# Micronutrient Enhancement in Staple Food Crops and their Products in West Africa: A Sustainable Approach to Mitigate Hidden Hunger

Project Proposal submitted to:

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by

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# 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 levels of micronutrients in maize-, sorghum- and millet-based diets through fortification of maize, sorghum and millet meal and flours with vitamin A, iron and zinc, improved processing and storage of maize, sorghum and millet flours and products, and determine the extent of genetic variation of the target micronutrients of African landraces, improved and introduced germplasm. These products will be disseminated through enhanced linkages with extension and the private sector.

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, Burkina Faso, Niger and Ghana, where maize, sorghum and millet are important staple food crops. 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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## Micronutrient Enhancement in Staple Food Crops and their Products in West Africa: A Sustainable Approach to Mitigate Hidden Hunger

### Statement of the Problem

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. 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 and tannins 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).

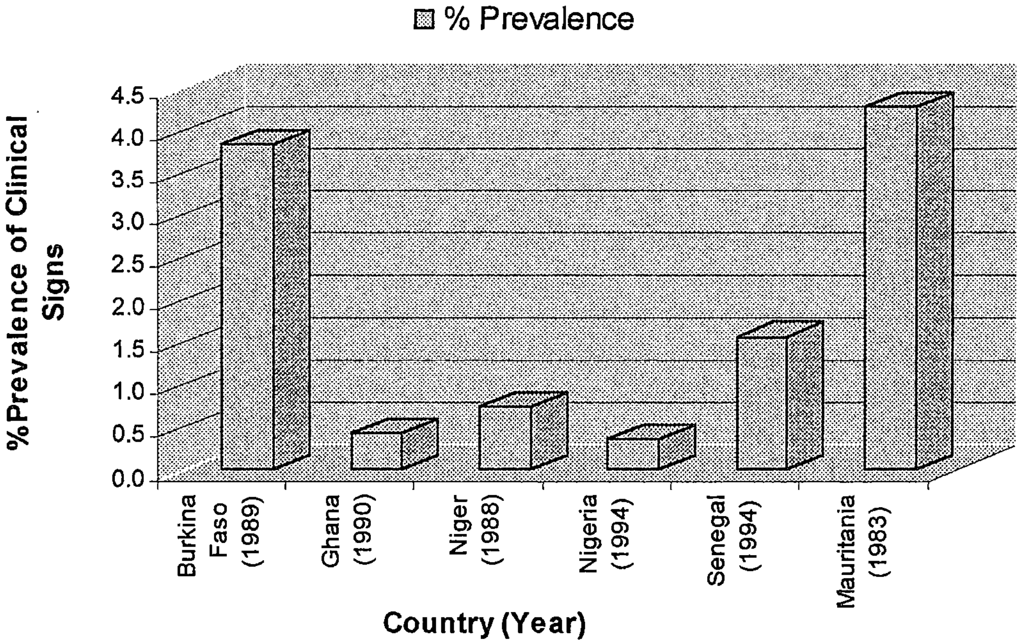


Fig. 1. **Prevalence of Clinical Signs of Vitamin A Deficiency (VAD) from National Survey data in selected countries of West Africa**

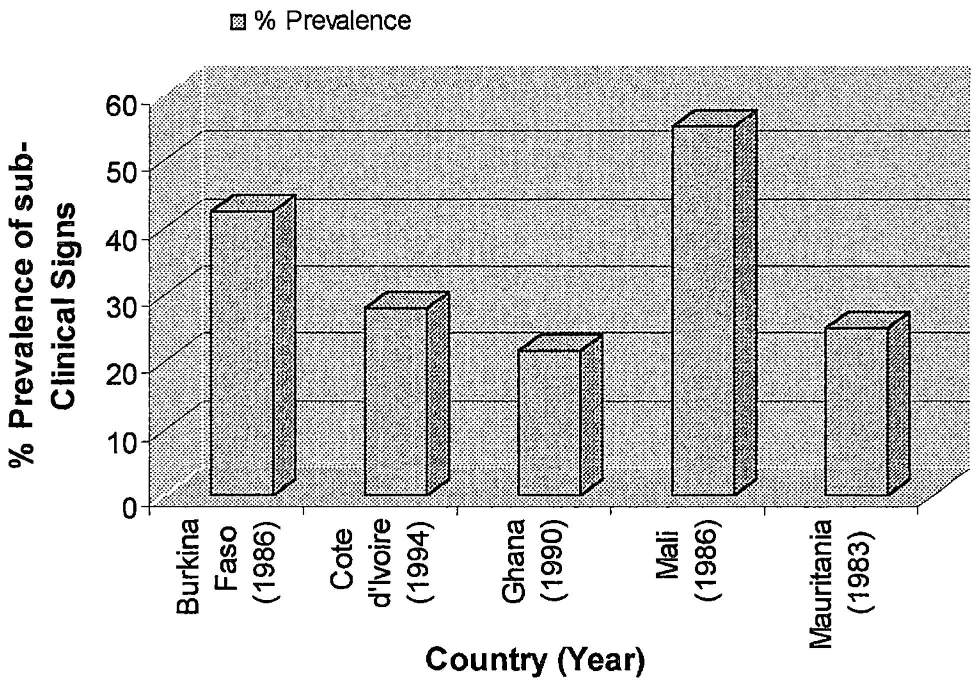


Fig. 2. **Prevalence of sub-Clinical Signs of Vitamin A Deficiency (VAD) from National Survey data in selected countries of West Africa**

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).

**Background of the situation**

Sub-Saharan Africa is the only region in the world where the human 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.

**Justification**

As staple cereals of the poor populations of semi-arid West Africa maize *(Zea mays)*, sorghum *(Sorghum bicolor)* and pearl millet *(Pennisetum glaucum)* are major sources of dietary carbohydrate and protein. They 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 while sorghum and millet is estimated between 200-250 kg per person per year. Sorghum and millet are grown on an estimated 25 million ha and produce 18 million tons of grain.

An inherent advantage of working with maize, sorghum and millet is that they can be appropriate vehicles for fortification, as they are staple foods consumed by 70% of the population particularly the poor in large quantities every day in many countries. Most of the locally available and affordable weaning foods use these cereals as main constituent. These crops have high productive potential and are easily converted into well-accepted local food products. They are largely consumed in the semi-arid region and are an important source of calories and protein. Enhancing the micronutrient content of maize-, sorghum- and millet-based diets through fortification 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.

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, sorghum and millet are important staple food crops. 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 network.

## 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. The key success of this program will depend in establishing productive partnerships with a number of institutions such as NARES, IARCs, SAFGRAD, NGO's, nutri-business, food science and nutrition units and micro food processors.

### 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-, sorghum- and millet-based diets through fortification of maize, sorghum and millet meal and flours with vitamin A, iron and zinc, improved processing and storage of maize, sorghum and millet flours and products, and determine the extent of genetic variation of the target micronutrients of African landraces, improved and introduced germplasm.

