Ready-to-Use Food (RUF) from Composite Flour of Local Commodities in Banten Province, Indonesia for Prevention and Rehabilitation of Malnutrition in Children Under Five

Dissertation to obtain the doctoral degree of

Natural Sciences (Dr. rer. nat.)

Faculty of Natural Sciences

University of Hohenheim

Institute of Nutritional Science

submitted by

Fetriyuna Fetriyuna

from *Taram, Indonesia*

2021

Dean : Prof. Dr. Uwe Beifuß
1st reviewer : Prof. (em.) Dr. med. Hans Konrad Biesalski
2nd reviewer : Prof. Dr. Donatus Nohr

Submitted on:

Oral examination on: September 10, 2021

Table of Contents

List of Figures

List of Tables

List of Appendix

Acronyms and Abbreviations

AAS	Atomic Absorption Spectrometry
BPS	Badan Pusat Statistik (Central Statistical Bureau)
BMI	Body Mass Index
CIMI	Calculator Of Inadequate Micronutrient Intake
CMAM	Community-Based Management Of Acute Malnutrition
CTC	Community-Based Therapeutic Care
COVID-19	Coronavirus Disease 2019
DHS	Demographic Health Survey
ENA	Emergency Nutrition Assessment
FAO	Food and Agriculture Organization
F-100	Catch-Up Formula
GDP	Gross Regional Domestic Product
HB	Haemoglobin
HH	Household
HAZ	Height-For-Age Z-Score
ICP-MS	Inductively Coupled Plasma - Mass Spectrometry
ICP-OES	Inductively Coupled Plasma - Optical Emission Spectrometry
IDA	Iron Deficiency Anemia
IDD	Iodine Deficiency Disorder
IU	International Units
KEMENKES RI	Kementrian Kesehatan Republik Indonesia (Ministry Of Health Republic Of Indonesia)
LNS	Lipid-Based Nutrient Supplements
MAM	Moderate Acute Malnutrition
MCDB	Maternal-Child Double Burden Nutrition
MDGs	Millennium Development Goals

MITRA PROGRAM	Micronutrient Supplementation For Reducing Mortality And Morbidity Program
MUAC	Mid-Upper-Arm-Circumference
ORS	Oral Rehydration Supplements
PEM	Protein-Energy Malnutrition
PMP	Locally Produced Fortified Peanut/Milk Paste
POSYANDU	Pos Pelayanan Terpadu (Integrated Health Post)
PUSKESMAS	Pusat Kesehatan Masyarakat(Community Health Center)
RJPMN	Rencana Pembangunan Jangka Menengah Nasional (Medium-Term National Development Plan)
RAE	Retinol Activity Equivalent
RNI	Recommended Nutrient Intake
RISKESDAS	Riset Kesehatan Dasar (Basic Health Survey)
RUF	Ready-To-Use Food
RUSF	Ready-To-Use Supplementary/Supplemental Food
RUTF	Ready-To-Use Therapeuthic Food
SAM	Severe Acute Malnutrition
SDGs	Sustainable Development Goals
SD	Standard Deviation
TTD	Tablet Tambah Darah (Blood-Added Tablets)
UNICEF	United Nations Children`S Fund
UN-SCN	United Nations System Standing Committee On Nutrition
VAD	Vitamin A Deficiency
WAZ	Weight-For-Age Z-Score
WFP	World Food Programme
WHO	World Health Organisation
WHZ	Weight-For-Height Z-Score

Chapter 1

Introduction

1.1 The relevance of the Topic

Malnutrition is a universal problem that hampers development with detrimental human consequences. The malnutrition problems are taking place in both developed and developing countries, but the low-income countries struggle with this problem the most. The Sustainable Development Goals (SDGs) and the United Nations Decade of Action for Nutrition 2016–2025 provide global and national stimulus to tackle malnutrition and accelerate progress and the opportunity to end malnutrition in a more comprehensive way than before (WHO, 2018).

Malnutrition is responsible for more health problems than any other cause. Children under five years of age face numerous burdens: almost 151 million are stunted, more than 50 million are wasted, and approximately 38 million are overweight (WHO, 2018). Furthermore, around 20 million babies are born of low birth weight each year and equal to 1 in 2 children under five years of age (at least 340 million) suffer from hidden hunger (United Nations Children's Fund (Unicef), 2019).

Malnutrition is divided into undernutrition and overnutrition. Undernutrition refers to the low consumption of calories, protein, carbohydrates, fat, and micronutrients (vitamins and minerals) that do not fulfill the requirement for optimal individual metabolism. The existence of undernutrition during the first 1000 days of life (conception, pregnancy, and before two years of age) may result in permanent problems in physical and mental development as well as a low immune system.

One of the causes of malnutrition is household food insecurity, which is further compounded by poor health and sanitation conditions, as well as the social environment and inappropriate care resulting in poor nutritional status. Food insecurity occurs when access to nutritious food is limited both in quantity and quality to support normal growth and development, as well as to live a healthy and active life. This may be the result of the unavailability of food, limited access, low purchasing power, inappropriate distribution, or insufficient utilization at the household level (FAO, 1992; 2014).

In the crucial first 1,000 days (from conception to the child's second birthday), approximately one in three children is not getting the sufficient nutrition needed for them to grow well. An increasing number of children and young people are surviving, but some are not thriving because of malnutrition (United Nations Children's Fund (Unicef), 2019). Child undernutrition is caused by the combination of insufficient quantity and quality of food, numerous illness, constraints in access to health and other social services, and poor care practices (United Nations Children's Fund (Unicef), 2012).

Based on the WHO Conceptual Framework of 2013, stunting is caused by the community and societal factors which include political and economic aspects regarding food security, access to healthcare, educational level, society and culture, food and agriculture system. Those factors further cause the poor quality of food intake in the household, poor sanitation, and hygiene practice, and also infection and disease. Stunting in children as a chronic outcome of insufficient nutrition and poor condition of environment can be prevented through interventions that improve nutritional status in women of childbearing age, micronutrient supplementation during pregnancy, appropriate infant and child feeding, diverse and adequate diets during childhood and adolescence (Stewart CP, Iannotti L, Dewey KG, 2013).

Indonesia faces a serious problem of malnutrition especially in stunting and underweight caused by micronutrient deficiencies. The high prevalence of undernutrition in Java Island (the most important island in Indonesia) was also found in Banten Province. The Demographic and Health Survey (DHS) in 2012 showed that from the 24.5 million children under five years of age in Indonesia, approximately 37% (9.2 million) are stunted and 12% are wasted. Furthermore, based on the Basic Health Survey (Riskesdas) in 2013 and 2018, the prevalence of stunting in children under five years was 37.2 % and 30.8%, and of underweight, 19.6% and 17.7%, respectively (Kementerian Kesehatan RI Badan Penelitian dan Pengembangan, 2018). These undernourished children have an increased mortality rate, increased risk of illness and infections, cognitive shortages, delayed development, poorer school performance, and fewer years in school.

Malnutrition depreciates economic productivity and human capital that can hamper progress in achieving the Sustainable Development Goals. Ready-to-use food (RUF) is a kind of food that is easily consumed without much preparation and can be made using various techniques for targeted consumers. RUF can be made using locally available food resources which is affordable for most people suffering from undernutrition. To improve and accomplish the nutrient content of RUF in order to meet the standard for rehabilitation food for malnutrition, a combination of various food resources could be utilized to enhance the nutritional composition. This formulation of nutritious RUF must have the following attributes: good nutritional quality in terms of macro and micronutrient content, highly palatable, has the appropriate taste and texture as food for children, ready-to-eat without any preparation, stable, has a long shelf life, and have readily available ingredients.

Indonesia has huge natural biodiversity that has a lot of potential as a source of nutrition. Some examples of these underutilized resources are taro (*Xanthosoma undipes* K. Koch) (local name called *Talas Banten*), groundnut/peanut (*Arachis hypogaea* L.), red rice (*Oryza longistaminata),* soybean (*Glycine max*), mungbean (*Vigna radiata*), banana (*Ambon*) (*Musa acuminata Cavendish*), banana (*Kepok*) (*Musa acuminata balbisiana*), banana (*Nangka*) (Musa textilia) maize (*Zea mays*) and sweet Purple Potato (*Ipomoea batatas var Ayumurasaki*). This combination of local food is believed to have sufficient nutrition to overcome micronutrient deficiencies.

The underutilized food resources have the potential to contribute more to the mix of food sources due to their higher nutrient content than globally known species or varieties commonly produced and consumed (Mayes *et al.*, 2012; P. Durst and N. Bayasgalanbat, 2014; FAO, 2013). Based on the report of Dandin and Kumar (2016), there are approximately 226 underutilized fruits and nuts in the region of Indochina and Indonesia. These foods remain underutilized due to the underestimation of their potential use, insufficient information of botanical attributes, nutritional composition, commercial potential, ecosystem, and environmental benefit, and the stigma as food for the poor.

The potential of the underutilized foods to feed the growing population as well as fulfill the nutrition (macro and micro) requirements of the world's population is huge. Underutilized food crops have the potential to improve the nutrient intake of children to improve their nutritional status especially in a food-insecure area where malnutrition is prevalent, (Andrias, Fahmida and Adi, 2019). These should be promoted through the utilization of underutilized nutrient-dense crops inappropriate recipes and formulation for feeding recommendations.

Improvement of the children's nutritional status is influenced by the quality of the food they consume and their existing health status. RUF biscuit from local food resources in Banten Province, Indonesia, fortified with micronutrient premix, was analyzed and tested with children under five years of age to evaluate the acceptability of this kind of food and its effect on the nutritional status. RUF biscuit was locally produced and was given as part of the habitual intake of the children, in addition to regular meals.

Through this research, the author tried to develop a RUF biscuit made from the combination of local food resources available in the Banten Province of Indonesia and evaluate its potential for use in the prevention and rehabilitation of malnutrition in children under five years old. The research work consisted of a preliminary study on the nutritional condition in the target area, RUF biscuit product development, and the acceptability study of the RUF biscuit for the target group of children under five.

1.2 The objective of the study

The general objectives of the study were to analyze the nutritional outcomes of the field study in Banten Indonesia, after the RUF provision and evaluate the acceptance of the target group of children under five. The specific research objectives were to :

1. Assess the nutritional condition in the research area (Banten Province, Indonesia) especially the target group of children under five years of age;
2. Explore and investigate the potential of local food resources in Banten Province (taro, groundnut, and red rice, plantain, other grain, and tubers) as nutritious food resources for prevention and rehabilitation of malnutrition in the research area;
3. Develop ready-to-use food (RUF) biscuits from the composite flour of local food resources according to FAO recommendation for the rehabilitation of malnutrition;
4. Analyze the nutrient content in RUF biscuit based on the standard for moderate acute malnutrition (MAM) children under five years old; and
5. Produce RUF locally in the research area

Chapter 2
State of the Art

2.1 Undernourishment

Children's malnutrition has three forms (United Nations Children’s Fund (Unicef), 2019). The first form is undernourishment which covers stunting (low height for age), underweight (low weight for age), and wasting (low weight for height). The second form is hidden hunger or micronutrient deficiencies such as vitamins A and B, iron, and zinc which have been often ignored. The third form is overnutrition or overweight and obesity, leading to diet-related degenerative diseases such as diabetes and cancer.

Malnutrition harms the immune system, inhibits human physical and cognitive development, increases the risk of communicable and non-communicable diseases, limits and reduces productivity, and increases negative social and economic consequences for individuals, families, communities, and countries (FAO, 2014) and undernutrition was the main underlying cause of death in children under five, causing 45% of all child deaths in the world in 2013.

A child grows and develops at an individual pace. Monumental growth and development that occurs in the first year of life include increases in body weight, height, and brain development. Babies experience physical development from birth to three years of age, a child usually has four times the weight and twice the height. Between three to five years old, children continue to grow rapidly and begin to develop fine motor skills and increase their appetite and eat accordingly.

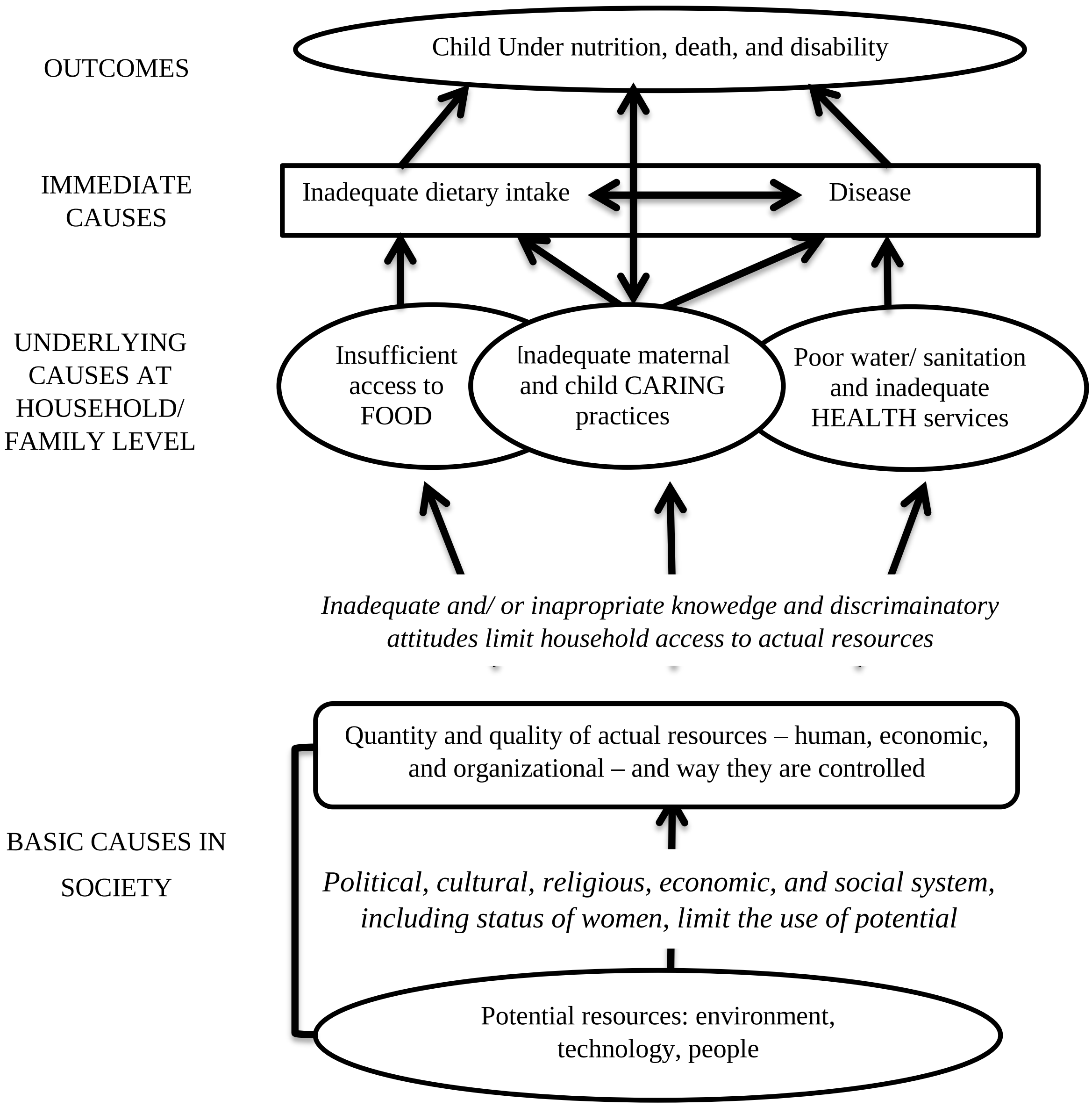
The United Nations System Standing Committee on Nutrition (UN-SCN) in 2006 stated the importance of a nutrition program for 1000 days of early life (window of opportunity) which focuses on pre-conception, pregnancy to the first two years of life. This period is important because it sets the foundation for optimal health, nerve and brain development. The Lancet series in 2008 also emphasized that this is a critical period for reducing undernourishment and its adverse consequences (Bryce *et al.*, 2008).

In former times, undernourishment was primarily characterized by growth retardation with lower than average gains in weight and/or height. This type of response was described as energy-protein malnutrition, of which inadequate intake of energy and protein were the responsible factors for the growth failure of the children. However, other nutrient deficiencies have been recognized in playing an important role in limiting the growth, since children who are lacking energy and protein are usually also deficient in other essential minerals (e.g. iron, zinc, iodine, potassium, magnesium, calcium), vitamins (A, C, E, D) and essential fatty acids, which are largely responsible for growth failure and increased proneness to infectious diseases (Biesalski, 2013)

Child malnutrition is caused by multisectoral factors, and the underlying factors leading to undernutrition are complex and multidimensional. Based on UNICEF's conceptual framework (1998), the causes are at the individual level (immediate causes), household/ family level (underlying causes), and society level (basic causes) (Figure. 2.1). All factors are interconnected and can influence each other. Effective action could be planned using this framework to enhance and empower nutrition at the village/rural, district, and national levels.

Undernutrition is an effect of consuming too few essential nutrients, of which the utilization and excretion are quicker than the replacement (United Nations Children's Fund (Unicef), 2019). The special groups - infants, young children, and teenagers as well as pregnant or breastfeeding women - need more nutrients. Some illnesses could accelerate nutrient loss like diarrhea, kidney failure, heavy bleeding (hemorrhage), or excessive sweating. Age-related illnesses and conditions could also inhibit the nutrient intake as well as food allergies, severe injury, excessive dieting, a lengthy hospitalization, serious illness, or substance abuse (Berdanier, Carolyn D. Dwyer, Johanna T. Heber, 2013). The major cause of death in children in developing countries is protein-energy malnutrition (undernutrition). Children who are already undernourished can suffer more from protein-energy malnutrition (PEM) when rapid growth, infection, or disease increases the need for protein and essential minerals or trace elements (Biesalski, 2013).

Figure 2.1 UNICEF's Conceptual Framework



Source : (United Nations Children's Fund (Unicef), 2012)

The United Nations General Assembly adopted a resolution of the UN Decade of Action on Nutrition from 2016 to 2025 which aims to catalyze policy commitments that result in measurable action to address all forms of malnutrition. The target of the action plan was to ensure the accessibility of healthier and more sustainable diets to eradicate all forms of malnutrition worldwide for all humankind.

Below are the recommendation indicators of the anthropometric methods in the context of the nutritional status of children below five years of age:

Weight-for-height (W/H) reflects body mass relative to height.

Low W/H is an indicator of acute malnutrition called wasting and is associated with acute starvation and/or severe disease. Wasting among children is a symptom of acute undernutrition and the life-threatening result of poor nutrient intake and/or disease. Children suffering from wasting are vulnerable to infectious disease due to the lower immunity, are limited, and suffer from long-term developmental delays, increased risk of death, particularly for severe wasting. These children require urgent treatment, nutritious feeding, and intensive care to survive. In 2018, about 50 million children under 5 were wasted and approximately 17 million were severely wasted. For children under five, wasting is characterized by a rapid deterioration in nutritional status over a short period of time, it can be measured using the weight-for-height nutritional index or mid-upper arm circumference (MUAC). Based on the severity, acute malnutrition can be classified as moderate acute malnutrition (MAM) and severe acute malnutrition (SAM).

Height-for-age (H/A) reflects height relative to sequential age.

Low H/A indicates the children are too small for their age, also called stunting. Stunted growth reflects a result of sub-optimal health and/or nutritional conditions as a failure to reach a potential linear growth. Stunting is caused by long-term nutritional deficiency and often results in retardation of physical and mental development, reduced school performance and intellectual capacity. Stunting is indicated by chronic undernutrition, insufficiencies in nutrition, and/or frequent illness. Infections lead to a greater risk for illness and death, the brains of the children may never develop to their full cognitive potential and may never attain their full possible height. This potentially reduces economic productivity at the national level. Stunted women have a high probability to give birth to stunted children and are at a greater risk of delivering a low birth weight infant. This contributes to the intergenerational cycle of malnutrition, as infants of low birth weight, tend to be smaller as adults.

Weight-for-age (W/A) reflects body mass relative to chronological age.

Low W/A is influenced by both W/H (weight-for-height) and H/A (height-for-age). Children are underweight if they are too light for their age. Weight is commonly used in the past as an indicator of nutritional status since it was easy to measure. Some proof has shown that the increase of mortality risk of children who are just mildly underweight, and severely underweight children at the greater risk. Undernutrition is the cause of insufficient quality and quantity of proper nutrition.

At the national level usually, all three indicators are used at the same time. With the use of only one of these parameters, the picture of the nutritional status is incomplete. In addition, to classify the children according to their nutritional status, the –z scores such as WHZ, HAZ, and WAZ are used with the following formula:

$$Z - score\ (SD - score)\ = \frac{observed\ value\ -\ median\ reference\ value}{standard\ deviation\ of\ the\ reference\ population}$$

Another indicator of malnutrition in children under five years is the Mid-Upper-Arm-Circumference (MUAC). The MUAC is generally comparable to other anthropometric measures in predicting succeeding mortality in community-based studies. In contrast, MUAC is a low-cost, objective method, and is a simple technique of assessing nutritional status. During the period of 1 to 5 years, a child's arm circumference shows only slight changes and is largely independent of height. So the exact age and the height of a child are not needed. Similar terms are used to classify the level of malnutrition however it is measured. Children are described as severely malnourished, moderately malnourished, or adequately nourished.

The prevalence threshold and the corresponding label for stunting, wasting, and underweight based on the WHO-UNICEF Technical Advisory Group on Nutrition Monitoring (TEAM) are presented in Table 2.1.

Table 2.1 Prevalence thresholds for stunting, overweight, and wasting and corresponding labels

Labels	Prevalence Thresholds (%)		
	Stunting	Overweight and Wasting	Underweight (WHO 1995)
Very low	<2.5	<2.5	
Low	2.5 - <10	2.5 - <5	< 10%
Medium	10 - <20	5 - <10	10-19%
High	20 - <30	10 - <15	20-29%
Very high	≥ 30	≥ 15	≥ 30%

Source: de Onis *et al.* (2018) *in* UNICEF, WHO and World Bank Group (2018)

Both stunting and wasting reflect long-standing illness, inappropriate feeding, poverty, and/or food insecurity, and the prevalence of underweight is an indicator of combination chronic and acute malnutrition as general nutrition status. The second Sustainable Development Goal (SDG) aims to improve nutrition, achieve food security, end hunger, and promote sustainable agriculture (World Health Organization and UNICEF, 2019), which has a target to :

- "by 2030, ensure access by all people, including the poor and people in vulnerable situations, infants, to safe, nutritious, and sufficient food all year round to end hunger"
- "by 2030, end all forms of malnutrition, including targets of reducing stunting and wasting in children under 5 years of age, and address the special and proper nutritional needs of adolescent, pregnant and lactating women, and elderly people".

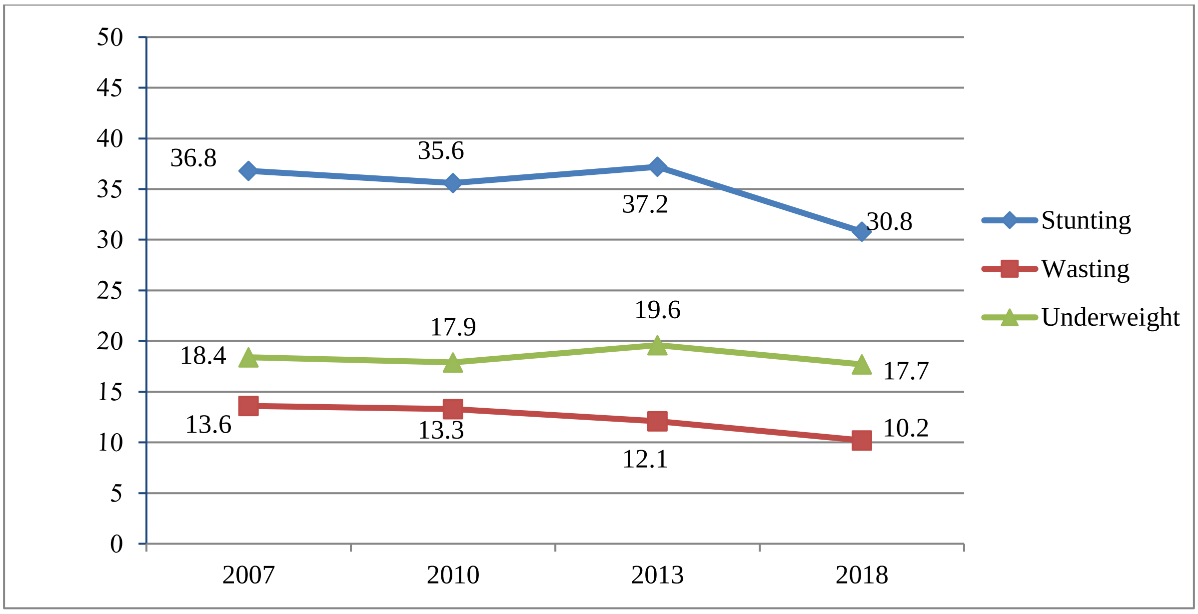
Also based on the WHO's Global Nutrition Targets 2025, "to reduce stunted children by 40% and reduce or maintain childhood wasting to less than 5%" (WHO, 2021).

2.2 Undernutrition in Indonesia

Indonesia has experienced remarkable economic growth during the last decade of 2000 - 2014. The Indonesian economy grew by approximately 5.5 % per year from 2000 to 2014. According to the World Bank and Central Statistics Bureau/ Badan Pusat Statistik (BPS), Indonesia's per capita gross national income increased from IDR 6 to 31 million in 2000 and 2013 respectively. Unfortunately, economic growth in Indonesia has not been accompanied by investments in human development. Despite a considerable increase in Gross Domestic Product (GDP) per capita, the levels of underweight and stunting remain steadily high in Indonesia and disparities exist among geographic areas and between wealth quintiles.

The stunting prevalence among children below five years old is a foremost nutritional problem facing Indonesia. Based on the report of nutritional status monitoring, the prevalence of stunting remains above the standard of WHO even though there is some slight reduction. Compared to the other undernutrition problem, the prevalence of stunting is highest. The prevalence of the undernutrition indicators is presented in Figure 2.2.

Figure 2.2 The Prevalence of Undernutrition I Indonesia from 2007-2018



Sources: Basic Health Survey (*RISKESDAS*) 2007, 2010, 2013 and 2018

The prevalence of undernutrition in Indonesia remains at very high levels. Based on the report of the Basic Health Survey (Badan Penelitian dan Pengembangan Kesehatan. Kementerian Kesehatan RI, 2007, 2013 and 2018), the stunting prevalence among children under five in Indonesia has a steady percentage around 36.8 -30.8% which is still above the global prevalence (22.2%) and the prevalence in Southeast Asia (25.7%) (UNICEF, WHO and World Bank Group, 2018) while wasting is about 13.6 – 10.2% and underweight 18.4 – 17.7%. According to the standards of the World Health Organization (WHO), Indonesia's prevalence of underweight indicates medium severity while facing a very severe wasting and stunting problem. Some treatments have been done to overcome undernutrition through supplementation of vitamin A for children and pregnant women, fortification of commonly consumed foods, and promotion of increasing the intake of vitamin and mineral-rich foods (FAO, 2014; The SMERU Research Institute, 2015; Budiastutik and Nugraheni, 2018; Kemenkes RI, 2018) but it still needs innovations that adapt to the specific situation in Indonesia.

The research conducted by the South East Asian Nutrition Survey (SEANUTS) in 2013 in forty-eight districts/cities in Indonesia, showed that that the development (height for age (weight for age, weight for height, and BMI for age) of Indonesian school-aged and pre-school children are below the WHO standards. The prevalence of anemia was exceeding 54% in children less than 2 years and around 10 – 5 % in children aged 2 – 12 years while iron deficiency was observed in 4 – 9% of the children. A high %age of children with dietary intakes of energy, protein, and vitamins A and C below the Indonesian RDA existed and varied across urban and rural areas and among age groups. (Sandjaja *et al.*, 2013).

The review of stunting determinant factors in Indonesia (Budiastutik and Nugraheni, 2018) concluded that the key determinant factors of child stunting in Indonesia were premature birthing, gender, birth length, inclusive breastfeeding, the height of and education of mother, infection sickness, economic status, living condition, the status of drinking water, and access to health service. Those factors were related to education, social culture, food, and the agricultural system. The same assessment also showed the deficiencies in three main micronutrients: Iron, Iodine, and vitamin A.

Indonesia is an island country that consists of 37 provinces, in geographical terms, malnutrition is spread across Indonesia, and the prevalence of undernutrition disparity exists between provinces, urban versus rural, and across income levels. The prevalence of stunting is steady in urban areas and increasing in rural areas, as a result of limited access to diverse diets, health services, clean water, and sanitation in the rural region. This indicates that in addition to consumption-related, behavior-related, and poverty are significant factors determinants of undernutrition.

Based on the research about disparities of undernutrition in Indonesia (Sandjaja *et al.*, 2013), the overall prevalence of stunting was 25% and 39% in urban and rural areas, respectively. In Java island (the most important island in Indonesia where Jakarta as capital is located), among its five provinces, Banten has a high prevalence of undernutrition where two districts (Pandegelang and Serang) has a high prevalence above the national average (Balai Penelitian dan pengembangan Kesehatan RI and Kesehatan, 2013). An Indonesian Food and Nutrition Security strategic review (The SMERU Research Institute, 2015) reported that malnutrition trends are connected with investments in improving health and social service.

The Indonesian government has demonstrated a strong political commitment to nutrition that is stated in Book I of the Medium-term National Development Plan (RPJMN) 2015–2019. This program targeted the reduction of child stunting, child underweight, and adult obesity which have also been included in the national priority for all sectors. Indonesia launched an integrated program for stunting prevention that involves cross ministries and agencies. In 2018, 100 districts in 34 provinces were designated as priority locations for stunting reduction, and an additional 60 districts in the following year. With the cooperation of cross-sectoral agencies, it could reduce stunting prevalence in Indonesia to achieve the target of the Sustainable Development Goals (SDGs) in 2025 to reduce the number of stunting up to 40% (Kemenkes RI, 2018).

Based on the Indonesia - Food and Nutrition Security Profiles (Indicators, 2014), Indonesia has poor dietary diversity. High in carbohydrates with low protein and vitamin consumption may be one determinant for this persistent gap of undernutrition in the nation. The typical diet is mostly rice-based (as a staple food) which caused approximately one-third of children age 6-23 months to not fulfill the minimum frequency of meals; nearly half did not achieve the recommended quality of diet and one-quarter did not meet the minimum dietary diversity.

Indonesia´s government has challenges implementing nutrition programs due to the less effective program delivery. Based on the report of UNICEF (2018), (United Nations Children's Fund (Unicef), 2018) the missed coordination between national and sub-national levels after decentralization in 2001 was the primary cause of the critical bottlenecks in delivering and sharing the responsibilities. Other factors include ignorance (insufficient attention to nutrition by key sectors), less information on all types of malnutrition and, insufficient budget allocations, and weaknesses in the capacity to monitor and evaluate due to unequal distribution of expert nutritionists, primarily at the sub-national level.

Indonesia still faces challenges in nutrition and food security which are covering the following issues: import dependency of certain commodities, low food diversity score as indicated low food diversity, the existence of double burden of malnutrition, fragmented and un-integrated policy and programs in food and nutrition security, low coordination for poverty alleviation strategy, and food insecurity are remained problems in particular remote areas due to lack of economic access and distribution. (ICN2, 2014).

2.3 Micronutrient deficiencies in Indonesia

Up to now, the three dominant micronutrient deficiencies in Indonesia are iron, iodine, and vitamin A.

Vitamin A Deficiency (VAD)

Vitamin A deficiency remains high as a serious micronutrient problem in Indonesia. Approximately 20% of preschool children lack vitamin A consumption which is categorized as a moderate and almost severe public health problem, which indicates vitamin A is still deficient in the daily diet (Indicator, 2014). Some programs and policies have been carried out since 1970 to minimize vitamin A deficiency through providing high-dose vitamin A capsules for infants and children under five as well as vitamin A fortification on widely consumed foods.

