DE GRUYTER OPEN
DOI: 10.2478/ats-2014-0018 AGRICULTURA TROPICA ET SUBTROPICA, 47/4, 131-136, 2014

Original Research Paper

Evaluation of Agronomic and Sensory Attributes of Quality Protein Maize for Acceptability in South-Western Nigeria

Bosede Olukemi Lawal[1], Olukemi Titilola Ayoola[1], Subuola Bosede Fasoyiro[2]

[1] *South West Farming Systems Research and Extension Programme, Institute of Agricultural Research and Training, Moor Plantation, P.M.B. 5029, Ibadan, Nigeria*
[2] *Product Development Programme, Institute of Agricultural Research and Training, Moor Plantation, P.M.B. 5029, Ibadan, Nigeria*

Abstract

Quality Protein Maize (*Zea mays L.)* (QPM) varieties have been developed by scientists at the Institute of Agricultural Research and Training in Nigeria. For these varieties to have significant impact, they must possess traits acceptable to farmers. A study was carried out to evaluate the agronomic and sensory traits of two Quality Protein Maize - ART-98-SW-6-OB (QPM1) and ILE-1-OB (QPM2), in comparison with ART-96-SW-1 (High Protein Maize) and SUWAN-1-SR (a popularly grown improved variety) in three maize growing communities of South West, Nigeria. Sixty (60) farmers comprising males and females were evaluated for six sensory parameters. The parameters tested were appearance, colour, flavour, texture, taste and overall acceptability. The results of the agronomic evaluation showed that there were no significant differences in the height of QPM varieties and HPM at harvest. QPM varieties gave the highest grain yield of 2.38t/ha for ART-98-SW-6OB and 2.36t/ha for ILE-1-OB. Sensory evaluation showed that when the maize varieties were processed into corn-soy milk, QPM corn-soy milk had the highest sensory scores for all sensory parameters tested. Quality Protein Maize varieties had high grain yield and were most preferred for maize pudding and corn – soy milk. The QPM varieties, if formulated into foods for household or commercial purposes, should have good chance of being accepted by farmers with continuous promotional campaigns.

Keywords: Nutritionally enhanced maize; field and sensory evaluation; consumer acceptability; resource poor farmers; malnutrition.

INTRODUCTION

Household diets in rural areas of South west Nigeria are dominated by staples, such as cereals and tubers, mostly produced at the homestead, whereas consumption of other foods that would improve dietary quality, such as legumes, vegetables, fruits, and animal source foods, is limited by availability and access (Maxiya-Dixon et al., 2004; Olarinde and Kuponiyi, 2005; Akinyele, 2010).

Nigeria is one of the 20 countries that account for 80% of global child malnutrition (Bryce et al., 2008). Forty-one percent of Nigerian children under the age of five were stunted, 23% were underweight and 14% wasted (NDHS, 2008). With the persistent malnutrition problem in Nigeria, efforts are being undertaken through collaborative research among scientists to enhance the nutritional quality of staple food crops, especially maize to improve nutritional security of households.

Maize (*Zea mays L*) accounts for about 15-56% of the total daily calories in the diets of people in developing countries (Vasal, 2000). Several million people in developing countries derive their protein and caloric requirements from maize (Prasanna et al., 2001; Mbuya et al., 2010). It is a major component in the diet of an average Nigerian and it is consumed in almost all homes. However, the problem with maize diet is that it is mostly deficient in essential amino acids. The poor nutritional value of maize grain is attributable to low content of lysine and tryptophan in the maize protein component (Mertz et al., 1965; Akalu et al., 2008; Edusei et al., 2008; Atlin et al. 2010).

