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A Review of Improving The protein Quality with the Composition of Quality Traits of Maize (*Zea mays* L.) Grain and Possible Breeding Techniques

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ABSTRACT

Maize is the second most vital among cereals next to wheat which is produced as food and feed intake globally. However the biological protein value of normal maize is low and deficient in essential amino acids lysine, tryptophan and threonine. Appropriate diet is crucial for health, physical and mental welfare for individuals. But apposite diet relics a contest mainly highest in African critically in the communities where highly depend on maize as a diet. The most imperative solustion was the advancement of quality protein maize (QPM) payable investigation of mutant opaque-2 gene which enhances the levels of lysine and tryptophan in the endosperm. This paper reviews certain current accomplishments in the revolution of QPM varieties through conventional and molecular breeding techniques under stressed and optimum soilconditions. It is also obvious that certain QPM geno types have been developed and released mainly by CIMMYT and International Institute for Tropical Agriculture (ITTA) globally applying both breeding approaches in the past and the present. However the review addressed certain gaps in research efforts and defies as well as adoption and promotion of QPM varieties emphasized and ideas to impressed. Various conventional breeding approaches have been used to develop and released QPM varieties in various soil conditions. However the application of molecular methods will advance the proficiency and speed of QPM improvement, the charge inferences could emped these technologies in the emerging countries. Further stress should be given for breeding QPM in stress tolerance (acidic soil, low soil nitrogen, drought) and post harvest loss (weevil) tolerance. Therefore it needs to more focu and emphasis for molecular breeding approaches and capacitate the breeders for this technology with the involvement of participatory breeding and variety selection through adoption and promotion enhancing the distribution and production of QPM varieties.

Keywords: Phytocenosis, Formation, Hole-meadow, Dominant, Association.

INTRODUCTION

Maize (2n=2x=20) is monoecious allogamous and highly cross pollinated crop [1,2]. It is genetically accepted its center of origin is Mexico and Central America with domesticated starting 6,000 to 7,500 years ago in the Mexican highlands [3]. Francisco Hernandez Boncalo was the first to report the existence of this crop in 1570 and carried out the study of Mexico's flora with several evidences about maize by Serratos-Hernandez [4]. Now maize is the second most grown cereal crop for human consumption after wheat globally criticaly in Sub Sharan Africa (SSA) including Ethiopia [5]. Maizeis extensively consumed in Central and West Africa used as raw materials in the food industry starting from 16th to 17th it has been highly and widely produced in Ethiopia mainly in the mid and lowland sub humid areas ot the country [6].

Several million people in the world predominantly in emerging countries derive their protein and calory supplies from maize. It accounts 15 to 56% of the total daily calories in the diets of people in the developing countries, like Latin America, Africa and Asia often used as the only protein source since animal protein is very costy with wasteful and not easly accessibl in various areas mainly in the rural people [1]. The relationship of several biological aberrations with the consumption of an imbalanced diet with famine is a main health dare in advanced as well as evolving countries [7]. Undernutrition is expected to straight cause 53% of child deaths mainly in the developing world 32% of offspring under 5 years are under sized and 20% under weight [8,9]. One of the central nutritive confines of ordinary maize kernel is its deprived of nutritional bases because of deficiency of indispensable amino acids lysine, tryptophan and methionine [1,10]. One approach to resolve the nutritive problems is to enhance the dietetic value of food crops in such bio fortification which is a promising strategy to address the underlying cause of under nutrition house holds pitiable access in the diet [11].

