

Current and potential role of
specially formulated foods and food supplements for
preventing malnutrition among 6-23 months old and
treating moderate malnutrition among 6-59 months old children

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Abstract

Reducing child malnutrition requires nutritious food, breastfeeding, improved hygiene, health services, and (prenatal) care. Poverty and food insecurity seriously constrain accessibility of nutritious diets, including high protein quality, adequate micronutrient content and bioavailability, macro-minerals and essential fatty acids, low anti-nutrient content, and high nutrient density. Largely plant-source-based diets with few animal source and fortified foods do not meet these requirements and need to be improved by processing (dehulling, germinating, fermenting), fortification, and adding animal source foods, e.g. milk, or other specific nutrients. Options include using specially formulated foods: fortified blended foods (FBFs), commercial infant cereals, ready-to-use foods i.e. pastes/compressed bars/biscuits, or complementary food supplements (CFS): micronutrient powders (MNP); powdered CFS containing (micro)nutrients, protein, amino acids and/or enzymes; or lipid-based nutrient supplements (LNS), 120-500 kcal/d, typically containing milk powder, high-quality vegetable oil, peanut-paste, sugar, (micro)nutrients. Most supplementary feeding programs for moderately malnourished children supply FBFs, such as corn soy blend, with oil and sugar, which has shortcomings: too many anti-nutrients, no milk (important for growth), suboptimal micronutrient content, high bulk and viscosity. Thus, for feeding young or malnourished children, FBFs need to be improved or replaced. Based on success with ready-to-use therapeutic foods (RUTF) for treating severe acute malnutrition, modifying that recipe is also considered. Commodities for reducing child malnutrition should be chosen based on nutritional needs, program circumstances, availability of commodities, and likelihood of impact. Data are urgently required to compare impact of new or modified commodities to current (FBFs) and to RUTF developed for treating severe acute malnutrition.

Keywords: child malnutrition, fortified blended foods (FBF), corn soy blend (CSB), ready-to-use foods, RUTF, complementary food supplements (CFS), micronutrient powder (MNP), supplementary feeding

Introduction

The treatment of malnutrition, as well as its prevention, among underfive children requires consumption of nutritious food, including exclusive breastfeeding for the first 6 months of life and in combination with complementary foods thereafter till at least 24 months of age, an hygienic environment (clean drinking water, sanitary facilities), access to preventive (immunization, vitamin A supplementation etc) as well as curative health services, and good (prenatal) care.

In this paper, the focus is on possible options for providing a nutritious diet, realizing the constraints faced by many people whose children are at risk of developing or suffering from moderate malnutrition (stunting as well as wasting), such as poverty and food insecurity. While the nutrient density requirements proposed by Golden [1] are for moderately malnourished children, much of the dietary recommendations and complementary food supplements proposed for improving dietary quality are also relevant for young children (6-23 months) at risk of developing moderate malnutrition, i.e. among populations with a high prevalence of stunting among 2-5 years and wasting among 6-59 months olds. Therefore, much of the discussion in this paper is applicable to young (6-23 months) and growth faltering children as well as to moderately malnourished children (wasted, i.e. weight-for-height <-2 and ≥-3 Z-scores or stunted, i.e. height-for-age <-2 Z-score).

We will also cover a range of interventions, from food assistance programs for people who are wholly dependent on food assistance (refugees, people affected by man-made or disaster-related emergencies) and populations requiring food assistance during lean / bad harvest periods, to populations who are not typically food insecure but consume a relatively monotonous diet with too few good quality foods to provide vulnerable groups with the required intake of specific essential nutrients (such as micronutrients, (macro-)minerals, essential amino acids, essential fatty acids).

This paper starts with a discussion of options for dietary improvement, modification possibilities for ready-to-use therapeutic foods, improvement of fortified blended foods, and different kinds, roles, limitations and applications of complementary food supplements. These considerations are then compared to current practices in programs treating moderately wasted children as reported to a questionnaire that was sent out by Ashworth and de Pee between Feb – Aug '08. This assessment of current practices is then followed by programmatic considerations for expansion of the use of new food (supplement) products for preventing and treating moderate malnutrition among young children.

This paper complements the papers by Golden [1], Michaelsen et al [2], and Ashworth and Ferguson [3], with Golden having established the nutrient requirements, Michaelsen et al having reviewed the value and limitations of specific foods and food groups, based on their content of nutrients and anti-nutrients, and Ashworth and Ferguson having assessed the adequacy of dietary recommendations for moderately malnourished children using locally available foods in relatively food-secure but poor households.

Option 1. Local diet – required food groups and options for improving nutrient adequacy

Among relatively food secure populations (i.e. adequate energy intake per capita), the primary approach to prevent and treat malnutrition is by providing dietary advice about which foods to consume. Such advice is characterized by emphasis on consumption from all food groups (anywhere between 4-8 groups are distinguished), changing kind of foods chosen from these food groups (thus for example to alternate plant and animal sources of protein), frequent and responsive feeding, and ensuring good energy density [3-5]. The paper by Ashworth and Ferguson in this supplement [3] assesses whether and how nutrient requirements proposed for moderately malnourished children can be met by selecting locally available foods and examines the evidence for an impact of diets and programs based on promotion of locally available foods.

Table 1 shows the nutrient groups and active compounds that are essential for good child growth and development, what the main dietary source of these nutrients and compounds are, and provides comments on the consumption of these foods. In summary, a relatively wide variety of foods is required, including breast milk, staples (for energy and some micronutrients (MNs)), legumes or lentils (particularly for protein), animal source foods (good source of protein, minerals and some vitamins), vegetables and fruits (for vitamins, minerals and vitamin C to enhance absorption of non-heme iron), oil (energy, essential fatty acids) and a source of iodine such as salt (but note that a high sodium intake in moderately malnourished children is not desirable). **Table 2** shows the important characteristics of diets for young (malnourished) children (adapted from ref [2]) and considerations with regard to foods required to realize consumption of such diets.

However, as one respondent to the questionnaire on current programs (see below) said “... *very often the causes of malnutrition are attributable to wide-scale food insecurity (...). In such instances, there is simply no choice of food at household level, lack of variety and high market prices create inaccessibility to a diversity of foods, in addition to exhausted household assets with which to purchase or barter and as such, people are often reported to be living off a single staple (...). During such times, diet diversity cannot be promoted, so education will focus on the importance of personal hygiene and household sanitation, appropriate breast feeding and timely complementary feeding practices.*”

Where the diet consists largely of plant foods with very few animal source foods and fortified foods¹, as is the case for many children and their families in developing countries, such as the situation described above, there are a number of issues to be addressed. As can be concluded from **Tables 1 and 2**, plant foods, especially staples (maize, wheat, rice), legumes, lentils and vegetables, contain considerable amounts of anti-nutrients (such as phytate, polyphenols, lectins, protease and alpha-amylase inhibitors), which reduce mineral bioavailability and interfere with digestion of specific compounds. Therefore, either special processing to reduce the content of anti-nutrients should be used, and/or the content of vitamins and minerals should be

¹ Typical fortified foods that tend to be available in developing country markets: fortified flour, fortified noodles, fortified margarine, fortified milk (powder), fortified complementary foods.

increased in order to compensate for the lower bioavailability. Furthermore, oil or sugar should be added to increase energy density.

Figure 1 summarizes these issues of a largely plant based diet and the possible mitigation options to improve dietary quality when it is not feasible, due to limited availability or poor access (poverty), to achieve dietary diversity to the extent that all nutrient needs are met, i.e. limited possibility to include adequate amounts of animal source foods and/or fortified foods. The options are divided into processing and preparation practices that should be done at home, either using just locally available, unprocessed, foods (germination, soaking, fermenting to reduce anti-nutrient content and increase bioavailability as well as preservation of plant source foods to increase intake of the micronutrients they can provide) or by also adding just these nutrients that are lacking through the use of complementary food supplements (i.e. home-fortification or point-of-use fortification); and steps that can be taken during industrial processing of foods.

Home-fortification options are discussed in greater detail below (see section on complementary food supplements). About the home-processing steps for reducing anti-nutrient content, very little information is available on their effectiveness for increasing mineral bioavailability (which has been the main focus) [2, 9]. For industrial processing, including the use of enzymes, some more information is available about their impact [10-12], but none has been implemented at scale for human consumption, due to various reasons. However, the recent increase of commitment to reducing child malnutrition and understanding of what nutrients and foods are required has also increased interest and Research & Development efforts on the side of food manufacturers to process foods and produce active ingredients for inclusion in special foods or for use in food preparation.

Option 2. Modifying RUTF for maximizing catch-up growth among moderately malnourished children

We now move from populations with food security but limited access to quality foods, to populations facing food insecurity and a high prevalence of child malnutrition, including severe wasting. It is in these populations that RUTFs for treatment of severe acutely malnourished (SAM) children used in Community-based Management of Severe Acute Malnutrition (CMAM) programs are increasingly making a difference to child survival [13-16], and the question has arisen about what foods to provide to moderately malnourished children.

The rehabilitation process of severe acutely malnourished children goes through the phase of moderate malnutrition before reaching the discharge criteria of having gained adequate weight. Thus, RUTF provides all the nutrients required to promote growth and health among the severe acutely malnourished, and could therefore also, in principle, be considered for treating moderately malnourished children. In fact, its effectiveness for such use has been shown in a study in Malawi [17] as well as in a program in Niger [18].

However, RUTF likely provides nutrients in excess of what moderately malnourished children need and providing RUTF is not realistic for the vast majority of (identified) children with moderate malnutrition, due to limitation of production capacity of this

special product^{2 3}, costs of the product, and acceptability of the product where peanuts (an important ingredient) are not commonly consumed. Because of this, efforts are being undertaken to modify the RUTF recipe so that costs are lower and more locally available ingredients are used. **Figure 2** illustrates some of the options that can be considered when trying to modify the RUTF recipe. When 'just' the nutrient content of RUTF is considered, quite a number of options exist for exchange of ingredients. However, when also considering anti-nutrient content, palatability, and processing, storage and packaging options, options become more limited.