Varieties of nutritionally enhanced maize, called quality protein maize (QPM) were recently developed and released at the Institute of Agricultural Research & Training (I.A.R&T), Nigeria. The nutritional value of QPM, both as human food and as animal feed for poultry and pigs, has been widely demonstrated in many countries (Vasal, 2000; Prasanna et al., 2001;Atlin et al., 2010; Gunaratna et al., 2010). The QPM has twice the lysine and tryptophan content of normal/ conventional maize. Nutritionally enhanced crops are highly effective in combating malnutrition where large numbers of poor people eat large quantities of staple food, as is the case in rural areas of many developing countries, including Nigeria. Unlike other strategies to improve nutrition, such as improving the diet through home gardens or education, nutritionally enhanced foods can reach large groups of rural people cheaply, without changing their dietary habits. Normal maize grain lacks adequate levels of two essential amino acids, lysine and tryptophan, thus reducing the overall biological value of its protein (Lauderdale, 2000).

Reportedly, consumption of Quality Protein maize varieties lead to greater protein utilization (Bressani, 1992)

and enhanced rates of growth among malnourished young children (Gunaratna et al., 2010). Estimated target QPM intake levels of 100 g/d for young children and 500 g/d for adults were calculated to meet 100% requirement for lysine, tryptophan and protein set by World Health Organization and Institute of Medicine (Nuss and Tanumihardjo, 2011). Dietary substitution of common maize with QPM can enhance intake of a more nutritionally balanced protein, which, as previous research suggests, can result in measureable health impacts (Nuss and Tanumihardjo, 2011).

Evaluating sensory attributes of new varieties is a relatively new area in adoption research in Africa. Attention has mainly been focused on agronomic evaluation while neglecting consumer-acceptability characteristics. Sensory evaluation studies have been carried out by researchers recently. These include fermented cassava products in Nigeria, provitamin A-biofortified maize in Mozambique and QPM in rural Tanzania (Tomlins et al., 2007; Stevens and Winter-Nelson, 2008; Kiria et al., 2010).

For QPM varieties to have a significant impact on the nutritional status of vulnerable groups, they must be accepted by consumers in the preparation of typical maize foods, whether in boiled or roasted form. They must also be accepted in agronomic attributes, particularly yield and early maturity. It is against this background that evaluation of sensory and agronomic characteristics of newly developed QPM varieties was undertaken. This study combines two evaluations conducted during cropping seasons in 2009 and 2010 in an attempt to understand more clearly farmers' perceptions regarding the newly developed varieties and to make the varieties widely acceptable to farmers. Farmers were asked to evaluate the agronomic and sensory characteristics of QPM varieties along with HPM and a popularly grown improved variety (Suwan-1-SR).

MATERIALS AND METHODS

Evaluations were conducted in three rural maize-growing communities in South Western Nigeria: Eleyowo, Moloko-Ashipa and Itagbolu. Two newly developed QPM varieties were evaluated along with HPM and Suwan-1-SR. The evaluation took place during 2009 and 2010 cropping seasons. The QPM varieties evaluated were ART-98 SW-6-OB and ILE-1-OB, while the HPM variety was ART-96-SW-1. The maize varieties were obtained from the Institute of Agricultural Research and Training, Ibadan, Nigeria, while Suwan-1-SR was obtained from participating farmers. The QPM varieties are both open-pollinated and early maturing. QPM1 (ART-98 SW-6-OB) has a lysine level of 3.67% and tryptophan level of 0.89%, while QPM2 (ILE-1-OB) has lysine level of 3.72% and tryptophan level of 0.89%. They are both tolerant to major fungal (downy mildew) and viral diseases (maize streak virus). The HPM (ART-96-SW-1) is a high protein maize developed by IAR&T, where the male parent is sweet corn and the female parent is Suwan-1-SR. Crude protein content of HPM is between 12.8% and 14.2%. Suwan -1-SR was developed in Thailand and was jointly improved by IITA and IAR&T for resistance to downy mildew and has been popularized among and well accepted by farmers in South-western Nigeria.

