has highly affected development of the genetically modified products in those areas. In some cases, biofortification of a variety may alter aspects such as its perceived naturalness, cooking, storage or sensory (taste, odour, colour, texture) qualities, all of which affect its acceptance. However, 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, The main objective of this study therefore, was to determine the acceptance and magnitude of willingness to pay for QPM by the rural consumers in the northern region of Tanzania, as part of a regional study covering four countries. The specific objectives were:

- To study the difference between stiff porridge made from QPM and conventional maize in blind testing in a laboratory.
- To determine consumers' acceptance of QPM through sensory evaluation of stiff porridge in central location as well as home-use testing.
- To estimate consumer's willingness to pay for QPM flour as compared to conventional maize flour using experimental auctions.

METHODOLOGY

Sensory evaluation

Factors influencing food preference can be divided into those related to food, individual or the economic and social environment (Shepherd, 1999). The physical and chemical properties of food lead to the consumer's perception of sensory attributes about the food. This further leads to attitudes which eventually lead to food choice and food intake. The physical and chemical composition of food is perceived by an individual as sensory attributes such as appearance, aroma, texture and taste (Cardello, 1994). The chemical compounds in the food, such as the amount of proteins or carbohydrates a food contains may affect the consumer's acceptance of the product.

Three methods are involved in conducting sensory evaluation, which include; laboratory tests, central location tests (CLT) or home use tests (HUT). (Meilgaard *et al.*, 2007). For this study, central location tests (CLT) and home use tests (HUT) were used. CLT involves assembling potential purchasers of a product in one central place, may be a school, church or in a hall. The products are prepared out of sight and served on uniform plates uniquely labelled. The potential purchasers are then asked to taste the products and say their level of likeness, and any misunderstandings can be cleared up. In addition, conditions are favourable for a high return of responses from a large sample size. 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).

Studying consumption characteristics of new varieties is relatively a new area in adoption research in Africa. Initially, most of the attention was mainly on support of agronomic

characteristics of new varieties while the consumer and nutritional characteristics of the new varieties were ignored. Recently however, studies have been undertaken on consumer acceptance of the new varieties in Africa. These include; pro-vitamin A orange maize (Meenakshi *et al.*, 2010) ,parboiled rice in Ghana (Tomlins *et al.*, 2007a), pale-fleshed and orange-fleshed sweet potatoes in Tanzania (Tomlins *et al.*, 2007b) and provitamin A-biofortified maize in Mozambique (Stevens & Winter-Nelson, 2008). Sensory valuation studies have been carried out broadly in Africa. This include; provitamin A orange maize in rural Zambia (Meenakshi *et al.*, 2010), fermented cassava products (Nigerian *fufu*) in Nigeria, (Tomlins *et al.*, 2007c), sweet potatoes in Tanzania, (Tomlins *et al.*, 2007b), provitamin A-biofortified maize in Mozambique (Stevens & Winter-Nelson, 2008) and parboiled rice in Ghana (Tomlins *et al.*, 2007a)**.**

Analyzing scores

In market surveys and consumer acceptance tests, ordinal responses are common. Consumers are asked to "rate" how they like a product to test their acceptance (Coe, 2002), using scores on an ordered but arbitrary scale, such as a 5-point hedonic scale (1=very bad, 2=bad, 3=fair 4=good and 5=very good). A product rated 4 however is not necessarily two times as much liked as a product rated 2. Also, the intervals between each score are not necessarily exactly the same. Therefore, consumers' scores are not measured on an interval scale, but on an ordered categorical scale, and should be treated and analysed as such, for example with ordinal regression (Coe, 2002), .

If the same consumer is asked to evaluate different products, these evaluations are likely to be related. To avoid that the error terms in the model are correlated, fixed or random effects can be included (Green, 2008).

The ordinal regression estimates the log odds ratio. If consumers scores two products, the log odds ratio estimated is the logarithm of the odds ratio. The odds ratio is the ratio of the odds of one 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 *et al.*, 2007).

