Micronutrient Enhancement in Maize and its Products in West Africa: A Sustainable Approach to Mitigate Hidden Hunger

Project Proposal

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by

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Micronutrient Enhancement in Maize and its Products in West Africa: A Sustainable Approach to Mitigate Hidden Hunger

Proposal Highlights

Goal To improve the nutritional status and livelihood of the rural and urban populations in West Africa by reducing diseases caused by micronutrient deficiencies.

Purpose Enhanced levels of micronutrients in maize-based diets through development of improved maize cultivars high in iron, zinc, and provitamin A, improved processing and storage of maize flour and products, and fortification of maize meal and flour with the target micronutrients.

Objectives

- Determine the prevalence of deficiencies in vitamin A, iron and zinc in populations of Ghana, Nigeria, Benin and Burkina Faso.
- Develop cultivars of maize fortified with high provitamin A, iron, and zinc content in the grain.
- Increase micronutrient content of maize products through dietary improvement and fortification.
- Promote the multiplication and distribution of maize cultivars and fortified maize products with high content of micronutrients.
- Enhance human capacity for dietary improvement and fortification through training, seminars and workshops with national agricultural research and extension systems.
- Assess the impact of dietary improvement and micronutrient fortification on nutritional status of the target groups.

Collaborating institutions International Institute of Tropical Agriculture (IITA), Semi-Arid Food Grain Research and Development Project (OAU/STRC-SAFGRAD), West and Central African Maize Collaborative Research Network (WECAMAN), National Agricultural Research and Extension Systems (NARES) in Benin, Burkina Faso, Ghana, and Nigeria.

Duration Three Years

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Contribution in-kind IITA $315,000; SAFGRAD $52,000; WECAMAN $87,000; Benin $29,000; Burkina Faso $29,000; Ghana $42,000; Nigeria $51,000.

Executive Summary

Deficiencies in micronutrients (vitamin A, iron and zinc) are widespread in West Africa affecting more than half of the population. Individuals and families suffer serious consequences including learning disabilities, impaired work capacity, illness and death. Several factors have contributed towards aggravating micronutrient deficiencies in the region, including high population growth, poverty, degradation of the environment, poor agricultural development support services, and lack of an enabling economic policy environment. The micronutrient initiative has evolved as a participatory, co-operative project involving several partners and stakeholders engaged in the alleviation of malnutrition.

This is a holistic project, which aims to improve the nutritional status and livelihood of the rural and urban populations in West Africa by reducing diseases caused by micronutrient deficiencies. This will be achieved by enhancing levels of micronutrients in maize-based diets through development of improved maize cultivars high in iron, zinc, and provitamin A, improved processing and storage of maize flour and products, and fortification of maize flour with the target micronutrients. These products will be disseminated through enhanced linkages with extension and the private sector. The project builds on IITA's strong relationships with SAFGRAD, WECAMAN and NARS in West and Central Africa while maintaining the research momentum that provides improved technologies.

The problem of micronutrient deficiency is complex, as it is influenced not only by agriculture and the available food supply, but also by socio-economic conditions and government policy. Furthermore, the urgency of the problem requires actions that will be effective in offering both immediate relief as well as solutions that will be self-sustaining over time. A major feature of the project is its emphasis on implementation in four pilot countries, Nigeria, Benin, Burkina Faso and Ghana, where maize is an important staple food crop. It involves key stakeholders in the research community and commercial sectors, yet maintains a focus on delivery of products high in micronutrient content to the end-users. The primary beneficiaries of this project are children under 6 years of age, pregnant women, and nursing mothers in West Africa.

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Background and Justification

Background

An estimated 180 million people in Africa are undernourished; it is predicted that by the year 2010 this number will grow to some 300 million people, representing nearly 32% of the continent's total population. The lack of food security for a large segment of the population continues to exacerbate poverty and malnutrition. Poverty and malnutrition are inter-related problems, which have devastated the livelihoods of millions of households. Sub-Saharan Africa is the only region in the world where the nutrition situation has deteriorated in recent decades. Despite growth in food production in recent decades, the poor performance of economies of sub-Saharan Africa has increased unemployment resulting in a decline in the purchasing power and a general deterioration in nutritional status of the people. Several factors have contributed to the aggravation of malnutrition in the region, including high population growth, poverty, degradation of the environment, poor agricultural development support services and lack of an enabling economic policy environment. This has resulted in a high incidence of deficiency diseases such as protein-energy malnutrition, iron deficiency anemia and corneal blindness due to vitamin A deficiency. The groups most vulnerable to malnutrition are pregnant and nursing mothers, and weaning and pre-school children. This project can contribute immensely towards improving the nutritional status of the population in West Africa.

As one of the main staple food crops in many countries of West Africa, maize can play a critical role in improving the nutritional status of the poor. FAO data for West and Central Africa from 1981 to 1990 show per capita maize utilization rising at an average rate of 2.5% per year. Per capita maize consumption ranges from 30 to 90 kg/yr in coastal countries of West Africa. An inherent advantage of working with maize is that it can be an appropriate vehicle for fortification, as it is a staple food consumed by the poor in large quantities every day in many countries. Most of the locally available and affordable weaning foods use maize as the main constituent. Maize has high productive potential and is easily converted into well-accepted local food products. For example, in Benin, Cameroon, Côte d'Ivoire, Ghana, Nigeria and Togo, maize is consumed as a starchy base in a variety of gruels, porridges and pastes. Green maize, consumed boiled or roasted on the cob, is important in bridging the "hunger gap" after a long dry season. Maize provides 50% or more of the total intake of micronutrients (iron and zinc) in the diets of the poor in sub-Saharan Africa (Ruel and Bouis, 1998) and 47% of the per capita protein intake (Bauernfeind and DeRitter, 1991). Developing fortified cultivars and products of maize with high available micronutrient content could significantly improve the health and nutritional status of the poor, especially women and children, which in turn would enhance the future economic well being of countries in West Africa.

Prevalence and potential impact of micronutrient deficiency

Millions of people in Africa suffer from the ravages of deficiencies in micronutrients, such as vitamin A, iron and zinc, and continue to live in poor health with low productivity and inferior quality of life (Calloway, 1994; FAO, 1987; Gibson, 1994; Lotfi et al., 1996). The major cause of micronutrient deficiencies is inadequate intake of foods rich in micronutrients. For example, in West Africa, vitamin A deficiency occurs in areas where red palm oil and plantain are not available in sufficient quantities. Even in areas where they are available and consumed regularly, pockets of endemic diseases caused by vitamin A deficiency can be found (Hettiaratchy, 1997). Although vegetables can be inexpensive and good sources of minerals and vitamins for the poor, their availability is seasonal (FAS, 1999). In addition, it has been observed that even in areas where families consume vegetables, sub-clinical and clinical signs of vitamin A deficiency have been found among children who are often reluctant to consume green leafy vegetables. Furthermore, the poor in West Africa often cannot afford animal products that are rich sources of vitamin A and minerals but rely on cereal- and legume-based diets as major sources of essential micronutrients. However, these diets do not provide adequate quantities of vitamin A, iron and zinc to fulfil the daily requirements of the population (Ruel and Bouis, 1998). Also, the high intake of antinutritional factors such as phytate in cereal- and legume-based diets reduces the absorption of iron and zinc.

In sub-Saharan Africa, an estimated 980 thousand pre-school children show clinical signs of vitamin A deficiency, of which 480,000 reside in West and Central Africa (MI, 1998). As many as 17.4 million people in West and Central Africa show sub-clinical signs of vitamin A deficiency. The average prevalence of clinical and sub-clinical vitamin A deficiencies in 19 countries of West and Central Africa is estimated at 1.1 and 20.4%, respectively (UNICEF, 1998). The sub-clinical and clinical signs of vitamin A deficiency in selected countries of West Africa are presented in Figures 1 and 2.

The prevalence of iron deficiency is high among children and women in West Africa. In Burkina Faso, 70% of the children below five years of age and 40% of pregnant women suffer from iron deficiency anemia. The prevalence of iron deficiencies in Ghana is 10.5% for pre-school children, 7.5% for school-age children, 13.5% for pregnant women and 12.5% for nursing mothers (Quarshie and Agble, 1999). In Nigeria, up to 50% of children and 61% of women in the Southeast are anemic (FGN/UNICEF, 1994). Little data is available on the prevalence of zinc deficiency in West and Central Africa. In the sub-region, it is estimated that 20 to 30% of mortality in children under five years of age can be prevented if they are fed diets with sufficient protein, vitamin A and other micronutrients.

Vitamin A deficiency can lead to permanent blindness in children (Bouis, 1995; Lotfi et al., 1996). Even mild vitamin A deficiency can suppress the immune system and, hence, predispose children to common diseases, including respiratory tract infections, measles, and diarrhea. Vitamin A deficiency can also increase the risk of dying from HIV infection (Cervinskas and Lotfi, 1995). Iron deficiency causes anemia, learning disability, mental retardation, poor physical development, and diminished ability to fight infectious diseases, reduced capacity to do physical work and premature death (Bouis, 1995; Lotfi et al., 1996).