Quality protein maize (QPM) contains nearly twice as much lysine and tryptophan amino acids essential for humans and monogastric animals. Homozygous o2 mutant (QPM) has a quality value equivalent to 90% that of milk [12] QPM kernel is a biofortified, non-transgenic substenance provides and enhanced the protein quality to customers. Comparatively its physical appearance, kernel texture, colour, flavors and other stress tolerance nature is similar to normal maize, but QPM encompasses naturally occurring o2 mutant allele at the α-zeins controlling gene opaque-2 shows 60-100% fit in maize genetic advances of lysine and tryptophan amino acids essential for protein synthesis in humans verified in the laboratory [13,14]. The overall quantity of protein in QPM is not actually amplified, rather the protein is enhanced [8]. Drawing on the earlier studies revealed, kids suffering from malnutrition in maize-dependent areas have QPM instead of normal maize were benefited and improved 12% for body weight as well as 9% for height. Breeders have been tremendously effective enlightening the yield for normal maize. But advancing the grain quality was difficult given little attention and contest for a long time, however imperative advances have been ended by breeders in this area and started from the recent [15]. Maize with extensive range of conformations within the main grain constituents has ensued from breeders winning improvement of biochemistry and inheritances over years [16]. Several studies have been directed on QPM concerning the enhancement of the nutritive values and disease resistance earlier through breeding packages globally [1,17-19]. The main emphasis was advancing the protein content and probing the genomic diversity among QPM and normal maize genotypes [20]. Hoewever most studies desires to view on the acceptance of QPM towards biotic and abiotic constraits, for instance insect pest (weevil, fallarmyworm, maize lethal necrosis disease (MLND) heat stress recipe of drought and poor soil fertility and acidty. The review of this paper grants the current confirmation on conventional and molecular breeding techniques used to advance QPM genotypes. It provides an ended sight of QPM varieties globally, trends and contests encountering on QPM at the stakeholders. Whereas the gaps in the study resolves emphasising and improving the embracing of QPM. It is a rudimentary biological belief that quantity andquality advancement of a crop regulated by its genetic potentialities and ecology over its interior physiological and biological process. Enhancing the grain yield and quality of main traits for maize advance the humans and livestocks health. [2,21-23] conveyed that Zein and starch are the major constraints highly influenced the quality of maize grain.

HISTORICAL DEVELOPMENT OF QUALITY PROTEIN MAIZE

The primary goal of breeders has dedicated on enhanced yield with significant achievement attained by the advancement of hybrid maize (*Zea* mays *L.* ssp. Mays), impression of wheat (*Triticum aestivum*) and rice (*Oryzasativa*) diversities that allowed the Emerald Revolt [24]. Normal maize has the magnitudes of endosperm elements of 3% albumins, 3% globulins, 60% zein and 34% glutelin. All portions except zein are stable and relatively rich in lysine and tryptophan, but zein part is totally devoid the two vital amino acids (lysine and tryptophan). This was the main motive consequences for the advancement of other elements ironic in lysine and adding these amino acids in protein, but not an entiresource of per entity of endosperm in the grain [25,26].

In the 1920s in USA maize field an ordinary impulsive alteration of maize through soft opaque kernels was obtaind and termed as o^2 or opaque2 [27]. Supplementary investigation was ended in the mid 1960s, determinations were in adequate selection exclusive maize landraces to detect the genotypes greater for this trait. In the deficiency of particular gene(s) related with enhanced protein successive selection and evident conversion in nutritive value was detected [11]. An extended research was also done through the 1964, Oliver Nelson's (pHD) with his team at Purdue University (USA), obtaind homozygous recessive o2 allele with extensively higher lysine (+69%) and tryptophan in the kernel endo sperm than normal maize [16]. The discovery at the university of USA the biochemical effects of two mutant alleles o2 and floury2 (fl2), modify the amino acid profile and configuration of maize endosperm protein marks double intensification the levels of lysine and tryptophan [28]. A reduction is perceived in other amino acids such as glutamic acid, alanine and leucine [29]. Reducing leucine is essential, since it makes the leucine/isoleucine ratio more stable and reliefs to release additional tryptophan for more niacin biosynthesis soaiding to contest pellagra. Sulphur-rich amino acid, methionine is improved only in fl2 modified gene. The QPM advanced by CIMMYT in 1990's comprises 70-100% more lysine and tryptophan and 10% yield advancement than the new released tropical normal maize varieties [25,30]Currently about 17 African countries have introduced and promoted QPM, includes South Africa, Burkina Faso, Cameroon, Ivory Coast, Ethiopia, Ghana, Guinea, Kenya, Malawi, Mali, Mozambique, Nigeria, Ouganda, Senegal, Tanzania, Togo and Zimbabwe [9]. The genetic grain yield enhancement of maize has been substantial through earlier 3 to 5 decades [31] but the problem was the potential modifications in grain quality. This was stated that the biochemical quality of the grain varies among hybrids of maize [32]. As stated in (Table 1), variousnormal maize mutants conversing advanced lysine and tryptophan were identified in the 1960s and 1970s [26].