Iron Deficiency Anemia (IDA)

Anemia is a serious public health issue, high among under-five children (45%), pregnant women (44%), non-pregnant women (33%), Deterioration of household food consumption, including low quality supplementary and complementary food for young children are correlated with the high prevalence of anemia among children. Iron supplementation and deworming programs and can be effective in reducing anemia in children as well as pregnant women.

Iodine Deficiency Disorders (IDD)

Approximately only 62.3% of households consumed sufficient iodine salt (Chapparo, C; Oot L,; Sethuraman, 2014), and in some areas, the consumption of iodized salt is very low (Atmarita 2005). Based on data from the Ministry of Health of Indonesia in 2013, 15-25% of school-age children (6-12 years), women of childbearing age, pregnant women, and nursing mothers are at risk of iodine deficiency. One of the causes of this problem is that more than 50 percent of household salt in Indonesia is not sufficiently iodized (<30 ppm I in the form of KIO3). In fact, since 2009, IDD prevention has only relied on iodized salt. Apart from salt, drinking water also contains iodine. However, it turns out that most (> 90%) Indonesian household drinking water has a low and very low iodine content.

Micronutrient deficiencies, such as iron, folic acid, zinc, and vitamin A are associated with high rates of stunting in Indonesia. The government of Indonesia through the Ministry of Health (Kemkes) has made a micronutrient supplementation program for stunting intervention through the provision of blood-added tablets (TTD), vitamin A capsules, and zinc tablets. The provision of micronutrients is part of the Micronutrient Supplementation for Reducing Mortality and Morbidity (MITRA) program that has been implemented since August 2015 (Kementrian Kesehatan RI, 2020). MITRA program with the support of Nutrition International, and the governments of Australia and Canada, reached approximately more than 211,000 pregnant women with folic acid and iron supplementation, about 720,000 children with two doses of vitamin A and around 64,000 children under five with zinc and oral rehydration supplements (ORS) for prevention of diarrhea (Nutrition International, 2020).

The MITRA program focuses on increasing access to health services and building awareness about stunting prevention, particularly the prevention of micronutrient deficiencies through the Behavior Change Intervention Strategy. The central, provincial, and district governments are committed to micronutrient supplementation programs by increasing the allocation of resources for the management, procurement, and implementation of these programs. Prevention and reduction of stunting is the Ministry of Health's priority for Indonesia. The national strategy to accelerate stunting prevention is an important program to ensure that all households with children under the age of two and pregnant women have access to a comprehensive package of services essential to stunting prevention.

Food fortification as an effort to fulfill micro-nutrition in society is an intervention that has proven to be cost-effective. The Indonesian government has established regulations for the fortification of micronutrients in foodstuffs. The Ministry of Health issued regulation No. 962 / MENKES / SK / VII / 2003 dated July 7, 2003, concerning the fortification of wheat flour with 30 ppm zinc, 60 ppm iron, 2.5 ppm, and 4 ppm for vitamin B1 (thiamine) and vitamin B2 (riboflavin) respectively, and 2 ppm folic acid. Furthermore, the Regulation of the Minister of Industry of the Republic of Indonesia Number 46 of 2019 requires the fortification of vitamin A for cooking oil, and the Indonesian National Standard Regulation (SNI) No. 01-3556-2000 requires iodine added in table salt is as much as 30-80 mg KIO3 / kg salt (30-80 ppm).

2.4 Dietary Recommendation

The information about recommended nutrient intake and human nutrient requirements is necessary to understand the average intake of the population. The FAO/WHO recommendations of macronutrients were developed as the concept of nutrient density per 1000 kcal (Table 2.2). A diet with adequate nutrient density has a good source of micronutrients and meets the needs for specific nutrients if adequate energy is consumed. The concept is beneficial especially for children, that nutrient-dense food is included in a diet (FAO, 1996).

Table 2.2 Reference nutrient densities per 1000 kcal of macronutrients

Nutrient	Density per 1000 kcal	Comments
Protein (g)	25-30	10-12% of total energy intake
Total fats (g)	16-39	20-30% of total energy intake
Carbohydrates (g)	140-190	55-75% of total energy intake
Dietary fiber (g)	8-20	Total energy fiber must be defined

Source: FAO (1996)

Recommended nutrient intake (RNI) is the daily consumption and nutrient intake that meets almost all (98%) of nutrient requirements for apparently healthy individuals in different population groups of age and gender. WHO and FAO established the guidelines which are used by many countries to be adopted as a part of their national dietary allowances, while the others use it as a foundation for their specific standards. The establishment of human nutrient requirements is the common basis for all countries to develop food-based dietary guidelines for their inhabitants. Table 2.3 shows the FAO/WHO recommendations of selected vitamins and minerals intake for children aged 1 to 5 years.

Table 2.3 Selected Micronutrients requirements per day of children from 1 to 5 years

Micronutrients	Age of the children				
	1 year	2 years	3 years	4 years	5 years
Vitamins					
Vitamin A [μg]	400	400	400	450	450
Thiamine [mg]	0.3	0.5	0.5	0.6	0.6
Riboflavin [mg]	0.4	0.4	0.5	0.6	0.6
Vitamin E [mg]	5	5	5	5	5
Minerals					
Calcium [mg]	500	500	500	600	600
Iron [mg] [(a)]	11.6	11.6	11.6	12.6	12.6
Magnesium (mg)	60	60	60	73	73
Iodine [μg]	90	90	90	110	110
Zinc [mg] [(b)]	8.4	8.4	8.4	10.3	10.3

(a): For the diet with 5% (low) iron bio-availability containing mostly non-haem iron and low vitamin C which enhances non-haem iron absorption (b): Assumed bio-availability of dietary zinc 15% (Source: Human Vitamin and Mineral Requirements. (FAO/WHO, 2001)

2.5 Approach for rehabilitation undernutrition

Undernutrition is one of the root causes of childhood death and illness in developing countries, especially low- and middle-income countries. The intervention is aimed at supporting the nutritional well-being of the target population by providing extra food to children or families beyond what they normally have at home (usually consumed). The provision of nutrient-dense supplementary food to children with moderate undernutrition has been promoted by The World Health Organization (WHO) as an approach to meet the child's extra needs for weight and height gain and functional recovery (WHO, 2012).

Moderate acute malnutrition (MAM), also called moderate wasting has different approaches which can be used to minimize this problem, such as prepared food of lipid-based nutrient supplements or blended food. Specially formulated foods for oral supplementary are defined as food in ready-to-eat, powdered or milled form which is modified in nutrient composition included protein, fat, energy density, and/or micronutrient content to fulfill the nutritional requirements of undernourished infants and children.

These foods can be provided based on needs (low, medium, or full dose) as a complement to the common diet, which is intended to supplement the family diet, and not to meet all the daily nutritional intake requirements of these children (Grobler *et al.*, 2015). The various types of supplementary foods include:

- Lipid-based nutrient supplements (LNS), which are usually ready-to-use (both the high energy density and high lipid content). The benefit of this kind of food is that needs no further preparation before consumption, for example, ready-to-use therapeutic food (RUTF)
- Blended food supplements or fortified blended foods, which are food mixtures - such as wheat-soy blends, corn-soy blends, legumes, sugar, oil, or others - that can be cooked or prepared at home by parents/caretakers to make a kind of porridge or soup for children
- Fortified powdered supplements, for example, soy-based powder or fortified milk that can be reconstituted with water

Necessary characteristics of foods for children with MAM include appropriate nutritional composition, acceptability (in terms of taste, texture, and cultural acceptability), affordable cost, and easy preparation and administration in the context of less-middle income countries (Lazzerini, Rubert and Pani, 2013). In an emergency context, food would also need to be easily handled (stored and distributed), and dry foods or special foods with limited water content are usually favored. The guidelines and nutritional requirements for moderate malnourished children have been recently reviewed (Golden, 2009) and the World Health Organization (WHO) has introduced recommendations on the nutritional composition of foods to rehabilitate children with MAM (WHO, 2012).

Ready-to-Use Food (RUF) is developed for treating moderately malnourished children and could be also called Ready-to-Use Therapeutic Food (RUTF) when tested and proven to promote the growth of severely malnourished (wasted) children. RUF is made from various food ingredients of cereals and legumes including chickpeas, peanuts, soybeans, maize, and sesame seeds, besides other RUF components including vegetable oil, sugar, dried milk powder, and mineral and vitamin premix.

Recently, UNICEF has been promoting the use of a highly nutritious, and specifically designed for young children called ready-to-Use Food (RUF). RUTF is an energy-dense food fortified vitamins and minerals with a comparable nutrient profile but greater energy (about 5 times) to F-100, which is the diet, recommended by WHO for severely malnourished children in the recovery phase of the treatment (Schoonees *et al.*, 2019).

RUTF has already achieved significant success in fighting malnutrition (Hendricks, 2010; Komari and Lamid, 2012; Purwestri *et al.*, 2012; Choudhury *et al.*, 2018; Wagh and Deore, 2018; Schoonees *et al.*, 2019). RUTF can be formulated from various ingredients to make energy-dense food (about 23 kJ/g or 5.5 kcal/g) which is a mixture of vegetable oil, butter, milk powder, peanut, sugar, and powdered minerals and vitamins. RUTF is so effective because malnutrition results from the combination of insufficient quantity and quality of food (as a macro and micronutrients).

Most importantly, RUTF is easily transported, easily distributed, serving is in individual portions, and has a long shelf-life (safely stored for several months, even in tropical climates). The consumption does not need to be diluted with additional liquid, thus reducing any potential contamination from the dilution process. As the name implies, RUTF can be consumed immediately without any preparation prior to consumption. With the lower moisture and water activity, RUTF could be safely stored at ambient tropical conditions for 3-4 months (Manary, 2006).

The first RUTF was developed in 1997 and was called "Plumpy' nut" it was made from milk powder (30%), sugar (28%), peanut butter (25%), cooking oil (15%), and vitamin-mineral mixture (1.6%) and provided 530 kcal per 100g. Plumpy' nut was designed by Nutriset (France) in partnership with IRD as a practical alternative to F-100 with a similar nutritional value. In Plumpy' nut dried milk was partly replaced by peanut paste, but it still has such qualities as simple technology of the production process and the low volume mainly due to its consistency. Moreover, it can be eaten without sophisticated preparation and is easily used at home.

The previous study in Nias, Indonesia (Scherbaum *et al.*, 2015), on the target group of mildly to moderate malnourished children, showed the success story of locally produced RUF biscuits using the locally available food resources and limited technology intervention. Local production of RUF would minimize the costs, associated supply challenges, time for preparation and transportation, and encourage local economies through the transfer of skills and knowledge, empower the use of local agricultural products, thereby increasing social impacts and sustainability (Manary, 2006).

Nowadays, the Community-based Therapeutic Care (CTC) or home-based care approach has been developed for less severe acute malnutrition (SAM) without clinical complications. One important element of the CTC program is treating severely malnourished children with the distribution of Ready-to-Use Therapeutic Food (RUTF) as a diet.

Compared to alternative dietary approaches, standard RUTF possibly expands recovery and may improve the rate of weight gain slightly. The production process is simple and can be made from local groups with simple technology. RUTF in the form of cereal-based recipes is currently being developed and examined as alternative foods to be offered in CTC programs. Initially, a RUTF was developed as a Ready-to-Use Food (RUF), made from a variety of cereals and legumes including peanuts, chickpeas, sesame seeds, maize, and soybeans, besides other RUF components included dried milk powder, sugar, vegetable oil, and mineral and vitamin premix which contain similar macro and micronutrients to F-100. Table 2.4 describes the detail of micronutrient recommendation for rehabilitation undernutrition (MAM) of children under five.

The community-based management of acute malnutrition targets to combine treatment with other various interventions designed to reduce the prevalence of malnutrition and improve both public health and food security. Malnutrition is not only a nutritional problem but also a social and political issue. Therefore, the program was designed to integrate the various aspects of socio-economic factors, particularly deprivation (poverty, gender issues) and the coordination of health services and the local government to set the quick response to the prevalence of undernutrition. A positive factor of the CTC concept is that intensive community consultation and mobilization are included. The role of the mother in this program is increased since she becomes active in preparing nutritious food for the child, which is based on local ingredients. This model is, therefore, decentralized to minimize geographical barriers to access and allow integrating health and nutrition education as part of the program. The knowledge given during education sessions makes sure that the mothers or other caretakers will actively practice maintaining of body weight of children also after they return home.

Table 2.4 Micronutrient recommendation for rehabilitation MAM children

Micronutrient	Unit	Proposed RNI for MAM[1]		Supplementary food for MAM[2]	
		Food	Supplement	Min	Max
Vitamins					
Vitamin A	*µg*	960	1900	2000	3000
Vitamin D	*µg*	7.4	11	20	60
Vitamin C	*mg*	75	100	150	
Vitamin B1 (Thiamin)	*mg*	0.6	1	1	
Vitamin B2 (Riboflavin)	*mg*	0.8	1.8	4	
Vitamin B6	*mg*	0.8	1.8	2	
Vitamin B12	*µg*	1	2.6	5	
Niacin	*mg*	8.5	18	25	
Biotin	*µg*	10	13	20	
Folic Acid	*µg*	220	350	400	
Vitamin K	*µg*	20	40	30	
Vitamin E	*mg*	11.5	22	50	
Pantothenate	*mg*	2.7	3	5	
Minerals					
Calcium	*mg*	600	840	1000	1400
Iron	*mg*	9	18	18	30
Iodine	*µg*	200	200	150	350
Zinc	*mg*	13	20	20	35
Sodium	*mg*	550	550	-	500
Potassium	*mg*	1400	1600	1500	2200
Magnesium	*mg*	200	300	280	420
Phosphorus	*mg*	600	900	850	1400
Copper	*mg*	0.7	0.9	1	35
Selenium	*µg*	30	55	35	90

[1](Golden, 2009); [2](WHO, 2012); Moderate Acute Malnutrition (MAM),

More recently, there are tendencies to promote local food resources for Ready-to-Use Food (RUF) production, which include the issue of food security, sustainability, and sovereignty to access the foods (Scherbaum, Lemke and Bellows, 2012a, 2012b; Scherbaum *et al.*, 2015). Meanwhile, the Indonesian government also encourages the utilization of diverse local foods and staple foods (The Indonesian Presidential Decree, 2009) for supporting the development of underutilized local foods.

Among many commodities, taro (*Xanthosoma undipes* K. Koch) (local name called *Talas Banten*) can be potentially used as a RUF ingredient due to its high energy, vitamin, and mineral contents. Talas Banten can be easily found as a wild plant or cultivated by small-scale farmers in Pandeglang District, Banten Province, Indonesia. Due to its unpopular nature, the limited publication can be found with regards to its cultivation, post-harvest, utilization, and economical aspects. Studies show that talas banten is a rich source of starch that can substitute rice as a staple food (Fetriyuna, Marsetio and Pratiwi, 2016). Meanwhile, research was also performed in analyzing the potential economic contribution of talas banten related to their rich nutritional profile (Budiarto and Rahayuningsih, 2017).

The aim of the study was to develop a ready-to-use food (RUF) from the composite flour of local food resources in Indonesia following the guidelines for the management of moderate acute malnutrition in infants and children under five years of age. Limited reports have revealed the use of talas banten as food ingredients (Haliza, Kailaku and Yuliani, 2017; Hakiki and Rostianti, 2019); thus in order to optimize the nutritional profile of the developed RUF, taro needs to be mixed with groundnut/peanut (*Arachis hypogaea* L.), soybean (*Glycine max*), and mungbean (*Vigna radiata*)as protein and lipid sources, red rice (*Oryza longistaminata),* maize (*Zea mays*) and sweet Purple Potato (Ipomoea batatas var Ayumurasaki) as carbohydrate sources, and also banana (*ambon)* (*Musa acuminata Cavendish*), banana (*kapok*) (*Musa acuminata balbisiana*) and banana (*nangka*) (*Musa textilia*) as mineral sources.

The biscuit was selected as the food carrier of the newly developed RUF from the composite flour of the local foods because the Indonesian children favored different types of ready-to-eat snacks, including biscuits (Inayati, 2011; Sekiyama, Roosita and Ohtsuka, 2012). Also, research investigating the effectiveness of locally produced RUF biscuits distributed among mildly and moderately wasted children on Nias island, Indonesia reported promising results in terms of acceptance (Purwestri *et al.*, 2012; Scherbaum *et al.*, 2015). The summary of the evolvement of ready-to-use foods for the treatment of acute malnutrition presents in Appendix 1.

Chapter 3

General Methodology of the Study

The study protocol was approved by the Ethics Committee of the Faculty of Medicine, University Padjadjaran, Bandung, Indonesia and conformed to the provisions of the Declaration of Helsinki in 1995 (as revised in Edinburgh in 2000). Eligible children were included only based on the informed consent of their caretakers.

3.1 The research site, Banten Province Indonesia

Banten is situated in the westernmost province on the island of Java, Indonesia, with a provincial capital city is Serang, and a total area of 9662.92 Km^2 (see Appendix 2). Banten Province has four Regencies and four Municipalities; these include Serang Regency, Pandeglang Regency, Tangerang Regency, Lebak Regency, Serang Municipality, Cilegon Municipality, Tangerang Municipality, Tangerang Selatan Municipality. Banten is the province with the fifth largest population and the third-density level in Indonesia. The total population of Banten in 2018 is 12.68 million or equal to twice the population of Singapore (BPS-Statistics Indonesia, 2018). The population density in Banten Province was 1313 people/Km2, with a population growth of 1.94%.

Based on Badan Pusat Statistik (BPS, Statistical Bureau) (Banten, 2018) Gross Regional Domestic Product (GDP) in 2018 was mostly from the manufacturing industry sector (49.75%), followed by the trade, hotel, and restaurant sector (17.13%), transportation and communication (8.58%), and agriculture which is only 8.53%. However, based on employment, industry absorbed 23.11% of labor, followed by agriculture (21.14%), trade (20.84%), and transportation/communication only 9.50%. Around 17% of the monthly expenditure is spent on food and beverage consumption. The proportion of the literate population in Banten province was 96.7% in 2019. Agriculture products are dominated by rice, maize, mung bean, soybean, peanut, cassava, and sweet potato. Other potential commodities are *melinjo, aren, anggrek, melon, and durian.* Talas Banten/Taro (Xanthosoma udipes) nowadays has full attention to be promoted as an iconic food resource from Banten Province.

Pandegelang regency has a total area of 2.746,89 km^2 with a total population in 2019 about 1.3 million people, a growth rate of 0.39% and a population density of 440 people/Km^2 (Badan Pusat Statistik Kabupaten Pandeglang, 2018) with 30.92 % of the population is 0-9 years (Badan Pusat Statistik Kabupaten Pandeglang, 2019). GDP of Pandegelang regency in 2019 was generated from agriculture forestry and fishery 33.80%, mining and quarrying 8.74%, Industry 5.86%, Big Scale and Retail Trade 11.69%, transportation and warehousing 5.81%, accommodation and services 5.37%.

Based on the Statistical Bureau of Banten Province (Banten, 2018), the total household in Pandegelang Regency in 2018 was 313,000 households, while 22.6 % (70,718 households), or equal to 122 thousand people are classified as Pre-prosperous (poor) Family (poverty line/threshold 440,538 (IDR/capita/month) (27.70 EUR) (Data of Indonesia 2018), which places Pandeglang as the poorest area in Banten Province. The standard for minimum regional/province wages in Pandegelang is 2.35 Million IDR per month (145 Euro).

3.2 Population Under Study

The population of children under five in Pandegelang regency in 2018 was 154 thousand children, with 38.5% of stunting (the highest rate in Banten Province), which is above the national prevalence of 30.8% ad standard of WHO for only 20%. The entry criteria of the respondents are children one to five years old, without birth defects and chronic disease which live in Kadomas sub-district. Children were chosen based on the list of potentially eligible children in two villages.

3.3 Design of the Study

The study is divided into three sections. The first section is a preliminary study, the second section is product development, and the third is the acceptability study of the RUF for the target group of children under five.

Figure 3.1. Research Procedure

	Research procedure	Methods
Preliminary Study The goals: information of nutritional condition in the research area and the potential of local food resources	Local Food Resources and Nutritional condition ↓	• Macronutrient (proximate) analysis • Micronutrient (vitamin and minerals) analysis • Baseline survey and Nutritional condition of the target group
RUF Product Development The goals: RUF biscuit meets the standard for MAM (Moderate Acute Malnourished) children	Ready to Use Food (RUF) Product Development ↓	• RUF formulation and baking process
	RUF Biscuits ↓	• Macronutrient • Micronutrient • Physical properties (dimension, color) • Sensory evaluation (hedonic test)
Acceptability Study The goals: local production of RUF biscuits and the acceptance of the target group of children under five	Pre-trial for Local Production ↓	• Locally produced of selected recipes RUF
	Local Production Ready to Use Biscuits	• Acceptability study • 2 recipes for 2 weeks of consumption

3.3.1 Preliminary/Baseline Studies

A preliminary study was conducted to elaborate on the nutritional status in the research area while observing the potential of local food resources as an alternative to overcome undernutrition. This phase consisted of three main activities:

A. Appraisal of nutrition status and condition

   To answer the first objective of the assessment of the nutritional condition in the research area (Banten Province, Indonesia) especially the target group of children under five years, a baseline survey was conducted for the assessment of nutritional status and hygiene practice of the target group of children under five. The following data were obtained from the results of the baseline survey in the research area: demography, socio-economic conditions, medication, environment, sanitation and hygiene, knowledge of mothers/caretakers in relation to health and nutrition, food and water scarcity, as well as nutritional status of the children under-five years old. Furthermore, data on local food consumption is also elaborated as information on the use of underutilized food. Baseline information was used to develop the RUF recipe, which was appropriated for the target group.

B. Analysis of nutrition composition of local commodity

   The analysis of the potential of local food resources was conducted for the second research objective for nutritious food as sources for the treatment of undernutrition. Local food resources of Taro *(Xanthosoma undipes K. Koch),* Red rice (*Oryza sativa),* Peanut (*Arachis hypogaea*), Soybean (*Glycine max*), Mungbean (*Vigna radiata*), Banana (Ambon) (*Musa acuminata Cavendish*), Banana (Kepok) (*Musa acuminata balbisiana),* Banana (Nangka) (*Musa textilia*) Maize (*Zea mays*), Sweet Purple Potato (*Ipomoea batatas var Ayumurasaki*) were analyzed for macro and micronutrient composition. Macronutrient composition consists of proximate analysis for protein, fat, moisture, ash, and carbohydrate content. Micronutrient analysis comprises mineral analysis (Ca, Mg, K, Na, P, Fe, Zn, Cu, Mn, I, Se) and vitamins (Vitamin A, B1, B2, E). The nutritional composition of those local food resources was used to develop the RUF recipe to meet the recommendation.

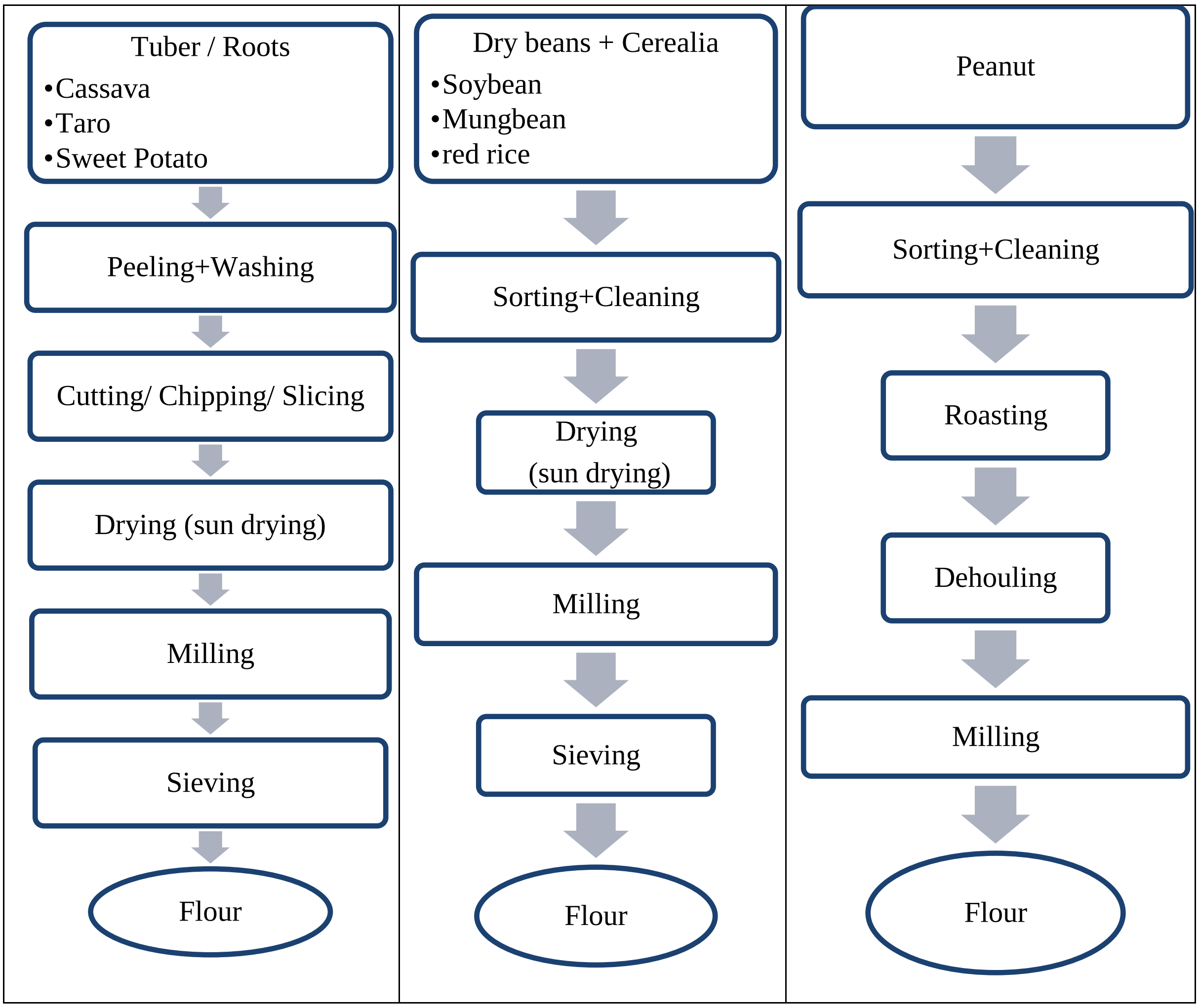
C. Assessment of available technology in the research area for RUF production

The observation of the appropriate technology was carried out to support the research objective of the local production of RUF biscuits. The technology for RUF production has to be available in the research area for the pilot project and local production of RUF Biscuit. The lowest and the minimum technology were appropriate for the implementation in the remote area.

3.3.2 RUF Product Development

RUF made using various compositions of local food resources to achieve the third research objective of the formulation of RUF biscuit to meet the standard of supplementary food for undernutrition. All the ingredients were prepared based on the initial condition in the research area. The local food resources were processed into flour before proceeding into the baking process. The preparation of local food resources was presented in Figure 3.2.

Figure 3.2. Preparation Processes of Local Food Resources



Twelve recipes were developed and analyzed for nutrition composition and sensory testing. The prediction of the RUF recipe was made based on the Nutrisurvey program using the Indonesia food database and made from the local food resources available in the research area. The composition was set to meet the nutritional composition as required in the recommendation. The nutritional composition of the RUF using local food resources from Banten Indonesia as compared to the recommendation of supplementary food for moderate Acute Malnourished (MAM) children.

The baking process was modified from (Shapiro, 2007) and (Novianty, 2008). The procedure initially mixed the entire dry ingredient until homogeny and continued with adding the liquid ingredient afterward. The procedures of the baking process for the RUF start with weighing all the ingredients, mixing, molding, baking, and packaging. The biscuit was baked for 15 minutes at 150 ^{0}C with the round shape of 7-8 g each.

The composition of the macronutrient of RUF biscuit was analyzed in the Core Facility of Hohenheim University includes the proximate analysis (protein, fat, moisture content, ash, and carbohydrate) based on (Europian Commission, 2009). The results were compared with the data generated from Nutrisurvey software. The entire recipe was tested for a sensory evaluation using a hedonic of preferences test for appearance, aroma, color, texture, mouthfeel, after taste, and overall acceptability attributes. Five selected recipes based on the nutritional composition and sensory evaluation were continued to be fortified with the micronutrient premix and analyzed for the micro-nutrition composition.

3.3.3 Fulfillment of Nutritional Composition of RUF Biscuit

The selected recipes were fortified with the micronutrient premix to increase the micronutrient composition to meet the standard for MAM children. The process production was the same and the micronutrient premix was fortified and mixed with other ingredients in the baking process. The RUF biscuit was fortified with a micronutrient premix of Centrum® from Pfizer.

3.4 Local Production and Acceptability Study of RUF biscuit

Selected RUF (with the fortified micronutrient) was tested on children under five in the research area and evaluated the potentiality of this food to improve the nutrition status for the target group. Dissemination of RUF recipe to the local community, as well as the training of production for locally produces RUF. Locally produce RUF biscuit was tested for microbiological contamination for total plate count (TPC) (AOAC, 1990) and shelf life (Accelerate Self Life Testing method with Arrhenius model) (Labuza, 1992), those analyses were determined to ensure the safety of the product to be consumed by targeted consumers. An acceptability study was conducted with the children under five as a respondent with the informed consent of their parents/caretakers.

Before conducting the real acceptability study on children under five, we piloted the trial for sensory evaluation tests among recipes. 2 selected recipes were continued to acceptability test for two weeks of observation. 2 Selected recipes were locally produced by the community under the supervision of the researcher using local food resources and ingredients. RUF biscuits were produced twice a week and directly distributed to the target group.

3.5 Data Collection and Analysis

3.5.1 Baseline data collection

The preparation and coordination with the community took place from the end of May to July 2017, baseline data collection and RUF acceptability study were conducted in October 2017. The study took place in Pandegelang regency, Banten Province Indonesia.

Several data were collected during the baseline survey, such as demographic characteristics, socio-economic conditions, breastfeeding practices and feeding practices, morbidity (diarrhea and respiratory infection), environment sanitation and hygiene, knowledge of mothers/caretakers concerning health and nutrition, food, and water scarcity. The food security situation in the family was assessed by using household food expenditure. All the data were collected using an interview and questionnaire.

Data on dietary intake of food consumption using the 24-h recall and the result was continued processed with CIMI-Indonesia (Jati *et al.*, 2014) to predict the adequacy of micronutrient consumption. Food consumption and check with CIMI (Calculator of Inadequate Micronutrient Intake) for Indonesia about the sufficient micronutrient intake of a targeted group.

Nutritional status of the children included: WAZ (Weight-for-Age z-score), HAZ (Height-for-Age z-score), and WHZ (Weight –for- Height z-score), as well MUAC (Mid-Upper-Arm-Circumferences) of children under-five.

3.5.2 Nutritional Content Analysis

a. Proximate analysis

The chemical properties of the flour (raw materials) and RUF biscuits were analyzed at the Core Facility of the University of Hohenheim (accredited testing institute DIN EN ISO/IEC 17025:2005) in duplicate with the advanced equipment coupled with well-established laboratory protocols. The composition of macronutrients was determined using the Commission Regulation (European Union/EU) (European Commision, 2009) for protein, fat, ash, and moisture content. The carbohydrate content was calculated by difference. The energy value was estimated using a formula of (4 times protein + 4 times carbohydrate + 9 times fat) and presented in kcal.

b. Minerals analysis

Dietary minerals (Ca, Mg, K, Na, P, Fe, Zn, Cu, Mn, I, Se) were analyzed using the Commission Regulation (EU) (Europian Commision, 2009) using ICP-MS NexION 300X (PerkinElmer, Inc., Massachusetts, USA) for Zn, Se, Fe, Cu, and I and atom-emission spectrometers of VistaPRO ICP-OES (Varian Inc., Palo Alto, USA) for Ca, Mg, K, Na, and P.

c. Sensory Evaluation Test

The sensory evaluation of the samples was conducted using a preference test with a 7-point hedonic scale. Twelve coded RUF biscuits were presented to each panelist in each session. The parameters that were tested were appearance, aroma, color, texture, mouthfeel, aftertaste, and overall acceptability. On the 7-point hedonic scale, 1 and 7 represent the least score (dislike very much) and the highest score (like very much), respectively.

d. Vitamin A, B1, B2, and E

Vitamins (A, B_1, B_2, and E) were analyzed using various HPLC (High-Performance Liquid Chromatography) methods. For Vitamin A using the method of (Wald, Nohr and Biesalski, 2018), B_1 and B_2 (European Committee for Standardization, 2014b, 2014a), and vitamin E (Irías-Mata *et al.*, 2017)

e. Determination of Physical Properties

The diameter and the thickness of the RUF biscuits were determined using a digital Vernier caliper. An average of five values for each of three replications was taken for each sample set and reported in millimeters. The spread ratio was calculated as diameter divided by thickness. Color analysis of the biscuits was carried out using a Chroma Meter (Minolta CR-400) based on CIA *L*, a*, and b** color system. L* measures black to white (0-100), a * value measures redness when positive, and b* value measures yellowness when positive.