Four products for moderately malnourished children that are basically modifications of the RUTF recipe have been identified so far, as follows:

- a) Supplementary PlumpyTM produced by Nutriset, France. In this product, the dried skimmed milk of RUTF (Plumpy'NutTM) has been replaced with whey and soy protein isolates⁴, to reduce costs (see **tables 3 and 4**, last categories of products). Otherwise, the ingredients and nutrient content are the same as those of RUTF. The product is being used in a few programs and in (operational) studies that assess its impact on linear growth, weight gain, length of stay in the programme among moderately wasted children.
- b) Project Peanut Butter in Malawi produces a peanut/soy paste from 25% whole roasted soy (not dehulled), 20% soy oil, 26% peanut paste, 27% sugar and 2% micronutrients (providing 1 RDA per daily dose of 125 g). This product was compared to FBF with additional fish powder, and no difference in linear growth was observed [21]. The absence of milk in the spread and the addition of fish powder to the FBF may explain this absence of difference. Studies are also being done with spreads that include milk powder and compare these to fortified blended food (*Likuni Phala*). A recent study suggests that such a spread (25 or 50 g/d) has greater impact on severe stunting, but not on weight gain [22]. However, another study that compared milk/peanut spread, soy/peanut spread and CSB, found that recovery from moderate wasting was higher in both spreads groups compared to the CSB group (80% vs 72% recovery) [23].
- c) Indian RUF (Ready to Use Food for Children) has been developed by WFP India and includes chick peas, rice flour, a higher amount of oil to replace peanuts, and less DSM to reduce costs. Because chick peas contain more anti-nutrients than peanuts and because the milk content has been reduced from 30% in RUTF to 10% in Indian RUF, the impact on growth and micronutrient status of moderately malnourished children needs to be assessed.

² Anticipated production capacity of RUFs by the Plumpy' field Network of Nutriset, the main producers of RUTF, by the end of 2010 is 63,800 MT (Zeilani, presentation Mar '08, Washington DC), which is sufficient to treat 5.3 of the 19 million underfives suffering from SAM worldwide. Of the total anticipated production, 77% will be produced in France and the remaining 23% in 10 countries across Central America, Africa and the Middle East (300-3000 MT/yr per location). The products will include RUTF (i.e. Plumpy'Nut) and its related RUF products, i.e. Supplementary Plumpy, Plumpy'Doz and Nutributter. By the end of 2011, production capacity will have reached 100,000 MT/yr (Zeilani, personal communication Sept '08).

³ At present (Dec 2008), manufacturers of RUF include Compact, Hilina, Nutriset, Project Peanut Butter, STA, Valid Nutrition.

⁴ Earlier versions of Supplementary PlumpyTM had a somewhat different formulation.

- d) A baked biscuit has been developed by a consortium of German and Indonesian universities in collaboration with CWS (Church World Services) that consists of wheat flour, peanut paste, soy beans, oil, sugar and micronutrient premix and is locally produced in Indonesia. This product also has a higher anti-nutrient content than RUTF due to the inclusion of wheat flour and soy beans, and likely less impact on linear growth due to the absence of milk.

While the latter three products are likely to be less effective compared to RUTF, they are presumably better than fortified blended food, the main product that is currently provided to moderate acutely malnourished children (see sections below on current programs as well as on ready-to-use vs to be prepared foods).

Option 3. Fortified blended foods, current composition and improvement options

Fortified blended foods, such as corn/soy blend and wheat/soy blend have been provided as one of the sole fortified food assistance commodities among many different populations, and for a wide range of purposes, for the past 30 years or more. They consist of 20-25% soy, 75-80% corn or wheat, and a micronutrient premix. Because of the protein content and quality (total PDCAAS score of CSB: 65%), from the soy beans, and the additional MNs, it has been regarded as being of reasonably good nutritional value for limited cost and it is being produced in more than 20 countries across the globe. As such, it also became the product of choice from the few non-perishable food items used in food assistance programs⁵ for providing to moderately malnourished children as well as other vulnerable groups (pregnant and lactating women, and chronically ill, i.e. HIV/AIDS and TB). In 2007, WFP distributed 242,000 MT of blended foods, including 192,000 MT of CSB, to specific groups as well as to general populations, especially because of the micronutrient and protein content.

However, it is not a product well-adapted to meet the nutritional needs of young or moderately malnourished children, for several reasons, including [24-27]:

1. It does not contain all the required nutrients in adequate amounts
2. It contains a relatively large amount of anti-nutrients and fibers especially when prepared from non-dehulled soy and non-degermed, non-dehulled maize or wheat (see below)
3. It does not provide enough energy per serving and is bulky
4. The overall fat content and essential fatty acid levels are low
5. There is no milk (powder) in the product which increasingly appears to be important for linear growth of young (malnourished) children [7, 8].

The issue of too low energy density has been partly addressed in supplementary feeding programs by providing the CSB (or WSB) together with oil and sugar (commonly reported weight-based ratio: 10:1:1, see program section below for more information on ratios used). Sometimes these ingredients are mixed together in the feeding or health center before distribution, other times they are provided alongside

⁵ Items included in the food basket used in food assistance programs typically include staples (whole grains of rice, wheat and/or corn, or flour in the case of wheat and corn, which has a shorter shelf life but can, and should, be fortified), pulses (grams, lentils), cooking oil (fortified with vitamin A), iodized salt and FBFs (the main source of MNs unless fortified flour is part of the food basket).

CSB to be mixed at home. Unfortunately, very little is known about the preparation and consumption of CSB at home, both by the malnourished child as well as by his/her family members.

Figure 3 summarizes the advantages and disadvantages of CSB (and other FBFs) when provided to young (moderately malnourished) children as well as options that are or may be considered for improvement. The options for improving the nutritional quality range from modifications that are relatively easy to implement (changing micronutrient premix, adding milk powder, dehulling soy), to those that require substantial adjustments to the production process (degerming maize, adding more oil during production, exploring use of phytase during production).

To limit costs of improving CSB, some of the improvements could be applied to FBFs used for young (malnourished) children but not necessarily to FBFs used for other vulnerable groups (pregnant and lactating women, people suffering from HIV/AIDS or TB). For practical reasons, however, the number of different varieties of FBF used in an operation should be limited (preferably not more than two) in order not to confuse program implementers and beneficiaries with different, but very similar, products for different target groups that all have to be distributed and prepared separately.

The three main buyers and distributors of CSB are WFP, UNICEF and USAID. The characteristics of the products they purchase are described below.

CSB from WFP⁶

WFP is currently revising its specifications for CSB (and other FBFs) to arrive at mainly two products⁷, as follows (for more details, see WFP's 10-min-to-learn series on Nutrition Programming [28]):

- 1) **Improved CSB** for general use, including pregnant and lactating women and people suffering from HIV/AIDS and TB, which will
 - a. Have improved micronutrient content (more kinds, increased amounts, better bioavailability)
 - b. Use dehulled soy in order to make a start with reducing fibre and phytate content and to reduce the content of toxins and contaminants
 - c. Have a lower maximum for aflatoxins (5 instead of 20 ppb) and tighter specifications for microbiological content
 - d. Include specifications for maximum content of heavy metals

- 2) **Improved CSB plus milk** for young (6-23 mo) and moderately malnourished children, which will
 - a. Have the same specifications as 'improved CSB' (see above) and in addition contains

⁶ WFP also distributes CSB donated by USAID and formulated according to USDA specifications, see below. Here, we describe the specifications of CSB as purchased by WFP, to a large extent from producers in developing countries.

⁷ In North Korea WFP purchases blended foods that also include milk powder, i.e. milk powder, corn and soy; milk powder and rice; and milk powder and wheat. However, no conclusive evaluation of impact is available on these operations.

- b. DSM (dried skimmed milk) at 8%
- c. Sugar, upto 10% of energy
- d. Oil (soy bean), ~3% added before extrusion and upto 7% added after extrusion (exact amount to be determined based on product rancidity and shelf life tests)

The specifications for ‘Improved CSB’ have been finalized and will be gradually implemented in consultation with producers. For ‘CSB plus milk’ production trials are ongoing to determine the optimal specifications from a technological and shelf life point of view. Once finalized, this product should be studied in comparison to other products (RUTF, improved CSB) for its impact on growth (linear as well as weight), micronutrient status, functional outcomes, acceptance and length of stay in (blanket or targeted) supplementary feeding programs among young (6-23 mo) as well as moderately malnourished children.

CSB from UNICEF (Unimix)

Unimix, the CSB procured and distributed by UNICEF, has virtually the same composition as (not yet improved) CSB procured by WFP, except that it also includes 5-10% sugar in exchange for corn. WFP and UNICEF are discussing the improvements that will be made to CSB and also to Unimix.

CSB from USAID

The CSB procured and distributed by USAID complies with the USDA (US Department of Agriculture) Commodity Requirement CSB13 [29] and contains: 69.5% cornmeal (‘processed, gelatinized’), 21.8% soy flour (‘defatted, toasted’), 5.5% soybean oil (‘refined, deodorized, stabilized’), 3% MN and antioxidant premix. The declared micronutrient content of CSB from USAID⁸ includes both the micronutrients from the ingredients themselves as well as from fortification, and is based on MN-content of the raw materials and the MN-premix, not on analysis. And, as with the CSB purchased by WFP, the micronutrient specifications for the premix are currently under review as well (personal communication with Liz Turner, SUSTAIN).

According to the CSB13 requirements, corn shall be dehulled and degermed and corn germ may be added back to the product (max 10%) to replace vegetable oil. Soy can be added as defatted or full-fat soy flour. Defatted soy flour shall be prepared from dehulled soy beans whereas dehulling is optional for full-fat soy flour. When full-fat soy flour is used, it should be added in an amount that ensures that protein content is equivalent to use of 21.8% defatted soy flour. Vegetable oil may be added to the final product to ensure adequate fat content.

Thus, the CSB donated by USAID contains less crude fibre, which is also in accordance with the specifications (2% on dry matter for USDA specs and 5%, to be changed to 3%, for WFP), because it uses dehulled (and possibly degermed) corn, and possibly dehulled soy (depending on whether defatted or full fat soy is used). For this product, some processing steps identified in **figure 3** have thus been taken already.