Table 1: High Lysine Mutants of Maize

No.	Gene	Allele	Investigators	Year of Discovery
1	Opaque-2	o2	Mertz, Bates and Nelson	1964
2	Floury-2	fl2	Nelson, Mertz and Bates	1965
3	Opaque-6	o6	McWhirter	1971
4	Opaque-7	o7	Ma and Nelson	1975
5	Floury-3	fl3	Ma and Nelson	1975

Maize endo sperm protein content

Endosperm of maize kernel is the stockpile of loading proteins [19]. Maize endosperm protein is entailed of different parts. Depending on their solubility categorized as albumins (watersoluble) globulins (soluble in saline solution) zein or prolamine (soluble with alcohol) and glutelins (alkali soluble). The problem of normal maize is low lysine gratified of protein in Zein maize endosperm and deleteriously affects the growth of humans and live stocks appirance. The pro lamine of maize grain are known as zeins and alcohol soluble proteins and consist of one major class α-zeins) and three minor classes β,γ and δ). The zein fraction α is rich in cystein while β- and γ-portions are rich in methionine [33]. These α, β,γ and δ found about 50-70% of maize endosperm and essentially rich in glutamine, leucine and proline, but poor in lysine and tryptophan [34,35]. As endosperm converts more and more vitrified the amount of lysine and tryptophan may decline due to affecting the inventive o2o2 phenotype, that is why intermittent quantification of amino acids in QPM packages is dynamic [36]. Currently through breeding at IITA to some extent improved the yield potential of QPM but still susceptible to stoirage pests (weevils) (Figure 1) [37].

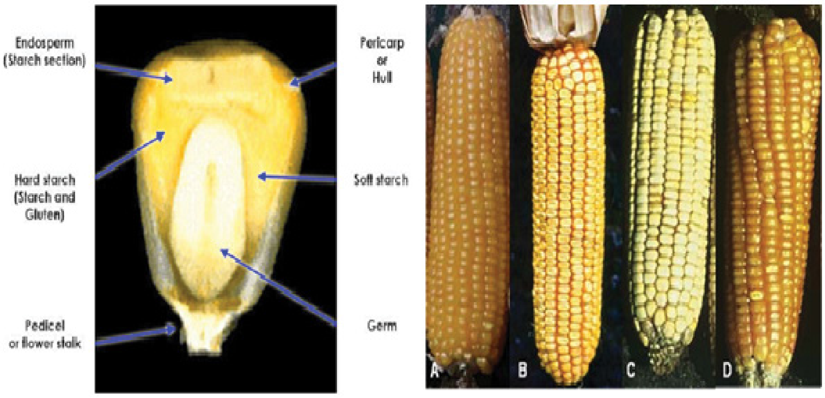

Figure 1: Kernel parts and structure of maize (A: Normal endosperm flint type ; B:normal endosperm dent type; C: opaque-2 and D: Quality Protein Maize) [35].

Comparisons of nutritional values of QPM and non-QPM

Under normal maize, the common ranges of endosperm constituents 3% for albumins, 3% for globulins, 60% for zein and 34% for glutelin but lack of lysine and tryptophan [20,26,38]. Earlier stated that 3.33% and 4.80% of crude fiber verified for QPM and normal maize correspondingly [28] also testified that Lysine content in MUDISHI 1 and MUDISHI3 the lysine/100g content were 3.6g and 3.5g of separately which substantial rise of 23% and 20% over the genetically enhanced normal maize. However it is quiet low comparing the average reference lysine content 58 mg/g of nutritional protein for the 2-5 year kid [39]. Nutrionally QPM kernel comprise 55 and 30% extra tryptophan and lysine respectively [40] 50-100% more lysine and tryptophan respectively CIMMYT [41] than normal maize varieties as a result of this the dietetic quality of protein in QPM kernel approaches with that of protein derived from cow's milk [36] reported normal maize enclosed larger amounts of methionine, while QPM had larger extents of lysine and tryptophan [12] also conveyed the endosperm of o2 maize contains twice as much lysine and tryptophan and 30% less leucine than normal maize. The decreased level of zein (5-27%) in o2 maize along with reduced leucine, leads to more tryptophan for niacin synthesis and thus helps to combat pellagra and significant advances its nutritional quality [42].

