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Food technology for safe and nutritious food

Dominique Bounie, Charlotte Bienfait, Shane Prigge and Bertrand Salvignol

1. Introduction

Food technology is the application of food science to the selection, preservation, processing, packaging, distribution, control and use of safe, nutritious, tasty and convenient food. Food technologists study the physical, microbiological and chemical make-up of food. Depending on their area of specialization, they may develop ways of designing, processing, packaging, controlling, transporting or storing food, according to consumers' expectations, industry specifications and government regulations.

Food technology at WFP serves mainly to support different units and country offices by providing technical advice and solutions to enable the production of safe and nutritious food that is appropriate for humanitarian aid. This chapter describes how food technology can support and improve WFP's operations in accordance with WFP's mandate and strategy – for example, in two of its recent corporate initiatives: Purchase for Progress (P4P) and the Nutrition Improvement Strategy. Figure 12.1 lists the types of food that WFP distributes for different groups of beneficiaries in order of the technological complexity of producing the foods; the prices of each are given in the notes.

This chapter is organized by type of food used by WFP, and provides examples of innovative experiences, trials or pilot studies aimed at improving the quality, taste, convenience or safety of WFP foods and the processes used to manufacture them.

Figure 12.1 Main families of foods distributed in WFP assistance programmes, and their technological demands

<table>
<tr><th></th><th></th><th>General population</th><th>Pregnant and lactating women</th><th>People with chronic illness</th><th>Children under 2 years</th><th>Moderately malnou-rished chidren</th><th>Moderately malnou-rished children 6-59 months</th></tr>
<tr><td rowspan="6">Increased food processing complexity</td><td></td><td>General food basket (GFB) 1</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>- (Cleaning, drying, milling)
- Mixing</td><td>Fortified foods (FF) [2]</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>- Cleaning, milling, mixing
- Cooking
- Grinding, mixing</td><td colspan="3">Fortified blended flours (FBF) [3]</td><td></td><td></td><td></td></tr>
<tr><td>- Cleaning, milling, grinding, mixing
- Cooking, (drying)
- Grinding, mixing</td><td></td><td></td><td></td><td colspan="2">Fortified blended flours + milk, oil, sugar (FBF++) [4]</td><td></td></tr>
<tr><td>- Cleaning, milling, mixing
- (Heating/ cooking)
- Homogeniz-ing/mixing</td><td></td><td colspan="5">Ready to use supplementary foods (RUSF) [5]</td></tr>
<tr><td>- Cooking
- Mixing
- Sterilizing</td><td colspan="6">Ready-to-eat meals (RTEM) [6]</td></tr>
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1 GFB: cereals US$$200–600/mt; pulses US$400–1,200/mt.

2 FF: flour US$300–400/mt; oil US$900–1,200/mt; salt and biscuits US$1,100/mt.

3 FBF: CSB+ US$600/mt; WSB+ US$650/mt).

4 FBF++: CSB++ US$1,100/mt; WSB++ US$1,200/mt).

5 RUSF: imported US$3,500/mt; locally made US$3,000/mt.

6 RTEM: US$2,500–3,500/mt.

2. General food basket (GFB): initiating and managing an overall food quality strategy for WFP

WFP's traditional food basket includes cereals such as rice, wheat, sorghum and maize; pulses such as beans, peas and lentils; and fortified foods such as fortified wheat flour, maize meal, oil and salt. Beneficiaries are often people affected by natural or human-incurred disasters. WFP also aims to identify and direct food assistance to food-insecure populations. Food technologists work to improve the quality of the food basket. An effective WFP food quality system is crucial for: (i) protecting the health and safety of WFP's beneficiaries; (ii) providing food at the right time, in the right place and in the right quantity, avoiding pipeline breaks; (iii) providing food at an acceptable cost, and in line with specifications, national regulations and, whenever possible, beneficiaries' expectations; and (iv) protecting the reputations of WFP, donors and host governments. Food safety is not the only component of quality requirements, but it requires priority attention so that WFP is able to ensure the safety and quality of the food it distributes, in conformity with its mandatory, regulatory and contractual obligations and in accordance with its financial, technical and human resources.

