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Promotion of the consumption of local foods to improve the diet of Vietnamese children

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ABSTRACT

Background: Despite great achievements of poverty and hunger reduction, ethnic minorities in rural and remote areas are still suffering from malnutrition in Vietnam. Thus, the research was carried out in Mai Son, Son La province of Vietnam, where the majority of the population were of the Thai ethnic minority group.

Objective: The study investigated whether the promotion of local food consumption within the frame of actual dietary patterns could be effective to address the current dietary challenges of children between 12 – 23 months in this area.

Methodology: The dietary intake data of 52 breastfed and 366 non-breastfed children, from repeated quantitative 24-hour recall surveys, was processed in Stata and MS Access developed specifically for Optifood. Computer-based linear programming analysis (Optifood) was used to identify the problem nutrients in the diets of these two target groups and select the best diets within the most frequently consumed local foods and food item/subgroup/group constraints.

Results: "Grains & grain products", "Meat, fish & eggs" and "Vegetables" were 3 food groups consumed more than two meals per day, while "Fruits" and "Legumes, nuts & seeds" were rarely consumed. Eggs were the main contributor for nutrients in the optimized diets. Iron and zinc could not reach 100% in the best-case scenarios, while fat, Ca, vitamin C, B1, B2, B3, B6, folate, B12 and vitamin A could achieve 100% RNIs in the best-case scenarios but remained below 70% RNIs in the worst-case scenarios. Local foods could be used to bridge these nutrient gaps (except for Fe and Zn) by following the daily food based dietary serving recommendations across 2 target groups: 1-2 servings of dairy products, 3-4 servings of vegetables, 1 serving of legume, 1-2 servings of meat, fish or egg, and the addition of 1-2 servings of fruits for only non-breastfed children.

Conclusion: locally available foods have the potential to improve the diet of children 12-23 months when the frequency of consumption increases from the average current dietary pattern but remains within the scope of actual observed dietary practice. Iron and Zinc intake still remained inadequate without additional interventions.

Key words: children, linear programming, local foods, Optifood, Vietnam

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ABBREVIATIONS

FAO	Food and Agriculture Organization of the United Nations
FBRs	Food-based Recommendations
FP	Food Pattern
IFAD	International Fund for Agricultural Development
MDG	Millennium Development Goal
NFP	Non-food Pattern
RAE	Retinol Activity Equivalents
RNIs	Recommended Nutrient Intakes
RE	Retinol Equivalents
WFP	United Nations World Food Program
WHO	World Health Organization
US	The United States of America

1. INTRODUCTION

1.1 Background and justification

1.1.1 Global situation

According to Food and Agriculture Organization of the United Nations (FAO) et al. (2015), although the effort to eliminate hunger with a decrease of 167 million undernourished people over the last decade, 795 million people still suffer this problem globally with 780 million estimated to be from developing regions. However, the significant decrease of undernourished people from 18.6 percent in 1990–92 to 10.9 percent in 2014–16 at worldwide level cannot be denied (FAO, et al., 2015). This decrease is especially observed in developing countries, and accounts for the majority of undernourished people globally (FAO, et al., 2015).

The year 2015 marks the end of the monitoring period for two international targets of hunger reduction, which are the hunger target goal of the Millennium Development Goal (MDG) - known as the first target goal and the World Food Summit goal. For the first MDG goal, which requires reducing the prevalence of people who suffer from hunger by half by 2015, almost all developing countries have reached this goal (FAO, et al., 2015). On the other hand, due to the growth in population, these countries cannot reduce the absolute number of undernourished people by haft to be only about 500 million as required by World Food Summit goal (FAO, et al., 2015).

Asia, the most populous region in the world, the attempt to reducing hunger has been different across regions and countries, with different outcomes. Over the past decade, the highest burden of hunger in South Asia has experienced a slight reduction from 23.9 percent in 1990-92 to 15.7 percent in 2014-16 (FAO, et al., 2015). This pace however, has been too slow to reach the international hunger target. On the contrary, the most successful sub regions in fighting hunger have been Eastern and South-Eastern Asia, in which the prevalence of undernourished people has fallen by almost 60 percent since the beginning of the monitoring period (FAO, et al., 2015). Most countries in this region show rapid progress toward international targets, with positive performance in Cambodia, Indonesia, Laos, Myanmar, the Philippines, Thailand and Vietnam (FAO, et al., 2015).

1.1.2 Situation in Vietnam

Since Vietnam signed the Millennium Declaration, working towards achieving the MDGs has become one of national development priorities of the country. At the end of the period in 2015, Vietnam achieved some MDG targets, including (a) eradicate extreme poverty and hunger; (b) achieve universal primary education and (c) promote gender equality (Ministry of Planning and Investment, 2015).

Vietnam was among the countries that achieved both the MDG first target to eradicate poverty and hunger and the World Food Summit goal of halving the number of hungry people by 2015. Due to the improvement of agriculture production and rural development policies, 7.5 million people escaped from hunger and the number of households suffering from hunger declined by more than four times (Ministry of Planning and Investment, 2015). For World Food Summit goal, the number

of undernourished people in Vietnam has decreased 68% from 1990-92 until now, the same result has also obtained in MDG goal with the significant reduction (75%) of undernutrition prevalence (FAO, et al., 2015). Another important indicator of MDG "hunger target" is the prevalence of underweight children under five years of age, which also showed a remarkable improvement. Prevalence of underweight reduced from almost 35% in 2000 to 15% in 2014. In addition, stunting (malnutrition indicator that reflects the long-term nutrition status), experienced a slight reduction from 38.7% (1999) to 24.9% (2014), more details in **Appendix 1** (National Institute of Nutrition, 2015a).

Despite great achievements, Vietnam is still facing many challenges to reduce poverty and hunger because a significant number of ethnic minority and households, particularly in the rural and remote areas where still suffer the most from malnutrition and have little chance of benefiting from economic growth (Ministry of Planning and Investment, 2015). According to the general nutrition survey of Vietnam 2009 - 2010, the northern midlands and mountainous areas had the highest proportion of the poorest households, accounting for 18.8% of total households in this area (National Institute of Nutrition, 2011). In addition, these areas had the highest prevalence of malnutrition and stunting among children under 5, with 22.6 % and 34.9% respectively (National Institute of Nutrition, 2014). The highest prevalence of anaemia and vitamin A deficiency in children under 5 was in the Northern west, with 43% and 19.4% respectively (National Institute of Nutrition, 2011).

1.1.3 Situation in the research area

This research was carried out in Mai Son, one of the districts in Son La province of Vietnam. This area is located in the Northern West of Vietnam, a remote rural area which is surrounding by mountains and considered as one of the poorest area in Vietnam with 34.8% households classified as poor in 2014 (National Institute of Nutrition, 2015b). In 2012, 77% people were working in the agriculture sector, with an average monthly income per capita of people in this area was only half of the country average/mean. In addition, an average of 58% of total monthly income was spent for food consumption (Central population and housing census committee, 2010).

Son La province consists of 51 ethnic groups, in which Thai people contributed for the vast majority of the population (53%). Almost 82% of the population followed Catholicism and Protestantism, therefore they can consume a wide variety of foods without religious restriction (Central population and housing census committee, 2010). On the other hand, there were some barriers limiting the development of this region, which were the big household size with 68% of household having at least 5 people. Moreover, primary school was the highest level of education of 90% Son La people (Central population and housing census committee, 2010).

According to National Institute of Nutrition (2015b), although there was a slight decrease in the prevalence of underweight and stunting among children aged 12-23 months from 2011 to 2014 in Son La, the prevalence was still high compared to the general prevalence of the whole country, with 7.4% of wasting, 19.25% of underweight, 33.45% of stunting. The prevalence of underweight increased with age, with the highest was found among children from 42 to 59 months. For wasting

and stunting, the highest prevalence was observed at the later age, more details in **Appendix 1** (National Institute of Nutrition, 2015b).

1.2 Rationale

At international level, attention has shifted to a sustainable diet, which addresses the consumption of foods with lower water and carbon footprints, promotes the use of food biodiversity including traditional and local foods with their nutritionally rich species and varieties, and can play a role in enhance food security (Burlingame & Dernini, 2010). Better utilization of local foods is one key message to obtain a sustainable diet and offers a solution to address malnutrition in poor rural areas. According to USDA (Martinez, et al., 2010), local food is defined as "a locally or regionally produced agricultural food product is less than 400 miles from its origin, or within the state which it was produced". Local food systems can give the great benefits for the communities in terms of local economic development, food and nutrition issues and environment (Martinez, et al., 2010). Firstly, with the reduction in transportation cost, foods produced locally can be more affordable for local poor people, local farmers can also benefit economically from the trading, and more jobs can be created (Martinez, et al., 2010). Second, short travel time from farm to fork can retain more nutrients in food, as some sensitive nutrients can be broken down due to the exposure of lights and temperature (Lea, 2005). Moreover, a higher availability of healthy and diverse foods can encourage consumers to make healthier food choices (Martinez, et al., 2010). Finally, when foods travel shorter distances, less fuel and energy is used for transportation, results in less pollution (Martinez, et al., 2010).

In Vietnam, despite of great achievements, there are still many challenges to reduce undernutrition as the methods are not really sustainable, which mostly focus on supplementation and have short-term impact (Ministry of Planning and Investment, 2015). In addition, due to the rise of population, limited land to meet growing production and allocation demand, as well as the increase of environmental pressures on the food system, it is required that policy makers consider a sustainable interventions to address challenges of future food and nutrition insecurity (Ministry of Planning and Investment, 2015). As a result, Vietnamese National Institute of Nutrition has emphasized the importance of local food promotion as one of the main approaches to tackle food and nutrition problem for the period of 2011 – 2020 (Minitry of Health, 2012).

In addition, according to Central population and housing census committee (2010), indigenous people account for the majority of residents in our research area. Those people often suffer the most severe financial poverty and health disparities in both developing and developed nations (Kuhnlein, et al., 2013). Moreover, they are mostly living in remote villages in upland areas, with limited access to transportation and social interaction, this is in conjunction with the high food insecurity (Department of Economic and Social Affairs, 2009). On the other hand, indigenous people's areas are often associated with high biological diversity, and they have their own value culture and traditional knowledge which need to be utilized to build good nutrition program (Kuhnlein, et al., 2013). As a result, many studies has worked on their traditional food systems to improve their food insecurity status and showed some possitive effects (Kuhnlein, et al., 2013).

Due to the potential of promoting sustainable diet through local food consumption, this study was carried out to identify the realistic combination of local foods within the constraints of actual dietary patterns that would meet or come as close as possible to meeting the nutrient needs of the target population.

1.3 Objectives

1.3.1 General objectives

The study investigated whether the promotion of local food consumption could be effective to address the current dietary challenges of children between 12 – 23 months in Mai Son, Son La province of Vietnam.

1.3.2 Specific objectives

- To describe the current dietary patterns of the target groups
- To identify the locally available food or subgroup sources of nutrients that can be promoted to bridge these nutrient gaps.
- To evaluate whether the current diet of children between 12 – 23 months in the study area is sufficient, and identify nutrient gaps ("problem nutrients").
- To develop appropriate food-based recommendations (FBRs) within the constraints of the normal local dietary patterns and cost of diets.

1.3.3 Research questions

- Is the current diet of the target population nutritionally adequate?
- How do locally produced and available foods contribute to the dietary pattern of children 12 – 23 months in Mai Son, Son La province?
- With only using locally available foods, could problems nutrients be solved among children 12 – 23 months in Mai Son, Son La province?

2. LITERATURE REVIEW

2.1 Nutrition interventions regarding undernutrition and micronutrient deficiency in Vietnam

2.1.1 Overview of nutrition interventions

Nutrition interventions in Vietnam mainly focus on supplementation, fortification and raising knowledge awareness. The effects of these interventions among children under five have been reported earlier. Firstly, regarding to supplementation, a study carried out from October 1996 to April 1997 in Hai Duong province of Vietnam showed that weekly and daily supplementation of micronutrients improved haemoglobin, zinc, and retinol concentration of stunted children (Bui, et al., 1999). Secondly, three studies using fortification interventions showed the effects on micronutrient status of children. One randomized controlled trial in Quang Nam province of Vietnam proved that children consuming micronutrient-fortified foods had a greater improvement in haemoglobin concentration compared to the control group (Pham, et al., 2010). In addition, fortified growing up milk with synbiotics showed the improvement of immunological (IgA) and micronutrient parameters (vitamin A and Zinc level), as well as body weight and height among children aged 18 and 36 months in Bac Ninh province during 5 months (Nguyen, et al., 2013). Another cluster randomized trial across 64 provinces of the country clearly stated the insufficient intake of micronutrients among children under five and indicated the impact of micronutrient fortification of staples and condiments on iron, vitamin A, zinc, vitamin B1 and B2 status of the intervention group (Laillou, et al., 2012). Finally, for the effect of community-based education, a three-year study in Khanh Hoa province, which established consultation rooms, monitoring systems, and developed training materials for health workers, showed the increase in body height and weight, the reduction in anaemia and stunting prevalence of children under 36 months (Tran, 2013).

At national level, currently there are two interventions with a wide coverage across country, which are vitamin A supplementation for young children and iodized salt. Vitamin A supplementation program was launched in seven pilot districts in 1988 and then gradually expanded to all the communes in the country in 1993, and reached the coverage of almost 100% in 2000 (Ha, et al., 2016). Regarding to salt iodization, mandatory national regulation were issued in 1999 with the positive compliance, and reached 90% of households by 2005 (UNICEF, et al., 2016). However, a revised decree in 2005 failed to uphold the mandatory iodization requirement and made salt producers feel no obligation to continue iodization. Thus nowadays, less than half of households consume adequately iodized salt and iodine deficiency has been found among 77% of pregnant women (UNICEF, et al., 2016). Other interventions have been implemented but not really successful, for example, although there is breastfeeding counselling, the breastfeeding practices have not improved since last ten years. In addition, iron and folate supplementation for pregnant women is included in the government policy but there are no central government resources allocated and no data on current coverage (National Institute of Nutrition, 2015c).

Moreover, Vietnam remains one of the countries with the highest stunting prevalence on over the world, with one in five are stunted, especially in Northern Midland and mountain areas in which 1 in 3 children are affected (Chaparro, et al., 2014). Furthermore, despite policies in place, nutrition and breastfeeding were not considered as priorities according to an analysis of opinion leaders in Vietnam (Alive & Thrive, 2012). As the results, Vietnamese government issued National Nutrition Strategy 2011 – 2020, which set the new priorities to reduce stunting prevalence to 23% in 2020, vitamin A deficiency and anaemia among children under five to 8% and 15% respectively in 2020. In addition, it ensured the coverage of iodized salt on over 90% households (Minitry of Health, 2012). On 28 January 2016, the Prime Minister of Vietnam signed a decree to mandate food fortification, in which salt will be fortified with iodine, wheat flour must contain iron and zinc, vitamin A should be added into vegetable oil (Scaling Up Nutrition, 2016). This policy was released to improve the general vitamin and mineral intakes of Vietnamese people. Furthermore, other policies have been released recently to promote breastfeeding, child survival, food hygiene and safety, as well as promote the participation of different stakeholders, but the effect has not been evaluated yet. In addition, Vietnam has cooperated with other international organizations in the attempt to reduce undernutrition and micronutrient deficiency, for example joining Scaling Up Nutrition movement, EU funding for nutrition and livelihoods project of ethnic minorities, IYCF project for breastfeeding and complementary feeding (Chaparro, et al., 2014).

2.1.2 Lessons learned from these interventions in Vietnam

Turning first to supplementation programs, the implementation of weekly iron-folic acid supplementation in Yen Bai province showed the concern relating to the sustainability of this program. This required developing a plan collaboratively among all stakeholders to ensure the acceptance and support of all involved. Furthermore, regular meetings between the project team and local parties were needed to timely solve any problems affecting the outcomes. In addition, small payments should be given to increase the incentives for all involved staff (Tran, et al., 2009).

Second, regarding to food fortification programs, the Universal Salt Iodization revealed that food fortification could effectively be scaled up if it was integrated into the national priority program and taken into the support of partnerships and the engagement of private sectors (Tran, et al., 2015). Vietnam has not only shown the positive outcome of a mandatory decree on iodine fortification, but also the risk of a relaxing political commitment (Chaparro, et al., 2014). In addition, the fish sauce fortification program discontinued due to lack of willingness for technical investment, this demonstrated the importance of private sectors engagement (Tran, et al., 2015). As the results, it is required to improve public awareness about micronutrient deficiency to reinforce the effect of political commitment.

Finally, for knowledge into practice of community-based interventions, two studies emphasized the crucial participation of (vice) chairpersons of the communes in the success of the projects (Duong, et al., 2015; Eriksson, et al., 2013). They played an important role, not only the approvals to establish the intervention groups but also during the implementation. These local representatives had a stronger voice in the society and were in the better positions to solve problems than other facilitators. Moreover, local authorities were helpful to motivate the participants and improve the cooperation among stakeholders (Duong, et al., 2015).

2.2 The benefits of local food promotion

2.2.1 The effects of local food promotion on food security, and nutrition status of indigenous people

There were two studies in South America, which focused on increasing the production, accessibility, knowledge and use of local nutritious foods, showed the improvement of health, nutrition and food availability of indigenous communities in Peru and Colombia (Creed-Kanashiro, et al., 2013; Caicedo & Chaparro, 2013). In the study in Peru, mean energy and nutrient intakes were close to recommended daily intake for children except for iron, zinc and calcium (Creed-Kanashiro, et al., 2013). This study also showed that ninety percent of energy was provided by locally produced or caught foods rather than market foods (Creed-Kanashiro, et al., 2013). Moreover, the reseach in Colombia reported the improvement in food security at household level during the project, in which 100% of the families confirmed the regular availability and accessibility of the traditional foods (Caicedo & Chaparro, 2013).

Promotion of local food consumption among 2 different indigenous communities in Asian countries also demostrated the same results. The project in Thailand showed the increase of awareness about the important of traditional foods, which led to the rise of vegetable and fruit varities in household diets from 81 to 137 after the intervention (Sirisai, et al., 2013). In addition, this 4-year study reported the improvement of nutrition status among children aged 0 to 12 years with the reduction of underweight and stunting incidence, from 14.1% to 11.6% and 20% to 18% respectively (Sirisai, et al., 2013). Furthermore, this finding was confirmed by research among Dalit rural communities in the Zaheerabad region of South India, in which using the local food system promoted through women farmers' organizations helped to increase the intake of energy, protein, fibre, vitamin C and iron in children compared with the controled group (Salomeyesudas, et al., 2013).

In Africa, a study of indigenous people in Madagascar proved the important role of wild yam on local food security. Wild yam tubers were used as a staple food by 42% of the households to substitute cassava, maize or sweet potato, especially in villages situated near forest areas, where daily plant collection was possible (Andriamparany, et al., 2014). Furthermore, a study in Nigeria confirmed the contribution of traditional foods to assuring nutrition security. With the appropriate combinations, traditional Nigerian foods can provide adequate energy, protein, iron, vitamin A, thiamin, niacin and ascorbic acid for children 3-5 years (Onimawo, 2010).

In Vietnam, Vuong (2000) reported the potential of Gac fruit (*Momordica Cochinchinnensis Spreng*) to alleviate the problem of vitamin A deficiency of indigenous children in Northern Vietnam. It was due to the fact that this fruit had an good source of beta-carotene, it was easy to grow and familiar with indigenous people. However, it was under-utilized due to the seasonal variation and lack of knowledge about the benefits (Vuong, 2000). After the promotion of the use of Gac fruit, the study showed an increase in the retinol and beta-carotene plasma concentations among indigenous children aged 31-70 months compared to the control group (Vuong, et al., 2002).

On the other hand, promotion of local foods could lead to the increase in the production and consumption of locally grown foods but might not affect the general health and nutrition status of

the intervention groups. Despite a significant increase in the intake of provitamin A carotenoid and dietary diversity among Pohnpei community of Micronesia during 2-year project, there were no significant changes in health indicators, for example Body Mass Index, waist circumference and blood pressure (Englberger, et al., 2013). Morover, although local food promotion in Peru showed an improvement among indigenous children, women's intakes of energy and some nutrients were generally still lower than recommendations (Creed-Kanashiro, et al., 2013). In addition, a study in India indicated that local foods can increase the intake of some macro-and micronutrients among indigenous children but had no impact on stunting and wasting prevalence (Salomeyesudas, et al., 2013).

Although there are mixed results on the effects of local food consumption on malnutrition status, conserving the traditional food systems is helpful to tackle the rise of overweight and obesity among indigenous youth (Department of Economic and Social Affairs, 2009). This is due to the rapid shift in diets, with less use of traditional foods and greater reliance on processed and unhealthy foods, combined with more sedentary lifestyles (Turner, et al., 2013). Moreover, in Canada, Kuhnlein et al. (2013) indicated a similar proportion of overweight/obese indigenous youth compared to the overall Canadian population. As the results, Turner et al. (2013) and Kuhnlein et al. (2013) documented the improvement of nutritional behaviors among indigenous youth by promotion of traditional food consumption. The study showed that people consuming traditional foods were more likely to consume less carbonated beverages (Turner, et al., 2013). The increase of fruits and vegetables consumption were shown significant improvements in their plasma carotene, retinol and folate (Kuhnlein, et al., 2013).

2.2.2 The effect of local food promotion on local economy and environment

Promotion of local food consumption can have a positive impact on local economy, especially small-holder farmers (Martinez, et al., 2010). A case study in many different states of United States of America (US) was confirmed that 13% to 62% of the retail price was spent for bringing the agricultural products to the non-local market, otherwise nearly 100% of the retail price could be retained by directly selling to local market chains (King, et al., 2010). Moreover, many studies indicated that the surpluses from local markets would improve local economy and generate more jobs (Connor, et al., 2008; Enshayan, 2008; Henneberry, et al., 2009; Hughes, et al., 2008; Myles & Hood, 2010; Swenson, 2006). For example, a case study in Michigan showed that promotion of seasonal available Michigan-grown fresh produces could create almost 2000 jobs and $2,000,000 income per year (Connor, et al., 2008). Finally, local food consumption is not only beneficial in the local system, but also has an impact on neighboring business, which triggers the agglomeration effects on the development of the whole region (Lev, et al., 2003; Myers, 2004). An Oregon study of farmers' markets found that for every dollar spent in the local market, people also spent $0.6 outside the market (Lev, et al., 2003). Another study of Myers (2004) reported the average expenditures on nearby business were ranged from $76 to $116 per month.

Turning to the impact of local foods on environment, it can be seen that locally sourced foods require a shorter travel to reach the final destination than non-local foods. In the US, Thompson et al. (2008) and Anderson (2007) reported that transportation reduction could decrease the use of fossil fuel, resulted in the reduction greenhouse gas emisson and pollution. A report of Saunders et

al. (2006) in New Zealand also confirmed the same results, CO_2 emission released during the transportation of imported produces was much higher than those of domestic produces. Moreover, not only at the stage of transportation, Edwards-Jones et al. (2008) found that non-local products tended to release more emissions during the whole life cycle, which included on-farm activities, processing, retailing and consumption.

2.2.3 Challenges, barriers and lesson learned in the promotion of local food consumption

Despite the benefits mentioned above, the promotion of local foods has been found some difficulties, especially in indigenous people. Firstly, almost all indigenous communities locate in the remote areas, which are difficult to access, monitor and follow-up the activities (Caicedo & Chaparro, 2013; Creed-Kanashiro, et al., 2013). Second, some foods are lacking documentation of the value of some or all nutrient content, which then need to be estimated. Salomeyesudas et al. (2013) reported the overestimated intakes of vitamin A due to the estimated values from colorimetry. Another limitation was also reported from this study, in which breast milk intakes were assumed at the standard for age. This reduced the true variance of nutrient intakes and limited the validity of comparisons, particularly at the younger age groups (Salomeyesudas, et al., 2013). Moreover, research of Caicedo & Chaparro (2013) indicated that the indigenous people in their research area did not allow for blood sample collection, in addition they feel more comfortable in the informal discussion, therefore the data were collected informally.

From the review of local food promotion, some lessons can be learned to ensure the success of future interventions. Firstly, multi-stakeholder partnership and community participation are crucial for the success of the project. It due to the fact that using local foods to improve the nutrition status required more than technical knowledge, it relied on human processes, long-term relationships, mutual trust and effective communication among multiple partners (Sirisai, et al., 2013). In addition, Creed-Kanashiro et al. (2013) emphasized the coordination with government institutions and community promoters to increase the consistency of key messeages and activities. Moreover, it should be noted that these culture-based approach are free-formed and organic approach rather than a mechanical and controlled approach, therefore to enhance community participation, the project should allow people to choose how they wish to live and maintain their own culture and traditions (Sirisai, et al., 2013).

As almost all indigenous people reply on natural resources, climate change is rising as a new challenge for their food security in the future. This concern was reported in 3 studies in different indigenous communities in Canada. Climate change had an impact on the ecosystems, and affected traditional food species. For example, early ice melting and snow reduction influenced in ringed seal pups (*Phosa hispida*) in Western Hudson Bay and continued to reduce the species (Egeland, et al., 2013). Turner et al. (2013) also confirmed the negative impact of environment on fish stocks, in which salmon and sockeye were less plentiful than they were 20 years ago. These affected food availability, as a result, 68% of the participants felt that it was difficult to access traditional foods and they did not eat as much of those food as they would like to (Kuhnlein, et al., 2013).

