Research Proposal: Aflatoxin free Peanut-based Recovery and Functional Food

Principal Investigator

Robert (Dick) Phillips
University Georgia
1109 Experiment Street
Griffin, GA 30223
Phone: (770) 412-4744
Email: rphilli@uga.edu

Co-Project Investigator(s)

Jinru Chen
University of Georgia
1109 Experiment St. Griffin,
GA 28426
Phone: (770) 412-4738
Email: jchen@uga.edu

Dorothy Nakimbugwe
Makerere University
Department of Food Science & Technology
Kampala, Uganda
Phone: (256) 782-246089
Email: dnakimbugwe@agric.mak.ac.ug

Firibu Saalia
University of Ghana
Legon-Accra
Phone: (233) 243-125-566
Email: fsallia@yahoo.com

Partner Scientist(s)

Konimba Bengaly
Institut d'Economie Rurale, Laboratoire de Nutrition Animale

Bamory Diarra
Institut d'Economie Rurale, Laboratoire de Nutrition Animale

Mme Cisse Traore
Laboratoire de Technologie, Laboratoire de Technologie Alimentaire

Geographical Locations
Uganda, Ghana

Submitted:

09/22/2007

Focus
Domain - Nutrition Region - Global

Background

A WFP document on the debilitating effects of HIV/AIDS and other opportunistic infections acknowledged the critical role of food as "The First Line of Defense" in the fight against HIV/AIDS (1). For the poor and malnourished all over the world, food is always the first necessity. Drug therapies are ineffective on patients with low nutritional status, and opportunistic infections help to exacerbate their hopelessness. To the severely malnourished or acutely poor, relief food items such as maize, oil and other non-processed foods are not helpful. They require ready to use therapeutic foods (RUTF) for fast recovery. RUTF is a generic term including different types of foods such as spreads or compressed products suitable for feeding severely malnourished people (2). Manary (2) in a WHO document described a spread RUTF made from a mixture of milk powder, vegetable oil, sugar, peanut butter and powdered vitamins and minerals using modest technologies. The product had a high energy density of 5.5kcal/g, and could solely be used to achieve complete recovery of a severely malnourished child in home based therapy. The use of peanuts is significant (and encouraging) in this product. Peanuts are increasingly being associated with good nutrition and human health and well-being. They have high oil content with an excellent fatty acid profile of MUFA and PUFA. They also have high proteins and a wide range of minerals and vitamins. Peanuts are widely cultivated in many countries in Africa, and are usually processed by women using simple traditional technologies. Recovery products that will be based on locally available and easily recognizable raw materials will not only have a high acceptability and sustainability rate; they will also improve the market value of peanuts and empower the women traders and processors. The target group of the proposed product is much wider than just malnourished individuals. It is proposed that the product will also be a functional food with added health benefits beyond basic nutrition. The use of probiotics will further add emphasis on the functional food character of the product.

Aflatoxin contamination is widespread in peanuts and products made from it. Considering the target consumers it will be a tragedy for them to be exposed to the toxin. HSCAS has been proven to irreversibly bind aflatoxins and make them unavailable even when ingested. The University of Georgia has a very wide range of expertise in all these, including microbiology and functional food/nutraceuticals research, and will clearly provide good and able leadership in the project. The host countries Ghana and Uganda, where possible human studies (sensory and efficacy) will be conducted have well established nutrition and food science programs at their respective universities

Technical Review:

It is an accepted fact that the first line of defense against hunger and disease is good nutrition. The WFP has amply demonstrated this by providing food relief such as maize, soybean, rice, oil and maize-soy blends to vulnerable groups. Peanuts have been widely proven to be a nutrient dense and energy dense commodity. A growing number of clinical studies have shown that the beneficial effects of peanuts may not only be due to their impressive nutritional profile (of MUFA and PUFA as well as high protein), but other components in it that are good for human health. Regular peanut consumers have been shown by research to have higher intakes of vitamin E, folate, magnesium, zinc, iron, heart-healthy monounsaturated fat and dietary fibre than people who rarely eat peanuts (3). A study showed that people with low levels of magnesium in their blood were brought up into normal ranges when they ate peanuts every day (3). Peanuts have been shown to have low glycemic index (and good for diabetics), and high amounts of the amino acid arginine which is a precursor to nitric oxide. Nitric oxide is a known secondary messenger that mediates smooth muscle relaxation and improves blood flow by dilating the vessels. Peanuts have also been reported to be protective against heart disease and contribute to lowering blood cholesterol in a large body of published research based on US population studies (4). The association between nut consumption and health in nearly 400,000 Europeans has been studied to take account of the different dietary habits and nut intake patterns between Americans and Europeans. The researchers identified that nearly half of Europeans rarely consume nuts, yet an intake of just 2 servings of nuts per week, where each serving is about a handful (30g/ 1oz) may reduce risk of death from CHD by 11%. These results provide increased validity for the health benefits of nuts in general and peanuts in particular (5). Research has also shown that peanuts contain bioactive compounds such as beta-sitosterol, flavonoids and a variety of other antioxidants that have beneficial effects on human health and well-being. Furthermore hydrolyzed proteins have been noted to contain bioactive

peptides, some of which positively impact on heart health. Protease hydrolyzed peanut proteins have been shown to have such activity, and may be beneficial to human health.

Probiotics in the intestine assist with food and nutrient digestion, inhibit harmful bacteria and stimulate the immune system (6). There are several strains of probiotics on the market, but those most often used include Lactobacillus aidophillus, lactobacillus reuteri, lactobacillus rhamnosus lactobacillus salivarius, Bifidobacterium bifidum and Bifidobacterium infantis. Lactobacillus paracasei F19 is another probiotic strain with numerous well documented health benefits. It is a patented strain that has the ability to improve digestive health, enhance immune system function and reduce the negative effects on GI well-being during antibiotic treatment (6). In this project suitable strains will be identified for use.

Peanuts and products made from them are very susceptible to aflatoxin contamination through infection by aflatoxigenic molds. Consequently aflatoxins monitoring as well as protocols for the inactivation of the toxin (possibly by the application of HSCAS) in the product will be essential.

Problem Statement

In many parts of Africa, there is widespread malnutrition due to food shortages, food insecurity, conflicts and infectious diseases. Added to these are a rapidly growing numbers of orphans and children born to people with HIV/AIDS (PLWAs). Infants born to HIV positive mothers often times eventually get infected through mother-to-child transmission (MTCT). For them, infant formulas are not within easy reach. Research has shown that maternal malnutrition may increase the risk of MTCT. Furthermore, for the malnourished and chronically sick, good nutrition helps lessen opportunistic infections. Even drug therapies require sound nutrition, because their effectiveness depends on the patient's nutritional status. Based on these facts, the World Food Program (WFP) and other agencies have often provided relief foods (maize, beans, maize- soya blends and vegetable oil) to vulnerable communities. Indeed, this has been credited with reducing the mortality of TB patients in some communities in Cambodia (1). To augment such efforts, this proposal seeks to study the use of peanuts as a base for a ready-to-use therapeutic food (RUTF) that will be easy to ingest and readily digestible. This will particularly be helpful for many who can neither afford the energy and time or fuel to cook. Peanuts are widely cultivated in most countries in Africa and commercially in the USA. Research has shown them to be highly nutritious, and they have several other benefits for human health and well-being beyond basic nutrition. It seems plausible to use them as an

ingredient in any health promoting and recovery food formulation. A successful and acceptable product based on peanuts will greatly enhance their utilization, widen market opportunities and improve the local economies.

Vision and Approach

Goals

The goal is to develop an intervention food that will easily be distributed among malnourished and vulnerable people. The product is a peanut based highly nutritious food that is easily ingested and highly digestible. The product will also be a functional food that would provide health promoting benefits beyond basic nutrition. In furtherance of this we propose to identify and add appropriate bacterial cultures to the product for probiotic benefits.

Characteristics of the product should be as follows:

1. It will be sufficiently liquid (sufficiently low viscosity) to be swallowed by children and adults who may be so malnourished that consuming solid foods is difficult. It will have a pleasant flavor with some sweetness deriving from the process and with a low level of appropriate flavoring.
2. It will be nutrient dense with high levels of fat and protein to promote recovery. It will also be balanced as to amino acid profile and contain the appropriate amounts of vitamins and minerals.
3. It will contain probiotic organisms to counteract diarrhea and intestinal pathogens.
4. It will contain HSCAS mineral (clay) to bind aflatoxins that might derive from ingredients, but more likely from other, inferior foods available to those consuming it (eg. moldy grains).
5. It will (in its liquid form) be sterile and stable with proper packaging, suitable for air dropping or trucking under extreme environmental conditions.
6. It may be possible to dry the product into a reconstitutable powder that could be more easily shipped provided sterile water is available for reconstitution.