Normal maize is frequently available without enhanced levels of lysine and tryptophan desirable to produce proteins and has its niacin (vitamin B_3) inevitable an indigestible complex and high in maize produce complaint of wet-malnutrition leads to 'Kwashiorkor'and 'marasmus'affected by extended deficiency of protein in the diet [17,26,43,44] The grain yield potential of QPM varietiesare similar andcompitative with the grain yield ofnormal maize [45]. The recessive o2 is a natural mutant and but not a genetically modifie (GMO) (Tables 2 and 3)[26].

Table 2: Relative mean % of lysine and tryptophan in opaque-2 and normal maize [46,47]

	Normal g/100 g Protein	Opaque-2
Lysine	2.6	4.2
Tryptophan	0.4	0.9

The nutritional quality and its impact

The nutritive quality in protein is indomitable by the magnitudes of indispensable amino acids, which cannot be synthesized by humans and live stocks and hence must be provided in the diet [48]. If only one of these amino acids is inadequate, the others will be fragmented and evacuated subsequent poor growth of live stock and humans with the loss of N in the diet. There are 10 essential amino acids namely: lysine, isoleucine, leucine, phenylalanine, tyrosine, threonine, tryptophan, valine, histidine and methionine [49] Starvation is an obstinate problem in the world, critically the poor farmers in Africa where live in the rural areas and inadequate access of nutrantive diet. Previously quality traits dependent on chemical composition were less studied for a long period. But currently it became pertinent and more imperative for a variety to be selected by the consumers to acquire nutritional value [50].

Table 3: Contrasting the protein value of normal and opaque maize with milk [46,47]

Quality as % of milk	
Normal maize	39
o2 maize	90
Milk	100

Animal nutrition

The previous study which was conducted on pigs reveald that animal nutrition tested high lysine or trptophan weight at unevenly double the degree of live stock fed only on normal maize with out extra protein supliments. As the report directed that later 60 days, 14 pigs fed HQ-61 suplimented through a high lysine/tryptophan maize, weighed 18 kg over those suplimented QPM than pigs fed normal maize as indicated in (Figure 2) [51].

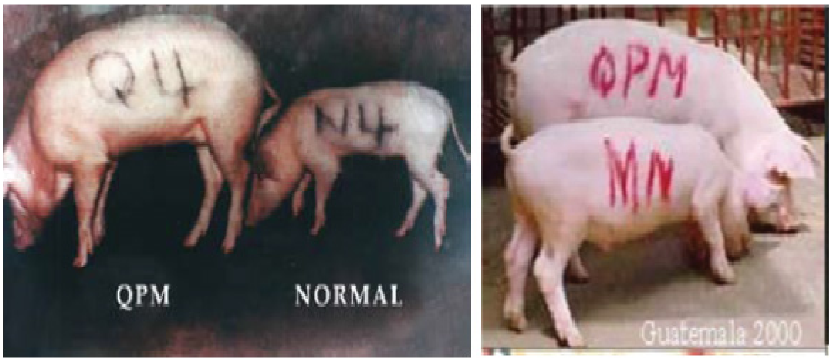

Figure 2: Pig fed high lysine/tryptophan maize (bigger animal tagged Q4) contrasted with its sisterly provide for normal maize (designated as N4). Source: Cited by Vivek [26].

Human nutrition

Various studies were conducted in human nutrions by different investigators [52] in Ghana investigated that the children who had food intake with high lysine/tryptophan QPM as a form of porridge acquire three main advantages: fewer illness in days and healthier opportunity to escape passing as aresult of diarrhea decrease impeding of growth and good physical strength. [11,35,44,50,51] supported the prominence of QPM for children supllying protein [53] indicated that antenatal ladies the aged and children below the age of 5 are the most exposed groups toprotein-energy under nutrition. The investigations conducted in Ethiopia, Madagascar and Burundi revealed that 1 in each 2 children is stunted and inhibited due to lack of liysine and tryptophane in the diet UNICEF [54]. Hence, hunger and malnutrition are predominant in economically depressed countries particularly the rural poor homistood thus QPM is very imperative to solve this problem [45].