3.5.3 Acceptability Study of RUF Biscuit

Locally produced RUF (2 selected recipes) were distributed for 2 weeks to the children under five years of age, and their preferences were observed. In addition to the RUF biscuit consumption data, the baseline and end-line data of the nutritional status of the children were recorded together with the 24h recall of food consumption. Nutritional indicators that were measured included weight (before and after RUF consumption), weight gain, consumption (RUF intake), and compliance rate. Additionally, the nutritional status of the children was reported as WAZ (Weight-for-Age z-score), HAZ (Height-for-Age z-score), and WHZ (Weight –for- Height z-score).

3.5.4 Data analysis

This research used several statistical analyzes following the 3 studies. The baseline study analyzed the nutritional status and the level of influence of factors that affected the children's nutritional status. Regression analysis was used to estimate the level of influence of predictors such as family, socio-economic status, and hygienic behavior.

The product development study used a comparative analysis of the RUF biscuit recipes based on their nutritional composition. This analysis used Analysis of Variance

(ANOVA), independent sample t-test, and paired sample t-test to test the diversity or difference among RUF Biscuit recipes.

At the acceptability study, the analysis was carried out to examine the effect of RUF biscuits on the nutritional status of children. A comparative analysis using ANOVA was carried out to examine differences in the nutritional status of children before and after consuming RUF biscuits.

The analyses, testing the regression model assumptions, data distribution, and its characteristics were carried out in the chosen analytical methods, and the set of hypotheses in this research. The post hoc test used was Duncan's Multiple Rank Test. The Statistical analysis was done using SPSS version 25 software from IBM.
Anthropometric data were transformed to Z-scores using WHO Anthro 2007. Data were checked for conformity to a normal distribution using chi-square goodness of fit for normally distributed data.

Chapter 4

Ready-to-Use Food (RUF) from Composite Flour of Local Commodities in Banten Province, Indonesia for Prevention and Rehabilitation of Malnutrition in Children Under Five

The study was carried out from 2016 to 2020 and comprised of laboratory analysis in Germany and field data collection in Indonesia. The presentation of the result is divided based on the research objectives.

4.1. Baseline Nutritional Situation and Dietary Intake of Children Under Five in Banten Province

Regarding the first research objective to assess the nutritional condition in the research area, a cross-sectional survey was conducted in October-November 2017 in Pandegelang Regency, Banten Province, Indonesia. Pandegelang district was chosen due to the high prevalence of undernutrition. Among the provinces and districts on Java Island, Pandegelang has a proportion of undernutrition above the average national level (stunting prevalence, 38.5%, wasting, 13.8, and underweight. 17.7%) and Kadomas subdistrict was selected based on the availability of taro production as an underutilized food resource.

The subject of this study was the oldest non-exclusively breastfed children (aged between 6- 60 months). The inclusion criteria were healthy under-five children and were domiciled in the region at least 6 months prior to the study. Baseline data collection was conducted with the coordination with the *Pusat Kesehatan Masyarakat/Puskesmas* (Community Health Center) and *Pos Pelayanan Terpadu/Posyandu* (Local Integrated Health Post). The eligible children were selected randomly from the lists of potential children collected from midwives or cadre of the local *Posyandus*.

The questionnaire was developed and pretested at the University of Hohenheim, Germany, and it was also pretested in Banten. The questionnaire was designed based on a set of sample questionnaires that had been applied during field research in some research sites in Indonesia (Purwestri *et al.*, 2012, 2017) and was further improved with specific questions relevant to the current research situation and objectives.

The interviews were individually scheduled by four trained enumerators who had received training prior to the study. During data collection, mothers or caregivers of eligible children were interviewed at home and asked about the child's general, family, and socio-demographic characteristics (such as the number of children in the household, household size, house condition, and ownership), source of income, and items that money was spent on. They were also asked about the child's feeding pattern and snacking habits. The anthropometric measurement was also applied for height, weight, and MUAC as well as the observation of the visible signs of undernutrition. The heights were measured using a height/length board (for above/below two years old), and a SECA 201 scale was used to determine their weights. All measurements were carried out twice unless a third measurement was needed for confirmation. The average of the measurements was used for the analysis. Birth dates of the children were obtained from birth certificates or other records. When not available, the birth dates were estimated using a calendar of local and national events and converted to the Gregorian calendar.

Data on food consumption from 24-h recall was analyzed using the CIMI (Calculator of Inadequate Micronutrient Intake) program, a rapid and direct tool that calculates nutrient intake, energy and compares the %age of fulfillment with the dietary recommendation (RNI) for under-five children in Indonesia.

4.1.1 Sampling procedure and sample size calculation

The population of children under five in Pandegelang regency in 2017 was 151 thousand, with 38.5% suffering from stunting (the highest rate in Banten Province) which is above the standard of WHO (only 20%). The inclusion criteria for the respondent are children under five (6- 60 months), and no longer exclusively breastfeeding (i.e. consuming some solid foods, supplementary food).

A minimum required sample size of n = 101 was determined using the formula of $z^2p(1-p)/d^2$ (Lachenbruch, Lwanga and Lemeshow, 1991). Based on the prevalence of moderate wasting in Baten province (the target group of RUF biscuit) which is about 7.3% *(p)* (Balai Penelitian dan pengembangan Kesehatan RI and Kesehatan, 2013) with a 95% confidence interval and 5% marginal error (*d*). The calculated sample size was 101, with a final sample size was 105 (including buffer). The small sample size is the limitation of the study due to the limited research budget.

4.1.2 Outcome Variables

The length of the children <2 years was measured using Seca-mobile-mat at the accuracy of 0.5 cm. Height was attempted for children >2 years by using a Seca-mobile stadiometer at the accuracy of 0.1 cm. All children were weighed with calibrated Seca-floor-scale at the accuracy of 0.1 kg, barefooted and minimal clothes (without diapers). Mid-upper arm circumference (MUAC) was measured using a non-stretchable tape at the mid-point of the left arm (relaxed position). The birth certificate was used to obtain the child's date of birth. The Anthro software 2011 from World Health Organization (WHO) was used in this study to compute the stunting, underweight, wasting, mid-upper arm circumference (HAZ, WAZ, WHZ, and MUAC) scores based on the 2006 WHO child growth standard as reference (WHO and Unicef, 2019).

Data on food consumption was entered into the CIMI program to calculate the amount of macronutrient (protein, carbohydrate, fats), minerals (iron and zinc), pre-formed vitamin A, carotenoids, retinol equivalents (RE) with a carotenoid conversion factor of 1:6 or 1:12, and % of total energy intake. The individual data will automatically generate. The % of the recommended intake of protein, iron, zinc, energy, and vitamin A was calculated based on the FAO/WHO age and gender-specific RNI (Jati *et al.*, 2014).

4.1.3 Ethics Approval and Consent to Participate

The study adapted to the provisions of the Declaration of Helsinki in 1995 (as revised in Edinburgh 2000). Eligible children were included only on the basis of the informed consent of their caretakers. The baseline study is registered with the study code no.: 840/UN6.C.10/PN/2017 at the Health Research Ethics Committee Faculty of Medicine Universitas Padjadjaran Bandung, Indonesia (July 28th, 2017) and approved by the *Badan Kesatuan Bangsa dan Politik* (Board of National and Political Unity) code no.: 070/160-kesbangpol/2017 (Oct 2nd, 2017). A full explanation of the purpose of the study was given before the enrollment to the communities especially to the parent and caretakers of respondents, and informed consent was obtained either by signature or thumbprint.

Results of the Baseline Study of Appraisal Nutrition Status and Condition

4.1.4 Prevalence of undernutrition

Baseline assessment was conducted in two villages, Kadomas and Kalanganyar, with a total of 105 children (aged 7-61 months), which consist of 56 (53.3%) boys and 49 girls (46.7%). Regarding the baseline household survey, 105 caretakers participated. The main person in charge of the children was the mother, 82 (78.2% with 14 are a single parent), grandparent, 19 (18.1 %), uncle/aunt 1, and others relative, 3 (2.9%). Around 53.3% of the children recruited in this study were boys, and the majority (76.2%) of them lived in a nuclear family.

Nearly every second child was found to be stunted (40.0%), almost every fourth was underweight (24.0%), and only a few suffered from moderate or severe wasting (5.0%). No significant differences concerning anthropometric measurements were found between genders. The age of the children (n = 105) was, on average 31.6 ± 16.0 months at baseline with no significant difference in the age distribution between both genders. There was a tendency that girls suffered slightly more from any form of undernutrition according to the levels of HAZ, WAZ, and WHZ. In contrast, boys were somewhat higher represented in the adequate z-score levels (Table 4.1).

Table 4.1 Nutritional Status of Children Under Five

Category	n	Mean	Sd	Median	Min	Max	Well-Nourished n (%)	Under Nourished n (%)
Children	105							
Age (month)	105	31.6	16.0	30.4	7.1	61.2		
Weight (kg)	105	11.5	3.3	11.7	6.1	28.7		
HeightLength (cm)*	105	84.6	11.0	86	63	109.5		
HAZ	105	-1.6	1.4	-1.7	-4.7	2.1	63 (60.0)	42 (40.0)
WAZ	105	-1.1	1.2	-1.3	3.4	4.9	80 (76.2)	25 (23.8)
WHZ	105	-0.3	1.3	-0.4	3.5	5.7	100 (95.2)	5 (4.8)
MUAC	105	0.09	1.74	0.04	-5.44	5.07	96 (91.4)	9 (8.6)
by Gender								
Age (months) Boys	56	31.3	16.6	31.4	7.7	61.2		
Age (months) Girls	49	31.9	15.5	29.9	7.1	59.7		
Weight (kg) Boys	56	11.6	3.3	11.8	6.8	28.7		
Weight (kg) Girls	49	11.4	3.3	11.3	6.1	21.7		
Height (cm) Boys	56	84.5	10.8	84.3	65	108.2		
Height (cm) Girls	49	84.9	11.3	86.5	63	109.5		
HAZ Boys	56	-1.6	1.4	-1.7	-4.7	1.8	32 (30.5)	24 (22.9)
HAZ Girls	49	-1.6	1.4	-1.7	-3.8	2.1	31 (29.5)	18 (17.1)
WAZ Boys	56	-1.2	1.2	-1.3	-2.9	4.9	42 (40.0)	14 (13.3)
WAZ Girls	49	-1.2	1.2	-1.3	-3.4	1.9	38 (36.2)	11 (10.5)
WHZ Boys	56	-0.4	1.3	-0.4	-3.5	5.7	54 (51.4)	2 (1.9)
WHZ Girls	49	-0.4	1.3	-0.4	-2.9	3.2	46 (43.8)	3 (2.9)
MUAC Boys	56	0.14	1.78	-0.05	-5.1	5.07	52 (92.9)	4 (7.1)
MUAC Girls	49	0.05	1.70	0.2	-5.44	2.97	44 (89.8)	5 (10.2)
by Age								
HAZ ≤ 2 year*	42	-1.3	1.3	-1.2	-4.0	2.1	30 (28.6)	12 (11.4)
HAZ > 2 year*	63	-1.6	1.4	-1.8	-4.7	1.4	33 (31.4)	30 (28.6)
WAZ ≤ 2 year	42	-1.2	1.2	-1.1	-3.4	0.8	31 (29.5)	11 (10.5)
WAZ > 2 year	63	-1.0	1.3	-1.2	-3.3	4.9	49 (46.7)	14 (13.3)
WHZ ≤ 2 year	42	-0.7	1.2	-0.7	-2.9	1.74	38 (36.2)	4 (3.8)
WHZ > 2 year	63	-0.1	1.3	-0.2	-3.46	5.7	63 (60.0)	1 (0.0)
MUAC ≤ 2 year	42	0.19	2.29	0.04	-5.4	3.6	36 (34.3)	6 (5.7)
MUAC >2 year	63	0.12	1.71	0.06	-3.37	5.07	60 (57.1)	3 (2.9)

* Undernourished (HAZ, WAZ, and WHZ z-score ≥ -2 SD). HAZ (Height-for-Age z-score), WAZ (Weight-for-Age z-score), WHZ (Weight –for- Height z-score), and MUAC (Mid-Upper-Arm-Circumferences)
* p<0.05: statistically significant different

The proportion of children affected by moderate or severe stunting (HAZ) showed an increase with age, this increase was shown to be significant ($p = 0.009$), between the youngest age group versus the older age groups, respectively. The number of children with moderate or severe stunting (HAZ) in the age group >2 years is more than double that in children ≤ 2 years (28.6 and 11.4 % respectively).

On the other hand, the proportion of children suffering from moderate or severe underweight (WAZ) and wasting (WHZ) remain the same between age groups. Only a slight increase for underweight was observed from the children ≤ 2 years to the children >2 years, from 10.3% to 13.3%, while WHZ slightly decreased from 3.8 % to 0.01%, and showed a difference that is not statistically different.

According to the MUAC z-score measurements, 8.6% of the children can be classified as undernourished. The prevalence of undernourished children based on the MUAC z-score is higher in the girls’ group compared to the boys'. Based on the age group, the prevalence of undernutrition is higher in the age group of ≤2 years and declined in the age group of more than 2 years.

Based on the anthropometric failure indicators (Table 4.2), the occurrence of both stunting and underweight affected 18% (n=19), both wasting and underweight, 3% (n=3), while all combinations of wasting, underweight, stunting occurred only in one child.

Table 4.2 Prevalence of undernutrition amongst children under five according to a composite index of anthropometric failure

Group	Nutritional Status of Children	Total n=105 n (%)	Sex		Age	
			Boys n=56	Girls n=49	≤ 2 year n=42	> 2 year n=63
1	Well-Nourished	57 (54)	28 (49)	29 (51)	26 (46)	31 (54)
2	Under Nourished	48 (46)	28 (58)	20 (42)	16 (33)	32 (67)
	Wasting only (WHZ moderate and Severe)	1 (1)	1 (100)	0	0	1 (100)
	Wasting and underweight (WHZ and WAZ moderate and Severe)	3 (3)	1 (33)	2 (67)	3 (100)	0
	Wasting, underweight, stunting (WHZ, WAZ, HAZ moderate and Severe)	1 (1)	0	1 (100)	1 (100)	0
	Stunting and underweight (WHZ and HAZ moderate and Severe)	19 (18)	11 (58)	8 (42)	6 (32)	13 (68)
	Stunting only (HAZ moderate and Severe)	22 (21)	13 (59)	9 (41)	5 (23)	17 (77)
	Underweight only (WAZ moderate and Severe)	2 (2)	2 (100)	0	1 (50.0)	1 (50.0)

* Undernourished (HAZ, WAZ, and WHZ z-score ≤ -2 SD)
HAZ (Height-for-Age z-score), WAZ (Weight-for-Age z-score), WHZ (Weight –for- Height z-score), and MUAC (Mid-Upper-Arm-Circumferences)

4.1.6 Dietary Intake based on CIMI Program

Every second of children had inadequate consumption of energy (55.2 %) and micronutrients - iron (50%), zinc (53%), with almost all the children having inadequate consumption of vitamin A (98%). There were no differences in consumption between gender except for iron (p-value=0.000). The consumption of energy was not significantly different between the age group (p-value =0.19), which appears significant for micronutrient iron and zinc (p=0.000). The inadequate consumption of iron is significantly decreased by the age of children, it is shown that the drastic decrease of more than half, from 74% to 35%, in the age group of ≤ 2 years to the age group > 2 years, respectively.

Table 4.3 Nutrient intake of the children under five in the research area

Category	n	RNI[a]	Mean	Sd	Median	Min	Max	Adequate (%)	Inadequate (%)
Energy (kcal)	105	1200	1,196.9	505.9	1,076.6	160.8	2,585.5	47 (45)	58 (55)
Boys	56		1,207.1	486.4	1107.3	322.9	2,263.5	24 (43)	32 (57)
Girls	49		1,185.2	528.9	1,007.9	160.9	2,585.6	23 (47)	26 (53)
≤ 2 year	42		1,080.2	256.3	990.6	160.9	2,585.6	23 (55)	19 (45)
> 2 year	63		1,278.8	495.8	1,187.9	467.3	2,450.5	24 (38)	39 (62)
Protein (g)*	105	32	33.6	13.6	33.8	4.0	68.2	102 (97)	3 (3)
Boys	56		33.1	13.3	32.8	9.2	68.2	54 (98)	2 (2)
Girls	49		34.1	13.9	33.8	4.0	59.5	48 (98)	1 (2)
≤ 2 year	42		28.0	12.8	25.3	4.0	53.1	39 (93)	3 (7)
> 2 year	63		37.4	13.4	35.0	12.2	68.2	63 (100)	0 (0)
Iron (mg)*	105	8	4.85	2.8	4.8	0.0	13.1	52 (50)	53 (50)
Boys	56		4.9	2.9	5.1	0.0	13.1	31 (55)	25 (45)
Girls	49		4.8	2.8	4.6	0.7	11.1	20 (41)	29 (59)
≤ 2 year	42		3.1	2.4	2.6	0.0	7.6	11 (26)	31 (74)
> 2 year	63		6.0	2.7	5.3	0.0	13.1	41 (65)	22 (35)
Zinc (mg)*	105	4	4.9	3.5	4.01	0.4	18.8	49 (47)	56 (53)
Boys	56		4.5	2.9	4.1	0.7	16.6	25 (45)	31 (55)
Girls	49		5.3	3.9	3.9	0.4	18.8	24 (49)	25 (51)
≤ 2 year	42		2.8	1.9	2.5	0.4	6.6	8 (15)	34 (85)
> 2 year	63		6.2	3.6	5.7	0.66	18.8	41 (64)	22 (36)
Vitamin A (mg)	105	400	167.8	86.9	164.3	0.0	448.1	2 (2)	103 (98)
Boys	56		161.7	82.4	157.0	0.0	401.4	1 (2)	55 (98)
Girls	49		174.6	91.9	174.8	0.0	448.1	1 (2)	48 (98)
≤ 2 year	42		171.9	56.7	162.0	2.11	314.0	0 (0)	42 (100)
> 2 year	63		173.8	92.5	170.6	0.0	448.1	2 (3)	61 (97)

[a] Recommended Nutrient Intake (RNI) (Ministry of Health RI, 2013), kcal = kilo calorie, g= gram, mg = milligram. * Statistically significant difference ($p<0.05$)

Similarly, the increasing age of children has decreased the inadequate consumption of zinc from 85% in children in the age group of ≤ 2 years to only 36% in children > 2 years. Children had insufficient vitamin A with no significant difference among gender and age groups.

Calculator of Inadequate Micronutrient Intake (CIMI) was used to analyze the daily intake of the children from a 24-h recall. The CIMI calculated the absolute intake of energy, macronutrients, retinol, ß-carotene, retinol equivalents, iron, and zinc and presented the %ages of RNI fulfillment (Jati *et al.*, 2014).

Rice and other carbohydrate sources were the main types of foods consumed in Banten with low fruit and vegetable consumption. However, consumption of this monotonous diet resulted in the habitual intake that was largely deficient in several nutrients.

The study of food consumption, nutritional and biochemical status of children by (Sandjaja *et al.*, 2013) found a similar result in that the weight for age, height for age, weight for height, and BMI for the age of Indonesian pre-school- and school-aged children are below the WHO standards. This study reported that the prevalence of stunting was 25.2 and 39.2% in urban and rural areas, respectively. As many as 4.1–8.8% of the children were iron deficient. In addition, the proportion of children with dietary intakes of energy, protein, and vitamins A and C below the Indonesian RNI was high and differed across urban versus rural areas and age groups.

4.1.7 Socio-economic condition

The mean age of the fathers was 35.7 years and that of the mothers was 30.7, with the youngest age for both groups at 20 years old. The guardians/caretakers vary from 14-75 years old and range from the siblings, aunt/uncle to grandparents. The average educational level of the guardians/caretakers was 6.3 years (or equal to elementary school) and the parents were 9 years (junior high school). Table 4.4 show that the proportion of undernourished children was higher in the groups with parental lower educational levels compared to the groups with a higher educational level (senior high school, >12 years).

This condition is in line with the other findings that the low educational level of parents or caretakers has a higher probability to have undernourished children (Rahman *et al.*, 2008; Budiastutik and Nugraheni, 2018; Beal *et al.*, 2018; Stiller *et al.*, 2020) and literacy of parent (Meshram *et al.*, 2012). Table 4.4 shows the household socio-economic characteristics.

Table 4. 4 Household socioeconomic characteristic

Variable	N	Mean	Sd	Median	Min	Max	Well-Nourished n (%)	Under Nourished n (%)
Social Variable								
Parent's Age	188	33.2	6.3	33	20	55		
• Father	93	35.7	6.8	35	20	55		
• Mother	95	30.7	5.8	31	20	41		
• Caretaker	22	47.3	13.1	46	14	75		
Parent's year of schooling	188	8.9	3.0	9.0	1	16		
• Father	93	8.9	3.0	9.0	1	16		
• Mother	95	8.9	3.0	9.0	3	16		
• Caretaker's	22	6.3	2.5	6.0	1	12		
Parent's year of Schooling								
• ≤ 6 years	47						20 (42.6)	27 (57.4)
• 7-12 years	54						34 (62.9)	20 (37.1)
• >12 year	4						3 (75.0)	1 (25.0)
Number of family member	105	4.7	1.7	4.0	3	14		
• ≤ 3 persons	26						17 (65.4)	9 (34.6)
• 4 - 5 persons	52						28 (53.8)	24 (46.2)
• > 5 persons	27						12 (44.4)	24 (55.6)
Housing status	105	1.5	0.5	1.0	1	3		
• Owned	57						28 (49.1)	29 (50.9)
• No rent cost	46						28 (60.9)	18 (29.1)
• With rent cost	2						1 (50.0)	1 (50.0)
Economic Variable								
Working sector*	105	3.2	0.8	3.0	1	4		
• Primary	7						2 (28.6)	5 (71.4)
• Secondary	4						1 (25.0)	3 (75.0)
• Tertiary	89						50 (56.2)	39 (43.8)
• Not Work	5						4 (80.0)	1 (20.0)
Monthly Earning (IDR Million)	105	1.9	2.1	1.5	0.2	15.0		
• Below minimum wages	81						43 (53.1)	38 (46.9)
• Above minimum wages	24						14 (58.3)	10 (41.7)

* Statistically significant difference ($p<0.05$)

The HH members were between three and 14 persons (with an average of five persons). The number of own children per HH ranged from one to five (on average1.7 ±0.8 children). The smaller families tend to have well-nourished children compared to the big families. In the group with more than three children, the proportion of undernourished children is higher than the number of well-nourished children.

The type of household (HH) structure (n = 105) was balanced between nuclear family (54.3%) and an extended form of HH structure, where father, mother, and children live together with other relatives under one roof (43.8 %) usually with the grandparents and other siblings. Data suggests that extended families are less vulnerable with commonly two persons earning an income and sharing for food. Accordingly, extended families show less undernourished children compared to nuclear families. This condition is in line with the finding of the study on the predictor of maternal-child double burden nutrition (MCDB) (Oddo *et al.*, 2012) which found that the large family size has a high correlation (positively associated) with MCDB in Indonesia.

Only 6.7% of the HH rely on their income from the primary sector (agriculture, forestry, and fishing, mining), 3.8% from the secondary sector (manufacturing, engineering, and construction), and most HH sources of income are from the tertiary sector (services, finance, retail) Among the parent's working sector, it showed the significant difference (p=0.000) with the children undernourished. Secondary and primary sectors of income have a higher %age of undernourished children (75 and 71 % respectively) compared to the HH depending on sources of income from the tertiary sector (44%).

Based on the research which observed the correlation between agriculture and stunted children, Purwestri *et al.* (2017) found that a higher proportion of households that grew rice solely or mainly for their consumption (62.4%) with the smaller sized rice-fields, had significantly (p = 0.041) stunted rather than non-stunted children.

More than three quarters (77.1%) of the HH earn below the minimum wages (2.1 million rupiah equal to 136.20 Euro per month (1 euro = 16 thousand rupiahs). The HH with the monthly earning below standard has a higher proportion of undernourished children compared to the HH with the monthly earning above the standard. Low household socio-economic status is one of the several determinant factors of child stunting (Beal *et al.*, 2018; Budiastutik and Nugraheni, 2018). Households with lower income are less likely to frequently acquire and provide diverse foods to feed their children.

Based on the findings of the baseline data collection, the prevalence of stunting is 40.0 %, wasting 4.8 %, and underweight 23.8 % in the children under five in the research area of Pandegelang regency/district in Banten Province of Indonesia. It is confirmed that the Pandegelang regency/district has the highest prevalence of undernutrition in Banten province. This condition is also higher than the national prevalence of undernutrition in 2018, when stunting was at 30.8 %, wasting at 10.2 %, and underweight at 17.7 %. Based on the WHO classification, Indonesia (as well as Banten Province) is classified as a country with medium severity of underweight, high severity of stunting and wasting, (WHO, 2020). The hygienic practice, maternal education level, and HH income are the determinant factors of undernutrition in the research area (the determinant factors of undernutrition are presented in Appendix 3.

4.2 Ready-to-use Food (RUF) Biscuit Product Development

This research section presents the development of the RUF biscuit formulation from the composite flour of local food resources according to the standard and recommendation for the prevention and rehabilitation of undernourished children under the age of five. This research section is in line with the second - fourth research objectives which are the assessment of the potential of local food resources, and the development of ready-to-use food (RUF) biscuits from the composite flour of local food resources to prevent and rehabilitate moderate acute malnutrition (MAM) children (Golden, 2009).

As mentioned in chapter 3, Banten province has agricultural products such as rice, maize, mung bean, soybean, peanut, and sweet potato, and some of them are still underutilized like taro (local name called *talas*). Formulation of RUF biscuit to overcome undernutrition using local food resources as an idea to promote food security and sovereignty while solving the nutrition problem in that area.

4.2.1 Nutritional Composition of Local Food Resources

The local food resources used in the study are shown in Table 4.5.

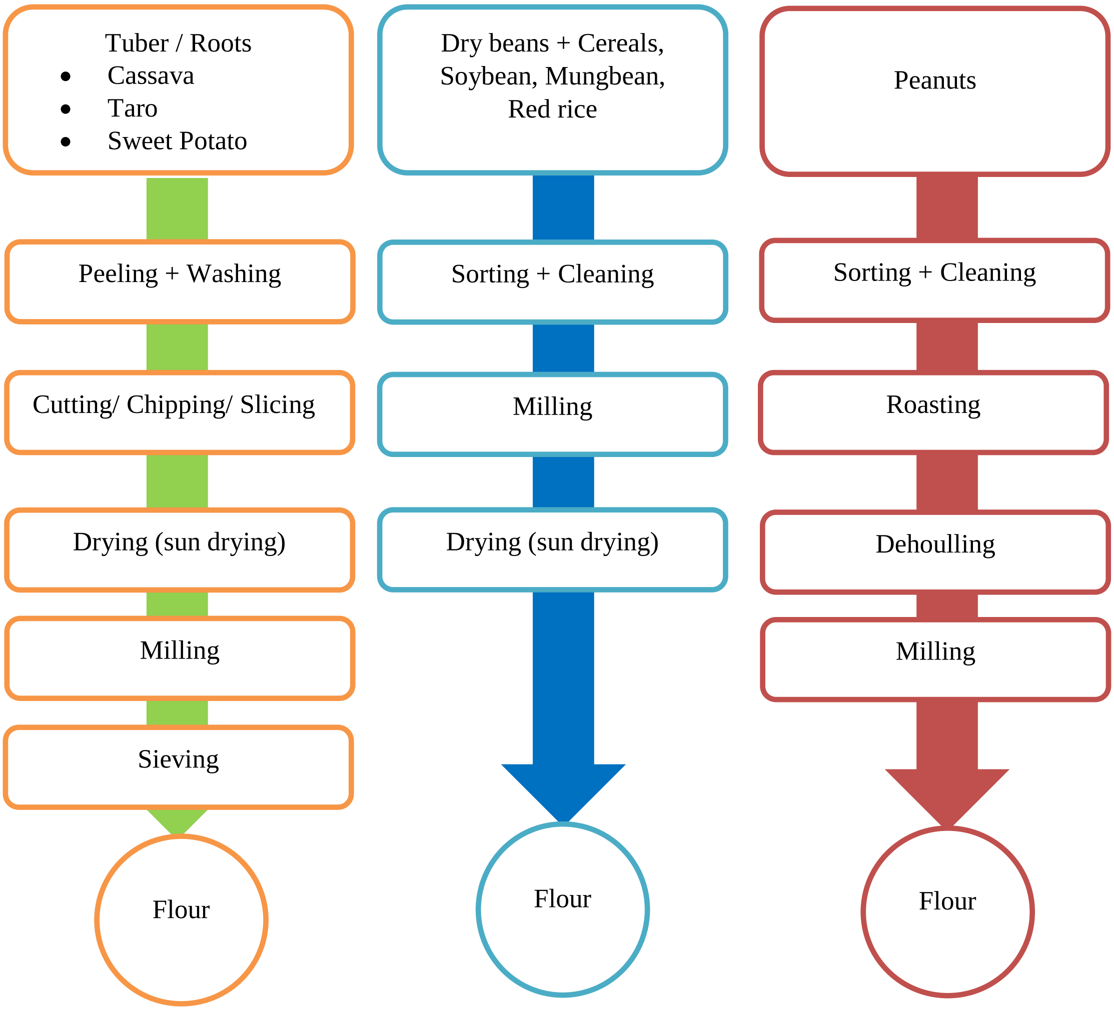
Table 4.5 Local Food Resources for RUF Formulation

English Name	Scientific Name	Local Name
Taro	*Xanthosoma undipes* K. Koch	Talas Banten/Beneng
Red Rice	*Oryza sativa*	Kacang Tanah
Soybean	*Glycine max*	Kacang Kedelai
Mungbean	*Vigna radiata*	Kacang Hijau
Banana	*Musa acuminata* Cavendish	Pisang Ambon
Plantain	*Musa textilia*	Pisang Nangka
Maize	*Zea mays*	Jagung
Sweet purple potato	*Ipomoea batatas var Ayumurasaki*	Ubi Jalar Ungu

All of the mentioned local food resources were cultivated and prepared as flour by a local farmer in Pandegelang District, Banten Province, Indonesia. Other consumable materials like salt, egg yolk, cooking oil, and refined sugar were purchased from the supermarket.

For the local food resources in the form of corm (taro, purple sweet potato) and banana, the flour production was based on the common practice of the farmers in that area. The method involved washing, peeling, cutting, drying, crushing, grinding, and sieving. The local food resources in the form of cereals (red rice, maize) and beans follow sorting, drying, and the same procedure as above. All the local food resources processed into flour were first sun-dried until having about 12-15% of the remaining moisture content (Figure 4.1).

Figure 4.1 Preparation Processes of Local Food Resources



The nutritional information on local food resources is shown in Table 4.6. Among the ingredients in the RUF biscuit recipes, the soybean flour had the highest protein, and total mineral content, while the peanut had the highest fat and energy content. For the mineral content, soybean had the highest Ca, Mg, K, P, and Cu, while the sweet purple potato followed by banana (ambon and kapok) had high Fe, and taro flour had the highest Zinc values. For the vitamins, taro had the highest vitamin A, while soybean had high B vitamins (thiamine and riboflavin).