⁸ Available at

http://www.usaid.gov/our_work/humanitarian_assistance/ffp/crg/downloads/fscornsoyblend.pdf

A comprehensive overview of the history of US Government Food Aid Programs has been written by Marchione [30]. It is noteworthy that between the mid '60s and late '80s blended foods contained nonfat dry milk (corn soy milk and wheat soy milk), but that milk was dropped from the blends when milk surpluses became exhausted. In 2001, nonfat dry milk was reintroduced in a number of commodities. Requirements for adherence to manufacturing standards, including micronutrient specifications, for US commercial food suppliers to the food aid programs, and their enforcement, were introduced in '99-'00. With a total US donation in '07 of 114,000 MT of CSB, 61,000 MT of which was donated through WFP⁹, good quality control is very important.

Need and feasibility of further adjustments to FBF

As mentioned above, one of the main issues with CSB that make it less suitable for young (malnourished) children is the high content of anti-nutrients, particularly phytate, and its fibre content. A study from 1979 documented better nitrogen absorption and retention (indicating protein uptake) from CSB made from degermed corn and dehulled soy as compared to whole cornmeal and dehulled soy bean flour as well as to whole corn meal and whole soy bean flour [23]. These effects were ascribed to the higher fibre content. High fibre content may also reduce energy intake through an effect on appetite, increased faecal losses of energy due to reduced absorption of fat and carbohydrate, and increased flatulence which can have a further negative effect on energy intake [2] and also lead to non-acceptance of the product. While reduced energy uptake could be compensated for by adding oil or sugar to the product, it does not improve mineral bioavailability and also reduces (micro)nutrient density unless fortification levels are increased.

A paper by Jansen, published in 1980, that reviewed more results, however, concluded that degerming corn also results in loss of protein and oil, from the germ, and that the higher protein content of whole corn compensates for the slightly lower absorption related to its higher fibre content [25]. With regard to likely lower bioavailability of minerals, Jansen said that this should be compensated by fortification. Given the considerable losses when using degermed corn meal (extraction rate of 65-75%, thus losing 25-35%), the desire to produce the product locally, and the possibility to at least dehull the soy, Jansen recommended in 1980 that CSB be composed of dehulled soy and whole maize meal, resulting in a crude fibre content <2%, and be mixed with an adequate MN premix.

The USDA specifications include the use of dehulled and degermed corn and dehulled defatted soy or optional-dehulled full-fat soy flour, and up to 10% of corn germ may be added back to the product. CSB purchased locally in developing countries by both WFP and UNICEF, however, is made from whole maize as well as whole soy beans¹⁰.

A study using WSB, provided by World Vision in Haiti, found a poor impact on anemia levels [31]. If the WSB was provided under the Title II programs and complied with USDA specs, crude fiber content was 2.5% of dry matter as it

⁹ Details about USDA's Food Aid can be retrieved from <http://www.fas.usda.gov/> - *Programs and Opportunities - Food Aid - Food Aid Reports*

¹⁰ Note that the new specs of WFP that will soon be rolled out require dehulling of soy (see above) and max crude fiber will be reduced from 5% to 3%.

contained partially debranned wheat [32]. This means that also for CSB that complies with USDA specifications it is not known whether phytate content is low enough to provide for adequate mineral absorption. For young children, a maximum intake of total dietary fibre of 0.5 g/kg body weight has been recommended by the American Academy of Pediatrics. For a 6 kg child, this would translate into 3 g/d. When this child consumes some vegetables and wheat or corn in addition to one or two cups of CSB, especially when made from whole maize and whole soy, intake is very likely higher than that.

Therefore, options to reduce fibre, and phytate content, need to be further explored for the product purchased by WFP and UNICEF. The cost of degerming corn, due to the need for specific equipment, the loss of 25-35% of the corn, and the need to compensate the loss of some protein and oil, are high. This means that if it were to be done for the products purchased by WFP and UNICEF locally in developing countries, it should probably only be done for CSB that is used for young (6-23 mo) and for moderately malnourished children.

Option 4. Complementary Food Supplements: Compensating shortage of specific nutrients

Complementary Food Supplements (CFS) can be defined as food-based complements to the diet that can be mixed with or consumed in addition to the diet and the purpose of which is to add nutritional value [33]. CFS are comparable to food fortification in the sense that they increase the intake of essential nutrients from food. However, the important differences are that CFS can be targeted to specific vulnerable groups as they are added to foods just before consumption (home- or 'point-of-use'-fortification), and that the dosage is not dependent on the amount of energy consumed in a day, i.e. one dose is added to one meal irrespective of meal size.

CFS can be divided in different categories, as shown in **table 3**. The first four categories (MNP, powdered CFS (protein, amino acids and/or active substances) with MNs, and LNS_{≤20g}) are CFS that provide essential micronutrients, amino acids, fatty acids and/or active compounds (enzymes), but contain little additional energy. The next three categories (industrially produced complementary foods, 45 g LNS [250 kcal] and 90 g LNS [500 kcal]) are foods of high nutritional value¹¹ that also provide a substantial amount of energy. Because they are meant to be consumed in addition to a daily diet, even when partly replacing it, and are composed in such a way that they are the main source of essential nutrients, i.e. they can be combined with little more than just carbohydrate sources, they are included in this table on CFS.

Because CFS are added to an existing diet, the added value of a particular CFS depends on the composition of the diet to which it is added and the needs of the target group or individual consuming it. For example, MNP was originally developed to address nutritional anemia [34] and was then expanded to include a wider spectrum of MNs [35]. However, when choosing (or developing) a CFS to enrich the diet of young (6-23 mo) or moderately malnourished children, a commodity with additional

¹¹ It should be noted though that the nutritional value of commercially available complementary foods is very variable. They have been listed here, because some are of high value, such as the products developed by GRET (see table 8).

nutrients, such as essential amino acids and essential fatty acids and a dairy component, may be more appropriate, assuming that local foods do not provide these in sufficient amounts.

Because the concept of CFS is relatively new, with MNP developed in the late 1990s being the first, they differ with regard to important ingredients, relatively few data exist on their impact, and depending on their purpose only certain outcomes have yet been tested [19-22, 34, 36]. However, the concept is promising because only the additionally required nutrients are added to an otherwise local diet or basic food ration. This limits costs as well as interference with prevailing dietary habits and sourcing of food assistance commodities. Programmatic experience is required to evaluate the feasibility of their use including prevention of sharing, required socialization messages, training needs etc, because the concept of a small food supplement to be consumed exclusively by a specific age group of young children (or pregnant or lactating women) is new for most populations, as is also true with home-fortification using MNP [35] or a protein or enzyme powder (~10 g) with micronutrients (powdered CFS).

Table 4 shows the nutrient content, indicative price per daily dose, estimate of the number of dosages required between 6-23 mo of age or to treat moderate malnutrition, and price of this number of dosages (for further information on fortified complementary foods and supplements see also the paper by the infant and young child nutrition working group [37]). Clearly, the more nutrients and the more energy the CFS contains, the more expensive it becomes. However, the cost of the accompanying diet becomes increasingly less as the CFS increase in size and amount of energy provided. But when the diet is of relatively low quality, the cost of what is replaced of course is less than the cost of the CFS that replaces it, also because the CFS is individually packaged, and needs to be transported and distributed.

Some adequacy calculations

In order to determine which kinds of CFS are most suitable to improve a typical complementary feeding diet, such that it is likely to meet the nutrient intakes recommended by Golden for moderately malnourished children, **table I** was prepared using linear programming [38, 39]. It shows the typical nutrient intake of a 12-15 months old, moderately underweight (7.4 kg) Bangladeshi child that is breastfed and receives three servings of locally prepared complementary food per day, consisting of rice, dal with potatoes, oil, sugar, and dark-green leafy vegetables (each of max 3 portions/d), small fish (max of 2 portions/d) and/or eggs (max of 1/d) when receiving various types of CFS. The portion sizes assumed for the local foods are average sizes and they have been modeled to provide the energy requirement not yet fulfilled by CFS, breast milk (40% of total energy intake) and a standardized portion size of rice of 150 g/d (i.e. 23% of total energy intake). The linear programming goal was to achieve the nutrient intakes proposed by Golden [1] and the same as those used in the paper by Ashworth and Ferguson [3]. However, it should be noted that the selection of foods for the analyses done in this paper was more restricted than in their paper (up to 9 vs 24 local foods). In particular, fruits, milk, chapatti, bread, semolina, pumpkin, chicken and chicken liver were not included here, as it was assumed they may not be available in the poorest and most food insecure households. This makes this analysis very different from the one presented by Ashworth and Ferguson [3] where a greater

selection of foods and somewhat different portion sizes were used.

From **table Ia to Ic** (kinds of MNP) and from **Id to If** (kinds of LNS), the dietary diversity is reduced through further exclusion of specific foods. Diets that included LNS had a lower dietary diversity in the best fit model than diets with MNP (Tables Ia to If). The lower dietary diversity is because the energy contribution from LNS (i.e., 12.7 - 57.5% of total energy intake) partly replaced that of local foods.

For the unsupplemented restricted diet, which includes spinach, dal, potatoes, fish (2 kinds), oil, sugar, rice and breast milk, without a CFS, nutrient content is inadequate for 10 MNs. With a MNP with 5 MNs, content is inadequate for 7 MNs, and with 16 MNs it is inadequate for 3, which are type II nutrients. TopNutri™ provides the most complete mix of MNs of all the different kinds of MNP & powdered CFS. With decreasing dietary diversity, the gap of micronutrients increases. When LNS are added nutrient intake becomes more complete as compared to when MNPs are added. However, they are still short in a number of nutrients, especially vitamins E and C, potassium, magnesium and zinc. This may be due to the fact that some LNS are designed for prevention rather than for treating moderate malnutrition (i.e. recommended intakes are different) and other LNS are designed to completely meet the required nutrient intake (with exact intake to be varied according to energy need) rather than to be consumed in addition to a local diet and breast feeding. For the Indian RUFC, micronutrient content will be adjusted to be comparable to Plumpy Doz™ when providing 50 g/d and to Supplementary Plumpy™ when providing 100 g/d.

