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Improving complementary feeding in Ghana: reaching the vulnerable through innovative business—the case of KOKO Plus

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Reaching vulnerable populations in low-resource settings with effective business solutions is critical, given the global nature of food and nutrition security. Over a third of deaths of children under 5 years of age are directly or indirectly caused by undernutrition. The *Lancet* series on malnutrition (2013) estimates that over 220,000 lives of children under 5 years of age can be saved through the implementation of an infant and young child feeding and care package. A unique project being undertaken in Ghana aims to bring in two elements of innovation in infant and young child feeding. The first involves a public–private partnership (PPP) to develop and test the efficacy and effectiveness of the delivery of a low-cost complementary food supplement in Ghana called KOKO Plus™. The second involves the testing of the concepts of social entrepreneurship and social business models in the distribution and delivery of the product. This paper shares information on the ongoing activities in the testing of concepts of PPPs, social business, social marketing, and demand creation using different delivery platforms to achieve optimal nutrition in Ghanaian infants and young children in the first 2 years of life. It also focuses on outlining the concept of using PPP and base-of-the-pyramid approaches toward achieving nutrition objectives.

Keywords: complementary foods; Ghana; innovative business

Introduction

Reaching vulnerable populations in low-resource settings with effective business solutions is becoming critical, given the global nature of food and nutrition and nutrition disorders. Over a third of all deaths of children under the age of 5 are directly or indirectly caused by undernutrition.[1] Infant and child feeding practices starting from birth are crucial and can affect immediate and long-term nutritional status. In a technical meeting convened by the World Health Organization (WHO) and UNICEF in 2008, it was agreed that there was a need to examine the evidence for effective interventions to improve complementary foods (CFs) and feeding practices along with identifying actions needed to integrate these interventions into health-service delivery.[1] This has also been a key area for intervention for the Scaling Up Nutrition Initiative.[2] Prevention of malnutrition in infants and children is multifaceted and requires access to and intake of nutritious food starting at birth with exclusive breastfeeding for the first 6 months of life, continued breastfeeding in combination with CFs from 6 to 24 months of age, access to clean drinking water and sanitation, and access to preventive and curative (including prenatal) health care.[3,4] While many countries have achieved steady (or major) increases in the proportion of children

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who are exclusively breastfed for the first 6 months, there has been far less progress with regard to effective interventions during the complementary feeding period.[1] Specifically, there is a need to improve quality, access, and utilization of the CFs as well as to improve overall complementary feeding behaviors. Further to that, evidence from the current *Lancet* series on malnutrition[a] has shown that 90% coverage with a core group of 10 interventions inclusive of infant and young child nutrition packages would save one million lives of children under 5 years of age (15% of all deaths). The implementation of an infant and young child nutrition package, which includes appropriate breastfeeding and complementary feeding education and/or delivery of supplements in food insecure populations, could save over 220,000 lives in children under 5 years of age.[5–8]

Availability and access to nutritionally adequate CFs is, therefore, of high priority in developing countries. At 6 months of age, breast milk is no longer nutritionally sufficient for infants, and CFs must be introduced.[9] The transition of exclusive breastfeeding to breastfeeding with appropriate CFs is considered problematic and is often wrought with issues such as introduction of poor-quality CFs, or replacement of breastfeeding with poor-quality CFs and/or cessation of breastfeeding.[9] The WHO has outlined a comprehensive set of guiding principles for appropriate infant feeding (breast-fed infants).[9] Nutrient-dense CFs can improve nutritional status and have long-term benefits;[9] however, in a review of plant-based CFs in developing countries, most of them failed to meet most micronutrient requirements.[10] An analysis of commonly used cereal–legume CF blends has shown that many do not meet either the protein-quality needs or the fat and essential fatty acid needs of this age group.[11] Thus, there is a need to provide other cost-effective alternatives to increase the quality of the diet during the complementary feeding stage of the lifecycle.

This paper reports on a unique and innovative project that aims to bring in two elements of innovation in the area of infant and young child feeding in Ghana. The first involves working in a public–private partnership (PPP) in the development and testing of a low-cost CF supplement so as to forward the common goal of improving access and availability of Ghanaian households to good nutrition. The PPP has focused on addressing the challenges of poor-quality CFs in Ghana through the development and testing of a high nutrient value CF supplement called KokoPlus™. The second involves utilizing the concepts of social entrepreneurship and social business models, testing their viability, feasibility, and sustainability in the distribution and delivery of a nutrient-dense product relative to the use of traditional marketing methods. As noted by the Grameen Creative Lab "unlike traditional business, a social business operates for the benefit of addressing social needs that enable societies to function more efficiently. Social business models provide a necessary framework for tackling social issues by combining business know-how with the desire to improve quality of life."[12] This paper shares information on ongoing work in the testing of concepts of PPPs, social business, social marketing, and demand creation, using different delivery platforms to achieve optimal nutrition in Ghanaian infants and young children under the age of 2 years. Using Ghana as a case example, we examine the potential for a base-of-the-pyramid (BoP) approach in achieving nutrition objectives.