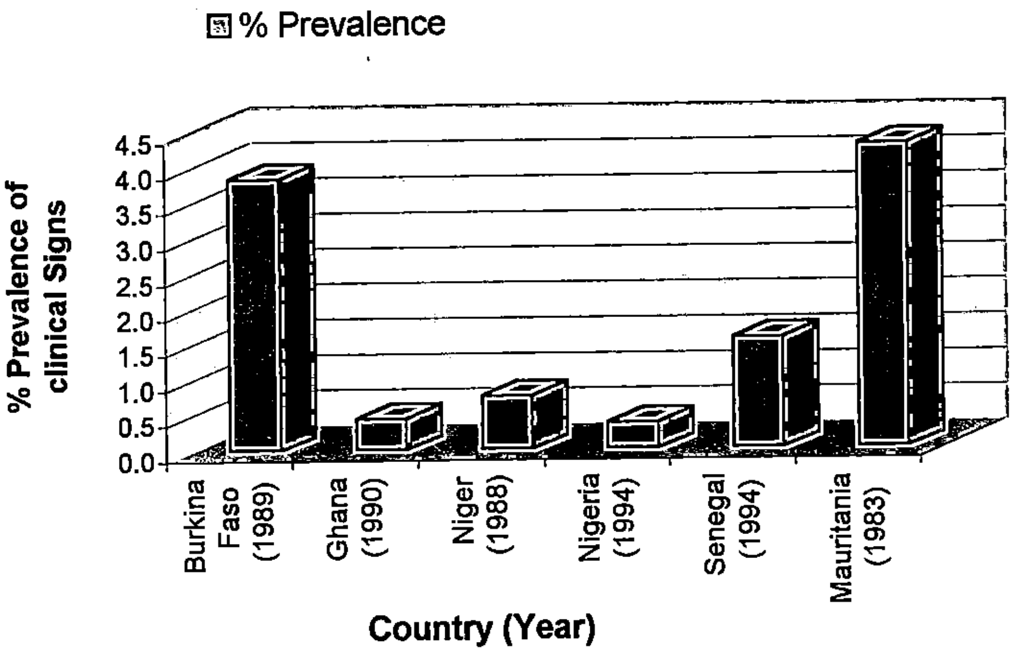

Fig. 1. Prevalence of clinical Signs of Vitamin A Deficiency (VAD) from National Survey data in selected countries of West Africa

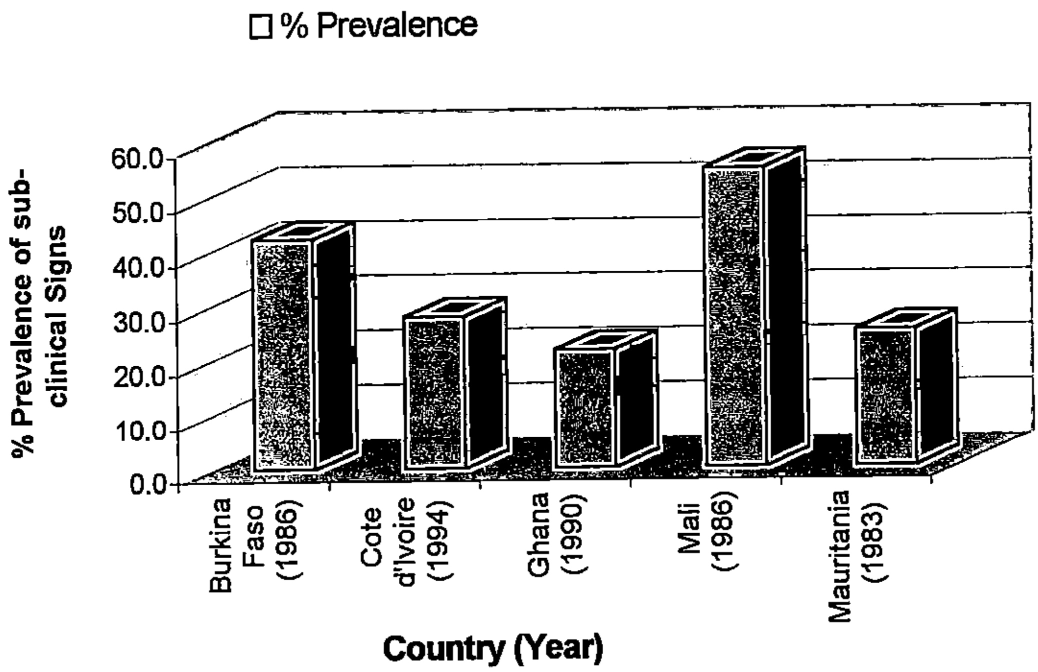

Fig. 2. Prevalence of sub-clinical Signs of Vitamin A Deficiency (VAD) from National Survey data in selected countries of West Africa

The adverse effects of iron are more severe among infants, pre-school children, pregnant women and nursing mothers because of their high physiological requirement for this nutrient (FAO, 1987; Lotfi et al., 1996; Wagt, 1995). Zinc deficiency can cause retarded growth, depressed immune system, loss of appetite, dermatitis, skeletal abnormalities, diarrhea, loss of hair as well as increased complications and mortality during childbirth (Graham and Welch, 1996; Bouis, 1995; Ruel and Bouis, 1998).

Program Goals and Objectives

Vision Statement

The present proposal responds to an urgent and increasing need for food products with enhanced nutritional quality for resource poor farmers and consumers in West Africa. These products will be developed through research and disseminated through effective research-extension-private sector linkages. It builds on IITA's strong relationships with SAFGRAD and NARES in West Africa while maintaining the research momentum that provides improved technologies.

Goal

To improve the nutritional status and livelihood of the rural and urban populations in West Africa by reducing diseases caused by micronutrient deficiencies.

Purpose

Enhanced levels of micronutrients in maize-based diets through development of improved maize cultivars high in iron, zinc, and provitamin A, improved processing and storage of maize flour and products, and fortification of maize meal and flour with the target micronutrients.

Objectives

1. Determine the prevalence of deficiencies in vitamin A, iron and zinc in populations of Ghana, Nigeria, Benin and Burkina Faso.

2. Develop cultivars of maize with high provitamin A, iron, and zinc content in the grain.

3. Increase micronutrient content of maize products through dietary improvement and fortification.

4. Promote the multiplication and distribution of maize cultivars and fortified maize products with high content of micronutrients.

5. Enhance human capacity for dietary improvement and fortification through training, seminars and workshops with NARES.

6. Assess the impact of dietary improvement and micronutrient fortification on nutritional status of the target groups.

Target Beneficiaries

The primary beneficiaries of this project are children under 6 years of age, pregnant women, and nursing mothers in West Africa. Through this project, they will obtain fortified maize products essential for improvement of their nutritional status and health. This project will also contribute to the productivity, mental and physical health as well as well being of school age children and adult males. Farmers will receive from this project improved maize cultivars with high micronutrient content. The project will provide a sustainable solution to the problem of micronutrient malnutrition by developing products that can be produced economically by the community after the life of this project. Scientists from the national programs will build their institutional capacity to undertake food and nutrition research. Extension organizations, NGOS and the private sector will also benefit from the availability of maize cultivars and products high in micronutrient content. Table 1 summarizes the benefits and beneficiaries of the project.

Table 1. Benefits of the project to target groups in West Africa.

Target group	**Benefits**
Farmers	• Better availability of high quality seed • Greater productivity and profitability of improved varieties • Better markets for seed and raw materials
Processors	• Better availability of high quality raw materials • Income generation through use of novel processing methods and products
Retailers	• Income generation through marketing of novel primary and secondary products high in micronutrients
Consumers (especially children under 6 years of age, pregnant women, and nursing mothers)	• Increased awareness of nutritional requirements • Increased availability of diversified food products • Reduced incidence of nutritional deficiency diseases

Project Components and Methodology

Activity 1: Assessment of the prevalence and distribution of micronutrient deficiencies and their underlying causes in pilot countries.

Objectives

1. Determine the prevalence of vitamin A, iron and zinc deficiencies and their underlying causes in populations of Ghana, Nigeria, Benin and Burkina Faso.
2. Identify populations at high risk of developing micronutrient deficiencies.
3. Determine the effect of traditional processing methods on micronutrient content of maize products.

Background

When attempting to assess the prevalence of micronutrient deficiencies, globally, regionally, or nationally, the first problem encountered is the paucity of data available. The prevalence data by country that do exist, moreover, are often confined to a segment of the population, who are likely to be one of the groups most at risk, but not the only one. Inevitably, the design of any relevant action will be constrained by a lack of understanding of how many people are affected, who they are, and to some extent why they are affected.

Limited studies have been conducted in West Africa to determine the prevalence of micronutrient deficiencies. Available data from smaller scale studies indicate that micronutrient deficiencies (vitamin A and iron, among others) are evident in many sub-populations. Data available on zinc deficiency is minimal in West Africa. There has been progress in many countries in combating micronutrient deficiency, but urgent action is needed to accelerate progress and to increase rapidly the number of countries that are bringing micronutrient malnutrition under control. Assessment of the problem, knowledge on nutrients supplied by the diet and methods used during processing can be the keys to this acceleration in some countries.

Methodology

1. Conduct survey on prevalence of deficiencies in vitamin A, iron, and zinc in target areas of the four pilot countries.
2. Assess the nutrient composition of major food products consumed by the target population.
3. Evaluate the effect of traditional processing methods on micronutrient content of maize products.

Outputs

- The prevalence of deficiencies in vitamin A, iron, and zinc in target populations of the pilot countries determined.
- Effects of traditional processing methods on micronutrient content of maize-based products assessed.
- Nutrient composition of major food products determined.

Indicators for monitoring and evaluation

- Information on the prevalence of deficiencies of vitamin A, iron and zinc in the pilot countries documented.
- Information on nutrient composition of the diet of target groups available.
- At least 4 surveys conducted in pilot countries.
- The effects of at least 4 traditional processing methods on micronutrient content of maize-based products determined.
- Published reports.

Activity 2: Development of maize cultivars with high levels of provitamin A, iron, and zinc in the grain.