### Specific Objectives

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

2. Increase micronutrient content of maize, sorghum and millet products through dietary improvement and fortification.

3. Assess the extent of genetic variation for provitamin A, iron, and zinc content in the grain of African landraces, improved and introduced germplasm.

4. Promote the multiplication and distribution of maize, sorghum and millet cultivars and their fortified 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. The project will provide a sustainable solution to the problem of micronutrient malnutrition by developing locally products that can be produced economically and commercialized 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. 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<br>• Greater productivity and profitability of improved varieties<br>• Better markets for seed and raw materials |
| Processors | • Better availability of high quality raw materials<br>• 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<br>• Increased availability of diversified food products<br>• 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 Nigeria, Niger, Ghana 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

In conducting the baseline studies in each country, two approaches will be adopted. The first is to assemble available data on prevalences of deficiencies of the three micronutrients. The second is to collect primary data to fill in the missing gaps. Two separate databases will be used to estimate the country level prevalences of VAD, one each for the clinical signs and symptoms and serum retinol. The Micronutrient Deficiency Information System (MDIS) No 2 (WHO 1995) will serve as the initial basis of the analysis for comparability purposes. However in the MDIS, the clinical signs reported differed substantially among surveys thus the first step in the analysis will be to select a subset of results reported in the MDIS on the basis of the most comparable indicators e.g. age groups and likelihood of reflecting national prevalences.

In building estimates of the prevalence and numbers affected by VAD, the multiplication factor utilized by WHO (1995) will be used in the analysis for consistency of approaches. In order to generate national estimates where none exists, interpolation models will be built. The models will maximize the concordance between the observed and predicted values for the pilot countries when generating the final country level estimates of both clinical and retinol based VAD. In estimating the prevalence of clinical VAD, multiple logistic regression analysis will be used to find the best prediction model for the clinical prevalence of VAD. Several independent variables will be included in the modeling exercise including dietary Vitamin A availability (RE/Caput/day). GNP per capita: log GNP per capita, estimated underweight prevalence, interaction terms for Vitamin A Supply with GNP, log GNP, IMR and underweight prevalence will also be tested in the model.
This model has been reported to be both highly sensitive and specific in predicting clinical deficiency with a sensitivity of mainly 95% and specificity of 94% when predicting prevalences greater than or less than one. A similar model will be used to determine VAD based on low serum retinol levels (less than 0.7 micromoles per liter).

The second approach to complement the secondary data is the collection of limited national primary data in the pilot countries. A questionnaire will be developed to administer to the target population which will be households with under five children, school age children, adolescents and women of child bearing age 15-49 years. The questionnaire will collect information on socio-economic characteristics of the household, food consumption pattern, and frequency for calculating intake from all sources (Helen Keller Food Frequency Questionnaire will be adopted) and Nutrition status data by anthropometry, (Height, Weight, Skinfold thickness) using standard methods (Latham, 1997). The questionnaire will also contain a section on clinical observations for signs and symptoms of VAD.

Prevalence of Iron Deficiency: Haemoglobin and haemotocrit levels of the sampled target population will be determined and classified with regard to age, sex and physiological status. This will be complemented with dietary assessment to measure iron intake. Dietary assessment will be most useful for infants who consume few other foods in a predominantly milk based diet. The determinations of haemoglobin concentrations will be done in the field using a Hemocue (Ban Schenck *et al* 1986) based on the laboratory cyanomethehaemoglobin method of assessment. The haematocrit or packed cell volume (PCV) method is also simple and can be done using a hard cracked microcentrifuge. Cut off points as specified by WHO will be used to determine prevalence in each sub group being studied.
Serum ferritin will be determined since it is the most specific biochemical test indicator of total body stores. The method of Flower et al (1986) will be used.

The prevalence of zinc deficiency will be determined by assessing the zinc status of the target group using the enzyme plasma alkaline phosphatase method, which has been found to give best results under survey conditions. (Hamibidge *et al* 1986, Mills 1989).

Sample Size Determination: The National Sampling frame of each country will be used with the required enumeration areas (EAs) needed calculated from the total number of EAs required. The minimum sample required for statistical representation will be calculated using the following formula:

$$\text{Sample Size (N)} = \frac{Zx2\ pq}{d2}$$

Zx2 = level of probability that the line percentage or prevalence is within the chosen value of 'd'

d = level of precision required of results ( +/- percent).

P = estimate of percentage or population of target group.

During the baseline survey in each country, major foods commonly consumed by the target population will be determined from the HKI food frequency questionnaire. Samples of these foods will be collected in triplicates from sources of purchase or recipes obtained from households which will then be prepared in triplicates. The samples will be transported to the laboratory for moisture determination with the dried food samples being used in the determination of Vitamin A, Iron and Zinc. HPLC will be used for vitamin A and carotenoids and Atomic Absorption Spectrophotometer for iron and zinc (AOAC, 1994). Results obtained will be used to determine the intakes of vitamin A, Iron and Zinc for comparisons with Recommended Dietary Allowance to assess the extent of the deficiencies of these micronutrients.

Products commonly eaten in each of the pilot countries will be identified from the food frequency questionnaires. The processing methods used in the production of the identified products will be evaluated to evaluate the amount of nutrient loss. During processing samples will be collected in duplicates from time 0 until the end of the process. Collection will be at regular intervals predetermined from the flow charts of the process technique. Vitamin A, carotenoids, Iron and zinc will be determined using standard procedures (IVACG and AOAC, 1994). The differences in the content of the micronutrients in the raw material (maize, sorghum and millet) and the final products will represent losses due to processing which can be used in a restoration and fortification programme for the products. The losses during the different stages of preparation can be used for progress modification to reduce the losses.
Data coding, tabulation and statistical computations will be carried out in each pilot country with the assistance of a statistician. The Biometrics Unit of IITA will provide backstopping when necessary.

## 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 6 surveys conducted in pilot countries.
- The effects of at least 6 traditional processing methods on micronutrient content of maize-, sorghum- and millet-based products determined.
- Published reports.

## Activity 2: Increase micronutrient content of maize, sorghum and millet products through fortification and dietary improvement.

## Objectives

1. Develop technologies for maize, sorghum and millet 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, sorghum and millet can be readily fortified with iron without any technical problems. For example, 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, sorghum and millet into either meal, flour 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 meal or flour. Yellow maize and new lines of sorghum contain provitamin A carotene. The form in which yellow maize and sorghum 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, sorghum and millet flours/meals 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). 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, sorghum and millet flours with micronutrients will take place in hammer mills in local communities as well as in commercial mills in urban and peri-urban areas. Since these cereals are 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.