Land clearing was done manually while land preparation included plowing once and harrowing twice. The demonstration/experimental plot used was 20 m × 50 m. The experiment was laid out as a randomized complete-block design (RCBD) and 3 farmers' field were planted in each community. A total of 9 farmers' fields were planted and each farmer's field served as a replicate. The plots served as demonstration and learning plots for farmers. Planting was done on flat bed after plowing and harrowing. Maize was planted at 0.9 m × 0.4 m at 2 plants/hill. Fertilizer rate used were 300 kg/ha of NPK 25 -10- 10 and 100 kg/ha of single super phosphate (SSP) per hectare. Weed control was achieved by applying S–2-chloro-N-(2-ethyl-6-mehtyl-phenyl)-N-(2-methxy-1-methylethyl)-acetamide and R-isomers known as Primextra at 3.0 kg a.i. per hectare (I.A.R&T, 2010) and supplementary hand weeding at 6 weeks after planting (WAP).

Agronomic evaluation

Agronomic data collected from each plot included plant height, days to 50% tasseling, ear weight, ear length, weight of 100 Kernels (seeds) and grain yield. Maize was harvested at 14 WAP and dried to 14% moisture content and dry grain weight was recorded. There were field tours of demonstration plots from planting to harvesting stage, which helped create awareness and also part of the learning process among farmers about the improved varieties.

Sensory evaluation

Sensory evaluation of maize products (roasted maize, boiled maize, maize pudding and corn soymilk) was conducted during field days organized for farmers, community village members and neighboring villages in the three locations. Demonstration of QPM-processing technology and sensory evaluation of QPM, HPM and farmers' popular maize products among the study group was done to first assess the acceptability of QPM varieties among farmers and, secondly, to facilitate the adoption of the QPM varieties among the farmers, and to create awareness of the various products that QPM can be used for through the demonstration process. Preparation methods for the products that were demonstrated to rural farmers included the following:

For roasted maize: Ear was roasted for 10 min on an open fire gauze using firewood until ear turned golden-brown in colour. Each maize variety was roasted separately.

Boiled maize: Maize on the cob was boiled directly in water for 30 min; no salt was added. Each maize variety was boiled separately.

Maize pudding "Abari": Each maize variety was ground separately and made into a thick paste. Ingredients, such as pepper, palm oil, onion and salt, were added. The preparation was packaged in maize leaves and steamed for 30 min.

Soy-corn milk: This was prepared using the method of Omueti et al. (2000). Soybean was soaked overnight. Fresh maize was mixed with the soaked soybean in a 3:1 ratio. This was ground into slurry and sifted with muslin cloth. The milk was boiled for 15 min, cooled and sweetened with sugar. Soymilk that was used as control was prepared using the same method but without addition of maize.

The field days were organized by IAR&T in conjunction with Agricultural Development Progamme (ADP) - an agricultural extension outfit of the state government in Nigeria. Preparation methods for the products were demonstrated before stakeholders (the rural women groups and farmers). Quality protein maize varieties were prepared into three commonly eaten maize products in south-western Nigeria (roasted maize, boiled maize and 'abari' and one other new product developed in IAR&T (corn-soy milk). Sensory evaluation was carried out to assess the acceptability of the products using the method of Iwe (2002). The evaluation was carried out by 60 farmers, comprising males and females. The parameters tested were appearance, color, flavor, texture, taste and overall acceptability. After demonstrating the preparation methods to the participants, the products from the different QPM varieties were coded and randomly presented to the participants who also served as assessors. The samples were independently evaluated using the difference method described by Larmond (1977). A nine-point hedonic scale was used to determine the preference of panelist. Ratings were: 1 = "extremely dislike" and 9 = "extremely like." The assessors were allowed to drink water in between product testing. The data were statistically analyzed using analysis of variance (ANOVA) and means were separated by Duncan's multiple range test.

RESULTS AND DISCUSSION

Characteristics of the participants

Fifty-five percent of the farmers that participated in the evaluation were male while 45% were female. The personal and socio-economic characteristics of participating farmers are listed in Table 1. The mean age of the participants was 43.26 years with a maximum of 65 years and a standard deviation of 8.54, implying that majority of the farmers are still within active and productive years. The mean number of years of schooling of the participants was 3.60 years, with a range of 0-12 years. Household size of participants varied from 1 to 8. Mean farm size cultivated was 1.64 hectares while mean area under maize was 1.25 hectares. Number of farm plots cultivated by participants varied from 1 to 3. The implication of this is that most farmers in the study area were resource –poor farmers who were mainly involved in maize production and might have leased pieces of land for the purpose of self-sustenance and household food security.