Optimal interventions for complementary feeding

An extensive review of the efficacy and effectiveness of complementary feeding interventions targeting growth, morbidity, and development outcomes found no universal "best package" of components in complementary feeding interventions, and concluded that the impact of interventions was dependent on baseline factors, including initial prevalence of malnutrition, degree of household food insecurity, energy density of the CF, and the availability of micronutrient-rich local foods.[13] In all interventions, while child growth was the most common outcome measured, the impact of interventions on child growth was mixed, with the strongest effects observed in those studies where CF was provided. In addition, in interventions where micronutrient fortification was the sole component, there was generally no effect on growth. In those studies that provided CF and where effect was observed, it was not possible to determine if the effects on growth were due to greater energy/protein/fat

[a]This special issue on malnutrition was published in 2013 in The *Lancet*, Volume 382, Issue 9890.

intake, greater micronutrient intake, or a combination of both interventions.[13]

Infant and young-child feeding (IYCF) interventions that specifically emphasize the use of animal source foods that are high in protein were also found to have an impact on growth.[13] Another meta-analysis reviewing the specific efficacy and effectiveness of home fortification of CFs with micronutrient powders (MNP) compared to crushable tablets and lipid- or soy-based products also found that the impact on child growth of home fortification using only micronutrients was not significant, but two efficacy trials in Africa suggest an effect size for products containing both micronutrients and a small amount of energy (including fat and protein) of ~0.4 for both weight and height.[14] In Ghana, an evaluation of Weanimix (a cereal–legume blend) with or without micronutrients compared to Weanimix or *koko* (a fermented maize/corn porridge) made with fish powder found improved growth in all intervention groups relative to the nonintervention group. The study found improved iron and vitamin A status only in the group given Weanimix with micronutrients.[15] A randomized comparison of the delivery of micronutrients via home fortification using sprinkles, crushable nutritabs, or energy-dense fat-based nutri Butter found positive effects on motor milestones in infants given either of the three supplements, whereas only infants in the nutri Butter group demonstrated better growth (both weight-for-age and length-for-age Z-score, reflective of underweight and stunting).[15]

Approaches to improving CFs

Effective approaches for improving quality of CFs may include one or more of the following: (1) increasing diet diversity; (2) use of fortified food products; (3) use of MNP or macronutrient supplements enriched with micronutrients; and (4) use of home-based technologies such as fermentation and malting, the latter being applicable in certain settings.[1] The private sector can play a promising role in all three approaches through improving and increasing production and access to local foods, fortified foods, and point-of-use fortificants and supplements.

Significant emphasis has been placed on the potential role of specially formulated foods and food supplements (especially CFS) for preventing malnutrition among 6- to 23-month-old children and for treating moderate malnutrition among 6- to 59-month-old children. A review by De Pee and Bloem presented at the "WHO, UNICEF, United Nations (UN) World Food Programme (WFP) and UNHCR Consultation on the Dietary Management of Moderate Malnutrition in Under Five Children by the Health Sector" identified several different options available for complementary and supplementary feeding, including fortified blended foods (FBFs); commercial infant cereals; ready-to-use foods (e.g., pastes/compressed bars/biscuits); CF supplements (CFS); MNP; powdered CFS containing micronutrients, protein, amino acids, and/or enzymes; and lipid-based nutrient supplements (LNS). They have noted, however, that most FBFs (e.g., corn–soy blend) are inadequate for feeding young and malnourished children owing to high levels of antinutrients, lack of high-quality protein sources (e.g., milk), suboptimal micronutrient content, high bulk, and viscosity.[3]

While efforts are in place in many countries to bring together governments, NGOs, and private-sector companies to improve food systems and there are several examples of explorations and implementation activities targeted toward increasing the access to fortified food products, the potential for scale-up of these activities to improve access to high-quality food and nutrition by utilizing the resources of the private sector has been largely unexplored. There is, however, a shift in the thinking with the Scaling Up Nutrition Business Initiative providing a forum for interactions between the public and the private sector (e.g., Project Laser Beam) with the goal of improving nutrition outcomes in low-resource settings.[2] Within the food and nutrition sector, the private sector can support increased availability and access to nutritious foods through the food value chain, both from the perspective of agricultural producers, driving income growth for producers and thus ensuring food security, and from the perspective of consumers, through increased availability of high-quality and low-cost locally sourced nutritious products.[16] However, there can be complexities owing to the multitude of players involved and fragmentation and inefficiencies in the value-chain system in low resource settings, which could lead to a decrease in value from the context of the consumer at the BoP, as well as the company.

With respect to market access to high-quality products using a non-BoP approach, several private-sector companies are involved in the production of

MNP and LNS; however, most of these products are donor targeted and are not accessible through regular market channels. Production and marketing of CFS is not common (except Ying Yang Bao), with most emphasis in the commercial markets on fortified infant cereal. Local businesses in many countries, including Ghana, have small-scale production of unfortified cereal–legume mixes with often no or low-quality assurance. Thus, market access to high-quality but low-cost CF products is low.