Most cereals store phosphorus as phytate. In sorghum and millet, phytate phosphorus ranges from 45-95% of total phosphorus. The importance of phytic acid in nutrition lies in its property of forming insoluble compounds with mineral elements, including calcium, iron and zinc and negatively influences the absorption and retention of these micronutrients in humans. Thus phytic acid is probably responsible for the low retention and high excretion of ingested calcium and iron. Polyphenols (tannins) are very important in sorghum. Tannins reduce total and protein digestibility and inhibit activity of enzyme systems including amylases.

**Methodology**

Maize, sorghum and millets are generally consumed in the form of grits, meals and flour in the region under study and cooked as grits or stiff paste in neutral, acid or alkali media. Levels and form of fortificants to be incorporated will be determined based on information collected during baseline studies regarding content and losses of the micronutrients during storage and cooking. Simple micronutrient fortification technique will be devised based on the products and available equipment. A dry mill-mix fortification process may be used. Rat studies and chemical methods will be used to determine the bioavailability of vitamin A, iron and zinc of products in cooked and uncooked fortified samples. Sensory evaluation of cooked samples will be conducted to determine acceptability of fortified products using participatory methods.

Traditional processing methods will be modified where necessary to produce an acceptable food with little or no loss of the added micronutrients. The stability of the nutrients in the fortified products during cooking will also be evaluated using standard AOAC methods. Stability of vitamin A, iron and zinc during storage will be evaluated. The fortified products will be stored in polyethylene bags of various thickness; transparent and opaque; and clear and dark bags. They will be sealed tight and stored at ambient temperature to determine storage stability of the fortified products. In addition, accelerated storage studies will be conducted as described by Hall (1991). Data will be analyzed using SAS (SAS, 1985).

**Outputs**

- Nutritional quality of maize, sorghum and millet flours and their other products enhanced through fortification with micronutrients.
- Technology for maize, sorghum and millet fortification at the commercial and village level developed and tested.
- Bioavailability of nutrients and acceptability of fortified maize, sorghum and millet products determined.
- Effects of processing and storage on micronutrient content of fortified products determined.

**Indicators for monitoring and evaluation**

- Improved processing methods, simple fortification techniques and appropriate level of fortification are available.
- At least 30 food processors are involved in fortification of maize, sorghum and millet 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, sorghum and millet products available in the market in each pilot country.
- Published reports.

## Activity 3: Assessment of African landraces, improved and introduced germplasm for the extent of genetic variation in provitamin A, iron, and zinc content in the grain.

**Objectives**

1. Determine extent of genetic variation for provitamin A, iron, and zinc content in the grain of African landraces, improved and introduced germplasm.
2. Determine if a relationship exists among morphological characteristics such as grain size and shape and provitamin A, iron and zinc.

**Background**

Increased concentration of micronutrients, such as provitamin A, iron and zinc, in maize, sorghum and millet 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 behavioral changes in the target population.

As genotypes with high micronutrient content are identified, processing (milling) quality would be assessed using participatory methods. The loss of nutrients during processing and their bioavailability will influence the nutritional value of the selected genotypes. Stability of carotene across different processing methods has been shown to be genotype-dependent and should be evaluated. Thus, more research is needed to develop food processing and storage methods to minimize losses of micronutrients and enhance their bioavailability. Cultivars identified as having relatively high amounts of these micronutrients will be used directly by the farmers for production while the information on the extent of genetic variability will lead to genetic fortification studies in the long term.

## Methodology

Landraces, improved and introduced maize, sorghum and millet germplasm will be evaluated for provitamin A content, iron, zinc, tannins, and phytate content. Provitamin A carotenoids, phytate and tannins will be separated, identified and estimated using HPLC (Gross, 1991; McDonough and Rooney, 1985). Iron and zinc content will be determined by atomic absorption spectrophotometer. The

best varieties with high micronutrient content from the existing elite and adapted germplasm will be identified for immediate multiplication and distribution to farmers. Physical and chemical characteristics of the grains will be determined using standard AACC methods (AACC, 1982) and simple correlation among evaluated characteristics will be done to determine if a relationship exist among morphological characteristics and micronutrient content in maize, sorghum and millet grain. Processing quality such as milling, stability of micronutrients during traditional processing and storage in the identified varieties will be evaluated with women groups using participatory methods. Data will be analyzed using SAS (SAS, 1985).

## Outputs

- Adapted improved maize, sorghum and millet varieties high in provitamin A, iron, and zinc content identified.
- Information on the extent of genetic variability for iron, zinc and provitamin A content in maize, sorghum and millet germplasm available.
- Information on the relationship between the grain's morphological characteristics and micronutrient content established.

## Indicators for monitoring and evaluation

- Published reports.
- The use of selected cultivars by farmers and micro food processors.

## Activity 4: Market sector analysis, promotion and commercialization of cultivars and fortified products.

## Objectives

1. Assess and project demand for the fortified maize, sorghum and millet 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, sorghum and millet 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, sorghum and millet 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, sorghum and millet cultivars and their fortified products.*
4. *Improve production of quality raw material (maize, sorghum and millet) 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

- Affordable prices for the fortified maize, sorghum and millet products determined.
- Demand and affordability of fortified maize, sorghum and millet products determined.
- Cost-benefit ratio for fortified maize, sorghum and millet 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 30 farmers contracted to produce raw materials (maize, sorghum and millet) in each pilot country.
- At least 30 small to medium scale processors produce micronutrient-fortified products.

**Activity 5: Capacity building 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, ICRISAT, Food Science and Nutrition Institutes 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 a few 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 in food science and nutrition. 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, ICRISAT, Food Science and Nutrition Institutes and other research institutes in the region. A planning and 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**

Conduct training courses, seminars, and workshops in food technology and nutrition to develop skills and knowledge on micronutrient fortification. During the life of the project various institutions will carry out training for a large number of people in all sectors of Nigeria, Niger, Ghana and Burkina Faso. This will take the form of group training in villages and at other gatherings with individuals in small businesses.

A training workshop on RA will be held, at the start of the project for some of the team members from Nigeria, Niger, Ghana and Burkina Faso. Four persons, from each country will be trained over a period of four days. Social scientists and technologists with experience in the use of RRA techniques will be responsible for the training activities with the help of a consultant and the Micronutrient Initiative staff. These project personnel will use the techniques learned to carry out the initial surveys and follow-up field assessment work during the life of the project.

Individualized training attachments will be organized based on needs of each pilot country. A planning and end of project workshops will be conducted to develop project workplans and to promote the spillover of project outputs and information to non-project countries in the region.

**Outputs**

- At least 150 research technicians, 450 micro food processors, several farm households and women groups, 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 research technicians, micro food processors, farm households, women groups, and industry workers trained.
- Workshop Proceedings.
- Reports of group training courses.
- Course evaluation reports.
- Individual attachment evaluation reports

**Activity 6: Impact assessment of micronutrient fortification of maize, sorghum and millet products and dietary improvement on nutritional status of target groups.**

**Objective**

1. Assess the rate of adoption fortified food products.
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 developed and improved food products. 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 nutritionists, food technologists, agriculturists and economists to work on impact studies.