Beneficiaries, donors and the public are increasingly interested in the safety and quality of the food delivered in humanitarian interventions (Webb, 2009). This is partly owing to information disseminated by the media, most of which relates to real or supposed risks of outbreaks of food-borne diseases or the misuse of food aid funding along the humanitarian food chain. This has led WFP to develop a more acute corporate commitment to quality by improving its control systems for identifying food that does not conform to requirements, preventing this food from reaching beneficiaries, and taking pre-emptive actions to avoid any potential hazard outbreaks (Menage and Salvignol, 2009).

However, effective food quality control is undermined by fragmented regulations, the involvement of multiple stakeholders, and weaknesses in monitoring and enforcement procedures in the humanitarian context in which WFP operates.

In response to the internationalization of trade and the related regulations, most modern food industries have extended their quality operations, moving from quality control in 1910–1950, to quality assurance in 1950–1980 and to total quality management from 1980 (Weil, 2001). Companies engaged in these new management methods have gained significant advantages by matching consumers' expectations. Humanitarian stakeholders recognize these advantages and are aware that they too will have to conform to this trend for increased quality management in coming years (The Sphere Project).[1]

Food quality encompasses food safety, which is compulsory by law, nutritional values, sensory values such as taste, smell and texture, and convenience values such as ease of cooking. To ensure that all food quality aspects are taken into account, WFP food technologists are drafting a quality management system that includes redefining food specifications and ways of controlling them, suppliers' contracts and food inspection companies' scope of work; developing new standard operating procedures; improving the monitoring and traceability system; engaging with host governments' food authorities to ensure mutual understanding of each others' quality control systems; and designing training materials for staff and food chain actors.

Some elements of these new systems have been tested or piloted in different countries. For instance, in Turkey, a new system for controlling the production of WFP's largest suppliers of wheat flour has been implemented, and new standard operating procedures for checking fortification have been developed and implemented. Once all the elements of this system are in place, the end-result will be a stronger food quality management system based on risk assessment and the prevention of quality issues. The system will apply to the general food basket and any food produced for WFP's operations. A second example of WFP working with the food processing industry is the milling operation in Pakistan to provide fortified wheat flour to beneficiaries. WFP worked with wheat flour millers to implement quality control and quality assurance systems that ensure the fortified wheat flour meets WFP's specifications. Throughout this process, WFP has been in dialogue with the government to help improve the quality of fortified wheat flour.

3. Fortified food (FF): implementing basic technologies appropriate to the poorest

WFP's new Nutrition Implementation Strategy aims to deliver about 80 percent fortified foods to beneficiaries, compared with the current 25 percent. Innovations in food production are necessary for achieving this target, but often provoke controversy and reflect different interests. Governments, the food market arena, the food industry and WFP's beneficiaries frequently differ on which fortified foods to use; owing to conflicting perceptions of any innovation, new products may be seen as difficult to use or accept, difficult or costly to produce, or unsustainable for addressing nutrition deficiencies.

3.1 Low-cost improvement of the nutritional value of staple foods: fortification of rice in Asia and Africa

In 2004, the Copenhagen Consensus ranked fortification as one of the most cost-effective means of improving the nutrition situation. A key tenet in fortification is to identify a suitable vehicle for delivering vitamins and minerals. An important factor in this is selecting a commodity that is consumed frequently, in relatively consistent quantities each day. Staple foods are therefore often selected for fortification.

Rice is the major staple for many people around the world, particularly in Asia, where almost 90 percent of rice is produced and consumed; worldwide, almost 96 percent of rice production is in developing countries. For low-income Asian countries, such as Indonesia, the Philippines, India, Bangladesh, Vietnam and Myanmar, per capita rice consumption has reached a high level and may not grow further because of very low income elasticity of demand and rapid urbanization. The major boost in demand will therefore come from countries in West Asia, sub-Saharan Africa and South America.