PPPs aimed at improving nutrition and food security

According to Kraak *et al.*, the WHO defines PPPs as "collaborations between public- and private-sector actors within diverse arrangements that vary according to participants, legal status, governance, management, policy setting, contributions and operational roles to achieve specific outcomes"[17] and these PPPS are designed to be social alliances to achieve common goals benefiting society.[18–20] Within the realm of nutrition and food security, several UN organizations identify global food and beverage companies as important stakeholders to help promote nutrition and food security.[21,22] There are significant benefits to be achieved from a successful PPP targeting nutrition and food security, including raising the visibility of nutrition and health on policy agendas, mobilizing funds and advocating for research, strengthening food system processes and delivery systems, facilitating technology transfer, and nutrition assistance during humanitarian crises.[18] PPPs can be philanthropic, transactional, or transformational: a philanthropic partnership involves limited engagement from the private sector with a charitable financial or food donation being the primary transaction between the private- and public-sector entities; a transactional partnership builds on mutually beneficial relationships to advance each partner's agenda; and a transformational partnership requires the highest level of engagement by both the private and public sector entities along with resource investment. Transformational partnerships are complex relationships that are built to influence the institutional cultures and practices of each partner.[18] Another classification of PPPs identifies four archetypes, including coordination PPPs, funding PPPs, product-development PPPs and delivery PPPs, thus focusing on the function of each PPP. The coordination PPPs seek to harmonize policies, objectives, messages, and relevant activities among a group of partners, while the funding PPPs consolidate financing for a specific issue in a single organization, a product development PPP brings multiple stakeholders together to develop products or processes that no one partner could develop alone, and delivery PPPs combine on-the-ground capabilities of different partners to deliver products or services, often in remote locations.[23]

PPP engagement targeting food and nutrition security is not a new concept, with attempts being made since the 1960s by agencies such as USAID to engage the food sector in providing nutritious food to malnourished target populations, but these earlier attempts, by and large, were unsuccessful owing to reasons such as little product demand, marketing and distribution problems, no or inadequate profit potential, and a lack of enabling food and fiscal policies in the countries of concern. While the commercial feasibility of marketing nutritious foods was encumbered, the research and development activities around these efforts set the stage for future activities, including "the evolution for tapping into business capabilities to improve food commodities and blended, fortified products for use in global institutional and emergency feeding programs once awareness of the nutritional needs had been raised and could be matched with private expertise." Also, as noted above, more recent initiatives including the Scaling Up Nutrition Business network have re-energized the interaction between the public and private sectors.[2] These current interactions between the public and private sectors around food and nutrition security are more likely to succeed, given the changes in the development landscape. These changes include "an increased recognition of the need and the value of an open, transparent and essential role of business in facilitating sustainable delivery of food, of the adaptability of tools, expertise and capabilities of the private sector in helping address food security and a greater understanding by the private sector of the long-term value of commitment towards the development of inclusive business models."[24]

According to Kraak *et al.*, while there are UN guidelines for engagement with the private sector, there are controversies and challenges with respect to such engagement. Challenges include "balancing private commercial interests with public health interests, managing conflicts of interest; ensuring that

co-branded activities support healthy products and healthy eating environments; complying with ethical codes of conduct; assessing partnership compatibility; and evaluating partnership outcomes."[18] From a private-sector perspective, Cordaro outlines the need for companies to move from business-as-usual models toward new business models that are inclusive of local communities, open to co-creation of initiatives and products, are willing to adjust return on investment lengths and amounts and to reduce gross-margin expectations, and willing to consider the contributions of additional social and economic values within the context of return-on-investment calculations.[24]

Social business and entrepreneurship to achieve nutrition and food security

That a business can reach the poorest of consumers (i.e., BoP) and eradicate poverty was first proposed by researchers, including Pralahad in 2002.[25,26] Since then, the concept of social engagement and social responsibility has evolved, with significant departures around the thinking of "What is a social business?" and how to best reach "the base of the pyramid." The premise is that most people in the world live on low incomes relative to their basic expenditure needs (including nutrition and health care), and by turning these people into customers, multinationals can bring access to much-needed consumer products and services at reduced prices, generating revenue and providing entrepreneurial opportunities for BoP consumers.[25] BoP business is likely to have an impact on economic development and poverty reduction, thereby creating both an economic and moral case for BoP business.[27] There have been critical analyses and criticisms of the BoP approach as proposed by Prahalad owing to limited empirical evidence and the suggestion that the original proposed theories based on case studies in India were not transferrable beyond the Indian market.[28] Furthermore, there has been an evolution in the fundamental concepts of BoP strategy.[29] Mohammad Yunus, a pioneer of microcredit and the founder of the Grameen Bank, approaches the issue of poverty eradication through the concept of social business. According to Yunus, "social business is a cause driven business" where investors/owners can gradually recoup money invested but cannot take any dividend beyond that point, and the purpose of the investment is purely to achieve one or more social objectives.[30] Thus, such an enterprise must cover costs and make a profit while achieving a social objective such as health or financial services for the poor or nutrition for malnourished children.[30]