Table 4.6 Nutritional Composition of Local Food Resources, per 100 g

	Taro	Red rice	Peanut	Soybean	Mungbean	Banana (*Ambon*)	Banana (*Kepok*)	Banana (*Nangka*)	Maize	Sweet Purple Potato
Water (g)	12	12	5	5	9	17	15	18	15	15
Protein (g)	12	11	31	40	26	4	4	4	11	5
Fat (g)	2	3	51	22	1	1	1	1	4	1
Carbohydrate (g)	74	73	10	28	60	76	78	76	69	76
Energy (kcal)	354	362	622	471	356	323	332	321	352	328
Ca (mg)	43	11	92	206	132	26	25	15	7	149
Mg(mg)	33	112	168	429	189	95	101	68	158	116
K (mg)	591	289	705	2515	1246	894	806	698	465	1111
Na (mg)	11	8	18	13	15	3	3	3	3	61
P (mg)	84	337	376	494	367	69	73	54	353	221
Fe (mg)	7	2	5	6	7	15	15	12	3	30
Zn (mg)	4	3	3	4	3	1	1	0	2	1
Cu (mg)	0	0	1	3	1	0	0	0	0	1
Mn (mg)	1	4	2	2	1	10	3	4	1	4
I (µg)	-	-	-	-	-	1	1	1	1	1
Se (µg)	1	-	7	8	8	31	33	33	33	95
Vitamin A (µg)*	398	32	34	37	51	35	32	28	101	42
Thiamin (mg)	1	2	2	3	2	0	1	1	3	1
Riboflavin (µg)	70	32	59	180	121	157	49	111	186	87
Vitamin E (mg)	3	2	7	2	1	0	0	0	1	1

*Vitamin A was based on retinol equivalent calculation : (µg α-carotene/12) + (µg β-carotene/6), the composition was based on a dry basis, kcal = kilo calorie, g= gram, mg = milligram, µg= microgram

4.2.2 Nutritional Composition of RUF Biscuit

The formulation of RUF biscuit's recipe used the combination of several food resources discussed above, in addition to the other ingredients such as milk powder, wheat flour, sugar, salt, and whole egg. Nutrisurvey software (nutrisurvey2007.exe) with the Indonesian food database was used for the ingredient composition in the proposed RUF biscuit recipes to meet the WHO standard and other recommended formulations. The different food sources resulted in different nutritional compositions to complement each other when combined and produce better nutrient content products.

There are 2 types of recommendation for micronutrients of RUF for MAM Children (Table 4.7), based on the proposed recommended nutrient densities for moderately malnourished children (food and supplement) and based on the technical note of supplementary foods for the management of moderate acute malnutrition in infants and children 6–59 mo’10nths of age. The formulation of RUF biscuit from the composite flour of local food resources followed the recommendation from the MAM children (food).

Table 4.7 Selected Micronutrient recommendations for rehabilitation of Moderately Acute Malnourished (MAM) children

Micronutrient	Unit	Proposes RNI for MAM[1]		Supplementary food for MAM[2]	
		Food	Supplement	Min	Max
Vitamins					
Vitamin A	*µg*	960	1900	2000	3000
Vitamin B1 (Thiamin)	*mg*	0.6	1	1	
Vitamin B2 (Riboflavin)	*mg*	0.8	1.8	4	
Vitamin E	*mg*	11.5	22	50	
Minerals					
Calcium	*mg*	600	840	1000	1400
Iron	*mg*	9	18	18	30
Iodine	*µg*	200	200	150	350
Zink	*mg*	13	20	20	35
Magnesium	*mg*	200	300	280	420
Phosphorus	*mg*	600	900	850	1400

[1](Golden, 2009), [2](WHO, 2012), Recommended Nutrient Intake (RNI), Moderate Acute Malnutrition (MAM), mg = milligram, µg= microgram

RUF biscuit was made for overcoming and rehabilitation undernourishment in children under five in Banten province, Indonesia. The RUF biscuit's nutritional content followed the proposed recommended nutrient densities for moderately malnourished children (Golden, 2009) The formulations of twelve newly developed RUF biscuits are shown in Table 4.8

Table 4.8 The Recipes of RUF Biscuits from Local Food Resources

Ingredients (% of weight)	RUF Biscuit											
	1	2	3	4	5	6	7	8	9	10	11	12
Wheat Flour	6	6	6	6	6	6	6	6	8	6	6	6
Taro Powder	6	6	6	6	4	6	4	8	8	8	8	4
Red Rice	5	5	6	5	9	7	9	5	3	5	5	9
Peanut	16	16	16	14	16	16	16	16	16	16	14	14
Sugar powder	18	18	18	18	18	18	18	18	18	18	18	18
Whole milk powder	12	12	12	14	12	12	12	12	12	12	14	14
Chicken egg yolk	19	19	19	19	19	19	19	19	19	19	19	19
Palm oil	7	7	7	7	7	7	7	7	7	7	7	7
Salt	1	1	1	1	1	1	1	1	1	1	1	1
Soy flour (full fat raw)	5	5	5									
Mungbean					4	4	4	4	4		4	
Banana powder (Ambon)	5				4					4		
Banana powder (Nangka)			4	5								
Banana powder (Kepok)							4			4		
Purple sweet potato		5				4						4
Maize				5				4	4		4	4
Total	100	100	100	100	100	100	100	100	100	100	100	100
Energy (kcal) *	420	421	423	416	415	411	416	416	416	405	414	429
Protein (g)*	13	13	13	12	12	12	12	12	12	11	12	12
Fat (g)*	25	25	25	24	24	24	24	25	24	24	24	24
Carbohydrate* (g)	37	38	38	40	39	38	39	39	39	38	40	43

* Nutritional composition based on NutriSurvey (per 100 g), kcal = kilocalorie. g= gram,

The RUF biscuits were prepared and baked in the Department of Nutritional Science laboratory and the metabolic kitchen of the Department of Applied Nutrition Science/Dietetic at the University of Hohenheim, Germany.

The dry ingredients were first mixed in each recipe until a homogeneous mixture was formed then the liquid ingredients were added and the dough was formed. The dough was molded into spheres and then baked in an electric oven (Siemens) with a temperature of 150^{0}C for 15 minutes (Purwestri *et al.*, 2012). After cooling down at room temperature, the RUF biscuits were put in airtight containers and kept at minus 80 ^{0}C until further analysis could be performed. The process of making the RUF biscuit is included: preparation of ingredients, weighing, mixing (manual), molding (@ 7-8 g per biscuit), baking (t= 15 minutes, T=150 ^{0}C), and packaging.

The proximate composition of the RUF biscuits is presented in Table 4.9. The results showed that there are significant differences for all parameters (moisture, ash, protein, fat, carbohydrate, and energy). The baking process resulted in slight losses in ash, protein, fat, and carbohydrate content within the RUF biscuit samples.

Table 4.9 Proximate Composition of RUF Biscuit from Composite Flour of Local Food Resources

RUF	Water	Ash	Protein	Fat	Carbohydrate	Energy
	%	%	%	%	%	kcal
Biscuit1	1.2±0.1^{bc}	3.0±0.2^{bc}	15.8±0.20^{cd}	29.4±0.0^{e}	50.7±0.3^{bc}	530.6±0.4^{f}
Biscuit2	1.1±0.1^{a}	3.1±0.2^{c}	16.0±0.20^{e}	28.3±0.1^{b}	51.6±0.5^{d}	524.9±0.1^{b}
Biscuit3	1.2±0.0^{c}	3.1±0.1b^{c}	16.0±0.05d^{e}	29.6±0.1^{f}	50.2±0.2^{a}	531.0±0.3^{fg}
Biscuit4	1.2±0.1^{bc}	3.0±0.1b^{c}	14.4±0.00^{a}	28.9±0.1^{d}	52.6±0.1^{e}	528.1±0.5^{d}
Biscuit5	1.2±0.0^{c}	3.0±0.1b^{c}	15.1±0.05^{b}	29.0±0.1^{d}	51.8±0.0^{d}	528.4±0.7d^{e}
Biscuit6	1.2±0.1^{c}	2.8±0.0^{a}	15.2±0.05^{b}	29.0±0.0^{d}	51.9±0.1^{d}	529.0±0.4^{e}
Biscuit7	1.2±0.1^{bc}	2.9±0.0^{ab}	15.2±0.10^{b}	29.8±0.1^{g}	51.0±0.2^{c}	532.6±0.0^{h}
Biscuit8	1.2±0.1^{bc}	3.1±0.1^{bc}	15.7±0.10^{c}	29.7±0.1^{fg}	50.5±0.3^{ab}	531.5±0.2^{g}
Biscuit9	1.2±0.0^{c}	3.0±0.0^{bc}	14.5±0.10^{a}	27.5±0.1^{a}	53.8±0.0^{g}	520.7±0.5^{a}
Biscuit10	1.1±0.0^{ab}	3.0±0.0^{bc}	14.4±0.05^{a}	28.5±0.1^{c}	53.1±0.1^{f}	526.1±0.5^{c}
Biscuit11	1.2±0.0^{c}	3.0±0.0^{bc}	14.5±0.10^{a}	27.5±0.1^{a}	53.8±0.0^{g}	520.7±0.5^{a}
Biscuit12	1.2±0.1^{bc}	3.1±0.1^{bc}	15.7±0.10^{c}	29.7±0.1^{fg}	50.5±0.3^{ab}	531.5±0.2^{g}
Max	1.3	3.3	16.2	29.8	53.8	532.6
Standard*	max. 4.5	max. 3.5	min. 10	min. 15		min. 450
p-value	0.009	0.009	0	0	0	0

Values are in the mean ± standard deviation of triplicate determination from each RUF biscuit sample. Data were analyzed using the Anova test continued with the posthoc Duncan test to determine the statistically significantly different ($p<0.05$). Values of macronutrients are on a dry basis, kcal = kilocalorie. Values with the same superscript in the same column are not significantly different ($p\geq0.05$). *Standard based on (World Health Organization *et al.*, 2007)

The RUF biscuit recipe no 7 has the highest energy content ((534 kcal) and is above the WHO recommendation. This result has similarities with the RUTF biscuit which was developed by (Purwestri, 2011) for soybean-based and mung bean-based RUTF biscuit with a total energy of 536 and 524 respectively.

All the macronutrient compositions of RUF biscuits meet the standard of nutritional composition for special purposes of food (World Health Organization *et al.*, 2007) that can be used for MAM (Moderately Acute Malnutrition) children.

Minerals in RUF Biscuit

The mineral composition of the RUF biscuits is presented in Table 4.10. The results showed that there are significant differences in mineral composition among recipes. Different mineral compositions in the RUF biscuits were caused by the different sources of local food resources which have diverse concentrations of minerals. The baking process did not significantly alter the mineral contents in the dough of the RUF biscuits.

All the selected parameters of minerals (P, Ca, Mg, Fe, Zn, Cu, and Iodine) in the RUF biscuit were lower than the recommendation for the supplementary food for the target of Moderate Acute Malnutrition (MAM) children under five. To improve the mineral content in the RUF biscuit, the fortification with the micronutrient premix might be the solution that is easier and cheaper for the low-income HH in the rural area. The same result presented by (Scherbaum *et al.*, 2015) about the locally produced RUTF biscuit for malnourished children in Nias Island, Indonesia shows the high concentration of minerals that meet the standard of WHO after using the micronutrient premix. The nutritional composition of twelve original recipes of RUF biscuits presents in Appendix 4.

Table 4.10 Selected Mineral Composition of RUF Biscuit

RUF	P	Ca	Mg	Fe	Zn	Cu	Iodine
	mg	*mg*	*mg*	*mg*	*Mg*	*mg*	*µg*
Biscuit1	367.4±0.5^{i}	186.0±0.2^{e}	85.6±0.2^{g}	4.5±0.2^{ef}	2.6±0.3^{c}	0.5±0.2^{b}	67.6±0.5^{c}
Biscuit2	375.1±1.2^{j}	186.4±0.7^{e}	83.9±0.8^{f}	3.7±0.3^{ab}	2.5±0.2^{bc}	0.4±0.1^{ab}	73.4±0.2^{e}
Biscuit3	363.8±0.3^{g}	188.5±0.2^{g}	81.6±0.1^{e}	4.5±0.2^{f}	2.5±0.1^{abc}	0.5±0.2^{ab}	66.4±0.5^{b}
Biscuit4	354.7±0.3^{d}	187.3±0.9^{f}	69.8±0.5^{a}	3.6±0.2^{a}	2.4±0.2^{abc}	0.4±0.2^{ab}	68.3±0.2^{d}
Biscuit5	351.9±0.5^{c}	166.0±0.6^{b}	76.5±0.2^{c}	3.9±0.1^{bc}	2.3±0.2^{abc}	0.5±0.3^{b}	66.1±0.5^{b}
Biscuit6	365.7±0.9^{h}	174.8±0.3^{c}	77.2±0.7^{d}	4.6±0.1^{f}	2.4±0.0^{abc}	0.3±0.0^{ab}	50.6±0.1^{a}
Biscuit7	350.7±0.0^{b}	165.3±0.1^{a}	73.1±0.1^{b}	3.8±0.1^{ab}	2.4±0.1^{abc}	0.3±0.0^{a}	50.6±0.0^{a}
Biscuit8	356.6±0.5^{e}	178.4±0.0^{d}	81.3±0.1^{e}	3.6±0.1^{a}	2.2±0.1^{a}	0.2±0.1^{a}	80.4±0.1^{f}
Biscuit9	357.6±0.1^{f}	186.0±0.1^{e}	69.8±0.2^{a}	4.1±0.0^{cd}	2.3±0.1^{ab}	0.3±0.1^{a}	80.7±0.1^{f}
Biscuit10	339.3±0.2^{a}	165.2±0.2^{a}	76.3±0.1^{c}	4.3±0.2^{de}	2.3±0.1^{abc}	0.4±0.1^{ab}	67.3±0.1^{c}
Biscuit11	357.6±0.1^{f}	186.0±0.1^{e}	69.8±0.2^{a}	4.1±0.0^{cd}	2.3±0.1^{ab}	0.3±0.1^{a}	80.7±0.1^{f}
Biscuit12	356.6±0.5^{e}	178.4±0.0^{d}	81.3±0.1^{e}	3.6±0.^{1a}	2.2±0.1^{a}	0.2±0.1^{a}	80.4±0.1^{f}
Max	376.3	188.7	85.8	4.7	2.9	0.8	80.7
Standard*	600	600	200	9	13	13	200
p-value	0	0	0	0	0.088	0.057	0

Values are in the mean ± standard deviation of triplicate determination from each RUF biscuit sample. Data were analyzed using the Anova test continued with the posthoc Duncan test to determine the statistically significantly different ($p<0.05$). Values of minerals are on a dry basis, mg=milligram, *µg= microgram*. Values with the same superscript in the same column are not significantly different ($p\geq0.05$). *Standard for minerals (Golden, 2009)

In order to promote RUF biscuits as supplementary food for children, the characteristics of biscuits which include color, shape, and texture should be adjusted to standards and can be compared with commercial products.

The mean diameter of the RUF biscuits was 40-41 mm, with a 7 mm thickness and a spread ratio of 6. The dimensions did not differ so much because all the RUF biscuits were formed using one mold, and since the amount of wheat was the same in all the recipes, the expansion of the biscuits was quite identical. The diameter, thickness, and spread ratio were not significantly different.

Compared to biscuits from cassava/soybean/mango composite flour by (Chinma and Gernah, 2007), the RUF biscuit spread ratio has a smaller score than those biscuits which about 7-9, or with the composite flour of germinated pigeon pea, fermented sorghum, and cocoyam flours which reported by (Okpala, Okoli and Udensi, 2013) with 14-20. The spread ratio of RUF biscuit from composite flour of local food resources is quite similar to the biscuit from (Adeola and Ohizua, 2018), which was likely due to some identical ingredient of the biscuit recipe which contains banana and sweet potato. The less expansion of the RUF biscuit from composite flour of local food resources was caused by the low proportion of the wheat flour for only 6% of the RUF biscuit recipe's total ingredients. The wheat flour has gluten, which can trap the dough's oxygen and expand the biscuit spread after the baking process.

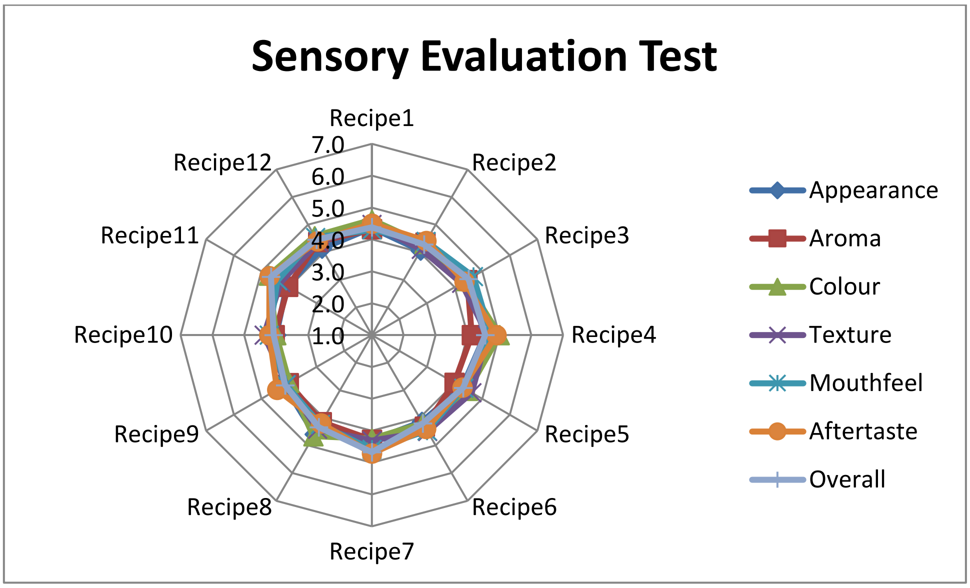
Color is one of the parameters used for quality control in the baking process and an important attribute for the biscuits' acceptability because it can pique the appetite. Factors that have been reported to affect the color's development on the product's surface included moisture content, temperature, air velocity, and heat transfer (Pereira, Correia, and Guiné, 2013). The positive value of a* and b* indicates the predominance of redness and yellowness in the RUTF biscuit. The biscuits' color changed to dark brown (final color) from creamy yellow as in the dough. The value of brightness (L*) was above 50 (L* = 0 is black and L* = 100 is white) for all the recipes. No significant difference was observed in the lightness, redness, and yellowness of both of the formulated biscuits, due to the similarity of factors that contribute to the color development of biscuits such as protein and reducing sugar content as well as moisture content, temperature, air velocity, and heat transfer (Chauhan, Saxena and Singh, 2016).

The RUF biscuits have a quite similar color, shape, and texture compared to the common commercial children’s biscuits in Indonesia.

Additionally, a sensory evaluation of the samples was conducted with 66 untrained, purposively chosen panelists composed of students and staff of the Institute of Nutritional Science, University of Hohenheim, and the Indonesian community in Stuttgart, Germany. Twelve coded RUF biscuits were presented to each panelist for each session. They assessed the R-UF biscuits for appearance, aroma, color, texture, mouth-feel, after taste, and overall acceptability using a 7-point hedonic scale, with 1 and 7 representing the least score (dislike very much) and the highest score (like very much), respectively.

The comparison of the score of preferences by the panelist to all the parameters presented in fig. 4.4 and fig. 4.2 presented the RUF biscuits' overall choices from the composite flour of local food resources. No significant differences were found on the attributes of appearance, aroma, color, texture, mouth-feel, and after-taste. All the parameters show a slight difference in the consumer's acceptance.

Figure 4.2 Radar Graph of the Sensorial Attributes of the RUF Biscuits



All the RUF biscuits' sensory attributes got similar scores with the range of 4-5 (neutral – like moderately). A similar result was shown in the research of (Weber *et al.*, 2017) with the liking score of about 3.5- 4.6 (neutral-slightly like), (Owino *et al.*, 2014) the preferences between ok-very happy with the RUF product, (Sigh *et al.*, 2018) patients expressing that they liked the product, and (Sandige *et al.*, 2004) that the locally produced RTUF was likely by the children under five.

Based on the nutritional composition weighting scores of all RUF biscuits, five recipes were selected for the further research section. The selected recipes were chosen based on the nutritional composition, the variety of local food resources used in the formulation, and additionally the acceptance for sensory testing.

The micronutrient contents of the locally produced RUF and RUTF usually can not fulfill the international standard for preventing and treating undernourished children (WHO, 2012) (Golden, 2009); therefore, the food supplements should be fortified with vitamins and minerals. For instance, the local RUF in Ghana, Ethiopia, Pakistan, and

India (Weber *et al.*, 2017) in Sinegal (Diop *et al.*, 2003), Nigeria(Uhiara and Onwuka, 2014), Cambodia (Sigh *et al.*, 2018), and on Nias (Scherbaum *et al.*, 2015) fortified the locally produced RUF with the vitamin-mineral mix.

4.2.3 Nutritional Fulfillment based on Moderate Acute Malnutrition (MAM) standard

Five selected recipes (recipes 3, 4, 7, 11 and, 12) from the previous section of research were continued to be fortified with the micronutrient premix to improve the nutritional composition. The procedures of making RUF biscuits were the same with including weighing the ingredients, mixing, molding, and baking with the electronic oven at 150 ^{0}C for 15 minutes. The micronutrient premix was mixed with other dry ingredients before the process uses the micronutrient premix of Centrum® from Pfizer. The ingredient of RUF Biscuit fortified micronutrient premix is presented in Table 4.11 and the micronutrient premix in table 4.12.

The nutrient composition of the RUF biscuit is just slightly different, with the total energy for 522.2 – 533.0 kcal; fat 29.2 – 30.1; protein 14.6 – 16.2 and carbohydrate for 48.9 – 53.3 %. All the compositions fulfill the standard for RUF recommendation and similar results were also found in (Purwestri et al. 2012; Weber et al. 2017; Diop et al. 2003; Owino et al. 2014; Fahmida & Santika 2016 and Sigh et al. 2018). The entire recipe has a quite similar nutrient composition which is statistically not different for macronutrients, selected vitamins, and important minerals (iron and zinc).

Table 4.11 Recipes of RUF Biscuit fortified micronutrient premix

Ingredients (% of weight)	RUF Recipe				
	3	4	7	11	12
Wheat Flour	6	6	6	6	6
Taro *(talas banten*)	6	6	4	8	4
Red Rice	6	5	9	5	9
Peanut/ (pealed)	16	14	16	14	14
Sugar powder	18	18	18	18	18
Whole milk powder	12	14	12	14	14
Chicken egg yolk	19	19	19	19	19
Palm oil	7	7	7	7	7
Salt	1	1	1	1	1
Soy flour (full fat raw)	5				
Mungbean			4	4	
Banana (*Nangka*)	4	5			
Banana (*Kepok*)			4		
Purple sweet potato					4
Maize		5		4	4
Premix	2	2	2	2	2
Total	100	100	100	100	100
Energy (kcal)*	532.5	529.6	534.2	522.2	533.0
Fat (g)	29.9	29.2	30.1	27.8	29.9
Protein (g)	16.2	14.6	15.4	14.7	15.9
Carbohydrate (g)	49.6	52.1	50.4	53.3	48.9

* Nutritional composition based on NutriSurvey (per 100 g), kcal = kilocalorie, g= gram

Through the baking process, only a small portion of macronutrients was lost during the process or denatured into a more available form of the nutrient. Food processing increases the bioavailability of macro and micronutrients through the destruction of inhibitors and anti-nutrient in food that originally occurs (Watzke, 1998) like phytate and oxalate. Table 4.13 presents the nutrition composition of a selected RUF biscuit fortified with micronutrient premix.

Table 4.12 Vitamin and mineral-mix used in the study from Pfizer (Centrum®)

Micronutrient	Unit	Premix
Selected micronutrients analyzed in the study		
Vitamin A	*µg*	666.7
Vitamin B1 (Thiamine)	*mg*	1.2
Vitamin B2 (Riboflavin)	*mg*	1.5
Vitamin E	*mg*	12.5
Calcium	*mg*	135.0
Phosphorus	*mg*	104.2
Magnesium	*mg*	83.3
Iron	*mg*	4.2
Zinc	*mg*	4.2
Other micronutrients		
Vitamin D	*µg*	8.3
Vitamin C	*mg*	83.3
Vitamin B6	*mg*	1.7
Vitamin B12	*µg*	2.1
Niacin (B3)	*mg*	16.7
Biotin (B7/B8)	*µg*	52.1
Folic Acid	*µg*	166.7
Vitamin K	*µg*	25.0
Phantotenate (B5)	*mg*	6.3
Iodine	*µg*	83.3
Copper	*mg*	0.4
Selenium	*µg*	25.0

g= gram, *µg*= microgram

Table 4.13 Nutritional compositions of selected recipe RUF biscuit fortified with micronutrient premix

Nutritional Composition	RUF Recipes					Standard*	p-value
	3	4	7	11	12		
Macronutrient							
Water (%)	1.2±0.0	1.2±0.1	1.2±0.1	1.2±0.0	1.2±0.1	max. 4.5	0.798
Ash (%)	3.1±0.1	3.0±0.0	3.0±0.0	3.1±0.1	3.0±0.0	max. 3.5	0.859
Protein (%)	16.1±0.1	14.6±0.0	15.4±0.1	15.9±0.1	14.7±0.1	min. 10	0.99
Fat (%)	30.0±0.1	29.2±0.1	30.1±0.1	30.0±0.1	27.8±0.1	min. 15	0.998
Carbohydrate (%)	49.6±0.2	52.1±0.1	50.4±0.2	49.9±0.3	53.3±0.0		0.997
Energy (kcal)	532.5±0.2	529.6±0.4	534.1±0.1	533.0±0.1	522.2±0.5	min. 450	0.993
Micronutrient							
P (mg)	556.7±4.5 c	528.7±2.5 a	527.7±2.5 a	557.0±4.0 c	537.0±3.0 b	600	0.000
Ca (mg)	471.0±1.0 a	462.3±8.1 a	463.0±7.2 a	484.0±5.0 b	470.3±2.5 a	600	0.004
Mg (mg)	269.0±2.0 c	246.7.±1.5 a	257.0±0.0 b	259.3±1.1 b	259.0±2.0 b	200	0.000
Fe (mg)	13.7±0.6 ab	12.7±0.6 a	13.7±0.6 ab	13.3±0.6 ab	14.3±0.7 b	9	0.057
Zn (mg)	12.0±0.0	11.0±0.0	12.0±0.0	12.0±0.0	12.0±0.0	13	
Iod (mcg)	195.7±12.5 b	177.0±2.0 a	197.7±4.5 b	176.3±6.5 a	188.3±12.5 ab	200	0.034
Vitamin A (mg)	1.0±0.1	1.0±0.1	1.0±0.0	1.0±0.0	1.0±0.0	0.96	0.587
Thiamin (mg)	1.3±0.1	1.4±0.1	1.5±0.2	1.4±0.1	1.4±0.3	0.6	0.737
Riboflavin (mg)	2.7±0.0	2.8±0.1	2.7±0.1	2.5±0.3	3.1±0.2	0.8	0.014
Vitamin E (mg)	18.8±0.5	18.6±0.2	18.6±0.0	18.7±0.1	19.0±0.2	11.5	0.350

Values are in the mean ± standard deviation of triplicate determination from each RUF biscuit sample. Data were analyzed using the Anova test continued with the posthoc Duncan test to determine the statistical significant different ($p<0.05$). [2]Values of macronutrients are on a dry basis, kcal = kilocalorie. kcal = kilocalorie. mg= milligram, mcg = microgram. Values with the same superscript in the same column are not significantly different ($p\geq0.05$). *Standard for macronutrient (World Health Organization *et al.*, 2007) while the standard for micronutrient (Golden, 2009)

A baking process resulted in some losses of vitamins. Heat-sensitive micronutrients should be added in slightly higher amounts in the vitamin-mineral premix to make up for losses during the baking process. The RUF biscuit should be consumed on the same day of production to ensure nutritional composition. To avoid further degradation and losses of micronutrients during storage, RUF biscuits should be kept in air-tightened packaging and container to preserve nutrition inside. For local production, we recommend producing smaller amounts of biscuits (a maximum of 1 kg for each batch of production) to ensure the homogenous mixing of all ingredients.

The baking process used an oven with a gas stove that cannot keep the exact temperature due to the distance between the fire and the oven. The oven has equipped with a heating sensor, and the additional thermometer was used to observe the real temperature inside the oven (it was measured before the baking process when the dough was put inside the oven for baking). The RUF biscuit was baked until they were light brown (which took about 15 minutes at about 140-160 ^{0}C).

The vitamin losses during the baking process were observed to be around 15-28%. The loss of Vitamin A varies between 15-22%, Vitamin B (Thiamin and riboflavin) between 23-28%, and vitamin E between 23-26%. It is a little bit lower than the other research, perhaps due to the short process of baking (15 minutes) and the sources of micronutrients were from micronutrient premix which has higher stability compared to the origin micronutrient in foods. Based on (Abe-matsumoto *et al.*, 2014), vitamin A reduces 15-34% during storage while vitamin E reduces around 32%. A different method of food processing is also observed by (Devi, 2015), which found that Vitamin A loses about 25% during cooking, Thiamin 55%, Riboflavin 25%, and no data about vitamin E.

Minerals were more stable during the baking process compared to other nutrients. The only change during food processing regarding minerals is the bioavailability. Processing of foods has a positive impact through separation, partitioning, or destroying inhibitors, and transforming food components into complex ligands for minerals thereby enhancing their availability (Watzke, 1998). The fortification of food with minerals compounds should be done at the end of the process to minimize the mineral loss during food processing. To anticipate the loss of micronutrients during the baking process, a higher concentration of micronutrient premix was added so that the final product was in accordance with the requirements. A detailed explanation of micronutrient losses during the baking process presents in Appendix 5.

Based on the prediction analysis of shelf-life testing using the Arrhenius model, the RUF biscuits fortified with the micronutrient premix will be last for 6-13 months in a normal condition of Indonesia (temperature around 20-30 ^{0}C with the relative humidity 70-90%). With the lower moisture and water activity, locally produced RUF would be safely stored at ambient tropical conditions for 3-4 months (Manary, 2006). The longer period of self-life will benefit the production and distribution of that product. With the low moisture content and water activity in the RUF biscuit, special treatment (i.e low temperature, vacuum packaging) is not needed.

The total microbe which is detected in the RUF biscuits fortified with micronutrient premix is about 9.0×10^2 – 2.7×10^3 CFU/g which is lower than the threshold for the supplementary food for about a maximum of 10^5 CFU/g (BPOM, 2018). Colony-formin unit (CFU) is the unit used to estimate the microbe (bacteria or fungal) in a sample. Plate counting aims to estimate the number of cells present based on their ability to give rise to colonies under specific conditions of nutrient medium, temperature, and time. This finding was ensured the food safety of the product to be consumed by the target group of children under five.

4.3 Local Production and Acceptability Study of RUF

Of five RUF recipes, (fortified with micronutrient premix) two of them were selected in the field by the local caregivers. The process production of RUF biscuits was identical to the procedures which were developed before. except we used an oven with a gas stove instead of an electric oven. The entry criteria of the respondents are children one to five years old, healthy without birth defects and chronic disease, and were domiciled in the region at least 6 months prior to the study. The goals of this research section are to produce RUF biscuits by the community, carry out an assessment for the respondent acceptance, and evaluate the effect of RUF biscuit consumption on the nutritional status of children under five.

For the production of RUF biscuit, the following instruments were used: balance graded with 1g intervals limited by 6000g; baking oven with plate; alarm clock for time measurement; thermometer; mixing bowls; biscuit mold; grinder; and other needed equipment was for cleaning (sponges, soap, cloths, and brooms). It is recommended to keep clean and disinfect the equipment. In principle, all hygienic arrangements were considered.

Process production of RUF biscuits involves some of the cadres of local health posts (*local name posyandu)* in the house of local midwives from the local health center (*puskesmas)*. Production was made into several batches, to provide fresh RUF biscuits for the children. The production was done two times a week during the acceptability study. The production took place in between the cadre household activity, usually in the afternoon after lunch.

All the recipes were using the local food resources available in the research area and the other ingredients were purchased at the local market. The critical part of the preparation of the ingredients was the post-harvest handling and processing of local food resources into flour. The manual mixing of ingredients during the processing was conducted until homogenous enough to ensure the nutrient composition is the same in every part of the batch.

