RESOLVING NUTRIENT DEFICIENCIES AMONG CHILDREN AND ADOLESCENTS OF THE B40 COMMUNITY IN SELECTED SCHOOLS AROUND GOMBAK, MALAYSIA

BY

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ABSTRACT

Malaysia's rapid urbanization has led to a significant increase in urban poverty, particularly affecting the B40 community, with approximately 56% residing in urban areas. Children and adolescents from low-income households within the B40 community are especially vulnerable to the detrimental effects of undernutrition and illness. Despite their vulnerability, this demographic has been relatively understudied in terms of cognitive performance and health status, as they are often perceived as less susceptible to malnutrition or poor health. Consequently, this study aims to address this gap by conducting primary data collection and implementing a pilot food intervention program targeting children and adolescents from the B40 community in selected schools across Selangor, Malaysia. The primary objective is to examine the relationship between nutrition intake and the health and cognitive performance of children and adolescents within the B40 community through comprehensive data cataloguing. Additionally, the study evaluates the efficacy of a health bar intervention in improving both health and cognitive performances among participants. The first phase of the study involved the development of several health bar formulations, assessing their nutritional composition. The health bar with the most optimal nutrient content was selected for mass production and used in the pilot intervention study. Participants aged between 13 to 16 years were recruited from two boarding schools in Selangor, and the intervention was conducted over a two-month period, during which participants' health and cognitive performance were assessed. Results indicated that the health bars exhibited favourable nutritional attributes, containing 1.38 g to 3.47 g of fibre, 5742.31 mg to 6797.84 mg linoleic acid, 1166 mg to 1152 mg magnesium, and 0.43 mg to 0.80 mg vitamin E. Moreover, the study identified several factors influencing cognitive performance and health status among children and adolescents from B40 households, including their environment, parental support, and internal motivation. Statistical analyses such as one-way ANOVA revealed significant differences in dimensions of the Pediatric Quality of Life Inventory (PedsQL 4.0) and Rey's Auditory Verbal Learning Test (RAVLT) scores between participants who underwent the health bar intervention. These findings underscore the positive impact of the health bar intervention on both health and cognitive performances. Overall, the study has important implications for health and education officials and policymakers in addressing the rising incidence of health and nutrition-related issues among children and adolescents from the B40 community. By targeting the root causes of these problems and implementing targeted interventions, policymakers can better support the critical needs of urban poverty-stricken populations, contributing to the achievement of Sustainable Development Goals (SDGs) 1: No Poverty and 3: Good Health and Well-being.

ملخص البحث

أدت وتيرة التحضر السريعة في ماليزيا إلى زيادة كبيرة في الفقر الحضري، مما أثر بشكل خاص على مجتمعB40 ، حيث يقيم حوالي 56% منهم في المناطق الحضرية. يعدّ الأطفال والمراهقون من الأسر ذات الدخل المنخفض في هذا المجتمع معرضون بشكل خاص للآثار الضارة لسوء التغذية والأمراض. وعلى الرغم من هشاشة هذا المجتمع، فإن هذه الفئة السكانية لم تحظَ باهتمام كافٍ في الدراسات المتعلقة بالأداء المعرفي والحالة الصحية، حيث يُنظر إليهم غالبًا على أنهم أقل عرضة لسوء التغذية أو تدهور الصحة .لذلك، تهدف هذه الدراسة إلى معالجة هذه الفجوة من خلال جمع البيانات الأولية وتنفيذ برنامج تدخل غذائي تجريبي يستهدف الأطفال والمراهقين من مجتمع B40 في مدارس مختارة عبر ولاية سيلانجور، ماليزيا. يتمثل الهدف الرئيسي في دراسة العلاقة بين مدخول التغذية والصحة والأداء المعرفي للأطفال والمراهقين داخل مجتمع B40 من خلال تصنيف شامل للبيانات. بالإضافة إلى ذلك، تقيم الدراسة فعالية تدخل صحي باستخدام ألواح غذائية صحية لتحسين الصحة والأداء المعرفي للمشاركين. تضمن المرحلة الأولى من الدراسة تطوير عدة تركيبات للألواح الصحية وتقييم مكوناتها الغذائية. تم اختيار اللوح الصحي الذي يتمتع بأفضل تركيبة غذائية متوازنة للإنتاج على نطاق واسع، واستخدامه كعنصر رئيسي في الدراسة التجريبية لتقييم فعالية التدخل على صحة وأداء المشاركين. تم اختيار مشاركين تتراوح أعمارهم بين 13 و16 عامًا من مدرستين داخليتين في سيلانجور، وأُجريت الدراسة التجريبية على مدى شهرين، حيث تم تقييم صحة وأداء المشاركين المعرفي خلال تلك الفترة. أظهرت النتائج أن الألواح الصحية تتمتع بخصائص غذائية مواتية، حيث تحتوي على 1.38 جم إلى 3.47 جم من الألياف، و5742.31 ملجم إلى 6797.84 ملجم من حمض اللينوليك، و1166 ملجم إلى 1152 ملجم من المغنيسيوم، و0.43 ملجم إلى 0.80 ملجم من فيتامين هـ. علاوة على ذلك، حددت الدراسة عدة عوامل تؤثر على الأداء المعرفي والحالة الصحية للأطفال والمراهقين من أسرB40 ، بما في ذلك البيئة، ودعم الوالدين، والدوافع الداخلية. أظهرت التحليلات الإحصائية، مثل اختبار تحليل التباين الأحادي(ANOVA) ، وجود فروق ذات دلالة إحصائية في أبعاد استبيان جودة الحياة للأطفال(PedsQL 4.0) ونتائج اختبار التعلم السمعي اللفظي لري (RAVLT) بين المشاركين الذين خضعوا للدراسة التجريبية بالألواح الصحية. تؤكد هذه النتائج التأثير الإيجابي لتدخل الألواح الصحية على كل من الصحة والأداء المعرفي. بشكل عام، تحمل الدراسة دلالات هامة لمسؤولي الصحة والتعليم وواضعي السياسات في معالجة ارتفاع معدلات المشاكل المتعلقة بالصحة والتغذية بين الأطفال والمراهقين من مجتمع B40 من خلال استهداف الأسباب الجذرية لهذه المشكلات وتنفيذ تدخلات محددة، يمكن لصانعي السياسات تلبية الاحتياجات الحرجة للسكان الذين يعانون من الفقر الحضري، مما يُساهم في تحقيق أهداف التنمية المستدامة (SDGs)، الهدف الأول: القضاء على الفقر، والهدف الثالث: ضمان الصحة الجيدة والرفاهية.

APPROVAL PAGE

I certify that I have supervised and read this study and that in my opinion, it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Master of Halal Industry Science.

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DECLARATION

I hereby declare that this dissertation is the result of my own investigations, except where otherwise stated. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at IIUM or other institutions.

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LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
B40	Bottom 40%
BAZ	BMI For-Age
BMI	Body Mass Index
DPPH	diphenyl-1-picrylhydrazyl
g	Gram
HAZ	Height-For-Age
HRQoL	Health-Related Quality of Life
kg	Kilogram
LDL	Low-Density Lipoprotein
mg	Milligram
NCCFN	National Coordinating Committee on Food and Nutrition
PedsQL 4.0	Pediatric Quality of Life Inventory
PUFA	Polyunsaturated Fatty Acid
RAVLT	Rey's Auditory Verbal Learning Test
RCT	Randomised Control Trial
RNI	Recommended Nutrients Intake
RISDA	Rubber Industry Smallholders Development Authority
SD	Standard Deviation
WAZ	Weight-For-Age
WHO	World Health Organization

CHAPTER ONE

INTRODUCTION

1.1 INTRODUCTION

The first chapter elaborates on a thorough investigation of the underlying principles that form the research background. This study aims to establish a pilot food intervention study especially for the B40 children and adolescents that can help to improve their cognitive performance. It proceeds by presenting a statement of the problem, followed by the formulation of research questions and objectives. Moreover, this chapter encompasses a description of the study's significance and the research scope. Lastly, this chapter concludes by providing clear definitions for each variable related to the study.

1.2 RESEARCH BACKGROUND

Malaysians are categorised into three different income groups: Top 20% (T20), Middle 40% (M40), and Bottom 40% (B40). The Bottom 40% (B40) is defined as those communities with an income threshold of lower than RM 4,849 monthly (Department of Statistics Malaysia, 2020). As of 2022, the B40 communities recorded an average income of RM 3,401 per month to feed the entire household (Department of Statistics Malaysia, 2022). This group faces a range of socio-economic challenges, particularly in urban areas.

Urbanisation, driven by Malaysia’s rapid transformation from an agricultural to a manufacturing hub, has led to urban poverty (Siwar et al., 2016). Urban poverty refers to the condition where individuals or families in urban areas lack sufficient resources, employment opportunities, and access to basic needs such as housing and healthcare, which has widened socio-economic disparities. According to Jayasooria (2016), the causes and consequences of urban poverty persist due to failures in governance structures, bureaucracy, and socio-political apathy. This is further corroborated by

Suzana et al. (2019), who reported that 56% of the B40 community reside in urban areas and face significant socioeconomic and healthcare challenges.

Policymakers must pay greater attention to the critical needs of minority communities in urban areas. These needs transcend ethnic divides and are increasingly prevalent in urban environments, a phenomenon once thought to be exclusive to rural dwellers (Khoo et al., 2018). This highlights the urgency for inclusive socio-economic development strategies to address the growing issues in urban poverty and healthcare.

Given these circumstances, this study utilized primary data cataloguing and a pilot food intervention approach. The study formulated several health bars for children and adolescents from the B40 community in selected schools in Selangor, Malaysia. These health bars were provided as part of their daily nutrition. The research investigated the correlation between cognitive and health performances of the participants, highlighting the impact of targeted nutritional interventions. The findings of this study are expected to assist health and education officials in addressing rising incidents of health and nutrition problems among children in the B40 group by focusing on measures that tackle the root causes.

This research contributes to the Sustainable Development Goals (SDGs), specifically SDG 1: No Poverty and SDG 3: Good Health and Well-being. It serves as part of a broader effort to advance these goals through education and public health interventions, aiming to improve socio-economic outcomes for vulnerable communities.

1.3 PROBLEM STATEMENT

In numerous regions worldwide, especially in less developed nations, growth assessment has emerged as the primary metric used to conveniently and accurately gauge the health and nutritional status of children and adolescents. Numerous factors contribute to health and nutrition challenges among this demographic. However, for those living in impoverished conditions, inadequate food intake caused by economic hurdle in selecting healthy food or severe and repeated infections or even a combination of these are the predominant causes of poor health and nutrition (Vilar-Compte et al.,

2021). For instance, common observations in underdeveloped nations have indicated that children and adolescents from impoverished households are susceptible to the hazardous blend of malnutrition and sickness (Food Research and Action Center, 2017). This is due to inadequate food accessibility, poverty, deprived quality diets, and limited nutritional knowledge (Kim & Kang, 2017), which prompted the establishment of health and nutrition programmes such as immunisation, medical care, and supplementary foods that focus on the needs of these children and adolescents. Moreover, the low-income has frequently become a challenge to this unfortunate group in getting access towards adequate healthcare, critical mental health and conducive living such as essential nutrients (Suzana et al., 2019).

Other than that, there have been numerous documentations of infants and young children's health and nutritional status in less developed countries, but little attention has been given to the condition of older children. Children and adolescents' health and nutrition in Malaysia have not received much attention, as indicated by the relatively little published information on this topic, primarily in urban areas. Suzana et al. (2019), elucidated the health and nutritional status of those living in the urban sector have been neglected as the focus has mainly been on the poor and the hard-core poor households in the rural areas of Malaysia. These children and adolescents have been the least studied in the evaluation of the cognitive performance and health status of a community since they are assumed to be less at risk of being malnourished or having poor health, although it is known that poor nutrition is associated with poor cognitive performance (Spencer et al., 2017).

In addition to this, a balanced and sufficient diet can affect cognitive performance in children and adolescents while exerting long-term positive effects in association with cognitive improvement (Kristo et al., 2020). More reasons are there to tackle the malnutrition issue to provide better cognitive performance and health status among children and adolescents as they are the guarantor for a better future ahead. The decision in choosing health bar as part of this study was greatly influenced by component of ingredients of health bar which are beneficial in promoting human health. Moreover, the placement of health bars in grocery stores has undergone significant changes in recent times, transitioning from a niche section to a prominent area within the cereal aisle, alongside breakfast cereals. This shift reflects a substantial increase in demand, thus propelling growth in the global health bar market (Andrew, 2018).

Meanwhile, the consumption of health bar among children and adolescents is second behind younger children, but the number is increasing day by day, providing an opening to substitute this health bar in their diets. As a result, this current proposal was undertaken to exercise and provide a 'healthy food bar' formulation as a wholesome effort to provide supplementary nutrients for school children and adolescents from primarily underprivileged households in the urban area of Selangor, Malaysia and to investigate the determinants of their cognitive performance.

1.4 RESEARCH QUESTIONS

1.1.1 What is the best health bar formulation that can help promote good health and improve the children and adolescents' cognitive performance of the B40 community?

1.1.2 What is the relationship between nutrition intake to health and cognitive performance of the children and adolescents of the B40 community?

1.1.3 How could the health and cognitive performance of the children and adolescents of the B40 community be improved through a food intervention study?

1.5 RESEARCH OBJECTIVES

1.1.4 To determine health bar formulation and its physical and chemical characteristics as part of the intervention study involving the children and adolescents of B40 community.

1.1.5 To identify the relationship between nutrition intake to health and cognitive performance of the children and adolescents of the B40 community through basic data cataloguing.

1.1.6 To assess the improvement of health and cognitive performance of the children and adolescents of the B40 community through survey and health bar pilot food intervention study.

1.6 RESEARCH METHODOLOGY

The detailed progress of this research can be depicted in the third chapter. Meanwhile, the current chapter visualises the summary of the research flow chart as shown in Figure 1.1 below

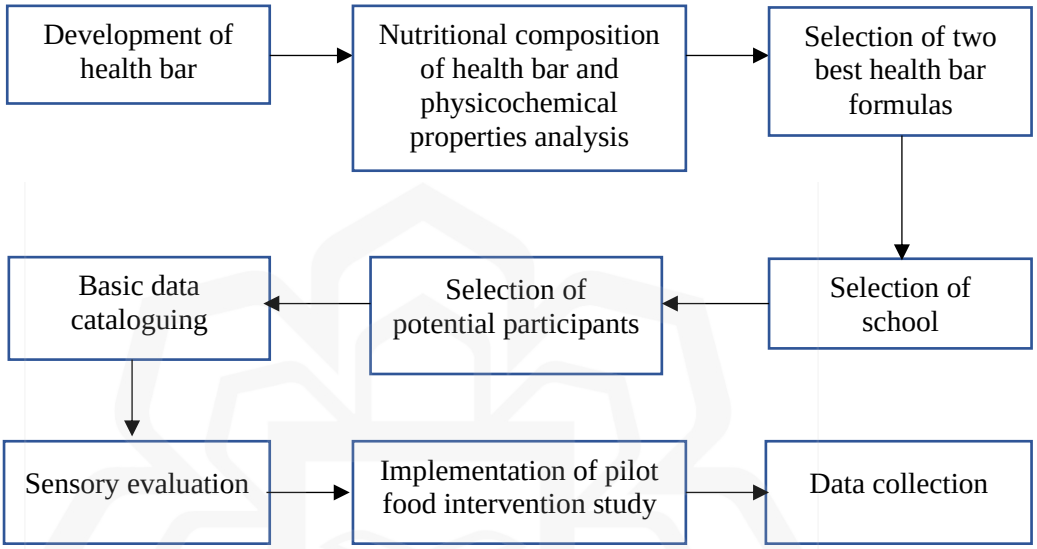

Figure 1.1 Summary of Research Flow Chart

1.7 RESEARCH SCOPE

Generally, this research aims to develop a health bar recipe that can provide balanced nutrients and improve health and cognitive function among its consumers. The targeted participants of this study are children and adolescents in the B40 community in selected schools around Selangor, Malaysia. The main focus of this study is to assess the health and cognitive performance of the participants for approximately two months and will be conducted through a pilot food intervention study. Several analyses will be conducted including Pediatric Quality of Life Inventory 4.0 (PedsQL 4.0) and Rey's Auditory Verbal Learning Test (RAVLT). Additionally, a pre-intervention and post-intervention data will be collected to evaluate the effectiveness of the study. Figure 1.2 below shows the summary of research scope.

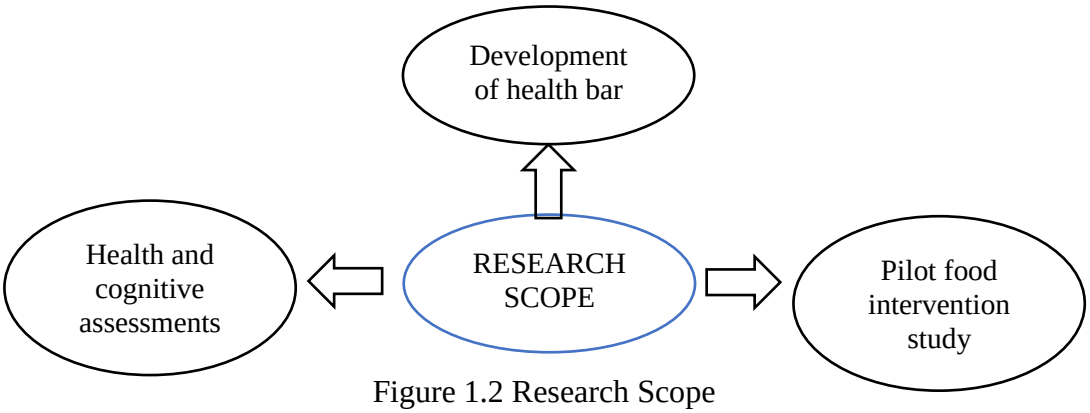

Figure 1.2 Research Scope

1.8 DEFINITION OF TERMS

The operational definition intents to provide a better understanding and explanation of terms and concepts connected to the topic of research. In relation to the research topics, this study targets to develop a nutrient-dense health bar that can help to improve health and cognitive performance among children and adolescents of the B40 community around Selangor, Malaysia. Hence, the operational definitions of the factors or constructs in this study are as follows:

1. Nutrient-dense food

Nutrient-dense food refers to food items that offer essential vitamins, minerals, and other beneficial compounds while containing minimal added sugar, saturated fat, and sodium, as defined by the U.S. Department of Agriculture and the U.S. Department of Health and Human Services (2020). The nutritional content of these foods is typically measured per 100 grams, 100 kilocalories, or per serving size.

2. Health bar

Health bar is a bar-shaped snack produced by pressing several ingredients together that provides health benefits upon its consumption (Bakha et al., 2019).

3. Isomalt

Isomalt, a sugar alcohol that comes naturally from sugar beet with a sweetening characteristic comparable to sugar. It contains only half the calories of sucrose with its natural sweetening profile (Beneo, 2016). Isomalt is widely used as sugar replacer in

confectionery and baked products whilst providing similar sweetness and texture to sucrose (Isik, 2011).

4. Maltitol

Maltitol refers to a disaccharide sugar alcohol derives from starch through the catalytic hydrogenation reaction of maltose (Saraiva et al., 2020). Maltitol has been applied in many sugar-free baked, dairy, and candy products given its similar sweetness to sucrose with zero aftertaste (Dobreva et al., 2013).

5. Cognitive performance

Cognitive performance is the measure of wellness of the brain function. It can be measured by determining the acquisition of knowledge, state of memory and reasoning (Kaur & Prajapati, 2022).

6. Children and adolescents

Children are defined as every human being below the age of 18 years old. Meanwhile, adolescents start at the age of 10 years old until 19 years old (United Nation General Assembly, 1989).

7. B40 community

The Bottom 40% (B40) is the community with a monthly household income of lower than RM4,849 (Department of Statistic Malaysia, 2020).

1.9 DISSERTATION ORGANISATION

The first chapter discusses the background of the study, the assertions of the problem, the aims of the research study, the methodology of the research, the scope of the research, and operational definitions of the research. In the second chapter, there are reviews on the current urban problem, the urban poverty as well as its implication towards health and nutrition status of the urban dwellers and an extensive review on the essential nutrients that can help to boost cognitive performance. The third chapter encompasses over the methodology of the study in great detail, including the materials,

the experimental techniques, and the analytical steps. In the fourth chapter, the findings of the experiments are presented, along with a discussion of the results interpretation. The fifth chapter presents a general summary of the findings of the research as well as some limitations and suggestions to improve the research in future studies. In addition, Table 1.1 below lists the summary of research questions, research objectives and research hypotheses.

Table 1.1 Summary of Research Questions, Objectives, and Hypotheses

No.	Research Questions	Research Objectives	Research Hypotheses
1.	What is the best healthy bar formulation that can help promote good health and improve the children and adolescents' cognitive performance of the B40 community?	To determine healthy bar formulation and its physical and chemical characteristics involving the children and adolescents of B40 community.	**H1:** Healthy bar can promote good health and improve the cognitive performance of the children and adolescents of the B40 community.
2.	What is the relationship between nutrition intake to health and cognitive performance of the children and adolescents of the B40 community?	To identify the relationship between nutrition intake to health and cognitive performance of the children and adolescents of the B40 community through basic data cataloguing.	**H2:** Poor nutrition is a major contributing factor to the poor health and cognitive performance of the children and adolescents of the B40 community.
3.	How could the health and cognitive performance of the children and adolescents of the B40 community be improved through a food intervention study?	To assess the improvement of health and cognitive performance of the children and adolescents of the B40 community through survey and healthy bar pilot food intervention study	**H3:** Health and cognitive performance of the children and adolescents of the B40 community can be improved through food intervention studies.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

Chapter Two provides an in-depth analysis of the literature relevant to the present study. It commences the serious issue surrounded the urban dwellers, urban poverty and its implications on health and nutrition status. The chapter extensively examines the health nutrition status of children and adolescents in Malaysia especially in the urban area and its correlation to cognitive impairment. The essential nutrients that can help to increase cognitive performance are also discussed. Then, this chapter shows the ingredients that have been selected for this study.