The product should be able to store under ambient conditions. It should be able to generate income for processors and extend market opportunities for peanut utilization.

Objectives:

1. Formulate and produce at pilot scale peanut-based RUTFs The proposed RUTFs will be nutrient dense but with a liquid consistency for

ease of swallowing. This objective comprises the core research activity of the proposed project. It is, in turn, comprised of two major components, formulation, and production of RUTFs.
2. Analyze safety, nutritional, chemical, physical and sensory properties of formulas
3. Small scale testing of formulas in human populations for acceptability and nutritional efficacy.
4. Training entrepreneurs to produce RUTF formulas on commercial scale
5. Training graduate students and publishing findings.
6. Capacity development of participant scientists and institutions.

Research Approach

The concept is to present a peanut based energy dense high protein "recovery food" in two fundamentally different forms; a semi solid food (like a meal replacement beverage), and a readily re-hydrated powder. (Partially) defatted blanched peanuts will be (protease) hydrolyzed and blended with malted cereal/hydrolyzed starches. Malted cereal or purified a-amylases will be used to hydrolyze the blended starches during processing. The relative proportions of the components will be a matter of appropriate optimization designs using specific critical response variables such as final product rheology and other quality attributes to monitor the effects of the predictors (components). Version 6.01.Concept4-S Creative formulation software will be used to generate ingredient formulations based on cost and final product nutritional quality and energy density. The levels of addition of vitamins and minerals will also be adjusted according to the product formulations since peanuts are rich in some minerals and vitamins. As to the addition of probiotics, bacterial viability is the key to the health benefits. Addition of the bacteria before any form of heat treatment will offer challenges, and so will storage conditions, since the shelf life might be shorter than a product without probiotics. The choice of bacterial strains will be based on their metabolic dependence on oxygen (i.e. strict anaerobes versus aerobes) since that will impact on packaging of the final product. Additionally, having a good survival rate during processing and during distribution and storage is important, but equally important will be the chosen bacteria's impact on the flavor, texture and other attributes of the final product. Heat processing of the formulations will vary from blending precooked, pre hydrolyzed components, through co- milling and cooking using simple modest processing techniques to more sophisticated extrusion cooking technology. A form of quality control of the raw materials and finished products may have to be put in place to monitor aflatoxin contamination and spoilage (bacterial and chemical). The addition of HSCAS will be necessary to inactivate aflatoxins and protect consumers. The clay (HSCAS) irreversibly binds aflatoxins and

makes them unavailable even when the contaminated food is ingested. This approach will also afford further opportunities to investigate the interaction of HSCAS with added vitamins, peptides and other bioactive molecules that may be present. The possible evaluation steps have already been outlined in the objectives as: chemical and nutritional analysis of the product, microbial inhibition studies to explore other biological activity of potential of the product, Tissue culture studies, Challenge studies with animal models, human studies (sensory analysis and efficacy in various populations among the vulnerable (poor, malnourished, sick, PLWAs, orphans).

Training & Capacity Development Approach

The acquisition of basic laboratory and processing equipment will enhance the capacity of the host departments, and help support graduate students' training. All three institutions, the University of Georgia (UGA), the University of Ghana (UGL), and Makerere University (MU) have long-established track records for training undergraduate and graduate students. They are also well equipped for training entrepreneurs in practical food processing techniques for producing RUFTs by appropriate technologies. Training of a minimal number of PhD level graduate students in food microbiology and possibly food processing at UGA is anticipated. Such students might be either from the U.S. (with strong interest in international development) or from one of the host countries or regions. However undergraduate training and the bulk of postgraduate training is expected to take place at UGL and MU. In addition training local entrepreneurs to produce RUFTs will take place in the two HC institutions with US scientists providing any assistance requested. UGL has a well-equipped pilot plant for food processing with milling, thermal processing, fermentation, and some packaging equipment, and also analytical and microbiological laboratories. MU has food chemistry, microbiology, nutrition and sensory laboratories; as well as a food processing pilot plant currently being equipped. Likewise, training in applied nutrition and assessment of nutritional assessment will take place the two HC institutions. While this proposal concentrates on design and production of novel RUTFs it is anticipated it will collaborate closely with IMC personnel in Uganda and corresponding efforts in Ghana.