Table 12.1 Changes in rice consumption, selected Asian countries

	Milled rice consumption	Per capita consumption		
	(mt)	(kg/person/year)		
	1999–2001	**1970–1972**	**1989–1991**	**1999–2001**
China	113.51	79	93	89
India	76.45	69	79	76
Indonesia	31.62	105	147	149
Bangladesh	21.37	150	153	155
Vietnam	13.03	157	154	167
Myanmar	9.71	160	209	203
Philippines	7.65	86	96	101
Japan	7.53	89	65	59
Thailand	6.83	152	110	109
Korea, Republic	4.12	119	104	88
Nepal	2.27	82	106	99
Cambodia	2.03	163	158	155
Malaysia	1.96	123	81	88
Iran, Islamic Republic	1.89	25	31	27
Pakistan	1.78	29	14	13
Sri Lanka	1.77	95	93	94
Korea, People's Democratic Republic	1.73	82	73	78

Countries in bold are where WFP has an ongoing operation.

Source: FAOSTAT database, 2004.

The major challenge in rice fortification has been finding the appropriate technology to ensure that the vitamins and minerals are safely distributed in the desired quantities to consumers. There are four main technologies used to fortify rice: hot extrusion, cold extrusion, coating and dusting.

Hot extrusion

DSM and Buhler joined forces to develop Nutririce®, which is micronutrient kernels produced with hot extrusion technology. The process consists of milling broken rice, blending the rice flour with micronutrients and other ingredients, processing the rice in an extruder, drying the micronutrient kernels and packing them. An interesting feature of rice produced by hot extrusion technology is that it very closely resembles traditional rice kernels and there is flexibility for mimicking many varieties of rice. The micronutrient retention in the Nutririce® kernels is very high.

Cold extrusion

PATH Ultrarice® technology applies cold extrusion technology, which is often used by pasta manufactures; the process is similar to that for hot extrusion. The final product closely resembles natural rice, and micronutrient retention has been demonstrated to be quite high. PATH has developed very strict standard operating procedures for producing and utilizing Ultrarice®, and is now transferring the production technologies to other companies, starting with those in Brazil and India.

Coating

In the coating process, micronutrients are mixed with waxes, gums and other ingredients, and the mixture is sprayed on to the surface of rice to produce micronutrient kernels that are blended with natural rice to produce fortified rice. This technology is used mainly in the United States, the Philippines and Costa Rica.

Dusting

The dusting process involves blending micronutrient premix with polished rice. The main disadvantage with dusting is that micronutrient retention is very low if the rice is washed before cooking or the water is drained off after cooking.

For the past two years, WFP has been working with partners to develop a rice fortification pilot project. It will be important to demonstrate that processes can be applied on a large scale where fortified rice is distributed to beneficiaries.

3.2 Extending the shelf-life of full maize meal: knowledge transfer from Bangladesh to the Democratic Republic of the Congo

For distribution to the most vulnerable groups in Bangladesh, wheat is milled and the whole flour is enriched with minerals and vitamins. The milling and fortification units are run by women, who produce nutritious whole wheat flour of very good quality. The equipment was specially designed to take into account the project's specific needs, such as the low technical capacity of operators and the need for durable machines that can withstand rigorous operations and are easy to maintain and repair in difficult conditions.

In the Democratic Republic of the Congo (DRC), WFP purchases locally produced maize meal, which becomes rancid very quickly. The reason for this is that the equipment used is too rudimentary to produce de-germed maize meal. This results in the presence of oxygen; the fat contents of the maize germ are oxidized and hydrolysed, leading to rancidity (Hamilton, 1994). The hot and humid conditions prevailing in tropical countries exacerbate the situation, making the maize meal unpalatable.

Several solutions are available for overcoming this issue:

- The maize could be de-germed, but this would require the purchase of new equipment. In addition, 25 percent of the maize meal – the germ and the bran – would have to be removed and sold as feed, but there is no local market for feed products.
- The germ and bran could be heat-treated before being reincorporated back into the meal. This would inactivate the enzymes responsible for lipid hydrolysis, but would require huge investments in new equipment, and a lot of space.
- A blender fitted with an automatic dosing system, similar to the one developed in Bangladesh, could be used to add antioxidants, minerals and vitamins, which would both solve the oxidation and rancidity problem and improve the maize meal's nutritional value through fortification with minerals and vitamins. Such a blender is simple, robust, durable and easy to operate for illiterate people, as dosage is by a volumetric device. WFP is currently looking into the feasibility of using this type of equipment in DRC. If this proves successful, the blender's use will be replicated in other countries.