2.2 URBAN POVERTY, HEALTH, AND NUTRITION

Hunger and poverty issues had been addressed extensively worldwide through development, health and nutrition programs. However, the recipients of these programs had been primarily the rural and agricultural subsistence households (Rosida, 2018). Similarly, the study of intrahousehold resource allocation had mainly focused on these households because of their lower socio-economic status and susceptibility to food shortages, which may affect household food allocation (Comola & Melo, 2010). While much attention had been given to rural poverty and hunger issues, there had been a relative neglect of urban problems. Indeed, there was no need to abandon the attention to these rural issues, but there is an urgency to change the balance to reflect the growing relative importance of urban health and nutrition, especially in the light that such unprecedented growth of urban population has consequences for hunger and malnutrition (Chukwukere & Amir Hussin, 2012). These issues of urban poverty, alongside rapid urbanization, have disproportionately affected the health and nutrition of children and adolescents, setting the stage for a more detailed examination of the impact on malnutrition and cognitive performance.

Urbanisation in less-developed countries was a post-World War II phenomenon and for past decades, there had been a marked demographic shift from rural to urban residences (Siwar et al., 2016). However, today, urban growth was less dependent on rural-urban migration. This was because two-thirds of urban growth was due to the natural increase in urban population (excess of births over deaths in both the pre-existing residents and rural migrants) (Jayasoonia, 2016). In a short period, significant acceleration of urban inhabitants led to a rapid expansion of urban growth, causing various problems, including economic and social costs. Rosida (2018) reported that rapid urbanisation had caused 50% of urban inhabitants in Latin American and African countries to be living below the poverty line in the 1980s, remarkably similar to those living in most developed countries in which the poverty rate escalated from 19% to 24% from 1993 to 2002. Katiman, Mohd Fuad & Mohd Ekhwan (2010), exposed that rapid urbanisation had been emerging in large cities in Malaysia for the past few decades leading to urban poverty. Urbanisation was an inevitable consequence of socio-economic development and industrialisation. In the less developed countries, the urbanisation process was accelerating uncontrollably, that it was outpacing the growth of services, infrastructures and employment. Consequently, slums and shanty towns began to appear in city centres or their peripheries and the inhabitants were forced to live in a state of economic deprivation and experience hunger and malnutrition in the cities (Osman Rani & Rajah, 2011). Urban poverty, health and nutrition increased attention as development issues with the many implications of urbanisation. Urban poverty had been highlighted as the major challenge in the next decade for governments in the less developed countries (Rosida, 2018).

The health problems in the urban centres of developing countries reflect both those observed in developing and developed countries. Three categories of health problems afflicting the urban poor had been identified (Hansen & Paintsil, 2016). First were the diseases related to poverty, including infectious diseases and malnutrition, prevalent among urban populations in slum areas and squatters (Geok Lin & Zalilah, 2019). The second included cardiovascular, neoplastic, hypertensive and mental diseases and accidents mainly related to the manufactured urban environment (Non et al., 2016). The diet-related non-communicable diseases (cardiovascular disease, hypertension, malignant neoplasm and diabetes mellitus) were also the consequences of the transitional changes in dietary intake, food availability, socio-economic status

and stress among the urban population (Council on Community Pediatrics, American Academy of Pediatrics, 2016). Meanwhile, the third group consisted of disorders associated with social instability and insecurity such as alcoholism, drug addiction, venereal diseases, child labour and street children (Suzana et al., 2019).

While rural poverty has been extensively researched, there is a notable gap in the literature concerning the malnutrition and cognitive performance of urban children, particularly those from the B40 community. This study aims to address this gap by investigating how malnutrition affects cognitive performance among urban children and adolescents in Malaysia.

Given these challenges, interventions targeting the nutritional needs of urban poor populations, such as the health bar used in this study, are essential to improving cognitive performance and overall health outcomes for children and adolescents in the B40 community.

2.3 CHILDREN AND ADOLESCENTS' HEALTH IN MALAYSIA

Malnutrition is prevalent in Malaysian children and adolescents and is widespread in rural and urban areas (Suzana et al., 2019). Anthropometric assessment studies in Malaysia since the 1930s had concentrated on the rural population as their lower socio-economic status had been associated with health and nutritional problems. However, more focus had been given to urban children and adolescents since the 1970s, especially in light of the fast pace of urbanisation in Malaysia (Nur Hamiza et al., 2017). Suzana et al. (2019) indicated that malnutrition among urban children and adolescents in Malaysia is significantly associated with low socio-economic status, households' food insecurity and poor child caring practices. Meanwhile, UNICEF Malaysia (2018) reported, through the Adolescent Health Survey conducted from year 2012 until 2017 an increasing trend in the thinness rate among children and adolescents in Malaysia had been recorded. A thinness rate of 6.4% was recorded in 2012 for children of the age 10-12 years old and inclined to 6.7% in 2017, with higher thinness rate for the adolescents aged 13-17 years from 2012 to 2017, approximately from 5.7% to 6.5%.

As many can see, malnutrition was directly related to cognitive performance among children and adolescents. Malnutrition was linked to delay growth, halting the

improvement of cognitive performance, and reduced intellectual quotient (IQ) (Salam et al., 2019). Other terms that might be relatable were micronutrient deficiencies or 'hidden hunger' due to inadequate amount of minuscule nutrients leading to growth impairment and stunted physical and mental development (Wan Manan, Jomo Kwame & Tan, 2019). Adequate and sufficient healthy intake of food was essential to brain function. Furthermore, optimizing brain function is vital for achieving the necessary cognitive abilities for focusing, understanding, evaluating, and applying knowledge in learning endeavours (Correa-Burrows et al., 2016). Many may agree with the foundational beliefs about the connection between food and learning: (1) that regular consumption of a sufficient, high-quality diet enhances cognitive abilities; (2) that a better-quality diet is linked to improved cognitive performance; and (3) that malnutrition contributes to lower cognitive abilities, particularly prevalent among impoverished adolescents. However, despite the widespread acknowledgment of food's importance in learning, empirical research on the precise relationship between overall diet and cognitive achievement in children and adolescents remains scarce. Moreover, the findings from existing studies are inconclusive in determining the exact nature and extent of this relationship. Disagreement persists regarding the specific foods that constitute an adequate diet, the impact of dietary habits on immediate and long-term cognitive outcomes, and the complexity of the relationship between nutrition and cognitive function.

This controversy arises from divergent findings across various studies, which often face challenges in research design, such as small sample sizes, short durations, or narrow focus. Additionally, conducting randomized controlled trials (RCTs) to investigate the effects of specific nutritional factors presents difficulties due to methodological constraints and unreliable measurement tools. Many studies, employing alternative methodologies, encounter confounding variables that compromise the validity of their results. Although statistical adjustments are made to control these variables, the shift from authentic correlations to theoretical interpretations undermines the reliability of conclusions. Despite ongoing debate, several studies provide evidence supporting a positive association between healthy dietary patterns and enhanced cognitive performance.

H2: Poor nutrition is a major contributing factor to the poor health and cognitive performance of the children and adolescents of the B40 community.

2.4 HALALAN TOYYIBAN FOOD INFLUENCED CHILDREN AND ADOLESCENTS WELL-BEING

Islam emphasizes the necessity of consuming halalan toyyiban (lawful and wholesome) food to maintain both physical and spiritual health. The concept of halalan toyyiban not only ensures the permissibility of food in accordance with Islamic law but also emphasizes the safety, cleanliness, and nutritional value of the food consumed. This principle is significant in shaping a healthy lifestyle for Muslims, particularly for children and adolescents, who are in critical stages of growth and development. As Malaysia increasingly emphasizes the halalan toyyiban food industry, it is important to understand its implications on health and well-being (Wahju Dyah et al., 2018).

The halalan toyyiban food concept is closely tied to Islamic teachings, which stress the importance of consuming food that is not only permissible but also beneficial for health. For instance, the Quran underscores the importance of wholesome foods, as seen in the following verse: "With it, We produce for you gardens of date-palms and grapevines, in which there are abundant fruits, and from which you may eat" (Quran, 23:11). This verse reflects the Islamic emphasis on consuming natural and beneficial food sources such as dates and other fruits, which are rich in essential nutrients and energy.

Additionally, Sunnah foods—those favored by Prophet Muhammad (SAW)—are believed to offer numerous health benefits. Examples of Sunnah foods include dates, honey, pumpkin, and pomegranate. These foods are not only significant in Islamic teachings but are also scientifically proven to be beneficial for physical and cognitive health (Siti Salwa et al., 2015). Dates, for example, are rich in glucose and antioxidants, making them a natural energy source that supports memory retention and cognitive function (Nasir et al., 2015).

Given the growing demand for halal and toyyib food products worldwide, many manufacturers have capitalized on this opportunity by expanding the production of halal-certified goods (Mohd Noor et al., 2023). For Muslims, the consumption of halal products is not merely a matter of religious obligation but is closely related to the pursuit of a healthy and balanced diet. According to Muhamad and Abdul Latiff (2017), the

behavior of consuming halal-certified products is deeply rooted in religious teachings, influencing individuals' food choices and contributing to better food habits. A balanced and sufficient diet, which includes halalan toyyiban foods, is critical for promoting children's and adolescents' well-being. Consuming a variety of halal foods rich in essential nutrients can support optimal physical and mental development during these formative years. For example, vitamins, minerals, and other nutrients derived from halal food sources are crucial for brain development and function, which are essential for learning and cognitive performance (Correa-Burrows et al., 2016).

Furthermore, early education on halalan toyyiban principles can help children and adolescents develop a strong understanding of the relationship between food choices and health. Teaching young individuals about the importance of halal and toyyib food can encourage them to adopt healthy eating habits and make informed decisions about their diets (Wahju Dyah et al., 2018). By fostering these habits early on, parents and educators can help ensure that children and adolescents are equipped with the knowledge they need to lead healthy and fulfilling lives.

In summary, halalan toyyiban food not only aligns with Islamic principles but also promotes overall health and well-being, especially for children and adolescents. The emphasis on consuming halal foods that are safe, nutritious, and beneficial supports the physical and cognitive development of young individuals, contributing to their success both academically and in their personal lives. The incorporation of halalan toyyiban foods into the daily diets of children and adolescents is an important step in promoting a healthy and balanced lifestyle.

2.5 NUTRITIONAL NEUROSCIENCE

The brain's framework consists primarily of nerve cells (neurons) and supportive glial cells (neuroglia), where cognitive processes occur through interactions within the brain's structure. All cells in the human body, including neurons and glial cells, rely on food calories, specifically from macronutrients like carbohydrates, proteins, and fats, to derive energy (Carreiro et al., 2016). However, before cells can utilize energy from food, it must undergo conversion into simple sugars, particularly glucose. Glucose serves as the primary fuel source for the brain, nervous system, and red blood cells, and

is the preferred energy source for all other cells and tissues in the body (Davis & Melina, 2010).

Food also provides the body with micronutrients, such as vitamins and minerals, which play vital roles in promoting neuronal survival (Paus, 2010). These micronutrients also contribute to the synthesis of brain chemicals known as neurotransmitters, which are responsible for transmitting information across synapses and supporting efficient transmission along neural pathways. Imbalances in specific vitamins or minerals can potentially damage nerves in the brain, leading to alterations in memory, impaired problem-solving abilities, and overall cognitive dysfunction (Gustafson, 2010). Given that the brain is an organ with high energy demands, it requires adequate glucose and nutrient intake to function optimally. During childhood, when the brain's energy demands are particularly high, the importance of proper nutrition for development becomes even more pronounced. Some studies have suggested that students who experience insufficient glucose supply or nutrient deficiencies may experience compromised cognitive potential (Schmitt, 2010).

2.5.1 Essential Micronutrients to Improve Cognitive Performance

Micronutrients such as vitamins and minerals were essential in human dietary intake to fulfil their physiological needs. Meanwhile, previous researches had summed up their important roles in human health, current research is likely to shift to finding the relationship between micronutrients and cognitive performance (Tardy et al., 2020). Scientifically proven micronutrients commonly linked to the improvement of cognitive performance were listed in Table 2.1 below

Table 2.1: Essential Micronutrients to Improve Cognitive Performance

Vitamins	Minerals
Vitamin B-complex	Iron
1) B_1 (Thiamine)	Zinc
2) B_2 (Riboflavin)	Calcium
3) B_3 (Niacin)	Magnesium
4) B_5 (Pantothenic acid)	
5) B_6 (Pyridoxine)	
6) B_7 (Biotin)	
7) B_9 (Folic Acid)	
8) B_{12} (Cobalamin)	
Vitamin E (alpha-tocopherol)	

These micronutrients had significant effects on cognitive performance as they were directly involved in the energy metabolism of neurons and neuroglia (cells that provided metabolic support for neurons), the synthesis of neurotransmitters, the binding of receptor and the maintenance of membrane-ion pumps (Huskisson, Maggini and Ruf, 2007). Inadequate amounts of these micronutrients can cause adverse effects related to cognitive performance.

2.5.2 Recommended Nutrients Intake for Children and Adolescents in Malaysia

Adequate and balanced nutrients intake were vital in ensuring optimal growth, healthy life and consistent cognitive improvement. Thus, it was essential to know the recommended nutrients intake for each stage of age, and this research specifically for children and adolescents in Malaysia, to provide sufficient nutrients needed later. The recommended nutrients intake (RNI) for adolescents were based on the one reported by National Coordinating Committee on Food and Nutrition (NCCFN), Ministry of Health Malaysia.

One of the leading nutrition goals was to ensure that energy ingested in food was sufficient to meet the energy demands as it was required to maintain body temperature,

metabolic activity, supporting growth and physical work (NCCFN, 2017). The first principle in determining the minimum energy required by the human body was based on energy expenditure rather than the energy needed. The amount of energy spent was the amount of energy needed to be consumed. Thus, several factors must be considered in determining the minimum energy required by a particular age group, such as physical activities, basal metabolic rate and age. According to NCCFN (2017), the minimum energy required by both children and adolescents (males and females) by the age 7 to 15 years old with moderately active and active physical activities were 1750 kcal/day, 1970 kcal/day, 1610 kcal/day, 1810 kcal/day, 2210 kcal/day, 2480 kcal/day, 1810 kcal/day and 2040 kcal/day respectively. Meanwhile, the minimum energy required for adolescents (males and females) by the age of 16 to 18 with moderately active and active physical activities was 2340 kcal/day, 2640 kcal/day, 189 kcal/day 2130 kcal/day, respectively.

Next, the human body needed protein to maintain body tissues, defend against diseases, and form regulatory compounds. Several factors were foreseen before the determination of minimum protein required by the human body, such as age, sex and physiological state. Referring to NCCFN (2017), the minimum protein required by both children and adolescents (males and females) by the age of 7 to 15 years old and 16 to 18 years old were 23.0 g/day, 30.0 g/day, 45.0 g/day, 42.0 g/day, 51.0 g/day and 42.0 g/day, respectively. Meanwhile, fat was required due to the essentiality for physiological function, growth and development. In addition, dietary fat aided the digestion, absorption and transportation of fat-soluble vitamins and fat-soluble phytochemicals, such as carotenoids and lycopene.

According to NCCFN (2017), daily energy required for children and adolescents (boys and girls), as mentioned previously, were used to calculate the absolute amount (in grams) of fat required per day for the age group of 7 to 15 years old and 16 to 18 years old. It was recommended that the minimum fat required for children and adolescents (males and females) from the mentioned age groups were 49.0 to 68.0 g/day, 45.0 to 63.0 g/day, 61.0 to 86.0 g/day, 50.0 to 70.0 g/day, 65.0 to 91.0 g/day and 53.0 to 74.0 g/day, respectively.

The carbohydrate requirement in the daily diet was explained in the least as it is usually calculated from the difference in the percentage of whole nutrients (100%) with

the total percentage of other nutrients, including energy, protein and fat. Thus, the carbohydrate requirement varied for each individual and population group (NCCFN, 2017).

The following discussion will be primarily for essential vitamins and minerals referring to NCCFN (2017). Table 2.2 below summarises the recommended nutrients intake of macronutrients and micronutrients for adolescents in Malaysia.

Table 2.2: Recommended Nutrients Intake for Adolescents in Malaysia as referred to National Coordinating Committee on Food and Nutrition (NCCFN), Ministry of Health Malaysia

Nutrients	Age group	Male		Female	
		Moderately active	Active	Moderately active	Active
Energy	7-15 years	2210 kcal/day	2480 kcal/day	1810 kcal/day	2040 kcal/day
	16-18 years	2340 kcal/day	2640 kcal/day	1890 kcal/day	2130 kcal/day
Protein	7-15 years	45.0 g/day		42.0 g/day	
	16-18 years	51.0 g/day		42.0 g/day	
Fat	7-15 years	61.0-86.0 g/day		50.0-70.0 g/day	
	16-18 years	65.0-91.0 g/day		53.0-74.0 g/day	
Vitamin B_1 (thiamine)	10-18 years	1.2 mg/day		1.1 mg/day	
Vitamin B_2 (riboflavin)	10-18 years	1.3 mg/day		1.0 mg/day	
Vitamin B_5 (pantothenic acid)	10-18 years	5.0 mg/day		5.0 mg/day	
Vitamin B_6 (pyridoxine)	10-18 years	1.3 mg/day		1.2 mg/day	

Vitamin B_9 (folate)	10-18 years	400.0 µg/day		400.0 µg/day	
Vitamin B_{12} (cobalamin)	10-18 years	4.0 µg/day		4.0 µg/day	
Vitamin A	10-18 years	600.0 µg/day		600.0 µg/day	
Vitamin D	10-18 years	15.0 µg/day		15.0 µg/day	
Vitamin E	10-18 years	10.0 mg/day		7.5 mg/day	
Calcium	10-18 years	1300.0 mg/day		1300.0 mg/day	
Phosphorus	10-18 years	1250.0 mg/day		1250.0 mg/day	
Potassium	10-18 years	4.7 g/day		4.7 g/day	
Magnesium	10-18 years	410.0 mg/day		360.0 mg/day	
Zinc	7-15 years	9.3 mg/day		7.7 mg/day	
	16-18 years	9.9 mg/day		7.7 mg/day	
Selenium	7-15 years	31.0 µg/day		24.0 µg/day	
		37.0 µg/day		26.0 µg/day	
		Bioavailability		Bioavailability	
		10%	15%	10%	15%

H3: Health and cognitive performance of the children and adolescents of the B40 community can be improved through food intervention studies

2.5.3 Ingredients to Improve Cognitive Performance in Adolescents

2.5.3.1 Dates

The ingredients to bake the health bar were thoroughly selected based on their nutritional benefits and also based on the recommendation in Holy Quran. Dates are a popular sunnah superfood as mentioned in the Quran:

"With it We produce for you gardens of date-palms and grapevines, in which there are abundant fruits, and from which you may eat" (23:11)

Dates were commonly grown in hot and dry climates in Asia, Middle East, Africa and Peninsula Arab. Dates are considered a significant energy source due to their high carbohydrate content, ranging from 55g to 80g per 100g of dates consumed, contributing approximately 12% to 15% of energy in adults (Nasir et al., 2015). This is attributed to the substantial presence of reducing sugars in dates, particularly glucose.and fructose, which are quickly absorbed during digestion, leading to a significant increase in blood sugar levels and providing the body with ample energy (Ali et al., 2012). Figure 2.1 provides an illustration of dates.

Figure 2.1 Dates Illustration

Additionally, dates contain a significant amount of dietary fiber, particularly insoluble fiber, which promotes satiety, a feeling that curbs further eating. Rebello, O'Neil, and Greenway (2016) explained that consuming food rich in dietary fiber requires more time and effort for chewing, increasing oral exposure to saliva. This

process leads to stomach expansion, sending signals to the brain and triggering sensations of satiety. Moreover, Shafiei, Karimi & Tazerhadeh (2010), stated that dates contained a significant amount of essential minerals (potassium, magnesium and calcium), vitamins (A, B and C), carotenoids (lutein, xeoxanthin and ß-carotene) and antioxidants (ferulic acid and caffeic acid).

Dates can improve reversal learning of left-right discrimination generating better cognitive flexibility as dates contained ferulic acid, an antioxidant that protects against amyloid-beta (αß) fibrils enhancing learning and memory impairment (Subash et al., 2015). Umer et al. (2015) also stated that dates contained high antioxidants, reducing the risk of anti-ageing diseases such as memory decline and Alzheimer's disease.

Eid et al. (2014) explained that the prebiotic found in dates promotes the proliferation of beneficial bacteria like lactobacilli. This increase in lactobacilli growth enhances colon health by suppressing the growth of pathogens such as Bacteroides and promoting the production of acetate and lactate. Polyphenols caused the inhibition of Bacteroides in dates that can bind to bacterial cell membranes, inhibiting their growth (Kemperman, Bolca and Roger, 2010). Besides, the incorporation of dates in snack bar had been discovered by precious research making it feasible with the latest study (Nadeem et al., 2012).).

2.5.3.2 Sacha Inchi Oil

Sacha inchi (*Plukenetia volubilis* L.) a perennial climbing plant, is also known as "Inca peanut", "wild peanut", "Inca inchi" or "mountain peanut" originated from Peruvian tropical jungles of South America mainly in Peru, Columbia, Ecuador and Brazil (Kodahl & Sorensen, 2021). It has star shaped fruit that contains about four, five or six lenticular seeds. The colour of the seed varies from green to brownish black as it ripe. Having the potential of becoming economic crop, the cultivation of this plant has expanded widely to other regions including China, Vietnam, Thailand and Malaysia (Rattana, Pattawee & Narirat, 2017). Given this known fact, Rubber Industry Smallholders Development Authority (RISDA), one of Malaysian federal agencies, had

taken the opportunity to plant Sacha inchi across the country in such a way to help the outgrowers gain additional incomes. Currently, this crop had been planted vastly in Melaka, Perak, Kelantan and Sarawak for its oil. Figure 2.2 shows the illustration of Sacha inchi oil.