Objectives

1. Develop cultivars of maize with high provitamin A, iron, and zinc content in the grain.

Background

Breeding for increased concentration of micronutrients, such as provitamin A, iron and zinc, in maize seeds is considered to be another cost-effective approach to improve the micronutrient status for areas of subsistence farming which are beyond the market reach of fortified foods. Once varieties with high micronutrient content are introduced to a target population, their production and consumption can be sustained without any additional cost. Furthermore, this approach complements fortification and does not require either central processing of flour for fortification or behavioral changes in the target population. There is good prospect for enhancing the micronutrient content in maize through breeding. This can be achieved by selecting genotypes that accumulate high levels of provitamin A, and those which are efficient in tapping the otherwise unavailable iron and zinc in the soil (Bouis, 1995; Ruel and Bouis, 1998)

Studies at IITA (unpublished) showed large genotype differences in iron and zinc concentration in seeds of elite maize germplasm. Iron content ranged from 14.96 – 174.23 ppm and zinc from 11.56 – 100.00 ppm. A positive relationship (r=0.85) was observed between iron and zinc. Considerable differences in total carotene content were detected in kernels of yellow-seeded open-pollinated varieties screened at IITA (unpublished). Total carotene content ranged from 143.49 – 278 μg/g. Furthermore, the genetics of seed color in maize are well established. Once those genes that impart high beta-carotene content are identified, they can be manipulated easily through simple breeding procedures. It is often argued that varieties with enhanced nutrient content are inherently low yielding. However, a study at CIMMYT found very weak negative correlation (r = -0.17 to -0.39) of iron and zinc content with grain yield. It is, therefore, possible to deliver high concentration of iron and zinc in cultivars with high yield potential. Furthermore, breeding can enhance the bioavailability of minerals by reducing the amount of phytic acid and raising the concentration of sulfur-containing amino acids that are believed to promote absorption of iron and zinc (Ruel and Bouis, 1998). Raboy (1996) identified a mutant of maize with low phytic acid. Since low phytic acid seems to be conditioned by a single gene and a simple screening assay is available, it may be easy to manipulate phytic acid content in a breeding program.

The choice of iron and zinc in this project is important not only for nutritional quality but also for other reasons. Kang and Osiname (1985) reported widespread zinc deficiency symptoms in crops grown in soils of tropical Africa. Breeding maize for enhanced iron and zinc efficiency can minimize fertilizer requirements, improve seedling vigor, overcome yield losses resulting from undetectable deficiencies, increase resistance to disease and improve the yield and nutritional quality of maize grain (Ruel and Bouis, 1998). Iron and zinc efficient maize cultivars also may allow full exploitation of water stored in the sub-soil. Such a response may improve the potential yield of maize in marginal areas where drought and alkalinity are problems (Graham and Welch, 1996).

Varieties developed for diverse growing conditions in West and Central Africa should be stable in expression of their high density of micronutrients in different environments. CIMMYT carried out a study (unpublished) to examine the effect of low soil nitrogen and drought on iron and zinc content in maize grain. The combined analyses over environments showed significant genotype by environment interactions for the two minerals. Genotype by environment interactions for iron and zinc content in the grain was also detected in rice (Senadhira and Graham, 1999). Thus, selecting sources of micronutrients with stable expression across diverse environments is as important as increasing the micronutrient concentration in maize grain.

Environmental factors which affect crop physiology during the growing seasons have also been found to affect processing quality of maize grain. Studies conducted at IITA to determine the relative effect of genotype and environment on maize grain quality characteristics indicated that physical properties related to dry milling performance showed large effects due to locations and environments, and significant genotype by environment interaction (Kling and Okoruwa, 1994). The influence of environmental factors on specific characteristics affecting nutritional quality needs to be investigated.

As new genotypes are developed, milling quality and bioavailability of the nutrients would be assessed progressively using participatory methods and animal models. The nutritional value of the selected genotypes will be influenced by the loss of nutrients during processing and their bioavailability. Stability of carotene across different processing methods has been shown to be genotype-dependent and should be evaluated after selecting for high carotene concentration in maize grain. Thus, more research is needed to develop food processing and storage methods to minimize losses of micronutrients and enhance their bioavailability.

Methodology

1. Characterize African landraces, improved and introduced germplasm for provitamin A, iron, zinc and phytic acid content.
2. Inter-cross among germplasm sources with increased levels of provitamin A, iron and zinc.
3. Identify the best varieties with high micronutrient content from the existing elite and adapted germplasm for immediate multiplication and distribution to farmers.
4. Evaluate the expression of high micronutrient concentration in different locations and seasons.
5. Determine the mode of inheritance of micronutrient concentration in grains of maize varieties.
6. Assess the bioavailability of increased micronutrients in grains of the best cultivars.
7. Evaluate the stability of micronutrients during processing and storage in the improved varieties using participatory methods.

Outputs

- Maize varieties high in provitamin A, iron, and zinc content than the most widely grown maize cultivar available.
- An effective breeding strategy to combine provitamin A, iron and zinc in a single genotype developed.
- Increased knowledge on the mode of inheritance of provitamin A, iron and zinc in maize.
- Stability of provitamin A, iron and zinc during processing and storage determined.
- Information on the bioavailability of increased micronutrients available.
- Adapted improved maize varieties high in micronutrients identified.

Indicators for monitoring and evaluation

- Published reports.
- Micronutrient rich varieties in IITA international trials.
- Reports from independent evaluations by NARS.
- Maize varieties with at least 10% increase in provitamin A, iron, and zinc content than the most widely grown maize cultivar are available.

Activity 3: Increase micronutrient content of maize products through dietary improvement and fortification.

Objectives

1. Develop technologies for maize fortification at both the commercial and village levels.
2. Assess the effects of processing on micronutrient content of fortified products.
3. Determine the bioavailability, acceptability and shelf life of fortified maize products.

Background

In developing countries, fortification is increasingly recognized as a measure to improve the micronutrient status of populations. Commercial food fortification is appealing because it assures high coverage and does not require a change in the eating habits of the consumer. Thus fortification can often be implemented and sustained over a long period. It can therefore be the most cost-effective means of overcoming micronutrient malnutrition. Maize can be readily fortified with iron without any technical problems. A pilot study in Zambia showed that fortification can be carried out by developing and adding micronutrient premix powder to maize meal in a hammer mill using one or more types of hand-operated blending equipment (MI, 1998). In Zimbabwe and Namibia a few commercial maize millers have fortified maize meal with vitamin A, B1, B2, B6, niacin, folate, iron and zinc (Hoffman, 1998).

Processing maize meal or grits causes losses in vitamin A, the longer the cooking time the greater the loss. Losses up to 30% with 30 minutes cooking were reported. Data from South Africa (Hoffman, 1998) show that the losses of vitamin A during traditional cooking of maize meal is somewhat higher than in maize flour. These losses can be overcome by adding an additional amount of the vitamin to the maize meal or flour. Yellow maize contains provitamin A carotene. The form in which yellow maize is consumed by the population and the influence of processing and storage on provitamin A have to be studied as such information will help consumers and processors choose the processing and storage conditions that favor provitamin A retention (Rodriguez-Amaya, 1997). The nutritional value of the selected food will depend on the loss of nutrients during processing and bioavailability after being consumed. Increasing the production and consumption of micronutrient rich foods will not always translate into improved nutritional status if the foods are processed in such a way that the content and bioavailability are reduced. Therefore, cooking methods that maximize nutritional benefits, and strategies that enhance absorption, should be considered and promoted.

The stability of the fortificant in the fortified food or the meal is highly dependent on the chosen compound, processing conditions, characteristics of the food, transport and storage conditions, and food preparation and storage habits of the consumer. Factors that influence the stability of added vitamins and minerals during storage and preparation of maize flour/meal are temperature, moisture content, presence of oxygen, length of storage, packaging, type of preparation and length of cooking (Hoffman, 1998). Storage stability of vitamin A in milled maize at room temperature is not good. Losses were up to 20% in 6 months, but the moisture content was an important factor. At 6.5% moisture content there was hardly any loss whereas at 11.4% moisture content there was a 20% loss of vitamin A in maize grits. Also at higher storage temperatures (45°C), vitamin A losses increase up to 40% in 3 months. Similar values have been observed for wheat flour. Information on the stability of micronutrients during processing and storage under tropical conditions is needed.

The solubility of iron compounds is inversely related to the duration of storage. The more soluble the compound, the greater its chemical reactivity, and the higher the risk of rancidity. Iron added in the reduced form was found to be stable in all milled maize products (Lofti et al., 1996). When stabilized ferrous sulfate was used, deterioration occurred. When iron levels were increased from 88 to 440 mg/kg, off flavors developed with all iron sources. In soy-fortified maize, stabilized ferrous sulfate was found to be an acceptable iron source for fortification. Segregation of iron sources in milled maize was not observed (Anderson, 1985). Derham et al (1977) reported 3.8% absorption of ferrous sulfate from maize meal porridge. Moron et al (1989) studied extruded maize-soybean fortified with iron, vitamin A and others. Iron absorption (ferrous fumarate) varied between 2.4% and 6.8%. Lee and Clydesdale (1980) report that iron sources when added to flour and baked as biscuits or bread do not remain in the original chemical form. The effect of baking seems to be the formation of an insoluble form of iron. Therefore, the form, level and source of iron to be used will have to be determined. In addition, information on iron stability and segregation during storage under different temperature and humidity conditions is needed.

In order to reach the sector of the population, which is at risk, fortification of maize flour with micronutrients will take place in hammer mills in local communities as well as in commercial mills in urban and peri-urban areas. Since maize is consumed in diverse forms in West Africa, suitable forms and levels of fortification need to be determined to cater for the various localities. Such specific requirements can be met by combining technical input related to the nutrient composition of staple foods and local knowledge on how foods are procured, processed, prepared and consumed.

Methodology

1 Determine the levels and form of fortificants to be incorporated. This will be determined from information collected during baseline studies. In addition information on losses during storage and cooking will also be considered.
2. Develop simple micronutrient fortification techniques.
3. Determine the bioavailability and acceptability of fortified maize products.
4. Develop processing methods that minimize losses of micronutrients during cooking of fortified products and improved adapted varieties.

5. Evaluate stability of micronutrients during processing and storage of fortified products and improved adapted varieties.
6. Determine the effect of traditional processing and preservation methods on the storage stability of added micronutrients.

Outputs

- Nutritional quality of maize flour and other maize products enhanced through fortification with micronutrients.
- Technology for maize fortification at the commercial and village level developed and tested.
- Bioavailability of nutrients and acceptability of fortified maize products and adapted improved varieties determined.
- Effects of processing and storage on micronutrient content of fortified products and adapted improved varieties determined.