2.3 Baseline survey report of the research area

2.3.1 Nutrition and health status of children

In the baseline survey, children and their mothers reported some common signs of illness such as fever, cough, cold, dyspnoea, and diarrhoea over the last two weeks, malaria in the last three months and parasite infection and treatment in the last six months. Half of children experienced cough or cold in the last two weeks, following by fever (34%) and shortness of breath (20%) (HealthBridge Foundation of Canada, 2015). Moreover, the survey also checked whether any nutrition supplements were taken or currently used. The report showed that 23% of children were using these supplements (HealthBridge Foundation of Canada, 2015).

2.3.2 Household food security

Two months, May and June, were reported with the highest rate of food insecurity, in which 50% of mothers said that they did not have enough food for their families in those months. In addition, the prevalence of food security was evaluated by Household Food Insecurity Access Scale in the last 30 days. The report showed that more households had food insecurity during the dry season, with the prevalence of 20.4% mildly food insecurity, 20.9% moderately food insecurity, though these figures are 13.2% and 15.5% respectively during the wet season (HealthBridge Foundation of Canada, 2015).

2.3.3 Knowledge of mothers/caregivers on nutrition

According to the report of HealthBridge Foundation of Canada (2015), the average age of mothers was 24 years old. Eighty-seven percent of them were literate, with 45% being education at secondary school level.

In this report, 64.2% of the mothers said that the children got malnourished because they do not have enough food, and 18% of them did not report any reasons. In addition, the mothers was asked for the method to prevent child malnutrition, 58.2% of the answers were giving more food, and only 18% of the mothers suggested to give children variety of foods. Furthermore, there were still 23% of them who did not know any ways to prevent malnutrition (HealthBridge Foundation of Canada, 2015).

Turning to breastfeeding and complementary feeding, children started to wean at the average age of 13 months old, and only 12.7% of mothers said that their children should be breastfed until 24 months or more. Moreover, 76% mothers introduced complementary food for their children at 6 months of age, and the reason was reported that exclusive breast milk was not sufficient to supply all nutrients for children from six months of age (HealthBridge Foundation of Canada, 2015). However, 61.1% of mothers said that thick porridge should be given to young children at the start of complementary feeding, only 38.9% of them agreed to give thin porridge to their children. In addition, most of the mothers (80%) knew the importance of adding other types of food to nourish children's porridge, and 96.7% of them suggested adding meat, following with 46.4% and 36.1% suggestions for vegetables and eggs respectively. Finally, most of mothers learned their feeding

practice from their mother or mother-in-law (36.5%), friends (32.4%), neighbours (31.6%) and only 23.8% from health professionals (HealthBridge Foundation of Canada, 2015).

Regarding to dietary diversity, most of mothers understood the importance of diversified diets, giving different types of food and several meals for their children each day, with the prevalence of 84.4%, 93.2% and 94.9% respectively. However, 51.4% of them also reported that the most difficulty of diversifying the diet was unavailability of food (HealthBridge Foundation of Canada, 2015). In addition, vegetables and fruits were given to children by 90.4% and 95% women respectively. The reasons for feeding children with vegetables and fruit were mainly "everybody did it", rather than their benefits. For mothers who did not give vegetables and fruits for their children, the main reasons were that the children did not like vegetables (62.5%), or the fruits were not locally available (33.3%) (HealthBridge Foundation of Canada, 2015). Turning to animal foods, almost women (98.8%) gave animal products to their children, but the reason also relied on imitation. Most of these foods were commonly available locally in the community. When choosing these foods, the main factor was food availability (81.7%) rather than the price. Furthermore, few mothers gave wild animals for their babies (HealthBridge Foundation of Canada, 2015).

HealthBridge Foundation of Canada (2015) also reported the knowledge of mothers about micronutrients and nutrition related diseases. There were only 61.4% of them who knew about the health risks of iron deficiency, and about 40% of them knew the cause and prevention of anaemia. These figures were much worse for vitamin A, with only 54.7% mothers could give the importance of vitamin A, only half of them knew the cause and prevention of vitamin A deficiency. In addition, almost haft of women did not know the health problems and the causes of overweight and obesity (HealthBridge Foundation of Canada, 2015).

2.3.4 Nutrition intake and eating habit

2.3.4.1 Dietary diversity

Based on the 24-hour dietary recall, children consumed average 3.7 food groups out of 7 food groups recommended by FAO. Almost sixty percent of children reached Minimum Dietary Diversity in both wet and dry seasons (HealthBridge Foundation of Canada, 2015).

Grains, other starchy foods and fruits were the most commonly consumed foods of all children, with the average consumed quantities per day were 300g of grains and other starchy food, 56.6g of fruits (HealthBridge Foundation of Canada, 2015). In addition, except for only vitamin A rich dark leafy vegetables, other vegetables as well as legumes, nut and eggs were less likely to be consumed by all children, with the average consumption were 22.75g, 1.8g, 33.1g, 28.6g respectively (HealthBridge Foundation of Canada, 2015).

Moreover, one third of consumed foods came from the family gardens, and the other two third were bought. There were 68.4% consumed nuts and seeds, 84% vitamin A rich fruits and vegetables from family production. Only 3% of foods were collected from the wild in the wet season, and this figure in the dry season was only 1% (HealthBridge Foundation of Canada, 2015).

2.3.4.2 The intake of micro-and macronutrients

On average for both wet and dry season, 95.6% of children met the Estimated Energy Requirement. Although energy from protein and carbohydrate was within the recommendation for Vietnamese people, energy from fat was lower. Moreover, the intakes of vitamin A, folate, iron and zinc did not meet the requirements, otherwise the consumption of Na was seven times more than the recommendation (HealthBridge Foundation of Canada, 2015).

2.3.4.3 Feeding practice

Children received average of 4.7 meals per day, in which 2.6 times for snacks, and 96.9% of meals were consumed at home. However 80% of foods in snacks were sugary products, which contributed to approximately 28% of total energy intake per day (HealthBridge Foundation of Canada, 2015).

2.4 The use of linear programming analysis for local food promotion

2.4.1 Introduction about linear programming analysis

The first method used to design a diet using locally available food was "Trial and error" approach, in which food combinations were repeatedly tried, based on informed guesses. However, this method required multiple backwards steps, manual works, time consuming, more prone to errors and the final results might not be an optimal diet. In addition, this method did not give space for diet modification, such as introduction a new food (Briend, et al., 2003). As the results, linear programming was introduced to solve these problems. It is a mathematical method for determining the optimal outcomes (minimize and maximize) with given certain constraints (Briend, et al., 2003). The calculation of linear programming requires computer technology, and Optifood is recent software introduced by World Health Organization (WHO).

2.4.2 Introduction about Optifood software

Optifood is a computerized tool based on linear programming analysis that can help the users to select the best diet among all possible alternative diets given in the model parameters and identify the need for other complementary nutrition intervention strategies (Daelmans, et al., 2013). This software was developed by the World Health Organization (WHO) incorporated with the London School of Hygiene and Tropical Medicine, the Food and Nutrition Technical Assistance II Project (FANTA-2) and an information technology company (Crampton, 2011).

According to Crampton (2011), Optifood allows users to:

- Formulate food based recommendations
- Based on locally available foods and dietary patterns, Optifood helps to determine nutrient dense foods that are important for improving dietary quality for a given target group.
- Identify key problem nutrients, which refer to nutrients that do not meet at least 70% of the daily recommendation intake for given local food sources and existing dietary patterns. In addition, the software can help the researchers to identify whether inadequate dietary intakes are related to the food selection practices of a target group, which can be solved by

changing consuming behaviour, or due to inaccessibility or unavailability of nutrient-dense food, which need to focus on alternative strategies.

- Test FBRs to determine whether they can help to correct the problem nutrients in the worst-case scenarios on the basis of nutritional adequacy and local budget. As the result, Optifood can develop a set of FBRs that are as close as possible to a nutritional optimal diet for individuals in the target group.
- Compare alternative food-based strategies on the basis of cost and likely reduction in the prevalence of nutrient inadequacies
- Identify the lowest cost nutritionally adequate diet, in which Optifood uses cost data to minimize cost while meeting or coming as close as possible to meet nutrient requirement. This ensures the affordability of the diet for specific target groups.
- Test the possibility to incorporating a new food into current dietary pattern

2.4.3 The application of Optifood

Since the introduction of the first trial, Optifood was used across South America, Africa and Asia, and focused on improving the diet of children and women. Two studies in Guatemala and Peru, 3 studies in Kenya, Ethiopia and Ghana, some studies in South East Asia used Opitfood to determine whether a nutritionally adequate diet could be achieved by using locally available foods, and then identify the key "problem nutrients" (Abizari, et al., 2014; Daelmans, et al., 2013; FANTA, 2014; Ferguson, 2014; Hotz, 2013; Samuel, 2014). In addition, a study in Cambodia used this software to predict whether formulated complementary food products can ensure dietary adequacy for the target population (Skau, et al., 2014).

In Vietnam, Optifood was introduced in the project "Sustainable Micronutrient Interventions to controL deficiencies and Improve Nutritional status and General health in South East Asia (SMILING)" (Tran, 2016). In this project, the diets of breastfed children aged 6-11 months was studied to identify the micronutrient gaps. The results showed that the combination of localunfortified foods could meet the micronutrient requirements of children in Vietnam (Vitta & Dewey, 2012).

2.4.4 Lessons learned during the implement of food-based recommendation

FANTA (2015) conducted a study in Guatemala to validate a set of FBRs developed by Optifood for pregnant, lactating women and children 6-23 months. In this study, the mothers was asked to implement the FBRs in 3 weeks, and then they would participate in 24-hour recall, food frequency questionnaire and interviews to identify perceived difficulties or barriers (FANTA, 2015). In this research, some challenges were reported during the practice of FBRs.

Firstly, the recommended foods were acceptable to mothers but they faced some difficulties to carry out them into practice. It was more feasible to providing children with the recommended quantity of foods rather than adopting the required frequency. In addition, when children refused certain FBR foods, mothers were less likely to consider the encouragement method to develop their children's preference and tended to claim that the children did not like these foods (FANTA, 2015). Moreover, some mothers reported the difficulties to implement the full set of FBRs together. For example, in the context of this research area, providing the children with green leafy vegetables was

more feasible than providing them with micronutrient fortified porridges, because the mothers could access the wide varieties of vegetables in their home garden feasibly (FANTA, 2015).

Secondly, certain beliefs were documented as barriers to practice FBRs. For example, people thought that eggs and/or beans should be introduced for children at the later ages because they could cause some negative effects on children less than a year old (FANTA, 2015).

Another challenge was that although recommended foods were not expensive, in order to put the recommendation into practice, the mothers would need to buy enough these foods for the whole family, which made it more costly than predicted. In addition, it should be taken into account the seasonal variation in food prices, difficulties in accessing and storing fresh food, and the cost and time to go to the markets (FANTA, 2015).

In this study, the influence of grandmothers, mothers-in-law, and husbands had significant impact on the use of recommended foods. It due to the fact that women were less likely to access money in the household, and did not have power to decide the purchase of food items, especially among young mothers living with their husband's families (FANTA, 2015).

In summary, the findings showed that FBRs were acceptable for the target population because they were based on locally available foods. However, to successfully carry them into practice, social and behaviour change strategy need to be considered, as well as the improvement of economic access and family support (FANTA, 2015)

3. METHODOLOGY

3.1 Data sources

This data was obtained from a running project of Bioversity International since 2014 in Mai Son, Son La province of Vietnam. This project is a part of the CGIAR Humidtropics Program, which aims to transform the lives of the rural poor in tropical Americas, Asia and Africa, and Bioversity International is one of core program partners (CGIAR, 2015). All research protocols and questionnaires were developed and evaluated by Bioversity International. Ethical clearance was obtained from Hanoi School of Public Health.

This study site consists of many ethnic groups and Thai people were chosen for this research, because they represented the majority of the population in this area. This is a cross-sectional study with 2 surveys conducted in August- the rainy pre-harvest and November 2014 - post-harvest dry seasons to see the differences in seasonal food availability and consumption at these times (Raneri, et al., 2014).

Women of child-bearing age with a child aged between 12-23 months and their children were eligible for the study. The reason was that the period of 1000 days between a woman's pregnancy and her child's second birthday has a significant impact on child's cognitive and physical development (USAID, 2016). As the result, the appropriate nutrition for the mothers and children during this time can have a significant impact on the children's growth and development and reduce further risk of diseases (USAID, 2016). In addition, the research focused on children between 12 – 23 months as from this age children could consume a more diverse diet and the feeding practices would have an effect on their nutritional status and child survival (Raneri, et al., 2014).

The data about food intake was derived by using a quantitative 24-hour recall from interviews conducted at the house hold level with 400 households in four randomly selected rural and farming communes with clear defined inclusion and exclusion criteria (Raneri, et al., 2014). Twenty five percent of sampled households were randomly selected and re-interviewed on a non-consecutive day to account for intra-personal variation and random error of the measurement of nutrient intake on any one day (Gibson & Ferguson, 2008). The survey was done in two seasons (dry and rainy) to capture seasonal dietary variations. The enumerators were recent graduated from the Son La Medical School who had been trained on the 24-hour recall (Raneri, et al., 2014). The interview was under the supervision of representatives from Bioversity International and researchers from HealthBridge Foundation. In this interview, portion sizes were directly weighed or estimated by using paper cuts, clay models and volume displacement (Raneri, et al., 2014).

Regarding to the anthropometric data, child weight and length were measured by the research team, who recruited from Thai Nguyen University of Pharmacy and Medicine. They were trained to use the equipment and record anthropometric data before participating in the fieldwork (Raneri, 2014). In this training, anthropometric measurements by each collector were verified with those of the supervisor to ensure standardization. In addition, each child's weight was measured twice, by using high-quality electronic scale (precision 0.10 kg). Child length was measured by a wooden board by one trained researcher and one commune health centre staff (Raneri, 2014).

Food cost was obtained from the market prices survey, which took place in the main markets of each commune. Key informant interviews were conducted to record all available foods and the price for each food in each market (Raneri, et al., 2014). The interviews were conducted between the research team and market vendors. The average price would be calculated to arrive at one figure per commune, and then one figure for the district (across the 4 communes) (Raneri, et al., 2014).

3.2 Data analysis

3.2.1 General nutrition status of children

Anthropometric data was processed in Stata 14 and compared with WHO cut-off database to identify the prevalence of underweight, stunting and wasting children (WHO, 2011).

3.2.2 Data preparation for Optifood

Optifood requires 3 main components:

- Data input to Optifood, which was extracted from the outputs of MS Access data preparation program for Optifood
- The food composition table which matches the food items of the data input
- Recommended daily intakes of the target population

3.2.2.1 Data input to Optifood

Raw 24-hour recall intake data was processed in Stata 14. First, the intake data of children was separated from those of other groups. Next, breastfed and non-breastfed children were identified to be analysed separately in Optifood, because breastfeeding could change the nutrient adequacy of the diet and their dietary patterns were found to be different with each other (FANTA, 2014). The children consumed breast milk at least one of observed days would be classified as breastfed children, similarly those who did not consumed breast milk at any observed days would be in non-breastfed group. Third, as the breast milk intake was not measured in the survey, therefore the published average breast milk intake of children aged 12-23 months of developing countries was entered into the dataset (WHO, 1998).

The processed data was imported into MS Access data preparation program following the required format, which included the following mandatory variables: subject identification, observation day, time of consumption, meal number, food name, food code, amount of food in grams. This program allowed assigning food groups and food subgroups corresponding to each food item (see more details in **Appendix 12**). Finally, the output data from MS Access data preparation program was processed to have the extracted table for each target group, which was then imported into Optifood (Wiesmann & Ferguson, 2012).

Data input to Optifood consisted of the following variables:

- Target group details
- List of food items that would be analysed by Optifood
- Food serving sizes corresponding to these food items

- Food frequency (numbers of servings per week) of these food items
- Food cost corresponding to these food items
- Group and subgroup constraints - the constraints at the food group and food subgroup level for the target group's use of food.

3.2.2.1.1 Target group details

- Average weight of each target group was calculated in Stata 14.
- Iron bioavailability: Iron absorption was not measured in this study because there was no simple method to measure iron absorption from the whole diet (FAO & WHO, 2001). Furthermore, FAO and WHO (2001) recommended using an estimate of 5% and 10% iron bioavailability for developing countries. In addition, 2 studies of Hallberg et al. (1977; 1978) indicated that the general iron absorption from South-East Asian diets containing meat and fish was around 5% to 6%. Moreover, children in this research area had high prevalence of iron deficiency (National Institute of Nutrition, 2011). As the results, it was realistic to assume the iron bioavailability of these target groups at 5%.
- Zinc bioavailability: Zinc absorption was also not measured in this study. According to FAO and WHO (2001), zinc absorbed from rural China diets was low, therefore it could be assumed that zinc bioavailability of these target groups was low.

3.2.2.1.2 The food items (see **Appendix 2**)

The purpose of this study was to promote the use of local available food and give the FBRs within the constraints of the existing local dietary patterns (as much as possible). As such, food items consumed by ≥ 5% of the target group was initially included (FANTA, 2014; Skau, et al., 2014). From this list, some food items were excluded before inputting into Optifood:

- Unhealthy food: instant noodles, "empty calories" food, etc.
- Condiments consumed in small amounts
- Condiment vegetables consumed in small amounts
- Foods that were only available in special events, such as mooncakes

3.2.2.1.3 Food serving sizes (see **Appendix 2**)

The values of median observed serving size of each food generated from MS Access data preparation program was used. The MS access outputs gave food servings sizes on a meal basis (g/meal) or on a day basis (g/day). The meal based serving sizes was used because the frequency of food items per day changed significantly which could affect the share of total energy intake. As a result, it was required to represent consumption quantities per meal and thus the food patterns was defined with more precision (FANTA, 2014). A day-basis serving size was only used for breast milk because the intake data of breast milk had been entered based on day basis.

3.2.2.1.4 Food group and food subgroup constraints (see **Appendix 3** and **4**)

The lowest, average and the highest number of servings per week were identified by the 5^{th}, 50^{th}, 95^{th} percentiles consumption of food (sub) groups of the target group (Abizari, et al., 2014). If the 5^{th} and 50^{th} percentile of food (sub) groups were also 0, a value of 1 needed to be entered in the average number of servings in Optifood to make sure that the lowest, average and the highest

number of servings per week differed with each other (Crampton, 2011). “Human milk” and related subgroup was expressed on a daily basis, the others at a meal basis.

3.2.2.1.5 Food frequency of consumption (see **Appendix 2**)

The minimum and maximum numbers of servings per week that each food could be consumed were defined based on food group and food subgroup constraints, as well as taken into account the percentage of children consumed the food.

3.2.2.1.6 Food cost (see **Appendix 2**)

The data of market price survey was used. The raw data was calculated to obtain the cost per 100 g of the edible portion for each food.

3.2.2.2 The food composition table

Nutrient content in food varies depending on regional environment due to the difference in feed, soil, climate and farming practices (FAO, 2015). In addition, genetic resources and processing methods influence significantly in the nutrients profile of food, in which nutrient values may vary up to 1000 times among different varieties of the same food or reduce dramatically after certain type of cooking (FAO, 2015). Moreover, the difference of consumption patterns and preferences can result in country-specific foods and recipes, with the same brand-name but the nutrition composition can vary due to the taste or fortification regulation in each country (FAO, 2015). As the results, to give the reliable results, it is important to incorporate the food composition table closest to Vietnamese culture.

For the purpose of this study, a food composition table was created under the format for Optifood import, which included food name in both English and local name, food group, food subgroup, country, sources of reference, energy and the list of nutrients (protein, water, fat, carbohydrate, Ca, Fe, Zn, vitamin C, B1, B2, B3, B6, folic, B12, vitamin A- Retinol Equivalents, vitamin A- Retinol Activity Equivalents).

The Vietnamese food composition table (Ministry of Health, 2007) was used as a starting point to complete the Optifood FCT. For the missing data, the following tables were consulted and values were inputted (in this order):

- SMILING food composition table for Vietnam, Laos, Thailand, Cambodia, Indonesia
- ASEAN food composition table
- Other food composition tables (Ex.: Japan, Korea, etc.)
- USDA food composition database

Regarding to food items whose nutritional values were not available in those databases, similar foods were used to fill in the gaps. If there were the nutritional values for raw foods but not for cooked foods, these cooked and processed foods were calculated by retention factors (USDA, 2007).

3.2.2.3 Dietary references

The latest version of Recommended Nutrient Intakes (RNIs) for Vietnamese population was published in 2013 and is currently being updated by the Vietnam National Institute of Nutrition to

be published by 2016. As such, the current published Vietnamese recommendation (2013) was out of date at the time when we conducted this study and it was decided that therefore the RNIs of WHO (2001) for children aged 1-3 years would be used in Optifood.

3.2.3 Data analysis in Optifood

3.2.3.1 Module 1: Check diets

After inserting the prepared data into Optifood for each target group, module 1 was run to check any validation errors in the input data prior to start the analysis, which ensured the sufficient flexibility in food choices for modelling diets (Crampton, 2011).

3.2.3.2 Module 2: Identify draft recommendations

According to FANTA (2014), this module gave the two best diets for the target population given the dietary constraints, which were:

- Food pattern optimized diet (FP diet): A diet that followed average food pattern (median portion size and serving frequency) which came as close as possible to meet recommended nutrient intakes while adhering to the actual average dietary patterns as much as possible
- Non-food pattern optimized diet (NFP diet): A diet that came as close as possible to meeting the target population's RNIs, without taking the actual average dietary patterns into account.

This analysis helped identifying the best food items and subgroup sources of nutrients, which would be a basis to formulate draft food based recommendation in Module 3 (FANTA, 2014). Moreover, the results from this Module were used to identify problem nutrients for which the optimized diets could not achieve 100% of RNIs. This meant that the nutrient requirements were difficult to achieve by only using local food sources within given dietary patterns (Ferguson, 2014).

3.2.3.3 Module 3: Test draft FBRs

The Module 3 was first run without adding any FBRs into the current dietary pattern. This module generated 34 diets, which included 17 maximized diet and 17 minimized diets. In a maximized diet, food and food (sub) group were arranged within the food item/subgroup/group constraints to achieve the highest intake of a specific nutrient, termed as best-case scenario. On the other hand, worst-cases scenario was defined as the opposite site, meaning that food and food (sub) group were arranged to achieve the lowest intake of a specific nutrient (Crampton, 2011; FANTA, 2014).

This step was crucial to classify the type of problem nutrients (Ferguson, 2014). Absolute problem nutrients were defined as nutrients, which could not achieved 100% RNIs in the best-case scenarios (Crampton, 2011). This meant that for this target group, these nutrients would more likely remain inadequate with the modelled given local foods and the current dietary patterns (included in the list) (FANTA, 2014). On the other hand, if nutrients reached 100% RNI in the in the best-case scenarios but remained 70% RNI in the worst-cases scenarios, these nutrients would be classified as partial problem nutrients (Crampton, 2011). It resulted in the fact that the dietary approach could possibly improve the intake quantity of this nutrient in the diets and it would be the target for developing the food-based recommendation (FBRs) (Ferguson, 2014).

From these results, this module helped to test and compare alternative sets of FBRs in terms of nutrient contents and cost of the diets. This provided an idea on whether the incorporating of certain type of foods or food (sub) groups could help to improve the nutrient content of the worst-case scenarios or not. It was due to the fact that the worst-case scenario represented the lower tail of the nutrient intake distribution (approximately the 5^{th} percentile), therefore improving worst-case scenarios could ensure the prevalence of inadequacy in the target group was no more than 2-3% (FANTA, 2014). To consider as nutrient adequacy, a particular FBR or a set of FBRs should cover at least 70% RNIs of the partial nutrients. This cut-off was well accepted by other studies using Optifood (FANTA, 2014; Skau, et al., 2014).

According to FANTA (2014), food-based recommendation would be done following three stages:

3.2.3.3.1 Stage 1 (Formulate the FBRs):

This stage would follow 5 steps to ensure a practical and affordable set of FBRs for each target group, while ensuring that these FBRs of both target groups was as similar as possible to each other to facilitate future application.

- Step 1: Identifying individual draft FBRs which were the recommendation of one type of foods or food (sub) groups (for example: the recommendation of 7 servings of dairy products per week) based on the results of Module 2. In this step, individual FBRs were chosen systematically following the order below (food group level-food subgroup level-food item level), because it gave the target groups more flexibility for choosing foods at food group level rather than food subgroups and food items.
    - The same food groups in the optimized diets of both target groups would be chosen and set at the maximum constraints corresponding to each target group. Each FBR would be run individually in the Module 3. The results of Module 3 would be analysed to know which nutrients of the worst-case scenarios met at least 70% RNIs.
    - After this analysis, if all these FBR at food group level could not cover 70% RNIs of certain nutrients, another individual FBRs would be formulated based on the same food subgroups in the top three nutrients sources of both target group (see more details in **Table 4.6**). These food subgroups would be set at the maximum constraints corresponding to each target group and run individually in the Module 3. These results were also analysed to know whether the nutrients of the worst-case scenarios met at least 70% RNIs.
    - The further steps would be repeated for food items if there were still nutrients that did not meet 70% RNIs from above FBRs.
    - Finally, the individual FBRs covering 70% RNIs of the most partial problem nutrients would be chosen for the combination in step 2. This selection would ensure that the combination in step 2 could reach the requirement of all partial problem nutrients with the simplest combination.
- Step 2: Combining individual FBRs to formulate the draft set of FBRs, which could cover 70% RNIs of all partial problem nutrients. The individual FBRs chosen in step 1 would be tested in combination with each other via Module 3 to produce a set of two or more FBRs.