Empirical framework

The attributes that were tested for the analysis of sensory evaluation results are hand feel texture, mouth feel texture, taste and overall evaluation. A 5-level hedonic scale was used with 1= "very poor"; 2= "poor"; 3= "neither good nor poor"; 4= "good" and 5= "very good". To analyse the data, ordinal regression model with fixed effects was used. , Since the evaluation of the products are categorical data, a vector x is used with a binary variable for each product. The basic model becomes:

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

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). Other factors that can influence the score are individual characteristics like gender, age and education. We are also interested in knowing if the technology is more appreciated by the wealthy, so wealth indicators as land and livestock ownership were also included, and the different districts. All these factors were combined in a vector **z.**

The new model is shown below:

$$\ln\left[\frac{P(Y \leq j)}{1 - P(Y \leq j)}\right] = k_j + \beta' x + \alpha' z + x' A_{sx} z \tag{2}$$

The coefficients β interpreted as the log odds ratio of women for both QPM and conventional maize varieties. The matrix A_{sx} has a row for the QPM maize variety in vector s, and a column

for female variable in vector *x* and every element represents a cross effect of female respondents for the specific maize variety (QPM). To analyse the effects age of the respondents to acceptance of QPM, a cross effects dummy variable was introduced representing respondents' age and maize variety. Similar calculations were done for the Hai and Babati districts (Karatu district was the base). Level of wealth of the respondents was also considered as one of the variables of the regression model, where livestock and land ownership were used to represent wealth.

Survey and experimental design

The central location test (CLT) was carried out first which involved 30 employees of SARI. Information on their individual characteristics was collected, then sensory evaluation followed and lastly triangle test was done. This was done in January 2010, and two researchers assisted in making the setup for the experiment.

Data on sensory evaluation and willingness to pay (WTP) were collected between January and February 2010, and rural consumers of three districts (Hai, Karatu and Babati) within the northern region of Tanzania were interviewed. Interviews and experiments were conducted by eight enumerators from Selian Agricultural Research Institute (SARI), specially trained, using tools specially developed and tested for this purpose.

In each household, either the household head or the spouse participated in the experiment. Data on farming activities, the family income for the past one year, demographic characteristics of the household, asset ownership and dietary information for the household were collected first, this was followed by the sensory evaluation and the WTP experiment.

A total of 120 respondents were interviewed, and all the households that participated in the modified HUT also participated in the experimental auctions. The respondents were randomly selected from the QPM villages and control villages that were sampled in an earlier survey using a stratified two-stage sampling procedure. The two strata 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.

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Secondary sampling unit were households, where ten were randomly selected within each village.

Sensory evaluation - Central location

For central location testing, 30 staff members of Selian Agricultural Research Institute (SARI) gathered in a hall within the premises of the organisation from where they undertake the experiment. QPM and conventional maize flour, labelled "circle" and "triangle" were given to one lady who cooked under the supervision of the researcher to ensure that the two varieties are cooked separately. Latter, the stiff porridge was served to the 30 respondents who started the evaluation after receiving instructions on how to undertake the experiment. The respondents were requested to taste the stiff porridge one at a time, and give their response on their perceived level of liking for the different stiff porridges. In this case, 9-level hedonic test was used, where 1=Extremely bad, 2=Very bad, 3=Bad, 4=Moderately bad, 5=fair, 6=Moderately good, 7=Good, 8=Very good, and 9=Extremely good/excellent. The consumers were asked to give their response with respect to aroma, appearance, texture in the hand, texture in the mouth, taste and overall evaluation. The order in which the respondents did the evaluation was randomised, and mineral water was provided to drink in between evaluations. When all the respondents finished the sensory evaluation of the two samples, they were prepared to undertake triangle testing (test of difference). This data was analysed using paired sample T-test.

A triangle test is a method used to determine whether a sensory difference exists between two products (Meilgaard *et al.*, 2007). An explanation was given on how to undertake the evaluation. Each respondent was given three samples of stiff porridge at the same time all labelled differently. They were informed that two of the samples were the same, and their task was to identify the sample that was the odd one out. The respondents were informed that they could use any method of sensory evaluation, (tasting, smelling, checking the hand/mouth texture or any method that they wished) to check the sample that was the odd one out, and record in the questionnaire that they were given. To analyse this data, the number of rightly identified odd sample were counted, and this was checked against table of critical numbers for interpretation.