Indicators for monitoring and evaluation

- Improved processing methods, simple fortification techniques and appropriate level of fortification are available.
- At least 10 millers are involved in fortification of maize with micronutrients in pilot countries.
- At least 2 traditional processing and storage methods improved and adopted in each pilot country.
- At least 2 fortified maize products available in the market in each pilot country.
- Published reports.

Activity 4: Multiplication, distribution and adoption of maize cultivars with high content of micronutrients in the grain.

Objectives

1. Promote the multiplication, distribution and adoption of maize cultivars with high content of micronutrients.
2. Promote the production of cultivars rich in micronutrients in pilot countries.

Background

Dietary improvement aims at increasing the availability and consumption of vitamin- and mineral-rich foods. It includes the way we cultivate, select, prepare and choose the foods we eat. Both availability and accessibility of such foods are important. One of the major constraints to the adoption of the available improved maize varieties in West Africa is the lack of well-organized seed industry in some countries. Making seed of the improved varieties available to farmers is one of the potential means of ensuring high adoption of the released maize varieties. The goal of WECAMAN's intervention in the seed industry in West and Central Africa is to assist farmers and seed producers to develop sustainable seed production systems capable of providing a regular supply of high quality seed of superior varieties to the farming communities.

Methodology

1. On-farm testing of maize varieties with increased micronutrients.
2. Demonstration of the best varieties with high micronutrient content.
3. Community seed production of the best cultivars for distribution to farmers.
4. Promotion of varieties high in micronutrient content.

Outputs

- Maize varieties with high content of micronutrients multiplied and distributed.
- Community production schemes in pilot countries strengthened.

Indicators for monitoring and evaluation

- At least 10 tons of seeds of maize varieties with high micronutrient content made available for commercial production in each pilot country.
- Monitoring tours by NARES scientists and other partners.
- Published reports.

Activity 5: Market sector analysis, promotion and commercialization of cultivars and fortified products.

Objectives

1. Assess and project demand for the fortified maize products.
2. Design a marketing and promotion strategy for the products.
3. Involve food processors and industry to promote the production and commercialization of cultivars and fortified products rich in micronutrients in pilot countries.

Background

An efficient pricing mechanism as well as good marketing and promotion strategy is important to popularize fortified maize products to consumers. A market survey to test the acceptability and demand for the fortified products will be carried out in each pilot country. Prices of the fortified maize products will be compared with those of competing or substituting products on the market. In addition, different marketing and promotion strategies for the products will be tested. This information will be useful in designing an efficient marketing or promotion strategy, thereby ensuring the availability and affordability of products to consumers. Through the market study, information for modifying the form and packaging of the products will be obtained to meet the requirements of different consumer groups.

Methodology

1. Conduct market surveys to determine the prices of competing products and to understand their marketing channels in pilot countries.
2. Carry out cost-benefit analyses for investing in production of fortified foods at both commercial and domestic processing levels.
3. Collect information on prospective markets, demands and affordability of improved maize cultivars and their fortified products.
4. Improve production of quality raw material (maize) by farmers for use by processors.
5. Facilitate contractual agreements between farmers and processors.
6. Investigate opportunities for cross-border information exchange to enhance product marketing and commercialization.
7. Build awareness among partners, including policy makers, of the need to improve competitiveness from production to technology transfer, product development, marketing and commercialization.

Outputs

- Efficient prices for the fortified maize products determined.
- Demand and affordability of fortified maize products determined.
- Cost-benefit ratio for fortified maize products in the four pilot countries determined.
- Information on cross-border marketing opportunities available.
- An effective marketing and promotion strategy for the products designed and implemented.

Indicators for monitoring and evaluation

- Prices for each product established in four pilot countries.
- Published reports.
- At least 3 farmers contracted to produce micronutrient rich varieties in each pilot country.
- At least 8 small to medium scale processors produce micronutrient-fortified products.

Activity 6: Improving the capacity of NARES and private sector for effective technology development and transfer.

Objectives

1. Enhance human capacity for dietary improvement and fortification through training, seminars and workshops with NARS.
2. Disseminate research findings and new techniques to researchers and technicians in pilot and non-pilot countries.
3. Improve research skills of technicians through individual attachments with IITA and other research institutes in the region.

Background

Experience over the years has shown that appropriate training collaboration with NARES leads to improved research and consequently improved productivity. A secondary benefit of training is a greater self-reliance and sustainability of research and training. This project aims to exploit these benefits by special purpose seminars/group training courses of duration ranging from 4 days to 4 weeks. These will be conducted to bring researchers and technicians of the collaborating countries together to update knowledge, develop and sharpen skills in using new technologies. Where appropriate individualized attachments of longer duration will be organized for researchers and technicians to acquire new skills in field and laboratory techniques at IITA. WECAMAN has embarked vigorously on training in its sphere of activities and this project will support and capitalize on the gains of WECAMAN, as the target crop is the same. An end of project workshop will be conducted to promote the spillover of project outputs and information to non-project countries in the region.

Methodology

1. Conduct training courses, seminars, workshops, and farmers' field days to develop skills and knowledge on micronutrient fortification.
2. Organize individualized training attachments.
3. Conduct a terminal workshop to promote the spillover of project outputs and information to non-project countries in the region.

Outputs

- At least 10 researchers, 20 technicians, 100 farmers, and 10 industry workers trained on micronutrient fortification.
- Human capacity for dietary improvement increased.
- Enhanced professional and scientific capacity of NARES scientist, private sector and technicians for micronutrient fortification technology development and transfer.
- Exchange of scientific information and new technologies.

Indicators for monitoring and evaluation

- Number of NARS scientist and technicians trained.
- Workshop Proceedings.
- Reports of group training courses.
- Course evaluation reports.
- Individual attachment evaluation reports

Activity 7: Impact assessment of micronutrient fortification of maize products, dietary improvement, and adoption of improved cultivars on nutritional status of target groups.

Objective

1. Assess the rate of adoption of cultivars and food products high in micronutrient content.
2. Measure the impact of micronutrient fortification and dietary improvement on nutritional status of the target groups.

Background

Adoption studies and impact analysis are important to assess progress in agricultural research. Good diffusion of technologies is essential to ensure that there is a positive impact on beneficiaries. Adoption studies should also provide information on the pattern and spread of newly generated maize technologies, while impact analysis will measure the social benefits, improvement in nutritional status of the target groups, gender distribution of benefits, and social welfare of different categories of farm families. There is a need for a more coordinated effort among economists, nutritionists, food technologists and agriculturists to work on impact studies.

In order to provide feedback to adjust the selection program and to predict the likely future impact of the products of the project, an adoption study will be conducted with farmers who had collaborated in on-farm trials to obtain their opinions about the positive and negative features of the technology produced by the project and to measure the extent of their adoption. A sample of neighboring farmers not involved in the trials will also be included so as to estimate the rate of farmer-to-farmer diffusion of technologies and implications for a fast dissemination of technologies among potential adopters.

Methodology

1. Evaluate the effect of new technologies on maize production at the farm level.
2. Conduct adoption studies on new post-harvest technologies.
3. Assess the effects of consumption of micronutrient fortified products on the improvement of nutritional status of target groups.

Outputs

- The prevalence and level of vitamin A, iron and zinc deficiency in target groups assessed.
- Impact of fortification with micronutrients on nutritional status of the target populations evaluated.
- Information on adoption processes available for feedback to technology developers or for extension to non-pilot countries.

Indicators for monitoring and evaluation

- Published reports.

Implementation Strategy and Sustainability

Strategy for delivery of research outputs to beneficiaries

The strategy adopted for this project is both holistic and pragmatic. It involves key stakeholders in the research community and commercial sectors, yet maintains a focus on delivery of products high in micronutrient content to the end-users. A major feature of the project is its emphasis on implementation in four pilot countries where maize is an important staple food crop: Nigeria, Benin, Burkina Faso and Ghana. During phase 1 (three years) the project impact will be measured only in these countries. Nonetheless, opportunities for extension of the benefits of the project to other countries are fostered through training and information exchange.

The flow of improved technologies to end-users in the pilot countries is shown in the central column of Figure 3. Baseline studies will include a review of available information on prevalence of micronutrient deficiency. Clinical tests of the target populations will be conducted to fill in gaps in existing knowledge and to provide a basis for impact assessment at the end of the project. IITA will interact closely with the national food research institutes to ensure that standard procedures are applied across the four pilot countries, and to facilitate the exchange of information and experiences among the pilot countries.

The ways in which research contributions of international and national organizations feed into the central scheme of technology delivery are shown in the upper left and right-hand columns of Figure 3. These partners will first assess existing varieties and products for micronutrient content. The most promising available technologies will be immediately tested in the pilot countries and channeled into commercial production. At the same time, IITA will initiate a breeding program to develop varieties with high, stable micronutrient content. Similarly, the food research institutes will develop better methods for processing and fortification, and new products high in micronutrients.