Another new concept that has emerged in this field is the term *inclusive business*. Promoted by the World Business Council for Sustainable Development (WBCSD) and the United Nations Development Programme (UNDP), inclusive business models involve the poor in corporate value chains—either as employees, entrepreneurs, suppliers, distributors, franchisees, retailers, customers, or sources of innovation. The objective of these initiatives is to link businesses to low-income populations for the benefit of both groups.[31] The International Finance Corporation (IFC) identifies seven inclusive business models that expand access to goods, services, and livelihood opportunities for the poorest while generating strong financial returns. The models range from microdistribution and retail to experience-based customer credit, last-mile grid utilities, small-holder procurement, value-for-money degrees, value-for-money housing, and e-transaction platforms. Key insights from the work conducted by the IFC first included the need to create value for the BoP in order to remain sustainable, and while this is clear, what is not clear is how to create value. Second, inclusive business models are high touch and require significant effort to turn (e.g., in the case of turning neighborhood shops into high-performing retail and distribution channels or turning cash-strapped and skeptical people into repeat consumers). Thus, there is a need for consistent and active cultivation of markets and/or sources of supply with respect to the BoP market. Furthermore, touch models are likely to be resource intensive, and significant personnel, time, and fiscal investments must be made with a relatively long-term commitment to the market while still being capable of generating sufficient revenue to ensure commercial viability. Third, most inclusive business models are whole-pyramid focused rather than just BoP focused. Engaging a broader consumer or supplier base allows high-touch inclusive business models to leverage existing infrastructure, achieve economies of scale, and cross-subsidize. Finally, public funding can be used in a strategic manner: for example, to defray the costs of high-touch activities, including generating product literacy/social marketing among consumers, or to deepen the market at the BoP.[32]

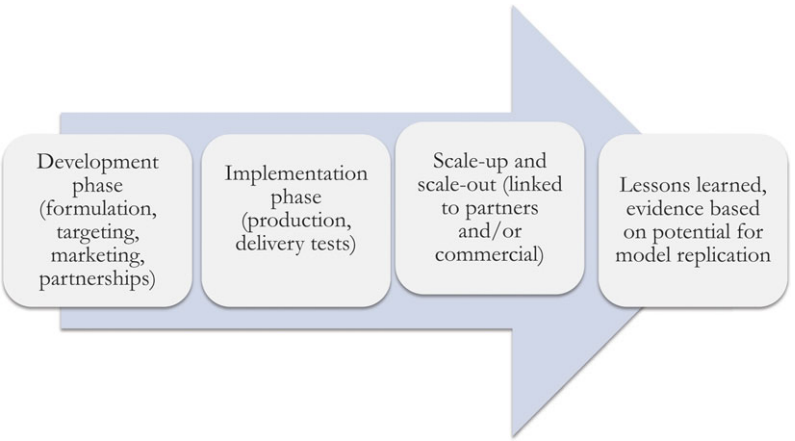

Figure 1. **Phases of R&D incubation and scale-up and scale-out of activities.**

What is the case for targeting the BoP to deliver good nutrition through market-based approaches (either social or inclusive)? An analysis of the BoP market indicates that about 4 billion BoP consumers live below U.S.$ 4, of these about 2.5 billion consumers live in rural areas. Most of the rural BoP consumers living in rural areas are small holders who are often net food purchasers rather than net food sellers. For most BoP consumers, food is the largest share of expenditure (80%), with an estimated U.S.$ 2.89 trillion spent annually by this demographic group.[16] A frequently cited example of a social business aimed at achieving income and nutrition outcomes is the Grameen–Danone initiative that produces "Shokti Doi" (yogurt) for BoP markets in Bangladesh. The Grameen–Danone business model includes the manufacturing, packaging, marketing, sales, and distribution of fermented fresh dairy products under the brand name Shokti+ using social-business methods.[33] There are additional core activities associated with social marketing and setting up a rural sales-and-distribution system. The business has been lauded for its innovation and for combining the strengths of the private sector and the nonprofit sector to create a profit-generating model that would simultaneously address the issue of child malnutrition in Bangladesh. In addition, the yogurt production operations provided a market to local dairy producers and jobs for factory workers and salespeople. Despite the seemingly well-focused and thought-through model as of 2010, Grameen–Danone has been a loss-making enterprise. Insights gathered through interviews with the management identified a combination of three factors that could explain the lowered business viability: these included an overoptimistic/unrealistic business plan, governance issues that affected the implementation capability during the start-up phase, and the global economic crisis.[33]

Innovation for improving nutrition of Ghanaian infants

The preceding sections outlined the nutritional need to be addressed in Ghana and the potential for using the concepts of PPP, BoP strategy, and social and/or inclusive business. The subsequent sections will present efforts of an innovative partnership, which utilizes a public–private approach along with principles of social business in reaching the BoP in Ghana with nutritionally sound products. A PPP has been developed that aims to prevent malnutrition in infants and young children aged 6–24 months in Ghana. The project involves several phases (Fig. 1) and aims to produce and scale up a low-cost CFS (KOKO Plus) to be added to fermented maize porridge (*koko*, which is a typical CF consumed by Ghanaian infants and young children) that is used as a first food for many Ghanaian infants.

Figure 1 provides an outline of the project and the phases, which include a development phase, an implementation phase, and a scale-up and scale-out phase. Overarching all these phases is the key phase of documenting lessons learned and generating an evidence base on the potential for replication of such a PPP model. The development phase began in early 2010 and focused on formulating the

supplement/product, determining the targets, understanding the markets, and developing partnerships. The implementation phase started in mid-2011 and focused on establishing the production system, including identifying a suitable location and a credible food-processing company that could be the production partner, construction of a dedicated production facility (building), procurement of appropriate machinery, developing the standard operating procedures (SOPs) for the production of the product, setting up quality-assurance protocols for the product to meet domestic and international food standards (Ghana Standards and Codex Alimentarius), and registering the product with the Ghana Food and Drug Authority. The efficacy of the product with regard to its nutritional improvement functions is being tested, and an understanding of the effectiveness of delivery was sought through two different delivery systems: (1) a BoP model tied to village-based women entrepreneurs as intermediary beneficiaries coupled with demand creation and behavior-change activities and (2) direct marketing through kiosks and local food vendors utilizing demand-creation, behavior-change, and social-marketing strategies. Following the implementation phase, findings of both efficacy and effectiveness will allow the private-sector partner to scale-up and scale-out activities, bringing them to a commercial level. The project will document lessons learned and anticipates building an evidence base that will allow considerations of model replication and transferability to other country contexts. Figure 2 provides an overview of the concepts of social business being considered within the Ghana project.