Sensory evaluation testing -modified HUT

For this study, a modified HUT was developed. Because the rural consumers in Tanzania like hammer mill maize flour which has been milled without de-husking, both QPM and conventional maize was bought and milled at the hammer mill according to the local consumers' preference. Respondents were given one kg of QPM and of conventional maize, but labelled with either a triangle or a circle. These symbols did not have a particular connotation in this area and are better than numbers to ensure that the judgement of the respondents was not influenced (Watts et al., 1989). The respondents would first prepare the two types of stiff porridge separately in their own kitchen using their own tools. Afterwards, they would carry out the sensory evaluation.

A 5-level hedonic test was used, from 1=very bad to 5=very good. Texture in the hand, texture in the mouth, taste and overall evaluation were the criterions used in the evaluation. The order of the sample was randomised to avoid positional errors (Meilgaard *et al.*, 2007; Watts *et al.*, 1989). Data from the HUT was analyzed using SPSS 15, using ordinal regression model with fixed effects.

Willingness to pay (wtp)

In the recent research, experimental methods have gained acceptance as a valuable tool in market research. Among the most important tasks in implementing an experimental auction is the incentive compatibility of the auction mechanism (Lusk *et al.*, 2004). An auction mechanism is considered to be theoretically incentive compatible if an individual's dominant strategy is to bid in such a manner that the evaluations are truthfully revealed. For this study, Becker-DeGroot-Marschak (BDM) individual auction mechanism was used to solicit the consumers' WTP for QPM flour. The BDM mechanism is individual and could therefore be combined with the modified HUT, which would be difficult with group type experimental auctions.

BDM mechanism compares individual 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 (Becker *et al.*, 1964). In BDM auction, participants bid against the randomly determined market price and not

against each other (Watts *et al.*, 1989). The BDM method has been successfully used to estimate maize consumers' WTP in Kenya before (De Groote *et al.*, 2010).

One kilogram of QPM flour and conventional maize flour were packaged in similar packets, and labelled "circle" and "triangle", to represent QPM flour and conventional flour. Both were bought and milled at the hammer mill without de-husking since that is what the consumers preferred. The consumers were then requested to indicate their WTP for the different maize flour depending on the sensory characteristics they attained from the sensory evaluation earlier. .

Data from the individual experimental auction was analyzed using SPSS 15, where the average bids for the different maize flour varieties were compared using paired-samples t-test method. The mean differences between average bids of QPM and conventional maize flour were also taken.

RESULTS

Central location testing results

Characteristics of the participants

Out of the 30 respondents who undertook CLT, 12 were female and 18 were male. All of them were employees of SARI, with ages ranging from 18 to 56 years and number of years in formal school ranging from 7 to 24 years.

Triangle test

Out of the 30 respondents who undertook the triangle test, 21 respondents correctly identified the odd sample. For this sample size, the critical number is 19 (for a significance of 0.1%), so the number of the correctly identifications is greater than the critical number, so the participants can distinguish QPM and conventional maize, and the test is are significant at the 0.1% level.

Central location testing (CLT)

The mean scores for QPM and conventional maize stiff porridge were significantly different in aroma, taste, texture in the mouth and texture in the hand (pair-wise t-test) (Table 2). The difference between appearance of QPM stiff porridge and conventional maize stiff porridge was however not significance.

The mean scores of QPM were always higher than those of conventional maize, and therefore more appreciated than conventional maize for all criteria.

(TABLE 1)

Consumer demographic and farming characteristics

From the 120 consumers interviewed, around 49% were female. Average age of the respondents was 49 years. The average non-agricultural income received by all the households during the year 2009 was $US 657, but substantially higher in Hai (1140 USD) than in Babati (352 USD) and Karatu (318 USD).

Out of an average 1.8 ha of land cultivated during the 2008/2009 main season, 1.5 hectare was under maize. 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. On an average year, each household produces around 3.3 tons of maize, of which about 54% is consumed. Respondents in Babati have the highest maize production per year (4.5 tons) compared to Hai and Karatu.