The best set of FBRs was chosen on the basis of nutrient requirement (covering 70% RNIs of all partial problem nutrients) and cost, but also other considerations, for example simplicity/feasibility.

3.2.3.3.2 Stage 2 (confirming the nutritional importance of each individual FBR in the set of FBRs)

In this stage, each FBRs was removed individually from the entire set of FBRs and analysed in Module 3. This stage was done to see whether the removal of any FBRs could result in the reduction of the nutrients, which met 70% RNI in the worst-case scenarios. If the removal of individual FBRs did not cause the reduction of nutrients meeting 70% RNIs in the worst-case scenarios, then this individual FBRs would be left out of the combination.

3.2.3.3.3 Stage 3 (Finalizing the set of FBRs)

In this step, the number of servings of individual FBRs could be adjusted to create the final set of FBRs for each target group. These final FBRs of each target group should be as similar as possible to each other to facilitate future promotion, as well as these recommendation should be practical and affordable while ensuring the nutrient adequacy for each target group.

4. RESULTS

4.1 Characteristics of respondents

There were 52 breastfed children and 366 of those who were not breastfed. In both target groups, the number of male children was slightly higher than those of female children, with male children (53.8% and 51.6%) and female children (46.1% and 48.3%) for breastfed and non-breastfed children respectively. Average weight of breastfed children was 9.24 ± 0.14 g, and this figure of non-breastfed children was 10.13 ± 0.06 g.

There were 13% of underweight, 42.5% of stunting and 1% of wasting children. Among breastfed children, the prevalence of underweight and stunting was 14%, 46% respectively, and there was no wasting in breastfed children. Regarding to non-breastfed children, 12.8%, 42% and 1.1% of children were underweight, stunting and wasting respectively.

4.2 Current food patterns

There were 180 and 369 food items reported by breastfed and non-breastfed in the surveys respectively. The difference in the number of foods recorded was that the sample size of breastfed children was smaller than those of non-breastfed children. For this reason, the survey could not capture as much food diversity in the diet as those of non-breastfed children.

There were 67 food items consumed by more than 5% of both breastfed and non-breastfed children. After excluding condiments, unhealthy foods and foods for special events, 47 and 44 food items was chosen to be included into Optifood for breastfed and non-breastfed children respectively, see more details in **Appendix 5**.

Among excluded items, condiments (ex. spices, sauces, seasoning powder, etc.) accounted for 5.6% and 8.9% of the frequently reported foods for breastfed and non-breastfed children respectively. Regarding to condiment vegetables, which were consumed in small amounts with average serving size 2.22g, they contributed to almost 9% of foods consumed by both breastfed and non-breastfed children. Although ready-to-eat snacks (ex. potato chips) as well as all types of biscuits and cakes were mostly consumed across more than 50% of both target groups, they were not included into the Optifood because these foods were high in calories but lacked in vitamins, minerals and fibres and not good for the growth of children (Ashakiran & Deepthi, 2012). Moreover, instant noodles were consumed by 31% of non-breastfed children and 23% of breastfed children, however it was also excluded because of its negative impact on health (Shin, et al., 2014). In addition, instant rice porridge consumed by 60% and 38% of breastfed and non-breastfed children respectively was not included for further analysis. It was due to the fact that the nutritional value of this product was not available in the referenced food composition table, therefore the nutrition value of similar food made from normal rice could possibly lead to overestimation of the nutrient intakes. Furthermore, instant rice porridge could be substituted by homemade rice porridge which was also widely consumed by the participants and could save up to half of the price of the instant porridge.

Apart from breast milk, which was consumed by all breastfed children, the most five frequently consumed foods were reported similarly across both target groups, which are shown in **Table 4.1**

Table 4.1: The most five frequently consumed foods

Food	% of breastfed children consuming food	% of non-breastfed children consuming food
Rice, sticky, all variety, milled by machine, steamed	96.1	97.3
Milk, cow, whole, sweetened, flavoured	67.3	57.4
Mustard greens, boiled	46.1	43.2
Chicken, egg, whole, boiled	36.5	41
Pig, fat, raw	28.8	37.7

(Source: own work)

There were 3 food groups that were consumed more than two meals per day across two target groups, which were "Grains & grain products", "Meat, fish & eggs" and "Vegetables". On the other hand, "Fruits" and "Legumes, nuts & seeds" were rarely consumed by any of these children, with <10% children consuming them. In the group of "Grains & grain products", "Refined grains and products, unenriched/unfortified" was an only reported food subgroup. In addition, among "Meat, fish & eggs", "Eggs" and "Pork" were the most frequently consumed food subgroups, with about 25% of children consumed eggs and more than 40% of those consumed pork. Moreover, "Vitamin A source dark green leafy vegetables" was the most reported food subgroup of "Vegetables", with approximate 18% children consumed.

The reported median serving sizes varied across all food items but the figures were almost the same among 2 target groups (see more details in **Appendix 5**). The highest median portion sizes were soybean milk and cow milk, with around 150-200ml per meal. Pig fat was consumed at the lowest median serving size, with almost 2g per meal. Turning to breastfed children, the meal-based serving sizes of the most consumed food group "Grains & grain products", "Meat, fish & eggs" and "Vegetables" ranged from 29-76g, 13-86g, 9-74g respectively. Regarding to non-breastfed children, the reported meal-based serving size of "Grains & grain products" was 32-99g, 35-81g for "Meat, fish & eggs" and 8-43g for "Vegetables".

Regarding to food biodiversity, in total of consumed food items, non-breastfed children consumed 113 different species, and this figure almost doubled the one of breastfed children (69 species). Moreover, turning to 67 most frequently consumed foods (by more than 5% consumers), the number of consumed species were reported the same across both target groups, with 29 different species. "Vegetables" and "Meat, fish & eggs" were the most diverse consumed food groups in both target group. Breastfed children consumed 10 species of both "Vegetables" and "Meat, fish & eggs" during the survey, while 7 species of "Vegetables" and 10 species of "Meat, fish & eggs" were found in non-breastfed children's diets. Besides this, there were only 1-2 species reported in "Added fats", "Dairy products", "Grains & grain products", "Legumes, nuts & seeds", "Starchy roots & other starchy plant foods" (see more details in **Table 4.2**).

Table 4.2: Number of consumed species counted in total most frequently consumed foods (by more than 5% children) of both target group[a]

Food group	Breastfed children	Non-breastfed children
	Number of species	Number of species
Added fats	1	1
Composites (mixed food groups)	-	-
Dairy products	1	1
Fruits	7	5
Grains & grain products	1	2
Human milk	-	-
Legumes, nuts & seeds	1	1
Meat, fish & eggs	10	7
Snacks	1	2
Staples	3	3
Starchy roots & other starchy plant foods	1	1
Vegetables	10	10

[a] The blank spaces in this table showed foods that did not have the scientific names to indicate the number of species

(Source: own work)

4.3 Results from Module 1 of Optifood

After inserting the prepared data into Optifood, the module 1 resulted that the analysis was possible with given input, therefore the data was accepted for further analysis.

4.4 Results from Module 2 of Optifood

4.4.1 Weekly food group servings needed to optimize nutritional content of diets

In Module 2, two optimized diets were generated by Optifood, in which one was close to the average food group pattern of the target group and the other might deviate away from the average food patterns but still remain within given food group constraints (Crampton, 2011; FANTA, 2014). The numbers of servings per week of each food group was illustrated in **Table 4.3**.

Table 4.3: Food group patterns (servings/week) selected for the two best diets from Module 2[a]

Group	Breastfed children			Non-breastfed children		
	FP diet[c]	NFP diet[d]	Median[e]	FP diet[c]	NFP diet[d]	Median[e]
Added fats	1	0	1[b]	1	0	1[b]
Composites (mixed food groups)	1	4	1[b]	0	0	0
Dairy products	5	1.8	5	4	7.6	4
Fruits	1	11	1[b]	2	5.5	2
Grains & grain products	14.7	12	18	21	14	21
Human milk	4	2	4	0	0	0
Legumes, nuts & seeds	1	7	1[b]	1	7	1[b]
Meat, fish & eggs	14	25	14	18	22.4	18
Snacks	1	0	5	1	2	7
Staples	15.7	12	23	22	16	25
Starchy roots & other starchy plant foods	1	0	1[b]	1	2	1[b]
Vegetables	11	23	11	14	30	14

[a] The numbers of servings per week were set at meal-based for all food groups except "Human milk" at daily-based
[b] The median was entered with the value of 1 instead of the observed value of 0 for mathematical reasons
[c] FP diet was set closely to the actual average dietary patterns, and in order to achieve RNIs of nutrients of the target groups as much as possible
[d] NFP diet was set to come as close as possible to the target population's RNIs, without taking the actual average dietary patterns into account
[e] The average food pattern was set at the median (or 50th percentile) of each target group

(Source: own work)

Turning first to FP diets, there was a small change in the diet of breastfed children compared to the average food group pattern. In order to make sure the diet come closely to RNIs of breastfed children, it was only required to reduce the number of "Grains & grain products" servings per week from 18 to 14.7 servings. In non-breastfed children, the optimized FP diet was the same as the average dietary pattern. However, it should be noted that although some observed food group servings in both target group was 0, the average consumption was entered into Optifood with the value of 1 for mathematical reasons (Crampton, 2011). Care should be taken to conclude that these average food patterns were acceptable without any changes in the current dietary patterns.

Regarding to NFP diets, these diets were optimized without taking into account the average dietary pattern, therefore many changes in the diet of both target groups were shown. There were the increases in the numbers of servings of "Fruits", "Legumes, nuts & seeds", "Meat, fish & eggs" and "Vegetables" in both target groups. Moreover, the highest increase was reported in "Fruit" group of breastfed children, in which it was recommended to consume 11 servings of fruit per week, while the median consumption was only 1 serving/week.

On the other hand, the numbers of servings for "Meat, fish & eggs" in two target groups increased at the lowest level, from 14 to 25 servings for breastfed children and from 18 to 22.4 servings for those who were not breastfed. Besides these, it was required to increase the servings of "Composites" for breastfed children, and the servings of "Dairy products" and "Starchy roots & other starchy plant foods" for non-breastfed children.

Besides the increased frequency of above the food groups in the NFP diets, some food groups showed a reduction in the number of the servings. First, in both target groups, "Added fats" was not included in the optimized diets. In addition, the numbers of "Grains & grain products" servings decreased by a third. Regarding to the breastfed children, "Dairy products", "Human milk" and "Starchy roots & other starchy plant foods" decreased in the numbers of servings per week.

4.4.2 Food items and subgroup sources of nutrients

Module 2 also generated the list of food items and subgroups, as well as the percentage of RNIs of nutrients, which they contributed to NFP diets. This list was used to identify the food items and subgroups that contributed the most to a certain nutrient.

Among 32 food items in the breastfed children's optimized diet, 18 foods provided at least 5% of a nutrients' RNI. Similarly, 20 of the 28 modelled foods of non-breastfed children were good sources of at least one nutrient which foods contributed for 5% or more. The name of these foods and the number of contributed nutrients are illustrated in **Table 4.4**.

From **Table 4.4**, despite a small difference in the dietary patterns of two target groups, the same 10 food items were the good sources of nutrients (see Food names in bold of **Table 4.4**). In breastfed children, cow milk powder contributed to 8 nutrients of the optimized diet, following by boiled chicken egg with 7 nutrients. On the other hand, boiled chicken egg and flavoured sweetened cow milk contributed the most for total nutrients of NFP diet of non-breastfed children with 8 nutrients. Then, grilled pork was following with 6 nutrients.

Turning to the list of food subgroup (see more details in **Table 4.5**), it could be expected that "Eggs" was the main contributor to 9 nutrients of the optimized diets of both target groups. In addition, "Fluid or powdered milk (non-fortified)" and "Flavoured milk (non-fortified)" contributed the most to 8 nutrients in the optimized diets of breastfed and non-breastfed children respectively.

Table 4.4: Foods providing > 5% of nutrients in the NFP diet of breastfed and non-breastfed children[a]

Breastfed		Non-breastfeed children	
Food names	**Nutrients[b]**	**Food names**	**Nutrients[b]**
Milk, cow, whole, powder	8	**Chicken, egg, whole, boiled**	8
Chicken, egg, whole, boiled	7	Milk, cow, whole, sweetened, flavoured	8
Milk, soybean	7	**Pork, meat only, grilled**	6
Buffalo, meat, average, grilled	6	**Guava, raw**	5
Milk, human	5	**Milk, soybean**	5
Pork, meat only, grilled	5	**Mustard greens, boiled**	4
Mustard greens, boiled	4	**Sauropus, leaves, boiled**	3
Sauropus, leaves, boiled	4	**Rice, sticky, all variety, milled by machine, steamed**	3
Guava, raw	4	Tofu, fried with oil	3
Chicken, egg, whole, fried with oil	4	**Fish, carp, grilled**	2
Fish, mud carp, grilled	3	Pork, meat only, fried with oil	2
Tofu, fried no oil	2	Sweet potato, pale, tuber, long cooked	2
Rice, sticky, all variety, milled by machine, steamed	2	**Mustard greens, leaves, fried with oil**	1
Mustard greens, leaves, fried with oil	1	Bamboo shoot, spring variety, boiled	1
Papaya, ripe, raw	1	Fish, tilapia, grilled	1
Orange, raw	1	Chicken, local breed, meat, average, fried with oil	1
Pomelo, fruit, raw	1	Duck, egg, whole, boiled	1
Fish, carp, grilled	1	Tomato, fried with oil	1
		Duck, egg, whole, fried with oil	1
		Pomelo, fruit, raw	1

[a] Food names in bold showed the same food items which were the good sources of nutrients in both target group
[b] The number of nutrients which certain food contributed to 5% or more

(Source: own work)

Table 4.5: Food subgroups providing > 5% of nutrients in the NFP diet of breastfed and non-breastfed children

Breastfed		Non-breastfeed children	
Food subgroup	**Nutrients[a]**	**Food subgroup**	**Nutrients[a]**
Eggs	9	Eggs	9
Fluid or powdered milk (non-fortified)	8	Flavoured milk (non-fortified)	8
Vitamin A source dark green leafy vegetables	7	Soybeans and products	7
Soybeans and products	7	Fish without bones	6
Pork	6	Vitamin A source dark green leafy vegetables	6
Red meat	6	Pork	6
Breastmilk	5	Refined grains and products, unenriched/unfortified	6
Refined grains and products, unenriched/unfortified	5	Vitamin A source fruit	5
Vitamin A source fruit	4	Other vegetables	2
Fish without bones	4	Other starchy plant foods	2
Vitamin C-rich fruit	3	Poultry, rabbit	1
		Vitamin A source other vegetables	1
		Vitamin C-rich fruit	1

[a] The number of nutrients which certain food subgroup contributed to 5% or more

(Source: own work)

4.4.3 The top three food sources and food subgroups per nutrient

From the share of selected foods and food subgroups in the total nutrients of the NFP diets, the top three food sources and food subgroups which contributed the most to each nutrient of the NFP diet of both target groups were produced in **Table 4.6**. This table and the results of the optimized diets (Module 2) and the worst-case scenario results (Module 3), guided the selection of tested FBRs in Module 3 (FANTA, 2014).

Looking at the top three food items and subgroups per nutrients, in spite of the differences among 2 target groups in **Appendix 6**, there were at least one food item and one subgroup contributing to the same nutrient. These food items/subgroups could be used to formulate a recommendation for both target groups, in order to facilitate the future implementation and adaptation (FANTA, 2014). However, there was no the same food items and subgroups in the top three sources of zinc (see more details in **Table 4.6**). Moreover, although there was "Soybeans and products" in the top three calcium source, there was not the same food items.

Table 4.6: The same food items and subgroups in the top three nutrients sources of both target group

Nutrients	Food subgroups	Food items
Calcium	Soybeans and products	
	Vitamin A source dark green leafy vegetables	
Vitamin C	Vitamin A source dark green leafy vegetables	Sauropus, leaves, boiled
	Vitamin C-rich fruit	Guava, raw
	Vitamin A source fruit	
Thiamine	Pork	Pork, meat only, grilled
Riboflavin	Eggs	Chicken, egg, whole, boiled
Niacin	Pork	Pork, meat only, grilled
	Fish without bones	
Vitamin B6	Pork	Pork, meat only, grilled
	Soybeans and products	Milk, soybean
Folate	Vitamin A source dark green leafy vegetables	Mustard greens, boiled
	Soybeans and products	Milk, soybean
	Eggs	
Vitamin B-12	Eggs	Chicken, egg, whole, boiled
Vitamin A RE[a]	Vitamin A source dark green leafy vegetables	Mustard greens, boiled
	Vitamin A source fruit	Sauropus, leaves, boiled
Vitamin A RAE[b]	Vitamin A source dark green leafy vegetables	Mustard greens, boiled
	Eggs	
Iron	Soybeans and products	Milk, soybean
	Eggs	Chicken, egg, whole, boiled

[a] Retinol Equivalent (RE): 1 RE = 1 µg retinol = 6 µ β-carotene = 12 µg other carotenoids
[b] Retinol activity equivalent (RAE): 1 RAE = 12 µ β-carotene = 24 µg other carotenoids

(Source: own work)

From **Table 4.6**, in both target groups, "Eggs" were in the top three subgroup sources of 5 nutrients (vitamin B2, folate, B12, vitamin A, Fe), following by "Soybeans and products" and "Vitamin A source dark green leafy vegetables" with 4 nutrients. However, "Vitamin C-rich fruit" and "Fish without bones" were the only important source of vitamin C and niacin respectively. Regarding to

food items, almost of food items contributed to the highest share of 3 nutrients, while guava was only in the top three of vitamin C.

4.5 Problem nutrients

From the results of Module 2, % RNI of 2 best diets are illustrated in **Figure 4.1** and **4.2**. These figures were used to identify the problem nutrients, which could not obtain 100% RNIs in both optimized diets.

Turning first to breastfed children (see more details in **Figure 4.1**), 10 nutrients, which were protein, fat, Ca, vitamin C, B1, B2, B3, B6, B12 and vitamin A (RE and RAE), met 100% RNIs in both optimized diets. In addition, folate just achieved 100% RNI in the NFP diet but remained inadequacy in the FP diet with 71.3% RNIs. This meant that some changes in the average dietary pattern of the population are required to reach the requirement of folate, within given frequently consumed local foods and model constraints. Moreover, iron and zinc were nutrients, which could not achieve 100% RNI in both optimized diets. The highest RNIs of iron and zinc obtained in the NFP diet were 74.6% and 84.2%. As the results, iron and zinc were the problem nutrients of breastfed children. This meant that these nutrients could not be met within given frequently consumed local foods and dietary patterns of breastfed children.

Regarding to non-breastfed children (see more details in **Figure 4.2**), protein, B1, B2, B3, B6, B12 and vitamin A (RAE) were 6 nutrients, which achieved 100% RNIs in both optimized diets. In addition, there were 4 nutrients (fat, Ca, vitamin C, folate) could not obtained 100% RNIs in the FP diet, with the % RNI at 81.5%, 58.9%, 92.8% and 72.7% respectively. However, if changing the average dietary pattern of the target group within given frequently consumed local foods and model constraints, these nutrients could reach 100% RNIs, which was shown in the results of NFP diet. Furthermore, the same as breastfed children, iron and zinc were also the problem nutrients, which remained below 100% RNI in both optimized diets. The highest RNIs of iron and zinc obtained in the NFP diet were 84.9% and 83.1%.

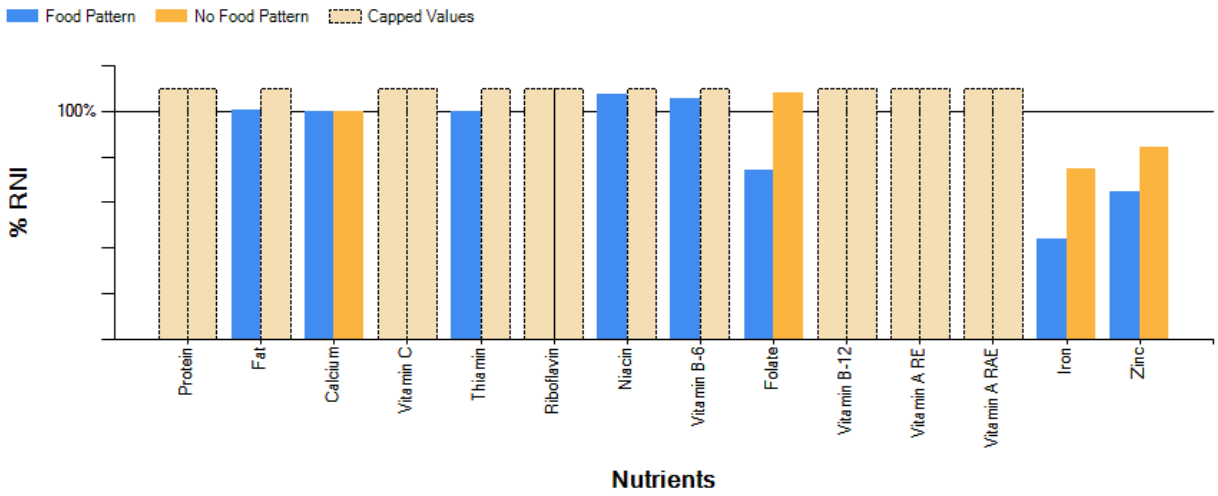

Figure 4.1: % RNI of 2 best diets generated from Module 2 of breastfed children

(Source: own work)

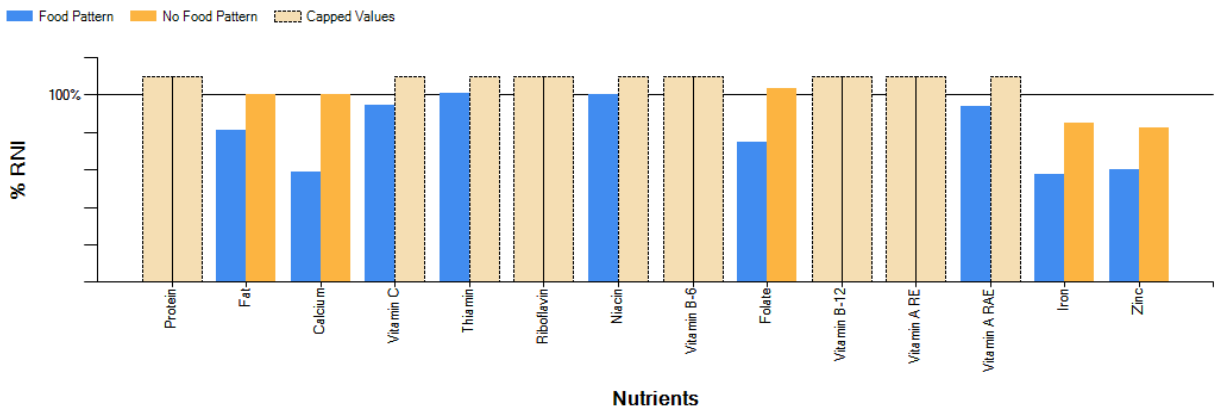

Figure 4.2: % RNI of 2 best diets generated from Module 2 of non-breastfed children

(Source: own work)

In the Module 3, the results of maximized (best-case scenarios) and minimized diets (worst-case scenarios) helped to identify the absolute and partial problems nutrients (see more details in **Figure 4.3** and **4.4**). There were consistent results of two target groups. Iron and Zinc were absolute problem nutrients. It was due to the fact that these nutrients remained below 100% RNIs in the best-case scenarios, with iron (81.4%) and zinc (86%) for breastfed children, iron (90.3%) and zinc (89.7%) for non-breastfed children. On the other hand, fat, Ca, vitamin C, B1, B2, B3, B6, folate, B12 and vitamin A were partial problem nutrients of both target groups. The reason was that these nutrients could achieve 100% RNIs in the maximized diets but remained below 70% RNIs in the minimized diets. As the results, these 10 partial problem nutrients would be the target to develop the food-based recommendation in next steps, because this approach could help to reach the requirement of these nutrients in the worst-case scenarios within given frequently consume local foods and model constraints.