The challenges with this last option are in ensuring that the system is fully adapted to the harsh local context and local needs in DRC. Prior to field implementation, WFP is experimenting with maize meal and various combinations of antioxidants in Europe. It is also asking its premix suppliers to try incorporating antioxidants into their mineral and vitamin premixes. A single dose that combines a mineral and vitamin premix with antioxidants will be simpler for operators in DRC to handle.

The success of this initiative depends on having a fully demonstrable and documented experiment that convinces other private manufacturers of maize meal to adopt the same process.

4. Fortified blended foods (FBF and FBF++): tailoring products to local needs and resources

With the help of the private sector, WFP has already designed a new and more stable premix for its FBFs, which became available in early 2010. WFP also plans to focus on products' acceptability, palatability, digestibility, energy density and shelf-life. Its efforts in this regard focus on encouraging technological development, promoting scientifically and technically valid standards, and advocating for local production to accommodate beneficiaries' preferences, including by developing formulas based on locally available raw materials; local production means fresher product, local purchase and agricultural development.

4.1 Improving FBFs' nutritional value by using new ingredients and new processes

In recent years, new equipment and techniques for producing improved FBFs have been tested. FBFs, such as CSB and WSB, are mixtures of 75 to 80 percent cereals with 20 to 25 percent soybean or other pulses. The raw materials are processed by mixing and cooking to improve their digestibility and safety, and to decrease the cooking time of finished products, such as rehydrated gruels for children. The mixture is milled into flour, and minerals and vitamins are added. The final product is then packed into plastic bags.

FBFs can be prepared according to local habits; for example, FBF in Lao People's Democratic Republic (PDR) is steamed, in Sri Lanka it is used as a porridge, in Nepal CSB is roasted, and in Cambodia it is fried. The formula is bland, so beneficiaries can add sweet or savoury ingredients, such as vegetables, fish or meat, according to their preferences.

The original CSB was formulated nearly 30 years ago, and is now being replaced by CSB+ and CSB++. Both of these contain an improved micronutrient formulation, with a wider range and different quantities of minerals and vitamins; in addition, CSB++ also contains 8 percent milk and 9 percent sugar, as it is intended mainly for older infants of 6 to 11 months and young children of 12 to 23 months.

4.2 Fine-tuning FBF thermal treatment to enhance the digestibility and energy-density of gruels

The quantity of energy that a child can consume each day from gruels depends on the number of meals eaten, the quantity consumed at each meal and the energy density of the gruels. In many societies, mothers are involved in multiple tasks and cannot prepare gruels more than twice a day. In addition, babies cannot eat more than 30 to 40 ml of gruel per kilogram of body weight at each meal, because of their small stomach capacity. Gruels that are prepared from starch-based foods – cereals – and have not undergone sufficient treatment involving water and temperature, such as extrusion-cooking and drum-drying, tend to absorb a lot of water, so their energy density is low; the concentration of flour in a gruel is the main determinant of its energy density. The viscosity of gruels increases quickly according to the concentration of dry matter/flour. The carers who prepare gruels therefore face the dilemma of increasing the proportion of flour or FBF with respect to water to obtain a gruel of very high viscosity – i.e., solid – that is difficult for children to swallow, or preparing a gruel of a suitable semi-liquid consistency but low energy density.

Wherever gruels are given no more than three times a day, the only way of increasing the quantities of energy consumed by children is to increase the energy density of the gruels. To achieve this, the flours/FBFs used must undergo extensive enzymatic and/or hydrothermal treatments, which modify the physico-chemical properties of the starch. These treatments break down the starch macro-molecules and limit their swelling during cooking, consequently reducing the gruels' viscosity. This makes it possible to prepare gruels of higher energy density while maintaining an appropriate consistency.

Technologies for producing FBFs include roasting, toasting or micronizing, but extrusion cooking technology is the preferred method for increasing the energy density in FBFs and decreasing the viscosity of gruels. This process has been used successfully to produce nutritious foods for distribution in dry packaged form.

The extrusion process creates heat by friction between the food and one or two high-speed screw(s); this pre-cooks the food and breaks down the starches in it. Such mechanical breakdown of starches reduces the viscosity of gruels made from extruded cereals, thereby enhancing their calorie and nutrient densities. Concurrently, the high-temperature heat treatment improves the product's hygiene.