Agronomic evaluation

Field evaluation showed significant differences among the four maize varieties for all agronomic characters (Table 2). Popular improved maize variety (farmers' variety) was significantly taller than QPM varieties and HPM. Number of days to 50% tasseling for QPM varieties and HPM ranged between 50 and 53 days, but farmers' variety tasseled at 61 days after planting. Mean ear weight (g) and ear length (m) were not significantly different for QPM and HPM varieties, but values for each were significantly higher than those for farmers' variety. ART-98 SW-6-OB gave the highest grain yield (2.38 t/ha), followed by ILE-1-OB (2.36 t/ha), which had yields significantly different from yields of HPM and farmers' variety (Table 2). The farmers' variety yielded the least, but it had the highest value for 100-kernel weight. High protein maize had the least value for 100-kernel weight. Despite being shorter than the farmers' variety, QPM varieties had higher yield attributes. Fewer number of days to tasseling for QPM and HPM than for farmers' variety was an indication that the former matured earlier than farmers' variety. It should, therefore, be possible for farmers to plant maize more than once in a year, especially in the forest zone where both early and late seasons exist.

Sensory evaluation

The sensory evaluation results are presented in Tables 3-6. Table 3 shows the mean sensory scores of roasted maize from different varieties. Roasted QPM varieties and farmers' popular

Table 1. Personal and socio-economic characteristics of farmers participating in maize evaluation (n = 60)

Personal /Socio-economic characteristics	Minimum	Maximum	Mean	Standard deviation
Age (in years)	32	65	43.26	8.54
Years of formal schooling	0	12	3.60	2.69
Household size	1	8	2.30	1.46
Farm size (hectares)	0.30	5.0	1.64	1.50
Number of plots	1	3	1.78	0.71
Area under maize (hectares)	0.3	3.0	1.25	0.93

Table 2. Plant height, number of days to 50% tasseling, ear weight, ear length, weight of 100 kernels and grain yield of QPM, HPM and farmers' popular variety in the three locations

Maize Variety	Plant height (m)	Day to 50% Tasseling	Ear weight (g)	Ear length (cm)	Weight of 100 kernels (g)	Grain yield t/ha
ART-98-SW-6-OB	1.94^{b}	51^{b}	276.7^{a}	22.8^{ab}	11.5^{a}	2.38^{a}
ILE-1-OB	1.92^{b}	53^{b}	274.5^{a}	23.0^{a}	11.2^{ab}	2.36^{a}
HPM	1.98^{b}	50^{b}	261.0^{a}	20.9^{b}	9.9^{b}	2.01^{b}
Farmers' variety	2.49^{a}	61.7^{a}	226.0^{b}	20.3^{bc}	12.1^{a}	1.52^{c}

Values carrying different superscripts in a column are significantly different ($P < 0.05$)

improved maize variety were not significantly different in colour, appearance and flavor but significantly different in terms of texture, taste and overall acceptability ($P < 0.05$). Roasted High Protein Maize (HPM) was not significantly different at $P < 0.05$ from roasted farmers' popular improved maize variety for sensory attributes of colour and flavour. For all the sensory parameters, all of the roasted maize varieties were accepted by the panelists but HPM had the highest sensory scores and overall acceptability for all the attributes. Roasted maize is a popular snack in Nigeria. Promotion of HPM as roasted maize will have high acceptability.

The sensory mean score of boiled maize from different varieties is shown in Table 4. The sensory scores of the attributes of boiled maize showed a similar trend as shown by the roasted maize. Boiled HPM had the highest scores for all the attributes. Popular improved maize variety and QPM varieties were not significantly different in color. The HPM and popular improved maize variety were not significantly different in appearance. The implication is that QPM and HPM would be easily accepted as the local variety being used by consumers as far as color and appearance are concerned, respectively.