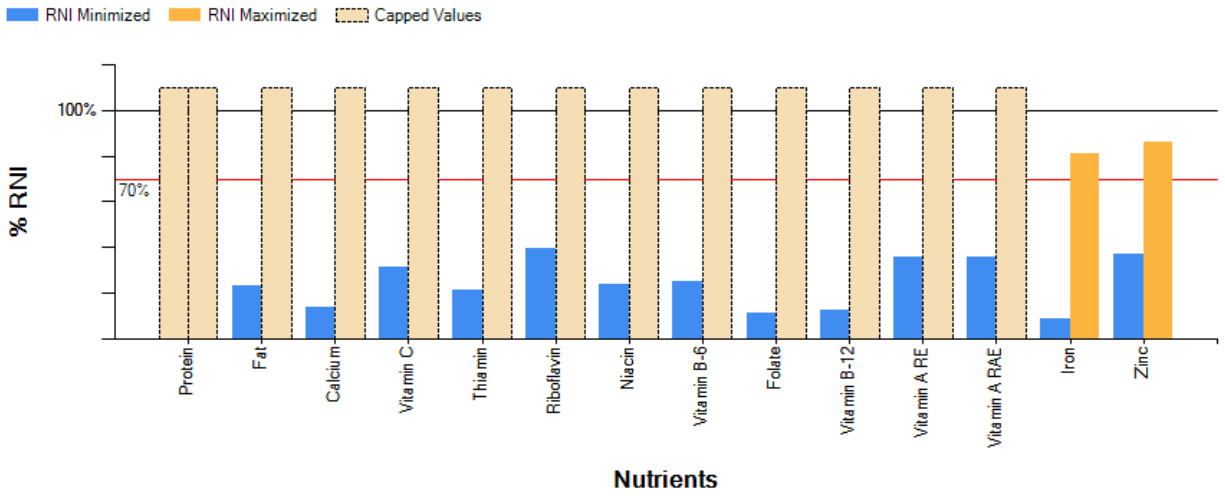

Figure 4.3: % RNI for each nutrient when it was minimized and maximized in the diets of breastfed children

(Source: own work)

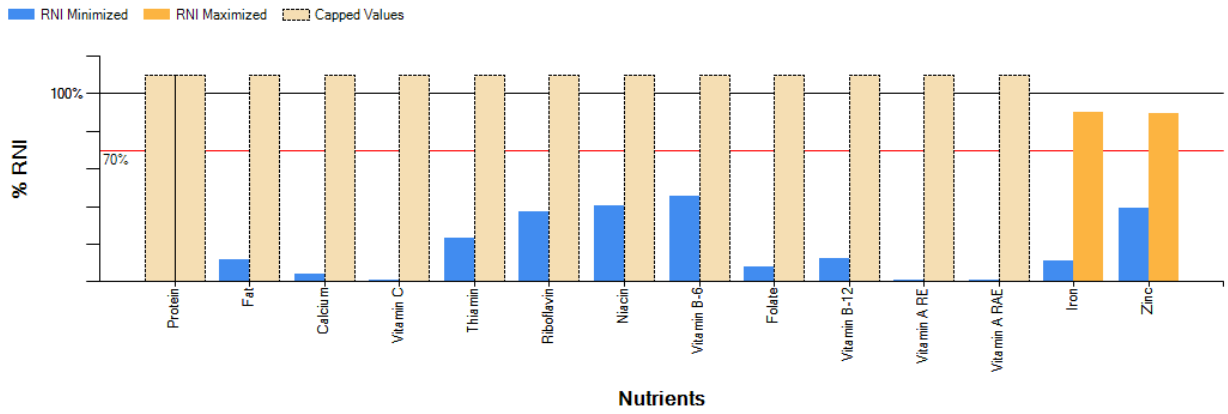

Figure 4.4: % RNI for each nutrient when it was minimized and maximized in the diets of non-breastfed children

(Source: own work)

4.6 Results from Module 3 of Optifood

4.6.1 Stage 1 (Formulate the FBRs)

4.6.1.1 Breastfed children

4.6.1.1.1 Step 1: Identifying individual draft FBRs

13 individual FBRs were chosen systematically and set at the highest model constraints in the first step. The first 7 food groups which were present in the optimized diets of both target groups were selected. They were "Vegetables", "Dairy products", "Fruits", "Grains & grain products", "Legumes, nuts & seeds", "Meat, fish & eggs" and "Starchy roots & other starchy plant foods". Next, because these FBRs could not cover 70% RNIs of vitamin B1, B6 and folate in the worst-case scenarios, 4 food subgroups "Pork", "Soybeans and products", "Vitamin A source dark green leafy vegetables" and "Eggs" of **Table 4.6** were added. Moreover, folate was the only nutrient, which could not be meet from these FBRs of food groups and food subgroups. For this reason, the main food sources of folate (in **Table 4.6**) were included in the list of individual FBRs, which were boiled mustard greens and soybean milk. The raw data is illustrated in **Table A.11** of **Appendix 7**.

From the results of these individual FBRs (see more details **Table 4.7**), 4 FBRs were selected for the further combination in step 2 to create the set of two and more FBRs, which could meet the requirement of all partial problem nutrients. The recommended consumption of dairy products (11 servings/week), and pork (12 servings/week) were first chosen because they could meet 70% RNIs of 3 partial problem nutrients in the worst-case scenarios. Moreover, there were 3 individual FBRs obtaining 2 partial problem nutrients, but only 2 FBRs were chosen for the combination in step 2, which were vegetables (24 servings/week) and eggs (7 servings/week). The recommendation of vitamin A leafy vegetables (17 servings/week) was excluded because it obtained the same nutrients as the recommendation of vegetables, therefore it would be more feasible for application if the recommendation of food group was carried out in the practice rather than recommended food subgroup.

Table 4.7: The results of individual FBRs in Module 3 of breastfed children

FBRs	#Nutrients[a]	Nutrients[b]	Included/excluded in the next step[c]
Dairy products (11 servings/week)	3	Ca, vitamin B2, B12	**Included**
Pork (12 servings/week)	3	Vitamin B1, B3, B6	**Included**
Vegetables (24 servings/week)	2	Vitamin C, vitamin A (RE and RAE)	**Included**
Vitamin A source dark green leafy vegetables (17 servings/week)	2	Vitamin C, vitamin A (RE and RAE)	Excluded
Eggs (7 servings/week)	2	Vitamin B2, B12	**Included**
Boiled mustard greens (11 servings/week)	1	Vitamin A (RE)	Excluded
Fruits (11 servings/week)	1	Vitamin C	Excluded
Meat, fish & eggs (25 servings/week)	1	Vitamin B3	Excluded
Legumes, nuts & seeds (7 servings/week)	0	-	Excluded
Soybeans and products (7 servings/week)	0	-	Excluded
Soybean milk (5 servings/week)	0	-	Excluded
Grains & grain products (30 servings/week)	0	-	Excluded
Starchy roots & other starchy plant foods (2 servings/week)	0	-	Excluded

[a] The number of nutrients were equal or higher 70% RNI in the worst-case scenarios
[b] The name of nutrients were equal or higher 70% RNI in the worst-case scenarios
[c] Whether a certain individual FBR was included or excluded in the next step

(Source: own work)

4.6.1.1.2 Step 2: Combining individual FBRs

In step 2, the individual FBRs were combined with each other to ensure that all partial nutrients of worst-case scenarios would meet 70% RNIs.

Firstly, the set of two FBRs was chosen based on the combination of 4 selected individual FBRs in step 1. These FBRs were combined in couple with each other to see which combination could increase the number of nutrients meeting 70% RNI in the worst-case scenarios. The results showed that there was only 1 combination obtaining the requirement of 7 nutrients, which was the combination of dairy products (11 servings/week) and pork (12 servings/week). As the results, this set of two FBRs was used for further combination (see more details in **Table 4.8**).

Table 4.8: The results of the set of two FBRs in Module 3 of breastfed children

The set of two FBRs		#Nutrients[a]	Nutrients[b]	Included/excluded in the next step[c]
Dairy products (11 servings/week)	Pork (12 servings/week)	7	Fat, Ca, vitamin B1, B2, B3, B6, B12	**Included**
Vegetables (24 servings/week)	Pork (12 servings/week)	6	Vitamin C, B1, B2, B3, B6, vitamin A (RE and RAE)	Excluded
Pork (12 servings/week)	Eggs (7 servings/week)	6	Fat, vitamin B1, B2, B3, B6, B12	Excluded
Dairy products (11 servings/week)	Vegetables (24 servings/week)	5	Ca, Vitamin C, B2, B12, vitamin A (RE and RAE)	Excluded
Dairy products (11 servings/week)	Eggs (7 servings/week)	4	Fat, Ca, vitamin B2, B12	Excluded
Vegetables (24 servings/week)	Eggs (7 servings/week)	4	Vitamin C, B2, B12, vitamin A (RE and RAE)	Excluded

[a] The number of nutrients were equal or higher 70% RNI in the worst-case scenarios
[b] The name of nutrients were equal or higher 70% RNI in the worst-case scenarios
[c] Whether a certain individual FBR was included or excluded in the next step

(Source: own work)

Second, the selected set of two FBRs was incorporated with another individual FBRs to create the set of three FBRs. Moreover, the results of this set showed that folate reached the lowest RNIs (17%) compared to other nutrients in the worst-case scenario, therefore folate was the target to choose individual FBRs. The criteria to select one FBR from the list of individual FBRs in step 1 was that this FBR should reach the highest RNI of folate in the worst-case scenario. In addition, when combining with the set of two FBRs, this FBR should be able to make the set of three FBRs to come as close as possible to 70% RNI of folate in the worst-case scenario. Consequently, the combination of vegetables (24 servings/week), pork (12 servings/week) and dairy products (11 servings/week) was selected. It was due to the fact that this set of three FBRs came closest to meet

70% RNI of folate, and this combination could reach 9 out of 10 partial problem nutrients (see more details in **Table A.12** of **Appendix 7**).

Third, the set of four FBRs was created to meet 70% RNI of folate, which could not be obtained from the set of three FBRs. The criteria for choosing the individual FBRs to be combined was the same as above. At the end, the final combination which could cover 70% RNIs of all partial problem nutrients in the worst-case scenario was selected. Finally, breastfed children aged 12-23 months was recommended to consume 24 meal-base servings of vegetables, 12 meal-base servings of pork, 11 meal-base servings of dairy products and 7 meal-base servings of legumes per week. The improvement of worst-case scenario is illustrated in **Figure 4.5**.

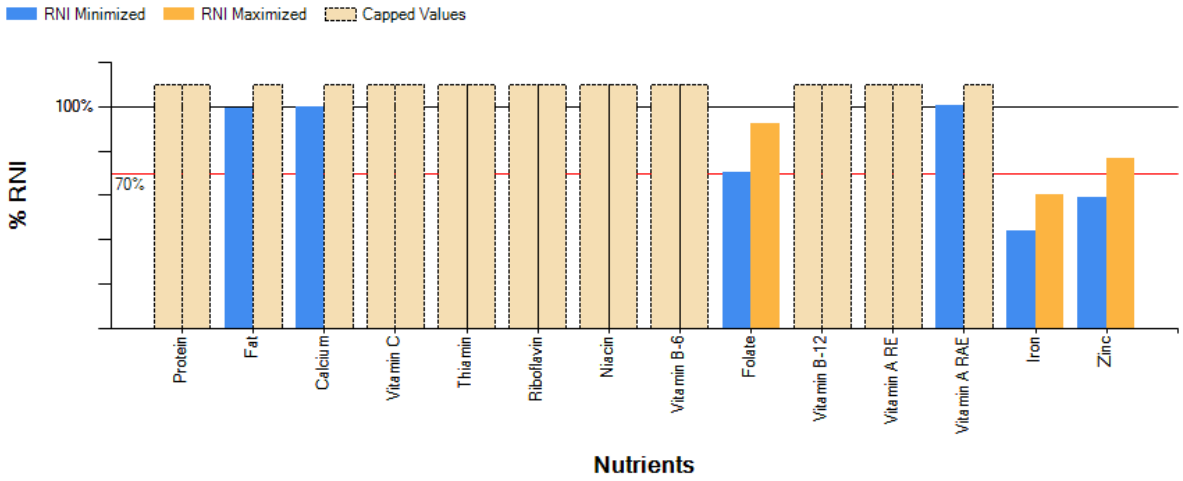

Figure 4.5: The results of maximized and minimized diets when the set of four FBRs in stage 1 was given to breastfed children

(Source: own work)

4.6.1.2 Non-breastfed children

4.6.1.2.1 Step 1: Identifying individual draft FBRs

16 individual FBRs were chosen systematically in this step. Among these FBRs, 7 food groups mentioned in the step 1 of breastfed children were included but set at different constraints corresponding to non-breastfed children. In addition, because these FBRs could not cover 70% RNIs of calcium, vitamin B1 and folate in the worst-case scenarios, therefore 4 food subgroups "Pork", "Soybeans and products", "Vitamin A source dark green leafy vegetables" and "Eggs" of **Table 4.6** were added. However, folate and calcium still did not reach 70% RNIs, therefore flavoured cow milk, boiled chicken egg, boiled mustard greens, soybean milk and fried tofu were added. The raw data is illustrated in **Table A.13** of **Appendix 8**.

These FBRs were run individually in Module 3. Among 7 individual FBRs obtained the highest number of nutrients, two of them were excluded. Firstly, although the recommended consumption of meat, fish & eggs (28 servings/week) could meet 70% RNIs of 4 partial problem nutrients in the worst-case scenarios, this recommendation was excluded. The reasons were that 28 servings of meat, fish & egg with the median serving size 55g/meal were double those in the complementary feeding guideline for Vietnamese children (Ministry of Health, 2015). Moreover, overconsumption

of animal protein in infancy was associated with the risk of overweight and obesity in later childhood (Voortman, et al., 2016). Second, among the FBRs meeting the requirement of 2 nutrients, the recommendation of flavoured cow milk was excluded because it obtained the same nutrients as the recommendation of dairy products, therefore it would be more feasible for application if the recommendation of food group was carried out in the practice rather than recommended food subgroup (see more detail in **Table 4.9**). Finally, 5 individual FBRs were chosen for the combination in step 2.

4.6.1.2.2 Step 2: Combining individual FBRs

In this step, the chosen FBRs in step 1 were combined in couple with each other to see which combination could increase the number of nutrients meeting 70% RNI in the worst-case scenarios. The results showed that there were two sets of two FBRs obtained the requirement of 6 partial problem nutrients in the worst-case scenarios, which were used for further combination (see more details in **Table 4.10**). These combination were below:

- Combination A: Pork (14 servings/week) and vegetables (30 servings/week)
- Combination B: Pork (14 servings/week) and dairy products (11 servings/week)

Second, one more individual FBRs need to be incorporated into these selected sets of two FBRs, to reach as much nutrient requirement as possible. In addition, the results of combination A showed that calcium reached the lowest RNI (15.5%) compared to other nutrients in the worst-case scenario, therefore the addition of calcium-dense food (such as dairy products) was required. On the other hand, folate obtained the lowest RNI (15.2%) in the combination B, hence the incorporation of vegetable was important to improve folate status. As the results, the combination of pork (14 servings/week), vegetables (30 servings/week) and dairy products (11 servings/week) was created. This set of 3 FBRs reached 9 out of 10 partial problem nutrients (see more details in **Table A.14** of **Appendix 8**).

Next, it was required to reduce the number of servings in the sets of three FBRs, in order to allow the incorporation of another individual FBR. It due to the fact that this set of recommendation obtained 100% RNI of energy in the worst-case scenario, therefore Optifood did not allow incorporating more foods. In addition, the reduction should ensure that 9 partial nutrients of the set of three FBRs would not fall far below 70% RNIs. Moreover, because one serving of dairy products was more expensive than those of meat, fish & eggs, therefore decreasing the number of servings of dairy products could reduce significant the total cost of the recommendation. From these criteria, the set of three FBRs was accepted with pork (14 servings/week), vegetables (30 servings/week) and dairy products (9 servings/week) (see more details in **Table A.14** of **Appendix 8**).

Furthermore, the new set of three FBRs was incorporated with another individual FBRs to create the set of four FBRs. Moreover, the results of this set showed that folate reached the lowest RNI (41.1%) compared to other nutrients in the worst-case scenario, therefore folate would be the target to choose individual FBRs. The criteria to select the individual FBRs was the same as those of breastfed children. Consequently, the results showed that the combination of pork (14 servings/week), vegetables (30 servings/week), dairy products (9 servings/week) and legumes (7

servings/week) could increase % RNI of folate but not reach 70% RNI in the worst-case scenarios (see more details in **Table A.14** of **Appendix 8**).

Table 4.9: The results of individual FBRs in Module 3 of non-breastfed children

FBRs	#Nutrients[a]	Nutrients[b]	Included/excluded in the next step[c]
Meat, fish & eggs (28 servings/week)	4	Vitamin B2, B3, B6, B12	Excluded
Pork (14 servings/week)	3	Vitamin B1, B3, B6	**Included**
Fruits (11 servings/week)	2	Vitamin C, B6	**Included**
Vegetables (30 servings/week)	2	Vitamin C, A (RE)	**Included**
Dairy products (11 servings/week)	2	Vitamin B2, B12	**Included**
Eggs (11 servings/week)	2	Vitamin B2, B12	**Included**
Milk, cow, whole, sweetened, flavoured (11 servings/week)	2	Vitamin B2, B12	Excluded
Vitamin A source dark green leafy vegetables (16 servings/week)	1	Vitamin A (RE)	Excluded
Boiled chicken egg (6 servings/week)	1	Vitamin B2	Excluded
Legumes, nuts & seeds (7 servings/week)	0	-	Excluded
Soybeans and products (7 servings/week)	0	-	Excluded
Boiled mustard greens (10 servings/week)	0	-	Excluded
Soybean milk (4 servings/week)	0	-	Excluded
Grains & grain products (28 servings/week)	0	-	Excluded
Fried tofu (3 servings/week)	0	-	Excluded
Starchy roots & other starchy plant foods (4 servings/week)	0	-	Excluded

[a] The number of nutrients were equal or higher 70% RNI in the worst-case scenarios
[b] The name of nutrients were equal or higher 70% RNI in the worst-case scenarios
[c] Whether a certain individual FBR was included or excluded in the next step

(Source: own work)

Table 4.10: The results of the set of two FBRs in Module 3 of non-breastfed children

The set of two FBRs		#Nutrients[a]	Nutrients[b]	Included/excluded in the next step[c]
Pork (14 servings/week)	Vegetables (30 servings/week)	6	Vitamin C, B1, B2, B3, B6, vitamin A (RE)	**Included**
Pork (14 servings/week)	Dairy products (11 servings/week)	6	Fat, vitamin B1, B2, B3, B6, B12	**Included**
Pork (14 servings/week)	Fruits (11 servings/week)	5	Vitamin C, B1, B2, B3, B6	Excluded
Vegetables (30 servings/week)	Eggs (11 servings/week)	5	Vitamin C, B2, B6, B12, vitamin A (RE and RAE)	Excluded
Vegetables (30 servings/week)	Dairy products (11 servings/week)	5	Ca, vitamin C, B2, B12, vitamin A (RE)	Excluded
Fruits (11 servings/week)	Dairy products (11 servings/week)	5	Ca, vitamin C, B2, B6, B12	Excluded
Eggs (11 servings/week)	Fruits (11 servings/week)	4	Vitamin C, B2, B6, B12	Excluded
Vegetables (30 servings/week)	Fruits (11 servings/week)	3	Vitamin C, B6, vitamin A (RE)	Excluded
Eggs (11 servings/week)	Dairy products (11 servings/week)	3	Ca, vitamin B2, B12	Excluded

[a] The number of nutrients were equal or higher 70% RNI in the worst-case scenarios
[b] The name of nutrients were equal or higher 70% RNI in the worst-case scenarios
[c] Whether a certain individual FBR was included or excluded in the next step

(Source: own work)

In addition, the set of five FBRs need to be created to meet the requirement of folate, but before that, the reduction of the number of servings in the sets of four FBRs was required to allow more incorporation in Optifood. Moreover, dairy products was reduced in the previous step, therefore pork was chosen for this reduction (see more details in **Table A.14** of **Appendix 8**). Finally, the set of five FBRs could cover 70% RNIs of all partial problem nutrients, and the combination was pork (12 servings/week), vegetables (30 servings/week), dairy products (9 servings/week), legumes (7 servings/week) and fruits (11 servings/week). The improvement of worst-case scenario is illustrated in **Figure 4.6**.

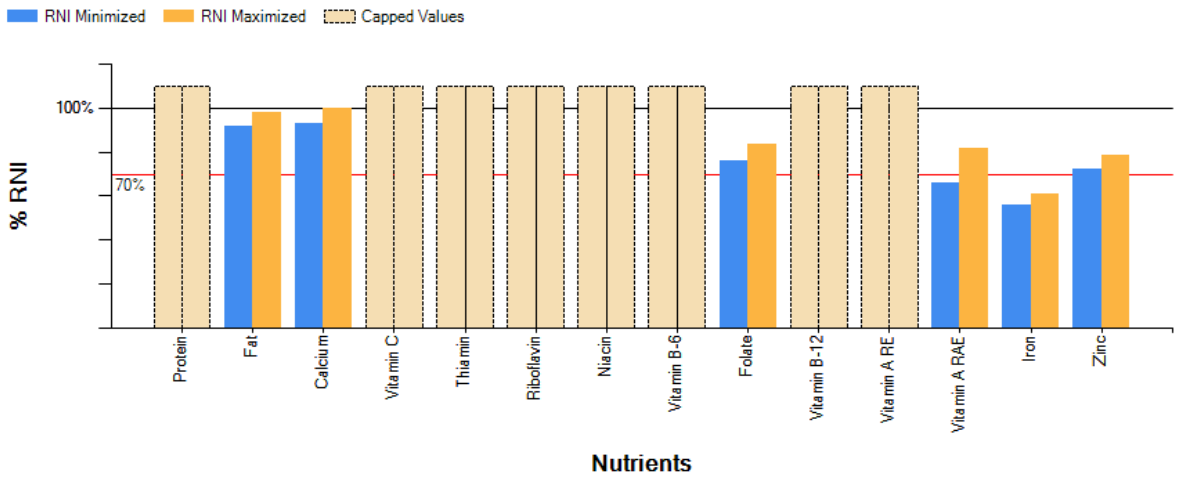

Figure 4.6: The results of maximized and minimized diets when the set of five FBRs in stage 1 was given to non-breastfed children

(Source: own work)

4.6.1.3 Summary of the draft set of FBRs of the two target group in the stage 1

Table 4.11: The draft set of FBRs of the two target group in the stage 1[a]

FBRs	Breastfed children		Non-breastfed children	
	Meal-based servings/week	Median serving size/meal (g)	Meal-based servings/week	Median serving size/meal (g)
Dairy products	11	120	9	174
Vegetables	24	30	30	24
Legumes, nuts & seeds	7	130	7	145
Pork	12	40	12	50
Fruits	-	-	11	70

[a] The blank spaces in this table showed foods that were not mentioned in the recommendation

(Source: own work)

4.6.2 Stage 2 (Confirming the nutritional importance of each individual FBR in the set of FBRs)

The removal of any individual FBRs out of the set of FBRs resulted in at least one nutrient below 70% RNIs in the worst-case scenarios of both target groups (see the summarized results in the **Table 4.12,** and the raw data in **Appendix 9**). For this reason, it was essential to include all these FBRs in the final recommendation. Moreover, this step also figured out which FBRs were the sources of nutrients in the worst-case scenario. This was helpful for further consideration of final recommendation.

Table 4.12: The summarized results of removing each individual FBR out of the set of FBRs in the stage 2 of two target groups[a]

Removed FBRs[b]	Breastfed children		Non-breastfed children	
	#Nutrients <70% RNI[c]	Nutrients <70% RNI[d]	#Nutrients <70% RNI[c]	Nutrients <70% RNI[d]
Dairy products	3	Ca, folate, vitamin B12	3	Ca, folate, vitamin B1
Vegetables	3	Folate, Vitamin C, A (RE and RAE)	1	Folate
Legumes, nuts & seeds	1	Folate	1	Folate
Pork	4	Folate, fat, vitamin B1, B3, B6	3	Fat, vitamin B1, B3
Fruits	-	-	1	Folate

[a] The blank spaces in this table showed foods that were not mentioned in the recommendation
[b] Individual FBRs were removed from the set of FBRs
[c] The number of nutrients were lower 70% RNI in the worst-case scenarios
[d] The name of nutrients were lower 70% RNI in the worst-case scenarios

(Source: own work)

4.6.3 Stage 3 (Finalizing the set of FBRs)

The purpose of this stage was to create the similar recommendation for both target groups while ensuring the practical, affordable and nutritional adequacy for each target group. As non-breastfed was recommended to consume 9 servings of dairy products per week, therefore a reduced number of dairy product servings was done for breastfed children to convey the similar message across two target groups. This led to the small reduction of folate, which was 68.9% RNI but still acceptable compared to other options (see more details in **Figure 4.7** and **Appendix 10**). Regarding to non-breastfed children, to facilitate the practice, it was required to reduce the number of servings of vegetables from 30 to 28 servings/week, and those of fruits from 11 to 10 servings/week. Although this reduction resulted in the decline of folate, which was 67.2% RNI (see more details in **Figure 4.8** and **Appendix 10**). The decreases in the number of servings of other FBRs in two target groups were not possible due to the negative effect on nutrient adequacy in the worst-case scenario, which fell far below 70% RNI. The final recommendation is illustrated in **Table 4.13**.