The possible quality measurement parameters of QPM

The most centralquality measurement components of maize are protein, oil and starch. At Elora the Research was conducted in 1987 and 1988 and the chemical concentrations were assessed for various nutrients and amino acids including the physical quality parameters like softness of the endosperm, density and kernels mashing of thegrain [36].The premeditated chemical quality parameters were focused on Nitrogen (N), Phosphorus (P), potacium (K), Calcium (Ca), and Magnisium (Mn) from macro while Zinc (Zn), Copper (Cu), Manganeze (Mn) and Se among micro elements withlysine and tryptophan as well as lipid. The Nitrogen deliberation was determined using calorimetrically with Technicon Auto Analyzer II after incorporation of 250 mg samples with sulphuric acid [55] and inductively together with plasma spectrometry used for determination of thse elements to extract the grain [56]. Lysine and tryptophan were analyzed with high enactment liquid chromatography [57-60]. Kernel breakage through samples were considered as physical quality factors where as volumetric test weights were indomitable conferring the way stated by the Canadian Grain Commission (1980). The investigation directed that the hybrid by plant density interface was non-significant for all elements except N. Hybrids varied for all the macro element contents except Ca. Lysine and tryptophan concentrations did not vary through plant densities among hybrids. Generally increasing the plant density will reduce the physical quality like weight kernel density and kernel weight. Reduction of chemical quality may have occurred with breeding for higher grain yield if the concentration of Mg, Cu, Mn, and Se will be higher. For chemical quality only N P and Mn applications were adversely affected by the higher plant density. The study also confirmed that maize homozygous recessive o2 mutation has extensively higher lysine and tryptophan content than either heterozygous (O2o2) or homozygous dominant (O2O2) for the opaque-2 locus [27].

THE POSSIBLE BREEDING APPROACHES FOR IMPROVING QPM

Genetic enhancement strategy of maize has been started when it started to be domesticated and produced immense amounts of allelic diversity and heritable factor in an energetic system of compatible rudiments in the previously from the wild relative teosinte (*Zea mays* subsp. parviglumis) conventionally [3]. Segregation nature of maize was also improved by normal selection particularly subsequent introduction into new evolving areas recombination drift and mutation contributed to the variability in maize germplasm [58]. Association mapping has been extensively used to study the genetic basis of traits in wide range of crops mainly vital for maize and a very efficient active technique imitating entrant genes or isolating new genes [61]. This is now more powerful than in humans or animals [62]. Genetic mapping via linkage or association may not be achieved in the absence of measurable polymorphisms, therefore large differences at the phenotypic level and a high density of polymorphisms at the DNA structure level are vital (Figure 3) [63].

Figure 3: Examples of the range of phenotypic variability in maize germplasm held in theCIMMYT gene bank.Source.photo provided by Dr. Suketoshi Taba, CIMMYT

QPM development through conventional breeding

There are various breeding options for developing hard endosperm, market acceptance and high lysine maize through competitive agronomic performance [64,65]. Quantitative heritable approaches was used to treat the amino acid levels as a multigenic trait with continuous variation. The QPM improvement was started with the finding of opaque-2 mutant (o2o2) from an ear through soft white seed in the 1920s via back crossing and advanced recurrent selection [42,66]. The QPM endosperm amendment study has been engaged in India about 1964 [11] and CIMMYT in 1969 [67]. In 1961 Researchers at Purdue University observed that mutant lines that were homozygous for o2 allele had significantly twice lysine content in endosperm compared to normal maizewas promising for the researchers in the genetic manipulation of QPM and other mutant types that had altered amino acid composition likefloury-2 (fl-2) [68] o7, o6 and (fl-3) [69] defective endosperm (De-B30).

Selection principles wasencompassing normal maize breeding populations have centered on altering germ endosperm ratio for multiple aleuronic layers and recurrent selection to exploit accepteddeviation for high lysine gratified. Varying the germ endosperm ratio to favor collection of larger germ size resolve the dual benefit ofimproving both the protein quantity and quality. Recurrent selection for high lysine in normal endosperm populations has been mostlyineffective due to the narrow genetic diversity and heavy reliance on laboratory services [70]. As dudley and lambert have reported in 2004, the levels ofone or more indispensable amino acids are negatively associated with total protein content expressed as a % of the total protein. The other problem with this approach is indicated in the Illinois long term selection populatlons in which a high protein population yielded less grain per unit area than a low protein population [71]. Using selection the levels of specific amino acids and increasing the essential amino acid content without increasing total protein content equivalently. Physiologically this may be possible by re allocation of nitrogen from non vital amino acids into essential amino acids and possiblyinclude increasing the ratio of non-zein to zein proteins. Recent QPM refinement approaches at CIMMYT emphasised onpedigree breeding wherever by the greatest success inherited lines, harmonizing in dissimilar traits are traversed to begin new segregating relatives [35].