(TABLE 2)

QPM and protein awareness

As expected, awareness of QPM is highest in the project areas, especially in Babati as compared to Karatu (75%) and Hai (92%) (Figure 1). Among the control households, respondents in Karatu district were reported to be the least control respondents aware of QPM (35%) compared to other districts. Control respondents in Hai district also reported a low level of QPM awareness (38%). On the other side however, awareness of protein in the three districts was quite impressive. Respondents from both the target and control household had protein awareness of 75% and above. Moreover, all the respondents in target households from Hai district were aware of protein.

(FIGURE 1)

Modified home use testing (HUT)

None of the maize varieties was rated as a very poor variety (Table 3). A close overview of the results however shows that QPM was ranked higher than conventional maize in all evaluation criteria. This means that the consumers perceived QPM to have better sensory characteristics than conventional maize. The taste of QPM stiff porridge was rated as a very good by 58% of the participants, whereas only 1.7% rated conventional maize stiff porridge as having a very good taste. Nobody scored QPM as poor for taste. On the other side, 0.8% of the respondents evaluated the stiff porridge from conventional maize to have a bad taste. Looking at the overall evaluation of the two types of maize varieties, around 61% of the respondents scored QPM stiff porridge as a very good stiff porridge, 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. 66% of the responde nts recorded QPM stiff porridge to have good hand feel texture, whereas 21 percent perceived QPM to have very good hand-feel texture. With conventional maize however, 66 % perceived conventional stiff porridge to have fair sensory characteristics. 55% of respondents

perceived QPM to have a good mouth feel, whereas 20% perceived it to have very good sensory characteristics.

(TABLE 3)

Ordinal regression model

The results of the ordinal regression model show the estimation of both the main effects and cross effects of different variables (Table 4). QPM is clearly evaluated better than conventional variety during the HUT. QPM variety had a log odds ratio of 4.5, which translated to an odds ratio of 90 when the exponent was taken. Therefore, it means that the odds of QPM variety being rated higher than odds of conventional maize variety is 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 however, was significant, but negative, estimated at -1.5. Taking the exponent resulted in an odds ratio of 0.22, indicating that female respondents appreciate QPM not as much above conventional maize than men do.

The main effect of age had a significant log odds ratio of 0.24, and an odds ratio of 1.3. This means that people who are older have higher scores. The cross effect age with QPM, however, is not significant, indicating that appreciation of QPM does not change with age, or with any of the other variables.

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, and their cross effects were also introduced. The estimated coefficient of livestock ownership was

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significant and negative. This indicates that both QPM and conventional maize varieties would be rated higher by consumers with less livestock. A cross effects of livestock and QPM was 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 any significant effect on the consumers' appreciation of the different maize varieties. When a cross effect between QPM and land ownership was introduced in the model, the estimated coefficient was still not significant, showing further that there is no relationship between land ownership and appreciation for QPM.

 To find out whether respondents from different districts had different levels of appreciation for QPM and conventional maize varieties, Babati and Hai districts were introduced in the model and Karatu district was the base. The log odds ratio of respondents in Babati was positive and significant (6.26). This means this means that respondents in Babati district (both men and women), are likely to appreciate both QPM and conventional maize varieties higher 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 respondents in Hai was 2.04 meaning that appreciation of QPM by Hai people is 2.04 times more than appreciation of QPM in other districts. Therefore, appreciation of QPM in Hai is (2.04+4.5) =6.54.

(TABLE 4)

Willingness to pay (WTP)

Analysis of the individual auction data showed that the rural consumers in the three districts were generally willing to pay more for QPM flour than for 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 shows a mean difference of $US 0.09 between the average consumers' WTP for QPM and conventional maize flour which was significant at 1%. Among the three districts, the

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consumers in Karatu district had the largest mean difference between their WTP for QPM and conventional maize flour ($US 0.11), while those in Babati district registered the smallest mean difference between their WTP for QPM and conventional maize flour ($US 0.06) and Hai registered a mean difference of $US 0.09 between their WTP for the two different varieties of maize flour. These results are tabulated in Table 5.