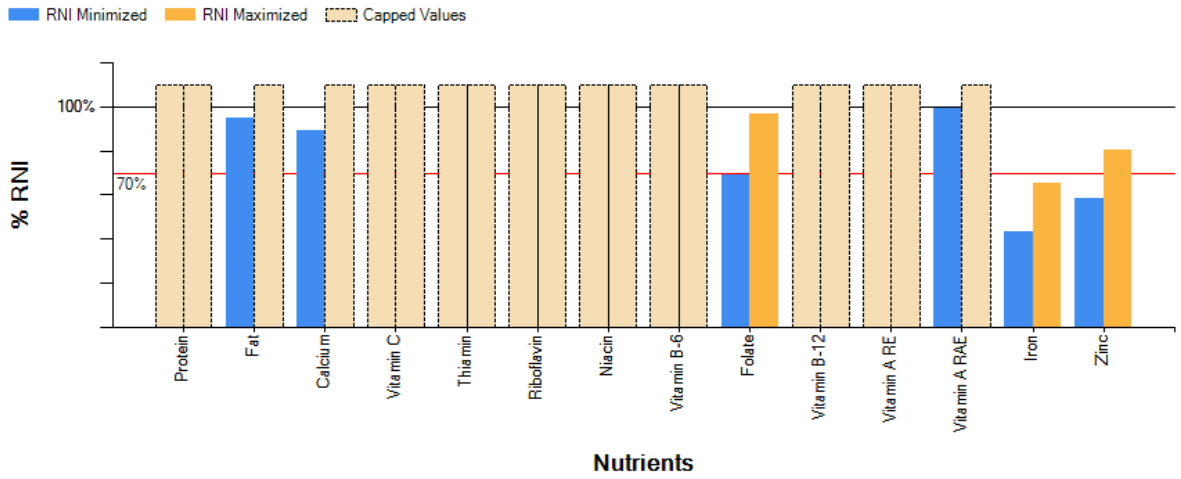

Figure 4.7: The results of maximized and minimized diets when the final set of FBRs in stage 3 was given to breastfed children

(Source: own work)

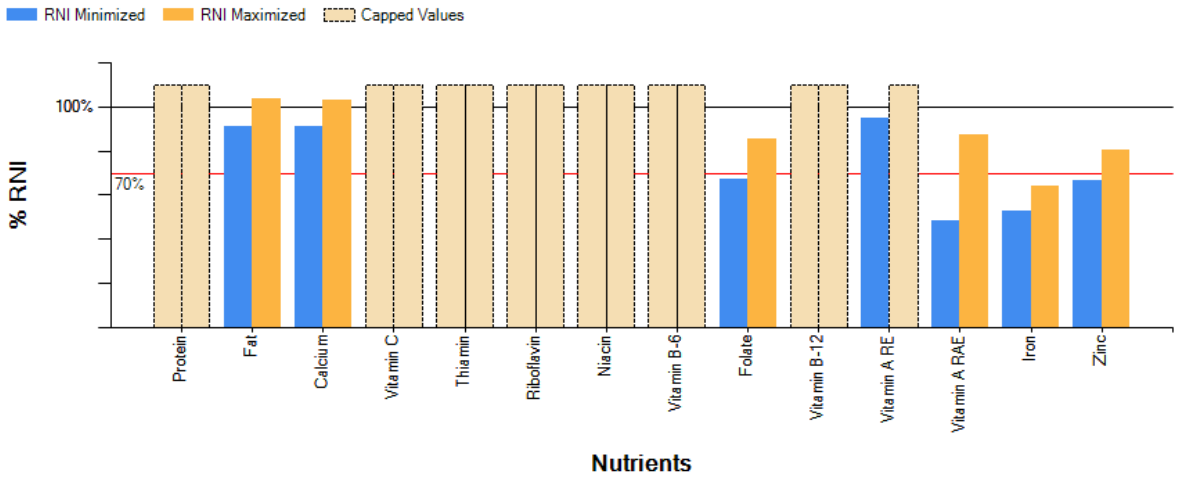

Figure 4.8: The results of maximized and minimized diets when the final set of FBRs in stage 3 was given to non-breastfed children

(Source: own work)

The final recommendation could be summarized as below (see more details in **Table 4.13**):

- The common messages across both target groups:
    - Consume 1-2 servings of dairy products every day
    - Consume 3-4 servings of vegetables everyday
    - Consume 1 servings of legumes, nuts & seeds everyday
    - Consume 1-2 servings of pork everyday
- In addition to non-breastfed children: consume 1-2 servings of fruits everyday

Table 4.13: The final recommendation in stage 3 of both target groups

FBRs	Breastfed children		Non-breastfed children	
	Meal-based servings/week	Servings/day	Meal-based servings/week	Servings/day
Dairy products	9	1-2	9	1-2
Vegetables	24	3-4	28	4
Legumes, nuts & seeds	7	1	7	1
Pork	12	1-2	12	1-2
Fruits	-	-	10	1-2

[a] The blank spaces in this table showed foods that were not mentioned in the recommendation

(Source: own work)

4.7 Other options of FBRs for both target group

The final FBRs of stage 3 were created systematically to obtain the simplest message across both target group. These FBRs consisted of the recommendation of 4 food groups ("Dairy products", "Vegetables", "Legumes, nuts & seeds" and "Fruits"), and "Pork", which was an only included food subgroup. In addition, to obtain the nutrient adequacy, pork should be consumed everyday with 1-2 servings, and this could limit the future application in terms of the feasibility. As the results, it was required to have other options for FBRs. This step was useful to inform future decisions with stakeholders regarding the most suitable set of FBRs to promote in this research area.

During the developing of FBRs in **section 4.6**, the inclusion of animal-based proteins was important to meet 70% RNIs of partial problem nutrients in the worst-case scenarios. However, the recommendation of "Meat, fish & eggs" required either high frequency per week or inclusion of other food items/subgroups/groups to meet the nutrient adequacy. For this reason, the second recommendations were given to incorporate the most consumed subgroups of "Meat, fish & eggs", which were "Pork", "Egg", "Poultry, rabbit" and "Fish without bones", in order to enhance dietary variety and the feasibility of choice while ensuring the requirement to meet 70% RNIs of partial problem nutrients in the worst-case scenarios.

The second recommendations were created on the base of final FBRs of stage 3 (called the first recommendation). Moreover, the recommendations ensured the frequency of consumption of "Pork", "Egg", "Poultry, rabbit" and "Fish without bones" was closest to the average dietary consumption. In addition, total consumed amounts of these subgroups did not exceed the recommended amounts for Vietnamese children aged 12-23 months, which was 100-130g/day (Ministry of Health, 2015). From these requirements, the second recommendations for each target group and the results of worst-case scenarios when the second recommendation is given are illustrated in **Table 4.14**, **Figure 9** and **10** (see the raw data in **Appendix 11**).

Table 4.14: The second food-based recommendation for both target groups

FBRs	Breastfed children		Non-breastfed children	
	Meal-based servings/week	Servings/day	Meal-based servings/week	Servings/day
Dairy products	9	1-2	9	1-2
Vegetables	24	3-4	28	4
Legumes, nuts & seeds	7	1	7	1
Fruits	-	-	10	1-2
Meat, fish & eggs	13	1-2	12	1-2
(with the frequency of each subgroup following as below)				
Eggs	4	-	4	-
Pork	5	-	4	-
Poultry, rabbit	2	-	2	-
Fish without bones	2	-	2	-

(Source: own work)

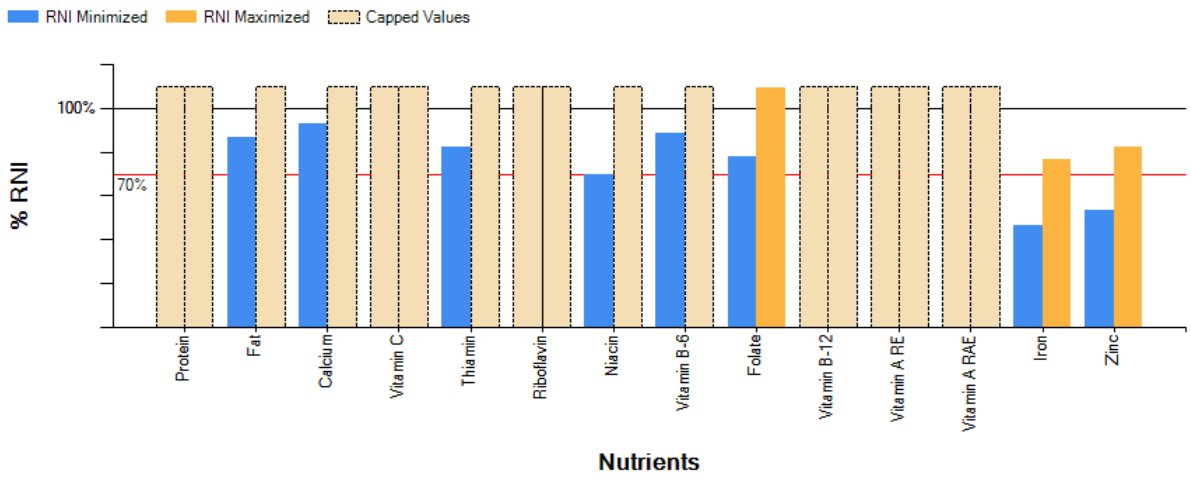

Figure 4.9: The results of maximized and minimized diets when the second FBR was given to breastfed children

(Source: own work)

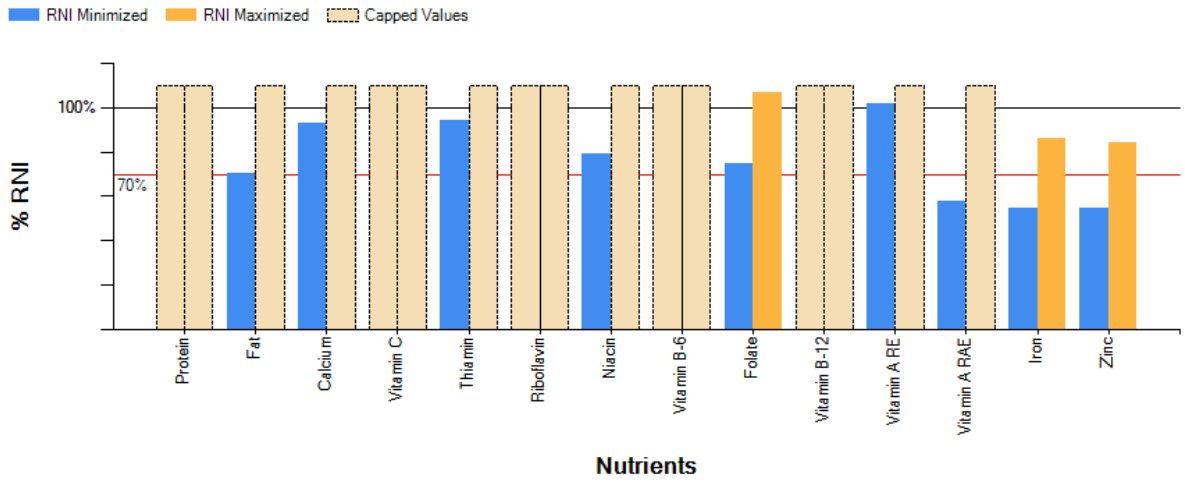

Figure 4.10: The results of maximized and minimized diets when the second FBR was given to non-breastfed children

(Source: own work)

The second recommendation could be summarized as below:

- The common messages across both target groups:
    - Consume 1-2 servings of dairy products every day
    - Consume 3-4 servings of vegetables everyday
    - Consume 1 servings of legumes, nuts & seeds everyday
- In addition to breastfed children:
    - Consume 1-2 servings of meat, fish & eggs everyday with the frequency of each subgroup following as below:
        - Eggs: 4 servings/week
        - Pork: 5 servings/week
        - Poultry: 2 servings/week
        - Fish without bones: 2 servings/week
- In addition to non-breastfed children:
    - Consume 1-2 servings of fruits everyday
    - Consume 1-2 servings of meat, fish & eggs everyday with the frequency of each subgroup following as below:
        - Eggs: 4 servings/week
        - Pork: 4 servings/week
        - Poultry: 2 servings/week
        - Fish without bones: 2 servings/week

4.8 Comparison between the recommendations and the median diets

The first recommendation was developed systematically to ensure nutrient adequacy and lowest cost as much as possible, with simple messages across both target groups. On the hand, the second recommendation was more complex message, but more feasibility of choice and a bit lower cost compared to the first recommendation. Nonetheless, according to **Table 4.15**, the cost of the two recommendations doubled those of median diet. However, when comparing with the cost of optimized diets generated in Module 2 of Optifood, the cost of the recommendations for breastfed children was lower than the cost of FP and NFP diets. Moreover, although the cost of the recommendations for non-breastfed children was higher than the cost of FP diet, this cost was equal to the cost of NFP diet.

The higher cost of the recommendations was due to the fact that the recommendations were set at higher number of frequency compared to the median diet (see more details in **Table 4.16**). The number of servings of "Dairy products", "Vegetables" almost doubled those of median dietary patterns in both target group. In addition, legume and fruits, which were rarely consumed foods in the median diets, were recommended to consume at least one serving per day.

Table 4.15: Comparing the cost of two recommendations with optimized diets and median

	Breastfed children		% median[g]	Non-breastfed children		% median[g]
	Cost (VND/day)	Cost (USD/day)[f]		Cost (VND/day)	Cost (USD/day)[f]	
Recommendation 1[a]	21819	0.98	185%	56672	2.55	193%
Recommendation 2[b]	20677	0.93	175%	55824	2.5	189%
FP diet[c]	26938	1.21	228%	35024	1.57	119%
NFP diet[d]	33804	1.52	287%	56639	2.55	193%
Median diet[e]	11881	0.53	-	29440	1.32	-

[a] The final set of FBRs developed in stage 3 of **section 4.6**
[b] The second recommendation developed in **section 4.7**
[c] FP diet was set closely to the actual average dietary patterns, and in order to achieve RNIs of nutrients of the target groups as much as possible
[d] NFP diet was set to come as close as possible to the target population's RNIs, without taking the actual average dietary patterns into account
[e] The average food pattern was set at the median (or 50th percentile) of each target group
[f] Cost (USD/day) was calculated from cost (VND/day), with 1USD = 22222VND
[g] How much percentage of the cost of a recommendation/diet was higher compared to the median diets

(Source: own work)

Table 4.16: Comparison of median and recommended dietary pattern in both target groups

	Breastfed children			Non-breastfed children		
	Median[a]	**FBR 1[b]**	**FBR 2[c]**	**Median[a]**	**FBR 1[b]**	**FBR 2[c]**
Dairy products (servings/week)	5	9	9	4	9	9
Vegetables (servings/week)	11	24	24	14	28	28
Legume (servings/week)	0	7	7	0	7	7
Fruits (servings/week)	0	-	-	2	10	10
Pork (servings/week)	4	12	5	4	12	4
Eggs (servings/week)	1	-	4	4	-	3
Poultry, rabbit (servings/week)	0	-	2	2	-	2
Fish without bones (servings/week)	1	-	2	4	-	2

[a] The average food pattern was set at the median (or 50th percentile) of each target group
[b] The final set of FBRs developed in stage 3 of **section 4.6**
[c] The second recommendation developed in **section 4.7**

(Source: own work)

5. DISCUSSION

5.1 Compare the results with other studies

5.1.1 General characteristic of the target group

According to the nutrition surveillance in Son La province among children aged 12-23 months, the proportion of breastfed children in this survey was consistent with our results. However, the prevalence of stunting in our study was higher, which was about 42% compared to 33.4% at the province level. Moreover, the prevalence of underweight (13%) and wasting (1%) in the target groups were lower than those of Son La province (19.2 and 7.4%, respectively) (National Institute of Nutrition, 2015b).

5.1.2 Food patterns

The current dietary pattern of the target groups was similar with the findings of two studies using Optifood in ASEAN countries. It could be seen that the reported consumed foods of our target group were 67 different types of food items, which were slightly higher than those reported among Cambodian (60 food items) and Indonesian children (51 food items) (Santika, et al., 2009; Skau, et al., 2014). This small difference could be explained that the target groups in those two studies were at younger age compared to our target group, therefore the dietary diversity was lower. However, in Cambodia, haft of the reported foods were excluded from the linear program models because these foods were either condiments or rarely consumed foods which were eaten only once and were not of high nutrient value (Skau, et al., 2014). On the other hand, only a third of food items were excluded in our study.

Regarding to the most frequent consumed foods, rice was reported as the most common foods consumed across all studies, which could be expected as the dietary pattern of these countries was rice-based (Santika, et al., 2009; Skau, et al., 2014). Moreover, among animal protein foods, most Cambodian infants consumed pork (40%) and this figure was consistent with those in our study (Skau, et al., 2014). However, while more than 35% Cambodian infants consumed fish without bones, this fugure was only about 10% in our target group (Skau, et al., 2014). The difference was also shown in the study of Indonesia, despite the availability of fish, it was not consumed by the children, because mothers thought fish could cause worm infestations (Santika, et al., 2009). Turning to vegetables and fruits, the findings in this study were consistent with the studies in Indonesia and Cambodia. Most vegetables and fruits were consumed by <20% of the children (Santika, et al., 2009), especially fruits were rarely consumed by any children (Skau, et al., 2014).

5.1.3 Food items and subgroups sources of nutrients

Although the difference in dietary patterns of published studies, whole chicken eggs were also reported as one of good sources of nutrients in the study among Guatemalan people. In addition, this study also showed that vegetables were important sources of most nutrients, and this result was consistent with our findings (FANTA, 2014). However, FANTA (2014) reported that fruits were not a main source of any nutrients in the NFP diets. In our study, although fruits did not provide as many nutrients as other food groups, they were a main source of vitamin C and A.

5.1.4 Problem nutrients

The results of other studies using Optifood were consistent with our findings, in which zinc and iron were commonly reported as problem nutrients among children aged 12-23 months across South American, African and Asian countries. Turning first to the study in Guatemala of South America, zinc was a problem nutrient of breastfed children aged 12-23 months but not for non-breastfed children (FANTA, 2014). Moreover, the same results were found in Ethiopia, in which zinc was a critical nutrient for all regions and all target groups, while iron was a problem nutrient for children aged 6-11 months but not for children aged 12-23 months (Samuel, 2014). Another report from Africa showed that the two optimized diets of breastfed children aged 12-23 months could not meet the requirements of Fe and Zn, while they were not problem nutrients in the diets of non-breastfed children (Abizari, et al., 2014). However, a study in Kenya showed that zinc and iron were inadequate in the two best diets of children aged 12-23 months (Hotz, 2013). In Asia countries, our finding was consistent with the study among Cambodian children aged 12-23 months, in which iron and zinc were reported as problem nutrients (Wieringa, et al., 2013).

Despite this consistency with other findings, there were differences in problem nutrients of our results compared with a study on the whole children aged 12-23 months in Vietnam. In this study, the data from the national nutrition survey of Vietnam in 2009-2010 was analysed in Optifood. The result showed that there were no problem nutrients in the optimized diets of children (Ferguson, 2014).

These results could help to explain the highest prevalence of anaemia among children under 5 in the Northern West of Vietnam, which was 43% compared to 29.2% at the national level in 2010 (Ministry of Health, 2010). In addition, the report of Food Fortification Initiative (2015) confirmed the prevalence of iron deficiency anemia in Vietnam was highest in children under 24 months of age. Moreover, this report also figured out that the main reason of anemia was due to low biological value of iron in Vietnamese diet, which was insufficient consumption of iron-rich animal foods as well as high consumption of iron inhibitors. The high prevelence of Zinc deficiency was also mentioned in this report, with the prevelence of 81.2% among chidren under 5 years of age. The reason was similar to iron deficiency, which was low zinc-rich animal sources (Food Fortification Initiative, 2015).

5.1.5 Food-based recommendations

Although the difference in the dietary patterns of Guatemalan and Vietnamese children, the recommendation of FANTA (2014) was similar with our study. Children aged 12-23 months were recommended to consume 4 servings of vegetables, 1 servings of legumes and 1 servings of meat, fish & egg per day. The only one difference was that there was no recommendation for dairy products. It was due to the fact that their recommendation included fortified blended foods, therefore it was not required the addition of dairy products. Moreover, fruits were also not included into the recommendation for Guatemalan children, because fruits was rarely consumed by children (FANTA, 2014).

Comparing with the complementary feeding guideline for Vietnamese children (Ministry of Health, 2015), our recommendations were similar to those guidelines. The guidelines also recommended

the children aged 12-23 months to consume 3-4 servings of vegetables (100-130g/day). Regarding to animal protein, it was recommended to consume 3-4 servings of meat, fish & egg per day with 100-130 g. The frequency of meat, fish & egg consumption was higher than those in our study, however the recommended serving size per day was similar as those of our study. The reason was that median serving size of our target group was about 40-50g/meal, therefore it was reasonable to recommend 1-2 servings of "meat, fish & eggs" per day. The recommendation of fruits was consistent with our study, with 1-2 servings per day (1 serving was about 50-60 g). However, the guideline did not include the recommendation of dairy products for breastfed children. For non-breastfed children, the recommendation was 1-2 servings of dairy products per day (1 serving = 250 ml milk), which was the same as our recommendation (Ministry of Health, 2015).

5.2 Implementation of the findings: advantages and challenges

5.2.1 Strengths of the findings

The strengths of the study were that the recommendation of local foods was created within the observed frequency of servings and based on the most frequently consumed foods. This could ensure the acceptability and sustainability strategies to solve the nutrition problems in this research area. Moreover, the recommendation of food groups or subgroups was chosen instead of specific food items to facilitate the implementation and feasibility.

This study also identified several important food sources for nutrients in the diet of children aged 12-23 months, which could be promoted through agricultural interventions, including increasing production and availability. For this reason, the results can help to strengthen agricultural/nutrition linkages in the government strategies to promote the production and consumption of foods identified in the recommendation.

5.2.2 Challenges of implementation

Firstly, in order to ensure the nutritional adequacy, the recommendations were set at their high constraint levels, which were at their high number of servings per week from food (sub) group according to the target groups' dietary patterns. As the results, adoption of the two recommendations will require a well-designed behaviour change intervention to shift away from the target group's usual consumption patterns.

Second, another challenge is regarding to the cost of the recommended diets, which doubles than those of median consumption in both target group (see more details in **Table 4.15**). In addition, the purpose of the set of FBRs was to stimulate the lower tail of the nutrient intake distribution, in which people mostly were at the bottom of the society, usually suffering the limited household budget. According to the lasted household living standard survey in 2012, monthly income per capita of poorest households at the first and second quintile of the total household income in Son La province were 351000 and 492000VND respectively (General Statistic Office, 2012). However, it should be taken into account the inflation rate since 2012 to 2016 in Vietnam when comparing with the cost of recommendations (which were based on the market survey in 2015). The inflation rate in Vietnam was 9.1% (2012), 6.6% (2013), 4.09% (2014), 0.63% (2015) (The Statistic Portal,

2016). In general, the average cost of recommendations for a children per month (637440VND for breastfed children and 1687440VND for non-breastfed children in 2015), was higher monthly income per capita (average of 421000VND in 2012). For this reason, without any support, these people can hardly adopt the recommendations.

Third, recommendation of dairy products for breastfed children can lead to a challenge in the future. This will result in unintentional promoting the consumption of milk in place of breast milk (FANTA, 2014). However, dairy products were the main contribution of 3 nutrients which were Ca, folate, B12 in the worst-case scenarios (see more details in **Table 4.12**), therefore it was essential to include dairy products into the diet of breastfed children. Moreover, the reduction in the frequency of dairy products in the recommendations will require the addition of other food groups/subgroups/items to reach nutrient adequacy. This can lead to the complex recommendations, which will be difficult to be implemented. As the results, it is required to have appropriate communication with the community when promoting the adoption of the recommendations and emphasizing the importance of continuous breastfeeding up to 2 years old.

Another challenge is that this study emphasized the improvement of all partial problem nutrients in the worst-case scenarios, which represented the lower tail of actual nutrient intake distribution. Moreover, the recommendations were given as simplest messages to the target group as possible, with the recommendations of some specific food groups/subgroups, therefore they did not cover the whole diet approach. Thus, some children at the upper tail of actual nutrient intake distribution, who probably consume a lot of other foods, will be overfed if the recommendations are carried out in the practice. As the results, it is important for the educators to emphasize the balance of the diets when communicating the recommendations to the population, in which the application of the recommendations should combine with the reduction of unhealthy foods (fatty and sugary foods).

These challenges were consistent with those in other studies which promote the use of local foods by linear programming analysis. First, in the study in Guatemala, to ensure the diet provided ≥70% of all micronutrient RNIs, the recommendation should come up with the set of six or seven individual FBRs and set at their highest constraint, this limited the feasibility of the recommendation (FANTA, 2014; Abizari, et al., 2014). Sometimes, the unrealistic diet was developed to meet the requirement of Iron and Zinc, which was required to consume liver everyday (Ferguson, et al., 2006; Vitta & Dewey, 2012). Moreover, FANTA (2014) also confirmed that the recommendation including animal-source foods was relatively expensive. Thus, this study emphazied the need of fortified complementary foods, which could be combined with local foods to obtain nutrient adequacy with more acceptable cost (FANTA, 2014).

5.2.3 Solutions

The studies promoting the use of local foods confirmed that food-based approaches could improve the micronutrient content of diets but they might not ensure dietary adequacy for all nutrients, especially iron, zinc, calcium (Santika, et al., 2009; Skau, et al., 2014; FANTA, 2014; Abizari, et al., 2014; Ferguson, 2014). Some strategies which combine the local foods with micronutrient supplementation or fortified foods can be developed (Santika, et al., 2009; Hotz, 2013; Skau, et al.,

2014; FANTA, 2014). Moreover, well-designed behavior change intervention can be used to successfully promote the recommendation (Santika, et al., 2009; FANTA, 2014; Hotz, 2013)

5.3 Limitations of the study

First, in this study, breastfed children were identified as those who was breastfed in the observed day. This could result in underestimation of the number of breastfed children. It was due to the fact that children who were still breastfed did not consume breast milk in the day of survey, therefore they was classified as non-breastfed children.

Second, there was small sample size of breastfed children aged 12-23 months (52 children). For this reason, the most frequently consumed food might have been missed, and the average dietary pattern might not represent the whole population.

Third, the intake of breast milk was not measured during 24-hour recall survey, therefore the published average breast milk intake of children aged 12-23 months of developing countries was used for all breastfed children in this study. This led to the assumption that all breastfed children consumed the equal amount of breast milk per day, which could result in the overestimation of nutrient intakes in these children.