**Methodology**

1. *Conduct adoption studies on new post-harvest technologies.*
2. *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.

**Indicators for monitoring and evaluation**

- Published reports.

## Implementation Strategy and Sustainability

### Strategy for delivery of research outputs to beneficiaries

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 flow of project activities is outlines in fig. 3. Baseline studies will include a review of available information on prevalence of micronutrient deficiency. Clinical tests of the target populations in each pilot country will be conducted to fill in gaps in existing knowledge and to provide a basis for impact assessment at the end of the project. The number of villages (pilot sites) and sample size will be determined in each pilot country. The initiative 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 assessment of genetic variability in landraces, improved and introduced cultivars and germplasm will be thrust of the international agricultural research centers. The most promising available technologies will be immediately channeled into commercial production. At the same time, the food research institutes will be assisted by IITA, SAFGRAD, and ICRISAT to evaluate the micronutrient content of existing maize, sorghum, and millet food products and develop better methods for processing and fortification, and new products high in micronutrients that will be used by micro food processors in each pilot country.

Once promising processing and fortification technologies have been identified for each country, it will be necessary to scale-up levels of production. SAFGRAD will work with small- medium- and large-scale commercial processors to establish linkages with contract farmers growing raw materials for processors. Linkages will be established with marketing agencies for distribution and product promotion within and across countries. Training courses on product development, nutrition and marketing will be offered both at the regional level (IARCs) and in the pilot countries by Food Science and Nutrition Units. 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. A planning workshop will be organized to enhance program implementation and regional end of project workshop will also be organized to exchange experiences, technical information as well as synthesize the outputs of the project in order to lay the groundwork for further extension of the benefits of the project to non-pilot countries.

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**<br>• Experience in facilitating communications between IARCs and NARS<br>• Experience in capacity building and empowerment of NARS<br>• Experience in forming linkages between research and commercial sectors<br>• Knowledge of the region and its institutions | • Coordinates project activities<br>• Linkages between research, raw material production and commercial sector<br>• Dispersal of funds for networking and commercialization of technologies in pilot countries<br>• Linkages with other projects, development agencies, and NGO's<br>• Promoting spillover to nonpilot countries<br>• Monitoring of project activities at all levels through annual monitoring tours by a team representing all partners |
| **IITA**<br>• Well-established maize breeding programs, food technology laboratories, and infrastructure<br>• Editing and publishing expertise and facilities available<br>• Audited accounting system | • Standardization and facilitation of baseline studies and impact assessment in pilot countries<br>• Facilitation of food processing research in pilot countries |
| **ICRISAT**<br>• Large deposit of improved and diversified landraces of sorghum and millet<br>• Well established sorghum and millet improvement programs<br>• Nutrient analysis and assessment capacity and training facilities | • Standardization and facilitation of baseline studies on sorghum and millet nutritional uses |
| **National Research Institutes**<br>• First-hand knowledge of preferences and needs of end-users<br>• Proximity and ease of communication with farmers, processors, marketing agencies, and consumers<br>• Access to available infrastructure at the local level | • Co-ordination and monitoring of pilot programs through an appointed individual (focal unit) in each country<br>• Preparation of pilot country workplans and reports<br>• In-country training and demonstrations |

## Sustainability

The success of increased micronutrient intake through the enhancement of the micronutrient content of maize, sorghum and millet and their 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 the Network'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, sorghum and millet 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, sorghum and millet products high in micronutrients.

### Monitoring

Pilot programs will be coordinated and monitored by a team representing the stakeholders (SAFGRAD, IITA, ICRISAT, Micro Food Processors, Food and Nutrition Scientist in each pilot country). This team will visit selected pilot countries at least once each year to monitor progress.

SAFGRAD will monitor production and commercialization of the micronutrient-rich products in pilot countries. IITA and SAFGRAD will coordinate and monitor food processing and product development research, baseline surveys and impact assessment for maize, sorghum and millet respectively.

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, a nutritionist/food technologist 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. 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, sorghum and millet 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.

