1. Introduction

In this chapter, acute malnutrition, therapeutic foods, along with essential fatty acid status and deficiency are introduced. Lastly, the thesis objectives are presented.

Undernutrition is a major health concern throughout the developing world, resulting in increased morbidity and mortality. Undernutrition was estimated to be an underlying cause of 3.1 million child deaths in 2011, or 45% of all child deaths [1]. Besides a higher risk of death, children affected by undernutrition are also at increased risk of impaired cognitive development and chronic diseases later in life [1,2].

Several classifications of undernutrition exist; the most commonly used is the division of undernutrition into moderate or severe acute malnutrition (MAM or SAM, respectively). SAM is a critical condition requiring immediate treatment with specialised therapeutic foods, and - if complications are present- hospitalisation [3]. However, hospitalisation is at the expenses of the caregiver’s work, the family and it predisposes the child to hospital-acquired infections [4,5]. These barriers and risks have been resolved with the introduction of community-based management of acute malnutrition and the use of ready-to-use therapeutic foods (RUTFs), which help to improve the survival of children with non-complicated SAM [5–7]. RUTFs are energy-dense products, providing all the nutrients required for rehabilitation of SAM [8,9], and are practical in settings with limited hygiene. Furthermore, the lower treatment cost in community-based management of SAM per child has meant that more children could be treated, and therefore more child lives saved.

Despite improvements in food security in Cambodia over the last decade, the prevalence of acute malnutrition remains high at around 9-12%, and has not changed since 2005 [10]. In 2008, there was an attempt in Cambodia to introduce the peanut-based-paste RUTF Plumpy’Nut®, which is successfully used to treat SAM globally. However, the introduction of Plumpy’Nut® was unsuccessful, due to its low acceptability and uptake by the health system in Cambodia [11]. The Cambodian government is currently using the imported BP-100™ bar in SAM treatment [12], even though BP-100™ not appear to be well accepted (F.T. Wieringa, personal communication). The lack of access to a well-acceptable RUTF suggests that the current SAM treatment in Cambodia may not be optimal. Therefore, a locally produced RUTF - adapted to taste and preferences in Cambodia - has been urgently needed. In 2013, an initiative led by United Nations Children’s Fund
(UNICEF), Cambodia, and the French National Research Institute for Sustainable Development (IRD), started the development of such a product, in collaboration with several Cambodian governmental institutions (the Ministry of Health; the Department of Fisheries Post-harvest Technology and Quality, the Fisheries Administration), Vissot, the National Pediatric Hospital and the University of Copenhagen, Denmark. The project “Development of locally produced, fish and lipid-based nutrient supplements for the treatment and prevention of malnutrition in Cambodia” aimed to develop two products: 1) a food supplement for preventing acute malnutrition (ready-to-use supplementary food (RUSF), and 2) a therapeutic RUTF for SAM treatment. In 2014, the first version of a locally produced, fish-based paste was piloted in pre-school children, assessing the acceptability of aforementioned paste compared to BP-100™. The pilot study found that both products had low acceptability and the local paste did not fulfil RUTF specifications for nutrition composition when it was tested [13]. This is why the locally produced, fish-based products needed to be optimised before assessing effectiveness.

Besides the importance of acceptability and the well-known effectiveness of commercial RUTFs, most focus in current research has been given to other factors such as diagnostic criteria and effectiveness of RUTFs for example by partly replacing milk powder with plant protein rather than polyunsaturated fatty acid (PUFA) status. Children with SAM might be vulnerable to insufficient PUFA intake and essential fatty acid (EFA) deficiency, which could be caused by a combination of three factors: a decreased food intake, an impaired nutrient absorption, and the presence of infection leading to higher nutrient requirements [14–16]. PUFAs play an important role in human brain, cognitive, and visual development, along with immune function and are thus vital for healthy growth and development of children [17–19]. Low levels of PUFAs might especially be a concern in children with acute malnutrition [20–28], who also are vulnerable to anaemia, infections, and other severe health challenges [16,29–33]. While PUFAs can be measured in various blood cell pools, whole blood samples have logistical advantages for field research collection due to less sampling processing post-collection, as well as the ability to collect dried blood spots. Therefore, recent studies have used whole blood to assess PUFA levels. However, when using whole blood to assess PUFA levels, the plasma itself and all the different blood cells can differentially impact the overall fatty acid composition [34], and any negative changes in health may also affect the cell counts. The onset of infection, which would result in monocyte cell counts increasing [35,36], or any alteration of blood cells may, for example, change the fatty acid composition of whole blood. Health challenges and/or changes in blood cell counts could therefore
Chapter 1 – Introduction

result in a not nutriture PUFA estimate in severely acutely malnourished and health compromised children. This could lead to insufficient nutritional support for the children to reach sufficient PUFA levels which is required to maintain essential body functions, growth and development of the child.

Conclusively: a well-accepted, locally produced, fish-based RUTF - adapted to the taste and preferences in Cambodia - might improve SAM treatment, increasing the likelihood of more children recovering from SAM. Likewise, children with SAM may have low PUFA status, potentially interfering with their rehabilitation from SAM. Using whole blood to measure PUFAs in health compromised children could result in reflecting a not nutriture PUFA estimate, which would lead to a misinterpretation of PUFA status.

Objectives of PhD research

The overall aim of this PhD study is to investigate the effectiveness of a fish-based RUTF in home-based treatment of SAM in children, who are also at risk of poor PUFA status. This has been done as a part of the project, “Development of locally produced, fish and lipid-based nutrient supplements for the treatment and prevention of malnutrition in Cambodia”. The specific objectives of the work described in this PhD thesis are to:

1. Optimise an already piloted, locally produced, and fish-based paste adjusted to Cambodian taste and preferences, along with following UN’s international RUTF specifications for nutrition composition. Furthermore, to include packaging and labelling of the fish-based RUTF (Paper I).

2. Conduct a taste trial and assess the acceptability of two locally produced, ready-to-use, fish-based products against a commercial milk-based RUTF among children and their caregivers (Taste trial) (Paper I).

3. Conduct an effectiveness trial and thereby assess the effectiveness of the locally produced, fish-based RUTF (named ‘Num Trey-RUTF’) compared to the imported milk-based RUTF (named ‘BP-100™’), for home-based treatment of SAM in Cambodian children (SAM trial) (Paper II).

4. Investigate fatty acid composition, particularly PUFA levels of whole blood and their potential associations with markers of nutritional- and health status in Cambodian children with SAM (Paper III).