There were field experiments in main seasons of 2006/2007 at CIMMYT Harare Research Station Zimbabwe and Bako Agricultural Research Centre, Ethiopia under both low and optimum N environments at each location. The aim of the study was to evaluate the protein quality and quantity in the endosperm and identify the GCA and SCA effects in protein quality traits of QPM inbred lines under both circumstances. The materials were evaluated from reciprocal crosses bulked to form a set of 105 F1 hybrids. Those F1 hybrids were evaluated along with two QPM (SC527Q and CML144/CML159//CML176) and one normal maize (SC633) hybrids as a standard check at Harare, and with two normal maize (BH540 and BH541) and one QPM (BHQP542) at Bako. Totally 108 hybrids (105 F1s and 3 checks) were used in the experiment with 9 × 12 alpha-lattice design with two replications at each location. The analysis of variance reveald that the hybrid performance and effects of soil nitrogen significantly different in all measured traits under both soil environments at both location (Harare and Bako). At Harare the mean tryptoph and eliberation in the kernel showed 0.68 g kg^{-1} for the QPM hybrids under low nitrogen was higher than the tryptophan concent ration 0.65 g kg^{-1} with comparable result at Bako. Higher values of quality index were detected for QPM hybrids compared to normal hybrid checks under all environments. The quantity of opaque endosperms and protein quality index enlarged where as tryptophan and protein concentration in the kernel reduced more under low nitrogen than optimum conditions at both sites. Tryptophan and protein amount in the kernel reduced at both sites where as protein quality index amplified under low nitrogen condition [72].

Additive heritable effects are more imperative than non-additive effects for grain yield and endosperm firmness in o2 background of the QPM. Similarly additive genetic variance is more vital regulating the face of protein quality traits than non-additive genetic divergence for protein and tryptophan in the kernel [73] Muzarabani, Zimbabwe Diallel crosses were made among 15 inbred lines in 2006. Soft endosperm of op2op2 genotypes primarily affected up to a 25% yield loss in line for the inferior thickness of the opaque kernels along with susceptibility to fungal rot diseases and storage insect pests like weevil [30]. From this review it can be concluded that the protein concentration in the kernel is more delicate to low nitrogen than tryptophan concentration as a result of this protein quality index improved under low nitrogen condition as compared to that of optimum nitrogen.

Molecular approaches for QPM development

Genetic enhancement of protein quality of opaque-2 mutants is skilled via reduction in levels of zeins through several mutant alleles and is achieved by more over decrease in levels of a number of zein sub elements, amount of accrual of zeins rise in methionine comfortable influence on technique and design of loading protein accrual. Molecular description of o2 allele reveald that it encodes a transcriptional issue that controls the expression of zein genes [74,75] Reducing the research length and to be confident via molecular approachis decisive even though conventional back crossing is vital for the improvement of QPM hybrids. Quantitative trait locus (QTL) is a principal and well-established tool for revising the genetic basis of complex measurable traits in crops and live stocks [32]. Genetic engenerring via transforming innumerable metabolic path ways in lysine and tryptophan is a prospective approaches and it could be exploited in extra for surplus protein quality enhancement. Molecular markers are known in the o2 gene and capable of detecting the o2 gene even in hetero zygous state. Previously 2000 years ago the hybrid was advanced crossing two inbreeds viz. CM 212 and CM 145 used as recipients of the o2 gene. CML 180 and CML 170 were acquired from CIMMYT and exploited advanced in the laboratory. Then converted CM 212 and CM 145 normal maize inbred lines in to QPM inbreeds VQL1 and VQL2 respectively. The two transformed QPM inbreeds were crossed to improve QPM hybrid Vivek QPM 9 [76]. This has been indicated in (Figure 4).