The sensory qualities of maize pudding (locally referred to

Table 3. Sensory qualities of roasted maize from different varieties assessed by farmers

Sample	Colour	Appearance	Flavour	Texture	Taste	Overall Acceptability
RQPM (ART-98 SW-6-OB)	7.16^{b}	7.33^{b}	6.83^{b}	6.00^{c}	6.00^{c}	6.50^{c}
RQPM (ILE-1-OB)	7.13^{b}	7.30^{b}	6.85^{b}	6.00^{c}	6.10^{c}	6.48^{c}
RHPM	8.16^{a}	8.16^{a}	8.16^{a}	8.00^{a}	8.16^{a}	8.17^{a}
RFarmers' variety	7.66^{ab}	7.50^{b}	7.33^{ab}	7.00^{b}	7.00^{b}	7. 00^{b}

Values carrying different superscripts in a column are significantly different ($P < 0.05$)

Table 4. Sensory qualities of boiled maize from different varieties assessed by farmers

Sample	Colour	Appearance	Flavour	Texture	Taste	Overall Acceptability
BQPM (ART-98 SW-6-OB)	6.83^{b}	7.33^{b}	6.17^{c}	6.00^{c}	6.00^{c}	6.00^{b}
BQPM (ILE-1-OB)	6.85^{b}	7.30^{b}	6.19^{c}	6.01^{c}	6.04^{c}	6.20^{b}
BHPM	8.17^{a}	8.17^{a}	8.00^{a}	8.00^{a}	8.17^{a}	7.83^{a}
BFarmers' variety	7.50^{ab}	8.00^{a}	7.00^{b}	7.00^{b}	7.00^{b}	7.33^{a}

Values carrying different superscripts in a column are significantly different ($P < 0.05$)

Table 5. Sensory qualities of Abari from different maize varieties assessed by farmers

Sample	Colour	Appearance	Flavour	Texture	Taste	Overall Acceptability
QPM-Abari (ART-98 SW-6-OB)	8.27^{a}	8.16^{a}	8.05^{a}	7.83^{a}	7.58^{a}	8.38^{a}
QPM Abari (Ile-1-OB)	8.25^{a}	8.13^{a}	8.07^{a}	7.88^{a}	7.60^{a}	8.37^{a}
HPM-Abari	7.77^{a}	8.00^{a}	7.61^{a}	7.50^{a}	8.05^{a}	8.05^{a}
Farmers' variety-Abari	8.27^{a}	8.05^{a}	8.05^{a}	7.72^{a}	7.88^{a}	8.05^{a}

Values carrying different superscripts in a column are significantly different ($P < 0.05$)

Table 6. Sensory qualities of soy-corn milk from different maize varieties in comparison with soymilk

Sample	Colour	Flavour	Texture	Taste	Overall Acceptability
QPM (ART-98 SW-6-OB)					
soy corn milk	8.22[a]	8.38[a]	8.61[a]	8.44[a]	8.66[a]
QPM (Ile-1-OB)					
soy corn milk	8.20[a]	8.39[a]	8.59[a]	8.45[a]	8.61[a]
HPM soycorn milk	7.72[a]	7.72[ab]	7.61[b]	7.22[b]	7.72[b]
Farmers'soycorn milk	7.55[a]	7.61[b]	7.88[ab]	7.83[ab]	7.83[b]
Soymilk	6.72[b]	6.38[c]	7.00[c]	5.33[c]	5.72[c]

Values carrying different superscripts in a column are significantly different ($P < 0.05$)

as '*Abari*') from different maize varieties are also shown in Table 5. There were no significant differences in all the attributes of the four maize varieties made into maize pudding. The implication is that formulation of QPM into foods is likely to be accepted by participants. The colouring effect of palm oil and the flavoring effect of other ingredients may have influenced response and scoring of the varieties. This could be the reason for the observed trend of similar scoring of the products from the varieties.