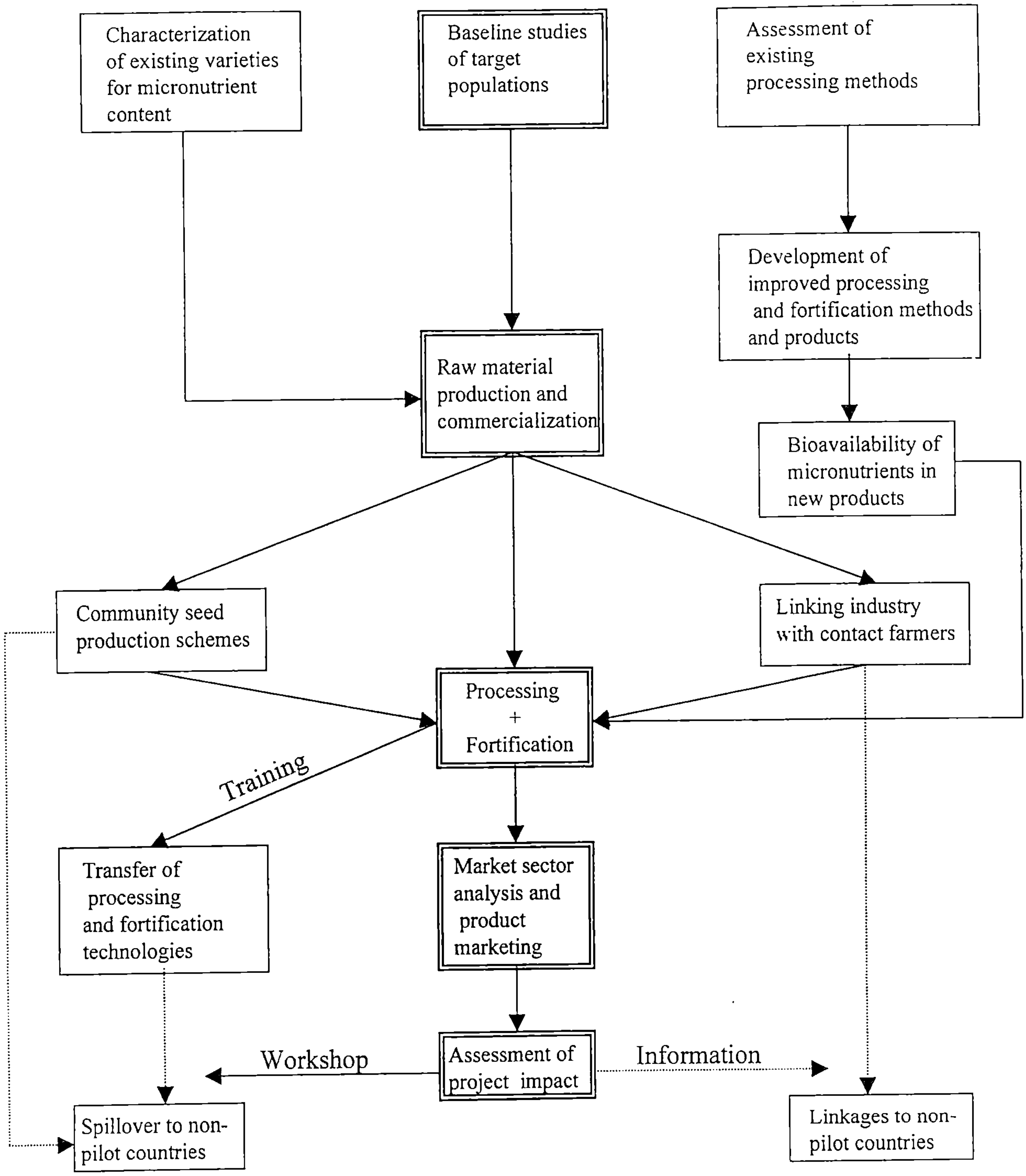


Fig. 3. **Flow Chart of Activities for Enhancement of Micronutrient in Staple Food Crops and their Products**

# APPENDICES

## Appendix 1. Budget

### Budget Summary (US$'000)

| Activities | Year 1 | Year 2 | Year 3 | Total |
|---|---|---|---|---|
| Personnel | | | | |
| Associate Scientist | 70 | 70 | 70 | 210 |
| Research Associate (2) | 15 | 15 | 15 | 45 |
| **Subtotal** | **85** | **85** | **85** | **255** |
| Capital Equipment | 70 | 0 | 0 | 70 |
| Vehicle (2) | 37.4 | 0 | 0 | 37.4 |
| **Subtotal** | **107.4** | **0** | **0** | **107.4** |
| *Activity 1. Assessment of micronutrient deficiencies* | | | | |
| Baseline surveys | 40 | 0 | 0 | 40 |
| Nutrient composition of food products | 20 | 0 | 0 | 20 |
| Analytical support (data analysis) | 8 | 0 | 0 | 8 |
| **Subtotal** | **68** | **0** | **0** | **68** |
| *Activity 2. Fortification (National Level)* | | | | |
| Processing and product development research | | | | |
| Equipment | 30 | 30 | 0 | 60 |
| Materials and supplies | 16 | 16 | 16 | 48 |
| Bioavailability studies | 40 | 40 | 0 | 80 |
| Food processing and product development research (Regional Level) | 15 | 15 | 10 | 40 |
| **Subtotal** | **101** | **101** | **26** | **228** |
| *Activity 3. Assessment of cultivars for nutritional quality* | | | | |
| Materials and supply | 30 | 30 | 30 | 90 |
| **Subtotal** | **30** | **30** | **30** | **90** |
| *Activity 4. Transfer of technology ,commercialization of fortified products and market sector analysis* | | | | |
| Raw materials production | 35 | 30 | 17 | 82 |
| Market studies | 0 | 30 | 0 | 30 |
| Packaging, distribution and marketing | 0 | 25 | 14 | 39 |
| **Subtotal** | **35** | **85** | **31** | **151** |
| *Activity 5. Capacity building* | | | | |
| Seminars and workshops (Country Level) | 32 | 0 | 32 | 64 |
| Training: | | | | |
| Regional Level | 18.88 | 18.88 | 0 | 37.76 |
| National level | 12 | 12 | 0 | 24 |
| Planning workshop (Regional level) | 40.68 | 0 | 0 | 40.68 |
| Terminal workshop (Regional Level) | 0 | 0 | 47.76 | 47.76 |
| **Subtotal** | **103.56** | **30.88** | **79.76** | **214.2** |
| *Activity 6. Impact assessment* | | | | |
| Adoption studies | 0 | 28 | 28 | 56 |
| Feeding studies | 0 | 28 | 28 | 56 |
| **Subtotal** | **0** | **56** | **56** | **112** |
| *Miscellaneous* | | | | |
| Consultant (from MI) | | | | |
| *Project coordination and management* | | | | |
| Focal unit (National Level) | 16 | 16 | 16 | 48 |
| Monitoring and evaluation (Team) | 0 | 19.5 | 19.5 | 39 |
| Travel | | | | |
| Regional | 11.44 | 11.44 | 11.44 | 34.32 |
| International | 0 | 8.7 | 8.7 | 17.4 |
| Support services | 34 | 34 | 23.8 | 91.8 |
| **Subtotal** | 61.44 | 89.64 | 79.44 | 230.52 |
| Grand Total | 591.40 | 477.52 | 387.20 | 1,456.12 |

# Appendix 2. Budget- Contributions in Kind (US$'000)

| ACTIVITIES | YEAR 1 | YEAR 2 | YEAR 3 | TOTAL |
|---|---|---|---|---|
| *IITA* | | | | |
| Provision of family vehicle, accommodation, etc. for Associate Scientist | 50 | 51 | 52 | 153 |
| Maize Breeders (10% time allocation) | 19 | 20 | 21 | 60 |
| 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 |
| Capital investment and depreciation | 5 | 5 | 5 | 15 |
| **Subtotal IITA** | **79** | **81** | **83** | **243** |
| *OAU/STRC-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 *OAU/STRC-SAFGRAD*** | **17** | **17** | **18** | **52** |
| ***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 |
| ***Burkina Faso*** | | | | |
| Human resources | 10 | 10 | 10 | 30 |
| Capital equipment and communication | 6 | 5 | 5 | 16 |
| Community contribution | 4 | 4 | 4 | 12 |
| **Total for Burkina Faso** | **20** | **19** | **19** | **58** |
| ***Niger*** | | | | |
| Personnel | 4 | 5 | 6 | 15 |
| Equipment | 5 | 5 | 5 | 15 |
| Institutional support | 2 | 2 | 2 | 6 |
| **Total for Niger** | 11 | 12 | 13 | 36 |

## Appendix 3. Budget Notes

**Personnel**
Full cost is estimated at $120,000 for the first year. The project coordinator will be assisted to carry out the work proposed herein by the addition of an Associate Scientist, Food Technologist (PhD level) and 2 Research Associates, a Nutritionist and Socio-economist (MSc level) whose salaries will be covered by the project. Benefits such as health insurance, housing and a vehicle for the Associate Scientist to be paid as in-kind contribution by IITA. The Associate Scientist and Nutritionist will be based at IITA and the Socio-economist at SAFGRAD.

**Capital Equipment**
Funds will be used to purchase an HPLC with its accessories for pro-vitamin A (Equipment must be approved by IDRC before purchase), phytic acid and tannins analysis.

**Vehicle**
IITA and SAFGRAD given the amount of travel that will be done will purchase two vehicles for use.

**Research Expenses**
*Activity 1: Assessment of micronutrient deficiencies:*

*Baseline surveys*: US $10,000 to be allocated to each pilot country making a sum of US $40,000.