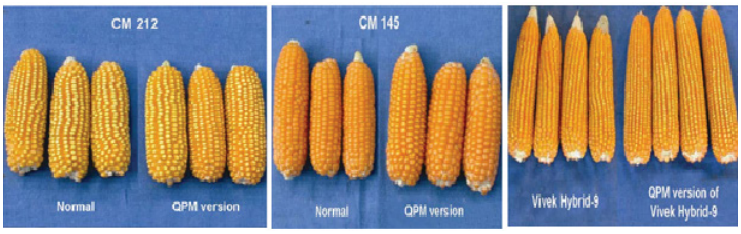

Figure 4: Normal and QPM version of CM 212 (VQL1) and QPM version of CM 145 (VQL2), andears of Vivek Maize Hybrid 9 and Vivek QPM 9

Nkongolo et al. [29] also studied the total protein and amino acid profile of QPM with their parental stocks and locally improved normal maize variety at Congo determining the amino acid profile using two improved QPM (MUDISHI1 and MUDISHI3) varieties, and advancing the variety-diagnostic through molecular markers (ISSR diagnostic-marker of 480 bp) breeding technique. The data analysis revealed that MUDISHI1 and MUDISHI3 are distinct from their original population, Longe5 QPM from NARI- Unganda and DMR-ESR-W-QPM from the International Institute for Tropical Agriculture (ITTA). MUDISHI1 showed better yield comparing the local checks (normal maize), but susceptible to down mildew and maize streak virus whereas MUDIDHI3 is highly resistant to downy mildew, lodging and maize streak virus but the grain yield was lower than normal maize.

THE SIGNIFICANCE OF QPM

Maize as a protein source places people at risk for nutritional protein deficiency due to the deficiency of two essential amino acids (lysine and tryptophan) but QPM maize used as a pitiable source of these essential amino acids. QPM also assist as a vital basis of protein for both humans and mono gastric live stocks [77-79]. Protein found in both the endosperm and embryo accounts about 85% of the kernel on a dry weight basis. The other study in Nigeria, concentrating to analyze thefunctional properties of maize meal soy flour and maize meal/soy flour blends, potentially important for sour maize bread making andpossibly, other applications in confectioneries. Normal maize QPM and soybean seeds (Glycine max) were encompassed in the study with the aid of different laboratory techniques for the flour meal quality analyses and nutrient compositions. The physical and chemical properties of samples analysis result of pH and proximate composition of the flour/meal was shown (Tables 4 and 5).

Table 4: Proximate compositions and pH of flour/meal samples

Parameters (%)	NSM	QPM	CSS	MSA	MSB
Moisture content	7.15^{b}	$6.90^{a,b}$	6.11^{a}	7.66^{b}	7.42^{b}
Fat content	4.09^{a}	4.80^{a}	14.03^{c}	8.66^{b}	9.14^{b}
Crude protein	8.96^{a}	11.76^{b}	36.00^{e}	20.73^{c}	22.76^{d}
Crude fibre	1.48^{c}	1.09^{b}	0.21^{a}	0.34^{a}	0.22^{a}
Ash content	$1.33^{a,b}$	1.02^{a}	2.95^{b}	2.85^{b}	2.88^{b}
Carbohydrate	77.06^{c}	74.43^{c}	40.67^{a}	59.76^{b}	57.58^{b}
pH	6.03^{a}	6.09^{a}	6.85^{a}	6.38^{a}	6.44

Keys: Nsm : Flour Soldfrom Normal Maize; Qpm : Flour From Quality Protein Maize; Css: Flour From Commercially Sold Soybeans; Msa : Maize-Soy Flour Blend 1(90% Maize Flour + 10% Soybean Flour) And Msb : Maize-Soy Flour Blend 2 (80% Maize Flour + 20% Soybean Flour). Values followed by different subscripts are significantly different by Duncan's Multiple Range Test across columns (p 0.05) .

Table 5: Vitamin and mineral contents of flour/meal samples

Component	NSM	QPM	CSS	MSA	MSB
Calcium	11.47^{a}	12.37^{b}	13.33^{d}	12.50^{bc}	13.10^{d}
Phosphorus	0.25^{a}	0.26^{a}	0.33^{b}	0.25^{a}	0.26^{a}
Potassium	0.02^{a}	0.02^{a}	0.04^{b}	0.04^{ab}	0.04^{b}
Iron	2.70^{a}	2.83^{a}	2.63^{a}	2.83^{a}	2.93^{a}
Vitamin A	0.06^{a}	0.13^{b}	0.46^{d}	0.12^{b}	0.23^{c}
Thiamin	0.35^{a}	0.39^{ab}	0.60^{c}	0.44^{b}	0.64^{c}
Riboflavin	0.13^{a}	0.15^{ab}	0.21^{c}	0.16^{b}	0.17^{b}
Ascorbic ac	4.27^{a}	4.07^{a}	5.13^{b}	4.40^{a}	4.55^{a}
Niacin	2.43^{b}	2.69^{b}	1.78^{a}	1.81^{a}	1.87^{a}