Acceptability Study and monitoring

The study was conducted from June to July 2019 in three sub-villages i.e Pabuaran, Kopeng, and Cijeruk part of Kadomas village in sub-district Kadomas, District Pandegelang, Banten Province. 70 under-five children were recruited based on our inclusion criteria after getting consent from their parents. The inclusion criteria for this study were those aged above 15 months; with no congenital diseases or any other disease that interfere with appetite; and willing to take part in this study for 2 weeks ahead. Provision of RUF biscuit was done every 2 days, but every child was prescribed to consume 100 g daily. This biscuit should be consumed by the selected children who are registered in this study. Respondent was assigned to two different groups randomly which received different biscuits. Group A was given RUF biscuits recipe 4 and be consumed for 2 weeks, while group B was given RUF biscuits recipe 4 in the first week and RUF biscuits recipe 11 in the second week. Both RUF biscuit recipes 4 and 11 have no significant difference in terms of macronutrients, vitamins, and important minerals. The nutritional condition before the RUF consumption also has not significantly different among groups.

During the RUF biscuit distribution, the enumerator monitor how much is it that already eaten. Respondents are measured weight and height in the initiation phase and at the end of the study by the enumerators. There is a structured questionnaire interviewed about nutrition and health status as well as about the socio-economy demography of respondents. At the end of the study, mothers or caregivers are asked about their child's preferences and the reason for the biscuits they consumed.

The heights of the children were measured using a height/length board (for above/below two years old) and their weights were weighed using a SECA 201 scale. Statistical analysis was carried out using IBM SPSS statistics version 25. Anthropometric data were transformed to Z-scores using WHO Anthro 2007. Data were checked for conforming to a normal distribution using the normal probability quintile-quintile plot.

The amount of RUF biscuit needed each day was calculated as follow:

- 100 g of biscuit contains 525.9 kcal;
- 100 g of biscuit consist of 7-8 pieces;
- 1 piece of biscuit weighs 13 g and contains about 65.7 kcal.

4.3.4 Ethics Approval and Consent to Participate

The acceptability study was registered with the study code No: 1050/UN6.KEP/EC/2019 at the Health Research Ethics Committee Faculty of Medicine Universitas Padjadjaran Bandung, Indonesia (April 07th, 2019) and approved by the *Badan Kesatuan Bangsa dan Politik* (Board of national and political unity) code No: 070/0014-SKP/DPMPTSP/2019 (Oct 2nd, 2017). Before enrolment, a full explanation of the study purpose was given to the communities, and informed consent was obtained either by signature or thumbprint.

Before the acceptability study, data about the nutritional status of each child has been collected as well as the 24-h recall of dietary intake and HH characteristics. Data on the general characteristic of respondent children under five are presented in table 4.13.

Table 4.14 General Characteristics of Respondent

Category	n	Mean	Sd	Median	Min	Max
Children						
Sex ratio	70	0.56				
Age (month)	70	35.78	14.20	35.10	13.10	60.17
Weight (kg)	70	11.96	2.77	11.95	6.60	23.50
Height/Length (cm)	70	88.39	9.65	91.10	67	106.3
Parents (include caretakers)						
Parent's Age	130	34.15	9.21	34.5	22	64
Father	65	35.06	7.85	35	22	55
Mother	65	33.25	10.58	34	22	64
Caretaker Age	9	54.25	3.72	53.8	48	60
Parent's year of schooling	130	8.58	2.70	9.0	1	16
father	65	8.58	2.69	9.0	1	16
mother	65	8.59	2.70	9.0	5	16
Caretakers	9	5.42	0.56	5.3	5	6

Seventy children were recruited for the RUF acceptability study with a sex ratio of 0.6 between boys and girls. The average age of the children was 35.8 months ±14.20 with the youngest was 13.1 months and the oldest was 60.2 months. The average weight of the children was 12.0 kg and the average height was 88.4 cm. The mean age of the father was 35.1 years and the mother was 33.3 years with the youngest age being both 22 years old. The guardian/caretakers vary from 48-60 years old range from the aunt/uncle to grandparents. The average educational level of both parents was 9 years (junior high school) and caretakers were 5 years (or equal to elementary school).

The person in charge of the children (mostly mothers) got a brief explanation about the study, the objective of the research, process, and expected result (RUF consumption improve the nutritional status of children) was communicated in advance of the acceptability study. The enumerators also pointed out that the caretakers have to record the consumed RUF and avoid the other family members consuming the RUF biscuit for the children. Data on the previous RUF consumption will be collected by the enumerators in the next RUF distribution.

Based on the 24-h recall of a dietary pattern before the acceptability study, found that half of the respondents did not meet the adequate RNI of energy, one-third had an insufficient iron intake, nearly two-third had insufficient zink intake, while almost all the children missed the RNI for vitamin A. The fulfillment of Recommended Nutrient Intake (RNI) of respondent children under five is present in table 4.14

Table 4.15 The Fulfillment of Selected Nutrient based on CIMI

Category	n	Mean	Sd	Median	Min	Max	Adequate n (%)	Inadequate n (%)
Energy (kcal)	70	1,133.5	523.6	1,128.8	86.3	2,251.7	37 (52.9)	33 (47.1)
Protein (g)	70	34.9	16.2	32.4	2.6	62.6	62 (88.6)	8 (11.4)
Iron (mg)	70	5.2	2.6	5.5	0.0	10.7	49 (70.0)	21 (30.0)
Zinc (mg)	70	3.4	2.0	2.9	0.2	9.3	25 (35.7)	45 (64.3)
Vitamin A (mg)	70	161.1	103.6	148.9	0.0	490.3	1 (1.4)	69 (98.6)

kcal= kilo calorie; g=gram; mg=milligram, Calculator of Inadequate Micronutrient Intake (CIMI)

Based on the validation of the CIMI program with the Nutrisurvey, it was found that both programs are comparable with regards to the average intake and range of data distribution ratio (Jati *et al.*, 2014). The range of correlation coefficient between NS and CIMI was from 0.889 (energy) to 0.713 (iron) in the children's group.

4.3.6 Effect of Locally-produced Ready-to-use Food (RUF) biscuit on the nutritional status of children under five years

Before and after the acceptability study, the nutritional status of the children was collected namely height and weight. The data was processed into the HAZ, WAZ, and WHZ z scores to evaluate the situation of the children. The weight gain during the RUF consumption varied between boys and girls for about 300 g and 150 g, respectively. Among different age groups, the weight gain of children ≤ 2 years was about 330 g, and for those at > 2 years, with about 220 g during the acceptability study. Table 4.15 presents a comparison of nutritional status during the acceptability study (before and after RUF consumption).

Through the consumption of RUF biscuits, it is hoped that there will be an improvement in the nutritional status of the children especially the increase in body weight. Weight gain is a primary indicator used in this study because it is easier to observe within the short duration of the intervention.

On the other hand, the height-for-age z-score and height gain were not used as the indicators in the program because the short period of intervention will not affect the changing of height. This reason was similar to the finding in (Purwestri, 2011; Sigh *et al.*, 2018) which showed that HAZ was not different during the short period of intervention.

The formulation of the RUF biscuit has the potential to contribute to improving the weight and WHZ of the children.

Both RUF Biscuits recipe 4 and 11 have no significant difference in macronutrients and important minerals, and it can be considered to have a similar effect on the nutritional status of the target group of children under five. Table 4.16 shows the effect of the RUF consumption on the nutritional status of children under five during the acceptability study.

Table 4.16 Comparison of Nutritional Status Before and After RUF Biscuit Consumption

Indica-tors	Subject	Total	Before RUF consumption				After RUF consumption				p-value
			Mean	Sd	Min	Max	Mean	Sd	Min	Max	
Weight (kg)	All Children	70	12.0	2.8	6.6	23.5	12.2	2.7	7.0	24.3	0.000 *
	Weight gain						0.25	0.36	-0.8	1	
Height (cm)	All Children	70	88.4	9.7	67.0	106.3	88.7	9.6	68.2	106.5	0.000 *
	Height gain						0.23	0.34	-0.1	2.25	
WAZ	All Children	70	-1.3	1.2	-5.4	2.7	-1.2	1.2	-5.1	2.9	0.000 *
	WAZ changes						0.13	0.25	-0.49	0.87	
WHZ	All Children	70	-0.7	1.7	-6.7	5.7	-0.5	1.6	-6.1	5.5	0.000 *
	WHZ changes						0.21	0.34	-0.74	1.22	
HAZ	All Children	70	-1.5	1.3	-4.2	2.6	-1.5	1.2	-4.3	2.4	0.053
	HAZ changes						-0.02	0.1	-0.18	0.47	

HAZ (Height-for-Age z-score), WAZ (Weight-for-Age z-score), WHZ (Weight –for- Height z-score)

Table 4.17 The Effect of RUF Biscuit Consumption On The Respondent's Nutritional Status

Indicators	N	Before		After		p-value
		Mean	Std	Mean	Std	
HAZ	70	-1.52	1.26	-1.54	1.24	0.053
WHZ	70	-0.66	1.65	-0.45	1.61	0.000*
WAZ	70	-1.29	1.23	-1.16	1.20	0.000*

* $p<0.05$: statistically significantly different,
HAZ (Height-for-Age z-score), WAZ (Weight-for-Age z-score), WHZ (Weight –for- Height z-score)
p-value as a colom = comparison before and after RUF consumption
p-value as a row = comparison among groups (1 and 2)

In general, group 1 (received only 1 RUF recipe) and group 2 (received 2 RUF recipes), and since both of biscuits have no difference in nutritional composition as well the nutritional status of children in group 1 and group 2, therefore, Table 4.17 presents full data. Data indicated that the consumption of RUF biscuits for two weeks could reduce severe underweight into underweight (WAZ indicator) by 4.3 %, and the severe wasting into wasting (WHZ indicator) by 1.4 % and there is no difference in stunting (HAZ indicator). It also proved that the formulation of RUF biscuit has the potential to reduce and overcome undernourishment for the targeted group in the research area.

Based on the in-depth interview with the caretakers, most of the children liked the RUF biscuit. Older children consumed more biscuits than younger children, and they were consumed mostly as a snack in between meals. A total of 22 children (31.4%) always consumed all the prescribed RUF biscuits (100g) while 48 children (68.6%) consumed only 60-75 g of RUF biscuits. Several reasons why the children did not consume all of the prescribed biscuits were: the RUF biscuit was harder than the commercial biscuit (38%), less like the taste of biscuits (13%), less appetite due to influenza (10%), incomplete teeth (7.6%). There is no significant difference in the consumption between group I (the same recipe for 2 weeks) and group II (different recipes for 2 weeks). A comparable finding was also found in the research of the effectiveness of locally produced RUF in Cambodia (Sigh *et al.*, 2018), experienced with the dynamic total of consumption of RUF by the target group of children.

For the children more than 2 years (24 months), they consumed RUF biscuits directly, while for the younger children (below 2 years), the consumption of RUF biscuits was usually helped with a drink (tea, milk, others) which makes the biscuits easier for children to swallow. In general, the children enjoyed the consumption of the RUF biscuit despite some comments from caretakers regarding the texture of the RUF biscuit as being a little bit harder than a commercial biscuit.

A similar finding was published by Wieringa *et al.* (2013) which showed that locally produced RUTF in Vietnam was considered acceptable by both target groups - adults and children with HIV, with a consumption rate of about 69%%. Also, the four weeks of RUTF consumption had a statistically significant effect on weight and BMI gain in both children and adults.

4.3.7 Habitual Intake of Children

Based on the 24-h recall of the respondents of the dietary consumption of children under five, the average habitual intake is presented in Table 4.18.

Table 4.18 Nutrient composition of average habitual dietary intake/day of children under five based on 24-hour dietary recall in Banten, Indonesia

Ingredients	Nutrient content	RNI[a]	% fulfillment
Cooked Rice 162.9 g	energy 1061.2 kcal	1125 kcal	94.3
Biscuit 80.5 g	proteins 32.7 g	26 g	130.9
Meat 49.0 g	Fats 22.0 g	44 g	50.0
Egg 66.6 g	Carbohydrate 178.5 g	155 g	115.2
Fish 44.5 g	Iron 4.9 mg	8 mg	61.6
Milk 65.6 g	Zinc 3.1 mg	4 mg	77.5
Tempe 56 g	Vit. A 150.3 µg	400 µg	37.6
Vegetables 102.7 g	Beta carotene 1289.3 µg	-	-
Ice cream/snack 39.4 g			

[a] based on Recommended Nutrien Intake (RNI) for Indonesian well-nourished children (Department Kesehatan RI, 2019)

Habitual mean daily intake of children in our study was deficient in nearly all nutrients especially micronutrients (vitamin and minerals). However, we observed a quite high level of protein and carbohydrates due to the consumption of fish/egg and the majority of rice. All selected micronutrient intake of the children‘s diet was deficient as compared to the guidelines of recommended nutrient intake (RNI) of Indonesian children. In comparison to RNI for well-nourished Indonesian children, all nutrients in the RNI for MAM children are substantially higher, because of its functions as therapeutic food for the rehabilitation of undernourished (wasted) children.

Compared to the RNI for Indonesia's well-nourished children, the RUF biscuit that was fortified with the micronutrient premix fulfills more than 70% of the recommendation for micronutrients. The nutrient fulfillment of RUF biscuit to RNI of Indonesian children 1-3 years is presented in figure 4.3, while the fulfillment to the of children 4-6 years presents in figure 4.4.

Figure 4.3 Fulfillment of the nutritional composition of RUF biscuit to the RNI for children 1-3 years

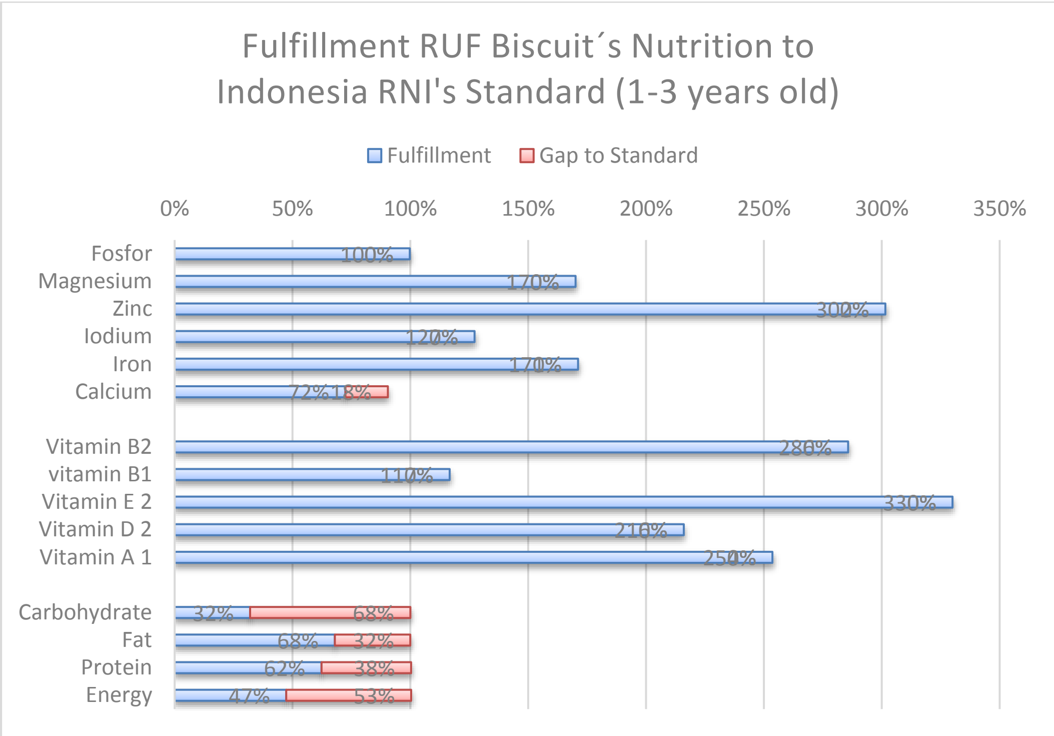
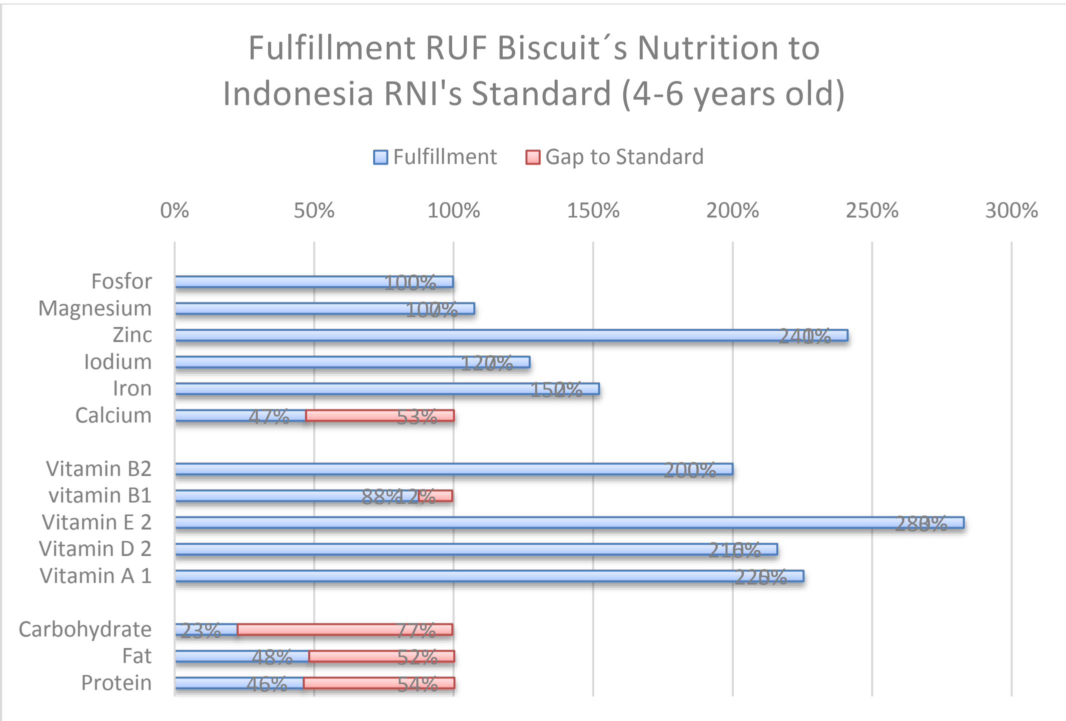


Figure 4.4 Fulfillment of the nutritional composition of RUF biscuit to the RNI for children 4-6 years



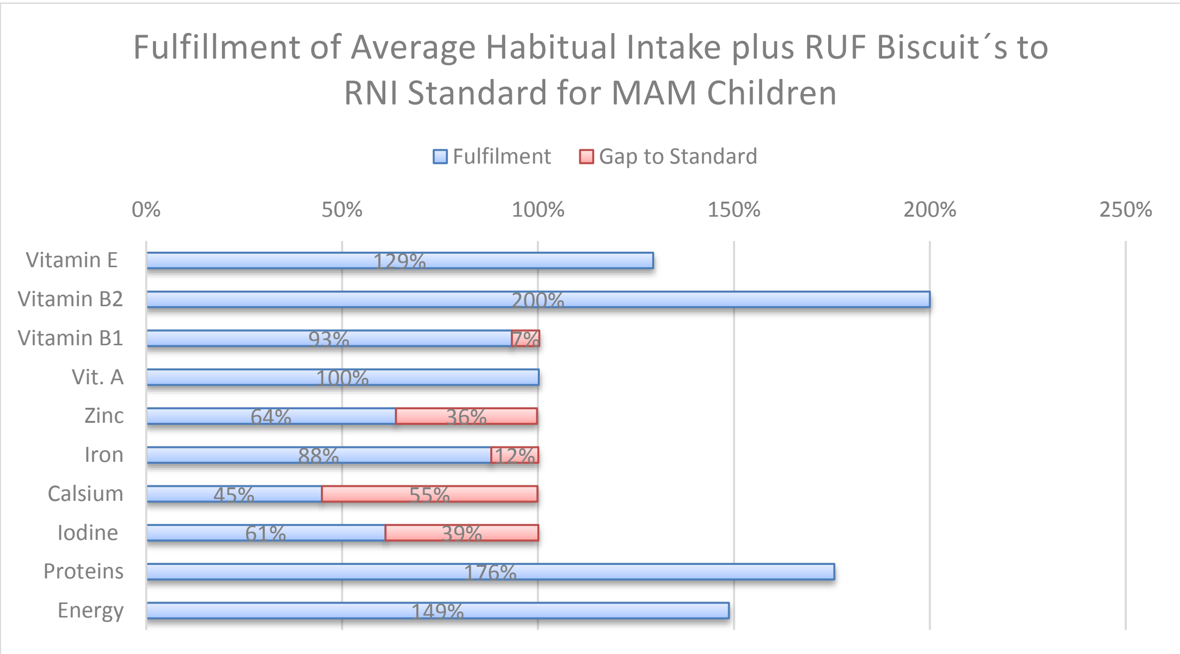
Since the RUF biscuit was designed as an additional food (snack food) and was supposed to be consumed between mealtimes, the combination of habitual intake of children with the additional RUF biscuit compared to the RNI for Moderate Acute Malnutrition (MAM) children is presented in figure 4.5, and the combination of RUF biscuit and habitual intake compared with the RNI for MAM children is presented in Table 4.19.

Table 4.19 Nutrients composition of average habitual dietary intake/day of children under five based on 24-hour dietary recall after the introduction of RUF biscuits

Ingredients	Nutrient content	RNI MAM*	% fulfillment
Cook Rice 162.9 g	energy 1487.2 kcal	1000 kcal	148.7
Bread 81.5 g	proteins 45.7 g	26 g	175.6
Meat 49.0 g	Iodine 122.2 µg	200 mcg	61.1
Egg 66.6 g	Calsium 376.8 mg	840 mg	44.9
Fish 44.5 g	Iron 15.9 mg	18 mg	88.1
Milk 65.6 g	Zinc 12.8 mg	20 mg	63.7
Tempe 56 g	Vit. A 961.8 µg	960 mcg	100.2
Vegetables 102.7 g	Vitamin B1 0.56 mg	0.6 mg	93.3
Banana 40 g	Vitamin B2 1.6 mg	0.8 mg	200.0
RUF biscuit 80 g			

* Moderate Acute Malnutrition (MAM), standard based on (Golden, 2009)

Figure 4.5 Fulfillment of Average Habitual intake



In addition, due to the consumption of RUF biscuits, the daily nutrient intake became closer to or even higher than the RNI for children with moderate acute malnutrition (MAM), which resulted in an improvement in their weight and nutritional status (WHZ and WAZ). After the consumption of the RUF biscuit, moderately and mildly wasted and underweight children were able to achieve their daily energy intake according to the daily recommended dietary intake for Indonesian children, and the nutrients adequacy per day came closer to the RNI for MAM children.

4.4 Feeding Recommendation

RUF biscuits were mainly developed as an alternative or in addition to nutritious meals for the children, while using the locally available food resources, with the goal to overcome the nutritional problem for children under five. In Indonesia, snacking among children is common practice, unfortunately, most of them are not nutritious. Mothers and caregivers were instructed to offer the RUF biscuit as a snack between family meals or after breastfeeding (for young children). They were informed that the RUF biscuit is a supplementary food designed to support weight and height gain in malnourished children, and for well-nourished children, to further improve their nutrition.

Originally, the recommended number of biscuits per day was calculated to cover about 50-70% of the daily requirement of individual children based on the daily energy and nutrition for the children (FAO, 2001; FAO/WHO, 2001)

The biscuits consumed on average were 60-75 % and cover a minimum of 60-70% of the daily energy and nutrition requirements based on the Indonesian guidelines of Recommended Nutrien Intake (Department Kesehatan RI 2019).

4.5 Cost Estimation

The cost of RUF biscuits from local food resources was calculated according to the local price for the ingredients (Table 4.20). The cost calculation was based on the average price of the ingredients used in Banten in 2020 (1 Euro was approximately 16,000.00 IDR).

The cost of production of RUF biscuits in Banten was higher than the study of RUF-Nias (Purwestri, 2011) because the study in Nias excluded the cost for the micronutrient premix. The micronutrient premix in the study in Nias was a donation from the Dutch State Mines (DSM) a company specializing in solutions for Nutrition, Health & Sustainable Living.

Compared to the price of children's commercial biscuits in Indonesia (around 0.35 - 0.45 euro per 100 g), the RUF price of 0.56 euro per 100 g is considered appropriate since it has the advantage of having the high micronutrients needed for children's growth.

If the RUF biscuit could be developed on a larger scale with support from the government, the RUF biscuit can compete with existing products. This alternative could be a solution to the problem of malnutrition as well as the use of local foodstuffs (food security and sovereignty) in Indonesia.

4.6 Recommendation

RUF biscuit made from local food resources was accepted by the children and caretakers, and for two weeks of consumption showed a slight positive effect in increasing weight gain among wasted and underweight children. The RUF biscuit should be tested for in a longer intervention study to prove the effectiveness of the RUF biscuit consumption on undernourished children. However, food interventions alone will not suffice to overcome the malnutrition problem among children, and it should be accompanied by nutrition education for the caretakers as well as for the adults to prepare for their children's first 1000 days, a great window of opportunity.

Chapter 5

General Discussion

5.1 RUF Biscuit for the Treatment for Undernutrition

Increasing the nutritional status of the community can be carried out in various ways, one of which is food diversification and increasing education and knowledge regarding nutrition and food. For areas or communities that have limited access to nutritious food, giving RUF from local food resources fortified with certain micronutrients can be used as a solution. This feeding can be done within a certain period to improve the nutritional status of the community, especially of children under five years of age. RUF can be made using local food ingredients so that it can increase the utilization of indigenous resources while increasing the welfare of the surrounding community, besides that the costs incurred would be minimized.

Twelve recipes of RUF biscuits have been developed to incorporate underutilized local foods into the children's diet. Five recipes were selected based on the nutritional analysis, and sensory evaluation, and were further assessed in the pilot project of nutrition intervention and product acceptability study for the children under five in Banten province, Indonesia. The two preferred recipes were tested on children to determine the level of acceptance and the effect on the nutritional status of children under five. The biscuit was chosen as the form of RUF because it is very attractive and is favored by children.

RUF biscuits could be produced locally, using locally available food resources and simple technology accessible to the community, and with the participation of all stakeholders (local government, health officers, caretakers). To promote the sustainable production of RUF biscuits, the local government should coordinate and find the solution to improve the post-harvest handling and processing of local food resources to minimize nutrient loss and to provide the micronutrient premix which can be used to fortify the RUF biscuit.

When the recipes' nutrient contents were compared with the international standard for prevention and rehabilitation of MAM children (Golden, 2009), it was noted that there is a gap in the amount of the required nutrients. Therefore, a vitamin-mineral mix was needed to fortify the RUF biscuits, as also reported in the development of the local RUF in Ghana, Ethiopia, Pakistan, and India (Weber *et al.*, 2017), in Sinegal (Diop *et al.*, 2003), Nigeria (Uhiara and Onwuka, 2014), Cambodia (Sigh *et al.*, 2018), and on Nias, Indonesia (Scherbaum *et al.*, 2015). The RUF biscuits given to moderately wasted children in Nias were prescribed as snacks and did not replace the home-based meals. To further improve the mineral composition of the biscuits, local foods rich in the missing minerals are recommended to be added in the recipes, e.g., chicken's liver, dried fish, etc. Also, the gaps in the nutrients are expected to be covered by the home-based meals of the children.

The role of the adequate consumption of RUF biscuits was to rehabilitate the moderately and mildly wasted children in Banten and prevent relapse cases by filling the gap between poor complementary food intake and the recommended nutrient intake (RNI). In addition, due to the consumption of RUF biscuits, the daily nutrient intake became closer to or even higher than the RNI for children suffering from moderate acute malnutrition (MAM) and was reflected in their increase in weight and nutritional status (WHZ). After the consumption of RUF biscuits, undernourished children were able to achieve their daily energy intake according to the daily recommended dietary intake for Indonesian children, and the nutrient adequacy per day came closer to the RNI for MAM children.

Almost all selected macro and micronutrient intake of the children‘s diet was deficient except carbohydrate and protein as compared to the guidelines of recommended nutrient intake (RNI) of Indonesian children. In comparison to RNI for well-nourished Indonesian children, all nutrients in the RNI for MAM children are substantially higher, because of its function as therapeutic food for the rehabilitation of moderately wasted children.

Some children in Banten consumed snacks bought from nearby shops regularly. Mostly they consumed less nutritious snacks that contain high sugars, salt, or food preservatives. Biscuits, puff snacks, wafers, jellies, different types of candies, peanuts, etc. were consumed interchangeably. Thus, the introduction of RUF in the form of a biscuit could be incorporated easily into the child‘s habitual diet. RUF biscuit made from local food resources is recommended to be consumed as a snack between meals, and should not replace family foods. During RUF biscuit distribution for the pilot project and acceptability study, the children mostly consumed RUF biscuits at home. Children assigned in the pilot project of the acceptability study of the RUF biscuits belonged to different socio-economic backgrounds, therefore, their daily dietary habitual intake varied a lot.

The minimum diet of the index child was only able to cover 50% of the energy and carbohydrates, 70% of the protein requirements, while the micronutrients were all below 40% of the RNI. The low consumption of fruit and vegetables means that there is a limited intake of micronutrients which is needed for child development. Consumption of inadequate food intake in combination with frequent illness was likely to be the main cause of the undernourished condition of the index children.

Understanding that nutrition education and behavior change of child care practices, including feeding practices usually need a longer time than RUF supplementation for improving the nutritional status of the undernourished children, thus the consumption of RUF biscuits was implemented as a stop-gap intervention. To fulfill the 100% energy intake of children under five, a home-based family diet was still needed after the introduction of RUF biscuits, since this food supplement was offered as a snack and should be consumed between meals

Rice is the major source of carbohydrates for children, while egg or fish are the sources of protein. The absence or lack of consumption of fruits and vegetables results in a low intake of micronutrients which have an impact on nutritional status resulting in undernutrition.

Given the high prevalence of MAM in many low- and middle-income countries, the sustainability of local strategies will necessarily need to take into account of cost-effectiveness and feasibility of different options, such as locally produced foods versus imported foods, and the integration of food strategies into complex intervention packages (Lazzerini, Rubert and Pani, 2013). The majority of children can be treated at home with ready-to-use therapeutic food under the community-based management of the acute malnutrition model with recovery rates of approximately 90% under optimal conditions.

Since food insecurity and malnutrition is multidimensional and multi-sectoral problem, comprehensive multi-sectoral solutions are needed. Coordination and cooperation between food, agriculture, health, other sectors, and stakeholders are needed to improve national and global nutrition. The results of this research imply that the RUF biscuit has a positive impact on reducing MAM (reducing severe wasting into moderate wasting, and severe underweight into moderate underweight) in children under five.

5.2 RUF and RUTF with COVID-19 pandemic

The spread of the novel coronavirus disease (COVID-19) was declared a global pandemic on March 11, 2020. The outbreak first occurred in Wuhan, Hubei, China in December 2019 and hit some European countries heavily in February 2020 (WHO 2020). Several countries are adopting a complete or partial lockdown to contain the virus. There are some speculations on a possible link between nutritional status and COVID-19 mortality (Cena and Chieppa, 2020)

A balanced diet, which includes the recommended intakes of macro and micronutrients, is essential for maintaining human health. The effect of nutritional status on the functionality of the immune system is evident from deficiency states. Protein and energy malnutrition results in secondary immunodeficiency, and vitamin A and Zn deficiencies lead to characteristic infectious complications (Rijkers, 2015). Various micronutrients are essential for immunocompetence, particularly vitamins A, C, D, E, B_2, B_6, and B_{12}, folic acid, iron, selenium, and zinc, as well as macronutrients likely omega 3 fatty acids and bioactive components like polyphenols (Cena and Chieppa, 2020) and (Aman and Masood, 2020). Micronutrient deficiency especially vitamin D was most prevalent in COVID-19 patients in Korea followed by selenium (Im *et al.*, 2020) and it was theorized by (Biesalski, 2020) that vitamin D could be used for treatment for COVID-19 patients.

With regards to the low intake of micronutrients among undernourished children, it would mean that this group would be vulnerable to the COVID-19 infection. The treatment with the RUF biscuit as a booster to improve the nutrition intake of children under five years of age, could perhaps also improve the immune system against the COVID-19 virus.