Fourth, the food frequency tables/questionnaires about the actual number servings of each food group/subgroup/item did not included in the dietary intake survey. As a result, for the purpose of this study, the frequency tables for each food (sub) group and items was estimated from the output tables of MS Access for Optifood preparation. In this program, the assumption that food patterns remained the same over 7 days for each individual was used. Moreover, average serves per food (sub) group were calculated across observation days for each individual and then multiplied by the factor seven before computing the summary statistics in the output tables. This method was applied by some studies using Optifood (Abizari, et al., 2014; Skau, et al., 2014). However, the created number of servings per week did not represent the real frequency of consumption in the population.

Fifth, although almost the nutrition values of the modelled food items were obtained from Vietnamese food composition table, the cooked foods and missing values of some nutrients was filled out from other different food composition databases. As a result, there might be the variation in nutrition content of foods due to the difference in local conditions.

Sixth, some RNIs of nutrients were based on adequate intake estimates, which were vitamin B1, B2, B3 and B6 (FAO & WHO, 2001). These adequate intake values were based on the intakes of healthy population and therefore might overestimate the actual nutrient needs (Skau, et al., 2014). Moreover, the use of international standards might not be appropriate for Vietnamese population.

5.4 Challenges of using Optifood

The software has been still on the trial and not yet released. For this reason, there was limited experienced of researchers and studies using Optifood, hence it was difficult during developing the most appropriate methodology for this study. Furthermore, although Optifood is quite user-friendly

software, the interpretation is quite complex and requires experienced researchers. In addition, Optifood analysis is dependent on model parameters, which are RNIs used, food composition tables, and the dietary data. As a result, it was important to accurately examine the quality of these parameters before analysing.

5.5 Further research

Food-based approaches using only local foods are not a successful way to solve all the nutrition problems in this area, in particular for iron and zinc. However, it is successful for reach other nutrients (protein, fat, Ca, vitamin C, B1, B2, B3, B6, B12, folate and vitamin A). Thus, promotion of local foods in combination with other complementary nutritional interventions such as the promotion of increased consumption of fortified foods can be appropriate approach. This is supported by the new policy issued by Vietnamese government at the beginning of 2016, which required the mandatory fortification of some nutrients in foods. In this policy, zinc and iron, which are the two absolute problem nutrients in this study will be fortified in wheat flour. In addition, salt will be fortified with iodine and vitamin A should be added into vegetable oil (Scaling Up Nutrition, 2016). As the results, in the future research, it is required to update the nutrition value of these foods and other derived products in Optifood, in order to give the most suitable recommendation for the target groups.

In addition, future research should collect the data regarding to the average frequency of consumption each food items, in order to better reflect the real dietary patterns of the target groups. Moreover, the implementation of FBRs in Guatemala revealed that children usually consumed the same foods as other family members, and in order to put the recommendation into practice, the mothers would need to buy enough these foods for the whole family, which made it more difficult to adopt the recommendation than predicted (FANTA, 2015). For this reason, it is required to take into account the dietary pattern of the whole family when giving the recommendation to facilitate future application. Moreover, studies are needed to determine whether the recommendations can be applicable to other districts within Son La province.

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APPENDICES

APPENDIX 1

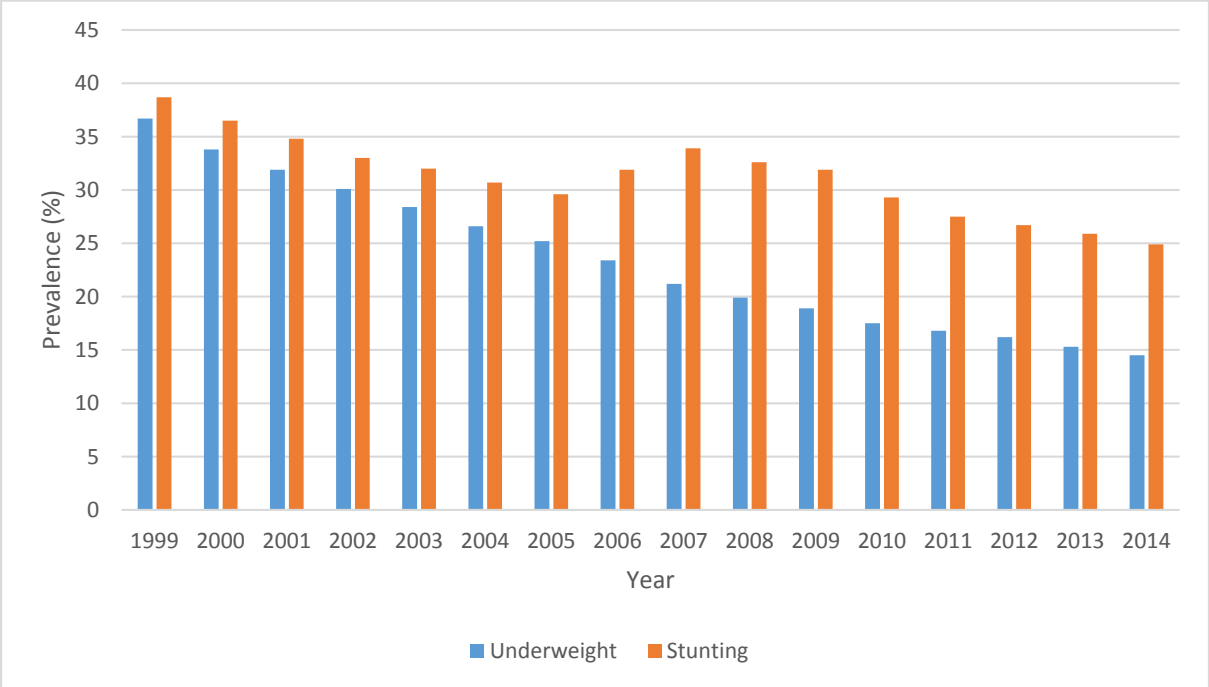

Figure A.1: Undernutrition prevalence of children under 5 in Vietnam from 1999 to 2014

(Source: National Institute of Nutrition, 2015a)

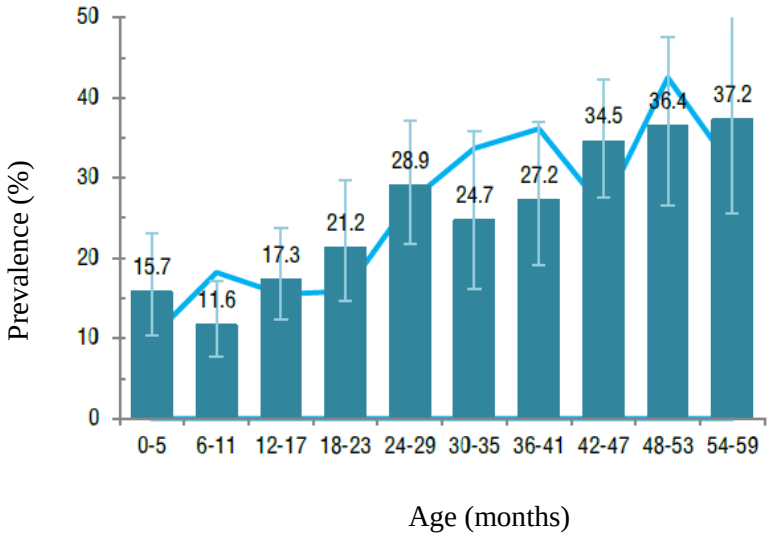

Figure A.2: The prevalence of underweight children below 5 years old at Son La province, Vietnam in 2014

(Source: National Institute of Nutrition, 2015b)

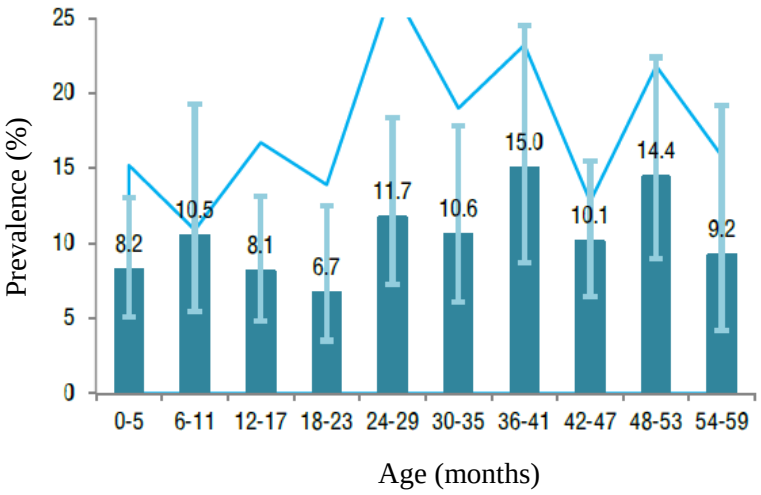

Figure A.3: The prevalence of wasted children below 5 years old at Son La province, Vietnam in 2014

(Source: National Institute of Nutrition, 2015b)

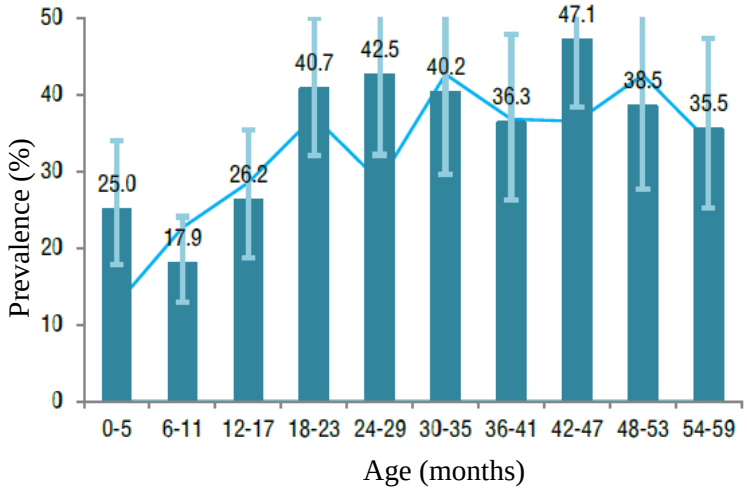

Figure A.4: The prevalence of stunted children below 5 years old at Son La province, Vietnam in 2014

(Source: National Institute of Nutrition, 2015b)

APPENDIX 2

Table A.1: Food lists entered into Optifood: median serving sizes, food frequency, cost per 100 g of the edible portion for non-breastfed children

Food	Serving Size (g)	Min #serves/ week	Max #serves/ week	Cost/ 100g	Snack	Starchy Staple
Bamboo shoot, spring variety, boiled	43.27	0	5	4000	FALSE	FALSE
Banana, common varieties, ripe, raw	78.04	0	2	4615	FALSE	FALSE
Banana, dwarf cavendish, ripe, raw	95.1	0	3	6500	FALSE	FALSE
Bread, French style	43.5	1	3	1333	FALSE	TRUE
Chayote, boiled	40	0	2	5000	FALSE	FALSE
Chicken, egg, whole, boiled	50.75	0	6	803	FALSE	FALSE
Chicken, egg, whole, fried with oil	38.5	0	3	1111	FALSE	FALSE
Chicken, local breed, meat, average, boiled	71.75	0	6	1324	FALSE	FALSE
Chicken, local breed, meat, average, fried with oil	67.04	0	2	1000	FALSE	FALSE
Chicken, local breed, meat, average, grilled	64.74	0	2	2500	FALSE	FALSE
Duck, egg, whole, boiled	54.5	0	1	813	FALSE	FALSE
Duck, egg, whole, fried with oil	39	0	1	2000	FALSE	FALSE
Fish, carp, grilled	56.3	0	2	1000	FALSE	FALSE
Fish, mud carp, deep fried	57.62	0	1	6202	FALSE	FALSE
Fish, mud carp, grilled	54.47	0	2	6202	FALSE	FALSE
Fish, tilapia, fried with oil	50.53	0	2	11000	FALSE	FALSE
Fish, tilapia, grilled	80.84	0	2	11000	FALSE	FALSE
Guava, raw	58	0	4	2300	FALSE	FALSE
Longan, fruit, raw	45	0	1	1500	FALSE	FALSE
Milk, cow, whole, sweetened, flavoured	174.34	0	11	11000	FALSE	FALSE

Food	Serving Size (g)	Min #serves/ week	Max #serves/ week	Cost/ 100g	Snack	Starchy Staple
Milk, soybean	205.41	0	4	8875	FALSE	FALSE
Muscovy, average, boiled	53.95	0	1	1200	FALSE	FALSE
Mustard greens, boiled	21.3	0	10	8875	FALSE	FALSE
Mustard greens, leaves, fried with oil	25.32	0	1	1500	FALSE	FALSE
Noodle, rice, all types, boiled	32.63	0	1	8000	FALSE	TRUE
Orange, raw	61.28	0	2	2333	FALSE	FALSE
Pig, fat, raw	2.89	0	7	4615	FALSE	FALSE
Pomelo, fruit, raw	39.4	0	1	1200	FALSE	FALSE
Pork, meat and fat, boiled	66.67	0	2	5000	FALSE	FALSE
Pork, meat and fat, fried with oil	48.34	0	2	2500	FALSE	FALSE
Pork, meat and fat, grilled	50	0	3	2000	FALSE	FALSE
Pork, meat and fat, steamed	55	0	1	4451	FALSE	FALSE
Pork, meat only, boiled	35.21	0	1	2125	FALSE	FALSE
Pork, meat only, fried with oil	50	0	1	11000	FALSE	FALSE
Pork, meat only, grilled	50	0	4	1324	FALSE	FALSE
Pumpkin, leaves, boiled	13.74	0	2	1300	FALSE	FALSE
Rice, ordinary polished, steamed	98.9	1	3	8000	FALSE	TRUE
Rice, sticky, all variety, milled by machine, long cooked	38.58	1	2	8000	FALSE	TRUE
Rice, sticky, all variety, milled by machine, steamed	85.63	6	19	8000	FALSE	TRUE
Sauropus, leaves, boiled	18.13	0	3	2300	FALSE	FALSE
Sweet potato, pale, tuber, long cooked	54.81	0	2	4000	TRUE	TRUE
Sweetsop, raw	118	0	3	1700	FALSE	FALSE
Tofu, fried with oil	85	0	3	8875	FALSE	FALSE
Tomato, fried with oil	8.25	0	7	500	FALSE	FALSE

(Source: own work)

Table A.2: Food lists entered into Optifood: median serving sizes, food frequency, cost per 100 g of the edible portion for breastfed children

Food	Serving Size (g)[a]	Min #serves/ week	Max #serves /week	Cost/ 100g	Snack	Starchy Staple
Bamboo shoot, fermented, boiled	74.1	0	1	2000	FALSE	FALSE
Bamboo shoot, spring variety, boiled	19.15	0	4	803	FALSE	FALSE
Banana, dwarf cavendish, ripe, raw	62.75	0	2	813	FALSE	FALSE
Beef, bone, all type, long cooked	26	0	5	4000	FALSE	FALSE
Bread, French style	46.4	0	2	2000	FALSE	TRUE
Broth, pork, boiled	51.41	0	4	0	FALSE	FALSE
Buffalo, meat, average, grilled	65	0	5	22000	FALSE	FALSE
Chayote, boiled	26.21	0	2	1000	FALSE	FALSE
Chicken, egg, whole, boiled	48	0	5	6202	FALSE	FALSE
Chicken, egg, whole, fried with oil	52.81	0	2	6202	FALSE	FALSE
Chicken, local breed, meat, average, boiled	61.03	0	4	11000	FALSE	FALSE
Chicken, local breed, meat, average, fried with oil	25.89	0	1	11000	FALSE	FALSE
Fish, carp, grilled	40.42	0	2	6500	FALSE	FALSE
Fish, climbing perch, grilled	83.33	0	1	7000	FALSE	FALSE
Fish, mud carp, grilled	53.8	0	3	4000	FALSE	FALSE
Fish, tilapia, grilled	56.75	0	1	5000	FALSE	FALSE
Guava, raw	36.09	0	4	2500	FALSE	FALSE
Jackal Jujube, raw	44.3	0	2	1200	FALSE	FALSE
Milk, cow, whole, powder	89	0	7	30417	FALSE	FALSE

Food	Serving Size (g)[a]	Min #serves/ week	Max #serves /week	Cost/ 100g	Snack	Starchy Staple
Milk, cow, whole, sweetened, flavoured	153.21	0	11	4451	FALSE	FALSE
Milk, human	549	2	7	0	FALSE	FALSE
Milk, soybean	215.68	0	5	2125	FALSE	FALSE
Muscovy, average, boiled	86.32	0	2	11000	FALSE	FALSE
Mustard greens, boiled	23.98	0	11	1324	FALSE	FALSE
Mustard greens, leaves, fried with oil	28.57	0	1	1324	FALSE	FALSE
Orange, raw	42.5	0	2	2500	FALSE	FALSE
Papaya, ripe, raw	97.21	0	1	1500	FALSE	FALSE
Pig, fat, raw	1.88	0	7	1200	FALSE	FALSE
Pomelo, fruit, raw	27	0	2	1333	FALSE	FALSE
Pork, meat and fat, boiled	40	0	1	8000	FALSE	FALSE
Pork, meat and fat, fried with oil	37.14	0	2	8000	FALSE	FALSE
Pork, meat and fat, grilled	32.37	0	2	8000	FALSE	FALSE
Pork, meat and fat, steamed	25.88	0	1	8000	FALSE	FALSE
Pork, meat only, boiled	71.9	0	1	8875	FALSE	FALSE
Pork, meat only, fried with oil	20.68	0	1	8875	FALSE	FALSE
Pork, meat only, grilled	66.82	0	2	8875	FALSE	FALSE
Pork, meat only, shredded and salted	13.26	0	1	15000	FALSE	FALSE
Pork, meat only, steamed	30	0	1	8875	FALSE	FALSE
Rice, ordinary polished, long cooked	29	0	1	1300	FALSE	TRUE
Rice, ordinary polished, steamed	76.25	0	2	1300	FALSE	TRUE

Food	Serving Size (g)[a]	Min #serves/ week	Max #serves /week	Cost/ 100g	Snack	Starchy Staple
Rice, sticky, all variety, milled by machine, long cooked	51	2	4	2300	FALSE	TRUE
Rice, sticky, all variety, milled by machine, steamed	72.29	5	21	2300	FALSE	TRUE
Sauropus, leaves, boiled	26.05	0	4	500	FALSE	FALSE
Sweet potato, pale, tuber, long cooked	80	0	2	1500	TRUE	TRUE
Sweetsop, raw	92	0	2	2333	FALSE	FALSE
Tofu, fried no oil	42.6	0	2	1200	FALSE	FALSE
Water spinach, boiled	8.88	0	1	250	FALSE	FALSE

[a] Serving sizes were expressed in g/meal for all foods except "Milk, human"

(Source: own work)

APPENDIX 3

Table A.3: Food subgroup constraints entered into Optifood for non-breastfed children

Food subgroup name	Low servings/week	High servings/week
Other added fats	0	7
Flavoured milk (non-fortified)	0	11
Other fruit	0	5
Vitamin A source fruit	0	4
Vitamin C rich fruit	0	7
Refined grains and products, unenriched/unfortified	9	28
Soybeans and products	0	7
Eggs	0	11
Fish without bones	0	9
Pork	0	14
Poultry, rabbit	0	11
Other starchy plant foods	0	2
Other vegetables	0	7
Vitamin A source dark green leafy vegetables	0	16
Vitamin A source other vegetables	0	7

(Source: own work)

Table A.4: Food subgroup constraints entered into Optifood for breastfed children[a]

Food subgroup name	Low servings/week	High servings/week
Other added fats	0	7
Broths	0	4
Flavoured milk (non-fortified)	0	11
Fluid or powdered milk (non-fortified)	0	7
Other fruit	0	4
Vitamin A source fruit	0	4
Vitamin C rich fruit	0	7
Refined grains and products, unenriched/unfortified	7	30
Breast milk	2	7
Soybeans and products	0	7

Food subgroup name	Low servings/week	High servings/week
Eggs	0	7
Fish without bones	0	7
Other animal parts	0	5
Pork	0	12
Poultry, rabbit	0	7
Red meat	0	5
Process meat	0	4
Other starchy plant foods	0	2
Other vegetables	0	7
Vitamin A source dark green leafy vegetables	0	18

[a] The constraints were set at meal-based for all food subgroups except “Breast milk” at daily-based

(Source: own work)

APPENDIX 4

Table A.5: Food group constraints entered into Optifood for non-breastfed children

Food group name	Low servings/week	Average servings/week	High servings/week
Added fats	0	1	7
Dairy products	0	3.5	16
Fruits	0	2.33	10.5
Grains & grain products	9.33	21	28
Legumes, nuts & seeds	0	1	7
Meat, fish & eggs	3.5	17.5	28
Starchy roots & other starchy plant foods	0	1	3.5
Vegetables	0	14	32

(Source: own work)

Table A.6: Food group constraints entered into Optifood for breastfed children[a]

Food group name	Low servings/week	Average servings/week	High servings/week
Added fats	0	1	7
Composites (mixed food groups)	0	1	4
Dairy products	0	5	11
Fruits	0	1	11
Grains & grain products	7	18	30
Human milk	2	4	7
Legumes, nuts & seeds	0	1	7
Meat, fish & eggs	0	14	25
Starchy roots & other starchy plant foods	0	1	2
Vegetables	0	11	28

[a] The constraints were set at meal-based for all food groups except “Human milk” at daily-based

(Source: own work)

APPENDIX 5

Table A.7: List of foods consumed by more than 5% of non-breastfed children

Food	Scientific names	#consumer[a]	% consumer[b]	Meal-based serving size (g)	Removal[c]	Reasons[d]
Rice, sticky, all variety, milled by machine, steamed	Oryza sativa var. glutinosa	356	97.27	85.63		
Seasoning, MSG	-	354	96.72	0.9	x	Condiment
Salt, iodine mix	-	349	95.36	1.27	x	Condiment
Snack, all types	-	235	64.21	10	x	Unhealthy food
Milk, cow, whole, sweetened, flavoured	Bos taurus	210	57.38	174.34		
Spring onion, raw	Allium fistulosum	191	52.19	2.27	x	Condiment vegetable
Mustard greens, boiled	Brassica juncea	158	43.17	21.3		
Chicken, egg, whole, boiled	Gallus gallus domesticus	150	40.98	50.75		
Porridge, rice, instant, boiled	-	138	37.7	50	x	Unhealthy food
Pig, fat, raw	Sus Suidae	138	37.7	2.89		
Ginger, rhizome, raw	Zingiber officinale	120	32.79	1.25	x	Condiment vegetable
Noodle, wheat, instant, boiled with seasoning	-	114	31.15	32.25	x	Unhealthy food

Food	Scientific names	#consumer[a]	% consumer[b]	Meal-based serving size (g)	Removal[c]	Reasons[d]
Chicken, local breed, meat, average, boiled	Gallus domesticus	106	28.96	71.75		
Bamboo shoot, spring variety, boiled	Gigangtochloa spp.	98	26.78	43.27		
Chicken, egg, whole, fried with oil	Gallus domesticus	93	25.41	38.5		
Pork, meat only, grilled	Sus Suidae	89	24.32	50		
Garlic, raw	Allium sativum	67	18.31	0.83	x	Condiment vegetable
Pork, meat and fat, grilled	Sus Suidae	67	18.31	50		
Prickly Ash, leaves, Indian, dried	Zanthoxylum rhetsa	64	17.49	0.15	x	Condiment vegetable
Guava, raw	Psidium guajava	59	16.12	58		
Cake, bun, cream stuff	-	55	15.03	22	x	Unhealthy food
Pork, meat and fat, fried with oil	Sus Suidae	54	14.75	48.34		
Milk, soybean	Glycine max	53	14.48	205.41		
Fish, mud carp, grilled	Cirhina molitorela	51	13.93	54.47		
Sauropus, leaves, boiled	Sauropus androgynus	51	13.93	18.13		

Food	Scientific names	#consumer[a]	% consumer[b]	Meal-based serving size (g)	Removal[c]	Reasons[d]
Chilli, red, ripe	Capsicum frutescens var. microcarpum	50	13.66	0.26	x	Condiment vegetable
Fish, carp, grilled	Cyprinus carpio	50	13.66	56.3		
Rice, ordinary polished, steamed	Oryza sativa	49	13.39	98.9		
Bread, French style	Triticum aestivum	48	13.11	43.5		
Chicken, local breed, meat, average, grilled	Gallus domesticus	47	12.84	64.74		
Sweetsop, raw	Annona murricata	46	12.57	118		
Banana, dwarf cavendish, ripe, raw	Musa acuminata	46	12.57	95.1		
Chicken, local breed, meat, average, fried with oil	Gallus domesticus	42	11.48	67.04		
Chayote, boiled	Sechium edule	41	11.2	40		
Pork, meat and fat, boiled	Sus Suidae	41	11.2	66.67		
Lemon grass, raw	Cymbopogon citratus	40	10.93	1.05	x	Condiment vegetable
Fish, tilapia, fried with oil	Oreochromis mossambicus	40	10.93	50.53		
Mooncake, stuffed with red bean paste	-	39	10.66	70	x	Not available all the time

