1. INTRODUCTION

Undernutrition is a major health burden for the world population. Globally it is estimated that at least 165 million pre-school children are stunted, 101 million are underweight and at least 52 million children are wasted (1). Undernutrition, including foetal growth restriction, suboptimal breastfeeding, stunting, wasting and deficiencies of vitamin A and zinc are estimated to be the underlying cause of 45% of all child deaths, or about 3.1 million preventable deaths annually (2).

In 2010, the launching of the '1000 days' initiative (3) renewed global attention to the critical importance of optimal nutrition in the period from conception, through pregnancy and until the child reach 24 months of age. Exposure to undernutrition during the foetal period and early life influence the long-term physical and mental development of the child and thereby impact its entire life cycle. This period of 1000 days is clearly marked as the optimal period for preventing undernutrition and is also named the "window of opportunity"(2–6). Global data across populations show that growth faltering is most evident in the period from 6 to 24 months of age (7–9). The first six months of the complementary feeding phase, when the child is about 6-12 months old, is the most crucial period, because solid foods gradually start to replace breast milk. The complementary food offered during this critical period must have the right consistency, viscosity and also taste, to ensure sufficient consumption (quantity) to meet the energy and nutrient requirements of the growing child. In addition the nutritional composition needs to be of high quality to allow fast growth and development during this period (10,11). Furthermore, in an unfavourable environment with unhygienic food preparation and poor sanitary conditions, incidence of infectious diseases such as diarrhoea is increased and thereby challenging healthy growth (2,12).

The typical diet of complementary food in many food insecure populations is dominated by a single starch-rich staple such as rice or maize, with only little vegetables and fruit and few or no animal source foods (ASF) (13–15). Such a complementary food diet is likely to be low in energy- and nutrient-density due to a low fat content and absence or very small amounts of non-staple foods. It may also have low mineral bioavailability due to high contents of phytate (13,16,17). Such a diet is unlikely to support healthy growth, which lead to growth faltering during early childhood.

Several strategies have been employed to improve the quality of complementary foods, including nutritional education of caregivers, distribution of fortified blended foods, lipid-based products, micronutrient powders or a combination of these (5,12,18). However, there is a general acceptance that there is no single universal "best" package of components in complementary feeding interventions, because the needs of the target population vary greatly from region to region (12,19,20). Intervention studies aiming to improve the quality of complementary foods have indicated that positive impact on growth and health can be achieved by providing either food or supplement alone or in combination with nutritional education. However, the assessed effect has been modest due to high heterogeneity in the study designs (12,20). Complementary foods, either promoted through nutrition education or distributed as a supplement, should preferably be based on locally available foods to increase

cultural acceptability of the foods, as well as being an integrated part of the local food supply system and the domestic food economy. The use of locally available foods, rather than imported products, will also improve dietary diversity, which again contributes to improve dietary quality (21). However, the diversity of locally available foods and variation between regions is also constraining the provision of solid scientific documentation for the potential achievement of improving nutrition through utilization of local foods. This knowledge gap needs to be addressed in well controlled studies, to generate specific understanding of the nutritional gains from using locally available foods in a specific setting, as well as compiling generic understanding of which food formulations are needed to support healthy growth in children.

Healthy growth during the first '1000 days' is the foundation of adequate organ formation and function, a strong immune system, physical health and neurological and cognitive development (22). Healthy growth is a term that has gained more and more attention, notably in a policy shift from the predominant concern with reducing underweight to focusing more on reducing stunting. The term may also include the absence of excessive weight gain or obesity (22,23).

In addition to the development of effective strategies and improved complementary food products, identification of appropriate measures for impact on healthy growth is also a challenge. Anthropometric measurements are the most commonly used outcome measure in nutrition intervention studies (24), but it might not be the most sensitive or most relevant indicator to assess healthy growth (25). To better understand the consequences or impact that these nutrition interventions have on child development and health, different indicators and improvements in measurement techniques are required (12,19). One alternative to standard anthropometry is determination of body composition. Body composition distinguishes between fat-free mass (FFM) and fat mass (FM) and can be argued to enhance our understanding of the long-term consequences of growth and nutrition in early childhood (26,27). Several methods have been developed to measure body composition, including skinfold measurement (28), air displacement plethysmography (29), bioimpedance (30), dual energy X-ray absorptiometry (DEXA) (31) and staple isotope techniques (32). All aim to distinguish between FFM and FM. In the recent years, the International Atomic Energy Agency (IAEA) has implemented and supported a programme to build capacity in low-income countries of using especially the staple isotope technique to measure body composition, as a contribution to improve the assessment methodology of nutrition interventions (32,33).

The present thesis is a component in the WinFood study, which is fully titled "Alleviating Childhood Malnutrition by Improved Utilisation of Traditional Foods (WINFOOD)". The overall aim of the whole WinFood study was to develop nutritionally improved complementary foods for infants and young children in low-income countries, based on improved utilization of locally available foods (including semi-domesticated and wild indigenous foods from uncultivated land or aquatic environment). The WinFood study aimed to develop a country/region specific approach with Cambodia and Kenya as model countries. In this thesis, only results from Cambodia will be presented. One component in the WinFood

study was an intervention trial where the impact on growth and iron status of the developed local complementary food was assessed. The WinFood study aimed to include more sensitive outcome measures on growth in combination with traditional anthropometric measures.

The rationale of the present thesis is to provide evidence on the potentials locally produced complementary foods' have on healthy growth and on the need for appropriate outcome measures to measure growth in 6-24 month old children. Specific, this thesis aims to assess the impact of locally produced complementary food products, on FFM, FM and linear growth in 6-15 month old Cambodian children (paper I). Furthermore, it seeks to estimate the capability of these locally produced complementary food products to prevent undernutrition (paper III). Finally it intends to assess nutritional status defined by anthropometric indices in relation to FFM and FM in 6 and 15 month old Cambodian children (paper II). Overall, these papers highlight the challenges of preventing undernutrition in Cambodia.