Once promising varieties and processing and fortification technologies have been identified for each country, it will be necessary to scale-up levels of production. WECAMAN, through its partnerships with national agricultural research scientists and extension, will oversee the on-farm testing of varieties and establish links with seed producers and farmers' associations to develop community seed production schemes. SAFGRAD will work with small-medium- and large-scale commercial processors to establish linkages with contract farmers growing micronutrient dense varieties, as well as linkages with agencies that market end products. Training courses will be offered both at the regional level (WECAMAN) and in the pilot

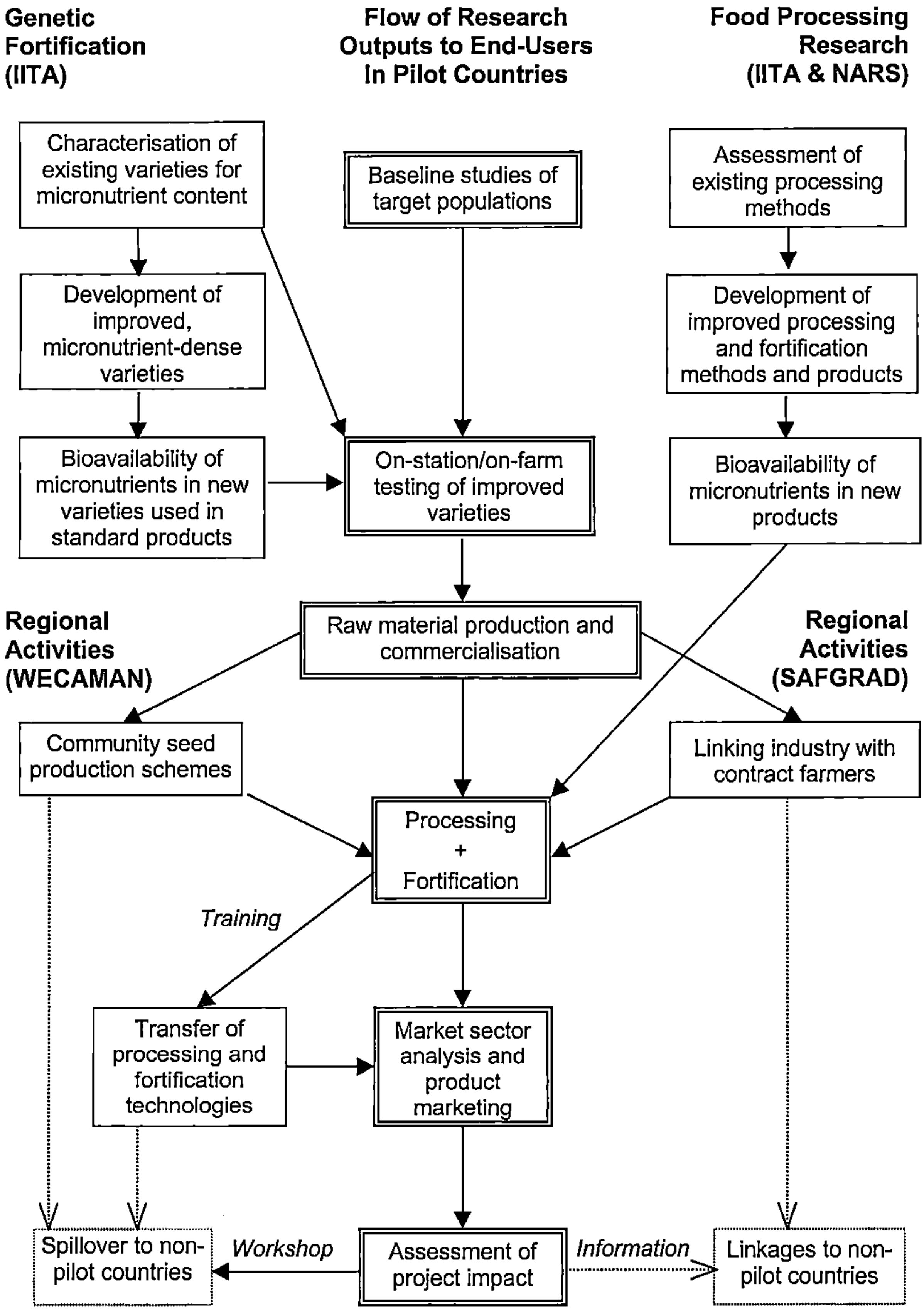

Figure 3. Strategy for development of raw materials and food products high in micronutrients and their utilization by the target populations (dotted lines show expected spillovers to non-pilot countries).

countries to transfer the processing and fortification technologies to a larger number of commercial processors. At the same time, market sector analysis will be conducted with the input of socio-economists and food technologists so that the fortified products can be made available to as many end-users as possible.

In the final year of the project, the national food and nutrition research institutes will conduct adoption studies and clinical tests. As for the baseline studies, IITA will facilitate use of standard procedures and information exchange among pilot countries. A workshop will be organized by WECAMAN to publicize results from the project in all of the WECAMAN member countries, in order to lay the groundwork for further extension of the benefits of the project to non-pilot countries.

Partnerships and Coordination

Pilot Countries

In most countries of West Africa, research on food science and nutrition is housed in different departments or even different institutions than the agricultural research sector. In some instances this has led to rather poor communication and limited collaboration between these two important sectors, although they share the common goal of improving nutritional status of the population. Furthermore, research often works in isolation from the private sector that can most effectively use and disseminate improved technologies to farmers and consumers. This project brings these key partners together to work on joint activities with concrete objectives.

The pilot countries were chosen to represent a cross-section of the countries in West Africa with high production of maize as a staple food crop, and documented health problems due to micronutrient deficiencies. The four selected countries have the institutional capability and expertise to carry out the activities and make significant contributions towards the goal of this project. These national institutes involved in food and nutrition research are well placed to carry out research on processing and fortification methods, and to develop fortified products with a high probability of adoption at the local level. The project focuses on four countries in the initial phase to ensure tangible outputs in a reasonable time frame. The flow of research outputs to end-users will also involve the Agricultural Research Institutes and Extension Services, farmers' organizations, seed producers, commercial processors, and marketing agencies in each of the pilot countries. The most successful models developed in these countries will serve as guides for future initiatives to combat micronutrient deficiencies in other countries.

The need for comprehensive campaigns within each pilot country to promote adoption of micronutrient-dense varieties by farmers and the production and marketing of fortified products cannot be underestimated. To be successful, the campaign must aim not only to create a supply of new technologies, but also to increase the demand among consumers for these products. Extension agents must not only disseminate improved varieties, but must also educate farming communities about the health benefits of consuming varieties high in micronutrients. Health workers and nutritionists carrying out baseline studies on the prevalence of micronutrient deficiency diseases must also conduct training about the importance of micronutrients in the diet and wide scale demonstrations of fortified products, as they become available.

The case of Nigeria illustrates the linkages that exist among stakeholders and the capacity of the selected countries to execute this project. Institutes involved in research on food science and nutrition have dedicated teams of scientists with experience in the production and fortification of foods with micronutrients and in evaluating the effects of these additives on the population. Members of the research team involved in this project carried out a baseline study on the prevalence of iodine and vitamin A deficiencies in 7 states of Nigeria. Laboratories at the University of Ibadan are equipped to quantify the micronutrient content of food products and develop technologies for micronutrient fortification. The team of scientists at Ahmadu Bello University has well-developed linkages with flourmills, that will be key functionaries in the production and distribution of micronutrient fortified flours to the local population. Linkages with NGOs and ADPs have been forged and used for transfer of technologies in the past. For example, a Soybean Utilization Project funded by the International Development Research Center (IDRC) was carried out in collaboration with IITA. This project conducted activities in villages, peri-urban centers, hospitals, antenatal clinics, maternal and health care facilities, and children's welfare homes to alleviate protein malnutrition. As a result, production and utilization of soybean has increased dramatically in Nigeria.

IITA

IITA has the capacity both to carry out laboratory work for micronutrients and to initiate an effective maize-breeding program for high micronutrient content using germplasm adapted to the region. The experience of IITA in managing and coordinating project activities span several decades. A Nigerian Government funded hybrid maize project was initiated in 1979 and led to the development and release of several first generation hybrids in West Africa. IITA provides technical backstopping and coordination for the West and Central Africa Maize Collaborative Research Network (WECAMAN) which works with national public and private research and development institutions, including NGOs. Through this network, participating countries receive funds, germplasm, and cultivars for on-farm testing, training, information and co-ordination.

Currently, IITA is managing a joint project with CIMMYT, the African Maize Stress Project (AMS), to combat four stresses in West and Central Africa. To generate stress tolerant germplasm adapted to the region, six screening sites for the various stresses have been developed in six countries in West and Central Africa. IITA scientists closely monitor the development of sites and screening of germplasm. IITA implements this project through WECAMAN. With the start of the AMS project, the membership of WECAMAN grew from eight to eleven. Thus, the experiences from the AMS project will be useful for implementation of the micronutrient project.

SAFGRAD

SAFGRAD has a long record of achievement in facilitating linkages between IARCs and NARS in the region and in capacity building. In collaboration with national food technologists, agriculturists, and socio-economists, SAFGRAD will promote the critical link between research and the commercial sector. SAFGRAD will use its contacts with International Agencies such as UNICEF and FAO to foster synergies with other projects promoting better health and nutrition at the community level. Complementarities with NGO's such as Sasakawa Global 2000 and Food Basket International will also be encouraged. SAFGRAD will also bear responsibility for organizing annual monitoring tours by a team comprising representatives from its own organization, IITA, WECAMAN, and the NARS.

Another important role of SAFGRAD is to link with governments in the region to create awareness of the need for increased consumption of micronutrients, and to gain their support for the release and dissemination of improved technologies. To create an enabling environment, SAFGRAD encourages governments to put in place innovative institutions and policies that lead to conducive legal and financial services (credit); guidelines to strengthen linkages between agriculture and agro-industries; mechanisms to forge partnerships among key stakeholders; and policies which increase availability of agricultural inputs and market information.

SAFGRAD will facilitate the efficient participation of the food processing industry. Through fair contract arrangements with the community farmers' groups, high quality micronutrient containing cultivars will be produced for sale to collaborating small- and medium-scale processors. These will be registered by the project to carry out fortification of micronutrients. Through this registration, prices offered to farmers and costs of fortified products can be monitored for profitability analysis and advice to the processors. Product quality would be assured by relevant agencies.

WECAMAN

WECAMAN plays an active role in maize research in 11 major maize-producing countries in the region. Presently, it coordinates and dispatches trials of early and extra-early maize varieties developed by WECAMAN and the NARS. WECAMAN already supports on-farm testing of improved varieties and community seed production schemes. Varieties high in micronutrient content can be incorporated into existing promotion efforts. These schemes involve the use of revolving funds and are therefore self-sustaining over time. WECAMAN organizes annual training courses and biennial workshops that serve the region. With the development of improved processing and fortification technologies, there will be a need to organize a course to train the trainers from pilot countries. Inclusion of some participants from non-pilot countries will have beneficial spillover effects without any loss in focus towards the objectives of this project. Funds requested for workshops during the second year would be used to bring additional participants to participate in the ongoing biennial workshops organized by WECAMAN. Thus, there will be synergies between this project and other activities funded by WECAMAN.