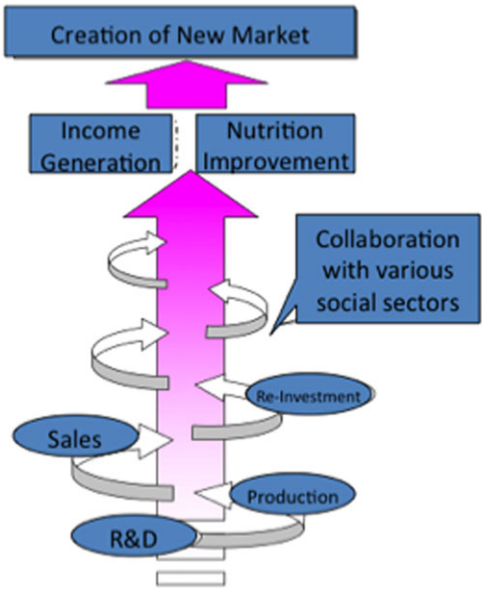

Figure 2. Social business to address nutrition in Ghana (Ajinomoto model).

What is the need for nutrition innovation in Ghana? Formative and market-research findings

From a nutrition perspective, in Ghana, prevalence rates of stunting, wasting, and underweight in children aged 0–59 months are 28%, 14%, and 9%, respectively.[34] Also, similar to global analyses,[35,36] in Ghana, height-for-age (HAZ) *Z*-score starts dropping from age 4 to 6 months, with children aged 6–23 months being more likely to be stunted (40%) than those below 6 months (4%). Stunting is high in the Eastern and Upper East regions (38% and 36%, respectively) and lowest in Greater Accra. It is higher in rural (32%) compared to urban areas (21%). Underweight prevalence was 14% in children under 5 years of age, with 3% severely underweight. High levels of underweight are found among children aged 18–23 months (19%), followed by 9–11 months (18%). Children in rural areas are more likely to be underweight than in urban areas (16% vs. 11%) and higher rates were found in the Upper East region (27%).[34] Wasting prevalence was the highest among children aged 6–8 months and lowest among children aged 48–9 months (3%). Wasting was most common in the Upper West (14%), Northern (13%), and Central (12%) regions.[34] Most recently, the UNICEF Multiple Cluster Indicator Survey (MICS) of 2011 found a stunting rate of 37% in the Northern region, even higher than the rate of about 32% in the Upper East. In addition, IYCF data in Ghana show that, for breast-fed children ranging from 6 to 35 months of age, cereals are predominantly the first foods introduced in the diet (6–8 months of age).[34] Only as the child grows older do mothers introduce fruits rich in vitamin A, other fruits and vegetables, and meat, fish, poultry, and eggs.[34] As seen in the DHS data (2008), less than 4% of infants under 6 months of age in Ghana are stunted; however, stunting prevalence rises rapidly with infants and young children in the 18- to 23-month age group exhibiting a prevalence of

almost 40%,[34] a strong indication of the effect of poor feeding practices.

A formative assessment conducted by Tano-Debrah, Armah, and Ghosh across the different regions of Ghana noted that *koko* is the most preferred first food because of its affordability and ease of preparation.[37] The qualitative study was conducted in three regions (Greater Accra, Upper West, and Cape Coast) to understand the major issues associated with complementary feeding, health, and food security in the three regions; to determine the different types of CFs used by mothers as well as those recommended by health workers in the three regions (and their differences); and to examine the differences in the preparation of CFs and the use of different staples for preparing CFs. Fifty-six respondents were interviewed in rural, peri-urban, and urban communities in the three regions. *Koko* has been found to be poor in energy density (about 25 kcal/100 g)[38] and protein quality, devoid of micronutrients, and has been implicated in protein–energy malnutrition.[39] *Koko* seems to be preferred because it is viewed as a lighter food than Weanimix (a cereal–legume blend promoted in Ghana through the public sector) and other commercially available and/or home-prepared foods. In addition to this formative work, a market analysis conducted in a series of interviews on 120 nursing mothers in Accra, Kumasi, and Tamale also found that porridge (a *koko*-type porridge) was the most popular CF fed to children in the mornings, followed by a commercially available infant food (in Kumasi and Accra) and tea in Tamale. Most mothers did not prepare special foods for the evening meal, preferring to feed the baby from the family pot, an indication, according to the authors, of the inability of the parents after a hard work day to prepare a separate CF preparation.