The same analysis has also been done for the addition of CFS to CSB of which energy density was increased through the addition of oil and sugar (**table II**). For CSB, the composition as published by USDA was used, which is based on the MN content of the raw ingredients and the MN-premix, and is a relatively complete kind of CSB. Because CFS are not designed to be added to CSB, which is already fortified itself, the intake of several MNs would become rather high. However for some, particularly the type II nutrients, intake would still be too low, for similar reasons as mentioned above for the combination of LNS with the local diet. It will be best to either adapt the MN-premix formulation of CSB (as will soon be implemented by WFP), or to add an appropriate CFS to a largely plant-source based unfortified diet. When adapting CSB, considerations discussed above should also be taken into account, i.e. ingredients and processing used, in addition to reaching adequate nutrient content.

The results shown should however be interpreted with caution, because they are calculated for a hypothetical child aged one year, weighing 7.4 kg, that is breastfed, probably by a mother with suboptimal nutritional status herself, and lives in a food insecure household in Bangladesh. For many children the situation will be different because they are of a different age, may or may not be breastfed, may have access to a greater variety of foods etc. The CFS are of the same size and composition irrespective of the specific age of the underfive child, whether he or she is breastfed and what the nutritional status is. Thus, adequacy of diet in combination with CFS will vary among as well as within populations.

Linear programming calculates possible solutions to reach certain goals, such as in this case energy and (macro and micro) nutrient intake from a specific set of foods

that can be consumed at certain minimum and maximum amounts. However, some important aspects of foods for young or moderately malnourished children discussed in this paper cannot yet be included in linear programming because of a lack of adequate data or because exact requirements have not yet been established. This includes:

- Selenium, iodine, biotin, vitamins K and D (too variable or unknown content)
- Essential fatty acids
- PDCAAS, i.e. protein quality
- Minimum requirement for animal source food or milk
- Anti-nutrients (content in individual foods not well known and maximum intake not established)
- Micronutrient bioavailability (depends on factors in a meal, not a daily diet, and is very complex).

Further, the linear programming results are very dependent on the model parameters, which for this particular analysis include the list of foods, their portion sizes and the desired nutrient intake levels. Thus, for households with access to a greater variety of foods or with different food portion size restrictions, the results would differ, as was shown when results from these analyses are compared with those for a breast fed child in the other paper (3). Likewise, these results depend on the validity of the nutrient goals modeled. In particular, estimating iron adequacy is complex because it depends on bioavailability which needs to be judged separately. An additional judgment is also required with regard to protein and fat quality and inclusion of milk (powder) or another animal source food (in addition to breast milk).

Future option, use of phytase

Another possible option to increase mineral bioavailability is the use of phytase to reduce phytate content, either during production, or by adding it to an end product as the last production step, or by using it as a home-fortificant (see **figure 3**). The latter two options however cannot yet be used at large scale because phytase is not yet widely approved for human consumption. It has GRAS (Generally Regarded As Safe) status for individuals aged 3 years and older, but not yet for younger individuals, and in some countries it is not permitted at all. When phytase is used during industrial processing and destroyed by a subsequent heating step, there is no problem because the product that reaches the consumer will not contain phytase.

A range of phytases is available with different pH and temperature optimums, thus different ones can be used for phytate degradation in different wet foods or in the low-pH environment of the stomach [40]. To what extent phytase reduces phytate, whether used during food production, in prepared, wet, food that is left to stand for a while, or in the stomach, needs to be determined, as should the impact on mineral absorption. A very recent stable-isotope trial among Swiss women that assessed iron absorption from a maize porridge with high phytate content to which a MNP with low iron content of high bioavailability and a phytase that degrades phytate both on the plate and in the stomach had been added showed promising results [41].

Thus, it is of urgent importance to obtain GRAS status for the use of phytase in foods consumed by young children (6-35 mo) and to test its impact on phytate degradation and mineral bioavailability in this target group as well.

Ready-to-use foods vs to-be-prepared foods: storage & preparation

So far, we have considered the nutrient content, anti-nutritional factors, and specific ingredients of specially formulated foods for young (moderately malnourished) children. Another important aspect to be considered is the form of these specially formulated foods that are provided as part of supplementary feeding programs, i.e. whether they are ready-to-use or need to be prepared, how easy and hygienic that is, and how well they can be stored.

These aspects are important for any of the above discussed options, whether referring to recommendations for foods prepared at home (i.e. germination, storing of fresh fish or meat) or to foods provided as food assistance (transport over considerable distance, storage, cooking fuel availability).

Foods that are ready-to-use are extremely convenient, from the point of view of storage as well as preparation (not required) and consumption. Because they are very energy dense and contain very little water (to prevent growth of molds and bacteria), it is important that there is access to clean drinking water. Where availability of cooking fuel or time for food preparation is limited, providing a ready-to-use food for individuals suffering from a special condition (i.e. a malnourished child) will be easier compared to providing a food that needs separate preparation in addition to cooking the family's meal. In addition, a food that needs to be cooked specifically for one individual may be more likely to be shared with other family members.

The same convenience is applicable to biscuits or compressed bars, which are also 'ready-to-use'. There is concern about using biscuits for complementary feeding, because of the difficulty for consumers to distinguish between nutritious and non-nutritious biscuits, and the possible promotion of a habit of biscuit consumption which may in fact lead to consumption of non-nutritious, high-sugar, biscuits. However, when feeding severe acutely malnourished children (BP100), use as a short-term measure for reducing the risk of malnutrition under sudden situations of food insecurity (BP5), or when feeding MM children for a limited period of time, these concerns would not apply. When designing biscuits as ready-to-use food it is important to realize that biscuit baking up to 200°C will destroy some of the heat sensitive vitamins. Compressed biscuits, such as BP100 and BP5, do not have this problem.

For (pre-cooked) dry foods that are to be prepared with water, to make a porridge, boiling for a 5-10 minutes is recommended in order to kill any microbes that could be in the water or the food. Instant foods with instructions that they only require adding of (warm) water are not preferred for use under less-hygienic circumstances.

Current programs for moderately malnourished children

Tables 5 and 6 summarize the responses received to a questionnaire on current programs for moderately malnourished children, which was sent to 10 UN agencies and donors, 20 international NGOs, 3 prominent paediatric associations and 6 large national programs. The information included in this paper pertains to the responses that included provision of a food supplement. For a more detailed description of the

questionnaire, responses received and information about programs providing dietary advice, see the paper prepared by Ashworth and Ferguson [3].

The majority of programs provide fortified blended food, especially corn-soy blend (CSB), to moderately malnourished children, and these are mostly wasted children. **Table 5** also shows the number of children reached with a mixture of CSB + oil + sugar by reporting programs. The total amounts to more than 550,000. Considering that many more programs are implemented, it can be estimated that at least a couple of million moderately wasted children receive CSB (or WSB) every year.

The majority of programs add oil and sugar to the FBF, usually by mixing it just before distribution (including oil reduces shelf life) but sometimes by handing out the three commodities separately¹². The ratio of CSB:oil:sugar varies, as was also observed in the SC-UK review of Supplementary Feeding Programs by Navarro-Colorado [28]. On average, the ratio is 10:1:1 and ~1000 kcal/d is provided.

Most organizations that answered the question on target intake from the CSB mixture for the malnourished child stated that this was 1000 kcal/d (equivalent to 200 g CSB + 20 g oil + 20 g sugar), while at the same time they said that they provided it as a take home ration that was likely to be shared. Considering that the energy needs of a moderately malnourished 12-15 mo old child of 6.7 kg with a weight gain target of 5 g/kg/d is 770 kcal/d and that many children also receive breast milk, a target intake of 1000 kcal/d from CSB is excessively high for many moderately wasted children and also not possible for a child that consumes 3-4 meals per day of 35 g dry weight each. However, unfortunately, little is known about actual intake of CSB preparations by different age groups of moderately wasted children. Some programs provided family food rations or a supply of CSB for siblings to limit sharing of the CSB mixture that was provided to the moderately wasted child.

A number of organizations provided other kinds of food supplements (see **table 6**). Some (reaching ~200,000 children) provided a mixture of (fortified) staple, pulse, oil and sugar (UNICEF Uganda, CWS Indonesia, Bangladesh National Nutrition Program and ACF Myanmar) some of which was locally produced, or BP 5 (Unicef Uganda). Some provided a supplement that also included milk and still had to be cooked, like the FBF mixtures (DREAM for HIV+ children in African countries, GRET in Burkina Faso, Madagascar and Vietnam). World Vision in Niger promoted home-preparation of a local peanut paste mixed with dried Moringa leaf concentrate for *mildly* malnourished children and provided the CSB mixture to *moderately* malnourished children (see **table 6** for details). And a few organizations use lipid-based ready-to-use foods such as Supplementary PlumpyTM, Indian RUF, peanut/soy paste, Plumpy DozTM or Plumpy NutTM for moderate acutely malnourished children (MSF, ACF, WFP, Project Peanut Butter in Malawi) or even to prevent malnutrition [42]. A rough estimate of the number of moderate acutely malnourished children receiving a lipid-based ready-to-use food is max 50,000/yr. Most lipid-based RUF is in the form of RUTF and provided to children suffering from severe acute malnutrition.

¹² Unimix, i.e. CSB provided by UNICEF, already contains sugar, usually 10% in exchange for corn.

Further programmatic considerations

Much of the discussions of the Technical Consultative MM meeting focus on the nutrient and food needs of individual, malnourished, children, which are a function of the % of lean body mass that they should gain and desired weight gain, which are dependent on the individual's nutritional status (stunted, wasted or both) as well as on whether a specific food will be provided or whether the diet should be changed. However, from a programmatic point of view, it will rarely be feasible to really tailor the treatment to the individual moderately malnourished child.

In targeted programs, that identify the individual malnourished (usually wasted) child, weight and height measures will be taken, a target for weight gain set, and the caretaker will be provided with dietary advice and CFS or special foods. The programs have no control over the diet consumed. Also, giving specific advice and amount of commodities to individual children is challenging, especially when working with community volunteers rather than medically or nutritionally qualified personnel. And, the number of different commodities and their quantities should be limited to reduce potential confusion.