The sensory qualities of soy-corn milk from the different varieties of maize were compared with soymilk (Table 6). Soy-corn milk is a nutritionally improved soymilk product with fresh maize (Omueti et al., 2000). All the varieties processed into soy-corn milk were more acceptable than ordinary soymilk for the various attributes tested. Soy-corn milk from QPM varieties, HPM and popular farmers' improved variety were not significantly different in color in relation to ordinary soy milk ($P < 0.05$).

Soy-corn milk from QPM and HPM varieties were not significantly different in flavor ($P < 0.05$). The QPM varieties and popular farmers' improved variety were not significantly different in texture and taste when compared with ordinary soy milk. ART-98-SW-6-OB soy-corn milk, however, had the highest sensory scores for all the attributes tested and the overall acceptability. This implied that QPM soy-corn milk could not be differentiated from ordinary soymilk in terms of color, flavor and texture. It could be consumed better and will provide more nutritional value than the ordinary soy milk. Generally, legumes and soy products are low in methionine and high in lysine. Cereals such as maize are generally high in methionine and low in lysine (Bhagavan, 2002). The combination of maize with soybean as in soy-corn milk is a good blend for improved amino acid profile and nutritional status. High acceptability of QPM soy-corn milk over ordinary soymilk among participants showed the need to popularize the product.

Generally, the sensory results showed acceptability for the two QPM varieties as roasted, boiled, maize pudding or soy-corn milk. The two QPM varieties could also be used for other maize-based food products, such as pudding, because of its relatively high scores for abari and soy-corn milk. It is, therefore, likely to perform better than farmers' popular improved variety in food product development.

CONCLUSIONS

Agronomically, QPM varieties had better ear length, ear weight and grain yield than HPM and popular farmers' improved variety. Sensory evaluation revealed that farmers highly preferred HPM variety in roasted and boiled form. However, no significant differences were observed among different maize varieties when processed into maize pudding. The QPM corn-soy milk had highest sensory scores for all sensory parameters tested.

The QPM varieties could be formulated into foods for household and commercial purposes. Good agronomic and sensory attributes, coupled with continuous promotional campaigns, could enhance the chance of QPM varieties being adopted by farmers for improved nutritional status and income generation.

REFERENCES

Akalu G., Tafesse S., Tekabe F., Taye G., De Groote H., Gunaratna N., Debello A., Friesen D. (2008): Quality Protein Maize: Comparative studies on its nutritional benefits for pre-school children in maize consuming households in two Ethiopian communities. Technical report of the "Quality Protein Maize Development for The Horn and East Africa" (QPMD) Project prepared for the Canadian International Development Agency (CIDA). Addis Ababa, Ethiopia.

Akinyele I.O. (2010): Ensuring Food and Nutrition Security in Rural Nigeria: An Assessment of the Challenges, Information Needs, and Analytical Capacity. Working paper.Nigeria Strategy Support Programme (NSSP). Background Paper No. NSSP 007.

Atlin G.N., Palacios N., Babu R., Twumasi-Afriye S., De Groote H., Vivek B., Friesen D., Pixley K.V. (2010): Quality Protein Maize: progress, impact, and prospects. Plant Breeding Reviews 34: 83-130.

Bhagavan N.V. (2002): Medical Biochemistry. 4th Edition Harcourt/Academic Press. 214 p.

Bressani R. (1992): Nutritional value of high-lysine maize in humans. In: Quality protein maize. St. Paul (MN): American Association of Cereal Chemists. 205 p.

Bryce D., Coitinho I., Darnton-Hill D., Pelletier, P. Pinstrup-Andersen P. (2008): Maternal and Child Undernutrition: Effective Action at National Level. Lancet 371 (9611): 510-526.

Edusei A.K., Asiedu M.S., Sakyi-Dawson E.O., Owusu W.B., Gunaratna N.S., Haag W.L. (2008): Capacity of quality protein maize (QPM) to improve nutritional status, serum proteins, hemoglobin level and leukocyte (WBC) counts of malnourished preschool children. Paper presented at the 4th International Maize HarvestPlus Meeting, Kumasi, Ghana, July7-11, 2008.