Based on the data announced by the Indonesian Paediatric Society (IDAI), about 300 Indonesian children (including newborn babies and those below the age of six), are believed to have died from COVID-19, which puts the record as the world's highest rate of child deaths from the novel coronavirus. This is also the greatest number of child deaths (from the virus) in the ASEAN region and the whole of Asia. This unfortunate situation has also linked malnutrition with poor health facilities. Through the program of improving the nutritional status of children, a strong immune system will be beneficial against infectious diseases.

Chapter 6

Summary

Indonesia faces a serious problem of malnutrition especially stunting and underweight caused by micronutrient deficiencies. The high prevalence of undernutrition was also found in Banten Province, Java Island, the most populated island in Indonesia. The Indonesian Demographic and Health Survey (DHS) in 2012 reported that of about 24.5 million children under five years of old, approximately 37% and 12% of them were stunted and wasted. Furthermore, based on the Basic Health Survey (Riskesdas) in 2013 and 2018, the prevalence of stunting in children under five years old was 37.2 % and 30.8%, while the proportion of underweight children was 19.6% and 17.7%. The undernourished children have an increased mortality rate, risk of illness and infections, cognitive shortages, delayed development, and poor school performance.

Ready-to-use food (RUF) is a kind of food easily consumed without much preparation and can be made using various techniques for targeted consumers. RUF can be produced using locally available food resources, which may be affordable for most people suffering from undernutrition. To improve and accomplish the nutrient content of RUF to meet the standard for rehabilitation food for malnutrition, the combination of various food resources might enhance the nutritional composition. This nutritious formulation must have the following attributes: good nutritional quality in macro and micronutrient content, highly palatable taste, consistency, and texture suitable for feeding to children, no additional processing required prior to feeding, product stability, long shelf life, and readily available ingredients.

This research was divided into three main objectives. The first objective was a baseline assessment of the nutritional condition of the target group of children below five years old. The second section was RUF biscuit product development. The third objective was to investigate the nutritional outcomes of the field study in Banten Indonesia, particularly in WHZ and weight after the RUF provision and weight gain of the children and acceptability. The RUF biscuit was made from the composite flour of local food resources available in Banten province Indonesia which are still underutilized.

The result of nutrition content analysis in local food resources showed that the foods have a high nutritional composition as a source of macronutrients and micronutrients (vitamins and minerals). Due to poor handling of post-harvest and processing into the intermediate product (flour), some vitamins were lost during the process.

Based on the baseline assessment in 2017, of the 105 children, 4.8% and 11.4% of them were wasted and overweight-obese, while 40% and 23.8% of the children were stunted and underweight. Based on the mid-upper-arm circumference, 16.1% of children were categorized as the risk of chronic energy deficiency (CED). In addition, it was found that most of the children have insufficient intake of protein, Vitamin A, Iron, and Zinc.

Twelve recipes developed using the combination of local food resources showed the macronutrient composition that met the requirement for the treatment of Moderate Acute Malnutrition (MAM) children, but not for micronutrient (vitamin and minerals). Five recipes (recipes 3, 4, 7, 11, and 12) were selected based on nutritional composition and sensory evaluation. The selected recipes were continued to further research of acceptability study in Banten, Indonesia. Before the acceptability study in the field, the micronutrient composition of the recipes chosen was improved according to the MAM treatment recommendation. It fortified the RUF with micronutrient premix. The micronutrient stability test was performed to analyze the loss due to baking. Around 15-28% of the vitamins (A, B1, B2, and E) were lost after baking, which was slightly lower than the other published articles, perhaps due to the short process of baking (15 minutes). Furthermore, the micronutrient sources were from the vitamin-mineral premix with higher stability than that from foods. Minerals content was stable during the baking process.

Before the acceptability study started, five fortified cookie recipes were tested to select two for the acceptance and intervention pilot study. Most of the children in the acceptance study reported that they accepted and liked the RUF cookies. The consumption of RUF biscuits for two weeks led to an improvement in the nutritional status: Reduction of severe wasting (WHZ) from 5.7% to 4.3% and of severe underweight (WAZ) from 8.6% to 4.3%. There was no difference in terms of stunting

(HAZ). Thus, it has been shown that the developed RUF biscuits have the potential to reduce malnutrition in the under 5-year-olds in the target area.

Zusammenfassung

Unterernährung stellt ein ernsthaftes Problem in Indonesien dar, insbesondere Untergewicht und Stunting aufgrund eines Mikronährstoffmangels. Die hohe Prävalenz von Unterernährung auf der Insel Java (der wichtigsten Insel Indonesiens) wurde auch in der Provinz Banten festgestellt. Laut dem Demographic and Health Survey (DHS) von 2012 sind in Indonesien von ca. 24,5 Millionen Kindern unter 5 Jahren etwa 9,2 Millionen (37%) zu klein für ihr Alter (Stunting) und 12% zu leicht für ihre Körpergröße (Wasting). Basierend auf den Daten des Basic Health Survey aus den Jahren 2013 und 2018 lag die Prävalenz von *Stunting* bei Kindern unter fünf Jahren bei 37,2% bzw. 30,8%, von Untergewicht bei 19,6% bzw. 17,7%. Unterernährung resultiert in einem erhöhten Mortalitäts- und Morbiditätsrisiko, außerdem weisen diese Kinder häufiger Entwicklungsverzögerungen, kognitive Defizite, sowie schlechtere Schulleistungen und eine geringere Dauer der Schulbildung auf.

Ready-to-Use Food (RUF) stellt ein gebrauchsfertiges Lebensmittel dar, das ohne weitere Zubereitung verzehrt werden kann. Es wird für Personen mit besonderen Bedürfnissen konzipiert. RUF kann mit lokal verfügbaren Nahrungsmitteln hergestellt werden, die für die meisten unterernährten Menschen erschwinglich sein sollten. Um den Nährstoffgehalt von RUF zu verbessern und um die Kriterien für ein Lebensmittel zur Behandlung einer Unterernährung zu erfüllen, kann die Kombination verschiedener Nahrungsressourcen die Nährstoffzusammensetzung verbessern. Ein solches diätetisches Lebensmittel sollte folgenden Eigenschaften aufweisen: gute Nährstoffqualität in Bezug auf Makro- und Mikronährstoffgehalt, sehr guter Geschmack, ansprechende Konsistenz und Textur, die für die Ernährung von Kindern geeignet sind, keine zusätzliche Verarbeitung vor dem Verzehr erforderlich, Produktstabilität, lange Haltbarkeit und leicht verfügbare Zutaten.

Diese Forschungsarbeit ist in 3 Hauptziele gegliedert. Das erste Ziel beinhaltet die Erhebung des Ernährungszustandes von Kindern unter fünf Jahren in einer Basisstudie. Der zweite Abschnitt befasst sich mit der Entwicklung von RUF-Keksprodukten, die im dritten Teil in einer Feldstudie in Banten Indonesien eingesetzt wurden, insbesondere im Hinblick auf antropometrische Endpunkte wie WHZ und

Gewichstentwicklung nach Gabe der RUF-Kekse sowie deren Akzeptanz. Die RUF-Kekse wurde aus Nahrungsmitteln hergestellt, die in der indonesischen Provinz Banten verfügbar sind, jedoch nicht in ausreichender Menge verzehrt werden. Die Analyse des Nährstoffgehalts lokaler Lebensmittelressourcen zeigte, dass die Lebensmittel eine geeigente Zusammensetzung bezüglich der Makro- und Mikronährstoffe (Vitamine und Mineralien) aufweisen. Aufgrund ungünstiger Bedingungen nach der Ernte und bei der Verarbeitung zum Zwischenprodukt Mehl gehen während dieser Prozesse viele Vitamine und Mineralien verloren.

In der Basiserhebung des Jahres 2017 mit 105 Befragten wurden 4,8% der Kindern aufgrund eines niedrigen WHZ-Scores als wasted klassifziert, 40% als zu klein für ihr Alter (stunted), 23, 8% als untergewichtig und 11,4% als übergewichtig. Wurde der mittlere Oberarmumfang (MUAC) betrachtet, wiesen 16,1% der Kinder ein Risiko für einen chronischen Energiemangel (CED) auf. Des Weiteren wurde festgestellt, dass die meisten Kinder eine unzureichende Protein-, Vitamin A-, Eisen- und Zinkaufnahme hatten.

Zwölf Rezepte, die für die Produktentwicklung unter Verwendung lokaler Nahrungsressourcen entwickelt wurden, zeigen, dass die Makronährstoffzusammensetzung die Anforderungen einer Ernährung zur Behandlung von Kindern mit mittelschwerer akuter Unterernährung (MAM) erfüllt, dies gilt jedoch nicht für alle Mikronährstoffe (Vitamin und Mineralien). Fünf Rezepte (Rezepte 3, 4, 7, 11 und 12) wurden aufgrund ihrer Nährstoffzusammensetzung und der sensorischen Bewertung für die Akzeptanzstudie in Banten, Indonesien ausgewählt. Vor Durchführung der Akzeptanzstudie wurden die Rezeptur der RUF-Kekse mit einer Mikronährstoffvormischung auf der Grundlage der Empfehlung für die MAM-Behandlung angereichert. Die Stabilität der Mikronährstoffe wurde nach dem Backprozess bestimmt, wobei die Verluste der Vitamine A, B1, B2 und E bei etwa 15 bis 28% lagen. Diese waren etwas niedriger als in anderen Untersuchungen beschrieben, was durch den kurzen Backvorgang (15 Minuten) und die Mikronährstoffherkunft begründet sein könnte. Die verwendete Mikronährstoffvormischung (Premix) weist im Vergleich zu Vitaminen aus Lebensmitteln eine höhere Stabilität auf, während der Mineralstoffgehalt durch den

Backvorgang nicht beeinflusst wurde.

Bevor die Akzeptanzstudie startete, wurden fünf angereicherte Keksrezepturen getestet, um zwei davon für die Akzeptanz- und Interventionpilotstudie auszuwählen. Die meisten Kinder der Akzeptanzstudie berichteten, dass sie die RUF-Kekse akzeptierten und mochten. Der Konsum von RUF-Keksen über zwei Wochen führte zu einer Verbesserung des Ernährungsstatus: Reduktion von schwerem Wasting (WHZ) von 5,7% auf 4,3% und von starkem Untergewicht (WAZ) von 8,6% auf 4,3%. In Bezug auf Stunting (HAZ) gab es keinen Unterschied. Somit hat sich gezeigt, dass die entwickelten RUF-Kekse das Potenzial haben, Unterernährung bei unter 5-Jährigen im Zielgebiet zu reduzieren.

References

Abe-matsumoto, L. T. *et al.* (2014) 'Stability of antioxidant vitamins in commercial vitamin supplements', *Brazilian Journal of Pharmaceutical Sciences*, 54(4).

Aman, F. and Masood, S. (2020) 'How nutrition can help to fight against covid-19 pandemic', *Pakistan Journal of Medical Sciences*, 36(COVID19-S4), pp. 121–123. doi: 10.12669/pjms.36.COVID19-S4.2776.

Andrias, D. R., Fahmida, U. and Adi, A. C. (2019) 'Nutritional potential of underutilized food crops to improve diet quality of young children in food insecure prone areas of Madura Island, Indonesia', *Asia Pacific journal of clinical nutrition*, 28(4), pp. 826–836. doi: 10.6133/apjcn.201912_28(4).0020.

AOAC (1990) 'Association of Official Analytical Chemists.', *Official Methods of Analysis, 15th ed. AOAC, Arlington, VA.*, 242(March), p. 2002.

Badan Pusat Statistik Kabupaten Pandeglang (2018) 'Statistik Daerah kabupaten Pandegelang'.

Badan Pusat Statistik Kabupaten Pandeglang (2019) 'Statistik Kesejahteraan Rakyat Kabupaten Pandeglang'. Available at: https://pandeglangkab.bps.go.id/webbeta/websiteV2/pdf_publikasi/Statistik-Kesejahteraan-Rakyat-Kabupaten-Pandeglang-2015.pdf.

Balai Penelitian dan pengembangan Kesehatan RI and Kesehatan, B. P. dan pengembangan (2013) *Riset Kesehatan dasar Provinsi Banten 2013*, *Departemen Kesehatan RI*.

Banten, P. (2018) 'Provins Banten in Figures'.

Beal, T. *et al.* (2018) 'A review of child stunting determinants in Indonesia', *Maternal and Child Nutrition*, 14(4), pp. 1–10. doi: 10.1111/mcn.12617.

Berdanier, Carolyn D. Dwyer, Johanna T. Heber, D. (editor) (2013) 'Handbook of Nutrition and Food- 2nd ed'. Boca Raton, United States: CRC Press, p. 1136. doi: https://doi.org/10.1201/b15294.

Biesalski, H. K. (2013) *Hidden Hunger*. Stuttgart, Germany: Springer. doi: 10.1007/978-3-642-33950-9.

Biesalski, H. K. (2020) 'Vitamin D deficiency and co-morbidities in COVID-19 patients – A fatal relationship?', *NFDS Journal*, (January).

BPOM (2018) 'Peraturan Badan Pengawas Obat Dan Makanan Nomor 5 Tahun 2018 Tentang Batas Maksimum Cemaran Logam Berat Dalam Pangan Olahan', *Badan Pengawas Obat Dan Makanan*.

BPS-Statistics Indonesia (2018) *Statistik Daerah Provinsi banten*.

Bryce, J. *et al.* (2008) 'Maternal and child undernutrition: effective action at national level', *The Lancet*, 371(9611), pp. 510–526. doi: 10.1016/S0140-6736(07)61694-8.

Budiarto, M. S. and Rahayuningsih, Y. (2017) ‘POTENSI NILAI EKONOMI TALAS BENENG (Xanthosoma undipes K. Koch) BERDASARKAN KANDUNGAN GIZINYA’, *Jurnal Kebijakan Pembangunan Daerah*, 1(1), pp. 1–12.

Budiastutik, I. and Nugraheni, A. (2018) ‘Determinants of Stunting in Indonesia: A Review Article’, *International Journal Of Healthcare Research*, 1(1), pp. 2620–5580.

Cena, H. and Chieppa, M. (2020) ‘Coronavirus Disease (COVID-19–SARS-CoV-2) and Nutrition: Is Infection in Italy Suggesting a Connection?’, *Frontiers in Immunology*, 11(May), pp. 1–6. doi: 10.3389/fimmu.2020.00944.

Chapparo, C; Oot L,; Sethuraman, K. (2014) ‘Indonesia Nutrition Profile’, pp. 2–5.

Chauhan, A., Saxena, D. C. and Singh, S. (2016) ‘Physical, textural, and sensory characteristics of wheat and amaranth flour blend cookies’, *Cogent Food & Agriculture*. Cogent, 2(1), pp. 1–8. doi: 10.1080/23311932.2015.1125773.

Choudhury, N. *et al.* (2018) ‘Ready-to-Use Therapeutic Food Made From Locally Available Food Ingredients Is Well Accepted by Children Having Severe Acute Malnutrition in Bangladesh’, *Food and Nutrition Bulletin*, 39(1), pp. 116–126. doi: 10.1177/0379572117743929.

Dandin, S. B. and Kumar, N. K. K. (2016) ‘Neglected and Underutilized Fruit Species – an Insurance Against Global Mal and Under Nutrition’, *FAO Regional Expert Consultation on Scoping, Prioritizing and Mapping of Neglected and Underutilized Crop Species in Asia*, pp. 1–40. Available at: http://www.fao.org/fileadmin/templates/rap/files/meetings/2016/161203_session1_4.pdf.

Depertemen Kesehatan RI (2019) ‘Peraturan Mentri Kesehatan REPUBLIK INDONESIA Nomor 28 Tahun 2019 Tentang Angka Kecukupan Gizi Yang Dianjurkan Untuk Masyarakat Indonesia’, 22, pp. 1–8.

Devi, R. (2015) ‘Food Processing and Impact on Nutrition’, *Scholars Journal of Agriculture and Veterinary Science*, 2(4A), pp. 304–311. Available at: http://saspjournals.com/sjavs.

Diop, E. H. I. *et al.* (2003) ‘Comparison of the efficacy of a solid ready-to-use food and a liquid, milk-based diet for the rehabilitation of severely malnourished children: A randomized trial’, *American Journal of Clinical Nutrition*, 78(2), pp. 302–307. doi: 10.1093/ajcn/78.2.302.

Durst, P. and Bayasgalanbat, N. (2014) *Promotion of underutilized indigenous food resources for food security and nutrition in Asia and the Pacific*, *Promotion of underutilized indigenous food resources for food security and nutrition in Asia and the Pacific*.

European Committee for Standardization (2014a) ‘Foodstuffs-Determination of vitamin B1 by high-performance liquid chromatography’, *EN 14152*, (August).

European Committee for Standardization (2014b) *Foodstuffs – Determination of vitamin B2 by high-performance liquid chromatography; German version EN 14152:2014*, *EN 14122*.

Europian Commission (2009) ‘Commission Regulation (EC) No 152/2009 of 27 January 2009 laying down the methods of sampling and analysis for the official control of feed’, *Official Journal of the European Union*, (L54), pp. 1–130.

Fahmida, U. and Santika, O. (2016) ‘Development of complementary feeding recommendations for 12-23-month-old children from low and middle socioeconomic status in West Java, Indonesia: contribution of fortified foods towards meeting the nutrient requirement’, *The British journal of nutrition*, 116, pp. S8–S15. doi: 10.1017/S0007114516002063.

FAO/WHO (2001) ‘Human Vitamin and Mineral Requirements’, *FAO/WHO expert consultation on human vitamin and mineral requirements*, (2nd ed), p. 341 p. Available at: http://apps.who.int/iris/handle/10665/42716.

FAO (1992) ‘World Declaration and Plan of Action for Nutrition’, *International Conference on Nutrition*, (December), pp. 1–42.

FAO (2001) ‘Human Energy Requirements: Report of a Joint FAO/ WHO/UNU Expert Consultation.’, *FAO Food and Nutrition Technical Report Series*, 26(1), p. 166.

FAO (2013) ‘Country Report on the State of Plant Genetic Resources for Food and Agriculture Indonesia’.

FAO (2014) ‘International Conference on nutrition.’, *Second International Conference on Nutrition (ICN2)*.

Fetriyuna, F., Marsetio, M. and Pratiwi, R. L. (2016) ‘Pengaruh lama modifikasi heat-moisture treatment (HMT) terhadap sifat fungsional dan sifat amilografi pati talas banten (Xanthosoma undipes K. Koch)’, *JP2| Jurnal Penelitian Pangan*, 1(1).

Golden, M. H. (2009) ‘Proposed Recommended Nutrient densities for moderately malnourished children’, *Food and Nutrition Bulletin*, 30(3 SUPPL. 1). doi: 10.1177/15648265090303s302.

Grobler, L. *et al.* (2015) ‘Benefits and harms of supplementary food in moderately under---nourished children’, *Review Paper*, X(3), pp. 373–379.

Hakiki, D. N. and Rostianti, T. (2019) ‘Development of Local Food Biodiversity of Nata De Taro from Talas Beneng (Xanthosoma undipes k. koch.)’, in *IOP Conference Series: Earth and Environmental Science*. IOP Publishing, p. 012030.

Haliza, W., Kailaku, S. I. and Yuliani, S. (2017) ‘Penggunaan Mixture Response Surfa Ce Methodology Pada Optimasi Formula Brownies Berbasis Tepung Talas Banten (Xanthosoma Undipes K. Koch) Sebagai Alternatif Pangan Sumber Serat’.

Hendricks, K. M. (2010) ‘Ready-to-use therapeutic food for prevention of childhood undernutrition’, *Nutrition Reviews*, 68(7), pp. 429–435. doi: 10.1111/j.1753-4887.2010.00302.x.

ICN2 (2014) ‘National Nutrition Strategy Paper of Indonesia’, pp. 1–52.

Im, J. H. *et al.* (2020) ‘Nutritional status of patients with coronavirus disease 2019 (COVID-19)’, *International Journal of Infectious Diseases*. International Society for

Infectious Diseases, 100, pp. 390–393. doi: 10.1016/j.ijid.2020.08.018.

Inayati, D. . (2011) *Nutritional interventions among mildly wasted children on Nias Island, Indonesia: impact on children's nutritional status and knowledge-practice of caregivers*. Doctoral thesis. University of Hohenheim.

Indicators, K. (2014) 'Indonesia - Food and Nutrition Security Profiles Indonesia - Food and Nutrition Security Profiles Food Availability / Food Access Access to food', pp. 2010–2015.

Irías-Mata, A. *et al.* (2017) 'Tocopherols, Tocomonoenols, and Tocotrienols in Oils of Costa Rican Palm Fruits: A Comparison between Six Varieties and Chemical versus Mechanical Extraction', *Journal of Agricultural and Food Chemistry*, 65(34), pp. 7476–7482. doi: 10.1021/acs.jafc.7b02230.

Jati, I. R. A. P. *et al.* (2014) 'Design and validation of a program to identify inadequate intake of iron, zinc, and vitamin A', *Nutrition*. Elsevier Inc., 30(11–12), pp. 1310–1317. doi: 10.1016/j.nut.2014.03.015.

Kemenkes RI (2018) 'Buletin Stunting', *Kementerian Kesehatan RI*, 301(5), pp. 1163–1178.

Kementerian Kesehatan RI Badan Penelitian dan Pengembangan (2018) 'Hasil Utama Riset Kesehatan Dasar', *Kementrian Kesehatan Republik Indonesia*, pp. 1–100. doi: 1 Desember 2013.

Kementrian Kesehatan RI (2020) *Cegah Stunting, Ratusan Ribu Ibu Hamil dan Balita Diberi Zat Gizi Mikro*, *Ministry of Health Indonesia*. Available at: https://sehatnegeriku.kemkes.go.id/baca/rilis-media/20200115/2232735/cegah-stunting-ratusan-ribu-ibu-hamil-dan-balita-diberi-zat-gizi-mikro/ (Accessed: 17 January 2021).

Komari and Lamid, A. (2012) 'Komposisi Gizi Dan Daya Terima Makanan Terapi: Ready To Use Therapeutic Food Untuk Balita Gizi Buruk (Nutrition Composition And Acceptance Test Of Ready To Use Therapeutic Food For Severe Malnourished Children)', *Panel Gizi Makanan 2012, 35(2): 159-167*, 13(1), pp. 50–56.

Lachenbruch, P. A., Lwanga, S. K. and Lemeshow, S. (1991) 'Sample Size Determination in Health Studies: A Practical Manual.', *Journal of the American Statistical Association*, p. 1149. doi: 10.2307/2290547.

Lazzerini, M., Rubert, L. and Pani, P. (2013) 'Specially formulated foods for treating children with moderate acute malnutrition in low- and middle-income countries', *Cochrane Database of Systematic Reviews*, 2013(6). doi: 10.1002/14651858.CD009584.pub2.

Manary, M. J. (2006) 'Local production and provision of ready-to-use therapeutic food (RUTF) spread for the treatment of severe childhood malnutrition', *Food and Nutrition Bulletin*, 27(SUPPL.3). doi: 10.1177/15648265060273S305.

Mayes, S. *et al.* (2012) 'The potential for underutilized crops to improve security of food production', *Journal of Experimental Botany*, 63(3), pp. 1075–1079. doi: 10.1093/jxb/err396.

Meshram, I. I. *et al.* (2012) ‘Trends in the prevalence of undernutrition, nutrient & food intake and predictors of undernutrition among under five year tribal children in India’, *Asia Pacific Journal of Clinical Nutrition*, 21(4), pp. 568–576. doi: 10.6133/apjcn.2012.21.4.12.

Ministry of Health Indonesia (2007) ‘Laporan Riskesdas Nasional 2007’, *Riskesdas*. doi: 1 Desember 2013.

Ministry of Health RI (2013) ‘Angka Kecukupan Gizi (AKG) Recommended Nutrient Intake (RNI) of Indonesia’, *Kementerian Kesehatan RI*, (mL), pp. 5–10.

Novianty, D. (2008) ‘Comparison of Vitamin and Mineral Content in Locally Produced Ready-to-Use Food (RUF) – Biscuits with International Recommendation for Treatment of Malnourished Children in Nias, Indonesia’, *Master Thesis, Organic Food Chain Management, Hohenheim University*, (November).

Nutrition International (2020) *Nutrition International and the Government of Indonesia helping to prevent and reduce stunting by reaching pregnant women and children under five with essential micronutrients*. Available at: https://www.nutritionintl.org/news/all-news/nutrition-international-and-the-government-of-indonesia-helping-to-prevent-and-reduce-stunting-by-reaching-pregnant-women-and-children-under-five-with-essential-micronutrients/ (Accessed: 2 January 2021).

Oddo, V. M. *et al.* (2012) ‘Predictors of maternal and child double burden of malnutrition in rural Indonesia and Bangladesh’, *American Journal of Clinical Nutrition*, 95(4), pp. 951–958. doi: 10.3945/ajcn.111.026070.

de Onis, M. *et al.* (2018) ‘Prevalence thresholds for wasting, overweight, and stunting in children under 5 years’, 22(1), pp. 175–179. doi: 10.1017/S1368980018002434.

Owino, V. O. *et al.* (2014) ‘Development and acceptability of a novel milk-free soybean-maize-sorghum ready-to-use therapeutic food (SMS-RUTF) based on industrial extrusion cooking process’, *Maternal and Child Nutrition*, 10(1), pp. 126–134. doi: 10.1111/j.1740-8709.2012.00400.x.

Pereira, D., Correia, P. M. R. and Guiné, R. P. F. (2013) ‘Analysis of the physical-chemical and sensorial properties of Maria type cookies’, *Acta Chimica Slovaca*, 6(2), pp. 269–280. doi: 10.2478/acs-2013-0040.

Purwestri, R. C. (2011) ‘Supplementary feeding and cost analysis of locally produced Ready-to-Use Food (RUF) for moderately and mildly wasted children in Nias Island, Indonesia : daily and weekly programs’, *Doctoral Thesis. Center of Gender and Nutrition. The University of Hohenheim*, (January).

Purwestri, R. C. *et al.* (2012) ‘Supplementary feeding with locally-produced ready-to-use food (RUF) for mildly wasted children on Nias Island, Indonesia: Comparison of daily and weekly program outcomes’, *Asia Pacific Journal of Clinical Nutrition*, 21(3), pp. 374–379. doi: 10.6133/apjcn.2012.21.3.07.

Purwestri, R. C. *et al.* (2017) ‘Is agriculture connected with stunting in Indonesian children living in a rice surplus area? A case study in Demak Regency, Central Java’, *Food Security*. Food Security, 9(1), pp. 89–98. doi: 10.1007/s12571-016-0634-2.

Rahman, S. M. M. *et al.* (2008) ‘Effect of parental formal education on risk of child stunting in Indonesia and Bangladesh: a cross-sectional study’, *The Lancet*, 371(9609), pp. 322–328. doi: 10.1016/j.annrmp.2005.04.008.

Rijkers, G. T. (2015) ‘Nutrition, immunity and human health’, *British Journal of Nutrition*, 114(9), pp. 1329–1330. doi: 10.1017/S0007114513002158.

Sandige, H. *et al.* (2004) ‘Home-based treatment of malnourished Malawian children with locally produced or imported ready-to-use food’, *Journal of Pediatric Gastroenterology and Nutrition*, 39(2), pp. 141–146. doi: 10.1097/00005176-200408000-00003.

Sandjaja, S. *et al.* (2013) ‘Food consumption and nutritional and biochemical status of 0·5-12-year-old Indonesian children: The SEANUTS study’, *British Journal of Nutrition*, 110(SUPPL.3). doi: 10.1017/S0007114513002109.

Scherbaum, V. *et al.* (2015) ‘Locally produced cereal/nut/legume-based biscuits versus peanut/milk-based spread for treatment of moderately to mildly wasted children in daily programs on Nias Island, Indonesia: An issue of acceptance and compliance?’, *Asia Pacific Journal of Clinical Nutrition*, 24(1), pp. 152–161. doi: 10.6133/apjcn.2015.24.1.15.

Scherbaum, V., Lemke, S. and Bellows, A. (2012a) ‘Das Recht von Kindern auf Gesundheit und angemessene Ernährung im Wandel von Forschung und weltweiten Strategien. Teil 1: Meilensteine auf dem Weg zur Kinderrechtskonvention’, *Ernahrungs Umschau*, 59(4), pp. 196–201.

Scherbaum, V., Lemke, S. and Bellows, A. (2012b) ‘Das Recht von Kindern auf Gesundheit und angemessene Ernährung im Wandel von Forschung und weltweiten Strategien. Teil 2: Weiterentwicklung von Zielen, Konzepten und Legislativen’, *Ernahrungs Umschau*, 59(4), pp. 264–269.

Schoonees, A. *et al.* (2019) ‘Ready-to-use therapeutic food (RUTF) for home-based nutritional rehabilitation of severe acute malnutrition in children from six months to five years of age (Review)’, *Cochrane Database of Systematic Reviews 2019 Art. No.: CD009000.*, (5). doi: 10.1002/14651858.CD009000.pub3.www.cochranelibrary.com.

Sekiyama, M., Roosita, K. and Ohtsuka, R. (2012) ‘Snack foods consumption contributes to poor nutrition of rural children in West Java, Indonesia’, *Asia Pacific Journal of Clinical Nutrition*, 21(4), p. 558.

Shapiro, O. (2007) ‘Development of Ready-to-Use Therapeutic Food (RUTF) for malnourished children in Indonesia’, *Diploma Thesis General and Applied Natural Sciences of the University of Hohenheim*.

Sigh, S. *et al.* (2018) ‘Effectiveness of a locally produced, fish-based food product on weight gain among Cambodian children in the treatment of acute malnutrition: A randomized controlled trial’, *Nutrients*, 10(7), pp. 1–17. doi: 10.3390/nu10070909.

Stewart CP, Iannotti L, Dewey KG, M. K. & O. A. (2013) ‘Childhood Stunting : Context, Causes, and Consequences’, *Maternal and Child Nutrition*, 9(2), pp. 27–45.

Stiller, C. K. *et al.* (2020) 'Prevalence of Undernutrition and Anemia among', *International Journal of Environmental Research and Public Health*, 17(342), pp. 1–32.

The Indonesian Presidential Decree (2009) *KEPPRES No. 22 Tahun 2009 tentang Hari Konservasi Alam Nasional*.

The SMERU Research Institute (2015) 'Food and nutrition security in Indonesia : a strategic review. Improving food and nutrition security to reduce stunting', *SMERU-UKP4-WFP*, p. 89.

Uhiara, N. S. and Onwuka, G. (2014) 'Suitability of Protein-Rich Extract from Okra Seed for Formulation of Ready to Use Therapeutic Foods (RUTF)', *Nigerian Food Journal*. Elsevier, 32(1), pp. 105–109. doi: 10.1016/s0189-7241(15)30102-8.

UNICEF, WHO and World Bank Group (2018) 'Levels and Trends in Child Malnutrition, UNICEF / WHO / World Bank Group Joint Child Malnutrition Estimates', *Midwifery*, 12(3), pp. 154–155. doi: 10.1016/S0266-6138(96)90067-4.

United Nations Children's Fund (Unicef) (2012) 'UNICEF 's approach to scaling up nutrition'.

United Nations Children's Fund (Unicef) (2018) 'Nutrition Capacity Assessment in Indonesia', *UNICEF, Jakarta*, August.

United Nations Children's Fund (Unicef) (2019) *The State of the World's Children in 2019. Children, Food and Nutrition: Growing well in a changing world*, *Unicef*.

Wagh, V. D. and Deore, B. R. (2018) 'Ready to Use Therapeutic Food [RUTF] formulation and packaging for malnutrition: an Overview', *Advances in Colloid and Interface Science*, 2(1), pp. 1–15. doi: 10.19080/NFSIJ.2018.04.555648.

Wald, J. P., Nohr, D. and Biesalski, H. K. (2018) 'Rapid and easy carotenoid quantification in Ghanaian starchy staples using RP-HPLC-PDA', *Journal of Food Composition and Analysis*. Elsevier, 67(December 2017), pp. 119–127. doi: 10.1016/j.jfca.2018.01.006.

Watzke, H. J. (1998) 'Impact of processing on bioavailability examples of minerals in foods', *Trends in Food Science and Technology*, 9(8–9), pp. 320–327. doi: 10.1016/S0924-2244(98)00060-0.