With the current development of new concepts and products for different types of malnutrition, many questions arise about what programs to implement, or how to modify ongoing programs, and what advice or commodities to use. While these program-related questions will be the subject of a follow-on meeting, some of them need to be answered now even when it is clear that guidance is likely to change as more products and information about their use and impact become available. **Table 7** suggests response options that can be considered for food assistance programs to prevent and treat moderate and mild child malnutrition (wasting, stunting). Which choice to make will depend on many factors, including:

- what is likely to have the best impact
- logistical considerations such as the accessibility of the area and presence and capacity of implementing partners
- availability of preferred commodities within desired timeframe
- human capacity for designing, supervising, implementing and evaluating the program, and
- funding for the program.

In situations of severe food insecurity where blanket supplementary feeding programs are implemented for young children and pregnant and lactating women, often also for reasons of logistics & safety, foods could be provided of which the composition is as recommended for treating moderate malnutrition, because these are designed to be inherently safe for non-malnourished individuals. Because of the larger number of beneficiaries, blanket feeding of high-quality and more expensive food supplements comes at a higher commodity cost. However, at the same time money is saved because there is no need to identify and follow individual moderately malnourished children.

Access, affordability and distribution of specially formulated foods

Because treatment of severe acute malnutrition is considered a right of the child and is too costly for most families (~50 USD for one child's treatment with RUTF), it is

generally provided by the public sector (governments or humanitarian agencies). For moderate malnutrition, the situation however depends on the target group, the commodities, and the context.

At one side are the CFS that are taken for preventive purposes, such as MNP, powdered CFS and LNS of ≤ 20 g/d, with an indicative product cost of 0.02 – 0.12 USD/d. While they should be used by the majority of children who consume too few animal source foods and fortified complementary foods, they cannot be afforded by all households [43].

Ways are sought to target different socio-economic groups in a country in different ways with the same product, which may be packaged differently for this purpose, such that wealthier households can cross-subsidize poorer households and public sector organizations can buy and distribute to the poorest. The use of vouchers for specific groups that are targeted for specific public programs is also considered [44].

Preventive or curative approach

Based on the successful treatment of SAM with RUTF, attention now also focuses on treatment of moderate acute malnutrition, the guidelines for which are similar to those for prevention of wasting and growth faltering among children aged 6-23 months. Also, as explained by Golden [1], when treating children with moderate acute malnutrition, weight gain should to a large extent be on the account of lean tissue, and hence also result in linear growth (note that many wasted children are also stunted). And stunting among non-wasted children is better prevented between conception and 24 months of age rather than treated [45].

Thus, a good strategy for a population would be to focus on preventing malnutrition through programs that target pregnant and lactating women and children aged 0-23 months, and on treatment of moderate and severe wasting among underfives. The former can also be considered treatment of a population, i.e. based on prevalence of stunting among 2-5 year olds, the younger children receive blanket treatment to reduce their risk of becoming malnourished. Ruel et al [46] conducted a trial in which they compared two populations, in one all children aged 6-23 mo received a monthly supply of FBF and oil, and in the other population all children aged 6-59 mo suffering from MAM received a monthly supply of the same. Three years later, the population levels of malnutrition were lower in the former than in the latter group and the authors concluded that the former strategy was more effective for combating undernutrition.

What appropriate ***preventive measures*** are depends on the adequacy of the local diet, i.e. which dietary gap has to be filled, and on the accessibility of required foods. ***For treating moderate acute malnutrition***, locally available foods can be used where accessible (see [3]). Where this option is not very feasible, processed and fortified foods or complementary food supplements can be made available through subsidies or for-free distribution. Such foods can be produced locally or be imported, depending on ingredient availability, local producer capacity and packaging facilities.

When specially formulated foods are used for treating moderate acute malnutrition, results should preferably be obtained more quickly than when modifying the diet, because delivery of such products incurs program costs, and there is a greater

expectation of the foods being a treatment (the argument of this being a treatment for the specific child should also prevent sharing with other household members). When treatment relies on dietary changes, this will hopefully result in a change of the diet of all young children in the family that is maintained for a longer period of time.

Discussion & Conclusions

Many of the recommendations for dietary management, including the use of specific food (supplements), for moderately malnourished children also applies to children aged 6-23 mo that are at risk of becoming malnourished because they live in populations with a high prevalence of stunting as well as wasting. Therefore, most of what is discussed in this paper is applicable to young (6-23 mo) as well as to moderately malnourished (WH Z-score <-2 and ≥-3 or HA Z-score <-2) children.

Important foods for young and/or malnourished children include breast milk, staples (for energy and some MNs), animal source foods (good source of protein, minerals and some vitamins), legumes or lentils (particularly for protein), vegetables and fruits (for vitamins, minerals and vitamin C to enhance non-heme iron absorption), oil (energy, essential fatty acids) and a source of iodine such as salt (but high sodium intake in moderately malnourished children is not desirable). Particularly important components of the diet are protein quality, essential fatty acid content, bioavailability of micronutrients, limited anti-nutrient content as well as high energy and nutrient density.

These requirements are difficult to fulfill when a diet includes few animal source foods and fortified foods. A largely plant based diet with few fortified foods is at a disadvantage, also when the child is breastfed, because of a relatively high content of anti-nutrients, lower bioavailability of certain micronutrients (iron, vitamin A) and the lack of specific nutrients and active compounds contained in animal source foods.

Where the diet is largely plant-source based, three main options can be considered for modification or development of food (supplements) for young or moderately malnourished children:

- 1) Improving the current standard of FBFs by reducing phytate content by dehulling and/or degerming of corn and soy, improving micronutrient premix specifications and adding milk powder, sugar and oil.
- 2) Modifying the RUTF recipe to develop RUSF (ready to use Supplementary food) using local foods as much as possible and limiting costs, for example by reducing milk content, replacing some dairy protein with soy protein (extracts), using chick peas or sesame instead of peanuts, and making biscuits or bars instead of a lipid-based food.
- 3) Development of CFS (complementary food supplements) that add the nutrients, ingredients and active compounds to diets that are not contained in adequate amounts. Different categories of CFS can be distinguished, ranging from micronutrient powder (MNP), powdered CFS of protein, amino acids, and/or enzymes and MNs, to lipid-based nutrient supplements (LNS) that range from 20 – 90 g/d (120-500 kcal/d) and typically contain milk powder, essential oil, peanut paste, sugar and micronutrients. Some CFS are primarily used for prevention of malnutrition (≤ 20 g/d) whereas others (>40 g/d) are used for blanket or targeted supplementary feeding of malnourished

individuals or populations with a high malnutrition prevalence.

Although we know what nutrients are required, which anti-nutrient content should be reduced, and what foods should ideally be used, choosing effective, available, appropriate, and cost-effective foods is a challenge. This is due to a number of factors, including

- a) The fact that as yet, only a few of the above mentioned specially formulated foods and food supplements have been assessed in terms of their impact on recovery from moderate malnutrition, i.e. length and weight gain, functional outcome, immunity, and micronutrient status. Thus, there is an urgent need for studies that determine impact of new or modified foods for treating moderate malnutrition in comparison to FBF and RUTF.
- b) Availability of RUTF is limited and it is preferentially used for treating SAM.
- c) Milk appears to be an essential food which comes at a relatively high cost compared to staples and soy.
- d) The need for high-quality, nutritious foods for young children is not yet understood by all development partners, which limits commitment and funding.

Also, many of the modified or new foods or CFS are a new concept, both for consumers as well as for program implementers, thus experience with their introduction, distribution and use needs to be built.

It is important to note that nutrient densities proposed by Golden for specific nutrients [1] are based on the assumption that the densities for other nutrients are also realized. For example, a higher intake of zinc than the RDA could affect copper metabolism except when copper intake is increased concurrently. Thus, when diets, with or without inclusion of special foods or CFS, meet the proposed requirements for some but not for other nutrients, this may have negative consequences for the status of the nutrient(s) of which too low amounts are consumed.

Recommendations

In order to move forward with the development and use of special food (supplements) for young and/or malnourished children, steps need to be taken in the following areas:

Use of new products

With the increasing development of products for preventing or treating different forms of malnutrition, there is a need for guidance on expected impact and on when, how and for whom they can be used. The MM meeting agreed that if it is expected that a new commodity has a better impact than currently used FBF, it can be used in programs, provided that the product is acceptable to the beneficiaries, while at the same time its impact is studied under controlled circumstances (but could be in another location). Programs that use a new product should collect data to monitor the time needed for recovery of MM children, when the product is used for treatment, or on the occurrence of new cases of malnutrition if it is used for prevention. Preferred comparison groups for a study under controlled circumstances are the current FBFs and RUTF. The latter being an adequately fortified nutrient-rich therapeutic food. Outcome indicators should include indicators of physiological, immunological,

cognitive and body compositional recovery as well as simple weight gain. See also the meeting's summary.

Product development

Urgent questions and issues to be addressed for the development of new foods and CFS include

- 1) How much milk is required for optimal growth at different ages?
- 2) Could a different combination of nutrients and active compounds achieve the same effect as milk powder?
- 3) The use of phytase for human consumption needs to be permitted also for young children, and its impact on mineral bioavailability and digestability be assessed.
- 4) Content and effect of specific anti-nutrients needs to be determined
- 5) Food composition tables need to include content of a wider range of (micro)nutrients, active compounds, including fibres, and anti-nutrients

Way forward for programs

Programmes need to be adapted based on the newly proposed nutrient requirements for moderately malnourished children [1], the use of existing ingredients [2], the development of new foods and CFS (this paper), improved understanding about which dietary changes to recommend and how [3], and increasing experience with production and use of new products in existing or modified programs. The following are some program related issues which will need to be addressed in the near future:

- a) How can production capacity for new, especially ready-to-use, products be increased?
- b) How can public and private sectors collaborate more effectively with regard to product development, production capacity as well as distribution?
- c) While the why of improved nutrition programming for young and for moderately malnourished children is clear, and the most suitable dietary options for different context are becoming clear, much experience needs to be gained with how to advocate for, design and implement modified programs.

This involves issues such as:

- Advocacy at global and national levels about why modification of programs and commodities is proposed
- Program design: exchanging commodities or modifying programs?
- Acceptability and awareness of new commodities among communities
- How are very similar commodities that are simultaneously distributed, such as CSB for general use and CSB with milk for young or malnourished children, used at household level?
- How to best limit sharing of special foods for specific individuals, i.e. can RUF for an individual child be provided with staple for general use by the family or should the RUF ration be doubled?
- Evaluation of program data about the use and impact of new products.