Next, from a market and consumer access perspective, the market analysis found several domestic and locally registered infant CF-manufacturing companies in Ghana.[40] While these enterprises are registered with Ghana's Food and Drug Authority, they do not have certification to produce CFs, which generates disincentivizes the consumers to purchase such products. Work around certification of locally made infant foods in the Greater Accra region has indicated low availability and uneven quality of products. Masters *et al.* note that, owing to current market conditions, quality of new products is not assured and households must rely on advertising and/or utilize labor-intensive methods to produce CFs at home.[41] They also indicate that low-income households cannot afford to buy or make quality foods for their infants, which is confirmed by market analysis that found only 25% of mothers purchasing CFs.[40,41] Furthermore, only one company, Yedent Agro Group of Companies Ltd., a key cereal producer in the market supported by the Global Alliance for Improved Nutrition (GAIN), actively produces locally certified fortified CFs (cereal–legume mixes). The market analysis by Sarpong *et al.* also showed that there are brand-name cereal-based CFs available at much higher prices than accessible to the average consumer, as well as several other home-based entities all over the country also producing weaning/complementary infant foods for the market. With respect to the latter, while there seems to be a market for such foods, there is relatively small volume of production with no wholesalers within the value chain, with producers often selling directly to the consumer and/or through shops and supermarkets that serve as retail centers. Most of these products are sold in quantities of 200–400 g, often an amount that is likely to be unaffordable by poorer consumers, especially those whose hourly earnings are 55 Ghana pesewas or less (women receive less, at 50 pesewas/h). This is particularly important, given that 25% of the sampled nursing mothers in the market analysis reported purchasing their CFs ready-made. Even those who make their own have to purchase the main ingredients such as maize, rice, soybeans, and fish to be processed into cereal–legume mixtures at the household level. Interestingly, while most mothers indicated preparing their own food, about 59% reported that they would be ready to buy an ideal ready-to-use food. Finally, while purchasing power seemed to be an issue, the majority of mothers in the formative study felt that a high-quality ready-to-use CF that could be purchased in small quantities is needed. Mothers and community-health nurses in the rural areas of Accra and Cape Coast believed that cost prohibits mothers from using ready-to-use CFs, though willingness to pay in the urban-market analysis ranged from 50 pesewas to 2 Ghana Cedi.[40]

The KOKO Plus formulation

On the basis of the findings of the formative and market-analysis research, CFS were considered the

most suitable products for intervention. A product named KOKO Plus was formulated with a linear-programming methodology outlined by Briend *et al.*[42] There are several commonly used cereals and legumes among the Ghanaian population. We considered maize, millet, and sorghum for the CF, but chose to use maize, as that is the most common ingredient for *koko.*[37] For legumes, peanut and cowpea (more commonly used) and soybean (a better source of quality protein) were considered. The formulation was based on the assumptions that the target child (1) is between 6 and 24 months of age; (2) consumes an average amount of breast milk for his/her age group; and (3) consumes an average amount of CF for his/her age group. CF requirements as outlined by Lutter and Dewey[43] were utilized, along with the revised amino acid requirements published by the WHO as guidelines for formulation.[44] Thus, the original optimal formulation developed utilizing linear programming was a cereal–legume mix with added fat and micronutrients. Team discussions led to another simple and innovative idea (i.e., the development of a supplement rather than a complete food). This involved the removal of the cereal component of the cereal–legume mix in order to reduce cost of production and packaging and thus the overall cost of the product. Second, while most households have access to the cereal component of porridge and fermented maize dough, which is used across many local dishes and is widely available in the markets, it is the legume/amino acid/micronutrient component that is not readily available and/or accessible. The details of the linear programming and formulation exercise, along with the findings of storage, stability, and sensory tests are published elsewhere;[11,45] the overall ingredient composition of KOKO Plus is presented in Table 1, while the micronutrient composition of the supplement is presented in Table 2. Following the formative and market-analysis research and the development of the formulation, the teams worked collectively in finalizing the packaging, the nutrient labeling, and the messaging on the package label.

Table 1. Formulation of complementary food supplement KOKO Plus

	KOKO Plus	
Ingredients	g	%
Soybean	7.313	48.8
Palm oil	0.976	6.5
Sugar	5.600	37.3
Lysine	0.112	0.75
Micronutrient premix	1.00	6.7
Total	15.00	100

KOKO Plus production system set-up

Production of the formulated KOKO Plus is undertaken locally, with the major ingredients (soybean, oil, and sugar) procured from local markets while the micronutrient premix and amino acid lysine are imported. The production system is set up to facilitate the production processes that meet local and international standards as well as Ajinomoto's internal requirements, which are based on Japanese regulatory requirements. A basic system for quality assurance has been introduced using standards such as ISO 9000. The location of the processing facility, the design and construction of the building, the selection and procurement of equipment, the arrangement and installation of equipment (the process flow), and staff recruitment and training are all aimed at ensuring that the product is produced and handled in a safe environment. Laboratory capacity has been built for routine analysis for quality-control and quality-assurance purposes. This laboratory has been validated through a comparative interlaboratory analysis with the Ghana Standards Authority, the Food Research Institute (Ghana), and the Ajinomoto Shanghai Food Research laboratories. In the context of the collaboration, Ajinomoto engineers worked closely with the University of Ghana and the local agrofood processor Yedent through the period of the set-up and training of the local production. The products are manually packaged in 15 g quantities. There are several areas that need to be considered in the process of scale-up/commercialization. First, while manual packaging and production have been successful, in the R&D phase, efforts will need to be made to improve and automate operations to meet product demands in the scale-up phase (i.e., commercialization), including an update of the on-site laboratory facility for the routine quality-control analysis. Issues such as the lack of traceability and ensuring the ability to replicate protocols will have to be addressed in the scale-up phase. The supply of packaging materials is a major issue identified in