Figure 2.2 Sacha Inchi Oil Illustration

The most common method to extract Sacha inchi oil is cold-pressed method (Carillo et al., 2018). This method introduces less heat during the extraction process which in turn preserves the heat-sensitive molecules mainly antioxidants. Sacha inchi seeds are composed of approximately 25% to 30% essential amino acids including cysteine, tyrosine, threonine, and tryptophan (Dah-Sol & Nami, 2019; Gomathy et al., 2020) as well as 35% to 60% essential fatty acids such as α-linolenic acid (C18:3, omega-3) and α-linoleic acid (C18:2, omega-6) (Betancur-Hoyos, Urango-Machena & Restrepo-Betancur, 2016; Ramos-Escudero et al., 2019). The same studies also reported Sacha inchi oil have significant number of tocopherols, sterols and polyphenols like flavonoids and phenolic alcohols.

These facts suggest, Sacha inchi oil can lower serum triglyceride (a type of lipid found in human blood) and cholesterol (Johnny et al., 2019). Content of α-linolenic acid (omega-3) in the oil imparting protective effect on the lipid profile. Gonzales, Gonzales & Villegas, (2014) elucidated, omega-3 fatty acids can reduce the expression of hepatic 4α factor (HNF-4α) that contribute to the activation of triglyceride microsomal transfer protein which responsible to transfer triglyceride and cholesterol to assemble low-density lipoprotein (LDL) at endoplasmic reticulum in a same way reduce the risk for cardiovascular diseases.

On the other hand, Kodahl & Sorensen, (2021) mentioned, the dietary intake of omega-3 among children and adolescents of the age 6 years old to 16 years old imparting positive effect with cognitive performance. Meanwhile, study conducted by

Ya-Nin & Phakkharawat, (2017) conclude that, the incorporation of Sacha inchi oil in diet increases theta, alpha and beta brainwaves simultaneously activate the function of inferior frontal cortex of brain relatively improving cognitive function particularly in memory and attention.

2.5.3.3 Moringa

Moringa (*Moringa oleifera*), a medicinal plant renowned for its pharmacological and nutritional properties, serves as a valuable resource for preventing and treating diseases in humans. Originally indigenous to Northern India, it has now proliferated across continents, including America, Africa, and Asia. Particularly in regions grappling with hunger and malnutrition, Moringa offers substantial health advantages, addressing nutritional deficiencies and aiding in disease management. According to Olson et al. (2016), the leaves of Moringa (*Moringa oleifera)* had a balanced level of essential amino acids and protein defining that human was able to obtain protein from plant products and not necessarily from animal products.

Moreover, Moringa (*Moringa oleifera)* had many essential nutrients such as minerals, vitamins and antioxidants (Abdull Razis, Ibrahim and Kntayya, 2014). Gopalakrishnan, Doriya and Kumar (2016) stated that the minerals present in Moringa (*Moringa oleifera)* leave mainly were calcium, potassium, zinc, magnesium and iron, as well as vitamins such as vitamin A (ß-carotene), vitamin B (folic acid), vitamin C, vitamin D and vitamin E and antioxidants such as flavonoids, phenols, tannins and saponins. Other than having essential nutrients, Moringa (*Moringa oleifera)* also contain polyunsaturated fatty acid (PUFA), mainly linolenic acid (omega-3) and linoleic acid (omega-6), which was essential to human health (Sanchez-Machado et al., 2010). Figure 2.3 below shows Moringa illustration.

Figure 2.3 Moringa Illustration

Due to the high flavonoids and phenols content in Moringa (*Moringa oleifera)*, the antioxidant activities were able to inhibit the generation of free radicals (unstable radicals) due to the reduction of oxidative damage caused by lipid peroxidation (Brilhante et al., 2017). Hannan et al. (2014) reported that the leaf extract of Moringa (*Moringa oleifera)* enhanced neurite outgrowth with increasing number and length of dendrites and axonal branches when incubated with a primary culture of hippocampal neurons unleashed the neuroprotective characteristic of the leaf. In certain countries, Moringa (*Moringa oleifera)* was used to treat malnutrition among breastfeeding children less than three years old due to the presence of phytosterols compounds such as stigmasterol and sitosterol, which stimulate the proliferation of the mammary duct to produce milk (Titi et al., 2013). Patel, Rangrez and Parikh (2013), claimed that the high flavonoids content in Moringa (*Moringa oleifera)* fruits and flowers increase ALP activity, an established marker for osteoblast activity promoting the formation of bones as increased the calcium and hydroxyproline content promoting osteoblast activity. Meanwhile, Singh et al. (2019) reviewed that consumption of Moringa (*Moringa oleifera)* fruits lowered down total cholesterol and low-density lipoprotein.

Low-density lipoprotein is the bad cholesterol that transport fat from the liver to the tissue; meanwhile, high-density lipoprotein was excellent cholesterol that transports the fat from the tissue back to the liver.

2.5.3.4 Pumpkin Seeds

Another sunnah superfood that the Prophet favoured was pumpkin. Being dry and cold, pumpkin helped to relieve the inflammation in stomach and was mentioned in the Holy Quran:

"And we caused a plant of gourd to grow over him" (36:146)

Then, there was a Hadith which stated that the Prophet loved pumpkin very much, he would eat it first before the meat and as a way for a proper digestion which was:

"I saw the Prophet being served with soup and containing gourd (pumpkin or squash) and cured meat, and I saw him picking and eating the pieces of gourd" (Bukhari, 348)

Meanwhile, pumpkin as a whole contained abundant of benefits mainly for heart and digestion, the pumpkin seeds possessed another benefit in boosting memory and brain function. Pumpkin seeds were semi-flat with a typical ovoid and conical tip, while the kernel is olive green in colour, having a nice buttery flavour and nutty texture. Pumpkin seeds were located in the core of the flesh usually discarded during processing. Despite that, many scientific research had proven the potential health benefits provided by pumpkin seeds. Pumpkin seeds were being called nutrient dense food due to the nutritional content of the seeds (Maheswari, Prasa and Batra, 2015). Pumpkin seeds were a good source of oil and protein (Devi, Prasad and Saganika, 2018). Syed, Akram and Shukat (2019), stated that pumpkin seeds had an abundance of minerals (mainly magnesium, zinc, phosphorus, potassium and selenium), dietary fibre, vitamins (A, B, C and E) and unsaturated fatty acid (oleic acid and linoleic acid). Figure 2.4 shows the illustration of pumpkin seeds.

Figure 2.4 Pumpkin Seeds Illustration

In pharmacological activities, pumpkin seeds served as antidiabetic, antiinflammation and antioxidant (Maheshwari, Prasa and Batra, 2015). The oil of pumpkin seeds is 50% of the total weight of vitamin E and is suitable for incorporating in food products (Nyam, Lau and Tan, 2013). Vitamin E, supported the human immune system and regenerating cells. Pumpkin seeds treated children with learning disabilities due to the high magnesium and zinc content (George, 2014). Magnesium assisted the transfer of oxygen from the lung to the cells, increasing children's focus and keeping their attention on the task provided; meanwhile, zinc enhanced the memory by helping the neurons in the hippocampus to communicate (Hoane, 2011).

George (2014) also added, the substantial amount of unsaturated fatty acid (linoleic acid, omega-6) improved mental health, aids memory and supports healthy brain development. The antioxidant activity of pumpkin seeds showed approximately 80% of radical scavenging activity, inhibiting lipid peroxidation, affecting the neurogenerative function (Andjelkovic et al., 2010).

2.6 HEALTH BAR VERSATILITY

The rapid growth of health bars, driven by their promising health benefits for consumers, has increased market diversity. There are three main types of healthy bars: (a) health and wellness snack bars, (b) organic snack bars, and (c) energy and nutrition bars (International Market Bureau Market Indicator, 2013). Nutrition bars can be further categorized into four subtypes: (i) cereal-based bars, (ii) energy bars, (iii) fruit-based

bars, and (iv) vegetable-based bars. With rising awareness of food safety and quality, there has been an increased demand for halal certification, particularly for cereal-based, fruit, and vegetable products (Fortune Business Insight, 2020). In response to this opportunity, many Malaysian producers have prioritized obtaining halal certification for their healthy bar products to target international markets, as healthy bars were the most exported processed food from Malaysia in 2020 (Flanders Investment and Trade Malaysia, 2020).

According to Constantin and Istrati (2018), cereal-based bars have strong market adaptability due to their high nutrient content and flexibility to be combined with various ingredients tailored to specific target groups, resulting in high consumer acceptance. Similarly, energy bars are often used by athletes and physically active individuals as dietary supplements to manage their calorie intake (Alla & Jithedran, 2018). Christmas et al. (2019) highlighted that energy bars containing high carbohydrates and moderate protein levels provide sustained energy for long-term physical and mental activities.

Fruit-based bars, typically mixed with ingredients such as corn flakes, oats, and chocolate, can offer consumers an adequate intake of essential vitamins and minerals (Nutrition Data, 2018). Meanwhile, the latest trend in the healthy bar market is the increasing popularity of vegetable-based bars, with products made from ingredients like lentils, chickpeas, and beans in flake or powder form becoming more widely available on supermarket shelves (Informa Markets, 2020).

These facts demonstrate the health benefits of consuming health bars, which align with the principles of *toyyib*. According to Idris Oyewale and Asnidar Hanim (2018), Muslim consumers consider halalan toyyiban food products to be indicators of hygiene, safety, and quality. Studies have shown that halal and *toyyib* food products can enhance both spiritual and physical well-being by improving energy levels, self-esteem, and mood (Shahida, Amena & Muhammad, 2021).

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2.7 CHAPTER SUMMARY

In this chapter, existing research on the urban poverty issue and its effects on the health and nutrition status of the urban dwellers, is thoroughly reviewed. Past studies related to the research goals are discussed, highlighting their findings and identifying gaps in the existing literature. The theories supporting correlation between malnutrition and its impacts on cognitive performance are also explored, elucidating how these theories are applied in the research. Based on insights gained from this literature review, hypotheses are formulated for testing in the subsequent chapter.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 INTRODUCTION

Chapter three outlines the research methodology applied to accomplish the research objectives, which include determining the physical and chemical characteristics of the formulated health bar, identifying the relationship between nutrition intake to health and cognitive performance and assessing the improvement of health and cognitive performance of the participants through pilot food intervention study. Fundamentally, Igwenagu (2016) defined research methodology as a set of systematic approaches employed in research and serves as a guide for conducting the study.

Chapter three is structured into several sections. The first section provides an elaborate explanation of development of health bar recipe as well as the ingredients chosen for the product. It further details the analyses conducted to evaluate the nutritional composition of the health bar and the statistical analysis used to validate the result. The subsequent section delves into the inclusion criteria and recruiting the appropriate sample size for the study. The final section of this chapter includes the start of the pilot food intervention study highlighting the pre-intervention and post-intervention tests. In addition, this particular chapter also clarifies the justification and reasoning for selecting a certain technique or procedure. Moreover, the summary of this research flow chart can be referred to Figure 3.1 below.

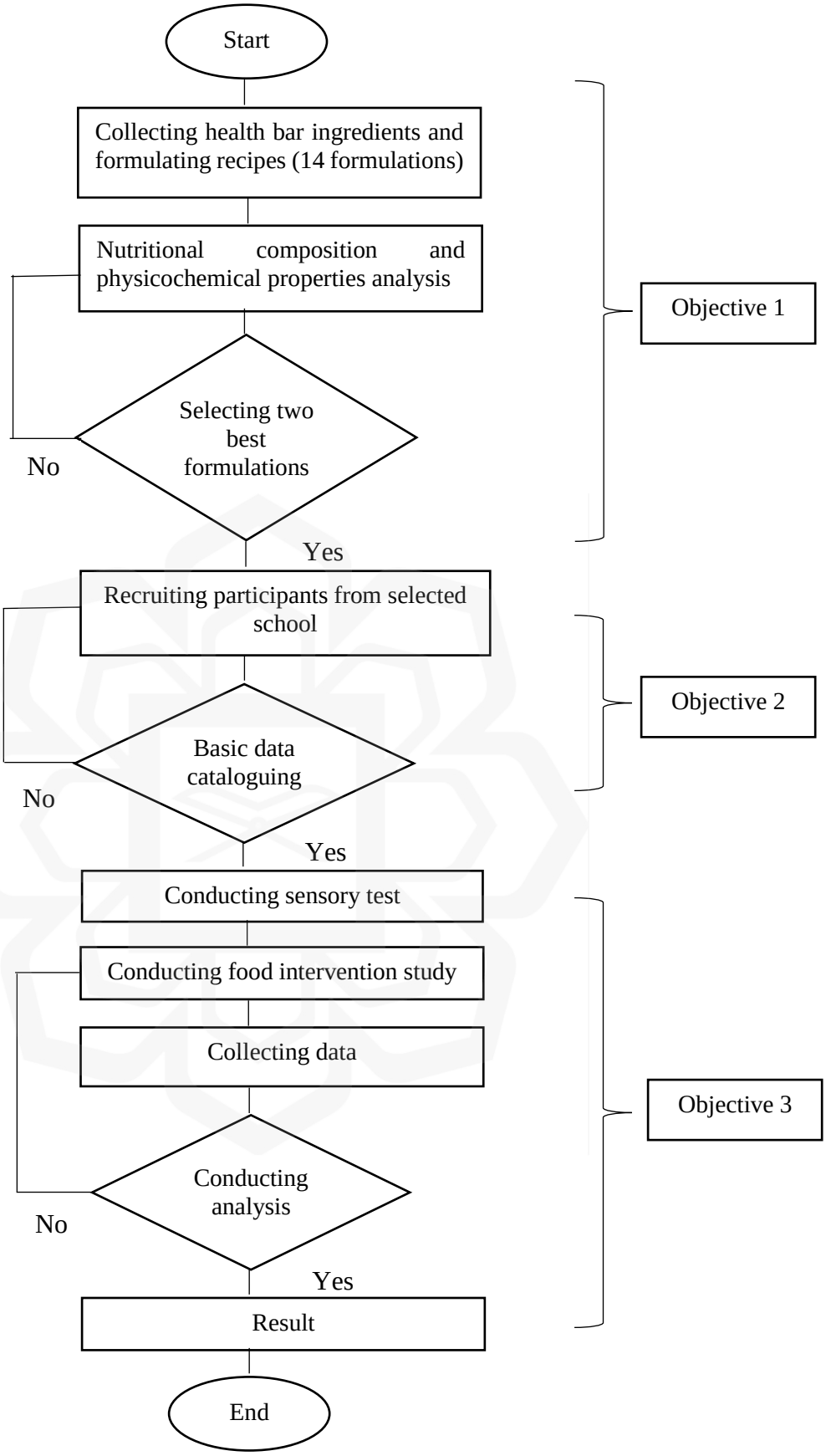

Figure 3.1 Research Flow Chart

3.2 INGREDIENTS OF HEALTH BAR

The health bar's functional ingredients — including date powder, Sacha Inchi oil (Plukenetia Volubilis), and Moringa powder (Moringa oleifera) — were procured from local manufacturers in Selangor, Malaysia. These ingredients were selected due to their potent benefits for cognitive function. Additional ingredients like pumpkin seeds, bubble rice, and oats serve as the health bar's structural components, providing texture and additional nutritional benefits. These ingredients were also sourced from local manufacturers. To enhance the overall palatability and increase the nutritional profile, Beryl's dark chocolate compound was added as a coating, along with sugar alcohols (maltitol and isomalt) to serve as sweeteners while keeping the bar low in refined sugar. Figure 3.2 below showed the ingredients used in the production of health bar.

Figure 3.2 Health Bar Ingredients

3.3 FORMULATION OF HEALTH BAR RECIPE

The ingredients for the health bar production including date powder, Sacha inchi *(Plukenetia Volubilis)* oil, and Moringa (*Moringa oleifera)* powder, were optimised according to simplex lattice design with a maximum of 25% of the total 25.00 g health bar recipe. The other ingredients used were 12.00 g dark chocolate compound, 10.00 g bubble rice, 10.00 g oats and 10.00 g pumpkin seeds were kept constant throughout the study. A previous study recorded that the upper limits of date powder, Sacha inchi *(Plukenetia Volubilis)* oil, and Moringa (*Moringa oleifera)* powder were 12.5%, 10.0% and 7.5%, respectively. Meanwhile, the lower limits of these ingredients were 7.5%, 5.0% and 2.5%, respectively. These limits were submitted in the Stat Ease Design Expert Version 12, resulting in the 14 formulas shown in Table 3.1 below.

Table 3.1 Mixture Ingredients of Healthy Bar

Formulations	Variable levels			Actual levels (%)		
	Date powder	Sacha inchi oil	Moringa powder	Date powder	Sacha inchi oil	Moringa powder
1	0.50	0.50	1.00	10.00	7.50	7.50
2	0.00	1.00	1.00	7.50	10.00	7.50
3	1.00	1.00	0.00	12.50	10.00	2.50
4	0.50	1.00	0.50	10.00	10.00	5.00
5	1.00	0.50	0.50	12.50	7.50	5.00
6	1.00	0.00	1.00	12.50	5.00	7.50
7	0.67	0.67	0.67	10.84	8.34	5.84
8	0.83	0.83	0.33	11.67	9.17	4.17
9	0.33	0.83	0.83	9.17	9.17	6.67
10	0.50	0.50	1.00	10.00	7.50	7.50
11	0.00	1.00	1.00	7.50	10.00	7.50
12	1.00	0.00	1.00	12.50	5.00	7.50
13	0.83	0.33	0.83	11.67	6.67	6.67
14	1.00	1.00	0.00	12.50	10.00	2.50

3.4 ASSEMBLING THE HEALTH BAR

All ingredients were precisely measured according to the recipe as the initial step in preparing the health bar. Following this, the pumpkin seeds and oats underwent toasting in an oven at 160℃ for approximately 5 minutes. They were then combined with bubble rice and Sacha inchi *(Plukenetia Volubilis)* oil. Next, the sugar alcohols (maltitol and isomalt) alongside date powder were melted at 150℃, before being incorporated into the main components of the health bar, including bubble rice, pumpkin seeds, and oats. The dark chocolate compound was melted using a double boiler method and mixed with Moringa *(Moringa oleifera)* powder, with careful stirring to prevent clumping. The resulting mixture was pressed into a mold measuring 20.0 cm x 20.0 cm x 3.0 cm to form the health bar. Finally, the melted dark chocolate compound was evenly drizzled over the health bar, which was then refrigerated before analyses.The health bar created in this study is formulated with a combination of nutrient-rich ingredients like dates, Sacha Inchi oil, Moringa powder, and pumpkin seeds, selected for their ability to enhance cognitive performance. Each ingredient contributes to both the nutritional value and structure of the health bar. The preparation process ensures that the ingredients are carefully handled to preserve their nutritional benefits. The health bar is designed to provide quick energy, essential fatty acids, vitamins, minerals, and antioxidants—all of which are crucial for brain health and cognitive function by addressing the common nutritional deficiencies seen in underprivileged communities, the health bar is expected to improve both the physical and cognitive well-being of children and adolescents in the B40 community, offering a practical intervention for enhancing their academic performance and overall quality of life. Figure 3.3 below showed the process of preparing the health bar.

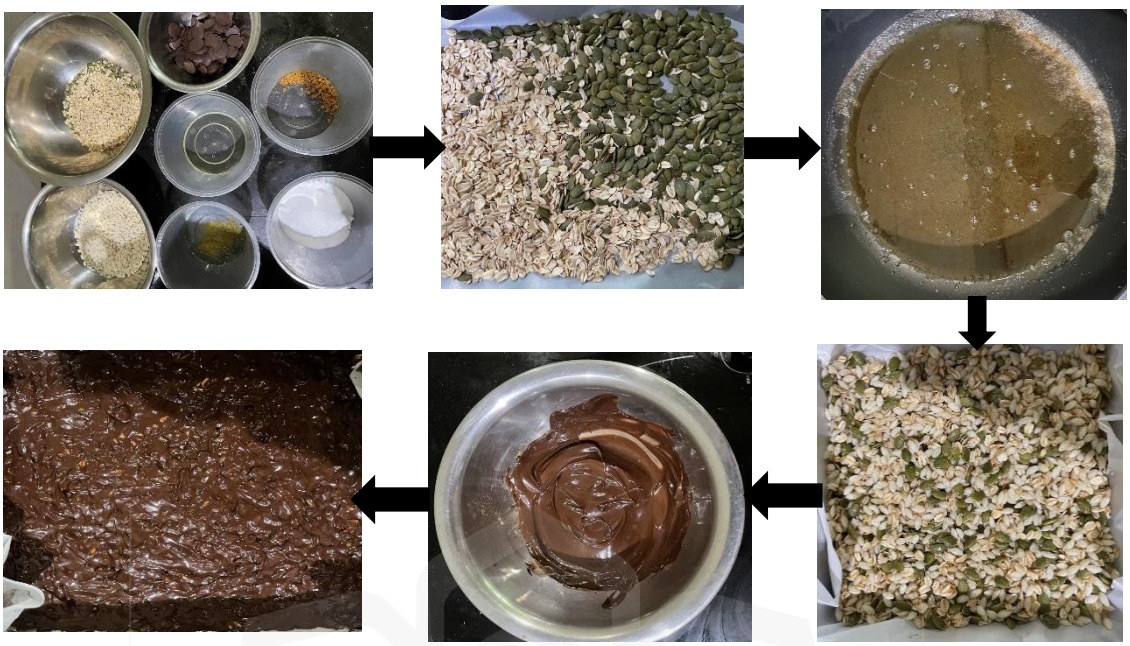

Figure 3.3 Process of Assembling the Health Bar

3.5 CHEMICAL ANALYSIS OF HEALTH BAR

Chemical analysis including proximate analysis, fatty acid profiling, vitamin analysis and mineral analysis was conducted to evaluate the nutritional composition of the health bar, as much as to validate that the formulated health bar contained essential nutrients for its consumers. Proximate analysis consisted of several analyses such as, moisture content, protein content, fat content, ash content, carbohydrate content, energy content and crude fibre content. Next, the fatty acid profiling was investigated to outline the detailed fatty acid composition of the health bar as to identify the essential fatty acid in the product that could improve cognitive performance. Meanwhile, vitamin E (alpha-tocopherol) and magnesium content of the health bar were also evaluated.