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Table 1. Essential nutrients and active compounds and their dietary sources, including recommended home-processing where applicable

Nutrients and active compounds of concern	Dietary sources	Comments
Vitamins, plant origin	Vegetables & fruits, grains	Bioavailability (due to anti-nutrient content of plant foods) as well as absolute quantity of foods to be consumed are of concern
Minerals	Animal source foods & plant foods	When largely relying on plant foods, intake has to be high (can for example be increased by using a dried leaf concentrate) and bioavailability has to be improved, particularly by reducing content of phytate and polyphenols, and/or adding vitamin C. For example, bioavailability of iron is much higher from meat than from vegetables (25 vs 2-10%) [6].
Vitamins, animal origin (especially B6, B12, retinol)	Breast milk, animal milk, organ meat, red meat, poultry, fish, eggs, butter (retinol)	No single animal source food (ASF) provides all the MNs that are required from ASF in adequate amounts ¹³ . Thus, a variety of ASF is required.
Iodine	Sea food, incl algae, and iodized salt	The use of iodized salt contributes greatly to the prevention of iodine deficiency disorders (approximately 70% of the world's households are covered).
Proteins, to result in a diet with high PCDAAS score	Soy beans, peanuts, legumes, breast milk, animal milk, organ meat, red meat, poultry, fish, eggs	Same comment as for vitamins from ASF, a mixture of foods is required to ensure adequate intake of all, essential, amino-acids. The plant sources of protein also have a relatively high content of anti-nutrients which affects absorption of minerals.
Essential fatty acids, esp a favourable n-6:n-3 ratio (~6)	Fatty fish or their products, soy bean oil, rapeseed oil (also known as canola oil)	Only fatty fish and a few oils have a favourable fatty acid profile and these are not generally consumed in large amounts in most developing country diets
Growth factor from milk ¹⁴	Dairy products (breast milk, animal milk, yoghurt, cheese)	Dried skimmed milk (DSM) when reconstituted with water is not appropriate for young children because of the lack of fat. Full cream milk powder is usually DSM to which, powdered, vegetable fat has been added. When reconstituted with clean, safe water this is good milk for children. Cheese is not recommended for feeding young malnourished children [2].
Phytase, α -amylase	Present in grains themselves, released when germinating (requires soaking for 24 h), malting (i.e. when germinating or adding malt), or fermenting	These processes require modification of food processing as well as use of whole grains rather than (purchased) flour. Also, the impact of these food processing technologies on improving mineral bioavailability and micronutrient status has not been shown to be complete / enough to, on their own, reduce MNDs enough.

¹³ Even breast milk is a poor source for certain micronutrients. When a child is born with adequate stores, these stores in combination with exclusive breastmilk consumption for the first 6 months of life from an adequately nourished mother will ensure that all needs are met. Introducing complementary foods early reduces bioavailability of some micronutrients, particularly minerals, from breast milk and could thus increase the risk of deficiencies when the complementary foods are not of appropriate composition. Children born prematurely or with low birth weight need micronutrient supplements, in addition to exclusive breastmilk consumption, from approximately 2 months of age.

¹⁴ The presence of factors in milk (peptides? Non-phytate bound phosphor?) that promote growth is very likely but not fully proven as yet [7, 8].

Table 2. Important characteristics of diets appropriate for young children to prevent and treat moderate malnutrition and considerations

Important characteristics (adapted from Michaelsen et al [2])	Considerations
High content of micronutrients, especially type II nutrients	Calcium, phosphorus, magnesium and potassium are nutrients that are not contained in most MN formulations such as MNP, and are required in larger amounts (100's instead of <10's of mg's)
High energy density	Fat and sugar increase energy content with minimum increase of volume, but adequate MN-content/1000 kcal of diet or meal needs to be ensured
Adequate protein content	Requires mixture of legumes, lentils and animal-source foods (ASF)
High protein quality and availability	
Low content of anti-nutrients	Requires processing of staples, legumes and lentils, industrially or at household level
Adequate fat content	Requires consumption of 30-40 en% from fat contributed by foods that have the right fatty acid composition, i.e. fatty fish or its products (oil), soy bean / rapeseed / canola oil
Appropriate fat quality, especially n-3/n-6 PUFA content	
Acceptability: taste, texture, and cultural acceptability	As much as possible, use locally available foods
Easy to prepare	The processing of plant foods to reduce anti-nutrient content should be done industrially, where (especially urban) populations have good access to such foods, because these are time consuming and more and more people are switching to use of convenient-to-prepare foods
Affordable	Poverty is the main reason why many children lack an adequate amount of animal source and fortified foods in their diet. Affordable, fortified, processed foods as well as subsidized and for-free distribution options need to be developed
Low risk of contamination	Food production and food processing standards need to ensure low risk of microbes, toxins and contaminants

Table 3. Classification of complementary food supplements

Kind of product (examples)	Nutrients and active substances contained	Ingredients used	Impact shown or expected	Most appropriate target groups
Micronutrient Powder (MNP) (Sprinkles TM , MixMe TM) ¹⁵	Micronutrients (type I and zinc)	MNs and carrier (maltodextrin or rice flour)	Yes, on nutritional anemia Assumed to have impact on other MND as well	Those with MNDs, not very effective for promoting linear growth
Powdered CFS, consisting of protein and/or specific amino-acids and MNs (<i>Ying yang Bao</i> , TopNutri TM)	Micronutrients, some with macro-minerals (i.e. type II nutrients), high-quality protein or limiting amino acids	MNs, soy protein concentrate or processed whole fat soybean flour (also contains EFAs), additional amino acids (lysine) for some	Formulation using whole fat soy bean flour with 6 mg Fe as NaFeEDTA ¹⁶ , impact shown on anemia and linear growth Providing several nutrients essential for linear growth. Impact depends on V&M bioavailability and should possibly be enhanced with dairy protein and EFAs	Those at risk of faltering linear growth (6-24 mo). Impact on growth remains to be proven
Powdered CFS, consisting of protein and/or specific amino-acids, enzymes and MNs (MixMe Plus TM) ¹⁷	Micronutrients, macro-minerals for some (i.e. type II nutrients), high-quality protein or limiting amino acids, enzymes for malting or phytate destruction	MNs, macro-minerals (calcium, potassium, magnesium?), lysine, malt	Impact not yet shown Fortificants should impact MNDs, type II nutrients and lysine to impact growth, and reduced viscosity to increase energy intake. Note, contains no dairy protein or EFAs	Those at risk of faltering linear growth (6-24 mo). Impact to be confirmed.
Lipid-based nutrient supplement (LNS) ≤20 g, ~108 kcal (Nutributter TM)	Micronutrients, macro-minerals, high-quality dairy protein, essential fatty acids (n-3 PUFA)	NutributterTM : Peanut paste, sugar, vegetable fat, skimmed milk powder, whey powder, MNs, maltodextrin, cocoa, lecithin	Yes, study from Ghana showed impact on MNDs, linear growth, motor development [19, 20]	Those at risk of faltering linear growth (6-24 mo). Appears to be most comprehensive CFS to make up for gap of essential nutrients in complementary foods. But, does not overcome low energy intake or anti-nutrient intake from other foods (but

¹⁵ *Moringa oleifera* leaf powder could also be considered a micronutrient supplement, but because composition is not well known and neither are levels of anti-nutrient and toxic substances, it is not included in this table.

¹⁶ Note that JECFA norms for EDTA intake translate to a maximum of 2.5 mg Fe from NaFeEDTA for an 8 kg child.

¹⁷ Power FlourTM consists of barley malt, but has no additional (micro)nutrients, therefore it has not been listed here.

				impact may be partly overcome through MN fortification).
Good quality complementary food to be prepared using boiled water, 30 g powder with <120 mL provides ~120 kcal	Micronutrients, macro-minerals, high-quality protein, carbohydrates, vegetable fat	Typical commercially available porridges, made from DSM or soy protein, vegetable fat, rice/corn/wheat/oats, sugar, MNs	Impact not studied. More impact expected on growth as well as MN status from porridges containing milk powder rather than soy protein. MN content varies widely.	Those at risk of faltering linear growth (6-24 mo). Impact to be confirmed.
LNS ≤50 g, i.e. high-quality nutrient and energy supplement, ~ 250 kcals (Plumpy Doz™, Indian RUFC)	Micronutrients, macro-minerals, high-quality protein, high-quality oil with good n-6:n-3 FA ratio, energy largely from oil and protein	Plumpy Doz™ : Peanut paste, vegetable fat, sugar, DSM, whey powder, MNs, maltodextrin Indian RUFC : chick peas, soy bean oil, sugar, rice flour, DSM, MNs, soya lecithin	Impact of Plumpy Doz™ currently being studied. Composition is based on RUTF (Plumpy Nut), but consumed in small amount added to daily diet. Question: are all nutrient needs met and anti-nutrient effects of other foods overcome? Indian RUFC's composition and production processes being finalized, subsequently to be tested.	Those at risk of faltering linear growth and morbidity, during highly food insecure periods
LNS ≤ 100 g, i.e. high-quality nutrient and energy supplement, ~ 500 kcals (Plumpy Nut™, Supplementary Plumpy™, Indian RUFC ¹⁸). Note: Compressed bars and biscuits (BP100) can also be included in this category.	Micronutrients, macro-minerals, high-quality protein, high-quality oil with good n-6:n-3 FA ratio, energy largely from oil and protein	Plumpy Nut™ : peanut paste, sugar, vegetable fat, DSM, whey powder, maltodextrin, MNs, cocoa, lecithin; Suppl Plumpy™ : peanut paste, sugar, vegetable fat, whey, soy protein isolates, maltodextrin, cocoa, MNs, lecithin Indian RUFC : chick peas, soy bean oil, sugar, rice flour, DSM, MNs, soya lecithin	Impact of Plumpy Nut™ (or other RUTF) on growth and MN status has been shown among children suffering from SAM that progressed through MAM stage to normalcy. Note that these children received no other food than RUTF during recovery. Impact of Supplementary Plumpy™ currently being studied. Indian RUFC's composition and production processes being finalized, subsequently to be tested.	Those suffering from moderate acute malnutrition, i.e. in targeted supplementary feeding programs, or for blanket supplementary feeding of young children in highly food insecure periods / areas.