(TABLE 5)

CONCLUSION

Results of this study show that consumer characteristics of this QPM variety are highly appreciated for stiff porridge. In the central location testing, the overall mean of QPM was 7.6, whereas that of conventional maize was 6.5. This shows that QPM was perceived to have better sensory attributes compared to conventional maize in general. The mean difference between appearance of QPM and conventional maize was however not significant. Such an outcome was expected because QPM and conventional maize are both white in colour. In the modified home use sensory testing, only 5% of the respondents perceived conventional maize to have a very good sensory attribute in general, 8% of the respondents perceived conventional maize to have a bad taste and 58% perceived QPM to have a very good taste. On average, 61% of the respondents reported QPM to have very good sensory attribute in general. This shows that QPM had better sensory attributes than conventional maize and consumers scored QPM higher.

This is different than Ghana where QPM was claimed to have organoleptic characteristics, especially making the dough more sticky (Ahenkora *et al.*, 1999). Therefore, the sensory evaluation needs to be repeated with other QPM varieties to ensure that it is not only a specific QPM variety that has favourable consumer characteristics.

Both home use sensory testing and central location sensory testing had similar results, where QPM was scored higher than conventional maize in all criteria.

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In addition, breeders need to focus on the agronomic characteristics of QPM. For instance, the size of QPM grain is small compared to majority of other hybrid and open pollinated maize varieties, which would affect the adoption of QPM.

Moreover, all respondents in all districts were willing to pay more for QPM than for conventional maize flour. Consumers in Karatu were willing to pay more for QPM than conventional maize, with a mean difference of 11%. Babati consumers also, had a higher WTP for QPM than for conventional maize, with a mean difference of 6%. Hai consumers recorded a 9% mean difference between their WTP for QPM and that of conventional maize, but still that of QPM remained higher. Sensory appreciation translated into a substantial economic appreciation, estimation of utility and an increase in WTP of 38% in Karatu, 29% in Hai and 21% in Babati for QPM.

The triangle test indicated that consumers can tell the difference between the QPM and the conventional variety. However, even though the difference is relatively big, the test was close (small difference between the critical number and the actual number correctly identified). In the future, a larger sample size is recommended for triangle test.

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 one is able to know the same consumer's willingness to pay for the same product.

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Table 1: Pair wise evaluation of QPM and conventional maize stiff porridge during central location sensory testing

Evaluation criteria	Statistics	QPM	CV	Mean difference	
Overall evaluation	Mean	7.6	6.5	1.1	***
	Std.dev	0.9	1.3	1.7	
Aroma	Mean	7.2	6.4	0.9	***
	Std.dev	0.8	1.0	1.3	
Taste	Mean	7.7	6.3	1.4	***
	Std.dev	1.1	1.5	2.0	
Hand feel	Mean	7.4	6.9	0.5	**
	Std.dev	0.9	1.1	1.3	
Mouth feel	Mean	7.6	6.3	1.3	***
	Std.dev	1.1	1.3	1.9	
Appearance	Mean	7.3	6.9	0.3	
	Std.dev	0.7	1.2	1.2	
n	30				

***, **,*, statistically significant at 1%, 5% and 10% respectively

Table 2: Consumer demographic and farming characteristics by district

| Type	Characteristic	Babati (n=36)		Hai (n=48)		Karatu (n=36)		Overall (120)	
		Mean	Std dev.	Mean	Std dev.	Mean	Std dev.	Mean	Std dev.
Individual	Female (%)	41.7	0.5	43.8	0.5	47.2	0.5	44.2	0.5
	Respondent Age (years)	44.2	8.8	52.4	10.1	48.1	13.5	48.6	11.3
	Years in formal education	6.2	2.2	7.8	2.1	6.3	2.4	6.9	2.3
	Non-Agricultural income received in 2009 (USD)	352	634	1,140	2,973	318	535	657	1,962
Farm	Total land cultivated (ha)	2.3	2.3	1.4	1.8	1.9	1.5	1.8	1.9
	Land under maize (ha)	1.9	2.0	1.1	1.7	1.6	1.3	1.5	1.7
	Maize produced on an average year (tons)	4.5	4.1	2.6	2.3	3.1	2.4	3.3	3.1
	Proportion of maize consumed on an average year (%)	49.9	24.8	55.1	25.6	58.0	31.2	54.4	27.1