3.5.1 Proximate Analysis

3.5.1.1 Moisture Content

The moisture content of all health bar samples (comprising 14 formulations) underwent analysis utilizing a moisture analyser sourced from METTLER TOLEDO, United States. Each health bar sample, approximately 2.0 g in weight and selected from each recipe, was precisely weighed using a Sartorius weighing scale from Germany. Subsequently, the samples were individually placed inside the moisture analyser and allowed to run until reaching the optimal moisture content. The moisture content readings for each sample were then recorded in the logbook.

3.5.1.2 Protein Content

The protein and nitrogen content of all health bar samples were determined using the Kjeldahl Method (AACCI, 1995), Method 46-11.02. This involved three main processes: digestion, distillation, and titration. Following the titration process, the instrument provided the final percentage of protein and nitrogen, which was duly recorded in the logbook. The percentage of crude protein was derived from the total nitrogen percentage by multiplying it by a factor of 6.25, which serves as the nitrogen-protein conversion factor for grain samples. The calculation of crude protein content was performed using the following equation:

$$Crude\ protein\ (\%) = Nitrogen\ (\%)\ in\ sample \times 6.25$$

3.5.1.3 Fat Content

The fat content of all health bar samples was determined using the Automatic Soxhlet extraction method (Gerhardt Soxtherm® extractor, Germany). Approximately 2.0 g of samples from each recipe were weighed on filter papers, which were then folded and placed into pre-dried extraction thimbles, lightly plugged in with glass wool. These thimbles were inserted into extraction beakers containing three boiling stones and filled with 130 mL of petroleum ether. The instrument was programmed according to the manufacturer's manual (Gerhardt's manual). After extraction, the residue was dried

overnight in a drying oven set at 105 ºC. The percentage of fat content was calculated using the following equation:

$$Fat\ (\%) = [(W1 - W2) \div W0] \times 100$$

W1 is the total weight of the extraction beaker with boiling stones and extracted fat, W2 is the total weight of extraction beaker and boiling stones and W0 is the weight of a healthy bar sample.

3.5.1.4 Ash Content

The total ash content of all health bar samples was determined according to the AOAC (1990), Method 923.03. The percentage of crude ash was calculated using the following equation:

$$Crude\ ash\ (dry\ basis)\ (\%) = (W1 \div W2) \times 100$$

Where W1 is the weight after ashing and W2 is the weight before ashing.

3.5.1.5 Carbohydrate Content

The carbohydrate content of all health bar samples was determined using the following equation:

$$Carbohydrate\ (\%) = 100 - [Moisture\ (\%) + Ash\ (\%) + Protein\ (\%) + Fat\ (\%)]$$

3.5.1.6 Energy Content

There were three major components to determine the energy content of any food including protein, fat and carbohydrate (Forouzesh et al., 2022). The energy content for each health bar samples was determined by multiplying the amount of protein, fat and

carbohydrate with the factor of 4, 9 and 4 respectively (Guide to Nutrition Labelling by Food Safety and Quality Division Ministry of Health Malaysia, 2007).

3.5.1.7 Crude Fibre Content

The crude fibre content of all health bar samples was determined according to AOAC (1990) Method. The crude fibre was determined under the digestion of samples with sulphuric acid. The crude fibre content will be calculated using the following equation;

$$Crude\ fibre\ (\%) = [(C - A) - (D - E)]\ /B \times 100$$

Where C is the weight of the crucible and dried fibre bag after digestion, A is the weight of fibre bag, D is the weight of crucible and ash, E is a blank value for empty fibre bag and B weight of healthy bar sample.

3.5.2 Fatty Acid Profile Analysis

The fatty acid profiling of health bar samples followed the methodology suggested by Wiercioch et al. (2018). Only two health bar samples with the most promising proximate results were chosen for further analysis. These selected health bars were homogenized, and 1.0 g of each sample was utilized in the subsequent steps. Fatty acids were extracted using a Folch mixture consisting of chloroform and methanol in a 2:1 (v:v) ratio, then saponified with 2.0 M potassium hydroxide (KOH) and methylated with a solution of BF3 in methanol, followed by incubation at 70°C. The resulting methyl esters were extracted with hexane, and to separate the phases, a saturated solution of sodium chloride (NaCl) was added. This led to the formation of two layers, with the upper layer being collected and transferred to glass vials. The obtained fatty acid esters underwent qualitative and quantitative analysis using gas chromatography. A Gas Chromatograph (Agilent Technologies 7890 GC System) was employed for the analysis, with specific conditions: an initial temperature of 60°C for 0 minutes, followed by an increase at a rate of 40°C/minute to 160°C (0 minute), further increased at a rate of 30°C/minute to 190°C (0.5 minutes), and then increased at a rate of 30°C/minute to 230°C for 2.6

minutes, where it was maintained for 4.9 minutes. The total analysis duration was approximately 8 minutes, with a gas flow rate of 0.8 ml/minute using hydrogen as the carrier gas. Qualitative analysis involved comparing the peak retention times of the identified substances with standard peak retention times. Meanwhile, quantitative analysis included comparing the surface areas of the peaks with the standard surface area for heneicosanoic acid (C21:0).

3.5.3 Vitamin Analysis

Two of the selected health bar formulations were evaluated for their Vitamin E (alpha-tocopherol) contents. According to Tardy et al. (2020), alpha-tocopherol was one of the most significant vitamins that contribute to the improvement of cognitive performance. Considering the ingredients of health bar that contain fat, the determination of alpha-tocopherol, a fat-soluble vitamin was conducted using Method No: STP/Chem/A11-HPLC.

3.5.4 Mineral Analysis

Magnesium content of the selected health bar formulations was analysed using Method No: STP/Chem/A13-AAS. Theoretically, the functional ingredients of the health bar are rich in magnesium, an essential mineral to boost cognitive function.

3.6 PHYSICAL ANALYSIS OF THE HEALTH BAR

Physical analysis was conducted to determine the outer characteristics of the health bar. It included testing the hardness of the health bar as well as evaluating its colour attributes. The physical analysis was important to identify consumers' preference of the health bar in the later stage.

3.6.1 Texture Analysis

Two health bar samples, exhibiting the most desirable proximate compositions, underwent hardness testing using a Texture Analyzer TA-XT Plus (Stable Micro System, London), following the protocol outlined by Puangjinda, Matan & Nisoa (2016). Each health bar was sliced into pieces measuring 2.0 cm x 5.0 cm x 1.5 cm. Subsequently, the health bar pieces were subjected to compression by a probe blade to assess their hardness under specific conditions: a diameter of 30.0 mm, a test speed of 5 mm s-1, and compression to 70% of the sample's height at 25℃. The Texture Analyzer TA-XT Plus data analysis software was utilized to determine the hardness (N) of the samples.

3.6.2 Colour Evaluation

Determination of colour for each health bar sample was evaluated using Hunter Lab Colorimeter (LabScan XE Spectrophotometer, Hong Kong). Approximately 10.0 g of a health bar from each recipe was crushed and filled in a specific glass container provided before being placed in the colourimeter. As for obtaining the best result, it was crucial to ensure that all samples covered the surface of the glass container (Prazeres *et al.*, 2017). The colour of the health bar samples was determined using the CIELAB system (L*, a*, and b*), and the results was recorded in the logbook.

3.7 ANTIOXIDANT ANALYSIS

3.7.1 Extraction of the Health Bar

The health bar samples from the selected formulations were blended into powder before being extracted. The extraction method was as described by Nayak et al. (2011). 10.0 g from each health bar sample was homogenised in 100 mL extraction solvent (1.5 M HCl/methanol/water; 10:70:20) using a medium speed orbital shaker for 30 minutes. The homogenate was then filtered out using a filter pump after being kept for 30 minutes

at 4°C. After that, the filtrate was centrifuged at 3000 g for 15 minutes. The supernatant was subjected to a rotary evaporator (Eyela, Japan) for an hour to remove the extraction solvent content.

3.7.2 Determination of Antioxidant Activity using DPPH

The DPPH assay involved spectrophotometric determination of the radical at 517 nm using a UV-Vis Spectrophotometer (Varian, America). Initially, a stock solution of 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical at a concentration of 6.10-5 mol L-1 was prepared in methanol. Subsequently, aliquots of 0.1 mL from each sample, diluted in methanol (1:50), were transferred into test tubes and mixed with 2.9 mL of DPPH radical solution. These test tubes were then incubated in darkness at room temperature (25 ± 1°C). Methanol was employed as a blank sample and for instrument calibration. The results were quantified in mM of Gallic Acid per gram of the sample (expressing antioxidant capacity equivalent to Gallic Acid) based on a standard curve generated with Gallic Acid.

3.8 STUDY DESIGN

The inclusion criteria for school selection were based on several aspects, which were i) boarding schools (Maahad Tahfiz), ii) near to Gombak area and iii) having a majority of B40 children and adolescents. Two schools that met these requirements were chosen for the research which were Raudhoh Tahfidz Al-Quran in Hulu Langat, Selangor and Maahad Tahfiz Integrasi Sains Madinatul Huffaz in Gombak, Selangor. After the schools had been successfully selected, data collection was conducted by interviewing school teachers and administrators to recruit potential participants (of the age 10 years old to 16 years old) for this study. After that, basic data cataloguing was conducted by evaluating potential participants' academic and health records to establish the relationship between their background and academic performance and health status and to be compared with previous studies conducted, including allergies towards specific ingredients. Next, interviews of teachers and administrators was conducted to assess

potential participants' condition and behaviour in class before consuming a health bar. The selected participants will be given health declaration form and informed consent form (Please Refer Appendix A) to assess their suitability to participate in the study. The participants were then subjected to conduct an acceptance test of the health bar to evaluate their acceptability and preference using 5-point hedonic scale (Please Refer Appendix B).

3.8.1 Participants

Apparently, according to Aday's (2006) equation, an approximate amount of 51 potential participants were required for this study by using the following equation;

$$n = \frac{2\sigma^2 \left[z_{1-\frac{\alpha}{2}} + z_{1-\beta} \right]^2}{(\mu_1 - \mu_2)^2}$$

Where n is a sample size, σ is the standard deviation from previous research (Teo *et al.*, 2019), $z_{1-\frac{\alpha}{2}}$ is standard normal variate at 95% confidence interval meanwhile $z_{1-\beta}$ is considering the research power at 80%. Based on the study, the mean words recall for Rey's auditory-verbal

Learning Test (RAVLT) before intervention were 8.8 words (μ_2) and 10.2 words afterintervention (μ_1) (Whyte & Williams, 2015). The sample size was then adjusted for an 80% response rate, giving 70 participants required while considering 80% power and 5% level of significance. A total of 70 participants (from both schools) who fulfilled the given criteria were selected and agreed to participate in the study.

3.8.2 Measurements

All selected participants were assessed before the start of the study (pre-intervention) and every two-week right after healthy bar intervention (post-intervention) for two months. The questionnaires were prepared in Malay to help participants in understanding the questionnaires better. The questionnaires involved socio-

demographic backgrounds of participants including sex, age, ethnicity and date of birth (Teo et al., 2019). The collected information was gathered for further study in the later stage.

3.9 ACCEPTANCE TEST (5-POINT HEDONIC SCALE)

The hedonic test was done according to Meilgaard, Civille & Carr. (2007) to evaluate participants' acceptance of health bar samples. All 70 untrained panellists of the age 10 to 16 years old were asked to evaluate two health bars of formulation with the most excellent proximate composition from proximate analysis previously. A picture hedonic scale of 5 points ranging from 1 (Extremely dislike) to 5 (Extremely like) was used to evaluate the two samples. Please refer Appendix B for example of the hedonic scale used. To avoid bias, all samples were weighed approximately 3.0 g and presented to panellists in plates with three-random digit coded numbers. The three-digit random codes assigned to the health bars were unique and not repeated. These codes were recorded in a master list, with the sequences known only to the researcher.

3.10 HEALTH BAR PILOT FOOD INTERVENTION STUDY

The health bar pilot intervention study was conducted by supplying health bar once (every morning) for 8 weeks (approximately 2 months) to observe the improvement of the participants' cognitive function (Ferry et al., 2013) and data collection was conducted for every 2 weeks. During the intervention period, all participants were asked to stop taking any supplements or 'sunnah food' to avoid bias to the study. According to Pribis et al. (2012), the human body required approximately two to three months to respond to the regular diet intake. The intervention consisted of two stages, before the study (pre-intervention) and during the study (post-intervention). The data collection included evaluating participants' health status, health-related quality of life, and

cognitive performance after two months of health bar consumption (Teo et al., 2019). Lastly, statistical analysis was conducted to evaluate the results obtained.

3.10.1 Pre-intervention of Health Bar

A briefing for all participants and teachers was conducted one day before the health bar intervention to explain the nature of this study. The participants were provided with a form to assess the frequency of healthy bar consumption within two weeks. They were instructed to maintain their usual daily food intake and consume meals of similar composition and quantity. This was to minimize the variability among participants (Al-Mana & Robertson, 2018). To ensure that these habits had not been modified during the study, the participants were instructed to record 24-hr dietary recalls (food logs) (Please Refer Appendix C) to ensure accuracy and completeness. The form was meant to be filled daily, weekly and monthly. Since the participants were in boarding school, their food intake was commonly similar. Any unclear aspect was clarified on the spot. Next, all participants were evaluated for anthropometric measurements, health-related quality of life and cognitive performance.

3.10.1.1 Anthropometric Measurements

At first, participants' body weight and height were measured using a weighing scale and stadiometer and recorded to the nearest 0.1 kg and 0.1 cm, respectively. These measurements were used to compute Body Mass Index (BMI) using the BMI formula (Teo et al., 2019):

$$BMI = \frac{weight\ (kg)}{height^2\ (m^2)}$$

The z-scores for weight-for-age (WAZ), height-for-age (HAZ) and BMI for-age (BAZ) were determined using WHO AnthroPlus software (World Health Organization, 2009) to assess the nutritional status of children by comparing the z-scores against the WHO Growth Reference 2007 tables (World Health Organization, 2009).

3.10.1.2 Health-related Quality of Life

The Pediatric Quality of Life Inventory 4.0 (PedsQL 4.0) was utilized to evaluate the health-related quality of life (HRQoL) of the participants (Varni, Seid & Kurtin, 2001), as detailed in Appendix D. This instrument consisted of 23 items divided into four subscales: My health and activities, My feelings, I can get along with others, and About school. Participants were instructed to recall any health-related issues experienced over the past month and rate each item on a 5-point Likert scale ranging from 0 (never) to 4 (almost always). Subsequently, scores were transformed onto a 0–100-point scale, with 0 representing the highest level of impairment and 100 indicating the absence of impairment.

3.10.1.3 Cognitive Performance

All participants were assessed using Rey's Auditory-verbal Learning Test (RAVLT) (Please Refer Appendix E) to evaluate their cognitive performance before health bar intervention. The recruited participants were listening to 15 words (List A) followed by immediate recall of the words for five times. After that, an interference list of 15 words (List B) was provided to the participants with immediate recall as well. The participants were then asked to perform short (2 minutes) delayed recall of the 15 words (List A). At the end of the test, each participant was provided a printed list of 50 words (15 words from List A, 15 words from List B and additional 20 words) and was required to circle only the 15 words from List A. The score was analysed using t-test of analysis of variance (ANOVA), (Whyte et al., 2015). The assessment results were recorded and compared with the post-intervention later.

3.10.2 Post-intervention of Health Bar

Post-intervention of health bar was conducted every two weeks by collecting the forms to assess the frequency of healthy bar consumption. According to Whyte & Williams (2015), the consumption frequency of 5-6 days for two weeks can be included for

further assessments. After that, all participants were being re-evaluated for health-related quality of life and cognitive performance. The results obtained were compared against pre-intervention of a health bar to assess the differences in both results. Figure 3.4 below showed the process during pre-intervention and post-intervention study.

Figure 3.4 Pre-intervention and Post-intervention Study

3.11 STATISTICAL ANALYSIS

All data had been analysed using one-way analysis of variance (ANOVA), followed by Tukey's test (t-test) to compare the means between samples. Data was analysed using SPSS 29.0.2.0.and the statistical will be established at ($p<0.05$). All proximate analyses will be done in triplicate.

3.12 CHAPTER SUMMARY

In conclusion, Chapter Three focuses on the research method applied to the whole study. This chapter offers explanations and rationales for the research design, sample size, research instrument, and data analysis. The development of questionnaires, the tool used in this study, is discussed thoroughly throughout the chapter. Furthermore, this current

chapter presents a step-by-step account of the various stages involved in developing the health bar recipe, evaluating the nutritional composition of the health bar, conducting basic data cataloguing, conducting the pilot food intervention study, as well as ANOVA and t-test procedures. It is important to highlight that this research had applied and obtained ethical approval from International Islamic University of Malaysia (IIUM) Research Ethics Committee (IREC) with reference of IREC No: IREC 2022-197 expiring on 28th November 2023 (Please Refer Appendix D).

CHAPTER FOUR

RESULT AND DISCUSSION

4.1 INTRODUCTION

This chapter discusses the proximate analysis, fatty acid profiling, vitamin analysis, mineral analysis and antioxidant, texture and colour evaluation results of the health bar. It further justifies of the obtained results. Moreover, this chapter also discusses the correlation between the targeted participants' background to their academic performances. The results for acceptance test using 5-point hedonic scale of the health bar are also displayed throughout the chapter. This result is significant to determine participants' acceptability of the health bar. Subsequently, this chapter provides the result of anthropometric measurements, health-related quality of life using Pediatric Quality of Life Inventory 4.0 (PedsQL 4.0), and cognitive performance assessment using Rey's Auditory-verbal Learning Test (RAVLT). These analyses are showed in two stages, the pre-intervention of health bar and post-intervention of health bar. The data analysis was conducted using SPSS 29.0.2.0 by analysing Analysis of Variance (ANOVA) and Tukey's test (t-test).

4.2 PROXIMATE CONTENT OF HEALTH BAR

Proximate analysis was conducted to determine the nutrient content of food products. It helped to determine the moisture, protein, fat, ash, carbohydrate, energy and fibre contents of the health bar. The nutrient content of the 14 health bars is in Table 4.1.

Table 4.1 Proximate Content of the Health Bar

Formulation	Test Parameter / Nutrition facts (per 100 g)						
	Moisture (g)	Protein (g)	Fat (g)	Ash (g)	Carbohydrate (g)	Energy (kcal)	Crude fibre (g)
1	6.09 ± 0.09^{b}	9.38 ± 0.45^{c}	17.80 ± 0.22^{c}	2.76 ± 0.03^{b}	63.97^{a}	453.61^{b}	2.30 ± 0.29^{b}
2	7.10 ± 0.27^{a}	9.67 ± 0.43^{c}	18.17 ± 0.73^{c}	2.49 ± 0.03^{b}	62.56^{a}	452.45^{b}	3.47 ± 0.24^{a}
3	7.69 ± 0.08^{a}	9.80 ± 0.09^{c}	19.68 ± 0.29^{b}	2.37 ± 0.03^{b}	60.48^{a}	458.21^{b}	2.34 ± 0.09^{b}
4	7.87 ± 1.51^{a}	9.51 ± 0.13^{c}	19.59 ± 0.49^{b}	2.43 ± 0.02^{b}	60.60^{a}	456.73^{b}	2.75 ± 0.04^{b}
5	6.80 ± 0.16^{b}	9.41 ± 0.06^{c}	16.83 ± 0.16^{c}	2.49 ± 0.06^{b}	64.47^{a}	446.98^{b}	1.67 ± 0.35^{c}
6	6.41 ± 0.11^{b}	9.82 ± 0.51^{c}	15.06 ± 0.23^{c}	2.85 ± 0.07^{b}	65.87^{a}	438.25^{b}	2.55 ± 0.25^{b}
7	6.02 g ± 0.07^{b}	2.57 ± 0.01^{b}	10.03 ± 0.11^{c}	17.86 ± 0.31^{c}	1.49 ± 0.29^{c}	63.52^{a}	454.92^{b}
8	5.97 ± 0.51^{c}	2.44 ± 0.05^{b}	9.43 ± 0.06^{c}	18.73 ± 0.90^{c}	1.38 ± 0.11^{c}	63.43^{a}	460.01^{b}
9	5.23 ± 0.15^{c}	2.36 ± 0.06^{b}	9.33 ± 0.08^{c}	21.01 ± 0.95^{b}	2.17 ± 0.32^{b}	62.07^{a}	474.67^{b}
10	5.15 ± 0.12^{c}	2.35 ± 0.011^{b}	10.38 ± 0.18^{b}	20.22 ± 0.27^{b}	2.14 ± 0.19^{b}	61.90^{a}	471.10^{b}
11	5.25 ± 0.12^{c}	2.31 ± 0.007^{b}	10.31 ± 0.08^{b}	22.76 ± 0.13^{b}	1.92 ± 0.04^{c}	59.37^{a}	483.58^{b}
12	5.81 ± 0.09^{c}	2.33 ± 0.009^{b}	10.86 ± 0.16^{a}	19.88 ± 0.64^{b}	3.36 ± 0.22^{a}	61.12^{a}	486.83^{b}
13	5.43 ± 0.35^{c}	2.17 ± 0.006^{b}	10.96 ± 0.04^{a}	20.91 ± 0.56^{b}	2.42 ± 0.43^{b}	60.53^{a}	474.13^{b}
14	5.62 ± 0.03^{c}	2.29 ± 0.005^{b}	10.51 ± 0.09^{a}	21.31 ± 0.43^{b}	3.34 ± 0.23^{a}	60.28^{a}	474.92^{b}

Values are means ± SD. Values with the same letters within the same column are not significantly different ($p < 0.05$).

The proximate analysis of the 14 health bar formulations revealed key nutritional content per 100 g sample, as shown in Table 4.1. The moisture content of the health bars ranged from 5.15% to 7.89%. These values are lower than those reported for snack bars made from date paste, which had moisture contents ranging from 15.73% to 26.25% (Parn et al., 2015). The lower moisture content in the current study can be attributed to the use of powdered ingredients, which typically have reduced moisture levels compared to paste-based products. Cuq et al. (2013) highlighted that powdered ingredients can extend the shelf life of food products by slowing down quality degradation, which supports the findings in this study.