Food	Scientific names	#consumer[a]	% consumer[b]	Meal-based serving size (g)	Removal[c]	Reasons[d]
Pork, meat only, boiled	Sus Suidae	39	10.66	35.21		
Biscuits, all types	-	38	10.38	20.75	x	Unhealthy food
Duck, egg, whole, boiled	Anas boschas	34	9.29	54.5		
Fish, tilapia, grilled	Oreochromis mossambicus	34	9.29	80.84		
Sugar, granulated	Saccharum officinarum	34	9.29	10.29	x	Condiment
Orange, raw	Citrus sinensis	32	8.74	61.28		
Fish sauce, ready to serve	-	32	8.74	2.81	x	Condiment
Cake, rice, industry cracker	-	32	8.74	17	x	Unhealthy food
Tofu, fried with oil	Glycine max	31	8.47	85		
Chilli, red, hot, powder	Capsicum frutescens	30	8.2	0.12	x	Condiment
Biscuits, trung nhen type	-	30	8.2	29.47	x	Unhealthy food
Banana, common varieties, ripe, raw	Musa	30	8.2	78.04		
Pork, meat only, fried with oil	Sus Suidae	29	7.92	50		
Muscovy, average, boiled	Cairina moschata	28	7.65	53.95		
Candy, fruit flavour	-	28	7.65	11	x	Unhealthy food
Rice, sticky, all variety, milled by machine, long cooked	Oryza sativa var. glutinosa	28	7.65	38.58		

Food	Scientific names	#consumer[a]	% consumer[b]	Meal-based serving size (g)	Removal[c]	Reasons[d]
Duck, egg, whole, fried with oil	Anas boschas	27	7.38	39		
Longan, fruit, raw	Dimocarpus longan	27	7.38	45		
Tomato, fried with oil	Lycopersicon esculentum	26	7.1	8.25		
Pumpkin, leaves, boiled	Cucurbita maxima	25	6.83	13.74		
Sweet potato, pale, tuber, long cooked	Ipomoea batatas	24	6.56	54.81		
Salt, not iodized	-	24	6.56	0.78	x	Condiment
Pork, meat and fat, steamed	Sus Suidae	24	6.56	55		
Wafers, all types	-	23	6.28	23.67	x	Unhealthy food
Mustard greens, leaves, fried with oil	Brassica juncea	22	6.01	25.32		
Pomelo, fruit, raw	Citrus grandis	22	6.01	39.4		
Noodle, rice, all types, boiled	Oryza sativa	20	5.46	32.63		
Sugarcane, whole, raw	Saccharum officinarum	20	5.46	119.21	x	usually used as snack, no nutrient dense
Fish, mud carp, deep fried	Cirhina molitorela	19	5.19	57.62		

[a] Number of children consumed a certain food item
[b] Among all different food items belong to the same food subgroup, these figures showed the percentage of children consumed a certain food item at the level of this subgroup.
[c] Whether a food item was included or excluded from the input of Optifood, “x” meant excluded, blank spaces meant included
[d] The reason why these food items were excluded

(Source: own work)

Table A.8: List of foods consumed by more than 5% of breastfed children

Food	Scientific names	#consumer[a]	% consumer[b]	Meal-based serving size (g)	Removal[c]	Reasons[d]
Milk, human	-	52	100	549		
Rice, sticky, all variety, milled by machine, steamed	Oryza sativa var. glutinosa	50	96.15	72.29		
Seasoning, MSG	-	48	92.31	0.69	x	Condiment
Salt, iodine mix	-	48	92.31	0.92	x	Condiment
Milk, cow, whole, sweetened, flavoured	Bos taurus	35	67.31	153.21		
Snack, all types	-	35	67.31	8	x	Unhealthy food
Porridge, rice, instant, boiled	-	31	59.62	50	x	Unhealthy food
Spring onion, raw	Allium fistulosum	25	48.08	1.67	x	Condiment vegetable
Mustard greens, boiled	Brassica juncea	24	46.15	23.98		
Chicken, egg, whole, boiled	Gallus gallus domesticus	19	36.54	48		
Ginger, rhizome, raw	Zingiber officinale	18	34.62	1.12	x	Condiment vegetable
Pig, fat, raw	Sus Suidae	15	28.85	1.88		
Bamboo shoot, spring variety, boiled	Gigangtochloa spp.	14	26.92	19.15		
Noodle, wheat, instant, boiled with seasoning	-	12	23.08	30.21	x	Unhealthy food
Cake, bun, cream stuff	-	12	23.08	31.07	x	Unhealthy food

Food	Scientific names	#consumer[a]	% consumer[b]	Meal-based serving size (g)	Removal[c]	Reasons[d]
Pork, meat only, grilled	Sus Suidae	12	23.08	66.82		
Garlic, raw	Allium sativum	10	19.23	1.42	x	Condiment vegetable
Pork, meat and fat, grilled	Sus Suidae	10	19.23	32.37		
Rice, sticky, all variety, milled by machine, long cooked	Oryza sativa var. glutinosa	9	17.31	51		
Sauropus, leaves, boiled	Sauropus androgynus	9	17.31	26.05		
Pork, meat and fat, fried with oil	Sus Suidae	9	17.31	37.14		
Fish, mud carp, grilled	Cirhina molitorela	8	15.38	53.8		
Chicken, egg, whole, fried with oil	Gallus gallus domesticus	8	15.38	52.81		
Chicken, local breed, meat, average, boiled	Gallus gallus domesticus	8	15.38	61.03		
Chayote, boiled	Sechium edule	8	15.38	26.21		
Pork, meat only, boiled	Sus Suidae	8	15.38	71.9		
Chilli, red, ripe	Capsicum frutescens var. microcarpum	7	13.46	0.56	x	Condiment vegetable
Fish sauce, ready to serve	-	7	13.46	0.87	x	Condiment
Guava, raw	Psidium guajava	7	13.46	36.09		

Food	Scientific names	#consumer[a]	% consumer[b]	Meal-based serving size (g)	Removal[c]	Reasons[d]
Pork, meat and fat, boiled	Sus Suidae	7	13.46	40		
Prickly Ash, leaves, Indian, dried	Zanthoxylum rhetsa	7	13.46	0.3	x	Condiment vegetable
Sweetsop, raw	Annona murricata	6	11.54	92		
Milk, soybean	Glycine max	6	11.54	215.68		
Banana, dwarf cavendish, ripe, raw	Musa acuminata	6	11.54	62.75		
Pork, meat and fat, steamed	Sus Suidae	6	11.54	25.88		
Milk, cow, whole, powder	Bos javanicus	5	9.62	89		
Fish, carp, grilled	Cyprinus carpio	5	9.62	40.42		
Mooncake, stuffed with red bean paste	-	5	9.62	50.16	x	Not available all the time
Pork, meat only, shredded and salted	Sus Suidae	5	9.62	13.26		
Fish, climbing perch, grilled	Anabas testudineus	4	7.69	83.33		
Beef, bone, all type, long cooked	Bos javanicus	4	7.69	26		
Muscovy, average, boiled	Cairina moschata	4	7.69	86.32		
Pomelo, fruit, raw	Citrus grandis	4	7.69	27		
Orange, raw	Citrus sinensis	4	7.69	42.5		
Lemon grass, raw	Cymbopogon citratus	4	7.69	0.65	x	Condiment vegetable

Food	Scientific names	#consumer[a]	% consumer[b]	Meal-based serving size (g)	Removal[c]	Reasons[d]
Biscuits, all types	-	4	7.69	18.5	x	Unhealthy food
Biscuits, trung nhen type	-	4	7.69	33.39	x	Unhealthy food
Cake, rice, industry cracker	-	4	7.69	42	x	Unhealthy food
Fish, tilapia, grilled	Oreochromis mossambicus	4	7.69	56.75		
Rice, ordinary polished, steamed	Oryza sativa	4	7.69	76.25		
Pork, meat only, fried with oil	Sus Suidae	4	7.69	20.68		
Bread, French style	Triticum aestivum	4	7.69	46.4		
Jackal Jujube, raw	Ziziphus oenoplia	4	7.69	44.3		
Mustard greens, leaves, fried with oil	Brassica juncea	3	5.77	28.57		
Buffalo, meat, average, grilled	Bubalus bubalis	3	5.77	65		
Chilli, red, hot, powder	Capsicum frutescens	3	5.77	0.04	x	Condiment
Papaya, ripe, raw	Carica papaya	3	5.77	97.21		
Coriander, leaves and stem, raw	Coriandrum sativum	3	5.77	3.31	x	Condiment vegetable
Chicken, local breed, meat, average, fried with oil	Gallus domesticus	3	5.77	25.89		
Bamboo shoot, fermented, boiled	Gigangtochloa spp.	3	5.77	74.1		

Food	Scientific names	#consumer[a]	% consumer[b]	Meal-based serving size (g)	Removal[c]	Reasons[d]
Tofu, fried no oil	Glycine max	3	5.77	42.6		
Water spinach, boiled	Ipomoea aquatica	3	5.77	8.88		
Sweet potato, pale, tuber, long cooked	Ipomoea batatas	3	5.77	80		
Wafers, all types	-	3	5.77	36	x	Unhealthy food
Rice, ordinary polished, long cooked	Oryza sativa	3	5.77	29		
Broth, pork, boiled	Sus Suidae	3	5.77	51.41		
Pork, meat only, steamed	Sus Suidae	3	5.77	30		

[a] Number of children consumed a certain food item
[b] Among all different food items belong to the same food subgroup, these figures showed the percentage of children consumed a certain food item at the level of this subgroup.
[c] Whether a food item was included or excluded from the input of Optifood, "x" meant excluded, blank spaces meant included
[d] The reason why these food items were excluded

(Source: own work)

APPENDIX 6

Table A.9: The top three food subgroup sources in ranked order of micronutrients in the NFP diets of two target groups

Nutrients	Breastfed children	Non-breastfed
Calcium	Fluid or powdered milk (non-fortified)	Flavoured milk (non-fortified)
	Soybeans and products	Soybeans and products
	Vitamin A source dark green leafy vegetables	Vitamin A source dark green leafy vegetables
Vitamin C	Vitamin A source dark green leafy vegetables	Vitamin A source fruit
	Vitamin C-rich fruit	Vitamin A source dark green leafy vegetables
	Vitamin A source fruit	Vitamin C-rich fruit
Thiamine	Pork	Pork
	Soybeans and products	Flavoured milk (non-fortified)
	Fluid or powdered milk (non-fortified)	Eggs
Riboflavin	Fluid or powdered milk (non-fortified)	Flavoured milk (non-fortified)
	Eggs	Eggs
	Red meat	Soybeans and products
Niacin	Red meat	Pork
	Pork	Refined grains and products, unenriched/unfortified
	Fish without bones	Fish without bones
Vitamin B6	Soybeans and products	Pork
	Red meat	Soybeans and products
	Pork	Eggs
Folate	Vitamin A source dark green leafy vegetables	Vitamin A source dark green leafy vegetables
	Soybeans and products	Eggs
	Eggs	Soybeans and products
Vitamin B12	Fluid or powdered milk (non-fortified)	Eggs
	Red meat	Flavoured milk (non-fortified)

Nutrients	Breastfed children	Non-breastfed
	Eggs	Fish without bones
Vitamin A RE	Vitamin A source dark green leafy vegetables	Vitamin A source dark green leafy vegetables
	Breast milk	Vitamin A source fruit
	Vitamin A source fruit	Eggs
Vitamin A RAE	Vitamin A source dark green leafy vegetables	Vitamin A source dark green leafy vegetables
	Breast milk	Eggs
	Eggs	Vitamin A source fruit
Iron	Soybeans and products	Soybeans and products
	Eggs	Eggs
	Vitamin A source dark green leafy vegetables	Poultry, rabbit
Zinc	Red meat	Pork
	Fish without bones	Refined grains and products, unenriched/unfortified
	Soybeans and products	Vitamin A source fruit

(Source: own work)

Table A.10: The top three food item sources in ranked order of micronutrients in the NFP diets of two target groups

Nutrients	Breastfed	Non-breastfed
Calcium	Milk, cow, whole, powder	Milk, cow, whole, sweetened, flavoured
	Milk, human	Tofu, fried with oil
	Tofu, fried no oil	Chicken, egg, whole, boiled
Vitamin C	Sauropus, leaves, boiled	Guava, raw
	Guava, raw	Sauropus, leaves, boiled
	Milk, human	Pomelo, fruit, raw
Thiamine	Pork, meat only, grilled	Pork, meat only, grilled
	Milk, soybean	Milk, cow, whole, sweetened, flavoured
	Milk, cow, whole, powder	Pork, meat only, fried with oil
Riboflavin	Milk, cow, whole, powder	Milk, cow, whole, sweetened, flavoured
	Chicken, egg, whole, boiled	Chicken, egg, whole, boiled

Nutrients	Breastfed	Non-breastfed
	Buffalo, meat, average, grilled	Tofu, fried with oil
Niacin	Buffalo, meat, average, grilled	Pork, meat only, grilled
	Pork, meat only, grilled	Rice, sticky, all variety, milled by machine, steamed
	Fish, mud carp, grilled	Pork, meat only, fried with oil
Vitamin B6	Milk, soybean	Pork, meat only, grilled
	Buffalo, meat, average, grilled	Milk, soybean
	Pork, meat only, grilled	Chicken, egg, whole, boiled
Folate	Mustard greens, boiled	Mustard greens, boiled
	Milk, soybean	Chicken, egg, whole, boiled
	Sauropus, leaves, boiled	Milk, soybean
Vitamin B12	Milk, cow, whole, powder	Milk, cow, whole, sweetened, flavoured
	Buffalo, meat, average, grilled	Chicken, egg, whole, boiled
	Chicken, egg, whole, boiled	Duck, egg, whole, boiled
Vitamin A RE	Mustard greens, boiled	Mustard greens, boiled
	Milk, human	Guava, raw
	Sauropus, leaves, boiled	Sauropus, leaves, boiled
Vitamin A RAE	Milk, human	Mustard greens, boiled
	Mustard greens, boiled	Guava, raw
	Milk, cow, whole, powder	Chicken, egg, whole, boiled
Iron	Milk, soybean	Chicken, egg, whole, boiled
	Chicken, egg, whole, boiled	Tofu, fried with oil
	Buffalo, meat, average, grilled	Milk, soybean
Zinc	Buffalo, meat, average, grilled	Pork, meat only, grilled
	Milk, cow, whole, powder	Guava, raw
	Milk, soybean	Rice, sticky, all variety, milled by machine, steamed

(Source: own work)

APPENDIX 7

Table A.11: The results of individual FBRs in the step 1 of stage 1 for breastfed children[a]

FBR[b]	Protein %	Fat %	Ca %	Vit C %	B1 %	B2 %	B3 %	B6 %	FOL %	B12 %	A-RE %	A-RAE %	Fe %	Zn %	Cost/ day[c]	Nutrients[d]
Food groups																
Dairy11	203.1	46.1	**70.5**	38.7	34.9	**202.3**	26	25.1	16.8	**91.3**	43.3	43.2	10.8	38.3	13227.7	3
Veg24	180.2	24.2	28.1	**120.7**	27.1	55.4	31.6	37	47.4	13	**155.9**	**91.5**	16.9	41	5067.6	2
Fruits11	161.7	23.5	15.3	**109**	25.5	40.9	28.8	32.4	20.4	12.7	41.7	38.5	12.9	37.5	5011.9	1
MFE25	341.3	51.7	14.5	31.5	26.5	63.7	**72.2**	59	11.2	52.9	35.8	35.6	14	42.2	9884.9	1
Legumes7	214.6	35.1	27.8	31.5	35.6	41.9	30.3	55.3	27.8	13.6	37.4	36.4	28.9	43.8	7123.1	0
Grains30	173.4	24.9	14.2	31.5	22.8	39.9	44.9	40.7	14.9	12.4	35.5	35.4	11.1	38.3	6260.5	0
Roots2	161.7	23.5	14.9	48.2	25.3	39.5	23.6	36.2	12.4	12.3	36.8	36	9.6	37.4	4345.6	0
Food subgroups																
Pork12	352.5	62.1	13.9	32.7	**137**	67.4	**107.9**	**84.9**	11.2	59	35.8	35.7	13.1	47.4	8898.3	3
Vegvita17	176.4	24	27.1	**115.3**	25.9	53.5	30.2	34.2	46.2	12.8	**155.9**	**91.4**	16.2	39.4	4762.1	2
Egg7	199.9	53.1	20.2	31.5	25.6	**80.6**	23.6	37.2	26.9	**77.1**	59.3	59.1	20.8	40	6360.3	2
Soy7	214.6	35.1	27.8	31.5	35.6	41.9	30.3	55.3	27.8	13.6	37.4	36.4	28.9	43.8	7123.1	0
Food items																
Mustard11	169	23.6	21.1	48.8	23.9	42.6	25.1	33.1	28.6	12.6	**102.2**	68.7	12.3	38	4703	1
Soymilk5	200.7	32.2	18.8	31.5	35.1	41.8	30.3	54.5	27	13.6	37.4	36.4	24.1	43.3	7116.4	0

[a] The nutrients were written as acronym, which means in sequence: protein, fat, calcium, vitamin C, vitamin B1, vitamin B2, vitamin B3, vitamin B6, folate, vitamin B12, retinol equivalent, retinal activity equivalent, iron and zinc. The results showed % RNI of these nutrients in the worst-case scenario. The nutrients in bold were those obtaining 70% RNIs of partial problem nutrients in the worst-case scenario.

[b] Individual FBRs were written as acronym, which means:
Veg24: vegetable (24 meal-based servings/week)
Dairy11: Dairy products (11 meal-based servings/week)
Fruits11: Fruits (11 meal-based servings/week)
MFE25: Meat, fish & eggs (25 meal-based servings/week)

Legumes7: Legumes, nuts & seeds (7 meal-based servings/week)
Grains30: Grains & grain products (30 meal-based servings/week)
Roots2: Starchy roots & other starchy plant foods (2 meal-based servings/week)
Vegvita17: Vitamin A source dark green leafy vegetables (17 meal-based servings/week)
Soy7: Soybeans and products (7 meal-based servings/week)
Egg7: Eggs (7 meal-based servings/week)
Pork12: Pork (12 meal-based servings/week)
Mustard11: Mustard greens, boiled (11 meal-based servings/week)
Soymilk5: Milk, soybean (5 meal-based servings/week)
[c] Cost/day in Vietnamese dong (VND)
[d] Nutrients: the number of partial problem nutrients were equal or higher 70% RNIs in the worst-case scenario

(Source: own work)

Table A.12: The results of combined FBRs in the step 2 of stage 1 for breastfed children[a]

FBR[b]	Protein %	Fat %	Ca %	Vit C %	B1 %	B2 %	B3 %	B6 %	FOL %	B12 %	A-RE %	A-RAE %	Fe %	Zn %	Cost/ day[c]	Nutrients[d]
Set of two FBRs																
Dairy11 - pork12	396.4	**85.8**	**70.9**	39.9	**151.7**	**234.6**	**111.7**	**84.9**	17	**138.4**	43.6	43.5	15.3	48.4	19342.9	7
Veg24 - pork12	372.1	63.3	28.5	**121.9**	**143.1**	**84.5**	**115.9**	**96.9**	47.5	59.8	**156.2**	**91.7**	21.4	50.9	9719.6	6
Pork12 - egg7	393.1	**92.7**	20.6	32.7	**142.2**	**112.7**	**107.9**	**97.5**	27.2	**124.1**	59.6	59.4	25.3	50	11689	6
Dairy11 - veg24	222.7	47.3	**85.1**	**127.9**	41	**219.5**	34.2	37	53.1	**92.2**	**163.7**	**99.3**	19	41.9	14040.4	5
Dairy11 - egg7	243.7	**76.8**	**77.2**	38.7	40.1	**247.7**	26	37.2	32.7	**156.5**	67.1	66.9	22.9	40.9	15903.3	4
Veg24 - egg7	219.4	54.3	34.8	**120.7**	31.6	**97.6**	31.6	49.1	63.2	**77.9**	**179.7**	**115.1**	29	43.6	7151.9	4
Set of three FBRs																
Veg24 - pork12- Dairy11	415.9	**87**	**85.5**	**129.1**	**157.8**	**251.7**	**119.9**	**96.9**	53.3	**139.2**	**164**	**99.6**	23.5	52.1	20348	9
Set of four FBRs																
Legumes7 - veg24 - pork12- Dairy11	471.7	**99.5**	**99.8**	**129.2**	**172.7**	**257.1**	**127.2**	**128.4**	**70.1**	**140.9**	**166**	**100.5**	43.8	59.3	23767.8	10

[a] The nutrients were written as acronym, which means in sequence: protein, fat, calcium, vitamin C, vitamin B1, vitamin B2, vitamin B3, vitamin B6, folate, vitamin B12, retinol equivalent, retinal activity equivalent, iron and zinc. The results showed % RNI of these nutrients in the worst-case scenario. The nutrients in bold were those obtaining 70% RNIs of partial problem nutrients in the worst-case scenario.

[b] Individual FBRs were written as acronym, which means:
Veg24: Vegetable (24 meal-based servings/week)
Dairy11: Dairy products (11 meal-based servings/week)
Legumes7: Legumes, nuts & seeds (7 meal-based servings/week)
Egg7: Eggs (7 meal-based servings/week)
Pork12: Pork (12 meal-based servings/week)
[c] Cost/day in Vietnamese dong (VND)
[d] Nutrients: the number of partial problem nutrients were equal or higher 70% RNIs in the worst-case scenario

(Source: own work)

APPENDIX 8

Table A.13: The results of individual FBRs in the step 1 of stage 1 for non-breastfed children[a]

FBR[b]	Protein %	Fat %	Ca %	Vit C %	B1 %	B2 %	B3 %	B6 %	FOL %	B12 %	A-RE %	A-RAE %	Fe %	Zn %	Cost/ day[c]	Nutrients[d]
Food groups																
MFE28	428.2	68.2	8	0.2	40.1	**81**	**87.1**	**106.2**	12.2	**98.1**	8.4	8	17.8	50.3	13863.1	4
Fruits11	164.3	11.7	5.8	**99.9**	29.6	40.7	45.7	**72**	22.5	13	3.4	1.8	15.1	39.6	15112	2
Veg30	180.8	12.4	15.3	**70.6**	30	51.9	46.8	60.1	35.5	13.3	**98.5**	45.5	18.9	45.2	18168.7	2
Dairy11	204.9	32.6	68.6	8.3	38.6	**220.4**	39.5	45.3	14.8	**102.2**	9	9	12.6	40.3	42033.1	2
Roots4	164.3	11.7	4.8	11.6	25.8	37.5	39.5	52.6	9.1	12.5	1	0.5	11.3	39.3	13863.1	0
Legume7	213	25.9	24.3	0.2	33.6	63.9	43	67.6	23.1	13.4	1.5	0.8	34.3	44.4	26379.1	0
Grain28	165.8	11.7	4.6	0.1	24.4	37.5	47.5	52.3	11.5	12.5	0.1	0.1	12.6	39.3	24335.5	0
Food subgroups																
Pork14	363.5	67.2	4	2	**188.8**	67.5	**148.2**	**103.1**	8.4	67.8	0.6	0.6	13.7	54.5	14765.7	3
Egg11	209.7	43.2	14	0.1	32.6	**97.3**	39.5	58	33.6	**158.2**	36.9	35.7	28.7	42.5	13995.8	2
Vegvita16	173.3	12	13.6	49.2	26.9	46.7	43.4	53.8	32.6	12.9	**92.1**	42.3	16.8	40.5	16611.4	1
Soy7	213	25.9	24.3	0.2	33.6	63.9	43	67.6	23.1	13.4	1.5	0.8	34.3	44.4	26379.1	0
Food items																
Milkcow-flavour11	204.9	32.6	68.6	8.3	38.6	**220.4**	39.5	45.3	14.8	**102.2**	9	9	12.6	40.3	42033.1	2
Eggchicken6	197.7	24.2	9.8	0.1	28.1	**70.5**	39.5	48.7	21.3	63.3	17.8	17.8	22.5	40.9	13863.1	1
Mustard10	169.3	11.7	9.9	14.1	25.4	40	40.4	51.6	22.3	12.8	54	27	13.7	39.7	16438.1	0
Soymilk4	189.4	15.7	7.9	0.2	33.6	39	43	66.7	20.3	13.4	1.5	0.8	22.3	43.8	23585.3	0
Tofu3	185	19.7	20.3	0.1	23.2	62.2	39.5	46.1	11	12.5	0.1	0.1	22.7	39.9	16257.5	0

[a] The nutrients were written as acronym, which means in sequence: protein, fat, calcium, vitamin C, vitamin B1, vitamin B2, vitamin B3, vitamin B6, folate, vitamin B12, retinol equivalent, retinal activity equivalent, iron and zinc. The results showed % RNI of these nutrients in the worst-case scenario. The nutrients in bold were those obtaining 70% RNIs of partial problem nutrients in the worst-case scenario.
[b] Individual FBRs were written as acronym, which means:
Veg30: Vegetable (30 meal-based servings/week)
Dairy11: Dairy products (11 meal-based servings/week)
Fruits11: Fruits (11 meal-based servings/week)
MFE28: Meat, fish & eggs (28 meal-based servings/week)
Legumes7: Legumes, nuts & seeds (7 meal-based servings/week)
Grains28: Grains & grain products (28 meal-based servings/week)
Roots4: Starchy roots & other starchy plant foods (4 meal-based servings/week)
Vegvita16: Vitamin A source dark green leafy vegetables (16 meal-based servings/week)
Soy7: Soybeans and products (7 meal-based servings/week)
Egg7: Eggs (7 meal-based servings/week)
Pork14: Pork (14 meal-based servings/week)
Mustard10: Mustard greens, boiled (10 meal-based servings/week)
Soymilk4: Milk, soybean (4 meal-based servings/week)
Milkcow-flavour11: Milk, cow, whole, sweetened, flavoured (11 meal-based servings/week)
Eggchicken6: Chicken, egg, whole, boiled (6 meal-based servings/week)
Tofu3: Tofu, fried with oil (3 meal-based servings/week)
[c] Cost/day in Vietnamese dong (VND)
[d] Nutrients: the number of partial problem nutrients were equal or higher 70% RNIs in the worst-case scenario