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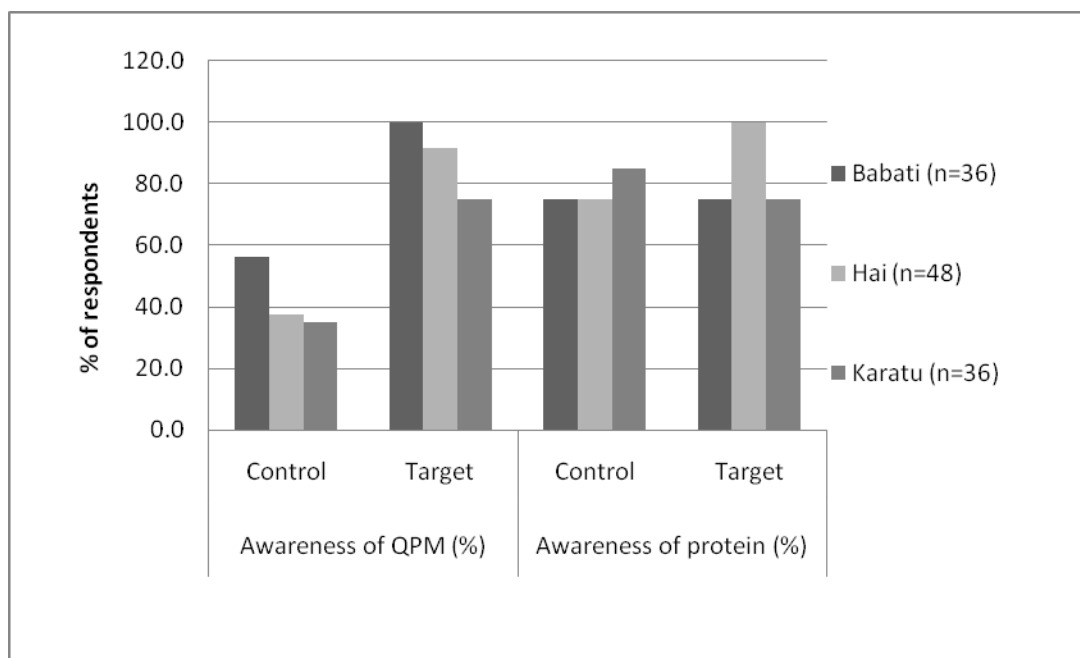
Figure 1: QPM and protein awareness by sample type and district

Table 3: 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	0.0	0.0	0.0	0.0	3.3	0.0	0.8	0.0
Fair	57.5	6.7	65.8	12.5	52.5	10.0	50.0	10.0
Good	37.5	32.5	33.3	66.7	40.8	55.0	47.5	31.7
Very good	5.0	60.8	0.8	20.8	3.3	35.0	1.7	58.3

Table 4: Estimates of the ordinal regression of sensory evaluation during home use sensory testing

Variables	Coefficient	Std.error	
QPM	4.50	1.86	**
Age	0.24	0.13	*
Women	9.55	4.03	**
Land ownership	0.46	0.64	
Livestock ownership	-0.18	0.10	*
Babati district	6.26	3.27	*
Hai district	5.89	5.72	
QPM_age	0.01	0.03	
QPM_women	-1.50	0.76	**
QPM_livestock	0.02	0.02	
QPM_land ownership	-0.06	0.06	
QPM_Babati	-0.26	0.89	
QPM_Hai	2.04	0.94	**
Pseudo R-Squared (McFadden)	0.50		
Pearson - (Chi-Square)	485.13		***
n	120.00		

***, **,*, significant at 1%, 5% and 10% respectively

Table 5: Average bid for maize flour ($US) by district

District	Statistics	Average bids for different maize varieties		Mean difference	
		QPM	CV		
Babati (n=36)	Mean	0.37	0.30	0.06	***
	Std. Dev	0.07	0.08	0.10	
Hai (n=48)	Mean	0.39	0.30	0.09	***
	Std. Dev	0.07	0.08	0.08	
Karatu (n=36)	Mean	0.39	0.28	0.11	***
	Std. Dev	0.05	0.08	0.07	
Total (n=120)	Mean	0.38	0.30	0.09	***
	Std. Dev	0.06	0.08	0.09	

***, **,*, significant at 1%, 5% and 10% respectively