Table 2. Micronutrient composition of complementary food supplement KOKO Plus

Micronutrient	Per 1 g of premix
Vitamin A	200 Mcg
Vitamin D3	2.5 Mcg
Tocopherol equivalent (vitamin E)	2.5 mg TE
Vitamin C	30 mg
Folic acid anhydrous (vitamin B9)	45 Mcg
Niacinamide	3 mg
Vitamin B12	0.45 Mcg
Calcium	200 Mg
Iodine	0.045 Mg
Iron, e.g., EDTA	2 Mg
Iron, e.g., fumarate	3.8 Mg
Zinc	2.05 Mg
Choline	54 Mg
Thiamine	0.25 Mg
Riboflavin	0.25 Mg
Pyridoxine	0.25 Mg
Vitamin K1	7.5 Mcg
Phosphorous (e.g., TCP)	103 Mg

the R&D phase. In Ghana, there is currently no local source for the packaging materials required for the sachets. The materials are imported, which adds to the final cost of the product. Getting high-quality packaging material at moderate cost is a significant priority for the future scale-up. Furthermore, a careful analysis of the procurement of raw ingredients has to be conducted, including identifying issues of production of soybeans and aggregation. Soybean is not a traditional food in Ghana, and while it is produced in the North, the scale-up phase will need to consider developing the agriculture value chain from farm gate to markets, procurement, and processing. Within the context of the latter, in the R&D phase, rather than establishing on-site production of soybean flour, processed soybean flour was sourced directly. However, that is not likely to be a long-term and sustainable procurement model. As part of the production set-up, the soy flour production facility has been audited and recommendations for changes have been made. These include procurement of the appropriate roasting and grinding equipment, modification in product flow, zoning of equipment, and training of the entire staff on issues related to handling the processing of soybeans into flour as well as general food safety.

Testing the efficacy of KOKO Plus

The efficacy of the use of KOKO Plus in improving nutrition and health outcomes of infants and young children aged 6–24 months is being tested through a cluster-randomized, single-blind, controlled intervention called "Trial for Reducing Undernutrition through Modified Feeding (TRIUMF)" being conducted in the Central Region of Ghana. The study tests the efficacy of KOKO Plus in improving growth, micronutrient status, and development outcomes in children aged 6–18 months and reducing morbidity. The intervention duration will be 12 months and will include the following groups: (1) intervention 1—a group that receives KOKO Plus with nutrition education; (2) intervention 2—a group that receives a micronutrient supplement with nutrition education; and (3) intervention 3—a group that receives only nutrition education and a control group that is followed cross-sectionally that receives routine care and support (i.e., access to health-care services including routine growth monitoring) by the Ghana Health Service. The study hypothesizes that infants who receive intervention 1 (KOKO Plus) will exhibit a greater increase in growth, improved micronutrient status, reduced micronutrient deficiencies, and reduced morbidity (diarrheal and respiratory morbidity, which will also affect growth) compared to those infants who receive intervention 2, intervention 3, or routine care (control).

Assessing effective delivery channels to distribute KOKO Plus in low-resource settings

This component of the collaboration is assessing two different delivery channels for distributing KOKO Plus, with the ultimate aim of developing an effective scale-up model in Ghana that reaches vulnerable population groups across the country.

Delivery channel 1: a village-based entrepreneur approach

This component of the project is being implemented by the nonprofit agency CARE Ghana, in 13 communities of Northern Region, Ghana, and builds off CARE International's Village Savings and Loan Associations (VSLA) platform, which provides vulnerable communities with self-managed savings-led financial services, as well as links to formal financial institutions. To distribute KOKO Plus, village-based entrepreneurs (VBEs) that are members of the

VSLA platform are recruited and trained to market and sell the product in their communities. The model, which follows a similar approach to the Avon beauty product sales model, consists of VBEs purchasing (or obtaining through credit) KOKO Plus in bulk from a central distribution hub, and then selling within communities at a profit. To facilitate sales, CARE Ghana carries out a series of demand-creation activities that include nutrition education (in partnership with Ghana Health Services), community theatre events, tasting demonstrations, and other traditional marketing formats such as billboards and posters.

Delivery channel 2: a social-marketing and microenterprise approach

This component of the project is being implemented by Exp Social Marketing Foundation (ESM) across three districts in Eastern Region, Ghana, and utilizes traditional microretail routes along with targeted demand-creation activities. ESM conducted significant formative research using their "Six Sense" methodology to understand the primary and secondary audience for marketing messages. This information was used to develop the advocacy and promotion activities for KOKO Plus. Activities included broadcasting of radio soap operas and talk shows on community radio stations, complementary billboards that relate to the soap operas, and direct outreach activities such as community discussions with niche consumer groups, mobile van broadcasting, cooking demonstrations, and market-day promotions.