Values followed by different subscripts are significantly different by Duncan's Multiple Range Test across columns (p 0.05)

From the investigation in Tables 4 and 5 can be concluded that the flour/meal or blend used for sour maize bread preparation influenced the nutritional value as well as physico-chemical possessions of the breads formed and can be suggested that to prepare nutritionally stable and organoleptically adequate bread artifact from maize the addition of protein complement in the ingredent of soybean flour and other pulses with amino acid profile should not superior than 10% comparable with soybeans. Ingeneral in maize producing areas consuming QPM subsidizes high protein lysine and tryptopnane in the diet that is comparable obtaind from cow milk and being cost effective due to easly accesibility critically in the rural areas.

MAJOR CHALLENGES FOR IMPROVING QPM

Breeding through the improvement of QPM is a challenge to produce high quality protein with high yield and other significant agronomic traits, especially with today to fulfill the food and feed demands answering the energy disaster. Among challenges, mutations adversely affect pleiotropic effects having multiple phenotypic expressions that reduce their agronomic compliance, need mainly to improve the kernel characteristics and soft endosperm structure. The appearance of the kernel is altered to a soft, chalky phenotype that is unattractive and physiological drying to maize growers in the developing countries. A higher vulnerability to ear rot observed, resulting in high pest infestation rates in stored grain. Even though many open pollinated and hybrid QPM maize varieties achieved in the mid 1970s, but oppositions are usual due to absence of competitiveness of these varieties with customers trait preference, soft endosperm make suseptable to fungal diseases and some what lower yields than the highest profitable released available normal maize varieties. This problem have been indicated in Figure 5. The other major challenges are lack of molelecular brreding and genetic engineering skills in the breeders as well as limitation of molecular brerding tools. Since maize is highly segregant crop with pollen contamination and reduced the protein quality (opaque-2).gragually depleted.

Figure 5: Soft endosperm o2ears showing intense of pericarp and ears of Pool25, C0 soft endosperm *o2*maize (left) and ears of its enhanced versionC18 (right side) Vivek et al. [26]. Both A and B,figures have highlysine and tryptophan levels. Though C18 is deliberated QPM due to it also has desired kernel characterstics.

FACTORS AFFECTING QPM GRAIN QUALITY AND ITS DISTRIBUTION

Physical quality parameters like plant density kernel breakage and colour mainly influence the physical quality of maize like Kernel weight density and total weight softness of the QPM endosperm make the crop easily influenced by weevil and reduced the shelf life for future food consumption and market value but it doesn't mean that the physical parameters affect the amino acids and lipid concentrations or the chemical quality of maize.

Protein quality is an important factor determining maize quality. The zein endosperm protein increases as protein concentration increases lowering feed quality some what because zein has only trace amounts of the essential amino acids lysine and tryptophan [80]. Even though there is QPM suplliment information and skill gap make hesitantat the societies practically the nutritive values of QPM in supplementing protein desires for human being moreover various constraints have ignored the advancement of QPM predominantly in Sub-Saharan Africa, as a result of privation of awareness on the protein ingredients of QPM and its contribution in the diet [81-85].

CONCLUSION

Generally QPM maize have a significant role in areas where exnsively produced and consumed for human nutrition, critically used as a poor source of protein in the diet for children, preginant mothers, refuges suffering defficiency of protein, investors participating in live stocks production and fattening. Conventional and molecular breeding approaches are very important for the improvement of advanced varieties and various QPM genotypes have been released globally. QPM production distribution needs an accessible distance based on the nutrentive quality of the varaties, there should be adoption and promotion rate of QPM globally mainly in the developing countries where maize extensively produced and consumed in the diet at the small scale farmers. Main limitation in QPM development is concentrating on conventional techniques and little attention for molecular breeding as well as infection of pollen which leads to gradual loss of QPM's nutritive quality. Therefore a proper and comprehensive seed development and delivery schemes should be embraced in the distribution of QPM maize producers in the future.

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