(Source: own work)

Table A.14: The results of combined FBRs in the step 2 of stage 1 for non-breastfed children[a]

FBR[b]	Protein %	Fat %	Ca %	Vit C %	B1 %	B2 %	B3 %	B6 %	FOL %	B12 %	A-RE %	A-RAE %	Fe %	Zn %	Cost/ day[c]	Nutrients[d]
Set of two FBRs																
Pork14-veg30 (A)	382.5	69.1	15.5	**72.5**	**196.1**	**83.5**	**156.1**	**118.8**	35.6	68.8	**99**	46.1	22	60.5	19371.5	6
Pork14-dairy11 (B)	412	**91.9**	69.1	10.2	**206.4**	**257.9**	**153.5**	**103.7**	15.2	**158.3**	9.5	9.5	16.6	55.9	43837.1	6
Pork14-fruits11	363.5	67.8	6.1	**101.8**	**196.2**	**74.7**	**156.6**	**131.7**	22.6	68.7	4	2.3	18.6	54.8	16553	5
Veg30-egg11	228.6	44.9	25.6	**70.6**	39.8	**112.5**	46.8	**72.8**	60.9	**159.1**	**135.3**	81.2	37	48.5	18292.6	5
Veg30-dairy11	223.9	34.5	**80.2**	**78.8**	45.8	**236.4**	46.8	60.1	42.1	**103.2**	**107.4**	54.4	21	46.3	46691.6	5
Fruit11-dairy11	204.9	33.2	**70.7**	**108.1**	46	**227.7**	45.7	**72**	29.7	**103.1**	12.3	10.7	17.6	40.6	43850.3	5
Egg11-fruits11	209.7	43.5	16.1	**99.9**	39.9	**103**	45.7	**84.7**	48	**158.8**	40.3	37.4	33.6	42.8	15130	4
Veg30-fruits11	180.8	12.4	17.4	**170.3**	36.7	55.3	52.9	**86.9**	49.8	13.8	**101.9**	47.2	23.4	45.5	19720.8	3
Egg11-dairy11	255.2	67.5	**79**	8.3	49.2	**286.1**	39.5	58	41.3	**248.3**	45.8	44.6	31.2	43.6	42077	3
Set of three FBRs																
Pork14-veg30-dairy11	432.4	**93.8**	**81**	**80.7**	**214.8**	**274.3**	**162.6**	**120.6**	42.9	**159.3**	**108**	55	25.4	62.2	48558.7	9
Reduction of the number of servings in the set of three FBRs																
Pork14-veg30-dairy10	427.1	**91.5**	**74.8**	**80**	**212.4**	**256.7**	**161.8**	**119.6**	42	**151**	**107.1**	54.2	24.8	61.9	45896	9
Pork14-veg30-dairy9	422	**89.3**	68.7	**79.2**	**210.5**	**239.1**	**161**	**119.2**	41.1	**142.8**	**106.3**	53.4	24.4	61.6	43233.4	8
Set of four FBRs																
Pork14-veg30-dairy9-legume7	486.8	**107.1**	**91**	**90.7**	**226**	**272.4**	**166.8**	**152.3**	59.8	**144.3**	**108.7**	54.6	51.2	69.1	56747.7	9

FBR[b]	Protein %	Fat %	Ca %	Vit C %	B1 %	B2 %	B3 %	B6 %	FOL %	B12 %	A-RE %	A-RAE %	Fe %	Zn %	Cost/ day[c]	Nutrients[d]
Reduction of the number of servings in the set of four FBRs																
Pork13-veg30-dairy9-legume7	463.4	**98.8**	**90.1**	**79.1**	**207.5**	**267.9**	**155.6**	**141.9**	57.1	**137.2**	**107.7**	54	48.8	65.7	55861.9	9
Pork12-veg30-dairy9-legume7	443.6	**90.6**	**89.5**	**78.8**	**189.8**	**263.7**	**144.4**	**134**	56.6	**130.9**	**107.6**	53.9	47.9	63.4	55515.7	9
Set of five FBRs																
Fruits11-pork12-veg30-dairy9-legume7	449.4	**92**	**93.4**	**201.2**	**210.1**	**274.9**	**156.9**	**169.5**	**76**	**131.9**	**132.1**	66.2	55.7	72	57809	10

[a] The nutrients were written as acronym, which means in sequence: protein, fat, calcium, vitamin C, vitamin B1, vitamin B2, vitamin B3, vitamin B6, folate, vitamin B12, retinol equivalent, retinal activity equivalent, iron and zinc. The results showed % RNI of these nutrients in the worst-case scenario. The nutrients in bold were those obtaining 70% RNIs of partial problem nutrients in the worst-case scenario.

[b] Individual FBRs were written as acronym, which means:
Veg30: Vegetable (30 meal-based servings/week)
Dairy11: Dairy products (11 meal-based servings/week)
Dairy10: Dairy products (10 meal-based servings/week)
Dairy9: Dairy products (9 meal-based servings/week)
Fruits11: Fruits (11 meal-based servings/week)
Egg11: Eggs (11 meal-based servings/week)
Pork14: Pork (14 meal-based servings/week)
Pork12: Pork (12 meal-based servings/week)
Legume7: Legumes, nuts & seeds (7 meal-based servings/week)

[c] Cost/day in Vietnamese dong (VND)

[d] Nutrients: the number of partial problem nutrients were equal or higher 70% RNIs in the worst-case scenario

(Source: own work)

APPENDIX 9

Table A.15: The results of removing each individual FBR out of the set of FBRs in the stage 2 of two target groups[a]

FBR[b]	Protein %	Fat %	Ca %	Vit C %	B1 %	B2 %	B3 %	B6 %	FOL %	B12 %	A-RE %	A-RAE %	Fe %	Zn %	Cost/ day[c]	Nutrients[d]
Breastfed children																
Legumes7 - veg24 - pork12-dairy11	471.7	**99.5**	**99.8**	**129.2**	**172.7**	**257.1**	**127.2**	**128.4**	**70.1**	**140.9**	**166**	**100.5**	43.8	59.3	23767.8	10
Removed-legume	415.9	**87**	**85.5**	**129.1**	**157.8**	**251.7**	**119.9**	**96.9**	53.3	**139.2**	**164**	**99.6**	23.5	52.1	20348	9
Removed-veg	451.7	**98.3**	**85.2**	39.9	**166.6**	**240**	**118.9**	**115.9**	33.7	**140**	45.5	44.5	35.6	55.4	22762.7	7
Removed-dairy	427.3	**75.8**	42.8	**122**	**158**	**89.9**	**122.6**	**127.3**	64.2	61.4	**158.1**	**92.7**	41.6	57.3	13051.6	7
Removed-pork	277.9	59.8	**99.4**	**128**	55.9	**224.9**	41.2	67.2	69.8	**93.8**	**165.7**	**100.2**	39.2	48.2	17265.9	5
Non-breastfed children																
Fruits11 - pork12-veg30-dairy9-legume7	449.4	**92**	**93.4**	**201.2**	**210.1**	**274.9**	**156.9**	**169.5**	**76**	**131.9**	**132.1**	**66.2**	55.7	72	57809	10
Removed-fruit	443.6	**90.6**	**89.5**	**78.8**	**189.8**	**263.7**	**144.4**	**134**	56.6	**130.9**	**107.6**	53.9	47.9	63.4	55515.7	9
Removed-legume	385.7	**73.7**	**70.9**	**178.5**	**186**	**239.6**	**149.6**	**137**	56.1	**130.4**	**109.5**	54.8	28.8	58	44149.6	9
Removed-veg	426.3	**89.6**	**80.9**	**111.5**	**193**	**256.2**	**146.4**	**149.5**	45.9	**130.9**	13.2	10.5	46	60.4	52748.1	8
Removed-dairy	400.2	**71**	38	**171.8**	**181.1**	**114.6**	**149**	**160.9**	64.7	57.7	**103.7**	48.3	49.9	62	33524.7	7
Removed-pork	269.2	48.1	**91.1**	**177.1**	61.1	240.2	56.5	**109.2**	**71.4**	**88.9**	**110.6**	55.2	49.6	51.5	56438.7	7

[a] The nutrients were written as acronym, which means in sequence: protein, fat, calcium, vitamin C, vitamin B1, vitamin B2, vitamin B3, vitamin B6, folate, vitamin B12, retinol equivalent, retinal activity equivalent, iron and zinc. The results showed % RNI of these nutrients in the worst-case scenario. The nutrients in bold were those obtaining 70% RNIs of partial problem nutrients in the worst-case scenario.

[b] Individual FBRs were written as acronym, which means:

Veg24: Vegetable (24 meal-based servings/week)
Dairy11: Dairy products (11 meal-based servings/week)
Legumes7: Legumes, nuts & seeds (7 meal-based servings/week)
Pork12: Pork (12 meal-based servings/week)
Dairy9: Dairy products (9 meal-based servings/week)
Fruits11: Fruits (11 meal-based servings/week)
Veg30: Vegetable (30 meal-based servings/week)

[c] Cost/day in Vietnamese dong (VND)

[d] Nutrients: the number of partial problem nutrients were equal or higher 70% RNIs in the worst-case scenario

(Source: own work)

APPENDIX 10

Table A.16: The results of the final set of FBRs in stage 3 of two target groups[a]

FBR[b]	Protein %	Fat %	Ca %	Vit C %	B1 %	B2 %	B3 %	B6 %	FOL %	B12 %	A-RE %	A-RAE %	Fe %	Zn %	Cost/ day[c]	Nutrients[d]
Breastfed children																
FP diet[e]	447.3	**100.5**	**100**	**181.3**	**100**	**217.6**	**106.9**	**106.1**	**71.3**	**240**	**188.8**	**143.1**	44	64.8	26938.1	10
NFP diet[f]	616.3	**114.3**	**100**	**241.4**	**123.2**	**201.2**	**149.3**	**164.9**	**107.9**	**309.9**	**238.4**	**157.2**	74.6	84.2	33804.4	10
Legumes7 - veg24 - pork12-dairy9	463.2	**95.2**	**89.4**	**127.9**	**170**	**226.7**	**126.1**	**127.7**	68.9	**126.4**	**164.5**	**99.1**	43.4	58.5	21819.4	9
Non-breastfed children																
FP diet[e]	395.1	**81.5**	58.9	**92.8**	**100**	**202.8**	**100**	**113.1**	**72.7**	**216.9**	**151.5**	**93.9**	57.6	60.2	35024.8	9
NFP diet[f]	546.2	**100**	**100**	**180.6**	**157.4**	**292.8**	**119.6**	**159.6**	**100**	**274**	**196.6**	**120.5**	84.9	83.1	56639.1	10
Fruits10 - pork12-veg28-dairy9-legume7	443.4	**91.1**	**90.9**	**154.6**	**201.4**	**268.4**	**152.3**	**158.6**	67.2	**131.6**	**94.9**	48.1	53	66.6	56672.3	9

[a] The nutrients were written as acronym, which means in sequence: protein, fat, calcium, vitamin C, vitamin B1, vitamin B2, vitamin B3, vitamin B6, folate, vitamin B12, retinol equivalent, retinal activity equivalent, iron and zinc. The results showed % RNI of these nutrients in the worst-case scenario. The nutrients in bold were those obtaining 70% RNIs of partial problem nutrients in the worst-case scenario.

[b] Individual FBRs were written as acronym, which means:

Veg24: Vegetable (24 meal-based servings/week)
Pork12: Pork (12 meal-based servings/week)
Dairy9: Dairy products (9 meal-based servings/week)
Veg28: Vegetable (28 meal-based servings/week)
Legumes7: Legumes, nuts & seeds (7 meal-based servings/week)
Fruits10: Fruits (10 meal-based servings/week)

[c] Cost/day in Vietnamese dong (VND)

[d] Nutrients: the number of partial problem nutrients were equal or higher 70% RNIs in the worst-case scenario

[e] FP diet was set closely to current dietary patterns, and in order to achieve RNIs of nutrients of the target groups as much as possible

[f] NFP diet was set to come as close as possible to the target population's RNIs, without taking dietary patterns into account

(Source: own work)

APPENDIX 11

Table A.17: The results of the second FBRs of two target groups[a]

FBR[b]	Protein %	Fat %	Ca %	Vit C %	B1 %	B2 %	B3 %	B6 %	FOL %	B12 %	A-RE %	A-RAE %	Fe %	Zn %	Cost/ day[c]	Nutrients[d]
Breastfed children																
Legumes7 - veg24 - dairy9 - egg4-pork5-poultry2-fish2	373.9	**86.9**	**93.3**	**127**	**82.5**	**227.6**	69.8	**88.7**	**78.2**	**141.9**	**176.4**	**110.9**	46.3	53.3	93.3	9
Non-breastfed children																
Veg28-dairy9-legume7-fruits10-egg4-pork4-poultry2-fish2	369	**70.5**	**93**	**137.6**	**94.4**	**266.6**	**79.5**	**125.9**	**74.7**	**134.3**	**101.8**	57.7	54.4	54.9	55823.9	10

[a] The nutrients were written as acronym, which means in sequence: protein, fat, calcium, vitamin C, vitamin B1, vitamin B2, vitamin B3, vitamin B6, folate, vitamin B12, retinol equivalent, retinal activity equivalent, iron and zinc. The results showed % RNI of these nutrients in the worst-case scenario. The nutrients in bold were those obtaining 70% RNIs of partial problem nutrients in the worst-case scenario.

[b] Individual FBRs were written as acronym, which means:

Veg24: Vegetable (24 meal-based servings/week)
Dairy9: Dairy products (9 meal-based servings/week)
Legumes7: Legumes, nuts & seeds (7 meal-based servings/week)
Egg7: Eggs (7 meal-based servings/week)
Pork5: Pork (5 meal-based servings/week)
Poultry2: Poultry, rabbit (2 meal-based servings/week)
Fish2: Fish (2 meal-based servings/week)
Veg28: vegetable (28 meal-based servings/week)
Fruits10: Fruits (10 meal-based servings/week)
Pork4: Pork (4 meal-based servings/week)

[c] Cost/day in Vietnamese dong (VND)

[d] Nutrients: the number of partial problem nutrients were equal or higher 70% RNIs in the worst-case scenario

[e] FP diet was set closely to current dietary patterns, and in order to achieve RNIs of nutrients of the target groups as much as possible

[f] NFP diet was set to come as close as possible to the target population's RNIs, without taking dietary patterns into account

(Source: own work)

APPENDIX 12

Table A.18: List of food group and food subgroup codes

Food group code	Food group name	Food sub group code	Food sub group name
1	Added fats	1	Butter, ghee, margarine (unfortified)
1	Added fats	2	Margarine (fortified)
1	Added fats	3	Other added fats
1	Added fats	4	Red palm oil
1	Added fats	5	Vegetable oil (fortified)
1	Added fats	6	Vegetable oil (unfortified)
2	Added sugars	7	Honey, syrup, nectar
2	Added sugars	8	Sugar (non-fortified)
2	Added sugars	9	Sugar (fortified)
3	Bakery & breakfast cereals[a]	10	Enriched/fortified bread, whole or refined grain
3	Bakery & breakfast cereals	11	Pancakes, waffles, scones, crackers
3	Bakery & breakfast cereals	12	Ready-to-eat (RTE) cereals, unfortified
3	Bakery & breakfast cereals	13	Ready-to-eat (RTE) cereals, fortified
3	Bakery & breakfast cereals	14	Refined grain bread, unenriched/unfortified
3	Bakery & breakfast cereals	15	Sweetened bakery products, enriched/fortified
3	Bakery & breakfast cereals	16	Sweetened bakery products, unenriched/unfortified
3	Bakery & breakfast cereals	17	Whole grain bread, unenriched/unfortified
4	Beverages (non-dairy or blended dairy)	18	Alcoholic beverages

Food group code	Food group name	Food sub group code	Food sub group name
4	Beverages (non-dairy or blended dairy)	19	Brewed coffee (w/wo sugar or milk)
4	Beverages (non-dairy or blended dairy)	20	Brewed tea, herbal infusions (w/wo sugar or milk)
4	Beverages (non-dairy or blended dairy)	21	Cereal-based beverages (w/wo milk and w/wo fermentation)
4	Beverages (non-dairy or blended dairy)	22	Chocolate beverage or powder mix (non-dairy)
4	Beverages (non-dairy or blended dairy)	23	Fortified beverage or powder mix
4	Beverages (non-dairy or blended dairy)	24	Fruit/dairy-containing blended beverages
4	Beverages (non-dairy or blended dairy)	25	Juices - commercial, pure, other[b]
4	Beverages (non-dairy or blended dairy)	26	Juices - commercial, pure, vitamin A source[b]
4	Beverages (non-dairy or blended dairy)	27	Juices - commercial, pure, vitamin C rich[b]
4	Beverages (non-dairy or blended dairy)	28	Other beverages
4	Beverages (non-dairy or blended dairy)	29	Sugar-sweetened beverages (soda, processed or artificial juices)
5	Composites (mixed food groups)[c]	30	Broths
5	Composites (mixed food groups)	31	Grain products w/fillings (sandwiches, burgers, samosas, enchiladas)
5	Composites (mixed food groups)	32	Main meal recipes
5	Composites (mixed food groups)	33	Other composites
5	Composites (mixed food groups)	34	Salads w/mixed food group ingredients
5	Composites (mixed food groups)	35	Soups
6	Dairy products[d]	36	Cheese
6	Dairy products	37	Cream, sour cream
6	Dairy products	38	Flavoured milk (non-fortified)
6	Dairy products	39	Fluid or powdered milk (fortified)

Food group code	Food group name	Food sub group code	Food sub group name
6	Dairy products	40	Fluid or powdered milk (non-fortified)
6	Dairy products	41	Infant formula (fortified)
6	Dairy products	42	Other dairy excluding butter
6	Dairy products	43	Sweetened dairy products/desserts (flan, custard, sweetened yoghurt, ice cream)
6	Dairy products	44	Yoghurt, solid and drinkable
7	Fruits	45	Other fruit[e]
7	Fruits	46	Vitamin A source fruit[f]
7	Fruits	47	Vitamin C rich fruit[g]
8	Grains & grain products[h]	48	Enriched/fortified grains and products, whole or refined
8	Grains & grain products	49	Refined grains and products, unenriched/unfortified
8	Grains & grain products	50	Whole grains and products, unenriched/unfortified
9	Human milk	51	Breastmilk
10	Legumes, nuts & seeds	52	Cooked beans, lentils, peas
10	Legumes, nuts & seeds	53	Nuts, seeds, and unsweetened products[i]
10	Legumes, nuts & seeds	54	Soybeans and products[j]
10	Legumes, nuts & seeds	55	Sweetened legume, nut, seed products
11	Meat, fish & eggs	56	Blood, blood sausage
11	Meat, fish & eggs	57	Eggs
11	Meat, fish & eggs	58	Fish without bones
11	Meat, fish & eggs	59	Insects, grubs

Food group code	Food group name	Food sub group code	Food sub group name
11	Meat, fish & eggs	60	Organ meat
11	Meat, fish & eggs	61	Other animal parts
11	Meat, fish & eggs	62	Pork
11	Meat, fish & eggs	63	Poultry, rabbit
11	Meat, fish & eggs	64	Processed meat
11	Meat, fish & eggs	65	Red meat
11	Meat, fish & eggs	66	Reptiles
11	Meat, fish & eggs	67	Seafood
11	Meat, fish & eggs	68	Small, whole fish, with bones
12	Miscellaneous	69	Condiments, herbs, spices[k]
12	Miscellaneous	70	Other miscellaneous[l]
12	Miscellaneous	71	Savoury spreads, sauces, pastes, salad dressing, pickles[m]
12	Miscellaneous	72	Sweet sauces, jams, pastes, spreads
13	Savoury snacks	73	Savoury snacks, salted, spiced, fried
14	Special fortified products (targeted)	74	Fortified special biscuits
14	Special fortified products (targeted)	75	Lipid-based Nutrient Supplement
14	Special fortified products (targeted)	76	Multiple Micronutrient Powders
14	Special fortified products (targeted)	77	Other special fortified products
15	Starchy roots & other starchy plant foods[n]	78	Other starchy plant foods
15	Starchy roots & other starchy plant foods	79	Vitamin A source starchy plant foods[f]
15	Starchy roots & other starchy plant foods	80	Vitamin C-rich starchy plant foods[g]

Food group code	Food group name	Food sub group code	Food sub group name
16	Sweetened snacks & desserts	81	Other sweetened desserts (gelatine, non-dairy ice)
16	Sweetened snacks & desserts	82	Sweet snack foods (candy and chocolate)
17	Vegetables[o]	83	Other vegetables
17	Vegetables	84	Vitamin A source dark green leafy vegetables6
17	Vegetables	85	Vitamin A source other vegetables[f]
17	Vegetables	86	Vitamin C-rich vegetables[g]
17	Vegetables	87	Condiment vegetables

[a] Bakery & breakfast cereals was created to isolate foods that tend to be highly processed, sweetened, and/or flavoured, that may be consumed as part of a main meal (e.g., breakfast), but are unlikely to be recommended as a major source of energy or nutrients. These include ready-to-eat cereals, pancakes, bakery products such as plain unsweetened breads, buns, chapattis, biscuits, highly processed and often sweetened or flavoured grain products and sweetened grain products consumed as desserts or sweet snacks, such as cookies, cakes, doughnuts and sweet breads.

[b] Pure, home-made fruit juice is categorized in the "Fruits" group and pure, home-made vegetable juice is categorized in the "Vegetables" group. If the pure, home-made fruit or vegetable juice has a vitamin A content ≥60 RE/100 g edible portion, it is classified in the "Vitamin A source fruits" subgroup or "Vitamin A source vegetables" subgroup. If the pure, home-made fruit or vegetable juice is not a Vitamin A source and if it has a vitamin C content ≥9 mg/100 g edible portion it is classified in the "Vitamin C-rich fruits" subgroup or the "Vitamin C-rich vegetables" subgroup. Juices that are commercially produced are categorized in the "Beverages (non-dairy or blended dairy)" group and in one of the following subgroups: "Juices – commercial, pure, vitamin A source", which have ≥60 RE/100 g edible portion; "Juices – commercial, pure, vitamin C-rich", which have ≥9 mg/100 g edible portion, or "Juices – commercial, pure, other". Note that juices that are both a Vitamin A source and Vitamin C-rich are classified as Vitamin A source.

[c] Composite dishes are defined as those with ingredients from more than one major food group, with the exception of additional salt and modest amounts of fats for cooking. It is desirable to minimize the number of composite dishes in dietary data collection as they interfere with the ability to generate accurate food-group based recommendations. This category should thus be reserved for foods where standard recipes are difficult to obtain. Note that this food group will NOT include composite dishes when all ingredients (except added salt and cooking fat) are derived from the same major food group (e.g., Pumpkin leaves + tomatoes + onions + vegetable oil would be categorized under the "Vegetables" group).

[d] Dairy products include unsweetened dairy and sweetened dairy products. Fruit/dairy blended beverages such as smoothies and licuados, that have little dairy, are classified in the "Beverages" group (subgroup: "Fruit/dairy-containing blended beverages").

[e] Includes mature and immature coconut meat. This food group does NOT include plantain (see footnote n).

[f] Vitamin A source fruits and vegetables are defined as those containing ≥120 RE/100 g (or ≥60 RAE/100 g) of food in the form that it is eaten. Vitamin A source fruits and vegetables are included in this category regardless of whether they are also considered to be vitamin C-rich (see footnote g). See footnote b regarding classification of pure, home-made juices and pure commercial juices.

[g] Vitamin C-rich fruits and vegetables are defined as those containing ≥18 mg/100 g of food in the form that it is eaten. Vitamin C-rich fruits and vegetables are NOT included here if they are categorized as vitamin A source.

[h] Grains & grain products include cereal grains and cereal-based porridges, etc., that are a major source of energy in the diet. The only exception is porridges to which sugar has been added at the household level (as per local recipes). Highly processed and often sweetened or flavoured grain products and sweetened grain products consumed as desserts or sweet snacks, such as cookies, cakes, and doughnuts, are included under "Bakery & breakfast cereals".

[i] The subgroup for “Nuts, seeds, and unsweetened products” includes whole and processed nuts and seeds such as unsweetened butters, pastes, and powders. The subgroup “Sweetened legume, nut, seed products” includes legume products that are sweetened and generally used as snacks or desserts.
[j] Tofu is included here based on the convention from Indonesia that tofu is a legume product.
[k] Includes both fresh herbs and dried herbs, and dried chilies but NOT fresh chilies; fresh chilies are included in the ‘Vegetables’ group.
[l] Other miscellaneous food items may include leavening agents, salt and powdered flavouring mixes.
[m] Includes food items preserved in salted brine that are typically consumed in small portion sizes, such as olives, capers, and pickled vegetables.
[n] In addition to starchy roots and tubers, this group also includes other starchy plant food parts that are typically used as ”staple” foods, defined as major sources of carbohydrate/energy in meals. These may include plantains, sago palms, and other starchy, non-root plant parts. Root types with energy content <~60 kcal/100 g on a raw weight basis are categorized as vegetables.
[o] Immature (green) maize is included in the “Vegetables” group. The higher water content does not justify its inclusion in “Grains & grain products”.

(Source: Wiesmann & Ferguson, 2012)