Weber, J. M. *et al.* (2017) 'Acceptability of locally produced ready-to-use therapeutic foods in Ethiopia, Ghana, Pakistan and India', *Maternal and Child Nutrition*, 13(2), pp. 1–9. doi: 10.1111/mcn.12250.

WHO (2012) 'Technical note: supplementary foods for the management of moderate acute malnutrition in infants and children 6–59 months of age', *Geneva, World Health Organization*. doi: 10.1016/0045-7906(90)90014-7.

WHO (2018) 'Global Nutrition Report 2018 - Executive Summary', p. 12. doi: 10.2499/9780896295643.

WHO (2021) *Global Targets 2025*.

WHO and Unicef (2019) ‘WHO child growth standards and the identification of severe acute malnutrition in infants and children’, *A Joint Statement by the World Health Organization and the United Nations Children’s Fund*. Available at: http://apps.who.int/iris/bitstream/10665/44129/1/9789241598163_eng.pdf?ua=1.

Wieringa, F. T. *et al.* (2013) ‘Acceptability of Two Ready-to-Use Therapeutic Foods among HIV- Positive Patients in Vietnam’. Available at: www.fantaproject.org.

World Health Organization *et al.* (2007) ‘Community-based management of severe acute malnutrition’, *A Joint Statement by the World Health Organization, the World Food Programme, the United Nations System Standing Committee on Nutrition and the United Nations Children’s Fund*, p. 7.

World Health Organization and UNICEF (2019) ‘The extension of the 2025 Maternal, Infant and Young Child nutrition targets to 2030’, *Discussion paper*, p. 12. Available at: https://www.who.int/nutrition/global-target-2025/discussion-paper-extension-targets-2030.pdf?ua=1.

Acknowledgment

I give glory to God Almighty Allah SWT, the Most Gracious and the Most Merciful. For all of my achievements, the good people, and the right persons with whom I am acquainted, and for all the opened doors during my study period, I wish to thank my doctoral supervisor, Prof. Dr. med. Hans K.Biesalski and Prof. Donatus Nohr for their excellent supervision, constructive suggestion, and sharing their valuable expertise throughout the study. Sincere thanks also to Prof. Jan Frank for his support.

I am grateful to Dr. Ratna Puswestri, who has been involved in this work from the initial stage until now, and for many fruitful discussions, continuous support, and assistance for both research and life studies. Throughout the fieldwork, I greatly appreciated the assistance of our co-workers: Ilmia Fahmi and Netta for their knowledge, assistance in the field data collection. Special thank health and nutrition field officers (dr. Umbiyati and Ibu Enong), for supervision during field research, Bp. Dudi Supyandy for providing the local food resource. This study would not have been possible without the support of our staff in the field and other enumerators, data entry, and assistants.

I am in debt to Fitriana Nasution and Novita Victorine Wattimene for helping with the RUF product development, Theodore Tarudji and Nathan Chandra Hemson for the technical assistance, and for all the panelists in the sensory evaluation test (Indonesian Student, Indonesian Muslim Community in Stuttgart, and all the colleagues in institute 140a).

My special thanks go to the staff of the department of nutritional science (140a) Dr. Christine Lambert for the German translation, Mr. Alexander Koza for giving me training on high-performance liquid chromatography techniques and helping me in the laboratory activities, Dr. Realm Koehler partner of analysis in the lab and for proofreading my thesis. I would also like to express my gratitude to my office mate Dr. Lucy Kariuki, Dr. Tibebesilasie Keflie, and Dr. Virtu Calabuig Navarro for their kindness and warm smiles always.

Sincere thanks to Kornelia Kasper, Natalia Omari, Nilza Andrade Binder, Sandra Siegfried, Silke Börner, Simone Lendl, and Dr. Heinrich Hagel for giving me advise, finding solutions to all the administrative issues.

Thanks to the colleagues in the Faculty of Agroindustrial Technology, Padjadjaran University Indonesia Prof. M. Djali, Dr. Edi Suryadi, Dr. Robi Andoyo, and Dr.Bambang Nurhadi for the support, and the encouragement to continue until the finish line. I am forever indebted to Prof. Anwar Kasim, Prof. Helmi, and Dr. Mimin Muhaimin for the recommendation letter to continue my study.

I would particularly acknowledge DAAD –IGSP (Indonesia German Scholarship Program) for granting me the scholarship. Food Security Center (FSC) University Hohenheim and foundation Fiat Panis for awarding me the Dr. Hermann Eiselen PhD Field Research Grant that financed my fieldwork, sampling, and various laboratory analysis, the Humboldt Reloaded Project for giving me the chance to mentor undergraduate students, and the Gender Equality Office for the Professorinnenprogramm III Grant for giving me my peace of mind at the final quarter of my dissertation.

My appreciation also goes to my parents, parents-in-law, siblings, brother and sister-in-law, and their families. I am also thankful to my dearest sons Ridho, Rafi, and Reynard, for their understanding during my absence, and to my beloved husband, May Susandy for constant prayers, love, and patience during this long endeavor.

Curriculum Vitae

Personal Information

Name	:	Fetriyuna Fetriyuna
Birthdate	:	23.08.1982
Nationality	:	Indonesien
Sex	:	Female
Address	:	Institute of Nutritional Sciences Garbenstr.30, 70599 Stuttgart, Germany
E-mail	:	fetriyuna@uni-hohenheim.de fetriyuna@unpad.ac.id

Education

2016 - 2021	Ph.D. in Natural Sciences Institute of Nutritional Science Hohenheim University, Stuttgart Germany DAAD-IGSP (Indonesia Germany Scholarship Program)
2004 - 2007	M.Sc in Integrated Natural Resources Management Andalas University, Padang, Indonesia Ford Foundation Scholarship
2000 - 2004	BSc in Food Technology Andalas University, Padang, Indonesia

Working Experience

2016 - 2021	Doctoral Fellow at Institute Nutritional Science, University of Hohenheim, Stuttgart, Germany
2008 – now	Lecture and researcher in Department of Food Industrial Technology, Padjadjaran University, Jatinangor, Indonesia
2011 - 2016	Manager of Food Engineering Laboratory Department of Food Industrial Technology, Padjadjaran University. Jatinangor, Indonesia
2010 - 2011	Manager of Analisis Laboratory Department of Food Industrial Technology, Padjadjaran University. Jatinangor, Indonesia

List of relevant publications

F Fetriyuna, RC Purwestri, I Fahmi, HK Biesalski, Health And Nutritional Situation Of Rural Children Coming From Poor Household In Pandegelang District, Banten Province, Indonesia. Proceedings Of Asian Congress Of Nutrition 2019. Nutrition And Food Innovation For Sustained Well-Being. Annals Of Nutrition And Metabolism 75, 197-198. E-Isbn: 978-3-318-06599-2

F Fetriyuna, RC Purwestri, D Nohr, HK Biesalski. Talas Banten (Xanthosoma undipes K.Koch), its potentiality for Indonesia's food security and Food Industry. Seminar proceeding of 1st International Conference on Food Security Innovation with the ISBN 978-602-51078-0-1.

F Fetriyuna, RC Purwestri, D Nohr, HK Biesalski. Talas Banten (Xanthosoma undipes K.Koch), its potentiality for Indonesia's food security. Poster presentation on Hidden Hunger Congress, Stuttgart Germany, 20-22 March 2017

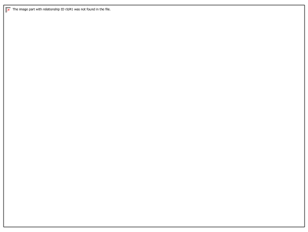
F Fetriyuna. Pengaruh Suhu Modifikasi Steam Preassure Treatment Terhadap Sifat Fungsional Dan Amilografi Pati Talas Banten (Xanthosoma Undipes K. Koch) . JP2| Jurnal Penelitian Pangan. No. 1 Volume 2 Tahun 2017

F Fetriyuna, M Marsetio, Rl Pratiwi. Pengaruh Lama Modifikasi Heat-Moisture Treatment (Hmt) Terhadap Sifat Fungsional Dan Sifat Amilografi Pati Talas Banten (Xanthosoma Undipes K. Koch). JP2| Jurnal Penelitian Pangan. No. 1 Volume 1 Tahun 2016

R Budiono, T Tarwinih, M Nurzaman, **F Fetriyuna**, Az Mutaqin. Uji Efektifitas Kombinasi Pupuk Organik Cair Dengan Npk Terhadap Pertumbuhan Padi (Oryza Sativa L.).Biotika Jurnal Ilmiah Biologi 14 (1), 72-80

F Fetriyuna. The Potential Of Darmo Black Soybean Varieties As An Alternative Of A Promising Food For Future. International Journal on Advanced Science Engineering Information Technology. Volume 5 (2015) No. 1. Halaman 44-46. No ISBN 2088-5334

E Mardawatia, Dw Wira, M Djali, **F Fetriyuna**, E Suryadi. Optimization And Kinetic Modelling Of The Enzymatic Hydrolysis Of Oil Palm Petioles. KNE Life Sciences, 439-447



Stuttgart, 15 April 2021

Place, Date

Signature

Affidavit

Annex 3 Declaration in lieu of an oath on independent work

according to Sec. 18(3) sentence 5 of the University of Hohenheim's Doctoral Regulations for the Faculties of Agricultural Sciences, Natural Sciences, and Business, Economics and Social Sciences

1. The dissertation submitted on the topic

Ready-to-Use Food (RUF) from Composite Flour of Local Commodities in Banten Province, Indonesia for Prevention and Rehabilitation of Malnutrition in Children Under Five

is work done independently by me.

2. I only used the sources and aids listed and did not make use of any impermissible assistance from third parties. In particular, I marked all content taken word-for-word or paraphrased from other works.

3. I did not use the assistance of a commercial doctoral placement or advising agency.

4. I am aware of the importance of the declaration in lieu of oath and the criminal consequences of false or incomplete declarations in lieu of oath.

I confirm that the declaration above is correct. I declare in lieu of oath that I have declared only the truth to the best of my knowledge and have not omitted anything.

Stuttgart, 15 April 2021

Place, Date

Signature

Appendix 1 Ready-to-Use Foods for the Treatment of Malnutrition

Table A. Summary of Evolvement of Ready-to-Use Foods for the Treatment of Acute Malnutrition (Purwestri, 2011) from 1997-2011

Year	Summary	References
1997	Introduction of new therapeutic food. The idea was to copy the nutritional content of the F100 diet by replacing part of milk powder with peanut paste.	Briend A. Treatment of Severe Malnutrition with a Therapeutic Spread. ENN Field Exchange, 1997; 3: 15.
1999	The first trial of RUTF that replaced the part of the milk in therapeutic milk F-100 with lactoserum and groundnut paste was given to 20 marasmus children	Briend A, Lacsala R, Prudhon C, Mounier B, Grellety Y, and Golden MHN. Ready-to-use therapeutic food for the treatment of marasmus. Lancet 1999; 353: 1767-8
2004	Home-based therapy for rehabilitation of SAM with energy-dense lipid-rich ready-to-use food after discharged from clinic-based treatment	Manary MJ, Ndekha MJ, Ashorn P, Maleta K, and Briend A. Home-based therapy for severe malnutrition with a ready-to-use food. Arch Dis Child 2004;89:557-61
2004	Home-based treatment of SAM and MAM with locally produced RUF resulted in similar program outcomes and lower cost as compared to imported fortified peanut butter RUF after a brief hospitalization and return of appetite	Sandige H, Ndekha MJ, Briend A, Ashorn P, and Manary MJ. Home-Based Treatment of Malnourished Malawian Children with Locally Produced or Imported Ready-to-Used Food. J Pediatr Gastroenterol Nutr 2004; 39: 141-6
2005	Comparison of standard therapy (hospital-based) vs. home-based therapy with RUTF resulted in superior results of home-based therapy in terms of recovery rate (78% vs. 46%), weight gain (3.5 vs. 2.0 g/kg/day), and coverage/sample size (992 vs. 186 children).	Ciliberto MA, Sandige H, Ndekha MJ, Ashorn P, Briend A, Ciliberto HM, and Manary MJ. Comparison of home-based therapy with ready-to-use therapeutic food with standard therapy in the treatment of malnourished Malawian children: a controlled, clinical effectiveness trial. Am J Clin Nutr 2005;81:864-70
2006	Local production and provision of RUTF spread for treatment of SAM.	Manary M. Local production and provision of ready−to−use therapeutic food (RUTF) spread for the treatment of severe childhood malnutrition. Food Nutr Bull 2006;27(suppl): S83−89

2006	Technical Background Paper for the meeting that was organized by the WHO, UNICEF, and the UN-SCN for discussion on key issues in the success of community-based management of severe malnutrition. The utilization of fortified milk/peanut spread RUTF was discussed.	Collins S, Sadler K, Dent N, Khara T, Guerrero S, Myatt M, Saboya M, Walsh A. Key issues in the success of community-based management of severe malnutrition. Food Nutr Bull 2006; 27(3 Suppl): S49-82
2009	A joint statement of WHO, WFP, UN-SCN, and UNICEF on Community-Based Management of Severe Acute Malnutrition. A fortified peanut/milk spread (Plumpy' nut) was formalized to be used as the RUTF reference.	WHO, WFP, UN-SCN, and UNICEF. Community-Based Management of Severe Acute Malnutrition. A Joint Statement by the World Health Organization, the World Food Programme, the United Nations System Standing Committee on Nutrition, and the United Nations Children's Fund. Geneva: WHO/WFP/UN-SCN/UNICEF, 2007
2009	Locally produced RUF in the form of cereal/legume-based biscuits (RUF-Nias biscuit) was piloted in mild and moderately wasted children in Nias Island, Indonesia, and was compared to locally produced peanut/milk paste RUTF. RUF-Nias biscuits were more acceptable, and the children who consumed them demonstrated comparable results of weight gain than PMP-Nias.	Scherbaum V, Shapiro O, Purwestri RC, Inayati DA, Novianty D, Stuetz W, et al. Locally produced Ready-to-Use Food (RUF). Piloting in mild and moderately wasted children in Nias Island, Indonesia. Sight and Life Magazine 2009;1:29-37

Table B. Summary of Evolvement of ready-to-use foods for the treatment of acute malnutrition from 2012-2020

Year	Summary	References
2012	Develop a method for determining the acceptability and safety of ready-to-use therapeutic foods (RUTF) before clinical trialing	Dibari, F., Bahwere, P., Huerga, H., Irena, A. H., Owino, V., Collins, S., & Seal, A. (2013). Development of a cross-over randomized trial method to determine the acceptability and safety of novel ready-to-use therapeutic foods. *Nutrition*, *29*(1), 107–112.

2012	RUTF is a more appropriate technology than formerly prevalent powdered milk solutions because it enables outpatient care, simpler treatment protocols, and production in the field.	Guimón, J., & Guimón, P. (2012). How ready-to-use therapeutic food shapes a new technological regime to treat child malnutrition. *Technological Forecasting and Social Change*, *79*(7), 1319–1327.
2013	Properly used, RUTF is safe, cost-effective, and has saved hundreds of thousands of children's lives in recent years.	Unicef. (2013). Position Paper Ready-To-Use Therapeutic Food. *Unicef Position Paper*, (1), 1–4.
2013	Ready-to-Use Therapeutic Food (RUTF) is a mixture of nutrients designed and primarily addressed to the therapy of severe acute malnutrition. The potential of this food is the low percentage of free water and high energy and nutritional density. Some possible new formulations as an alternative to novel recipes for this promising food.	Santini, A., Novellino, E., Armini, V., & Ritieni, A. (2013). State of the art of ready-to-use therapeutic food: A tool for nutraceuticals addition to foodstuff. *Food Chemistry*, *140*(4), 843–849.
2014	Technical brief of Community-based Management of Acute Malnutrition (CMAM) in 2014 consists of three sections. Section 1 seeks to provide an overview of the steps involved in the production of RUF and the quality requirements of the product for treating or preventing malnutrition. Section 2 discusses the identified constraints influencing the quality and price, and sustainability of local RUF production. The third section explains case studies of common challenges experienced by local producers.	Duclercq, M. (2014). Production of Ready-to-Use Food (RUF): An overview of the steps and challenges involved in the "local" production of RUF - CMAM Forum Technical Brief. *Technical Brief of Community-Based Management of Acute Malnutrition (CMAM)*
2015	The effectiveness of ready-to-use therapeutic food within the person's own home for the treatment of severe acute malnutrition in children under five years of age is not different than standard care. This formulation is a need for	Wagh, V. D., & Deore, B. R. (2018). Ready to Use Therapeutic Food [RUTF] formulation and packaging for malnutrition: an Overview. *Advances in Colloid and*

	low-income countries and developing countries to combat the malnutrition of children.	*Interface Science*, *2*(1), 1–15.
2017	Therapeutic foods (RUTF) are used to treat severe acute malnutrition in children 5 years and under in low and middle-income countries (LMI), while liquid nutritional supplements (ONS) are used in affluent societies. RUTF and ONS are equivalently effective in improving nutritional outcomes in children 5 to 10 y at risk of malnutrition	Fatima, S., Malkova, D., Wright, C., & Gerasimidis, K. (2016). Impact of therapeutic food compared to oral nutritional supplements on nutritional outcomes in mildly underweight healthy children in a low-medium income society. *Clinical Nutrition*, 1–6.
2019	Compared to alternative dietary approaches, standard RUTF probably improves recovery and may increase the rate of weight gain slightly, but the effects on relapse and mortality are unknown. Standard RUTF meeting total daily nutritional requirements may improve recovery and relapse compared to a similar RUTF given as a supplement to the usual diet, but the effects on mortality and rate of weight gain are not clear.	Schoonees_A, Lombard_MJ, Musekiwa_A, Nel_E, Volmink_J. Ready-to-use therapeutic food (RUTF) for home-based nutritional rehabilitation of severe acute malnutrition in children from six months to five years of age. *Cochrane Database of Systematic Reviews* 2019, Issue 5. Art. No.: CD009000.
2020	Ready-to-use therapeutic food (RUTF) is recommended by the World Health Organization for community-based management of uncomplicated forms of severe acute malnutrition. Studies have found similar results with supplemental food aid and controversy over the role of RUTF in prevention efforts continues.	Hendricks, K. M. (2010). Ready-to-use therapeutic food for prevention of childhood undernutrition. Nutrition Reviews, 68(7), 429–435. https://doi.org/10.1111/j.1753-4887.2010.00302.x

Table C. Development of Locally Produce Ready-to-use Food (RUF)

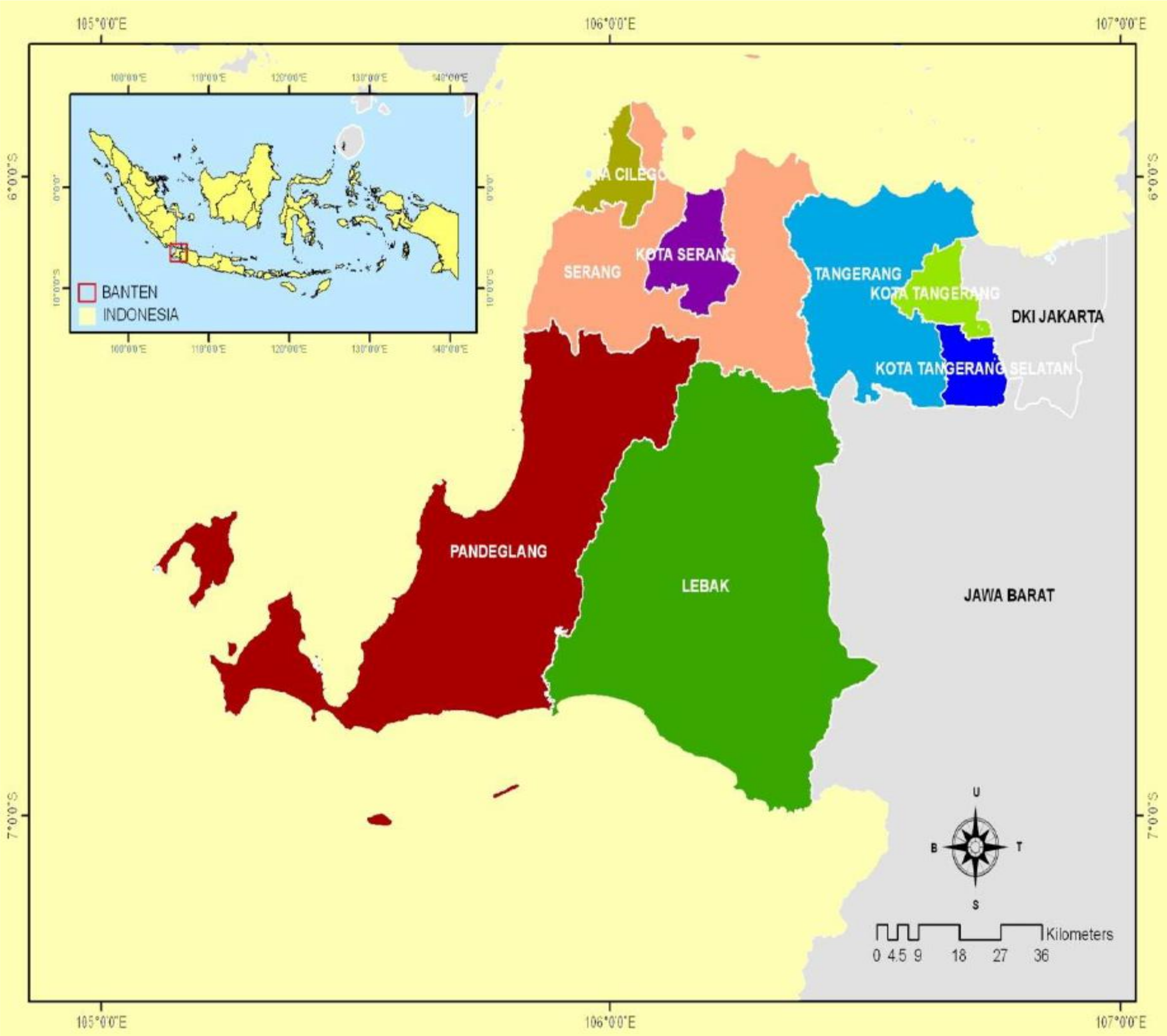
Year	Summary	Target Group	References
2004	Home-based treatment of SAM and MAM with locally produced RUF resulted in similar program outcomes and lower cost as compared to imported fortified peanut butter RUF after a brief hospitalization and return of appetite	Severe and Moderately Acute malnourished children under five	Sandige H, Ndekha MJ, Briend A, Ashorn P, and Manary MJ. Home-Based Treatment of Malnourished Malawian Children with Locally Produced or Imported Ready-to-Used Food. J Pediatr Gastroenterol Nutr 2004; 39: 141-6
2004	Home-based therapy of malnutrition with RTUF, RTUF supplement, or blended maize/soy flour. Compare to other treatments, therapy with RUTF has shown a higher impact to overcome malnutrition	Severe malnourished children under five	Manary, M. J., Ndekha, M. J., Ashorn, P., Maleta, K., & Briend, A. (2004). Home-based therapy for severe malnutrition with ready-to-use food. *Archives of Disease in Childhood*, *89*(6), 557–561. https://doi.org/10.1136/adc.2003.034306
2006	Local production and provision of RUTF spread for treatment of SAM.	Severe malnourished children under five	Manary M. Local production and provision of ready−to−use therapeutic food (RUTF) spread for the treatment of severe childhood malnutrition. Food Nutr Bull 2006;27(suppl): S83−89
2009	Locally produced RUF in the form of cereal/legume-based biscuits (RUF-Nias biscuit) was piloted in mild and moderately wasted children in Nias Island, Indonesia, and was compared to locally produced peanut/milk paste RUTF. RUF-Nias biscuits were more acceptable, and the children who consumed	Moderately to mildly wasted children under five	Scherbaum V, Shapiro O, Purwestri RC, Inayati DA, Novianty D, Stuetz W, et al. Locally produced Ready-to-Use Food (RUF). Piloting in mild and moderately wasted children in Nias Island, Indonesia. Sight and Life Magazine 2009;1:29-37

	them demonstrated comparable results of weight gain than PMP-Nias.		
2012	Ready-to-Use Therapeutic Food (RUTF), composed of highly digestible components such as milk, vegetable oil, sugar, vitamins, minerals, and indigenous food such as peanut, mungbean, and tempeh (fermented soy) powder. The local RUTF was examined for nutrient content and sensory acceptability. The RUTF was acceptable to malnourished children under five years old.	Severe malnourished children under five	Komari, . Lamid.A. (2012). Komposisi Gizi Dan Daya Terima Makanan Terapi: Ready To Use Therapeutic Food Untuk Balita Gizi Buruk (Nutrition Composition And Acceptance Test Of Ready To Use Therapeutic Food For Severe Malnourished Children). Panel Gizi Makan 2012, 35(2): 159-167, 13(1), 50–56.
2012	The study was compared the Peanut milk-based ready-to-use therapeutic food (P-RUTF) and the alternative milk-free soybean–maize–sorghum-based RUTF (SMS-RUTF) using locally grown ingredients that have the potential to support the local economy and reduce the cost of RUTF. The result has shown that the SMS-RUTF meets expected standards and is acceptable to children	Severe acute malnutrition (SAM)children under five	Owino, V. O., Irena, A. H., Dibari, F., & Collins, S. (2014). Development and acceptability of a novel milk-free soybean-maize-sorghum ready-to-use therapeutic food (SMS-RUTF) based on industrial extrusion cooking process. *Maternal and Child Nutrition*, *10*(1), 126–134. https://doi.org/10.1111/j.1740-8709.2012.00400.x
2014	Integrated Management of Acute Malnutrition (IMAM) in Vietnam, developed ready-to-use-therapeutic foods (RUTFs) using locally available food resources for treating children with SAM. This program was highly successful	Severe acute malnutrition (SAM)children	Phuong, H., Nga, T. T., Mathisen, R., Nguyen, M., Hop, L. T., Hoa, D. T. B., Wieringa, F. T. (2014). Development and implementation of a locally produced ready-to-use therapeutic food (RUTF) in

	with more than 90% of the children recovering.	under five	Vietnam. Food and Nutrition Bulletin, 35(2), S52–S56.
2016	Pooled analysis of three quasi-randomized controlled trials in Malawi, which evaluated ready-to-use therapeutic food (RUTF) in the home management of children with uncomplicated severe acute malnutrition (SAM) compared with standard diets, revealed that RUTF was associated with higher recovery rates (risk ratio 1.32, 95% CI 1.16 to 1.50).	Severe acute malnutrition (SAM)children under five	Bhandari, N., Mohan, S. B., Bose, A., Iyengar, S. D., Taneja, S., Mazumder, S, Group, S. (2016). Efficacy of three feeding regimens for home-based management of children with uncomplicated severe acute malnutrition : a randomized trial in India, 1–12. https://doi.org/10.1136/bmjgh-2016-000144
2017	The study was determined whether the new formulation of RUTF produced using locally available ingredients was acceptable to young children in Ethiopia, Ghana, Pakistan, and India. The local RUTFs were formulated using a linear programming tool that allows for the inclusion of only local ingredients and minimizes cost. The alternative RUTF formula compared with the standard peanut-basedRUTF containing powdered milk.	Moderate wasting children under five	Weber, J. M., Ryan, K. N., Tandon, R., Mathur, M., Girma, T., Steiner-Asiedu, M., … Manary, M. J. (2017). Acceptability of locally produced ready-to-use therapeutic foods in Ethiopia, Ghana, Pakistan, and India. *Maternal and Child Nutrition*, *13*(2), 1–9. https://doi.org/10.1111/mcn.12250
2017	*NGO Hamara Prayatan* (Child community in India) developed and produced freshly made RUTF at the community level using the locally available food ingredients thereby making the food more palatable, easy to administer	Severe acute malnutrition (SAM)children under five	Shintre, K. (2017). Ready to Use Therapeutic Food from Locally Available Food Ingredients for Children with Severe Acute Malnutrition in India. http://www.peah.it/2017/10/ready-to-use-therapeutic-

	without changing the food habits of the children.		food-from-locally-available-food-ingredients-for-children-with-sam-in-india/
2018	Two RUTFs were developed, one based on chickpea and the other on rice–lentils. The total energy content of 100 g of chickpea and rice–lentil-based RUTF were 537.4 and 534.5 kcal, protein 12.9 and 13.5 g, and fat 31.8 and 31.1 g, respectively. Chickpea-based and rice–lentil-based RUTF was well accepted by children with SAM.	Severe acute malnutrition (SAM)children under five	Choudhury, N., Ahmed, T., Hossain, M. I., Islam, M. M., Sarker, S. A., Zeilani, M., & Clemens, J. D. (2018). Ready-to-Use Therapeutic Food Made From Locally Available Food Ingredients Is Well Accepted by Children Having Severe Acute Malnutrition in Bangladesh. *Food and Nutrition Bulletin*, *39*(1), 116–126.
2018	NumTrey, a locally-produced fish-based RUTF was developed and was compared to an imported milk-based RUTF for weight gain among children aged 6–59 months in the home-treatment for acute malnutrition. A locally produced RUTF is highly relevant to improving nutrition interventions in Cambodia. A locally produced fish-based RUTF is a relevant alternative to imported milk-based RUTF for the treatment of SAM in Cambodia.	Severe acute malnutrition (SAM)children under five	Sigh, S., Roos, N., Chamnan, C., Laillou, A., Prak, S., & Wieringa, F. T. (2018). Effectiveness of a locally produced, fish-based food product on weight gain among Cambodian children in the treatment of acute malnutrition: A randomized controlled trial. *Nutrients*, *10*(7), 1–17. https://doi.org/10.3390/nu10070909

Appendix 2. Map of Research Area, Banten Province Indonesia



Source: (Banten, 2018)

Appendix 3. Factors that influence undernutrition

Undernutrition was influenced by five direct factors (health status, dietary intake, childcare practices, number of children, and hygiene practices) and one indirect factor (socioeconomic aspect). Statistical analysis shows that only 13 out of 59 potential predictors were significantly correlated with the nutritional status of children under five.

Children's age was detected as one important factor influencing the state of stunting and wasting in the present research. Undernutrition implies long-lasting numerous physiological changes, contributing to lower linear growth as well as lower lean body mass, thereby enhancing the state of undernutrition itself. These alterations may explain the increased prevalence of undernutrition in the upper age groups as found in this study.

a. Health status

The health status aspect consists of six predictors of prevalence namely diarrhea, fever, cough, cold, upper respiratory infections, and tuberculosis. Childhood illness over the previous 14 days was diarrhea 21.9 percent (23), fever 54.3 percent (57), cough 47.6 percent (50), cold 74.3 percent (78), and upper respiratory infection 45.9 percent (48) and tuberculosis only 1 percent (1).

Merely diarrhea correlates with underweight (Pearson chi-square 3.8; sig. 0.05) whereas 36 percent of children with underweight had diarrhea. An upper respiratory infection correlates with wasting prevalence (Pearson chi-square 7.8; sig. 0.00) whereas 40 percent of wasting children had upper respiratory infections.

The study in Tanzania (Kejo *et al.*, 2018) for the children above 2 years of age found that being a male, morbidity, nonexclusive breastfeeding, maternal age above 35 years, and living at Oturumeti or Seliani were predictors of children being undernourished. Childhood illness over the previous 14 days was associated with being underweight and wasting (Basit *et al.*, 2012; Manyike *et al.*, 2014). Infections weaken the immune competence to fight against diseases. The illness causes failure to gain weight or loss of weight due to an increase in energy expenditure, demand for nutrients, and depressed appetite (Asfaw *et al.*, 2015). Diarrhea and multiple infections were more prevalent among children aged 6–23 months and seem to have a connection with the contamination in complementary food preparation.

b. **Dietary intake (Food consumption and dietary pattern)**

Based on dietary intake and nutrition fulfillment in Table 4.3, only half (55.2 percent) of the children have the fulfillment of the energy, iron (50.5%) zink (53.3%) while almost all of them (98.1%) have insufficient consumption of vitamin A.