The ash content of the health bars ranged from 2.17% to 2.85%, indicating a significant presence of minerals. This is higher than the ash content reported for date-based snack bars (1.88% to 1.93%) (Parn et al., 2015) but lower than snack bars made from oat and date paste, which had ash contents between 1.4% and 4.5% (Munir et al., 2018). The higher ash content observed in this study suggests that the health bars contain substantial micronutrients, likely derived from ingredients such as Moringa oleifera and pumpkin seeds, both known for their mineral content (Syed, Akram & Shukat, 2019; Gopalakrishnan, Doriya & Kumar, 2016).

The protein content was notably high, ranging from 9.33% to 10.96%, which is higher than the values reported in previous studies (Ho et al., 2016; Parn et al., 2015), where protein content ranged from 2.22% to 6.36%. This is likely due to the inclusion of Moringa oleifera and pumpkin seeds, which are rich sources of protein (Devi, Prasad & Saganika, 2018; Olson et al., 2016). According to the European Consumer Health and Consumers Directorate-General (2012), health bars should contain between 10 g and 40 g of protein per 100 g. Impressively, the formulations in this study contributed between 21% and 26% of the daily recommended nutrient intake (RNI) for Malaysian children and adolescents, making them an excellent source of protein for the target population.

The fat content ranged from 15.06% to 22.76%, which is higher than the fat content of 1.93% to 6.43% reported in other studies (Munir et al., 2018; Parn et al., 2015). Although high fat content is generally viewed as undesirable, the fats in these health bars are primarily derived from Sacha inchi oil and Moringa oleifera, both of which are rich in essential fatty acids like omega-3 and omega-6. These fatty acids are

known to improve cognitive function, particularly in children and adolescents (Ya-Nin & Phakkharawat, 2017). Additionally, the health bars in this study could provide between 25.0% and 30.8% of the daily recommended fat intake for Malaysian children and adolescents, as outlined by the National Coordinating Committee on Food and Nutrition (NCCFN), Ministry of Health Malaysia (2017).

The crude fibre content was relatively low, ranging from 1.38% to 3.47%. However, these values are consistent with those reported by Saini et al. (2021) and Javed et al. (2020), who found fibre contents between 2.05% and 2.52%. According to European Parliament and Council Regulation (No. 1924/2006), products that contain at least 3 g of fibre per 100 g can be classified as "containing a source of fibre." Several of the formulations in this study meet this criterion. Consuming fibre-rich health bars is linked to improved satiety and longer periods of fullness (Ho et al., 2016), which suggests that the formulations developed here could offer similar benefits.

In terms of energy provision, the health bars in this research supplied between 438.25 kcal and 486.83 kcal per 100 g, which translates to approximately 16.60% to 18.44% of the daily energy requirement for adolescents and 20.60% to 22.86% for children. This is in line with the energy values of carbohydrate-rich bars, with carbohydrate content in this study ranging from 59.37% to 65.87%, which is similar to the 56.77% to 72.65% range reported by Parn et al. (2015).

In conclusion, the health bars developed in this study exhibit favourable proximate composition, particularly in terms of protein, fat, and fibre content. The inclusion of nutrient-dense ingredients such as Moringa oleifera and Sacha inchi oil significantly contributed to the nutritional quality of the bars, making them a suitable option for improving the dietary intake of children and adolescents. The findings are well-supported by previous studies and adhere to relevant nutritional guidelines, further validating the health benefits of these formulations.

4.3 SELECTION OF TWO BEST HEALTH BAR FORMULATIONS

Based on the results of the proximate composition analysis in Table 4.1, Formulation 12 and Formulation 14 were selected for further evaluation due to their superior nutrient profiles. The selection criteria for these two formulations were based on their lower moisture content, and higher values of ash, protein, fat, and crude fibre, all of which are critical for ensuring the health bar's nutrient density and shelf stability.

Firstly, moisture content is a significant factor in the selection process, as it directly affects the shelf life and texture of the health bar. A lower moisture content reduces the risk of microbial growth, enhancing the product's stability. Formulation 12 exhibited a moisture content of 5.81 g per 100 g sample, while Formulation 14 recorded 5.62 g, making them among the lowest in moisture content compared to other formulations. This reduction in moisture is advantageous as it extends the shelf life of the bars and maintains product quality over time.

Secondly, the ash content in both formulations was higher than in others, indicating a richer presence of minerals essential for health. Formulation 12 recorded 2.33 g of ash, and Formulation 14 contained 2.29 g. These values suggest that these formulations are likely to provide a significant amount of micronutrients, such as magnesium and other essential minerals, which contribute to the overall nutritional value of the product.

The protein content in both formulations was another deciding factor in their selection. Protein is a crucial nutrient for growth and cognitive development, especially for the target consumers—children and adolescents. Formulation 12 and Formulation 14 exhibited the highest protein contents, with 10.86 g and 10.51 g per 100 g sample, respectively. This high protein content, mainly derived from ingredients like Moringa oleifera and pumpkin seeds, ensures that the health bars provide a substantial portion of the recommended daily protein intake, contributing to the dietary needs of the target group.

Additionally, the fat content in both formulations was also found to be optimal for providing essential fatty acids, which are crucial for brain function and cognitive development. Formulation 12 contained 19.88 g of fat, while Formulation 14 had 21.31 g. Both formulations include essential fats such as omega-3 and omega-6 fatty acids, primarily sourced from Sacha inchi oil and Moringa oleifera. These fats play a vital role in maintaining cognitive performance, memory, and attention, particularly in growing children and adolescents.

Lastly, the crude fibre content was also an important factor in the selection process. A higher fibre content enhances satiety, which can help manage hunger levels, making the health bar a more effective snack for the target population. Formulation 12 contained 3.36 g of fibre, and Formulation 14 had 3.34 g, both of which meet the criteria for being considered a "source of fibre" as per European Parliament regulations (No. 1924/2006).

In conclusion, Formulation 12 and Formulation 14 were selected for further analysis because they exhibited the most desirable nutrient compositions, including lower moisture content and higher values of ash, protein, fat, and crude fibre. These characteristics not only align with the study's objectives of developing a nutrient-dense health bar but also ensure that the final product will provide the necessary nutrients to support the cognitive performance and overall health of the targeted group of children and adolescents.

4.4 FATTY ACID PROFILING OF HEALTH BAR

The fatty acid profiling for both health bar formulations, Formulation 12 and Formulation 14 had been carried out to evaluate the polyunsaturated fat content of the health bars. Polyunsaturated fatty acid is a healthy dietary fat that can enhance body growth and brain functions (Hashimoto & Hossain, 2011). The polyunsaturated fatty acid contents for both formulations were displayed in Table 4.2 and 4.3.

Table 4.2 Polyunsaturated Fat Content of Formulation 12

Structure	Fatty Acid Methyl Ester Polyunsaturated Fat	% in Fat	mg/100g Sample
C 18:2n6t	Linolelaidic (Trans)	0.0000	0.00
C 18:2n6c	Linoleic (Cis)	38.7994	5742.31
C 18:3n6	γ-Linolenic	0.0000	0.00
C 18:3n3	a-Linolenic	8.6702	1283.18
C 20:2	Cis-11,14-Eicosadienoic	0.0000	0.00
C 20:3n6	Cis-8,11,14-Eicosatrienoic	0.0000	0.00
C 20:3n3	Cis-11,14,17-Eicosatrienoic	0.0000	0.00
C 20:4n6	Arachidonic	0.0000	0.00
C 20: 5n3	Cis-5,8,11,14,17-Eicosapentaenoic	0.0000	0.00
C 22:2	Cis-13, 16-Docosadienoic	0.5049	74.73
C 22:6n3	Cis-4,7,10,13,16,19-Docosahexaenoic	0.0000	0.00
	Total	**47.9744**	**7100.21**

Table 4.3 Polyunsaturated Fat Content of Formulation 14

Structure	Fatty Acid Methyl Ester Polyunsaturated Fat	% in Fat	mg/100g Sample
C 18:2n6t	Linolelaidic (Trans)	0.0000	0.00
C 18:2n6c	Linoleic (Cis)	35.0404	6797.84
C 18:3n6	γ-Linolenic	0.0000	0.00
C 18:3n3	a-Linolenic	15.5247	3011.79
C 20:2	Cis-11,14-Eicosadienoic	0.0000	0.00
C 20:3n6	Cis-8,11,14-Eicosatrienoic	0.0000	0.00
C 20:3n3	Cis-11,14,17-Eicosatrienoic	0.0000	0.00
C 20:4n6	Arachidonic	0.0000	0.00
C 20: 5n3	Cis-5,8,11,14,17-Eicosapentaenoic	0.0000	0.00
C 22:2	Cis-13, 16-Docosadienoic	0.2971	57.63
C 22:6n3	Cis-4,7,10,13,16,19-Docosahexaenoic	0.0000	0.00
	Total	**50.8622**	**9867.27**

The highlighted components from Table 4.2 and Table 4.3 were Linoleic (Cis) acid and a-Linolenic acid, both were omega-6 and omega-3 respectively. These polyunsaturated fats were essential for the development of brain function and improvement of memory (Dighriri et al., 2022). The obtained profile was then submitted to SPSS software to test its significance. The further results were as shown in Table 4.4.

Table 4.4 Polyunsaturated Fat Content of the Health Bar

Formulation	Fatty acid profile (mg /100 g sample)	
	Linoleic (cis)	α-Linolenic
12	5742.31 [a]	1283.18 [a]
14	6797.84 [a]	3011.79 [a]

Values with the same letters within the same column are not significantly different ($p < 0.05$).

Fatty acid profiling (polyunsaturated fatty acid) of the health bars (Formulation 12 and Formulation 14) was conducted to profile the composition of fat content recorded from the result of proximate analysis. Both formulations showed no significant difference in the amount of Linoleic (cis) acid and α-Linolenic acid ($p < 0.05$). Approximately 5742.31 mg (80.88%) and 1283.18 mg (18.07%) of Linoleic (cis) acid and α-Linolenic acid per 100 g sample were found in Formulation 12 respectively. Meanwhile, Linoleic (cis) acid (omega-6) and α-Linolenic acid (omega-3) in health bar of Formulation 14 consisted about 6797.84 mg (68.90%) and 3011.79 mg (30.52%) for each 100 g sample respectively. Both formulations produce no statistically significant differences in the content of these acids as denoted by the same letter in each column.

As mentioned in Table 4.4, both polyunsaturated fatty acids played pivotal role in improving consumers' cognitive performance, hence the determination of these fatty acids were imperative. The high values of both essential fatty acids were contributed by the significant amount of Sacha inchi oil added in both formulations. Beforehand, the recent study analysed the Linoleic (cis) acid and α-Linolenic acid in pure Sacha inchi oil and found approximately 39.86% and 42.71%, marking nearly 83.00% of the total fat content. One of the main functions of omega-3 (α-Linolenic acid) was to transmit ions and neurotransmitter inside and outside of nerve cells (Dong et al., 2020). The insufficiency of omega-3 fatty acid will cause other fatty acids to fill in and might reducing the fluidity of cell membrane, damaging synapses and dendrites while disrupting the concentration of neurotransmitter inside and outside the nerve cells, resulting in difficulties for brain to function well (Hashimoto & Hossain, 2011). Moreover, Dighriri et al. (2022) explained, that the supplementation of omega-3 and

omega-6 in diets could lead to a greater saturation and concentration of haemoglobin oxygen, promoting the blood circulation in the brain, thus, improving early memory and learning deficiencies mainly in young children. The results suggested that the health bar contained a significant amount of essential polyunsaturated fat that may impart a positive effect on the cognitive performance.

4.5 MINERAL, VITAMIN AND ANTIOXIDANT CONTENT OF HEALTH BAR

The analyses conducted were important to determine mineral, vitamin and antioxidant level in the health bar samples. Previous research conducted, elucidated that magnesium and vitamin E (alpha-tocopherol) enhanced cognitive performance (Tardy et al., 2020). Table 4.5 displayed the content of magnesium, vitamin E (alpha-tocopherol), and the percentage of DPPH inhibition in the chosen health bar formulations (Formulation 12 and Formulation 14).

Table 4.5. Mineral, vitamin, and antioxidant content of the health bar

Formulation	Analysis		
	Magnesium (mg/kg)	Vitamin E (alpha-tocopherol) (mg/100g)	DPPH (% inhibition)
12	1166[a]	0.43 [a]	7.37 [a]
14	1152 [a]	0.80 [a]	8.91 [a]

Values with the same letters within the same column are not significantly different ($p < 0.05$).

Based on table 4.5, it can be concluded that Formulation 12 and Formulation 14 were not significantly different in terms of the magnesium, vitamin E (alpha-tocopherol) and DPPH inhibition. The amount of magnesium recorded for both formulations were 1166.0 mg/kg (Formulation 12) and 1152.0 mg/kg (Formulation 14) respectively, slightly higher than the result obtained by Munir et al. (2018),

approximately 1074 mg/kg. The daily RNI suggested that both male and female children and adolescents to consume at least 410.0 mg and 360 mg accordingly, proposing these health bars could fulfil the requirement. Meanwhile, as compared to the RNI, both health bars contained a lower vitamin E, 0.43 mg/100 g (Formulation 12) and 0.80 mg/100 g (Formulation 14) to which the recommended amount was 10.0 mg/100 g (for male) and 7.5 mg/100 g (for female). The health bars could only provide a range of 4.3% (Formulation 12) to 5.7% (Formulation 14) for male and female children and adolescents correspondingly.

Formulation 12 documented 7.37% of DPPH inhibition whereas 8.91% DPPH inhibition for Formulation 14 relatively smaller than the findings reported in previous study which recorded a range of 12.40% to 26.04% (Yasinta, Yao & Chang, 2021), suggesting that the latest health bar formulations might exerted a minimal scavenging effect on free radical. DPPH assay was a stable radical used to measure the scavenging capacity of antioxidant towards it by donating a hydrogen atom to reduce the odd electron of nitrogen atom (Kedare & Singh, 2011). The DPPH inhibition could represent the ability of the antioxidant to donate its hydrogen atom to stabilise free radical that can harm brain function. Previous study listed the essential micronutrients to improve cognitive performance including, magnesium, potassium, zinc, vitamin E and vitamin B-complex (Tardy et al., 2020). These micronutrients had significant effects on cognitive performance as they were directly involved in the energy metabolism of neurons and neuroglia (cells that provided metabolic support for neurons), the synthesis of neurotransmitters, the binding of receptor and the maintenance of membrane-ion pumps (Huskisson, Maggini & Ruf, 2007). It was safe to conclude that the recent health bar formulations could provide essential nutrients that can help to boost cognitive performance.

4.6 TEXTURE AND COLOUR EVALUATION OF HEALTH BAR

Determining the texture and colour attributes were important as they were the indicator for the level of acceptance of the health bars by consumers. The texture of the health bars (Formulation 12 and Formulation 14) recorded a hardness (N) of 24.03 ± 2.49 and 23.59 ± 2.67 respectively similarly to the previous research 24.27 ± 0.29 and 25.14 ±

0.69 (Yasinta, Yao & Chang, 2021). The authors explained that the hardness of the health bar was due to the gelatinisation of sugar alcohol as it cooled down and infused together with the hygroscopic date powder causing the compact structure of the health bar. However, the hardness of the health bar was on an acceptable range, indicating that it can be chewed easily (Parn et al., 2015). Meanwhile, colour properties of the selected healthy bars were **L*** 48.97 ± 0.84 and 44.02 ± 0.14, **a*** 4.79 ± 0.11 and 6.62 ± 0.14, and **b*** 20.82 ± 0.60 and 24.70 ± 0.40 accordingly. The letter **L***, **a*** and **b*** in colour analysis were denoted for lightness, redness and yellowness. For **L*** spectrum the value of 0 – 50 indicated that the product was dark in colour whereas 51 – 100 indicated that the product was light in colour. From the results, both health bars were dark in colour because of the caramelisation of sugar alcohol used in the preparation of the health bars (Lucas et al., 2019). Besides, the positive value of **a*** and **b*** showed that the health bars were in red and yellow spectrum, resulting in an orange hue (Parn et al., 2015).

All results displayed justified the first research question, objective and hypothesis in which to develop health bar formulation that can exert excellent nutrients for its consumers' health and cognitive performance. The next section will discuss the second and third research questions, objectives and hypotheses, catering the pilot food intervention aspect.

4.7 BASIC DATA CATALOGUING AND ITS CORRELATION TO NUTRIENT AND COGNITIVE PERFORMANCE OF THE B40 CHILDREN AND ADOLESCENTS

4.7.1 Descriptive Analysis of Participants' Demographic

The first stage to recruit the potential participants was by providing questions pertaining to the demographic background of the participants and the health screening form to assess any allergy reaction towards certain types of food. The summary of the descriptive analysis results for the first stage can be found in Table 4.6. Frequency, mean, and standard deviation were calculated using SPSS for each scale in the demographic profile (gender, age, religion, and health status).

Table 4.6 Demographic Background of Participants

Demographic	Description / Characteristics	Frequency	Percent (%)
Gender	Male	54	77.1
	Female	16	22.9
Age	10 – 11 years	-	-
	12 – 13 years	6	8.6
	14 – 15 years	50	71.4
	16 – 17 years	14	20.0
Religion	Islam	70	100.0
	Budha	-	-
	Christian	-	-
	Hindu	-	-
	Atheist	-	-
	Sikhism	-	-
Allergy towards any food	Yes	7	10.0
	No	63	90.0
Food that caused the allergy	Seafood	6	86.0
	Egg	1	14.0
	Legume and nuts	-	-
	Cereals	-	-
	Dairy products	-	-
Reaction as became in contact with the food	Irritation and nauseous	7	100.0
	No reaction	-	

As can be seen from Table 4.6, this current research comprised 54 male participants (77.1%) and 16 female participants (22.9%), indicating a major representation of males. In terms of age distribution, the participants were divided into four categories: 10 to 11 years, 12 to 13 years, 14 to 15 years, and 16 to 17 years. Most of the respondents were between 14 to 15 years with 50 participants (71.4%), followed by the age between 16 to 17 years with 14 participants (20.0%) and age between 41 to 50 years with 65 respondents (21%). There were 22 respondents (7.1%). Lastly, a

minority of six participants (8.6%) were 12 to 13 years. In terms of religion, all participants in this study were Muslims with 70 participants (100.0%) considering they were from Maahad Tahfiz.

Since this research involved pilot food intervention study, it was crucial to conduct health screening assessment prior the intervention (Teo et al., 2019). This is to assess the suitability of the participants to participate in the study. The health screening form had been distributed to all participants and each question had been explained deliberately. Majority of the participants, 63 participants (90.0%) had no allergy towards any food meanwhile a total of seven participants (10.0%) had allergy reaction towards certain food. Six of the participants (86.0%) had allergy reaction towards seafood and only one participant (14.0%) had an allergy reaction towards egg. They were having symptoms of irritation and nauseous as became in contact with the mentioned food. Fortunately, all participants were safe to consume legume, nuts, cereals, and dairy products, the main ingredients in the health bar. From the first stage, all participants were eligible to participate in the current research.

4.7.2 Descriptive Analysis of Participants' Background

In the later stage, the school teachers from both schools had been interviewed to identify participants' background and their academic achievement. Most of the participants, approximately 50 participants (71.4%) came from underprivileged households. Only 20 participants (28.6%) were from a decent household. According to the teachers, an apparent difference was observed between the participants of the B40 communities and M40 communities mainly based on their academic performance and adaptability in the school environment. Figure 4.1 and 4.2 displayed the pie chart of the B40 and M40 participants in the current research.

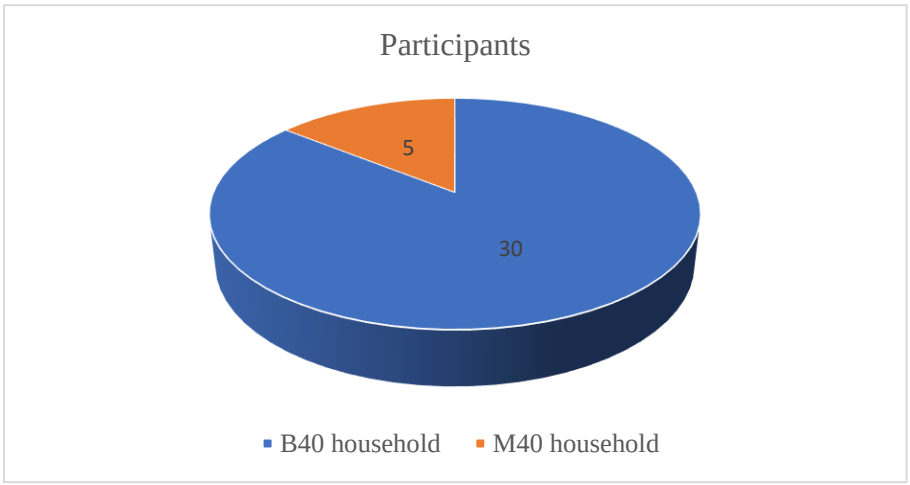

Figure 4.1 Household Background of Participants in Raudhoh Tahfidz Al-Quran

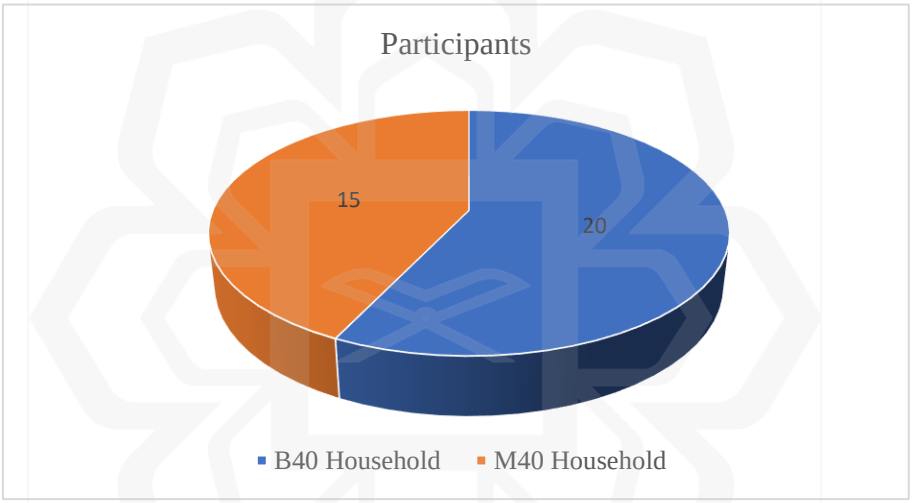

Figure 4.2 Household Background of Participants in Maahad Tahfiz Integrasi Sains Madinatul Huffaz

Comprehensive research had been conducted by reviewing previous studies to establish the relationship between participants' background to their academic and health status. Suzana et al. (2019) explained that lower socioeconomic status affected three major aspects of life; physical health, mental health, and nutritional status especially among children and adolescents. In another research, 22.8% children and adolescents from underprivileged households were suffering from obesity, one of the non-communicable diseases and greatly associated with poor cognitive function (Poh et al., 2019). This situation occurred due to limited knowledge on nutrient intake, low-income status, and household's food insecurity (Rosli et al., 2018).