¹⁸ When Indian RUFC is to provide 500 kcals/d, MN content per 1000 kcal of product will be lower than when providing 250 kcal/d.

Table 4. Composition and price, per daily recommended dose, of various complementary food supplements that are already being used or in final stage of development (see **table 3** for classification and ingredients)

	MNP, nutritional anemia, 1g	MNP, 15 V&M, 1 g	Soy Sprinkles, 10 g	MixMe Plus™, 5 g	TopNutri™, 7.5 g	Nutributter™, 20 g	Plumpy Doz™, 46 g	RUFC India ¹ , 50 g	Suppl Plumpy™, 92 g	Plumpy Nut™, 92 g
Energy (kcal)			44.00		20.00	108.00	247.00	260.00	500.00	500.00
Protein (g)			3.80		3.80	2.56	5.90	5.00	12.50	12.50
Fat (g)			3.00		<0.1	7.08	16.00	15.50	32.90	32.90
lysine, mg				400.00	36% excess					
malt flour, mg				1000.00						
PCDAAS (%)					100.00					
Vitamin A, ug	300.00	400.00		400.00	340.00	400.00	400.00	100.00	840.00	840.00
Beta Carotene, ug								400.00		
Vitamin E, mg		5.00		5.00	5.60	--	6.00	3.00	18.40	18.40
Vitamin B1, mg		0.50		0.50	0.50	0.30	0.50	0.25	0.55	0.55
Vitamin B2, mg		0.50	0.20	0.50	0.70	0.40	0.50	0.25	1.66	1.66
Niacin, mg		6.00		6.00	6.80	4.00	6.00	3.70	4.88	4.88
Pantothenic Acid, mg				2.00	3.00	1.80	2.00	0.50	2.85	2.85
Folic Acid, ug	160.00	150.00		90.00	90.00	80.00	160.00	75.00	193.00	193.00
Vitamin C, mg	30.00	30.00		60.00	45.00	30.00	30.00	30.00	49.00	49.00
Vitamin B6, mg		0.50		0.50	0.60	0.30	0.50	0.25	0.55	0.55
Vitamin B12, ug		0.90		0.90	0.90	0.50	0.90	1.00	1.70	1.70
Calcium, mg			385.00	400.00	320.00	100.00	387.00	200.00	276.00	276.00
Magnesium, mg					90.00	16.00	60.00	40.00	84.60	84.60
Selenium, ug		17.00		17.00	20.00	10.00	17.00	10.00	27.60	27.60
Zinc, mg	5.00	4.10	4.10	2.50	3.80	4.00	9.00	4.10	12.90	12.90
Iron, mg	12.50	10.00	6.00	2.50	7.70	9.00	9.00	10.00	10.60	10.60
Iodine, ug		90.00		30.00	86.00	90.00	90.00	-	92.00	92.00
Copper, mg		0.56		0.34	0.34	0.20	0.30	0.30	1.60	1.60

Phosphorus, mg					230.00	82.13	275.00	75.00	276.00	276.00
Potassium, mg				400.00	280.00	152.00	310.00	305.00	511.00	1022.00
Manganese, mg					0.90	0.08	0.17	0.80	--	--
Vitamin D, ug		5.00	280 IU	5.00	4.90	--		2.50	15.00	15.00
Vitamin K, ug					37.50	--		15.00	19.30	19.30
Biotin, ug					18.80	--			60.00	60.00
sodium mg					70.00					
molybdenium ug					7.50					
chromium ug					7.50					
phytomenadion, ug				30.00						
Product cost per dose (US\$)	0.02	0.027 ¹⁹	?	0.04?	?	0.11	0.20	0.13 (0.26 for 100 g)	0.33	0.41
Min # doses for 6-23 mo old	225 (150/yr)	225 (150/yr)		225 (150/yr)	225 (150/yr)	180 (daily 6-12 mo)	120?	120?	120?	120?
Total product cost (US\$) for required # dosages	4.5	6.1		9		19.8	24	15.6	39.6	49.2
Supplement to or replacement of normal diet	supplement	supplement	supplement	supplement	supplement	supplement	supplement/replacement	supplement/replacement	replacement	replacement

¹The micronutrient premix that is added to Indian RUFC is being modified. The composition shown here was the initial composition and has been used for the calculations in tables 5d-f and table 6.

¹⁹ For single-dose packaging. For multi-dose packaging cost could go down to 0.008 US\$ per dose.

Table 5. FBF mixtures provided by organizations implementing supplementary feeding programs for moderate acutely malnourished children.

Organisations implementing ¹	# children / yr ²	CSB (g/d)	Oil (g/d)	Sugar (g/d)	Additional information
ACF USA (E/C Africa, Tajikistan)	42,000	180-200	20	20	Mixed before distribution. Target: 1000 kcal/d. Also providing VAC, Fe/FA, Mebendazole
CONCERN (W.Darfur & DRC)	16,500	200	20	20	In case of pipeline break of WFP, maize/soy mixture purchased locally, but unfortified
CONCERN (S. Sudan)	5,000	200	30	30	
CONCERN (Niger)	?	250	25	15	
FH (Bolivia, DRC, Kenya)	57,000	400	31		
GOAL (Ethiopia)	?	277	33 mL		
GOAL (Malawi)	?	357			
HKI (Niger)	40,000	250	25	15	
HKI (Burkina)		200	20	15	
HKI (Mali)		250	25	20	
SC UK (6 African countries, Afghanistan)	30,000	Different ratio's, see table in appendix			
GTZ-UNHCR (Kenya)	7,955	250	25	20	
IRC-UNHCR (Kenya)	?	270 (Unimix)	25		Unimix already contains sugar. Target: 1000-1200 kcal/d
MSF Spain (Uganda)	3,532	300	40	20	Reflects program Jun 07 – Apr 08. Planned to change to RUFs in May 08.
UNHCR (Djibouti)	1,000	250	40	20	
UNHCR (Uganda)	2,000	229	29	29	
UNHCR (Tanzania)	2,671	120	20	20	Target: 1000 kcal/d
UNICEF (Niger)	350,000	250	25	15	Families or siblings receive another ration, to maximize intake of the supplementary feeding ration by the target child. Target: 1200 kcal/d. Replaces other foods in the diet.
VALID (Ethiopia, Sudan, Zambia, Malawi)		Different ratio's depending on organization supported			

¹It should be noted that most of the CSB (or WSB) distributed by the organizations listed below is donated either by WFP, who has received it from the US or purchased it from local producers in a range of countries or by UNICEF.

²Most organizations provided the number of beneficiaries for supplementary feeding programs in 2007.

Table 6. Other foods provided to moderately malnourished children

Organisations implementing	Food ration provided, ingredients	Target group	Comments
UNICEF (Uganda)	CSB+oil+sugar, or BP5 when the former is not available	50-70,000 moderately malnourished children	
CWS (Indonesia)	WSB and recipes, with demonstration, such as cake, meat balls etc, and fortified food from Kids against Hunger, made of rice, soy flour, dried vegetables, salt, maltodextrin, dextrose, hydrolyzed soy protein, soybean oil, MNs	Moderate acutely malnourished on Nias and West-Timor Islands	
Bangladesh National Nutrition Program (BNNP)	20 g roasted rice, 10 g roasted lentils, 5 g molasses, 3 mL oil: 150 kcal	91,435/yr, 150 kcal/d for underweight 6-11 mo and 300 kcal/d for underweight 12-23 mo olds	
ACF France (Myanmar)	Fortified mixture of 125 g rice, 125 g yellow beans and 50 g sugar. 43 g oil is added just before distribution. Instant food, requires adding hot water. Locally produced.	11,650/yr, moderately malnourished underfives	In 2 nd half of 2008 a study will be done to compare impact of this mixture to Plumpy Doz and Supplementary Plumpy.
World Vision, Niger	Three different treatment groups receiving different foods under different schemes: <ul style="list-style-type: none"> • SAM: RUTF • Moderately malnourished: CSB (250g) + oil (25 g) + sugar (15 g), referred to as 'therapeutic food' • Mildly malnourished: PD/Hearth + locally made food supplement Zogala Nut (leaf powder from Moringa oleifera (25%), peanut paste (55%), sugar (10%), peanut oil (10%) and iodized salt) 	So far, in 2008: <ul style="list-style-type: none"> # 12,929 <-3 Z scores (W/H <70%) MUAC<110 # 1,167 -3 and -2 Z scores (70%<W/H<80%) # 560 -2 and -1 Z Scores (80% <W/H< 85%) and stunted All received MNs (VA, Fe/FA, Zn, Vit C). And 23,000 healthy children enrolled in growth monitoring	<ul style="list-style-type: none"> • Depending on the amount of Zogala Nut consumed and the composition of the local diet, the foods consumed by the mildly malnourished may be of similar nutritional value as the CSB+oil+ sugar diet. • The source of nutrient content of Zogala Nut has not been specified and is likely to vary because it is locally prepared (most MNs are from the leaf concentrate, i.e. no fortification). • Numbers of mild and moderately malnourished are very small compared to those with SAM.
DREAM (9 African	A variety of mixes, for example 70 g CSB/WSB, 5 g	3,000/yr, children born to HIV+	