Monotonous food consumption which is dominated by carbohydrate sources (rice, cassava, and bread) and a small portion of vegetables and animal food sources resulted in poor nutrition of consumption. Children require high value and diversity of food consumption for optimal growth and development. Poor diet always comes out with undernutrition as a result. The study

About the potential of food carrier for micronutrients in Indonesia also found that the low food diversity and less animal source, fruit and vegetables cause the undernutrition in some remote areas in Indonesia (Melse-Boonstra *et al.*, 2000) low divers diet of animal source foods (ASF)

(Muslimatun and Wiradnyani, 2016) and dietary diversity and household food security (Pipi, Nanseki, and Chomei, 2014) and (Meshram *et al.*, 2012).

Table D. Recommended Nutrient Intake (RNI) Children under five in Indonesia

(Ministry of Health RI, 2013)

The dietary intake aspect consists of ten predictors namely energy, protein, fat, carbohydrate, Fe, zinc, vitamin A, beta carotene, retinol 6, and 12.

Vitamin A has the correlation with HAZ (p=0.00, 95% CI), WAZ (p=0.02, 95% CI) and WHZ (p=0.00, 95% CI). Retinol 6 has correlation with underweight (p=0.04, 95% CI). Retinol 12 has a correlation with HAZ (p=0.01, 95% CI), WAZ (p=0.04, 95% CI), WHZ (p=0.00, 95% CI), MUAC (p=0.03, 95% CI) and underweight (p=0.05, 95% CI).

A similar result was found in (Appiah *et al.*, 2020) which found that the key predictors of child undernutrition were factors concerning mothers' infant and young child feeding practices. This study provides evidence on maternal care practices as key potential drivers of undernutrition in a low-resource setting known for the high prevalence of child undernutrition

c. Childcare practices

Childcare practice aspects consist of four predictors namely breastfeeding, colostrum intake, complementary and supplementary food. Children got breastfeeding for an average of 17 months. Only three children never got breastfeeding since they were born, one of them indicated severe stunting and underweight, one moderate stunting and underweight, and the other is well-nourished. Breastfeeding practice has a correlation with WHZ (p=0.01, 95% CI) and stunting whereas 26 percent of children with stunting still got breastfeeding and the rest has stopped breastfeeding.

Colostrum intake and supplementary food correlate with wasting. Four out of five children with wasting got colostrum in early life while eighty percent of children without supplementary food indicated wasting. Complimentary food correlates with being underweight. More than half (62 percent) of children got the introduction of complementary food before six months of age, eleven children (17 percent) of them were underweight.

Study Ethiopia (Asfaw *et al.*, 2015) found that providing Pre-lactation feeding associated with underweight, stunting, and wasting while having an extra meal during pregnancy or lactation only associated with stunting.

d. Number of children

The number of children aspects consists of two predictors of total children under five and gender.

Merely a total of children under five correlate with wasting.

The same condition found in the research in Ethiopia (Asfaw *et al.*, 2015), Ghana (Appiah *et al.*, 2020), India (Meshram *et al.*, 2012), and Maluku Indonesia (Ramli *et al.*, 2009) families with children more than 3 tend to have stunted, wasting and underweight children.

e. Hygiene practice

Hygiene practice aspects consist of eight predictors namely mother and child nail condition, washing hand habits, floor type, toilet type and status, water sources, and treatment. Mother nail condition has a correlation with HAZ (p=0.00, 95% CI), WAZ (p=0.03, 95% CI), MUAC (p=0.03, 95% CI) and stunting. Forty percent of stunting children, their mother had dirty nails. Children's nail condition correlates with HAZ (p=0.00, 95% CI) and stunting. More than half (62 percent) of stunting children with dirty nails.

Washing hand habits correlate with WAZ (p=0.04, 95% CI), MUAC (p=0.03, 95% CI), and underweight. More than half (60 percent) underweight children, their mother had no washing hand habits. Toilet status correlates with stunting and being underweight. Forty percent of stunting and underweight children have no private toilet and had to go for the toilet outside the house. A water source correlates with stunting and water treatment correlates with WHZ (p=0.04, 95% CI) and WAZ (p=0.02, 95% CI). In 42 stunting children, the majority of HH (85.7 percent) used groundwater for drinking sources, while others consumed processed water.

Similar findings that the hygiene practice has a contribution for children undernutrition as availability of latrine (Asfaw *et al.*, 2015), washing hand (Stiller *et al.*, 2020), and water treatment (Meshram *et al.*, 2012).

Determinants of Nutritional Status

Risk factors associated with the children's nutritional status as represented by predictors have a strong correlation, including the child's age, hygiene practices, and maternal education level. A strong or significant level of influence is indicated by the results of the binomial logit regression test and linear regression.

21.1.1 Stunting

Stunting prevalence is represented by HAZ calculation. Predictors that affected HAZ and Stunting that have a strong correlation include the child's age, mother nails, and underweight status (WAZ). The determinant model had a significant relationship (p = 0.00 95% CI) and was able to determinant the HAZ by 51.4%.

$$HAZ = -2.45 – 0.23\ Age^{*} + 0.64\ WAZ^{*} + 0.21\ MUAC + 0.04\ Fedu + 0.01\ Medu + 0.01\ VitA + 0.00\ Ret12 + 0.27\ Mnail^{*} + 0.01\ Cnail$$

* significant at 95% CI

HAZ

Parameters	**β**	**P-value**
Intercept	-2.448	.007
Child's Age	-.228	.013
WAZ	.639	.000
MUAC	.208	.237
Father's year of schooling	.042	.279
Mother's year of schooling	.013	.753
Mother's nails condition	.266	.034
Child's nail condition	.010	.934
Vitamin A	.002	.179
Retinol 12	.000	.821

R^2 = 0.556 (Adjusted R Square 0.514). Predictive significance of the model = 0.000

The stunting model also showed a significant relationship (sig. 0.62 95% CI) and was able to determinants the stunting by 50.7%.

$$Stunting = -1.35 + 0.45^{Age*} + 2.98^{Underweight*} + 0.03^{ASI} + 0.12^{Fedu} – 0.26^{Medu} + 0.65^{Toiletstatus_1} + 0.04^{Toiletstatus_2} + 0.41^{Watersource} + 0.92^{Mnail1} + 0.07^{Mnail2} - 0.03^{Mnail3} - 0.61^{Cnail1} – 1.40^{Cnail2}$$

* significant at 95% CI

Stunting

Parameters	β	P-value
Intercept	.070	.580
Age	.454	.055
Underweight	2.976	.000
Father's year of schooling	.120	.344
Mother year of schooling	-.256	.048
Mother's Nail dirty long		.652
Mother's Nail dirty short	.923	.583
Mother's Nail clean long	.070	.966
Mother's Nail clean short	-.033	.984
Child's Nail dirty long		.400
Child's Nail dirty short	-.614	.727
Child's Nail clean short	.454	.435
Toilet inside	2.976	.836
Sharing toilet	.120	.552
Toilet outside	-.256	.960
Drink water source		.579
ASI	.923	.218

Nagelkerke R Square 0.507. Hosmer and Lemeshow test = 0.620

The increasing age of the child was significantly associated with stunting (OR= 1.57, 95%CI). The existence of WAZ and underweight increase the odds of stunting (OR 19.6 95%CI). The predictor of hygiene, mother nail status, showed increasing stunting if the nails were dirty (OR 2.52) and decreasing the stunting when the nails were clean (OR 0.97)

21.1.2 **Wasting**

Wasting has a strong correlation with the age of the child, and the status of Underweight (WAZ). The WHZ determinant model had a significant relationship (p = 0.0095% CI) and was able to determinant by 59.1%.

$$WHZ = 0.69 + 0.26\ Age^{*} + 0.86\ WAZ^{*} - 0.15\ MUAC - 0.01\ VitA + 0.00\ Ret12 + 0.01\ ASI + 0.05\ Houseown - 0.23\ Watproc$$

* significant at 95% CI

WHZ

Parameters	**β**	**P-value**
Intercept	.685	.249
Child's Age	.258	.000
WAZ	.860	.000
MUAC	-.152	.294
Vitamin A	-.001	.198
Retinol 12	.000	.879
Drink Water treatment	-.226	.277
ASI	.010	.269
House ownership	.052	.755

R^2 = 0.622 (Adjusted R Square 0.591). Predictive significance of the model = 0.000

The wasting model also shows a significant relationship (sig. 0.99 95% CI) and can predict the stunting by 78.9%.

$$Log\ Wasting = -73.95 + 34.80^{Houseown} - 0.13^{Underweight} + 20.17^{ISPA} + 50.53^{Kolostrum} - 16.87^{supplemenfood1} + 3.87^{supplemenfood2} + 2.22^{TotalChild}$$

Wasting

Parameters	**β**	**P-value**
Intercept	-73.952	.994
Underweight	3.313	.946
House ownership	4.832	.995
Upper respiration infection	.538	.996
No Colostrum is given	1.593	1.000
Colostrum given	-.003	.996
No Supplementary food	.946	.997
Supplementary food	-.442	1.000
Number of Child	.751	.074

Nagelkerke R Square 0.789. Hosmer and Lemeshow test = 0.996

Increasing the child's age will increase the wasting, while the increasing of the prevalence of WAZ and underweight will decrease the odds of wasting (OR 0.88).

21.1.3 **Underweight**

Underweight is represented by WAZ. Predictors of WAZ and underweight that have a strong correlation include HAZ and WHZ. The determinant model of WAZ had a significant relationship (p = 0.0095% CI) and was able to predict by 99.2%.

$$WAZ = -0.07 + 0.58\ HAZ^{*} + 0.70\ WHZ^{*} + 0.01\ MUAC + 0.00\ Medu + 0.00\ VitA + 0.00\ Ret12 + 0.02\ Mnail - 0.04\ Watertreat + 0.02\ Focc + 0.04\ Washhand$$

* significant at 95% CI

WAZ

Parameters	**β**	**P-value**
Intercept	-.071	.481
HAZ	.582	.000
WHZ	.698	.000
MUAC	.009	.661
Mother's year of schooling	.000	.922
Mother's nail condition	.021	.121
Father Occupation	.018	.232
Vitamin A	.000	.141
Retinol 12	9.456E-5	.312
Drink Water treatment	-.040	.175
Wash hand habit	.035	.143

R^2 = 0.992 (Adjusted R Square 0.992). Predictive significance of the model = 0.000

The determinant model of underweight shows a significant relationship (sig. 0.84 95% CI) and could predict by 63.3%.

$$\text{Log Underweight} = -6.71 + 4.83^{\text{wasting}\,*} + 3.31^{\text{stunting}\,*} + 1.92^{\text{washhand}\,*} + 1.59^{\text{Diare}} + 0.75^{\text{Complemfood}} - 0.44^{\text{Toiletstat}} + 0.54^{\text{Famsize}\,*} - 0.00^{\text{Ret6}} + 0.00^{\text{Ret12}}$$

* significant at 95% CI

Underweight

Parameters	β	P-value
Intercept	-6.709	.000
Stunting	3.313	.000
Wasting	4.832	.004
Family size	.538	.030
Diarrhea	1.593	.069
Retinol 6	-.003	.654
Retinol 12	.000	.988
Toilet inside		.538
Sharing toilet	.946	.366
Toilet outside	-.442	.638
Complementary food	.751	.297
Wash hand before meal	1.920	.019

Nagelkerke R Square 0.633. Hosmer and Lemeshow test = 0.843

Increasing wasting has significantly increased the odds of being underweight (OR 124.5) while increasing stunting correlated with increasing underweight (OR 27.5). The increasing family size (>5) was significantly associated with being underweight (OR 1.71).

21.1.4 **MUAC**

Increasing father education was significantly associated with the reduction of the odds of MUAC below 12.5 cm (p=0.00 95% CI) and the prediction model could assess the correlation for 15.2%.

Predictor MUAC yang memiliki tingkat korelasi kuat yaitu Father occupation. Predictors pada model penentu MUAC memiliki hubungan yang signifikan (p=0.00 95% CI) dan mampu menjelaskan penentu MUAC tersebut sebesar 15.2%.

$$MUAC = 2.92 - 0.01\,HAZ + 0.27\,WAZ - 0.08WHZ + 0.16\,Focc^{a} - 0.13\,Washhand_7 + 0.00\,Ret12 - 0.02\,Mnail - 0.67\,Wash_3 + 0.05\,Wash_4 + 0.01\,ISPA$$

[a] significant at 95% CI

MUAC

Parameters	**β**	**P-value**
Intercept	2.918	.000
HAZ	-.012	.968
WHZ	-.080	.823
WAZ	.269	.600
Father Occupation	.164	.032
Wash hand before caring	-.668	.083
Wash hand before breastfeeding	.054	.842
Wash hand habit	-.127	.301
Mother's nail condition	-.022	.745
Retinol 12	.000	.603
Upper Respiration infection	.005	.980

R^2 = 0.233 (Adjusted R Square 0.152). Predictive significance of the model = 0.004

Appendix 4. Nutritional Composition of Twelve Recipes RUF Biscuit

Table E. Macronutrient Composition of RUF Biscuit

Ready to Use Food	Water	Ash	Protein	Fat	Carbohydrate	Energy
	%	%	%	%	%	kcal
Biscuit1	1.2±0.1^{bc}	3.0±0.2^{bc}	15.8±0.20^{cd}	29.4±0.0^{e}	50.7±0.3^{bc}	530.6±0.4^{f}
Biscuit2	1.1±0.1^{a}	3.1±0.2^{c}	16.0±0.20^{e}	28.3±0.1^{b}	51.6±0.5^{d}	524.9±0.1^{b}
Biscuit3	1.2±0.0^{c}	3.1±0.1b^{c}	16.0±0.05d^{e}	29.6±0.1^{f}	50.2±0.2^{a}	531.0±0.3^{fg}
Biscuit4	1.2±0.1b^{c}	3.0±0.1b^{c}	14.4±0.00^{a}	28.9±0.1^{d}	52.6±0.1^{e}	528.1±0.5^{d}
Biscuit5	1.2±0.0^{c}	3.0±0.1b^{c}	15.1±0.05^{b}	29.0±0.1^{d}	51.8±0.0^{d}	528.4±0.7^{de}
Biscuit6	1.2±0.1^{c}	2.8±0.0^{a}	15.2±0.05^{b}	29.0±0.0^{d}	51.9±0.1^{d}	529.0±0.4^{e}
Biscuit7	1.2±0.1^{bc}	2.9±0.0^{ab}	15.2±0.10^{b}	29.8±0.1^{g}	51.0±0.2^{c}	532.6±0.0^{h}
Biscuit8	1.2±0.1^{bc}	3.1±0.1^{bc}	15.7±0.10^{c}	29.7±0.1^{fg}	50.5±0.3^{ab}	531.5±0.2^{g}
Biscuit9	1.2±0.0^{c}	3.0±0.0^{bc}	14.5±0.10^{a}	27.5±0.1^{a}	53.8±0.0^{g}	520.7±0.5^{a}
Biscuit10	1.1±0.0^{ab}	3.0±0.0^{bc}	14.4±0.05^{a}	28.5±0.1^{c}	53.1±0.1^{f}	526.1±0.5^{c}
Biscuit11	1.2±0.0^{c}	3.0±0.0^{bc}	14.5±0.10^{a}	27.5±0.1^{a}	53.8±0.0^{g}	520.7±0.5^{a}
Biscuit12	1.2±0.1^{bc}	3.1±0.1^{bc}	15.7±0.10^{c}	29.7±0.1^{fg}	50.5±0.3^{ab}	531.5±0.2^{g}
Max	1.3	3.3	16.2	29.8	53.8	532.6
p-value	0.009	0.009	0	0	0	0

Values are in the mean ± standard deviation of triplicate determination from each RUF biscuit sample.
Data were analyzed using the Anova test continued with the posthoc Duncan test to determine the statistical significant different ($p<0.05$)
[2]Values of macronutrients are on a dry basis, kcal = kilocalorie. kcal = kilocalorie. Values with the same superscript in the same column are not significantly different ($p≥0.05$).

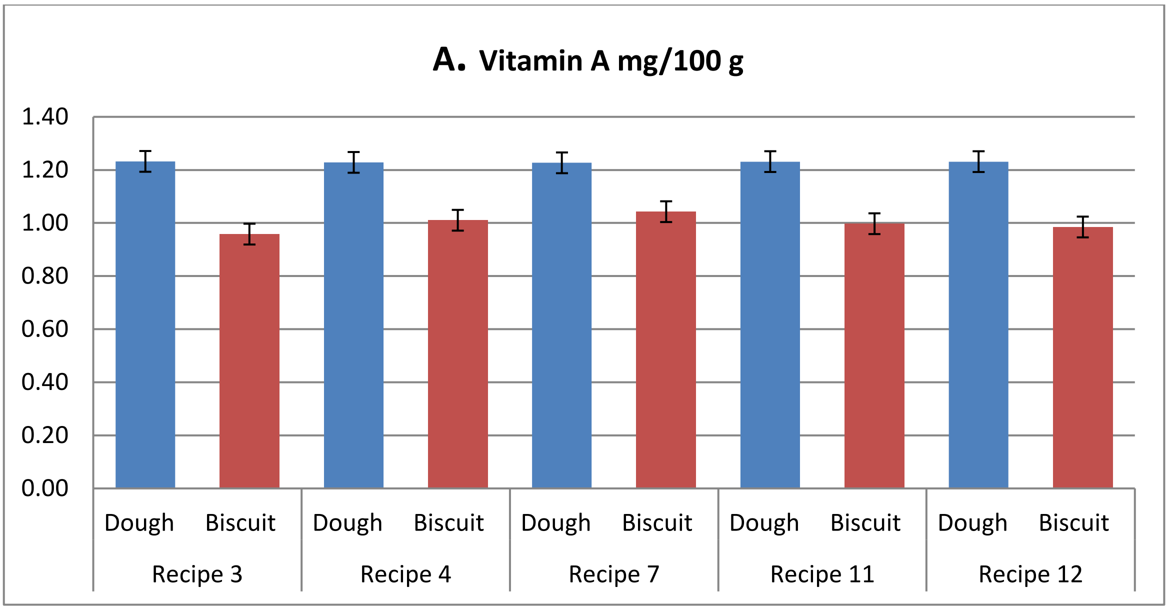
Table F. Minerals Composition of RUF Biscuits

Ready to Use Food	P	Ca	Mg	K	Na	Fe	Zn	Cu	Se	Iodine
	mg	*mg*	*mg*	*mg*	*mg*	*mg*	*mg*	*mg*	*µg*	*µg*
Biscuit1	367.4 ± 0.5^{i}	186.0 ± 0.2^{e}	85.6 ± 0.2^{g}	585.2 ± 0.7^{i}	520.5 ± 0.7^{g}	4.5 ± 0.2^{ef}	2.6 ± 0.3^{c}	0.5 ± 0.2^{b}	0.2 ± 0.2^{b}	67.6 ± 0.5^{c}
Biscuit2	375.1 ± 1.2^{j}	186.4 ± 0.7^{e}	83.9 ± 0.8^{f}	594.5 ± 0.2^{j}	533.1 ± 0.2^{h}	3.7 ± 0.3^{ab}	2.5 ± 0.2^{bc}	0.4 ± 0.1^{ab}	0.1 ± 0.0^{a}	73.4 ± 0.2^{e}
Biscuit3	363.8 ± 0.3^{g}	188.5 ± 0.2^{g}	81.6 ± 0.1^{e}	554.8 ± 0.4^{g}	502.7 ± 0.5^{c}	4.5 ± 0.2^{f}	2.5 ± 0.1^{abc}	0.5 ± 0.2^{ab}	0.0 ± 0.0^{a}	66.4 ± 0.5^{b}
Biscuit4	354.7 ± 0.3^{d}	187.3 ± 0.9^{f}	69.8 ± 0.5^{a}	488.8 ± 0.3^{d}	557.9 ± 0.0^{i}	3.6 ± 0.2^{a}	2.4 ± 0.2^{abc}	0.4 ± 0.2^{ab}	0.1 ± 0.1^{a}	68.3 ± 0.2^{d}
Biscuit5	351.9 ± 0.5^{c}	166.0 ± 0.6^{b}	76.5 ± 0.2^{c}	484.4 ± 0.3^{c}	513.2 ± 0.4^{f}	3.9 ± 0.1^{bc}	2.3±0.2abc	0.5 ± 0.3^{b}	0.1 ± 0.1^{a}	66.1 ± 0.5^{b}
Biscuit6	365.7 ± 0.9^{h}	174.8 ± 0.3^{c}	77.2 ± 0.7^{d}	521.5 ± 0.0^{f}	477.4 ± 1.0^{a}	4.6 ± 0.1^{f}	2.4 ± 0.0^{abc}	0.3 ± 0.0^{ab}	0.1 ± 0.0^{a}	50.6 ± 0.1^{a}
Biscuit7	350.7 ± 0.0^{b}	165.3 ± 0.1^{a}	73.1 ± 0.1^{b}	456.9 ± 0.2^{a}	504.4 ± 0.5^{d}	3.8 ± 0.1^{ab}	2.4 ± 0.1^{abc}	0.3 ± 0.0^{a}	0.0 ± 0.0^{a}	50.6 ± 0.0^{a}
Biscuit8	356.6 ± 0.5^{e}	178.4 ± 0.0^{d}	81.3 ± 0.1^{e}	557.9 ± 0.5^{h}	487.4 ± 0.4^{b}	3.6 ± 0.1^{a}	2.2 ± 0.1^{a}	0.2 ± 0.1^{a}	0.0 ± 0.0^{a}	80.4 ± 0.1^{f}
Biscuit9	357.6 ± 0.1^{f}	186.0 ± 0.1^{e}	69.8 ± 0.2^{a}	466.8 ± 0.3^{b}	509.5 ± 0.2^{e}	4.1 ± 0.0^{cd}	2.3 ± 0.1^{ab}	0.3 ± 0.1^{a}	0.1 ± 0.0^{a}	80.7 ± 0.1^{f}
Biscuit10	339.3 ± 0.2^{a}	165.2 ± 0.2^{a}	76.3 ± 0.1^{c}	500.8 ± 0.1^{e}	520.2 ± 0.3^{g}	4.3 ± 0.2^{de}	2.3 ± 0.1^{abc}	0.4 ± 0.1^{ab}	0.1 ± 0.1^{ab}	67.3 ± 0.1^{c}
Biscuit11	357.6 ± 0.1^{f}	186.0 ± 0.1^{e}	69.8 ± 0.2^{a}	466.8 ± 0.3^{b}	509.5 ± 0.2^{e}	4.1 ± 0.0^{cd}	2.3 ± 0.1^{ab}	0.3 ± 0.1^{a}	0.1 ± 0.0^{a}	80.7 ± 0.1^{f}
Biscuit12	356.6 ± 0.5^{e}	178.4 ± 0.0^{d}	81.3 ± 0.1^{e}	557.9 ± 0.5^{h}	487.4 ± 0.4^{b}	3.6 ± 0.1^{a}	2.2 ± 0.1^{a}	0.2 ± 0.1^{a}	0.0 ± 0.0^{a}	80.4 ± 0.1^{f}
Max	376.3	188.7	85.8	594.7	557.9	4.7	2.9	0.8	0.4	80.7
Sig.	0	0	0	0	0	0	0.088	0.057	0.169	0

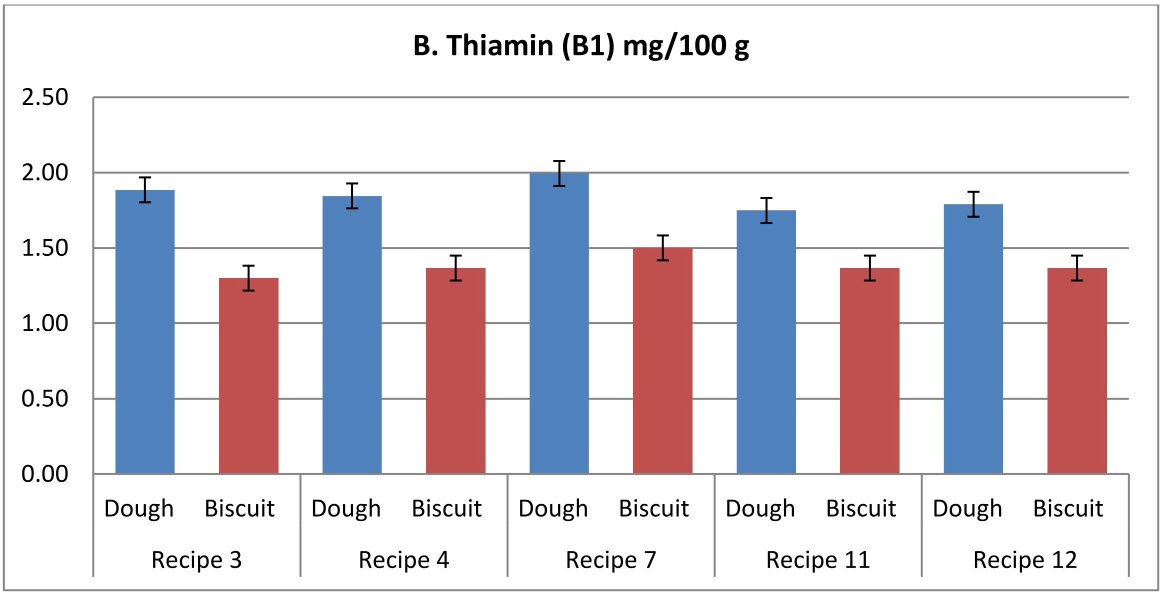
Values are in the mean ± standard deviation of triplicate determination from each RUF biscuit sample.
Data were analyzed using the Anova test continued with the posthoc Duncan test to determine the statistical significant different ($p<0.05$)
[2]Values of macronutrients are on a dry basis, kcal = kilocalorie. mg=milligram, *µg= microgram*. Values with the same superscript in the same column are not significantly different ($p\geq0.05$).

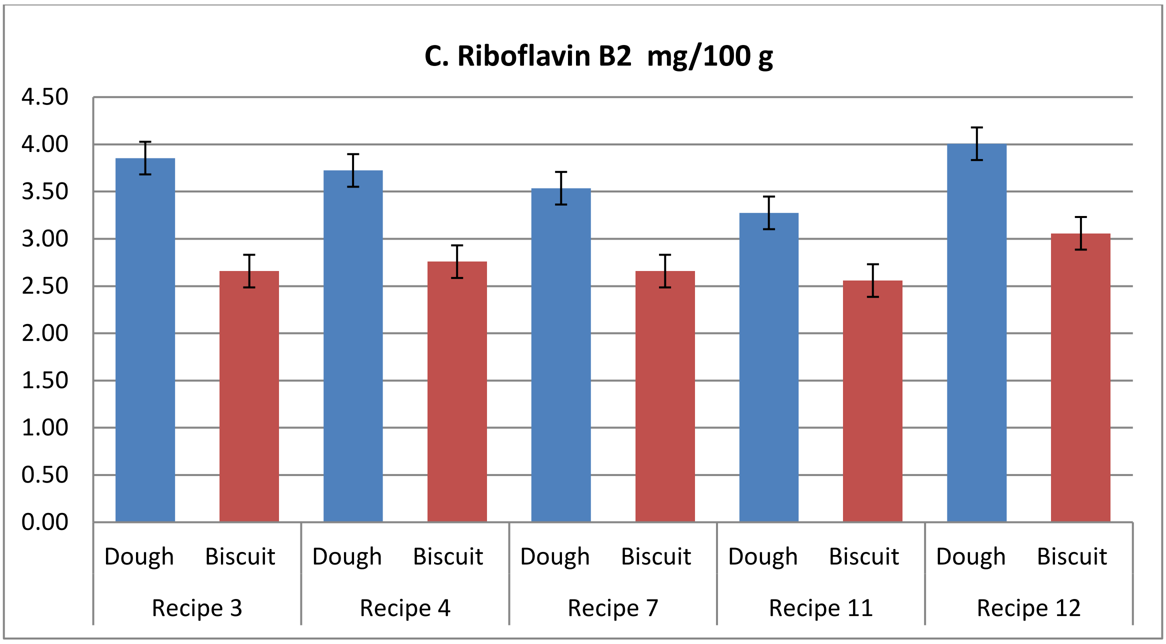
Appendix 5. Stability test of micronutrient in RUF Biscuit

Vitamin A, B1, B1, and E concentration in RUF biscuits, before (dough) and after baking (biscuit)

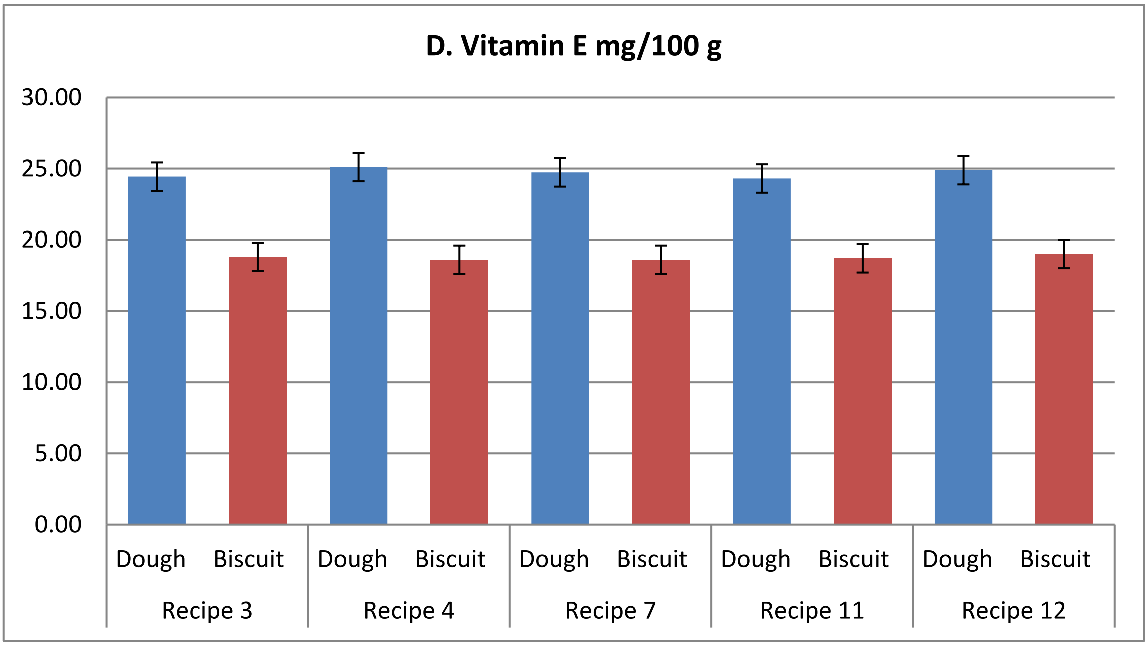


The loss of Vitamin A varies between 15-22%





The loss of Vitamin B (Thiamin and riboflavin) varies between 23-28%



The loss of vitamin E varies between 23-26%

Table G. Minerals Stability test of RUF fortified Micronutrient premix before (dough) and after baking (biscuit)

Micronutrient	Unit	Standard*		Dough (With Premix)					RUF Biscuit (With Premix)				
		Min	Max	3	4	7	11	12	3	4	7	11	12
Minerals													
Calcium	*mg*	300	600	474.0	472.1	460.1	451.5	464.1	471.0	457.9	458.9	484.2	470.4
Iron	*mg*	10	14	15.1	14.5	15.2	14.4	14.2	13.7	12.7	13.7	13.4	14.3
Iodine	*µg*	70	140	166.0	167.2	149.9	149.9	179.3	152.7	150.4	137.9	137.9	164.9
Zink	*mg*	11	14	15.6	15.5	15.7	15.5	15.5	12.1	11.4	11.8	11.8	11.8
Sodium	*mg*	-	290	257.7	264.0	248.6	275.6	253.3	257.7	264.0	248.6	275.6	253.3
Pottasium	*mg*	1110	1400	1162.9	1085.5	1108.4	1130.4	1114.1	1151.3	1074.6	1097.3	1107.8	1103.0
Magnesium	*mg*	80	140	103.1	91.1	99.5	94.8	102.9	102.1	90.2	98.5	93.8	101.8
Phosphorus	*mg*	300	600	503.8	494.8	504.8	491.5	497.5	498.8	489.8	499.8	486.6	492.6
Copper	*mg*	1.4	1.8	2.1	2.0	2.1	2.1	2.1	1.9	1.8	1.9	1.9	1.9
Selenium	*µg*	20	40	30.6	30.6	30.6	30.6	30.6	28.2	27.6	28.2	28.2	28.2