Low-cost extruders, which rely on dry extrusion and that process foods at moistures of less than 20 percent, have the lowest capital and operating costs and can produce fortified, packaged, stable food products for 30 percent more than the cost of the raw ingredients. The term "wet extrusion" implies that the extruder requires an external source of heat or steam, with steam and/or water being injected either directly into the extruder or into a continuous preconditioner. In dry extruders, all the cooking is accomplished by friction – the shearing of highly viscous material – which is diminished as extra water or oil is added; this explains why wet extruders require external heat to cook the product fully. It also explains why these equipments require high energy inputs from the driving system, which may rapidly be a limiting factor at high feed rates – as a rule of thumb, dry extrusion of 10 kg of product requires 1 kW of energy input. Wet extruders can process materials of higher moisture and fat contents, and at higher throughputs, but the extruded products will need to be dried.

As CSB++ contains more fat and is intended for children requiring more energy-dense food, the use of wet extrusion is recommended. Dry extrusion limits the use of fat and does not completely gelatinize the starch; the energy density of the gruel is therefore lower. WFP experiments show that wet extrusion allows the fat content to be increased to 15 percent and increases the energy density of the meal by at least 50 percent.

Table 12.2 Effects of dry and wet extrusion on gruel characteristics

	Maximum fat (%)	Gruel energy content (kcal/100 ml)
Dry extrusion	8%	50
Wet extrusion	15%	75

As products manufactured by wet extrusion need to be dried, WFP has tested a new machine that combines drying and grinding at the same time. This is a pin mill augmented by the circulation of hot air, which mills and dries the product in less than a second. The finished powder is finer than traditional CSB, making it more acceptable to beneficiaries, who often claim that CSB is too coarse; the cooking time is also reduced, to five minutes instead of the usual ten. In this extent, use of roller mills, as used in the production of wheat flours, might also be prospected

4.3 Developing new formulas that suit local food habits and support national sustainable development

WFP's food technologists have also been supporting efforts to produce FBFs that are adapted to beneficiaries' tastes or convenience. The use of food products made from locally grown produce offers a promising market for the local economy and farmers, while helping to improve local populations' access to nutritious food. Although existing food fortification activities play an essential role in addressing malnutrition, the potential for using locally grown produce is largely untapped.

The idea is to develop new recipes using locally produced raw materials other than maize and soybeans. The nutritional value of these products is equivalent to that of traditional CSB, and because the raw materials are familiar to beneficiaries, the new FBFs are often more acceptable. New formulas have been developed in Lao PDR, where finer granulation and improved cooking have been achieved; Myanmar, using rice and soybean; Timor Leste, using maize, mungbean and soybean; Pakistan, using chickpeas and wheat; Nepal, using wheat, maize and soybean; and Senegal, using maize, peanuts and soybean. New products are also expected soon in Sierra Leone, using niebe, soybean and maize, and Sudan, using sorghum and soybean. General impacts include improved nutritional adequacy of locally produced fortified foods, delivery of fresher products, reduced risk of pipeline breaks, the development and production of different FBF formulas, increased knowledge about WFP's processed food experience, and higher consumption of locally produced FBFs.

In Lao PDR, each 1,000 mt of locally produced CSB feeds about 40,000 schoolchildren for one year, while providing extra income to 10,000 farming family members. The acceptability of the product has been increased, leading to a higher consumption rate. Production depends on local maize and soybean, and the quality of these improved during development of the new FBF; Chinese traders now cross the border to buy maize or soybean for food, rather than for feed, and this has also helped increase farmers' incomes.

The development of new food products faces many challenges, but these are less likely to arise if a proper feasibility study is made in advance, taking into account the sustainability of production and the implications for local markets. Challenges encountered so far include a lack of responsiveness to local needs, food habits and capacity to innovate; failure to understand seasonality, in terms of the prices as well as the availability of raw materials; efficiency and cost issues; manufacturers' lack of administrative capacity and ownership, including lack of access to credit for factory improvements, running costs, raw material purchases, etc.; local people's lack of ownership or acceptance; issues related to the quality of the food, including failure to match WFP's quality specifications and problems with analysing some food quality parameters in developing countries; and producers' reliance on WFP as their only client.