Allang et al. (2019) suggested three factors that influenced academic performance of children and adolescents from the B40 households including growing environment, supportive parents, and internal motivation. The first factor was based on Ecological System Theory, developed by Bronfenbrenner, 1979. This theory accentuated that the interaction between environment and individuals influenced their growth from birth to adulthood. This interaction involved the individuals living closely to the children and the condition of the household they grew (Muhd Zuri et al., 2013). These environments were responsible to shape the growth of the children. Zuraidah et al. (2019) elucidated, children from poor households seek comfort from their parents'support and love especially in the form of financial provisions to aid their education, constructive and harmony encouragement and being supportive of their growing teenage phase.

Next, referring to Havighurst's Development Theory (Azizi et al., 2011), the human development consisted of three stages; children, adolescents and adults. The most critical stages were the children and adolescents as they were the determinants of the upbringing into adulthood. The development process of children revolved around the beginning of life and environment. Meanwhile, in the adolescence stage, they were being exposed to real-life experience to adapt to the surroundings and often responsible for decision making and independent. However, they may experience different problems and conflicts during this stage and in need of support. Allang et al. (2019) explained that there were three stages in the development tasks; i. Protective parents hindered the development tasks whilst democratic parents aided to accelerate the tasks. ii. Children and adolescents' cognitive performance was greatly affected by poverty and starvation as they denied individual's educational opportunity. iii. Incompatible and violence households interrupted children's psychological needs.

The third theory was based on McClelland's Theory of Motivation of Achievement, 1961 which displayed internal motivation that carved individual's behaviour influenced individual's achievement. Therefore, he highlighted that success was greatly related to achievement motivation. Individuals that were successful, gained sufficient moral support, and lived a conducive lifestyle, would be highly motivated to pursue success.

The deep explanation answered the second research question, objective and hypothesis in which background of children and adolescent influenced their academic

performance and health status. The next section will further discuss the third research questions, objectives and hypotheses, catering the pilot food intervention aspect.

4.8 ACCEPTANCE TEST (5-POINT HEDONIC SCALE)

Acceptance test involved rating the acceptability between two samples. 5-point hedonic scale (visual rating) was applied due to the suitability with the age of the panellists (10 to 16 years). A simple graphic hedonic scale of 5-point was distributed to 70 untrained panellists with a range of 1 = Very bad, 2 = Bad, 3 = Maybe good or maybe bad, 4 = Good, and 5 = Very good (Stone et al., 2008). All panellists were to rate two health bar formulations (Formulation 12 and Formulation 14) based on their acceptability of the samples. The results obtained were as shown in Table 4.7 and Figure 4.3 below.

Table 4.7 Acceptance Test Result of Health Bar

Attribute	Health Bar Formulation	Frequency n = 70	Percent (%)
Very bad	Formulation 12	-	-
	Formulation 14	-	-
Bad	Formulation 12	-	-
	Formulation 14	-	-
Maybe good or maybe bad	Formulation 12	5	7.2
	Formulation 14	3	4.3
Good	Formulation 12	50	71.4
	Formulation 14	15	21.4
Very good	Formulation 12	15	21.4
	Formulation 14	52	74.3

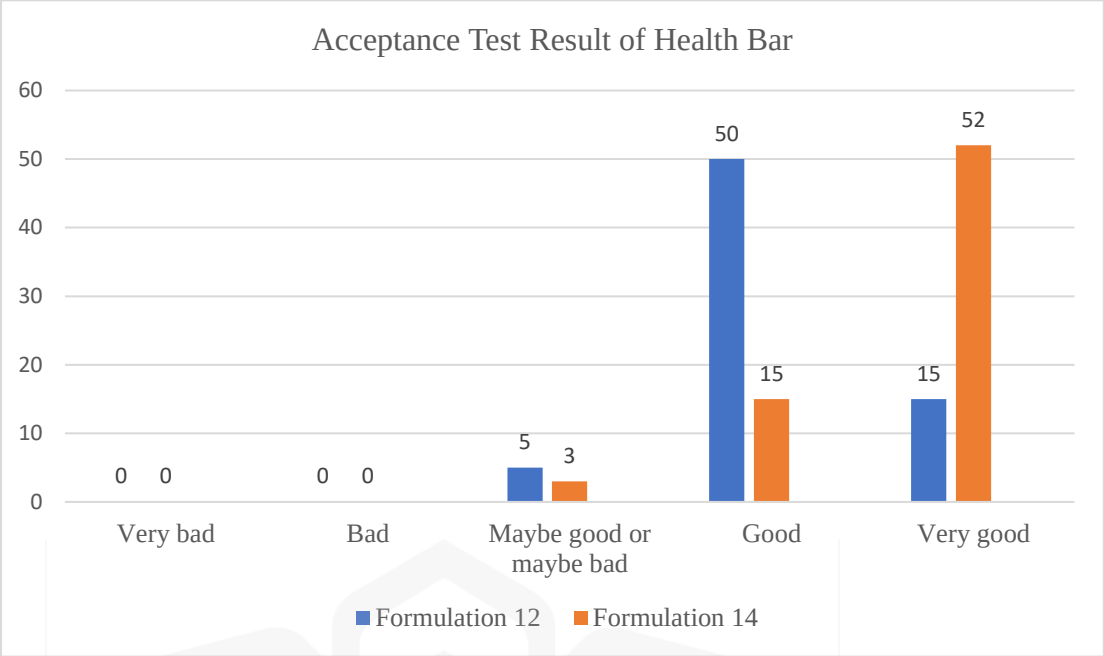

Figure 4.3 Acceptance Test Result of Health Bar

Based on the data presented in Table 4.7 and Figure 4.3, majority of the panellists preferred health bar from Formulation 14. 74.3% of the panellists voted “very good” for health bar of Formulation 14 and another 21.4% voted for health bar of Formulation 12. Meanwhile, approximately 71.4% of the panellists voted “good” for health bar of Formulation 12 while another 21.4% voted for health bar of Formulation 14. There was a small percentage of panellists voted “maybe good or maybe bad” with only 7.2% and 4.3% for health bar of Formulation 12 and Formulation 14 respectively. Although, the percentage of panellists voted “good” for health bar of Formulation 12 was relatively high, the research continued to mass-produced health bar of Formulation 14 that gained the highest votes at the highest degree of acceptance, which was “very good”.

Compared to the recipe of health bar of Formulation 12, the recipe of health bar of Formulation 14 comprised of a higher amount of date powder, slightly increased the sweetness of the health bar and a lower amount of Moringa *(Moringa oleifera)* powder, reduced the aftertaste of the sample. Thus, it probably contributed to the higher acceptability of the health bar among the panellists. Both formulations had a significant amount of nutrients that might improve cognitive performance upon their consumption However, only health bar of Formulation 14 was greatly produced based on the acceptability by panellists to be supplied during the pilot food intervention study.

4.9 PRE-INTERVENTION SETUP

In the beginning of the study, all participants were requested to submit Informed Consent Form as the validation that they agreed to participate in the study with permission or consent from their guidance. A total of 70 Informed Consent Forms were collected and all participants were allowed to participate in the study. Next, the participants were given a set of forms; i. Frequency of Health Bar Consumption (meant to be filled daily for two weeks) and ii. Frequency of Food Intake or food logs (meant to be filled daily, weekly and monthly). The food logs were important to ensure all participants consume similar type of food within the study period and to prevent any variability in the outcome. Each form was requested to be presented before every visit during the intervention period. After the distribution of related forms, the anthropometric measurements started.

4.10 ANTHROPOMETRIC MEASUREMENTS INFORMATION

The weight and height of each participant were recorded by their physical and health education teacher. The related data was computed into WHO AnthroPlus Software to generate the body mass index (BMI), weight-for-age z-score (WAZ), height-for-age z-score (HAZ), and BMI-for-age z-score (BAZ). The obtained z-scores were compared against the WHO Growth Reference 2007 for children and adolescents aged 5 to 19 years to assess the health and nutrient status of the participants (Teo et al., 2019). Table 4.9, Table 4.10, and Table 4.11 present the anthropometric data of the participants aged 12 to 13 years, 14 to 15 years, and 16 to 17 years, respectively. Meanwhile, Figures 4.4 to 4.13 display the graphs imported from WHO AnthroPlus Software for HAZ and BAZ of both male and female participants across all age groups.

Table 4.8 Anthropometric Data of Participants of the Age 12 to 13 Years

Parameter	n (%) / Mean ± SD		
	Male (n = 4)	Female (n = 2)	*p*-value
Body weight (kg)	29.95 ± 6.98	37.00 ± 0.78	0.296
Height (cm)	154.00 ± 2.58	149.00 ± 1.41	0.615
BMI (kg/m^2)	12.60 ± 3.12	15.70 ± 0.07	0.286
WAZ	NA	NA	-
HAZ	-0.28 ± 1.22	-1.06 ± 0.77	0.110
BAZ	-4.04 ± 2.34	-0.97 ± 0.81	0.432
Severe thinness	3 (75.00)	-	-
Thinness	-	-	-
Normal	1 (25.00)	2 (100.00)	-
Overweight	-	-	-
Obesity	-	-	-

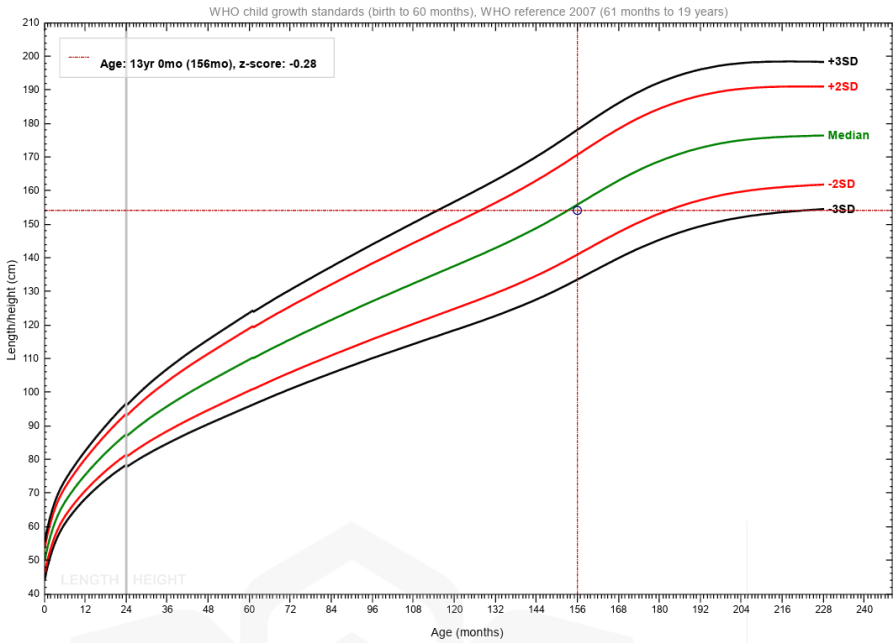

Figure 4.4 HAZ z-score Graph for Male Participants of the Age 12 to 13 years

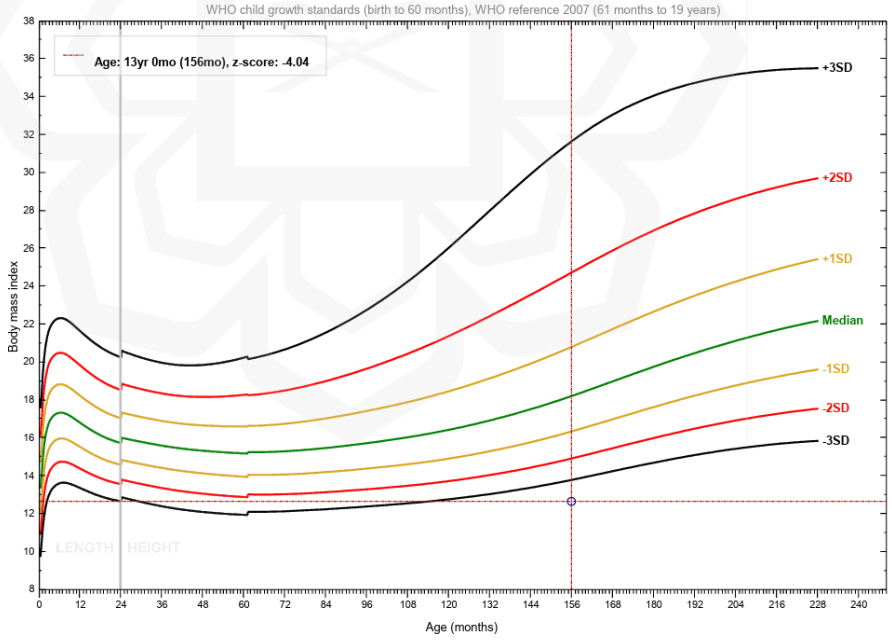

Figure 4.5 BAZ z-score Graph for Male Participants of the Age 12 to 13 years

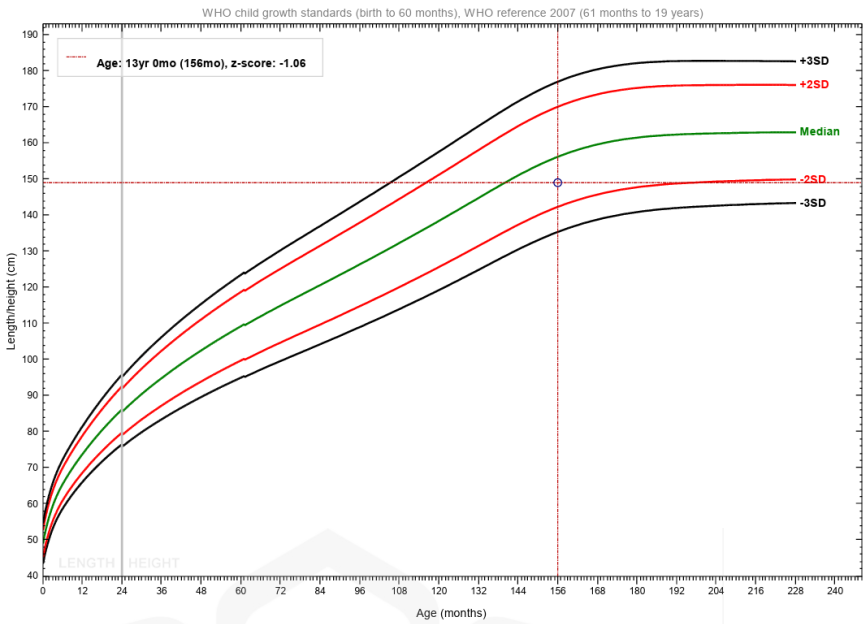

Figure 4.6 HAZ z-score Graph for Female Participants of the Age 12 to 13 years

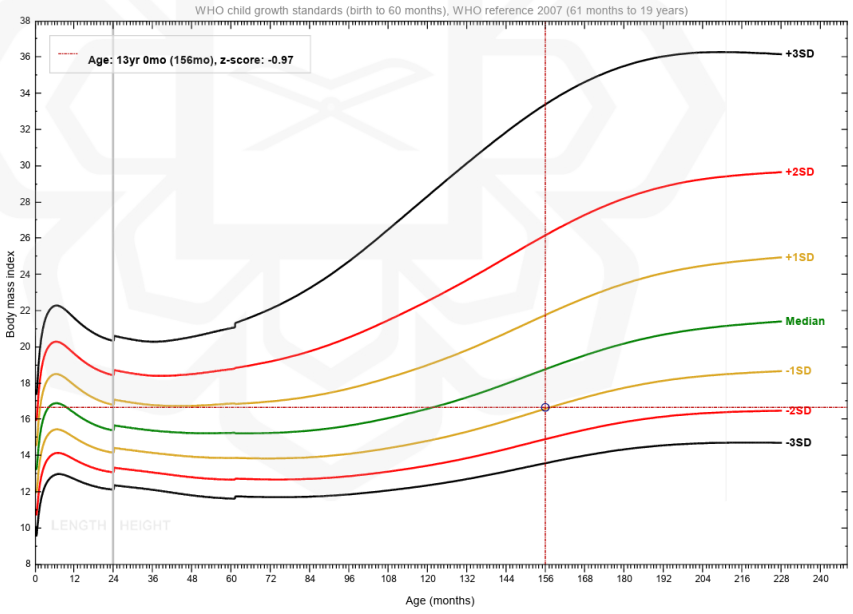

Figure 4.7 BAZ z-score Graph for Female Participants of the Age 12 to 13 years

As can be seen from Table 4.8, the means body weight and height for both male and female participants of the age 12 to 13 years were 29.95 ± 6.98 kg, 37.00 ± 0.78 kg, 154 ± 2.58 cm and 149 ± 1.41 cm respectively with no significant different ($p > 0.05$). Meanwhile, the HAZ mean z-score and BAZ z-score for both female and male participants of the same age were -0.28 ± 1.22, -1.06 ± 0.77, -4.04 ± 2.34 and -0.97 ± 0.81 respectively. The results were also had no significant difference ($p > 0.05$) between male and female participants. The BAZ mean z-score were then compared to WHO Growth Reference 2007 cut-off, 5.56% of the male participants from this age group (12 to 13 years) were in the severe thinness category with a normal or median HAZ z-score indicating that the participants were of normal height. Similar result can be observed as reported by Cheah et al. (2022) in which 7.60% of urban children (10 to 12 years) were in the severe thinness category. The same research also explained, the impoverished family background influenced this condition. In addition, approximately 1.85% of the male participants and 12.50% of the female participants from this age group were having a normal BAZ and HAZ. Figure 4.4, Figure 4.5, Figure 4.6, and Figure 4.7 illustrated the graph from WHO AnthroPlus Software.

Table 4.9 Anthropometric Data of Participants of the Age 14 to 15 Years

Parameter	n (%) / Mean ± SD		
	Male (n = 36)	Female (n = 14)	*p*-value
Body weight (kg)	58.26 ± 12.50	52.87 ± 8.53	0.398
Height (cm)	166.20 ± 5.59	152.30 ± 6.84	1.000
BMI (kg/m^2)	21.02 ± 3.96	22.69 ± 2.46	0.416
WAZ	NA	NA	-
HAZ	0.39 ± 1.34	-1.08 ± 2.21	0.593
BAZ	0.79 ± 1.46	1.02 ± 1.54	0.075
Severe thinness	-	-	-
Thinness	4 (11.11)	-	-
Normal	16 (44.44)	7 (50.00)	-
Overweight	11 (30.56)	7 (50.00)	-
Obesity	5 (13.89)	-	-