*Nutrient composition of foods*: $5,000 per country = $20,000

*Analytical support*: $2,000 per country for data analysis for a total of $ 8,000

*Activity 2: Fortification (National level)*

*Equipment*: Funds will be used to buy food-processing equipment such as mixers, grinders and blenders. Equipment must be approved by IDRC before purchase.
$15,000 per country x 4 countries = $60,000.

*Materials and Supplies*: This budget line covers laboratory chemicals and other consumables. $4,000 per country and per year x 4 countries = $16,000 for a total of $16,000 x 3 = $48, 000

*Bioavailability Studies*: $10,000 per country x 4 countries = $40,000 per year for the first two years. Total: $40,000 x 2 = $80,000.

*Food processing and product development*: IITA will carry out research on processing and product development to support research activities in pilot countries. A total of $40,000 has been allocated. $15,000 for years 1 and 2 and $10,000 for year 3.

*Activity 3: Assessment of maize, sorghum and millet cultivars for nutritional quality.*

This budget line covers laboratory chemicals and other consumables for characterisation studies by IITA and ICRISAT. Each centre is allocated $15,000 per year.

| | | | |
|---|---|---|---|
| IITA | $15,000 x 3 years | = | $45,000 |
| ICRISAT | $15,000 x 3 years | = | $45,000 |
| Total | | | $90,000 |

*Activity 4: Transfer of technology, commercialisation, and market sector analysis*

*Raw materials production*: For support to community and farmer-based seed production schemes in producing adequate quantities of high quality seeds.
Year 1 = $35,000; Year 2 = $30,000; Year 3 = $17,000. Total = $82,000

*Market studies*: For market surveys and demand studies in each pilot country:

| | | |
|---|---|---|
| $5,000 x 4 pilot countries | = | $20,000 |
| $5,000 x 2 non-pilot countries | = | $10,000 |
| Total | = | $30,000 |

*Packaging, distribution, and marketing*: For studies on packaging materials, distribution channels and marketing strategies.
Year 2 = $25,000; Year 3 = $14,000. Total = $39,000

*Activity 5 – Capacity building*

*Seminars and workshops (Country level):* Training of extension workers and community based organisation to disseminate results of the project.
$8,000 x 4 countries= $32,000
$32,000 x 3 years = $64,000

*Training (Regional Level):* Research Technicians: 16 technicians (4 per country) for 5 days at $100 per day per diem (boarding and meals) and $680 per person for air fare.
16 x 5 x $100 + 16 x $680 = $18,880 x 2 years = $37,760.

*Training (National Level):* Project staff in each pilot country will receive training in participatory appraisal and other methodologies during the first two years of the project.
$3,000 x 4 countries = $12,000
$12,000 x 2 years = $24,000

*Regional planning workshop:* an initial planning workshop will take place at the beginning of the project. A total of 18 participants with at least 3 per country for 5 days.
$100 per diem/person/day = 18 x $100 = $1,800 x 5 days = $9,000

Simultaneous interpretation at $560/person/day= $560 x 2 interpreters x 5 days = $5,600
5 days x $100 per diem x 2 interpreters = $1,000.
Air fare for interpreters $680 x 2= $1,360
Materials and labour for organization = $2,900.
Airfare at $680 per participant – 18 x $680 = $12,240
Total = $32,100
2 participants each from IITA, ICRISAT and SAFGRAD:
Air fare at $680 per participant.
6 x $680 = $4,080
5 x 150 per diem/day = $4,500
Total for the workshop is $40,680

*Terminal workshop (Regional):*
Same as above but, with 24 participants
Total amount is $47,760.

*Activity 6: Impact Assessment:*

For adoption studies to be conducted during the second and third year of the project in each pilot country, $4,000 is allocated for each country.
$7,000 x 4 = $28,000 x 2 years = 56,000

*Feeding trials*: Studies to be conducted using malnourished children in recuperating centers, $4,000 per country.
7,000 x 4 = $28,000 x 2 years = $56,000.

Consultant to be hired by the Micronutrient Initiative:

*Project co-ordination and management – Focal unit (National level):*
$4,000 /country/year x 4 countries = $16,000. For co-ordinating country level activities, organisation of national workshops and other project activities:
Year 1 = $16,000; Year 2 = $16,000; Year 3 = $16,000. Total = $48,000

*Monitoring and evaluating team*: For co-ordinating and monitoring pilot programs. A team representing SAFGRAD, IITA, ICRISAT, Micro-food processors, Food and Nutrition Scientist will visit selected countries to assess progress of the project. Two members will be from pilot countries which will be on rotational basis every year. The team will prepare a progress report at the end of the monitoring tour.
4 days per country for 4 countries = 4 x 4 = 16 days
5 persons (IITA, ICRISAT and SAFGRAD and 2 from pilot countries)
Per diem = $150/day
Air fare = $1,500/person
16 days x $150 x 5 persons = $12,000
5 x $1,500 (air fare) = $ 7,500
Total = $19,500 per year for the last two years
Total = $39,000

*Travel*

*Regional:* To assist in setting up national programs and to put in place the technical components of the program and training. Representatives of IITA, ICRISAT, and SAFGRAD will travel to pilot countries at least two times a year for 5 days each time to monitor projects.
Air fare: $680 per trip x 4 countries = $2,720
Per diem: $150 x 5 days x 4 countries = $3,000
Each country to be visited 2 times (during the first quarter and last quarter each year). $5,720 x 2 trips x 3 years = $34,320

*International conferences:* Presentation of program results and interaction with the international community.
Two international conferences for three people:
Air fare $2000 per trip x 3 people x 2 trips = $12,000
Per diem: $150 x 6 days x 3 people x 2 trips = $5,400
Total international conferences: $17,400

*Support Services*: For disbursement and management of funds, co-ordination of activities, preparation of training programs and secretarial work. A total of $91,800 is budgeted for the three years.

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*Semi-Arid Food Grain Research and Development (SAFGRAD)*

The Semi-Arid Food Grain Research and Development of the Scientific, Technical and Research Commission of the Organization of African Unity (OAU/STRC-SAFGRAD) established in 1977, is a non-profit making Agency. SAFGRAD advances agricultural research and development and natural resource management and improvement of basic diets in semi-arid ecology in more than 30 countries of sub-Saharan Africa.

OAU/STRC-SAFGRAD mobilizes scientific talents and resources of National Systems and that of International Agricultural Research Centers (IARC's) to enhance food security and nutrition through the development of sustainable agriculture in the semi-arid agroecological zones. It promotes integrated farming systems and environment protection, thus, improving the quantity and quality of food grain produced (i.e. maize, sorghum, millets, grain legumes, etc.) that constitutes about 70 per cent of staple foods in sub-Saharan Africa.