The standard process for setting up local production involves five steps:

(i) a needs assessment establishing the specific needs of a particular target group in the country concerned;
(ii) a feasibility study determining whether there are sufficient infrastructure, available commodities, reliable partners and donor support to ensure a successful operation;
(iii) a business plan outlining the sustainability of the project, including its costing;
(iv) development and testing of the product, and installation of the technical equipment needed for production;
(v) monitoring and evaluation, including impact studies.

The whole process takes about 12 to 18 months. It is crucial that the local government and partners have ownership of and commitment to the project.

WFP is concentrating its efforts on purchasing locally available foods and, when feasible, making these foods more nutritious by fortifying or processing them. The objectives are not only to develop local food markets and food processing industries, but also to provide WFP beneficiaries with commodities of higher nutritional value.

4.4 Capacity building

From experience, WFP knows that food industries need technical support to produce fortified foods or improved products that match WFP's specific requirements. It is therefore working to improve coordination between private sector and WFP food technology standards, while informing and training relevant government personnel.

5. Investing for the future by filling the gap between emergency and development: smart concepts and products

5.1 Building versatile solutions through containerized food production units

Containerized food production units (CFPUs) are food production lines built into standard 20-foot (6 m) shipping containers for transportation. The units are standardized and can be integrated into almost any environment. They enable the production of food that matches WFP's specifications, and are provided with services to facilitate their quick installation.

This project is still in its early stages, but CFPUs are thought to be a solution for local food production in times of crisis. During initial project design, two scenarios emerged for consideration: emergencies, and medium- to long-term development.

In an emergency, CFPUs would aim to provide beneficiaries with local food using local resources within 1.5 months of the emergency's onset. In such crisis situations, beneficiaries are often destitute and may be cut off from their traditional food resources, so require an alternative source of locally produced food that satisfies their nutritional needs and food habits. As already mentioned, the use of local resources always benefits a country in crisis. CFPUs are manufactured in advance and are stored at United Nations Humanitarian Response Depots (UNHRDs). When a crisis strikes, they can be mobilized and transported by ship, taking about one month to reach their destination. They may be accompanied by a stock of raw ingredients for processing during the first weeks. While the CFPU is in transit, its reception site is prepared to allow quick installation when it arrives. The first trials are prepared while the unit is being installed on site. The CFPU would be used for the duration of the emergency and would then be either dismantled for transport to another location or back to the UNHRD storage facility, or adapted and left in the country for use in rehabilitation and development schemes.

In medium- to long-term development situations, WFP aims to develop local markets and economies in line with its new orientation of providing food assistance rather than food aid. CFPUs are considered standard turnkey factories. Five types of units have already been designed, and two others are under development (Table 12.3).

Table 12.3 Types of CFPU developed by WFP

Type	Description	Capacity (mt/hour)	Cost (million US$)
1 Cereals and pulses	Drying, cleaning, grading, bagging	1–2	< 1.1
2 Maize meal	Fortified maize meal production	1	< 1.7
3 Wheat flour	Fortified wheat flour production	2	< 1.1
4 FBFs	Adapted to various raw materials	1– 3	< 1.7
5 Oil extraction	Oil production	0.3	< 0.9
6 RUSFs	Ongoing development		
7 Biscuits	Fortified biscuits	0.5–1	< 1.9

Prices are estimates and vary among manufacturers. They include the CFPU, transport costs, preparation of the reception site, installation of the unit on site, and training and assistance in running the unit.

While developing the CFPUs, a team of WFP food technologists contacted various manufacturers and studied their proposals, testing the performances of their machinery. The team then drafted several guide books:

- a site preparation manual, giving technical specifications for the CFPU reception site;
- an operating manual on starting up, running, controlling, cleaning, maintaining and repairing the unit;
- a quality manual to ensure the production of quality food;
- a laboratory manual to ensure that testing protocols are performed correctly.