WECAMAN would increase the support for the testing and promotion of improved maize varieties through funding support to the collaborative research projects executed by the NARS in Burkina Faso, Ghana, Benin and Nigeria. Through the collaborative projects, high yielding, disease and pest resistant normal endosperm maize varieties, Quality Protein Maize (QPM) varieties and micronutrient dense maize varieties would be tested both on station and on-farm and promoted for adoption by farmers. The network will rely on participatory research approaches involving farmers as partners in technology development, refinement and in dissemination in order to continuously improve the adoption of available technologies. Also, WECAMAN will make deliberate efforts to promote vertical and horizontal partnerships involving NGOs and the private sector, especially traders and processors in the pilot countries in order to have their input in determining the technologies that are most responsive to market demand.

Table 2 summarizes the administrative and facilitative roles of the key stakeholders and highlights their comparative advantages that were considered in allocating both research and administrative responsibilities for the project.

Table 2. Administrative and facilitative roles of partners in the project.

Partner/comparative advantages	Role
SAFGRAD • Experience in facilitating communications between IARCs and NARS • Experience in capacity building and empowerment of NARS • Experience in forming linkages between research and commercial sectors • Knowledge of the region and its institutions	• Linkages between research, raw material production and commercial sector • Dispersal of funds for commercialization of technologies in pilot countries • Linkages with other projects, development agencies, and NGO's • Promoting spillover to nonpilot countries • Monitoring of project activities at all levels through annual monitoring tours by a team representing all partners
IITA • Well-established maize breeding programs, food technology laboratories, and infrastructure • Editing and publishing expertise and facilities available • Audited accounting system	• Standardization and facilitation of baseline studies and impact assessment in pilot countries • Facilitation of food processing research in pilot countries • Project accounting and dispersal of funds to pilot countries • Compilation and editing of technical and financial reports for submission to donor
WECAMAN • Membership includes NARS from all of the major maize producing countries in West and Central Africa • Experience in organization of regional variety trials and community production schemes • Experience in organization of regional workshops and training	• Compilation and dissemination of results of regional variety trials • Promotion of community seed production schemes • Regional workshops and training • Publishing and dissemination of information on the project
NARS • First-hand knowledge of preferences and needs of end-users • Proximity and ease of communication with farmers, processors, marketing agencies, and consumers • Access to available infrastructure at the local level	• Co-ordination and monitoring of pilot programs through an appointed individual (focal unit) in each country • Preparation of pilot country workplans and reports • In-country training and demonstrations

Sustainability

The success of increased micronutrient intake through the enhancement of the micronutrient content of maize and its products will depend on the sustainability of the initiative. Successful implementation and sustainability of a food-based micronutrient fortification program requires effective monitoring regulation and enforcement as all fortification programs must address quality assurance and safety concerns. Also adequate technical, operational and support for production marketing and mass education are essential ingredients for sustainability of the program. This calls for a multi-sectoral effort involving the participation of government, private industry, NGOs, scientific expert groups, farmers and consumer groups. These stakeholders will participate in the design, implementation, management (including monitoring) and evaluation of the project.

Sustainability of the initiative depends on the success of three major components of this project. These are: production and commercialization of raw materials, processing and fortification of food products; and effective product marketing. All of these depend on development of appropriate technologies through research. Sustainability of these components will be enhanced by (1) use of participatory methods at all stages of technology development and transfer, (2) training of trainers, producers, and consumers, and (3) establishment of revolving funds to finance these major activities.

Sustainability of seed production in adequate quantities to the processors would be assured by WECAMAN's assistance to farmers and seed producers to develop sustainable seed production systems capable of providing a regular supply of high quality seed of superior varieties to the farming communities. To ensure sustainability of the project, collaborating farmers in each country sell the maize seeds and pay back the cost of inputs provided by the project offices.

To ensure that processing technology is sustained, medium and small-scale processors would be chosen and trained in the production of micronutrient fortified products. Equipment would be simple, relatively inexpensive, easy to maintain with locally available spare parts. Overheads of such industries are low enough to allow the processors to make profit while keeping the price of the product within the reach of the majority of the populace. Assessment of existing products and new food formulations would be made to maintain continued demand for maize and maize products high in micronutrients.

Project Coordination and Monitoring

Monitoring

Pilot programs will be coordinated and monitored by a team representing the stakeholders (SAFGRAD, IITA, WECAMAN and the pilot countries). This team will visit the pilot programs at least once each year to monitor progress.

SAFGRAD will monitor production and commercialization of the micronutrient-rich maize in pilot countries. WECAMAN will monitor regional activities and capacity building including regional variety trials and community seed production schemes. IITA will coordinate and monitor food processing and product development research, baseline surveys and impact assessment.

Within each pilot country, a national coordinator (focal unit) will be identified in consultation with the Director of the NARS, and a memorandum of understanding will be established. That individual will coordinate and monitor all project activities within the country, and will be responsible for preparation of annual work plans and reports.

Reporting

All parties involved in the project will have to prepare annual work plans according to specified guidelines before funds can be allocated. Reports are to be given at intervals appointed for each program. The report would include set goals, achievements and financial statements. Parties involved in the project will each prepare reports and recommendations in their areas of responsibilities, which will be forwarded to respective coordinating institutions and ultimately to IITA for compilation, editing, and submission to the donors. All information generated through the project activities will be the joint property of all participating NARS.

Expected end-of-project situation

In order to improve the nutritional status of the population in West Africa, a significant long-term investment in research is needed. In this project, emphasis will be on capacity building of NARS and small to medium scale processors to generate and disseminate maize cultivars and products high in micronutrients. Successful implementation of this initiative will lead to sustainable dietary improvement, health, vigor, and productivity of the vulnerable groups.

Budget

The budget is based on existing realities in the benefiting countries. About 52 per cent of the budget is for capacity building including product development, dissemination, and project activities in pilot countries; nearly 27 per cent is for genetic fortification and 21 per cent is for technology transfer, commercialization, coordination and monitoring, and implementation of project activities.

BUDGET SUMMARY (US$'000)

ACTIVITIES		YEAR 1	YEAR 2	YEAR 3	TOTAL
Genetic Fortification (IITA)					
Personnel		123	130	137	**390**
Capital equipment		110	0	0	**110**
Materials and supplies		62	64	66	**192**
Bioavailability studies		0	45	45	**90**
Travel		10	10	10	**30**
Subtotal Genetic Fortification		**305**	**249**	**258**	**812**
Coordination and Monitoring (SAFGRAD)					
Linking production and commercialization in pilot and nonpilot countries		25	20	18	**63**
Travel		12	10	12	**34**
Communication		8	8	8	**24**
Monitoring*		16	14	14	**44**
Subtotal Coordination and Monitoring		**61**	**52**	**52**	**165**
Regional Activities/Capacity Building (WECAMAN/IITA)					
Food processing and product development research; and facilitation and linkage of related activities among pilot countries		10	10	10	**30**
Preparation and dispatch of regional variety trials; analysis and compilation of results		0	10	10	**20**
Regional communication		10	10	10	**30**
Workshops		20	10	30	**60**
Travel		10	10	10	**30**
Training		30	30	0	**60**
Information dissemination/publications		0	10	10	**20**
Subtotal Regional Activities		**80**	**90**	**80**	**250**
Pilot Country Programs†					
In-country coordination		8	8	8	**24**
Baseline studies		52.5	0	0	**52.5**
Testing of improved varieties		66	66	66	**198**
Food processing and product development research	Equipment	124	0	0	**124**
	Materials and Supplies	54	54	54	**162**
	Bioavailability studies	40.5	40.5	40.5	**121.5**
In-country training/workshops/and demonstrations		60	60	60	**180**
Community seed production schemes‡		16	16	16	**48**
Raw materials production and commercialization‡ (administered through SAFGRAD)		62	62	62	**186**
Processing and fortification‡ (Capital upgrading, raw materials)		88	60	0	**148**
Market sector analysis and product marketing		0	29.5	16	**45.5**
Evaluation/monitoring of impact		0	0	56.5	**56.5**
Subtotal for all Pilot Country Programs		**571**	**396**	**379**	**1,346**
Subtotal, funds administered through IITA		***894***	***673***	***655***	***2,222***
IITA overhead (18.8%)		*168*	*127*	*123*	***418***
Subtotal, funds administered through SAFGRAD		***123***	***114***	***114***	***351***
SAFGRAD overhead (15%)		*18*	*17*	*17*	***52***
TOTAL		**1,203**	**931**	**909**	**3,043**

*Does not include cost of external evaluation by donor representatives.
† Funds to be administered to pilot programs through IITA, unless otherwise indicated.
‡ Revolving funds to be established.

BUDGET – GENETIC FORTIFICATION (US$'000)

ACTIVITIES	YEAR 1	YEAR 2	YEAR 3	TOTAL
Personnel				
Associate Scientist†	100	105	110	**315**
Research Associate (MSc. level)	7	8	9	**24**
Laboratory and Field Technicians§	16	17	18	**51**
Subtotal personnel	**123**	**130**	**137**	**390**
Capital Equipment				
HPLC with accessories	60	0	0	**60**
Digestion system	20	0	0	**20**
Fluorometer	5	0	0	**5**
Vehicle	25	0	0	**0**
Subtotal capital equipment	**110**	**0**	**0**	**110**
Operating Expenses				
Materials and supplies (Laboratory)	27	28	29	**84**
Materials and supplies (Field)	35	36	37	**108**
Bioavailability studies	0	45	45	**90**
Travel	10	10	10	**30**
Subtotal operating expenses	**72**	**119**	**121**	**312**
Total Genetic Fortification	**305**	**249**	**258**	**812**

Budget Notes:

†Full cost of an associate scientist is estimated at $150,000 for the first year. Balance to be paid as in-kind contribution by IITA.