Intended Benefits & Impact Responsiveness

Development Benefits

The host departments in the universities in the developing countries will benefit from taking part in such a project. Training of graduate students and research communication by way of technical publications, and training

workshops will in no small way promote peanuts as a vital and functional food commodity. The project also affords the opportunity to add needed laboratory and pilot plant equipment. Added value to peanuts will influence marketing and distribution patterns of the commodity, with great benefits and empowerment to women who largely control the trade and processing. Most importantly, success of the product affords an inexpensive product for the poor and malnourished. A population of adults with improved health, even those living with devastating diseases like HIV/AIDS will be better able to care for their children and contribute to society and the economy. Malnourishment and disease in children deny a country its rising generation. Any improvement in that vicious cycle will provide a multiplier effect far beyond the economic one.

US Benefits

A major benefit to the US is the training of American students in the technical and, by collaborative experience, the sociological aspects of international development. Gaining these perspectives and expertise will make them superior professionals, whether in the US food industry, in government agencies or in universities. In a time of rapid globalization knowledge of the international food industry and markets provide along with language skills graduates who will be vigorously sought by US employers. In addition, the proposed concept opens many opportunities for developing nutrient dense foods for ill and malnourished individuals in clinical and home-care situations in the US as well as the HCs. The growing emphasis on food for health in the developed countries provides a fertile area for academic and industrial research.

Potential Impacts

Impact will be measured and realized by the success of the product based on a. Sensory acceptability b. Positive human efficacy study results from vulnerable communities c. Positive results from tissue culture studies and challenge studies with animal models

Equipment

Much processing equipment will be simple and cost less than $5,000 per piece. At this point prices are difficult to estimate due to uncertainties of scale. Equipment to be acquired will include: Mixers, packaging and (plastic) sealing equipment, (can seamers?), roaster, fluid mixer. In terms of laboratory equipment, colorimeters, viscometers, and accessories for other analytical equipment will be required. A CO2 incubator may be required if tissue studies are to be undertaken.

Project Timeline

Year 1

Site visits among investigators will allow for planning and initiation of the project. Identification and acquisition of critical equipment will begin. Potential ingredients will be identified and their nutritional profiles and costs obtained. Where necessary, nutrient analysis of some commodities will be initiated. Lab-scale processing and fermentation trials will begin.

Year 2

Pilot scale processing trials will be undertaken using several approaches from low to intermediate technology. Extensive in vitro and in vivo nutritional analysis as well as physicochemical analysis will be conducted on formulations, identifying the most promising ones. Animal studies will prove safety as well as nutritional quality.

Year 3

Consumer trials will begin, first with university volunteers, then among target populations. In collaboration with medical professionals, such as IMC, efficacy of formulations within limited populations will be assessed. Nutritional evaluations as well as screening for aflatoxin biomarkers will be conducted. Training of entrepreneurs capable of and interested in producing RUFT formulations will be initiated.

Year 4

Large scale feeding trials among undernourished and ill populations will be undertaken in the HCs. This will necessitate increased production by a number of private processors. Clinical evaluations including nutritional, health, and toxicity (aflatoxin) status will be conducted.

Year 5

Based on results to date, expansion of RUFT production will be implemented by increased recruitment and training of urban and village processors. In all years, findings will be disseminated by technical and non-technical publications in English, French and if possible local languages.

USAID Mandate Responsiveness:

MDGs

Poverty/Hunger: Improved Health: Raised Rural Incomes: Sustainable Development

Foreign Assistance Framework

Governance: Human Capacity: Economic Structure: Persistent Dire Poverty:

Global Issues (HIV and Infectious Diseases, climate change, biodiversity)

IEHA

Science and Tech Applications: Increased demand for peanuts: Market Access: Increased Trade

USAID Focal Areas

Greater incomes: Greater value and market demand: Public Health: Food

Security: Sustainable Value Chain: Improved Human Capacity