CFPU's many advantages include: (i) rapid deployment; (ii) pre-assembly, full electrical wiring, pre-testing, uniformity and flexibility; (iii) staff training at the manufacturing site; (iv) sustainability owing to adaptation to different contexts and the attention paid to local environments; and (v) the provision of a global solution, including plant layout, operation and control and laboratory facilities, at a similar cost to that for a traditional factory. CFPUs are also a challenging way for WFP to become directly involved in managing production activities, and to translate theoretical approaches into pragmatic field solutions.

The CFPU project has involved designing, implementing and following up on new food processing activities, through project identification and management, process engineering, safety and control, e-learning, and outreach support for sustainable entrepreneurship. This experience provides corporate capacity building that can be used later for improving existing or creating new applications.

A pilot CFPU may be deployed in Afghanistan in 2010. This would be a containerized fortified biscuit production facility, for installation in an area that is not traditionally covered by food industries. The use of local nuts and dried fruits is being studied, as this would support the local agricultural economy.

5.2 Beyond traditional approaches: stimulating experiences with RUSFs and RTEMs

Ready-to-use food for children (RUFC)

RUFC is a RUSF designed for children. Successful use of ready-to-use therapeutic food (RUTF) at the community level has revolutionized the treatment of severe malnutrition, and efforts have been made to develop other lipid-based nutrient supplements adapted to different contexts, such as for the prevention of malnutrition in highly vulnerable populations through blanket feeding, or for the rehabilitation of moderately malnourished children through supplementary feeding.

At the end of 2007, WFP India took the initiative in developing RUFC, in collaboration with Indian producers. This initiative was expanded into Pakistan in early 2009. The main objectives were to expand the food options available to WFP for addressing malnutrition among infants and young children; to adapt RUFs to local tastes and preferences by using locally available ingredients that are familiar to the population; to produce food at lower costs than those for similar products produced elsewhere; and to build capacity and increase WFP's collaboration with the local food processing industry.

RUFC consists of locally procured soybean oil, fried chickpeas, extruded rice flour, icing sugar, dried skim milk, and extruded soy flour. Local procurement provides an opportunity for engaging the local food processing industry in producing products that are appropriate for humanitarian aid, while providing a market for local farmers to sell their produce, which has a positive impact on improving their livelihoods and is consistent with WFP's Purchase for Progress (P4P) initiative.

Growing evidence indicates that lipid-based foods have a greater impact on addressing malnutrition than FBFs (Cilberto *et al.*, 2005). Studies conducted in Ghana and Malawi found that lipid-based spreads registered significant improvements on anthropometric indicators and haemoglobin concentrations

(Adu-Afarwuah *et al.,* 2007; Kuusipalo *et al.,* 2006).

There is huge potential for this type of food in WFP's operations in South Asia and beyond. According to the World Bank, the prevalence of underweight children in India is among the highest in the world, and the number is nearly double that in sub-Saharan Africa; approximately 60 million Indian children are underweight (World Bank, 2005a). Malnutrition is an underlying cause of mortality; in India, there are an estimated 2.4 million deaths of children under 5 every year (Black, Morris and Bryce, 2003).

Owing to its lower cost and suitability for South Asia, many neighbouring countries, including Afghanistan, Bangladesh, Nepal and other low-income, food-deficit countries, have shown an interest in using RUFC in their programmes. RUFC has huge potential as a WFP emergency food for infants and young children, and in national food programmes and South-South collaboration, as an affordable option for addressing hunger and malnutrition. Tailored to other specific nutritional needs, such as malnourished adults and AIDS patients (Figure 12.1), similar products could target other vulnerable groups and enlarge the scope for applying RUSFs.

Ready-to-eat meals (RTEMs) for emergencies

WFP has been working on the development of RTEMs for emergencies to address a gap in its emergency response. At the onset of an emergency, it may not be appropriate to distribute common WFP commodities, such as grain, pulses and oil, because these require cooking, the facilities for which have often been affected by the disaster or left behind when people are forced to migrate. WFP is therefore identifying suppliers capable of producing foods that can be eaten directly as a complement to fortified biscuits.

The RTEMs should be filling while delivering the nutrition that affected people need to carry on rebuilding their lives. Many food processing technologies pre-cook foods to make them ready to eat, and many innovative packaging formats are easy to open and allow consumers to eat the food directly from the package. Appropriate packaging also allows RTEMs to be kept for extended periods, so they can be stored in UNHRDs ready for immediate dispatch when an emergency strikes. Owing to the varied environments where WFP is called to respond to disasters, these foods should be versatile and suitable for populations with different tastes and preferences.