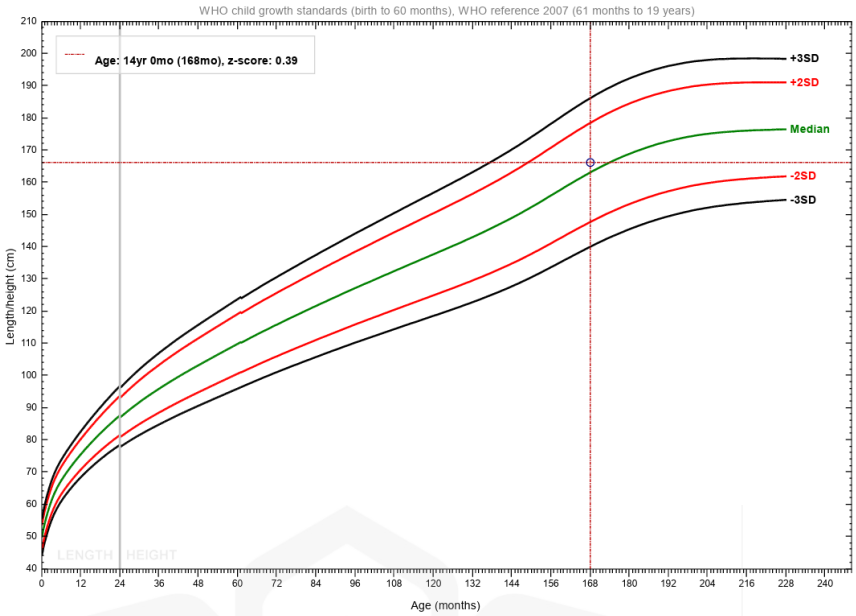

Figure 4.8 HAZ z-score Graph for Male Participants of the Age 14 to 15 years

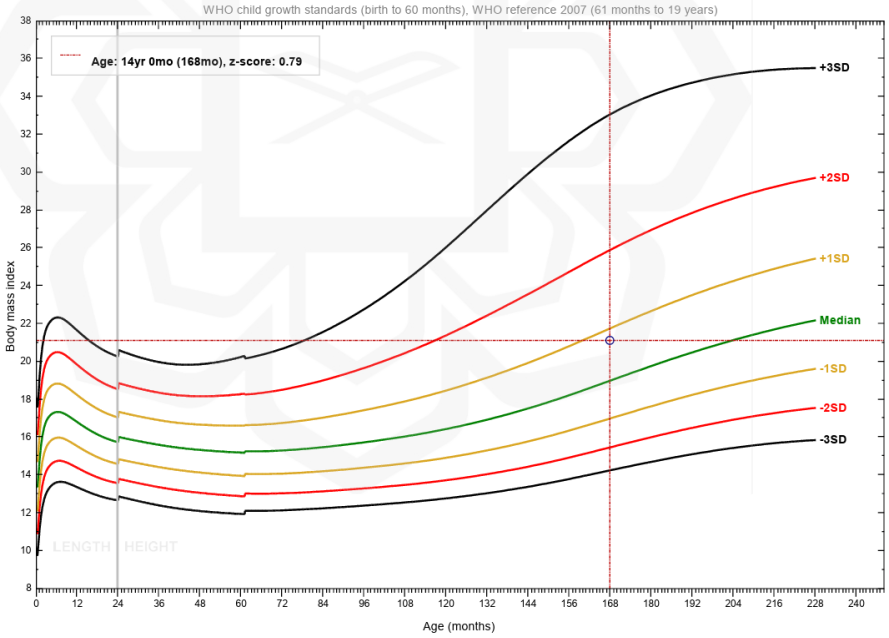

Figure 4.9 BAZ z-score Graph for Male Participants of the Age 14 to 15 years

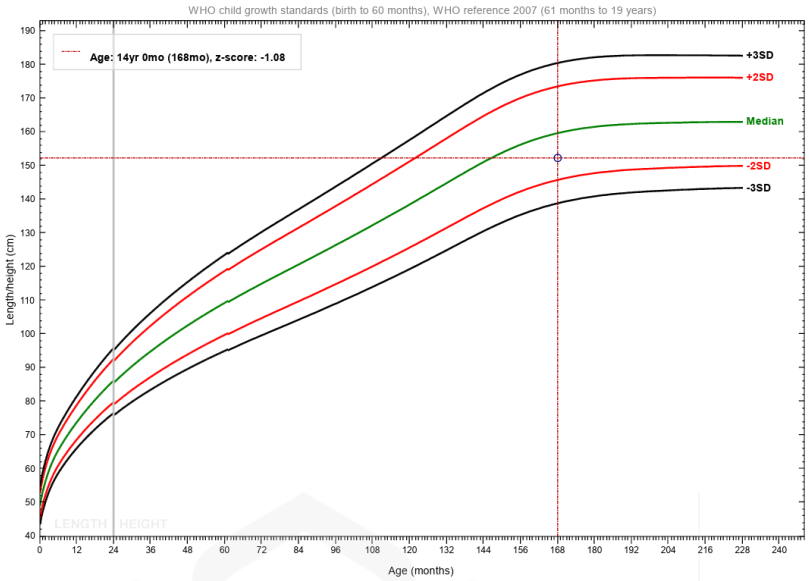

Figure 4.10 HAZ z-score Graph for Female Participants of the Age 14 to 15 years

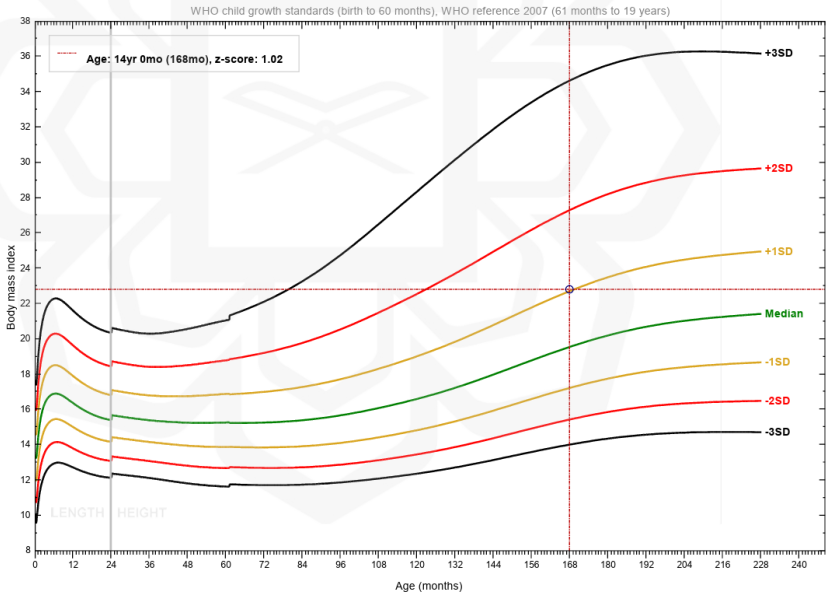

Figure 4.11 BAZ z-score Graph for Female Participants of the Age 14 to 15 years

The data in Table 4.9 showed the average body weight and height for both male and female participants of the age 14 to 15 years were 58.26 ± 12.50 kg, 52.87 ± 8.53 kg, 166.20 ± 5.59 cm, and 152.30 ± 6.84 cm consecutively with no significant difference ($p > 0.05$) for both genders. Furthermore, the result for both means of HAZ and BAZ z-scores for male and female participants of the similar age group were 0.39 ± 1.34, -1.08 ± 2.21, 0.79 ± 1.46, 1.02 ± 1.54 with no significant different ($p > 0.05$). The tabulated BAZ z-score data were compared to the WHO Growth Reference cut-off, more than half of the male participants who were between 14 to 15 years were within normal category, 20.37% of the total male participant were overweight and minority of 7.41% and 9.25% were slightly thin and obese respectively. Meanwhile, equally half (43.75%) of the female participants in this age category fell into both classes normal and overweight based on their BAZ z-score data. Another research by Teo et al. (2019) explained that children and adolescents from this age of group (14 to 15 years) already had the ability to choose a balanced diet for their meal intake. Although, some might be disadvantage to make the choice because of their urban-poor household (Suzana et al., 2019). Figure 4.8, Figure 4.9, Figure 4.10, and Figure 4.11 illustrated the graph computed from WHO AnthroPlus Software.

Table 4.10 Anthropometric Data of Participants of the Age 16 to 17 Years

Parameter	n (%) / Mean ± SD	
	Male (n = 14)	*p*-value
Body weight (kg)	58.21 ± 12.96	1.000
Height (cm)	166.71 ± 4.94	1.000
BMI (kg/m^2)	20.76 ± 3.86	1.000
WAZ	NA	-
HAZ	-0.80 ± 1.54	0.437
BAZ	0.17 ± 2.34	0.057
Severe thinness	-	-
Thinness	1 (7.14)	-
Normal	11 (78.58)	-
Overweight	1 (7.14)	-
Obesity	1 (7.14)	-

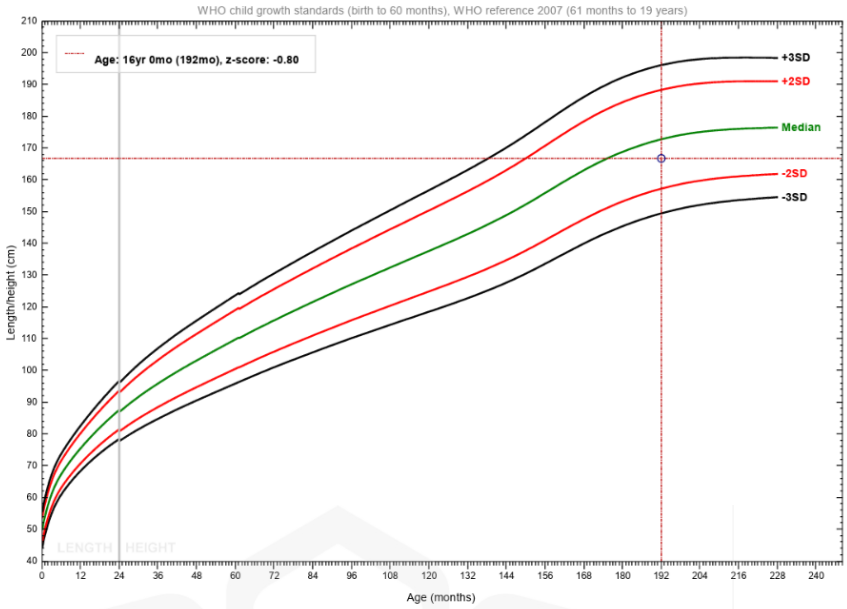

Figure 4.12 HAZ z-score Graph for Male Participants of the Age 16 to 17 years

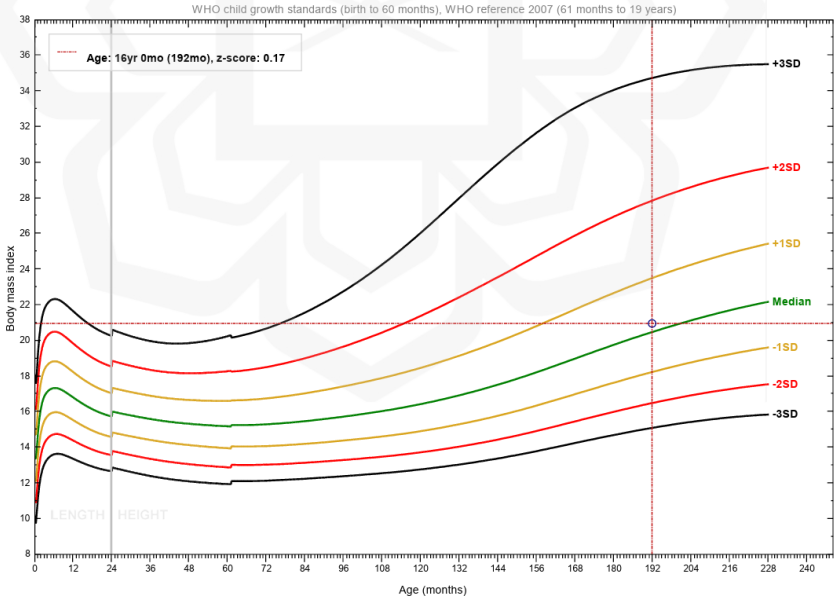

Figure 4.13 BAZ z-score Graph for Male Participants of the Age 16 to 17 years

The presented data in Table 4.10 was for male participants of the age 16 to 17 years. The selection of participants was conducted randomly resulting in negative participation of female participants from this group of age. The means body weight and height of the participants were 58.21 ± 12.96 kg and 166.71 ± 4.94 cm respectively with a BMI recorded at 20.76 ± 3.86 kg/m^2. The HAZ and BAZ means z-scores obtained were -0.80 ± 1.54 and 0.17 ± 2.34. The comparison of BAZ z-score with WHO Growth Reference cut-off, more than half of the participants were of the normal category meanwhile another 5.56% were either slightly thin, overweight or obese. Figure 4.12 and Figure 4.12 were the graphs from WHO AnthroPlus Software.

To summarise, 28 (58.85%) out of 54 male participants from all ages were classified as having normal BMI-to-age. Meanwhile, 9 (56.25%) out of 16 female participants recorded normal BMI-to-age. This result showed that the health condition of all participants was at satisfactory level (Lee et al., 2012). However, another half of the participants were either fell in severe thinness, thinness, overweight or obesity categories. The data showed nearly 5.55% of the participants were severe thinness while 9.26% were slightly thin. Approximately 22.22% and 43.75% of the male and female participants were overweight respectively. Although a small amount, 11.11% (6 out of 54) male participants were obese, the situation was very much worrisome since Malaysia aspired to have zero school children obesity (Suzana et al., 2019). Most of the participants in the current research were from poor households, the result obtained can be justified with a poor nutrition knowledge, household food insecurity and low socioeconomic income (Shoesmith et al., 2020). The policymakers should start serving the critical needs of the minority group to prevent the obesity and severe thinness condition to increase.

4.11 RESULT ON HEALTH-RELATED QUALITY OF LIFE

Before the evaluation, all participants were required to present their frequency of health bar consumption form in order to assess their eligibility of their participation on that day. Participants that consumed at least five health bars during the past two weeks were allowed to proceed in the evaluation (Whyte et al., 2015). Since the daily health bar intake was monitored by the school teachers, all participants had successfully consumed at least the minimum amount of health bar in the two weeks period. The food logs were

also collected to analyse any variability on the food intake of the participants to avoid false result obtained. The health-related quality of life (HRQoL) of the participants was evaluated using Pediatric Quality of Life Inventory 4.0 (PedsQL 4.0). Health-Related Quality of Life (HRQoL) served as a crucial metric in healthcare, providing a comprehensive assessment of the participants physical, emotional, social, and functional well-being in relation to their health status and medical interventions (Teo et al. 2019). All participants were required to answer 23 items from four dimensions such as physical, emotion, social, and school. They were requested to recall the health-related dimensions for the past one month and rated the items in a range of 0 to 4 and the scores were plotted on a different scale given 0 = 100, 1 = 75, 2 = 50, 3 = 25, 4 = 0. The results for HRQoL for male participants using one-way analysis of variance (ANOVA) were recorded as of the before intervention, after one month of intervention, and after two months of intervention were presented in Table 4.11.

Table 4.11 Pediatric Quality of Life Inventory (PedsQL 4.0) Result for Male Participants

Dimension	Intervention Period	Mean (%)	Std. Deviation	F	Sig.
Physical	Pre-intervention	93.25	0.167	24.181	<.001
	1-month intervention	95.00	0.151		
	2-month intervention	97.50	0.063		
	Total	95.00	0.153		
Emotional	Pre-intervention	89.00	0.313	14.460	<.001
	1-month intervention	91.25	0.226		
	2-month intervention	95.00	0.110		
	Total	91.75	0.251		
Social	Pre-intervention	83.00	0.335	34.409	<.001
	1-month intervention	86.00	0.215		
	2-month intervention	94.00	0.282		
	Total	87.75	0.335		
School	Pre-intervention	86.00	0.000	598.881	<.001
	1-month intervention	87.75	0.107		
	2-month intervention	95.00	0.000		
	Total	89.25	0.180		

The analysis results of One-way ANOVA for the Pediatric Quality of Life Inventory 4.0 (PedsQL 4.0) among male participants revealed significant findings across multiple dimensions. Firstly, in terms of the physical dimension, there were notable differences in mean scores across the intervention periods, indicating varying levels of improvement in physical well-being over time ($F = 24.181$, $p < .001$). This suggested that the intervention had a discernible impact on the physical aspects of participants' quality of life, with potential implications for their overall health and functioning.

Similarly, the emotional dimension also demonstrated significant differences in mean scores across intervention periods ($F = 14.460$, $p < .001$). This implied that the intervention had varying effects on the emotional well-being of male participants, potentially influencing factors such as mood, stress levels, and coping mechanisms. Similar finding had been reported by Cheah et al. (2022), that the intervention conducted had positive effects on the emotional well-being of the participants especially in boosting the mood and stress levels. Understanding these emotional changes can be crucial for devising targeted interventions to support participants' mental health needs.

Moreover, the social dimension exhibited significant differences in mean scores across intervention periods ($F = 34.409$, $p < .001$). This highlighted the intervention's impact on participants' social functioning and interactions. Variations in social well-being may reflected changes in peer relationships, social support networks, and overall social adjustment, underscoring the importance of addressing social aspects in interventions aimed at enhancing quality of life. Allang et al. (2019) mentioned that schoolchildren mainly in boarding school required a healthy peer relationships and support as they spent most of the time at school. A friendly environment among the children and adolescents could led to a positive quality of life.

Remarkably, the school dimension showed highly significant differences in mean scores across intervention periods ($F = 598.881$, $p < .001$), indicating substantial changes in participants' school-related functioning. This suggests that the intervention had a profound effect on participants' academic performance, school engagement, and overall school experience. Understanding these effects was vital for implementing interventions that promote academic success and educational attainment among male participants.

Table 4.12 Pediatric Quality of Life Inventory (PedsQL 4.0) Result for Female Participants

Dimension	Intervention Period	Mean (%)	Std. Deviation	F	Sig.
Physical	Pre-intervention	92.50	0.062	45.500	<.001
	1-month intervention	95.00	0.062		
	2-month intervention	96.75	0.000		
	Total	94.75	0.087		
Emotional	Pre-intervention	83.75	0.339	19.891	<.001
	1-month intervention	88.75	0.089		
	2-month intervention	95.00	0.000		
	Total	89.25	0.272		
Social	Pre-intervention	88.75	0.089	27.036	<.001
	1-month intervention	91.50	0.120		
	2-month intervention	95.00	0.073		
	Total	91.75	0.140		
School	Pre-intervention	87.50	0.310	6.980	.002
	1-month intervention	90.00	0.207		
	2-month intervention	94.75	0.089		
	Total	90.75	0.248		

The analysis results of one-way ANOVA for the Pediatric Quality of Life Inventory 4.0 (PedsQL 4.0) among female participants offered valuable insights into how intervention periods influence different dimensions of their quality of life. In terms of the physical dimension, the findings revealed significant improvements over the course of the intervention. With a substantial (F-value of 45.500, $p < .001$), the mean

scores demonstrated a clear trend of enhancement in physical well-being among female participants. This suggests that the intervention has a notable impact on aspects related to physical health, potentially leading to increased overall vitality and functioning.

Similarly, the emotional dimension displayed significant differences in mean scores across intervention periods ($F = 19.891$, $p < .001$). This highlighted the intervention's effectiveness in addressing emotional well-being among female participants. As the intervention progresses, there was a discernible improvement in emotional health indicators, indicating enhanced coping mechanisms and emotional resilience.

The social dimension also showed noteworthy improvements throughout the intervention, with significant differences in mean scores observed ($F = 27.036$, $p < .001$). This suggested that the intervention positively influences social functioning among female participants, fostering stronger interpersonal relationships and social support networks. Such improvements were crucial for overall well-being and sense of belonging within social contexts. Qiao et al. (2021) delineated those female children and adolescent exhibited a propensity for encountering greater challenges in peer interactions in contrast to their male counterparts, attributable to factors such as diminished self-esteem and reticence. The researchers emphasized the pivotal role of peer support in fostering a sense of belonging and social integration among female children and adolescents.

While the effect size appears smaller, the school dimension also demonstrated significant differences in mean scores across intervention periods ($F = 6.980$, $p = .002$). This indicated that the intervention contributed to improvements in school-related functioning among female participants, albeit to a lesser extent compared to other dimensions. Nonetheless, these enhancements were valuable, as they can lead to better academic performance and school engagement. Next, the comparative results of PedsQL 4.0 for both male and female were recorded below.

Table 4.13 Comparative Results of Pediatric Quality of Life Inventory (PedsQL 4.0) for Male and Female Participants

Dimension	Male (n = 54)		Female (n = 16)		*p*-value
	Total mean (%)	Std. Deviation	Total mean (%)	Std. Deviation	
Physical	95.00	0.153	94.75	0.087	1.000
Emotional	91.75	0.251	89.25	0.272	1.000
Social	87.75	0.335	91.75	0.140	1.000
School	89.25	0.180	90.75	0.248	1.000

The results of the ANOVA analysis comparing male and female participants' scores on the Pediatric Quality of Life Inventory 4.0 (PedsQL 4.0) revealed several noteworthy findings. Across all dimensions, physical, emotional, social, and school there were no statistically significant differences in mean scores between male and female participants, as indicated by p-values of 1.000 for each dimension.

In terms of physical well-being, both male and female participants reported comparable mean scores, with males averaging 95.00% and females averaging 94.75%. This suggested that there were no discernible gender differences in self-reported physical health and functioning among the participants in this study.

Similarly, in the emotional dimension, males had a mean score of 91.75% compared to females' mean score of 89.25%. Despite a slight numerical discrepancy, the lack of statistical significance (p = 1.000) indicated that both genders perceived similar levels of emotional well-being.

The Social dimension also showed similar patterns, with males scoring an average of 87.75% and females scoring 91.75%. Once again, the absence of a significant difference (p = 1.000) suggested that both male and female participants reported comparable levels of social functioning and satisfaction.

Finally, in the school dimension, males had a mean score of 89.25% while females had a slightly higher mean score of 90.75%. However, the lack of statistical significance ($p = 1.000$) implies that there were no significant differences in how males and females perceived their school-related functioning and experiences.

The results obtained from the current research were comparable to the one reported by Cheah et al. (2022). There weas no significant difference among the means across the dimensions between male and female participants. It was safe to conclude that the gender disparity had littlest to no impact towards the HRQoL.

The favorable outcome observed in the health bar intervention's impact on Health-Related Quality of Life (HRQoL) was largely attributed to the beneficial components presented in the health bar formula. This included the incorporation of dark chocolate compound, known to enhance mood according to research by Shin et al. (2022), alongside date powder, recognised for its potential to bolster mental well-being based on findings by Moslemi, Dehghan, & Khani (2022). Over the span of two months, the dietary intervention involving the consumption of health bars showed potential for improving individuals' overall quality of life.

In summary, the ANOVA analysis underscored the significant impact of the intervention on various dimensions of the Pediatric Quality of Life Inventory 4.0 among male participants. By recognizing these differences across intervention periods, healthcare professionals and researchers can tailor interventions more effectively to address specific aspects of quality of life, ultimately improving the well-being and overall outcomes for male participants. Further exploration through post-hoc tests can provide deeper insights into the specific effects of the intervention at different time points and dimensions.

Moreover, the ANOVA results underscored the effectiveness of the intervention in enhancing various dimensions of quality of life among female participants. By targeting physical, emotional, social, and school-related aspects, the intervention demonstrates a comprehensive approach to promoting overall well-being among this demographic. Further analysis with post-hoc tests can provide additional insights into the specific effects of the intervention at different time points within each dimension, aiding in the development of targeted interventions tailored to the needs of female participants.

Overall, the ANOVA results indicated that there were no significant gender disparities in the perceived quality of life across various dimensions among the participants in this study. These findings suggested a level of parity in self-reported physical, emotional, social, and school-related aspects of well-being between male and female participants, underscoring the importance of considering gender-neutral approaches when assessing and addressing quality of life in pediatric populations.

4.12 RESULT ON REY'S AUDITORY VERBAL LEARNING TEST

As usual, all participants were requested to present their frequency of health bar consumption form and food logs before the test. Rey's Auditory Verbal Learning Test (RAVLT) was conducted every two weeks prior intervention for two months. The results were tabulated in Table 4.14.