The main thrust of SAFGRAD program is to: i) Promote the transfer, adoption, and commercialization of agricultural technologies to generate income and employment in sub-Saharan Africa; ii) facilitate the industrial utilization and transformation of food grains into value-added products; iii) enhance the enrichment of staple food with micronutrients using soybean; and iv) improve basic diet of resource poor people at village level.

*International Institute of Tropical Agriculture (IITA)*

The International Institute of Tropical Agriculture (IITA) was founded in 1967 as an international agricultural research institute with a mandate for major food crops, and with ecological and regional responsibilities to develop sustainable production systems in tropical Africa. It became the first African link in the worldwide network of agricultural research centers supported by the consultative Group on International Agricultural Research (CGIAR), formed in 1971.

IITA conducts research, training, and germplasm and information exchange activities in partnership with regional bodies and national programs in many parts of sub-Saharan Africa. The research agenda addresses crop improvement, plant health, and resource and crop management within a farming systems framework. Research focuses on smallholder cropping systems in the humid and sub-humid tropics of Africa and on the following major food crops: cassava, maize, plantain and banana, yam, cowpea, and soybean. The goal of IITA's research and training mission is to "Improve the nutritional status and well-being of low-income people of the humid and sub-humid tropics of sub-Saharan Africa". IITA has carried out many projects supported by IDRC and it provides support to national programs in sub-Saharan Africa.

*International Crops Research Institute for Semi-Arid Tropics (ICRISAT)*

ICRISAT is a nonprofit, international organization for science-based agricultural development. Established in 1972, it is one of 16 centers supported by several donor governments, foundations, and development banks, through the Consultative Group for International Agricultural Research (CGIAR).

ICRISAT's Mission and Focus are to help developing countries apply science to increase crop productivity and food security, reduce poverty, and protect the environment. ICRISAT focuses on the semi-arid tropical areas of the developing world, where low rainfall is the major environmental constraint to agriculture. Special emphasis is placed on five crops that are particularly important in the diets of the poor: sorghum, millet, groundnut, chickpea, and pigeonpea.

ICRISAT's Strategy is to form research partnerships with governmental, non-governmental, and private sector organizations in developing countries, and to link these partners to advanced research institutions worldwide. Each partner contributes its unique strengths to make the whole greater than the sum of its parts. ICRISAT excels in strategic research on global issues and on international exchanges of knowledge, technologies, and skills. These products and services help partners enhance their capabilities to meet regional, national, and local development needs.

## Appendix 6. Collaborating Agencies

Centre National de la Recherche Scientifique et Technologique (CNRST)
09 BP 471
Ouagadougou 09
Burkina Faso

Département de technologie alimentaire
IRSAT
03 BP 7047
Ouagadougou 03
Burkina Faso

Centrale de Transformation de Produits Agricoles (CTRAPA)
06 BP 10100
Ouagadougou 06
Burkina Faso

SODEPAL
01 BP 1749
Ouagadougou 01
Burkina Faso

Council of Scientific and Industrial Research (CSIR)
Food Research Institute (FRI)
P.O. Box M. 20
Accra, Ghana

Institut de Recherches Agronomiques du Niger (INRAN)
BP 429 Niamey
Niger

Ahmadu Bello University/ Institute of Agricultural Research (IAR/ABU)
Food Science and Technology Research Department
P.M.B. 1044, Samaru, Zaria
Nigeria.

Nigerian Eagle Flour Mills Ltd
P. O. Box 4868, Ibadan
Nigeria.

Department of Food Technology
Faculty of Technology
University of Ibadan
Ibadan, Nigeria.

Department of Human Nutrition
Faculty of Basic Medical Sciences
University of Ibadan
Ibadan, Nigeria.

Food Basket Foundation International
46 Ondo Street, Old Bodija Estate
U.I., P. O. Box 4127
Ibadan, Nigeria

## Appendix 7: Logical Framework

| PROJECT PLANNING MATRIX (PPM) | Project Ref. No: | Project Title: Micronutrient fortification of maize, sorghum and millet and their products in West Africa: A sustainable approach to mitigate hidden hunger | Estimated Project Duration: 3 years | PPM Prepared: September 1999: |
|---|---|---|---|---|
| **Summary of Objective/Activities** | | **Objectively Verifiable Indicators** | **Means/Sources of Verification** | **Important Assumptions** |
| *Overall Goal to which the project contributes:*<br><br>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.<br>• Increased demand for maize.<br>• Decrease in micronutrient deficiency diseases. | Reports from health centers<br>Product sales volume<br>Public Health statistics<br>UNICEF/WHO reports | Favorable policies<br>Resource availability |
| *Project Purpose:*<br><br>Enhanced levels of micronutrients in maize-, sorghum- and millet-based diets through fortification of maize, sorghum and millet meal and flours with iron, zinc, and vitamin A, improved processing and storage of maize, sorghum and millet flours and products, determine the extent of genetic variation of the target micronutrients of landraces, improved and introduced germplasm. | | • The prevalence and level of vitamin A, iron and zinc deficiency in target groups reduced by 10%.<br>• At least 30% of the people in target areas consuming fortified maize products.<br>• At least 20% of households using improved postharvest technologies. | Project reports<br>Published reports<br>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, sorghum and millet and their products in West Africa: A sustainable approach to mitigate hidden hunger | Estimated Project Duration: 3 years: | PPM Prepared: September 1999: |
|---|---|---|---|---|

| Summary of Objective/Activities | Objectively Verifiable Indicators | Means/Sources of Verification | Important Assumptions |
|---|---|---|---|
| *Results/Outputs 1:*<br><br>The prevalence and distribution of micronutrient deficiencies and their underlying cause in pilot countries assessed.<br><br>*Activities:*<br><br>1. Conduct baseline survey on prevalence of deficiencies in vitamin A, iron and zinc in target areas in pilot countries.<br>2. Assess the nutrient composition of food products consumed by the target population.<br>3. Evaluate the effect of traditional processing methods on micronutrient content of maize, sorghum and millet products. | • The effects of at least 7 traditional processing methods on micronutrient content of maize-, sorghum- and millet-based products determined.<br>• Information on the prevalence of deficiencies of vitamin A, iron and zinc in the pilot countries documented.<br>• Information on nutrient composition of the diet of target groups available.<br>• At least 7 surveys conducted in pilot countries. | Published reports<br>Survey reports<br>Annual reports<br>Journal publications | There is good cooperation with the health sector and government agencies in pilot countries |

| PROJECT PLANNING MATRIX (PPM) | Project Ref. No: | Project Title: Micronutrient fortification of maize, sorghum and millet and their products in West Africa: A sustainable approach to mitigate hidden hunger | Estimated Project Duration: 3 years: | PPM Prepared: September 1999: |
|---|---|---|---|---|