In the aftermath of cyclone Nargis in Myanmar, WFP aimed to distribute RTEMs that were a mixture of rice, pulses, oil and spices processed using a retort process. The success of this distribution was limited, however, as WFP had to purchase from suppliers that had only small quantities available and whose supplies did not necessarily match WFP's requirements. In preparation for future emergencies, WFP food technologists are collaborating with other units and food manufacturers to develop a full ration that matches the needs of a general population and can be produced quickly and/or stored for long periods. The University of Lille (France) is developing a new type of emergency rations based on multi-compartmented RTEMs, whose dry base is processed mostly through extrusion cooking. Other products are also being developed; special attention should be paid to processing texturized vegetable proteins (TVPs), as it could provide a low-cost means of producing analogues of meat or meat extenders from locally available non-conventional proteins.

5.3 Embedding quality into WFP routine activities: quality control in the field and food traceability

To cope with changing environments and anticipate emerging problems and challenges, WFP tracks promising technological innovations that may be usefully transferred to humanitarian contexts: new processes, new equipment, new regulations, new technological skills, and evolving scientific theories. This involves keeping a watchful eye on recent publications and other documentation, and collaborating with industries and universities. The following paragraphs describe two examples of how knowledge tracking and transfer can benefit WFP's activities in terms of safety and quality.

Mobile laboratories for quality control in the field

Food quality control requires continuous attention. Up to now, WFP has relied on external laboratories that make regular checks on selected samples of the food being distributed. This is a costly, time-consuming and complicated process, especially for representative sampling and the safe storage and transport of products for further analysis. The lengthy process delays and undermines WFP's capacity to prevent food that does not fit its specifications from being delivered, and puts beneficiary populations at risk of ingesting unsafe or unhealthy locally processed food. It also creates extra work for the WFP agents in charge of food control and slows down the solving of problems and the conciliatory procedures for cases of litigation. This may have a major impact on WFP's work and image, and on the sustainability of the local production being supported, so WFP is seeking ways of avoiding or shortening the delay in quality control by implementing analyses closer to production sites.

For short- or medium-term production sites, such as for quality control of the raw materials and end-products of CFPUs, the solution could be to allocate one container unit to routine food analysis. WFP is therefore investigating the analyses, equipment and chemicals that could be applied in isolated and difficult conditions by moderately trained staff.

For longer-term production sites, WFP warehouses and plants that are not directly under WFP supervision, another solution would be to use mobile laboratories, which can be easily and regularly transported around scattered sites. For this, WFP is in contact with companies that supply vans fitted out with all the equipment needed for routine analyses: moisture, ash, protein and fat contents; rapid microbiology tests; aflatoxin determination; and measurement of particle size, density, colour, etc. A special cabinet for sensory evaluation could be added to the vans, to allow sensory testing.

Radio frequency identification (RFID) food traceability

Traceability refers to the tracing of goods along the distribution chain to allow: (i) responses to the risks that can arise in food, and assurance that all food products are safe to eat; and (ii) identification of risks and their sources, for swift isolation of the problem and to prevent contaminated products from reaching beneficiaries. Food traceability is a core component of modern quality management. RFID technology facilitates traceability by allowing the instantaneous and constant exchange of numeric data. WFP has been working with leading companies on adapting RFID technology to its operations, this involves tackling the cost and technical constraints and also ensuring compatibility with WFP's corporate Commodity Movement Processing and Analysis System (COMPAS).

As well as the benefits that this technique would bring to WFP's complex global logistics, it could also be developed to use special active tags containing moisture (Johan *et al.,* 2007) and temperature sensors (Jedderman, Ruiz-Garcia and Lang, 2009). Such devices have recently been developed to track temperature and moisture variations during transportation, which are known to alter food conservation irreversibly. Application of such technology to the real-time tracking of quality in the particularly harsh environments that usual prevail in humanitarian contexts could bring benefits for WFP, and immediate returns on investment.

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1 www.sphereproject.org/.