Monitoring and evaluation developed for these models have focused on all stages of implementation, including wholesale purchasing and distribution of the supplement, demand-creation activities, and purchasing and use by consumers in the two regions. The evaluation, which consists of a series of cross-sectional household-level surveys, focuses on assessing access and utilization (i.e., coverage) of KOKO Plus among the target group of children under 2 years of age in the respective program areas.

Metrics and assessment of the BoP approach

Evaluation of BoP approaches provides useful information such as effectiveness in meeting targeted needs, economic efficiency, effect on competition, and technological innovation and distributional effects. However, there is very little literature on specific metrics (either process or outcome) with respect to evaluating BoP approaches that aim to improve nutrition outcomes such as child growth. Examining the poverty-alleviation literature, we find that two types of assessments are crucial for evaluating BoP approaches—these include theory- or program-driven assessment (also referred to as process assessments) and impact assessment. Paton considers theory-based evaluation as an important tool in the assessment of the social impact of the BoP approaches, including successes and limitations in achieving impact. Theory-based assessments can be normative or causative, the former focusing on goals/methods and outcomes that should be pursued by a BoP business to achieve a social objective while the latter examines the causal links between the intervention being evaluated and its outcomes. Causative theory-based assessments specifically evaluate the components of a BoP approach, an action theory that describes the link between the intervention and the immediate change in behavior of the target participants, while conceptual theory describes the link between the change in target participant behavior and the desired outcome. While there are limitations with theory-based assessments, including the complexities of identifying theories underlying a particular business, they are valuable, as they force practitioners to be explicit about the chain of events that the BoP business is intended to set into motion.[46]

With respect to impact assessment of BoP approaches, finding standard metrics to measure the success of impact investing in achieving social objectives (let alone nutrition objectives) is challenging. Killian and Menachem provide a comprehensive overview of approaches and metrics to be used in BoP-impact assessment.[47] A useful framework that can be used is the BoP impact assessment framework, which helps identify and enhance the positive effects of a venture's products and services, understand and mitigate the negative effects, and articulate current performance and prospects for improvement. The framework measures how a venture affects the well-being of its critical constituencies, including sellers (local distributors/producers), buyers (local consumers or agents), and communities across three dimensions: the economic situation, capabilities, and relationships of the different constituencies.[47]

Conclusions and next steps

The paper provided an overview of a PPP in Ghana that aims to improve access to high-quality low-cost CFS. Such soy-based food supplements have been tested in other countries (e.g., Ying Yang Bao in China); however, this is the first example of a low-cost soy-based product that is micronutrient enhanced in West Africa. Through the research and development phases, the focus of the team has been to understand local cultural and dietary habits and identify the most commonly consumed CFs. Activities are ongoing and the findings of each of the studies being undertaken will allow the multidisciplinary team to provide input for scale-up models. While lessons learned will allow the team to develop a plan for scale-up and take steps toward precommercialization of the product, it must be noted that there are limitations to the extent to which the data being collected will allow for a clear understanding of the issues and challenges associated with scale-up.

More work also needs to be conducted on considering the supply-chain aspects, including a value-chain analysis focusing on procurement and aggregation of the raw materials as well as an analysis of cost–benefit and cost-effectiveness of product distribution, delivery, and use relative to the nutrition gains. Other areas for consideration for scale-up models that have already been identified include ensuring a safe raw material supply, managing production such as to satisfy Ghanaian and international standards and regulations for food production, reducing the cost of packaging materials yet maintaining the quality level to meet company standards, and determining the optimal marketing/distribution system.

Future research needs to examine the issue of sustainability and viability of the enterprise within the context of the two different business models tested in Ghana. Work also needs to be done on understanding if the overall PPP/BoP approach is achieving the objectives of improved nutrition through causative evaluations as well as a clear understanding of the approach. Furthermore, the concept of BoP has evolved into different paradigms ranging from social business to inclusive business. While social business requires the enterprise to cover costs and not just make profit but achieve a social objective, inclusive models, while likely to be more sustainable than social business models, are high touch and require consistent and active cultivation of markets and/or sources of supply with respect to the BoP market. Inclusive models are likely to succeed, as they focus on the entirety of the pyramid, and this might be particularly interesting from the perspective of marketing of CFS, as the target group cuts across the entire consumer pyramid. Finally, the use of public funding becomes important so as to deepen the market at the BoP. The Ghana delivery models primarily utilize the social business approach, but the traditional marketing channels target a broader consumer base. Literature on the metrics associated with the process/performance and impact of this approach in achieving its goals and outcomes needs to be adapted for defining the specific metrics (process and impact) with BoP approaches that target nutrition as a social objective.

Finally, for a business to be sustainable requires investment and returns, and these expectations of a private-sector partner need to be managed within the context of public-sector needs and demands for improved access to good nutrition at the population level. Due considerations have to be given to issues, including local and national governance, implementation, and scale-up capacity, as well as the potential to build resilience to external shocks such as price crises. Furthermore, the concepts of inclusive business rather than social business might be gaining more traction and should be examined as an alternate viable sustainable model for the distribution and delivery of products such as KOKO Plus.

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Conflict of interest

This paper focuses on the use of social business by a public–private partnership, and several of the authors (S.K., H.M., C.F., Y.N., and Y.T.) are

affiliated with a private-sector company, Ajinomoto Co., Inc.

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