| Summary of Objective/Activities | Objectively Verifiable Indicators | Means/Sources of Verification | Important Assumptions |
|---|---|---|---|
| *Results/Outputs 2:*<br><br>Micronutrient content of maize, sorghum and millet products increased through fortification and dietary improvement.<br><br>*Activities:*<br><br>1. Determine the levels and form of fortificants to be incorporated.<br>2. Develop simple micronutrients fortification techniques.<br>3. Determine the bioavailability and acceptability of fortified maize, sorghum and millet products.<br>4. Determine the levels and form of fortificants to be incorporated<br>5. Develop processing methods that minimize losses of micronutrients during cooking of fortified products and improved adapted varieties.<br>6. Evaluate stability of micronutrients during processing and storage of fortified products and improved adapted varieties.<br>7. Determine the effect of traditional processing and preservation methods on the storage stability of added micronutrients.<br>8. Assess the effect of processing on antinutritional factors. | • Improved processing methods, simple fortification techniques available and appropriate level of fortification determined.<br>• At least 30 food processors are involved in fortification of maize, sorghum and millet with micronutrients in pilot countries.<br>• At least 2 traditional processing and storage methods improved and adopted in each pilot country.<br>• At least 2 fortified maize, sorghum and millet products available in the market in each pilot country.<br>• Information on the levels of antinutritional factors in maize, sorghum and millet available. | • Published reports<br>• Availability of fortified products<br>• Project reports<br>• Visits to pilot countries | • Good cooperation with millers and the private sector<br>• Strong linkages among partners |

| PROJECT PLANNING MATRIX (PPM) | Project Ref. No: | Project Title: Micronutrient fortification of maize, sorghum and millet and their products in West Africa: A sustainable approach to mitigate hidden hunger | Estimated Project Duration: 3 years: | PPM Prepared: September 1999: |
|---|---|---|---|---|
| **Summary of Objective/Activities** | | **Objectively Verifiable Indicators** | **Means/Sources of Verification** | **Important Assumptions** |
| *Results/Outputs 3:*<br><br>Extent of genetic variation for provitamins A, iron, and zinc content of landraces, improved and introduced germplasm determined.<br><br>*Activities*:<br><br>1. Characterize African landraces, improved and introduced germplasm for provitamin A, iron, zinc and phytic acid.<br>2. Identify the best varieties with high micronutrient content from the existing elite and adapted germplasm for immediate multiplication and distribution to farmers.<br>3. Assess the bioavailability of micronutrients in grains of the best cultivars.<br>7. Determine the relationship between grain morphological characteristics and micronutrients. | | • Knowledge on the extent of genetic variability for iron, zinc and provitamin A in maize, sorghum and millet germplasm enhanced.<br>• Information on the bioavailability of micronutrients available.<br>• Adapted improved maize, sorghum and millet varieties high in provitamin A, iron and zinc identified.<br>• Information on the relationship between grain morphological characteristics and micronutrients content available. | • Published reports<br><br>• The use of selected cultivars by farmers and food processors. | |

| PROJECT PLANNING MATRIX (PPM) | Project Ref. No: | Project Title: Micronutrient fortification of maize, sorghum and millet and their products in West Africa: A sustainable approach to mitigate hidden hunger | Estimated Project Duration: 3 years | PPM Prepared: September 1999 |
|---|---|---|---|---|

| Summary of Objective/Activities | Objectively Verifiable Indicators | Means/Sources of Verification | Important Assumptions |
|---|---|---|---|
| *Results/Outputs 4:*<br><br>Market sector analysis conducted and strategies for promotion and commercialization of improved cultivars and fortified products determined.<br><br>*Activities:*<br><br>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.<br>2. Facilitate contractual agreements between farmers and processors.<br>3. Investigate opportunities for cross-border information exchange to enhance product marketing and commercialization. | • Efficient price for the products determined.<br>• An effective marketing and promoting strategy for the product designed.<br>• Cost-benefit ratio for fortified maize, sorghum and millet products in the four pilot countries determined.<br>• Demand and affordability of fortified maize products determined.<br>• At least 30 farmers contracted to produce raw materials (maize, sorghum and millet) in each pilot country.<br>• At least 30 small to medium scale processors produce micronutrient-fortified products. | • Market prices of products.<br>• Published reports on cost-benefit analysis.<br>• Market survey reports. | Conducive regional marketing policies. |

| PROJECT PLANNING MATRIX (PPM) | Project Ref. No: | Project Title: Micronutrient fortification of maize, sorghum and millet and their products in West Africa: A sustainable approach to mitigate hidden hunger | Estimated Project Duration: 3 years | PPM Prepared: September 1999 |
|---|---|---|---|---|
| **Summary of Objective/Activities** | | **Objectively Verifiable Indicators** | **Means/Sources of Verification** | **Important Assumptions** |
| *Results/Outputs 5:*<br><br>Capacity building for effective technology development and transfer improved.<br><br>*Activities:*<br><br>1. Conduct training courses, seminars, workshops, and farmers' field days to develop skills and knowledge on micronutrient fortification.<br>2. Organise individualized attachment programs. | | • At least 150 research technicians, 450 micro food processors, several farm households and women groups and 10 industry workers trained on micronutrient fortification.<br>• Enhanced professional and scientific capacity of NARS scientist, private sector and technicians for micronutrient fortification technology development and transfer.<br>• Exchange of scientific information and new technologies. | • Number research technicians, micro food processors, several farm households and women groups and industry workers trained.<br>• Workshop Proceedings.<br>• Reports of group training courses.<br>• Course evaluation reports.<br>• Individual attachment evaluation reports.<br>• NARS reports. | |

<table>
<tr><td>PROJECT PLANNING MATRIX (PPM)</td><td>Project Ref. No:</td><td>Project Title: Micronutrient fortification of maize, sorghum and millet and their products in West Africa: A sustainable approach to mitigate hidden hunger</td><td>Estimated Project Duration: 3 years</td><td>PPM Prepared: September 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 6:<br><br>Impact of micronutrient fortification, dietary improvement and adoption of improved maize cultivars assessed.<br><br>Activities:<br><br>1. Assess the effects of consumption of micronutrient fortified products on the improvement of nutritional status of target groups.<br>2. Conduct adoption studies on new postharvest technologies.<br>3. Evaluate the effect of new technologies on maize production at the farm level.</td><td>• The prevalence and level of vitamin A, iron and zinc deficiency in target groups assessed.<br>• Information on micronutrients nutritional status of the target population available.</td><td>• Published reports.<br>• Reports from Health clinics, UNICEF etc.</td><td>• Availability of fortified maize, sorghum and millet products</td></tr>
</table>

## Appendix 8.

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

1. Dr Taye Bezuneh
   International Coordinator
   OAU/STRC-SAFGRAD,
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8. Mr D. Jean Monhouanou
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9. Dr Victor B. Anihouvi
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Faculte des Sciences Agronomiques
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Ibadan, Nigeria.

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Nutritionist
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## 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 Staple Food Crops and their Products in West Africa: A Sustainable Approach to Mitigate Hidden Hunger

AU-SAFGRAD

AU-SAFGRAD