Gunaratna N.S., De Groote H., Nestel P., Pixley K.V., McCabe G.P. (2010): A Meta analysis of Community level Studies on Quality Protein Maize. Food Policy 35: 202-210.

Institute of Agricultural Research and Training (IAR&T) (2010): Guide on Maize Production. IAR&T Farmers' Guide Series 1 No. 4, 7 p.

Iwe M.O. (2002): Handbook of Sensory Methods and Analysis. Rojoint Communication Services Limited, Enugu, Nigeria, pp. 71-72.

Kiria C.G., Vermeulen H., De Groote H. (2010): Sensory evaluation and Consumers' willingness to pay for Quality Protein Maize (QPM) using Experimental Auctions in Rural Tanzania. 2010 AAAE Third Conference/AEASA 48th Conference, September 19-23, 2010, Cape Town, South Africa 96417, African Association of Agricultural Economists (AAAE) & Agricultural Economics Association of South Africa (AEASA).

Larmond E. (1977): Laboratory methods for sensory evaluation of food. Research Branch Canadian Department of Agriculture Publication 1637.

Lauderdale J. (2000): Issues Regarding Targeting and Adoption of Quality Protein Maize(QPM). CIMMYT (International Maize and Wheat Improvement Center), Mexico D.F., 30 p.

Maziya-Dixon B., Akinyele I.O., Oguntona E.B., Nokoe S., Sanusi R.A., Harris E. (2004): Nigeria food consumption and nutrition survey 2001-2003. International Institute of Tropical Agriculture, Ibadan, Nigeria.

Mertz E.T., Veron O.A., Bates L.S., Nelson O.E. (1965): Growth of Rats Fed on Opaque-2 Maize Science 148: 1741-1742.

Mbuya K., Nkongolo K.K., Kalonji-Mbuyi A., Kizungu R. (2010): Participatory selection and characterization of quality protein maize (QPM) varieties in Savanna agroecological region of DR-Congo. Journal of Plant Breeding and Crop Science 2(11): 325- 332.

NDHS (2008): National population commission and ICF Micro, Calverton. MD 20705, USA.

Nuss E.T., Tanumihardjo S.A (2011): Quality Protein Maize for Africa: Closing the protein Inadequacy gap in vulnerable populations. Advances in Nutrition 2: 217-224.

Olarinde L.O., Kuponiyi F.A. (2005): Rural livelihood and food consumption patterns among households in Oyo State, Nigeria: Implications for food security and poverty eradication in a deregulated economy. Journal of Social Science 11(2): 127-132.

Omueti O., Oguntona E.B., Jaiyeola O., Ashaye O.A. (2000): Nutritional Evaluation of home-level prepared soycorn milk-a protein beverage. Nutrition and Food Science 30: 128-132.

Prasanna B.M., Vasal S.K., Kassahun B., Singh N.N. (2001): Quality protein maize. Current Science 81:1308-1319.

Stevens R., Winter-Nelson A. (2008): Consumer acceptance of provitamin A biofortified maize in Maputo, Mozambique. Food Policy 33(4): 341-351.

Tomlins K., Sanni L., Oyewole O., Dipeolu A., Ayinde I., Adebayo K., Westby A. (2007): Consumer acceptability and sensory evaluation of a fermented cassava product (Nigerian fufu). Journal of the Science of Food and Agriculture 87(10): 1949-1956.

Vasal S.K. (2000): The quality protein maize story. Food and Nutrition Bulletin 21: 445-450.

Received: July 10, 2014
Accepted after revisions: December 15, 2014

Corresponding author:

Bosede Olukemi Lawal
South West Farming Systems Research and Extension Programme
Institute of Agricultural Research and Training
Moor Plantation, Ibadan
Nigeria
E-mail: bosedelawal@gmail.com