§Laboratory staff include one with a BSc. (pay grade 7) and two experienced staff with high school diplomas (pay grade 2's).

§Field staff include two with two-year technical diplomas (pay grade 4's) and two experienced staff with high school diplomas (pay grade 2's).

BUDGET – PILOT COUNTRY PROGRAMS (US$'000)

ACTIVITIES		YEAR 1	YEAR 2	YEAR 3	TOTAL
Nigeria					
In-country coordination		2	2	2	**6**
Baseline studies (literature review, clinical tests)		15	0	0	**15**
Testing of improved varieties (on-station, on-farm)		19	19	19	**57**
Food processing and product development research	Equipment	31	0	0	**31**
	Materials and Supplies	16	16	16	**48**
	Bioavailability studies	12	12	12	**36**
In-country training/workshops/and demonstrations		20	20	20	**60**
Community seed production schemes†		4	4	4	**12**
Raw materials production and commercialization†		18	18	18	**54**
Processing and fortification† (Capital upgrading, raw materials)		22	15	0	**37**
Market sector analysis and product marketing		0	8	4	**12**
Evaluation/monitoring		0	0	16	**16**
Total for Nigeria		**159**	**114**	**111**	**384**
Ghana					
In-country coordination		2	2	2	**6**
Baseline studies (literature review, clinical tests)		13.5	0	0	**13.5**
Testing of improved varieties (on-station, on-farm)		17	17	17	**51**
Food processing and product development research	Equipment	31	0	0	**31**
	Materials and Supplies	14	14	14	**42**
	Bioavailability studies	10.5	10.5	10.5	**31.5**
In-country training/workshops/and demonstrations		16	16	16	**48**
Community seed production schemes†		4	4	4	**12**
Raw materials production and commercialization†		16	16	16	**48**
Processing and fortification† (Capital upgrading, raw materials)		22	15	0	**37**
Market sector analysis and product marketing		0	7.5	4	**11.5**
Evaluation/monitoring		0	0	14.5	**14.5**
Total for Ghana		**146**	**102**	**98**	**346**
Benin and Burkina Faso§					
In-country coordination		2	2	2	**6**
Baseline studies (literature review, clinical tests)		12	0	0	**12**
Testing of improved varieties (on-station, on-farm)		15	15	15	**45**
Food processing and product development research	Equipment	31	0	0	**31**
	Materials and Supplies	12	12	12	**36**
	Bioavailability studies	9	9	9	**27**
In-country training/workshops/and demonstrations		12	12	12	**36**
Community seed production schemes†		4	4	4	**12**
Raw materials production and commercialization†		14	14	14	**42**
Processing and fortification† (Capital upgrading, raw materials)		22	15	0	**37**
Market sector analysis and product marketing		0	7	4	**11**
Evaluation/monitoring		0	0	13	**13**
Total for Benin/Burkina Faso		**133**	**90**	**85**	**308**

§ Values shown are for a single country
† Revolving funds to be established.

BUDGET – CONTRIBUTIONS IN KIND (US$'000)

ACTIVITIES	YEAR 1	YEAR 2	YEAR 3	TOTAL
Genetic Fortification (IITA)				
Provision of family vehicle, accommodation, etc. for Associate Scientist	50	51	52	**153**
Maize Breeders (20% time allocation)	38	40	42	**120**
Field Research Supervisor (10% time allocation)	1	1	1	**3**
Casual labor	2	2	2	**6**
Land preparation (4 ha/year)	2	2	2	**6**
Official vehicle maintenance and operation	3	3	3	**9**
Capital investment and depreciation	6	6	6	**18**
Subtotal Genetic Fortification	**102**	**105**	**108**	**315**
Coordination and Monitoring (SAFGRAD)				
Researcher time (7%)	3	3	4	**10**
Coordination and Monitoring	4	4	4	**12**
Institutional support	5	5	5	**15**
Vehicle use	5	5	5	**15**
Subtotal Coordination and Monitoring	**17**	**17**	**18**	**52**
Regional Activities/Capacity Building (WECAMAN/IITA)				
WECAMAN Coordinator (10%)	19	20	21	**60**
Secretarial Support (5%)	1	1	1	**3**
Research Technician (5%)	2	2	2	**6**
Casual labor	1	1	1	**3**
Vehicle use	5	5	5	**15**
Subtotal Regional Activities	**28**	**29**	**30**	**87**

CONTRIBUTIONS IN KIND – PILOT COUNTRIES (US$'000)

ACTIVITIES	YEAR 1	YEAR 2	YEAR 3	TOTAL
Nigeria				
Personnel	5	5	7	**17**
Equipment	7	5	7	**19**
Institutional support	5	5	5	**15**
Total for Nigeria	**17**	**15**	**19**	**51**
Ghana				
Personnel	4	5	6	**15**
Equipment	6	6	6	**18**
Institutional support	3	3	3	**9**
Total for Ghana	**13**	**14**	**15**	**42**
Benin and Burkina Faso §				
Human resources	10	10	10	**30**
Capital equipment and communication	6	5	5	**16**
Community contribution	4	4	4	**12**
Total for Benin/Burkina Faso	**20**	**19**	**19**	**58**

APPENDICES

Appendix 1. References

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Appendix 2: Logical Framework

PROJECT PLANNING MATRIX (PPM)	Project Ref. No:	Project Title: Micronutrient fortification of maize and its products in West Africa: A sustainable approach to mitigate hidden hunger	Estimated Project Duration: 3 years	PPM Prepared: June 1999:
Summary of Objective/Activities		**Objectively Verifiable Indicators**	**Means/Sources of Verification**	**Important Assumptions**
Overall Goal to which the project contributes: To improve the nutritional status and livelihoods of the rural and urban populations in West Africa by reducing diseases caused by micronutrient deficiencies.		• Improvement in nutritional status of children under 6 years of age, pregnant women, and nursing mothers. • Increased demand for maize. • Decrease in micronutrient deficiency diseases.	Reports from health centers Product sales volume Public Health statistics UNICEF/WHO reports	Favorable policies Resource availability
Project Purpose: Enhanced levels of micronutrients in maize-based diets through development of improved maize cultivars high in iron, zinc, and provitamin A, improved processing and storage of maize flour and products, and fortification of maize meal and flour with the target micronutrients.		• The prevalence and level of vitamin A, iron and zinc deficiency in target groups reduced by 10%. • At least 30% of the people in target areas consuming fortified maize products. • At least 20% of households using improved production and postharvest technologies.	Project reports Published reports Annual reports	Socio-economic environment conducive to small and medium scale business development

PROJECT PLANNING MATRIX (PPM)	Project Ref. No:	Project Title: Micronutrient fortification of maize and its products in West Africa: A sustainable approach to mitigate hidden hunger	Estimated Project Duration: 3 years:	PPM Prepared: June 1999:

Summary of Objective/Activities	**Objectively Verifiable Indicators**	**Means/Sources of Verification**	**Important Assumptions**
Results/Outputs 1: The prevalence and distribution of micronutrient deficiencies and their underlying cause in pilot countries assessed. *Activities:* 1. Conduct baseline survey on prevalence of deficiencies in vitamin A, iron and zinc in target areas in pilot countries. 2. Assess the nutrient composition of food products consumed by the target population. 3. Evaluate the effect of traditional processing methods on micronutrient content of maize products.	• The effects of at least 4 traditional processing methods on micronutrient content of maize-based products determined. • Information on the prevalence of deficiencies of vitamin A, iron and zinc in the pilot countries documented. • Information on nutrient composition of the diet of target groups available. • At least 4 surveys conducted in pilot countries.	Published reports Survey reports Annual reports Journal publications	There is good cooperation with the health sector and government agencies in pilot countries

<table>
<tr><td>PROJECT PLANNING MATRIX (PPM)</td><td>Project Ref. No:</td><td>Project Title: Micronutrient fortification of maize and its products in West Africa: A sustainable approach to mitigate hidden hunger</td><td>Estimated Project Duration: 3 years:</td><td>PPM Prepared: June 1999:</td></tr>
<tr><td colspan="2">Summary of Objective/Activities</td><td>Objectively Verifiable Indicators</td><td>Means/Sources of Verification</td><td>Important Assumptions</td></tr>
<tr><td colspan="2">Results/Outputs 2:

Genetically fortified maize cultivars with high levels of provitamin A, iron, and zinc content in the grain developed.

Activities:

1. Characterize African landraces, improved and introduced germplasm for pro-vitamin A, iron, zinc and phytic acid.
2. Inter-cross among germplasm sources with increased levels of vitamin A, iron and zinc.
3. Identify the best varieties with high micronutrient content from the existing elite and adapted germplasm for immediate multiplication and distribution to farmers.
4. Evaluate the expression of high micronutrient concentration in different locations and seasons.
5. Determine the mode of inheritance of micronutrient concentration in grains of maize varieties.
6. Assess the bioavailability of increased micronutrients in grains of the best cultivars using rat models.
7. Evaluate the stability of micronutrients during processing and storage in the improved varieties using participatory methods.</td><td>• Maize varieties with at least 10% increase in pro-vitamin A, iron, and zinc content than the most widely grown maize cultivar available.
• An effective breeding strategy to combine pro-vitamin A, iron and zinc in a single genotype developed.
• Knowledge on the mode of inheritance of pro-vitamin A, iron and zinc in maize increased.
• Information on the stability of pro-vitamin A, iron and zinc during processing and storage available.
• Information on the bioavailability of increased micronutrients available.
• Adapted improved maize varieties high in micronutrients identified.</td><td>• Published reports

• Micronutrient rich varieties in IITA international trials

• Report from independent evaluations by NARS</td><td></td></tr>
</table>

PROJECT PLANNING MATRIX (PPM)	Project Ref. No:	Project Title: Micronutrient fortification of maize and its products in West Africa: A sustainable approach to mitigate hidden hunger	Estimated Project Duration: 3 years:	PPM Prepared: June 1999:

Summary of Objective/Activities	Objectively Verifiable Indicators	Means/Sources of Verification	Important Assumptions
Results/Outputs 3: Micronutrient content of maize products increased through dietary improvement and fortification. *Activities:* 1 Determine the levels and form of fortificants to be incorporated. 2 Develop simple micronutrients fortification techniques. 3 Determine the bioavailability and acceptability of fortified maize products. 4 Determine the levels and form of fortificants to be incorporated 5 Develop processing methods that minimize losses of micronutrients during cooking of fortified products and improved adapted varieties. 6 Evaluate stability of micronutrients during processing and storage of fortified products and improved adapted varieties. 7 Determine the effect of traditional processing and preservation methods on the storage stability of added micronutrients.	• Improved processing methods, simple fortification techniques available and appropriate level of fortification determined. • At least 10 millers are involved in fortification of maize with micronutrients in pilot countries. • At least 2 traditional processing and storage methods improved and adopted in each pilot country. • At least 2 fortified maize products available in the market in each pilot country.	• Published reports • Availability of fortified products • Project reports • Visits to pilot countries	• Good cooperation with millers and the private sector • Strong linkages among partners

PROJECT PLANNING MATRIX (PPM)	Project Ref. No:	Project Title: Micronutrient fortification of maize and its products in West Africa: A sustainable approach to mitigate hidden hunger	Estimated Project Duration: 3 years	PPM Prepared: June 1999

Summary of Objective/Activities	**Objectively Verifiable Indicators**	**Means/Sources of Verification**	**Important Assumptions**
Results/Outputs 4: Maize cultivars with high content of micronutrients multiplied, distributed and adopted. *Activities:* 1. On-farm testing of maize varieties with increased micronutrients. 2. Demonstration of the best varieties with high micronutrient content. 3. Community seed production of the best cultivars for distribution to farmers.	• At least 3 maize varieties with high content of micronutrients multiplied and distributed. • At least 10 tons of seeds of maize varieties with high micronutrient content made available for commercial production in each pilot country.	• Monitoring tours by NARES scientists and other partners. • Published reports.	

PROJECT PLANNING MATRIX (PPM)	Project Ref. No:	Project Title: Micronutrient fortification of maize and its products in West Africa: A sustainable approach to mitigate hidden hunger	Estimated Project Duration: 3 years	PPM Prepared: June 1999

Summary of Objective/Activities	Objectively Verifiable Indicators	Means/Sources of Verification	Important Assumptions
Results/Outputs 5: Market sector analysis conducted and strategies for promotion and commercialization of improved cultivars and fortified products determined. *Activities:* 1 Market survey to determine the prices of competing products as well as understanding their marketing channel will be carried out in pilot countries. Cost benefit analysis for investing in producing the products will be done for both commercial and domestic processing levels. 2 Facilitate contractual agreements between farmers and processors. 3 Investigate opportunities for cross-border information exchange to enhance product marketing and commercialization.	• Efficient price for the products determined. • An effective marketing and promoting strategy for the product designed. • Cost-benefit ratio for fortified maize products in the four pilot countries determined. • Demand and affordability of fortified maize products determined. • At least 3 farmers contracted to produce micronutrent rich cultivars in each pilot country. • At least 8 small to medium scale processors produce micronutrient-fortified products.	• Market prices of products. • Published reports on cost-benefit analysis. • Market survey reports.	Conducive regional marketing policies.

PROJECT PLANNING MATRIX (PPM)	Project Ref. No:	Project Title: Micronutrient fortification of maize and its products in West Africa: A sustainable approach to mitigate hidden hunger	Estimated Project Duration: 3 years	PPM Prepared: June 1999
Summary of Objective/Activities		**Objectively Verifiable Indicators**	**Means/Sources of Verification**	**Important Assumptions**
Results/Outputs 6: The capacity of NARS and private sector for effective technology development and transfer improved. *Activities:* 1. Conduct training courses, seminars, workshops, and farmers' field days to develop skills and knowledge on micronutrient fortification. 2. Organise individualized attachment programs.		• At least 10 researchers, 20 technicians, 100 farmers, and 10 industry workers trained on micronutrient fortification. • Enhanced professional and scientific capacity of NARS scientist, private sector and technicians for micronutrient fortification technology development and transfer. • Exchange of scientific information and new technologies.	• Number of NARS scientists and technicians trained. • Workshop Proceedings. • Reports of group training courses. • Course evaluation reports. • Individual attachment evaluation reports. • NARS reports.	

PROJECT PLANNING MATRIX (PPM)	**Project Ref. No:**	**Project Title: Micronutrient fortification of maize and its products in West Africa: A sustainable approach to mitigate hidden hunger**	**Estimated Project Duration: 3 years**	**PPM Prepared: June 1999**
Summary of Objective/Activities		**Objectively Verifiable Indicators**	**Means/Sources of Verification**	**Important Assumptions**
Results/Outputs 7: Impact of micronutrient fortification, dietary improvement and adoption of improved maize cultivars assessed. *Activities:* 1 Assess the effects of consumption of micronutrient fortified products on the improvement of nutritional status of target groups. 2 Conduct adoption studies on new postharvest technologies. 3 Evaluate the effect of new technologies on maize production at the farm level.		• Information for feedback to technology developers or for extension to non-pilot countries on adoption processes available • Information on micronutrients nutritional status of the target population available.	• Published reports. • Reports from Health clinics, UNICEF etc.	• Availability of fortified maize products

Appendix 3.

List of Participants for the workshop on the Initiative for Improving the Micronutrient Content of Staple Food Crops and their Products in West Africa.

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Appendix 4. Workshop Program

Initiative for Improving the Micronutrient Content of Staple Food Crops and their Products in West Africa

Program

6 –8 April 1999, IITA, Ibadan, Nigeria

PROGRAM

Tuesday 6 April 1999

08:00 - 08:10: Registration of workshop participants

OPENING CEREMONY
Chairperson: B. Maziya-Dixon

08:10 - 08:20: Welcome address: Dr J.G. Kling, Coordinator, Improvement of Maize/Grain Legume Production Systems Project.

08:20 - 08:30: Opening address: Dr R. Asiedu, Acting Director for Crops Improvement Division, IITA

SESSION 1: Developments in micronutrients research in pilot countries
Chairperson: D.J. Monhouanou
Rapporter: E. Williams

08:30 - 08:50: Background of the workshop and framework for developing the micronutrient initiative: Taye Bezuneh.

08:50 - 09:10: Genetic fortification of staple food crops: A. Menkir and J.G. Kling

09:10 – 09:30: Industrial processing and fortification of cereals and their products: A. Oduncon

09:30 - 10:00: Discussion

10:00 - 10:30: Coffee break and group photograph

SESSION 2: Discussion of project components
Chairperson: T Bezuneh
Rapporter: P.S. Chindo

10:30 - 10:50: Country presentation (Benin)

10:50 – 11:10: Country presentation (Ghana)

11:10 - 11:30:	Country presentation (Burkina-Faso)
11:30 - 11:50:	Country presentation (Nigeria)
11:50 - 12:30:	Comments and discussion on country reports
12:30 - 14:00:	Lunch
14:00 - 14:20:	Comments on the future of genetic fortification program on sorghum and millets: ICRISAT
14:20 – 14:40:	Promotion of micronutrient fortification technologies: B. Badu-Apraku and Taye Bezuneh
14:40 – 15:00:	Discussion

SESSION 3: Development of Project Proposal

Chairperson: **N.M. Zagre**
Rapporter: **J.O. Akingbala**

15:00 – 15:20:	General comments and formation of working groups: T. Bezuneh
15:20 – 15:30:	Coffee break
15:30 – 17:30:	Meeting of working groups
18:00:	Cocktail

Wednesday 7 April 1999

SESSION 4: Development of Project Proposal continued

08:00 - 10: 00:	Meeting of working groups
10:00 – 10:30:	Coffee break
10:30 – 12:30:	Meeting of working groups continued
12:30 – 14:00:	Lunch
14:00 – 17:30:	Meeting of working groups continued

Thursday 8 April 1999

SESSION 5: Working group reports, discussion and synthesis of proposal
Chairperson: J. Kling
Rapporter: B. Badu-Apraku

08:00 - 10:00:	Meeting of working groups (Preparation of rapporteur's report)
10:00 - 10:30:	Coffee break
10:30 - 11:00:	Group presentation (Group 1)
11:00 - 11:30:	Group presentation (Group 2)
12:30 – 14:00:	Lunch
14:00 – 14:30:	Discussion and follow up actions
14:30 - 15:00:	Closing remarks: Dr Taye Bezuneh, International Coordinator, (OAU/STRC-SAFGRAD)
	Dr Robert Booth, Deputy Director General, IITA
15:00:	Departure

Working Groups

Two working groups (WG) will be formed namely Institutional Arrangement and Technical groups.

WG-1 Institutional Arrangement

This group will focus on the following issues:

- Framework for program management
- Partnership of stakeholders
- Institutional linkages
- Coordination, monitoring and evaluation
- Perspective of donors and budget

WG-2 Technical

This group will focus on the following issues:

- Description of project components
- Rationale/need, background
- Objectives
- Logical framework
- Partnerships including beneficiaries

Each group to appoint a Chair (who will present the group's report) and a rapporteur (who will take notes on the group's discussion, and on the recommendations following the Chair's presentation)

Group Members

WG-1 Institutional Arrangement	*WG-2 Technical Issues*
T. Bezuneh	N. Zagre
B. Badu-Apraku*	B. Maziya-Dixon
O. Akingbala	D. Monhouanou
Mr Victor Anihouvi	A. Oduncon
ICRISAT	A. Aba
P. Chindo	S. Aminu
E. William	A. Menkir
D. Maigida	R. Obubo
J.G. Kling*	S. Ajala

* Will shuffle between the groups.

1999

Micronutrient Enhancement in Maize and its Products in West Africa: A Sustainable Approach to Mitigate Hidden IHunger

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