countries: HIV/AIDS)	oil, 8 g sugar, 25 g DSM	mothers and HIV+ children	
GRET in collaboration with IRD, Montpellier (Madagascar, Vietnam, Burkina Faso)	Developed complementary foods for feeding young children (6-23 mo), to prevent malnutrition. Target population ~150,000 children. From below mixtures, recommended consumption 70-140 g/d Madagascar: Maize, Rice, Soybean, Peanuts, Sugar, Salt, MNs, alpha-amylase Vietnam: Rice, Soybean, Sugar, Milk powder, Sesame, Salt, MNs (produced by very-low cost extrusion cooking) Burkina Faso - 1: Millet, Soybean, Sugar, Sesame, Cowpea, Milk powder, Salt, MNs, alpha-amylase Burkina Faso - 2: Millet, Soybean, Peanuts, Sugar, Salt, MNs, alpha-amylase Burkina Faso - 3: Sorghum, Millet, Soybean, Sugar, Peanuts, Monkey bread, Salt, MNs, alpha-amylase Burkina Faso - 4: Maize, Soybean, Sugar, Peanut, Milk powder, Salt, MNs, alpha-amylase		GRET supports local enterprises to produce fortified infant food and to sell it to the poor at adapted price. Note that out of 6 mixtures 5 contain alpha-amylase (to reduce viscosity), 3 contain milk powder, and staple is the main ingredient in all (maize, rice, millet, sorghum). No studies available on impact.
Project Peanut Butter (Malawi)	125 g of peanut/soy paste providing 75 kcal/kg/d and 1 RDA for all micronutrients. The paste is made from 25% whole roasted soy, 20% soy oil, 26% peanut paste, 27% sugar, 2% micronutrients.	2000 moderately malnourished children/ yr	This has replaced the use of CSB, oil and sugar in these operations
WFP (Ethiopia, Somalia, Myanmar)	1) Supplementary Plumpy, 90 g per day 2) Improved CSB with milk powder 3) Indian RUFC + Plumpy Doz TM	1) Targeted distribution to moderately wasted underfives in Ethiopia and Somalia 2) Blanket distribution to under-two's in Somalia 3) Blanket distribution to under-two's affected by Myanmar cyclone	
ACF (Sudan, S. Darfur)	Supplementary Plumpy, 2 x 90 g per day	5,000 in 2007, moderately wasted (WH \geq 70% & <80% and/or MUAC \geq 110 & <120 mm(6-18 mo old), only during hunger gap Jun-Oct '07	Questionnaire response says that it is complementary to the diet, not a replacement. However, it provides 1000 kcal/d for 6-18 mo old children (!).
MSF Suisse (Niger, Sudan, Somalia)	2 sachets of Plumpy Nut per child per day, i.e. 1000 kcal/d	10,000 moderately malnourished children / yr	This has replaced the use of CSB, oil and sugar in these MSF Suisse operations
MSF France (Maradi, Niger)	Moderate and severe acutely malnourished treated with Plumpy Nut (2006); Blanket distribution of Plumpy Doz during lean season (2007) as preventive measure	2006: 60,000 MAM and 5,000 SAM	The preventive distribution in 2007 reduced case load of MAM and SAM and limited the burden on health care system of identifying and following malnourished individuals

Table 7. Current response options for food assistance programs to prevent and treat moderate and mild child malnutrition (wasting, stunting)

Intervention	Potential target groups	Considerations
Blanket supplementary feeding (Where the prevalence of malnutrition is high, i.e. under-5 underweight $\geq 30\%$ or wasting $\geq 15\%$)	All young children, especially under-2's	Blanket supplementary feeding of all under-2's is likely more effective than targeted supplementary feeding of underweight under-5's [43]. Where possible, improved fortified blended foods (FBF) should be used (which have better micronutrient profile, and where possible include milk powder, sugar and oil). Alternative to be explored: staple for general population with additional CFS that provides 250-500 kcal for 6-23 or 6-35 mo old children.
Targeted supplementary feeding (appropriate where blanket feeding is not necessary due to lower malnutrition prevalence)	Children under 5 with moderate acute malnutrition	RUTF (500 kcal/d), new RUF commodity (500 kcal/d), CFS (250 kcal/d) + staple, improved FBF with DSM, oil and sugar, or standard FBF mixed with sugar and oil.
Home-fortification using Complementary Food Supplements (CFS) such as MNP, LNS, powdered-CFS	Young children (<5) who cannot meet their needs from the general food ration, or from the (available, affordable, acceptable) local diet	Home-fortification commodities can be used where primarily dietary quality is insufficient. Depending on the age group, prevailing malnutrition rate, and the diet, a selection of most appropriate CFS can be made.
Cash transfers/vouchers to obtain nutritious foods or CFS	Vulnerable households in settings where food is available in markets and capacity for implementing programs exists	May be particularly suited for urban and peri-urban areas. And to maximize impact on nutrition, collaboration with private sector should ensure availability of specific nutritious commodities to which the vouchers provide access. Eligibility for receiving a voucher can be linked to conditional-cash transfer or food-for-work programs. Collecting vouchers and reimbursing shop keepers requires reasonably functioning markets and administrative systems [40].

Figures

Figure 1. Options to modify the currently prevailing local diet, largely consisting of plant foods, to treat moderate malnutrition among underfives or prevent it among young children (6-23 mo) where intake of animal source and fortified foods is limited due to access (affordability and availability) constraints.

Figure 2. Steps to be explored for the development of an effective ready-to-use supplementary food of lower cost than RUTF for moderately malnourished children.

Figure 3. Steps to be considered for upgrading fortified blended foods to supplementary foods of better nutritional quality for moderately malnourished children.

Local Diet – Issues

Modification options

<p>Not enough of</p> <ul style="list-style-type: none"> • Micronutrients (cause: low intake of animal source and fortified foods and low bioavailability) • N-3 poly unsaturated fatty acids • Essential amino acids 	<p>Home-fortification to correct too low nutrient intake</p> <ul style="list-style-type: none"> • Add micronutrients (micro-nutrient powder [MNP], lipid-based nutrient supplement [LNS], MN-fortified protein powder or dried leaf concentrate [but has limited content of vitamins found in animal source foods]) • Add n-3 PUFAs (soy bean oil: ALA, fish oil: DHA, separate or added to home-fortificant such as LNS) • Add protein extract or add amino acids, such as lysine, to home-fortificant (MN-fortified protein powder or LNS) 	
<p>Too much</p> <ul style="list-style-type: none"> • Phytate (binding minerals, including phosphorus) • Other anti-nutrients such as polyphenols, trypsin inhibitors 	<p>Processing of food – at home</p> <ul style="list-style-type: none"> • Soaking, germination, malting; requires whole grain (i.e. not applicable to flour) and time • Fermentation; specific practice for specific foods, not too easy to introduce 	<p>Adding enzymes, when industrially processing food or at home, to reduce phytate content, by</p> <ul style="list-style-type: none"> • Soaking FBF ingredients together with phytase, before extrusion cooking and drying, requires equipment (conditioner and dryer) • Adding phytase to the processed product (note: needs time to act once food has been prepared) • Adding phytase to prepared product (i.e. home fortification) <p>Note: Last two options require approval for (young) human use and a different phytase because of different temperature and pH (see also footnote to figure 3).</p> <ul style="list-style-type: none"> • Using germinated flour for making porridges as it will then be less thick and have less phytate • Adding malt to the prepared product (home-fortification) to reduce viscosity and phytate content
<p>Other issues</p> <ul style="list-style-type: none"> • Low energy density in watery porridges • Bulk & viscosity are limiting intake 	<p>Increasing energy density</p> <ul style="list-style-type: none"> • Adding oil and sugar will increase energy density without increasing volume very much. However, sugar should be added in limited amounts and adequate micronutrient density (per 1000 kcal) should be ensured. 	

Ready-to-use therapeutic food

Steps to be explored for reducing costs and increasing (local) production

<p>Positive</p> <ul style="list-style-type: none"> • Shown to promote growth very well • Can be safely stored and used in communities and households 	<p>Negative</p> <ul style="list-style-type: none"> • Production capacity not enough to also treat MAM • Costs of ingredients are high, especially milk • Peanut taste is not familiar in certain parts of the world (e.g. South Asia) and in those places peanut availability is also limited 	<p>Modify from...</p> <ul style="list-style-type: none"> • 30% full fat milk powder • 25% ground peanuts • 15% soy bean or rapeseed/canola oil • 28% sugar (lactoserum, maltodextrin) • 2% V&M incl macro-minerals (type II nutrients) 	<p>...to, options</p> <ul style="list-style-type: none"> • Lower the milk content • Replace milk powder with whey concentrate • Use soy protein isolates (provided that phytate content is lower) • Use other legumes, such as beans, peas or lentils instead of peanuts • When replacing peanuts, their oil content needs to be compensated for 	<p>Comments/Drawbacks</p> <ul style="list-style-type: none"> • Minimum milk content unknown • Whey availability linked to cheese production • If milk contains growth factor, soy protein at disadvantage • Protein content of lentils and beans is comparable to soy beans and peanuts (20-30 vs 35 and 23 g/100 g, resp), but they contain very little fat (<1 g/100g vs 18 and 45 g/100 g, resp), and have relatively high amounts of phytate and other anti-nutrients. Thus, how to reduce anti-nutrients, enzymes? • Texture, consistency and homogeneity to be adapted
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Fortified blended foods

<p>Positive</p> <ul style="list-style-type: none"> • Can be produced almost anywhere • Soy: good protein profile • Fortified with MNs 	<p>Negative</p> <ul style="list-style-type: none"> • Limited impact on growth and MN-status • Fibre in non-dehulled maize, wheat and soy beans • Anti-nutrients in non-degermed maize as well as in wheat and soy beans • Fortified with too few MNs and limited bioavailability • Energy density too low and viscosity too high for young (malnourished) children
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Options for improving nutritional quality

<p>Limited complexity</p> <ul style="list-style-type: none"> • Add dried skimmed milk, for promoting growth (10%?) • Soy: dehulling • Improve MN profile (more MNs and higher amount) 	<p>More complex and costly</p> <ul style="list-style-type: none"> • Use soy protein isolates instead of (dehulled) soy • Use degermed and dehulled maize flour (means discarding 25% of maize and altering production steps) • Add sugar (already done for Unimix) and oil (soy bean, rapeseed or canola) during processing to increase energy density and EFA content, and compensate for oil lost when using soy protein isolates rather than soy beans. 	<p>Worth exploring - phytase</p> <ul style="list-style-type: none"> • Reduce phytate by soaking FBF ingredients together with phytase before extrusion cooking and drying (requires equipment: conditioner and dryer) • Reduce phytate by adding phytase to the processed dry product¹ • Reduce phytate by adding phytase to prepared product (i.e. home-fortification)¹
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¹It is important to note that phytase is not yet widely approved for human consumption. It has GRAS (Generally Regarded As Safe) status for individuals aged 3 years and older, but not yet for younger individuals. When it is used during industrial processing and destroyed by a subsequent heating step, there is no problem because the product that reaches the consumer will not contain phytase. To what extent phytases reduces phytate and enhances mineral absorption under different conditions needs to be tested.