Table 4.14 Rey's Auditory Verbal Learning Test (RAVLT) Result for Male Participants

Total Recall	Intervention	Mean	Std. Deviation	F	Sig.
A1	PI	5.0	0.116	2.760	<.001
	I2	6.2	0.231		
	I4	7.3	0.116		
	I6	8.9	0.058		
	I8	9.2	0.288		
	Total	7.4	1.629		
A2	PI	7.2	0.116	1.001	.451
	I2	8.4	0.231		
	I4	38.7	50.518		
	I6	11.4	0.231		
	I8	12.5	0.173		
	Total	10.3	22.597		
A3	PI	9.9	0.173	2.814	<.001
	I2	10.6	0.116		
	I4	11.4	0.116		
	I6	13.3	0.289		
	I8	14.1	0.173		
	Total	11.8	1.660		

A4	PI	10.6	0.116	2.836	<.001
	I2	11.8	0.173		
	I4	12.5	0.173		
	I6	14.5	0.173		
	I8	15.2	0.404		
	Total	12.9	1.793		
A5	PI	10.9	0.173	1.173	<.001
	I2	11.9	0.116		
	I4	13.4	0.173		
	I6	14.9	0.404		
	I8	15.2	0.462		
	Total	13.2	1.756		
B1	PI	4.9	0.115	3.436	<.001
	I2	5.8	0.289		
	I4	7.2	0.231		
	I6	10.1	0.346		
	I8	10.6	0.115		
	Total	7.7	2.367		
A6	PI	10.0	0.173	1.600	<.001
	I2	10.7	0.404		
	I4	11.8	0.173		
	I6	13.6	0.115		
	I8	14.4	0.288		
	Total	12.1	1.724		
A7	PI	10.5	0.173	8.422	<.001
	I2	11.4	0.115		
	I4	12.6	0.115		
	I6	14.7	0.115		
	I8	15.0	0.000		
	Total	12.8	1.838		
Sum	PI	43.2	1.039	2.398	<.001
	I2	49.0	0.866		
	I4	54.2	0.692		
	I6	63.1	1.097		
	I8	66.3	1.501		
	Total	55.2	8.937		
Recognition	PI	10.4	0.231	4.713	<.001
	I2	11.6	0.115		
	I4	12.7	0.173		
	I6	14.8	0.173		
	I8	15.0	0.000		
	Total	12.9	1.852		

A1 – A5: Number of recalls for List A (5 times), B1: Number of recall for List B (1 time), A6 – A7: Immediate recalls for List A (2 times), Recognition: Number of words from List A.

The Rey Auditory Verbal Learning Test (RAVLT) results for male participants following several weeks of intervention offer insights into the impact of the intervention on their memory performance. Across different intervention periods, significant improvements were observed in total recall scores, as evidenced by notable increases in mean scores from the pre-intervention (PI) phase to subsequent intervention periods (I2, I4, I6, and I8) for each recall trial (A1 to A7). For instance, in trial A1, the mean recall score rose steadily from 5.0 in the pre-intervention phase to 9.2 in the final intervention phase (I8). This pattern of improvement is consistent across all recall trials, demonstrating the effectiveness of the intervention in enhancing participants' ability to recall verbal information.

Furthermore, the sum of recall scores across all trials also demonstrated a significant increase over the intervention periods, indicating a cumulative enhancement in memory performance. From a mean score of 43.2 in the pre-intervention phase, the total recall score rose to 66.3 in the final intervention phase (I8), underscoring the overall efficacy of the intervention in improving memory function among male participants.

Additionally, in the recognition phase, significant improvements in recognition memory were observed across intervention periods. Similar to the recall trials, there was a consistent upward trend in mean recognition scores from the pre-intervention phase to subsequent intervention phases (I2, I4, I6, and I8). This suggested that the intervention not only enhanced participants' ability to recall information but also improved their ability to recognize previously presented verbal stimuli. The result for RAVLT for female participants was displayed in Table 4.15.

Table 4.15 Rey's Auditory Verbal Learning Test (RAVLT) Result for Female Participants

Total Recall	Intervention	Mean	Std. Deviation	F	Sig.
A1	PI	5.8	0.289	1.497	<.001
	I2	6.4	0.231		
	I4	7.4	0.058		
	I6	9.0	0.000		
	I8	9.1	0.289		
	Total	7.6	1.394		

A2	PI	7.4	0.116	4.687	<.001
	I2	8.7	0.289		
	I4	9.7	0.000		
	I6	11.6	0.116		
	I8	12.5	0.173		
	Total	9.9	1.942		
A3	PI	10.1	0.173	3.321	<.001
	I2	10.8	0.173		
	I4	11.4	0.116		
	I6	13.4	0.173		
	I8	14.1	0.173		
	Total	11.9	1.597		
A4	PI	10.8	0.173	1.964	<.001
	I2	11.8	0.173		
	I4	12.5	0.173		
	I6	14.6	0.116		
	I8	15.2	0.404		
	Total	12.9	1.741		
A5	PI	11.0	0.058	1.518	<.001
	I2	11.9	0.116		
	I4	13.4	0.173		
	I6	15.1	0.289		
	I8	15.3	0.462		
	Total	13.3	1.740		
B1	PI	5.0	0.000	3.502	<.001
	I2	5.8	0.289		
	I4	7.2	0.231		
	I6	10.1	0.346		
	I8	10.6	0.115		
	Total	7.7	2.332		
A6	PI	10.2	0.289	1.096	<.001
	I2	10.9	0.462		
	I4	11.8	0.173		
	I6	13.6	0.115		
	I8	14.4	0.289		
	Total	12.2	1.647		

A7	PI	10.7	0.000	2.030	<.001
	I2	11.5	0.000		
	I4	12.6	0.115		
	I6	14.7	0.115		
	I8	15.0	0.000		
	Total	12.9	1.760		
Sum	PI	45.1	0.231	3.020	<.001
	I2	49.7	0.982		
	I4	54.4	0.519		
	I6	63.6	0.693		
	I8	66.3	1.501		
	Total	55.8	8.364		
Recognition	PI	10.7	0.000	7.498	<.001
	I2	11.6	0.115		
	I4	12.7	0.173		
	I6	14.8	0.173		
	I8	15.0	0.000		
	Total	12.9	1.776		

A1 – A5: Number of recalls for List A (5 times), B1: Number of recalls for List B (1 time), A6 – A7: Immediate recalls for List A (2 times), Recognition: Number of words from List A.

The Rey Auditory Verbal Learning Test (RAVLT) results for female participants following several weeks of intervention shed light on the effects of the intervention on their memory performance. Across various intervention periods, significant improvements were evident in total recall scores, underscoring the intervention's positive impact on memory function among female participants. Notably, in each recall trial (A1 to A7), mean recall scores exhibited consistent increases from the pre-intervention (PI) phase to subsequent intervention phases (I2, I4, I6, and I8). For example, in trial A1, the mean recall score rose steadily from 5.8 during the pre-intervention phase to 9.1 in the final intervention phase (I8). This trend persisted across all recall trials, reflecting the effectiveness of the intervention in enhancing participants' ability to retrieve verbal information from memory.

Moreover, the sum of recall scores across all trials also demonstrated a significant increase over the intervention periods, indicating a cumulative improvement in memory performance among female participants. From a mean score of 45.1 in the pre-intervention phase, the total recall score escalated to 66.3 in the final intervention

phase (I8), highlighting the overall efficacy of the intervention in enhancing memory function.

Furthermore, in the recognition phase, significant enhancements in recognition memory were observed across intervention periods. Similar to the recall trials, there was a consistent upward trajectory in mean recognition scores from the pre-intervention phase to subsequent intervention phases (I2, I4, I6, and I8). This indicated that the intervention not only enhanced participants' ability to recall previously presented verbal stimuli but also improves their ability to recognise these stimuli when presented again. The comparative result of RAVLT for both male and female participants were recorded in table 4.16.

Table 4.16 Comparative Result of RAVLT for Male and Female Participants

Total recall	Male (n = 54)		Female (n = 16)		*p*-value
	Total mean score	Std. Deviation	Total mean score	Std. Deviation	
A1	7.4	1.629	7.6	1.394	0.075
A2	10.3	22.597	9.9	1.942	0.052
A3	11.8	1.660	11.9	1.597	0.055
A4	12.9	1.793	12.9	1.741	0.050
A5	11.8	1.660	13.3	1.740	0.835
B1	7.7	2.367	7.7	2.332	0.050
A6	12.1	1.724	12.2	1.647	0.055
A7	12.8	1.838	12.9	1.760	0.054
Sum	55.2	8.937	55.8	8.364	0.057
Recognition	12.9	1.852	12.9	1.776	0.050

A1 – A5: Number of recalls for List A (5 times), B1: Number of recalls for List B (1 time), A6 – A7: Immediate recalls for List A (2 times), Recognition: Number of words from List A.

The Rey Auditory Verbal Learning Test (RAVLT) results comparing male and female participants following several weeks of intervention provided valuable insights into the effects of the intervention on memory performance across genders. While the total mean scores for most recall trials (A1 to A7) and the sum of recall scores showed no statistically significant differences between male and female participants, several trials exhibited marginal p-values, suggesting potential trends worth exploring further. Notably, in trials A1, A2, A3, A4, B1, A6, A7, and the sum of recall scores, the p-values range from 0.050 to 0.075, indicating a borderline significance level. Although these p-values did not reach conventional thresholds for statistical significance, they warranted attention as they approached significance, suggesting possible gender-related differences in memory performance that may be influenced by the intervention.

Additionally, the recognition phase showed similar trends, with no statistically significant differences in mean recognition scores between male and female participants. However, the marginal p-value of 0.050 suggests a potential trend toward significance, hinting at gender-related variations in recognition memory that may be worthy of further investigation.

The Rey Auditory Verbal Learning Test (RAVLT) results exhibited notable influence from the health bar intervention, attributed to its exceptional nutrient composition. The health bars, enriched with 1152 mg/kg magnesium, 0.80 mg/100g vitamin E, 8.91% DPPH inhibition, 6797.84 linoleic acid, and 3011.79 alpha-linolenic acid, showcased a robust combination of essential nutrients. These nutrients were renowned for their potential cognitive benefits, including improved memory function and cognitive performance (Hashimoto & Hossain, 2011). The incorporation of date powder, moringa powder, sacha inchi oil, and pumpkin seed further enhanced the health bars' nutritional profile, contributing to their overall efficacy in promoting cognitive health.

Magnesium played a pivotal role in synaptic plasticity and neurotransmitter release, vital processes underlying memory formation and retention (Yasinta, Yao & Chang, 2021). Kedare & Singh (2011) elucidated, vitamin E, with its antioxidant properties, safeguarded neuronal membranes from oxidative stress, potentially preserving cognitive function and mitigating age-related cognitive decline. The observed 8.91% DPPH inhibition underscored the health bars' antioxidant capacity,

which may protect against neuronal damage and support cognitive health (Tardy et al., 202). As explained by Dong et al. (2020), Linoleic acid and alpha-linolenic acid, essential fatty acids abundant in the health bars, are integral components of neuronal membranes and contribute to synaptic integrity and cognitive function.

Furthermore, the inclusion of date powder, moringa powder, sacha inchi oil, and pumpkin seed enriched the health bars with additional bioactive compounds and micronutrients known for their neuroprotective properties. Date powder, for instance, contains phenolic compounds with antioxidant and anti-inflammatory properties (Nasir et al., 2015), while moringa powder is rich in polyphenols and flavonoids, which may exert neuroprotective effects (Singh et al., 2019). Sacha inchi oil provides a rich source of omega-3 fatty acids, supporting cognitive function and synaptic plasticity (Carillo et al., 2018). Pumpkin seed contributes essential nutrients like zinc and magnesium, which play key roles in neuronal signalling and cognitive processing Syed, Akram, & Shukat (2019).

Overall, the RAVLT results indicated that the intervention implemented over several weeks had a profound and positive impact on memory performance among male participants. The observed improvements in both recall and recognition memory underscore the effectiveness of the intervention in enhancing cognitive function, with implications for their overall cognitive health and well-being. In addition, the RAVLT results demonstrated that the intervention implemented over several weeks has a considerable and positive impact on memory performance among female participants. The observed improvements in both recall and recognition memory underscore the effectiveness of the intervention in enhancing cognitive function, with implications for their overall cognitive health and well-being.

In summary, while the differences in memory performance between male and female participants following the intervention were not statistically significant in most cases, the borderline significance observed in some trials underscores the importance of considering gender as a factor when analysing the effects of interventions on memory function. Further research with larger sample sizes may helped elucidated these trends and provided a more comprehensive understanding of gender differences in response to memory interventions.

The presented results addressed the third research question, objective, and hypothesis, focusing on the potential enhancement of health and cognitive performances among participants from the B40 community through a pilot health bar intervention study. The findings demonstrated promising outcomes regarding the intervention's impact on cognitive function, as evidenced by the Rey Auditory Verbal Learning Test (RAVLT) results and on health quality of life, from Pediatric Quality of Life Inventory (PedsQL 4.0).

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 INTRODUCTION

The objective of this concluding chapter is to summarise and analyse the findings presented in Chapter Four in line with the research objectives. Furthermore, this section will explore the implications and limitations of the study, while also providing recommendations for future research.

5.2 CONCLUSION

This preliminary food intervention investigation has shed light on the viability of the research endeavor. The favorable outcomes observed in both health and cognitive assessments indicate a meaningful that further study should be conducted to obtain better results in the future.

5.3 SUMMARY OF FINDINGS

In this section, the investigator provides a thorough overview of the research outcomes in accordance with its objectives. The first objective of the study is to determine health bar formulation and its physical and chemical characteristics as part of the intervention study involving the children and adolescents of B40 community. Then, the second

objective focuses on the relationship between nutrition intake to health and cognitive performance of the children and adolescents of the B40 community through basic data cataloguing. The final objective is to assess the improvement of health and cognitive performance of the children and adolescents of the B40 community through survey and health bar pilot food intervention study.

5.3.1 Research Objective 1

To determine health bar formulation and its physical and chemical characteristics as part of the intervention study involving the children and adolescents of B40 community.

To achieve this objective, the researchers established upper and lower limits for key ingredients such as date powder, Sacha inchi *(Plukenetia Volubilis)* oil, and Moringa (*Moringa oleifera)* powder. The upper limits of date powder, Sacha inchi *(Plukenetia Volubilis)* oil, and Moringa *(Moringa oleifera)* powder were 12.5%, 10.0% and 7.5%, respectively. Meanwhile, the lower limits of these ingredients were 7.5%, 5.0% and 2.5%, respectively. These limits were meticulously calculated and inputted into the Stat Ease Design Expert Version 12 software, resulting in the creation of 14 distinct formulations.

Each of these formulations was subjected to comprehensive analysis, encompassing several essential parameters including moisture content, ash content, protein levels, fat content, crude fiber, carbohydrate composition, and overall energy content per 100 grams. The findings unveiled notable variations across the formulations, highlighting differences in nutrient profiles and energy density. Subsequently, two health bars exhibiting exceptional nutrient content were selected for further analysis.

Furthermore, the study delved into the fatty acid profiles of two specific formulations, revealing significant disparities in the levels of linoleic and α-linolenic acids. This aspect is crucial as these fatty acids play vital roles in human health, particularly in relation to cardiovascular health and cognitive function. Moreover, the

analysis extended to the examination of magnesium content, vitamin E (alpha-tocopherol) levels, and DPPH (2,2-diphenyl-1-picrylhydrazyl) inhibition, which served as an indicator of antioxidant activity. The results showcased distinct differences between the formulations, underscoring variations in their nutritional and functional properties.

In addition, texture analysis was conducted to assess the hardness of the health bars, revealing that they fell within an acceptable range, suggesting that they can be easily consumed by the target population. Furthermore, color properties were evaluated, elucidating differences in L* (lightness), a* (redness/greenness), and b* (yellowness/blueness) values among the selected formulations. These color variations were not only aesthetically significant but may also influence consumer perception and acceptability.

In conclusion, these findings provide valuable insights into the nutritional composition and physical characteristics of health bars, which are essential for informing the development of effective intervention strategies aimed at enhancing the health and cognitive performance of children and adolescents within the B40 community.

5.3.2 Research Objective 2

To identify the relationship between nutrition intake to health and cognitive performance of the children and adolescents of the B40 community through basic data cataloguing.

The research objective aimed to establish the correlation between nutritional intake, health, and cognitive performance among children and adolescents in the B40 community through fundamental data collection. The findings underscored the profound impact of lower socioeconomic status on various aspects of life, including physical health, mental well-being, and nutritional status, particularly evident among children and adolescents. Studies indicated that a significant portion of youngsters from

economically disadvantaged backgrounds faced challenges such as obesity, which is intricately linked to cognitive impairment. This situation often arises due to limited knowledge about proper nutrition, financial constraints, and household food insecurity.

Moreover, the research highlighted three pivotal factors influencing the academic performance of children and adolescents from B40 households. Firstly, drawing on Bronfenbrenner's Ecological Systems Theory, the study emphasized the interplay between individuals and their environment, shaping their growth and development from infancy to adulthood. Additionally, Havighurst's Development Theory delineated human development into distinct stages, including childhood, adolescence, and adulthood, each with its unique challenges and milestones. Lastly, McClelland's Theory of Achievement Motivation underscored the significance of internal motivation in driving individual behavior and ultimately influencing academic achievement.

To sum up, this research serves to deepen our understanding of the complex interplay between socioeconomic factors, nutritional status, and cognitive performance among children and adolescents from disadvantaged backgrounds. By elucidating these relationships and drawing on established theoretical frameworks, the study provides valuable insights that can inform targeted interventions aimed at addressing the multifaceted needs of these vulnerable populations.

5.3.3 Research Objective 3

To assess the improvement of health and cognitive performance of the children and adolescents of the B40 community through survey and health bar pilot food intervention study.

The research objective aimed to evaluate the enhancement of health and cognitive performance among children and adolescents within the B40 community through a combined survey and health bar pilot food intervention study. This investigation sought

to gather comprehensive data on anthropometric measurements and cognitive functioning across different age groups within the target population.

The findings from the survey and intervention study revealed several key insights. Anthropometric measurements, including body weight, height, and body mass index (BMI), were assessed across different age cohorts, indicating variations in nutritional status and growth patterns. Notably, the prevalence of severe thinness, thinness, overweight, and obesity varied among the age groups, underscoring the diverse nutritional challenges faced by children and adolescents within the community. By analysing these measurements, researchers could identify trends and patterns in growth and development, shedding light on the prevalence of malnutrition, obesity, and other health-related issues within the community.

Moreover, cognitive performance was evaluated using the Pediatric Quality of Life Inventory (PedsQL) and the Rey Auditory Verbal Learning Test (RAVLT). The PedsQL scores indicated improvements in physical, emotional, social, and school-related aspects of quality of life following the health bar intervention, particularly among males. Similarly, the RAVLT results demonstrated enhancements in total recall and recognition scores among both males and females' post-intervention, albeit with slight variations between genders.

The findings revealed significant improvements in both health outcomes and cognitive performance following the intervention, with notable enhancements observed in physical health, emotional well-being, social interactions, and academic performance. These improvements were particularly pronounced among male participants, suggesting potential gender differences in response to the intervention. Furthermore, the results underscored the importance of considering socioeconomic factors and environmental influences in shaping health and cognitive outcomes among children and adolescents. By addressing these underlying determinants through targeted interventions, such as the health bar pilot food intervention, researchers aimed to mitigate the adverse effects of poverty and food insecurity on the development and well-being of vulnerable populations.

Overall, the findings suggest that the health bar pilot food intervention had a positive impact on both health outcomes and cognitive performance among children and adolescents within the B40 community. These results underscore the potential of

targeted nutritional interventions to mitigate the adverse effects of socioeconomic disparities on health and cognitive development in vulnerable populations.

5.4 IMPLICATION OF THE RESEARCH

5.4.1 Academic Implication

By identifying the relationship between nutrition intake and cognitive performance, particularly among children and adolescents, educators and policymakers gain insights into the importance of nutrition in academic success. This understanding can inform the development of targeted interventions and policies aimed at improving nutritional support within educational institutions.

The study's findings emphasize the holistic nature of development, highlighting the interconnectedness between physical health, mental well-being, and academic achievement. Educators can use this knowledge to advocate for comprehensive approaches to student support that address not only academic needs but also health and well-being. The study advocates for the integration of health promotion initiatives into educational settings to support students' overall development. This may include initiatives such as nutrition education programs, access to healthy meals, and opportunities for physical activity, all of which contribute to improved academic outcomes.

Educators can benefit from professional development opportunities that increase their awareness of the importance of nutrition and health in academic success. Training sessions on nutrition education, classroom strategies for promoting healthy eating habits, and understanding the impact of nutrition on cognitive function can equip educators with valuable knowledge and skills to support their students effectively.

In conclusion, the study's implications for academic settings highlight the need for a holistic approach to education that prioritizes students' physical, mental, and

emotional well-being alongside academic achievement. By recognizing the role of nutrition in supporting cognitive function and academic success, educators can contribute to creating healthier and more supportive learning environments for all students.

5.4.2 Policymakers Implication

Educators can use the findings to advocate for policy changes at the institutional or governmental level that prioritize nutrition and health in educational settings. This may involve lobbying for increased funding for school meal programs, enhanced nutrition standards for school lunches, or policies that support access to nutritious foods for all students.

The implications of this study for policymakers are significant and multifaceted. Firstly, it underscores the urgent need for targeted interventions aimed at addressing the nutritional needs of children and adolescents, especially those from low-income households. Policymakers can use these findings to inform the development of comprehensive strategies that prioritize access to nutritious foods and nutrition education programs in communities facing socioeconomic challenges. Additionally, the study highlights the critical role of schools in promoting health and well-being among students. Policymakers can advocate for policies that support the implementation of school-based nutrition initiatives, such as healthy meal programs and nutrition education curriculum, to ensure that all students have access to the resources they need to thrive academically. Furthermore, the study emphasizes the importance of fostering collaboration between health and education sectors to address the complex interplay between nutrition, health, and academic performance. Policymakers can work towards creating integrated systems that facilitate communication and coordination between healthcare providers, educators, and community organizations to support the holistic development of children and adolescents. Overall, the implications of this study underscore the need for comprehensive, multi-sectoral approaches to address the

nutritional needs of children and adolescents and promote their overall health and academic success.

5.5 LIMITATIONS OF THE RESEARCH

Due to restrictions or constraints in the research design, methodology or sample, this current study has a number of limitations or drawbacks which may impact the findings and discussion, emphasizing the need for future research to address these limitations and ensure high-quality results.

The first limitation is that the study may have included a relatively small sample size, which could limit its applicability to larger populations. For instance, if the study focused on a specific community or region, the findings may not be representative of children and adolescents in other areas with different socioeconomic or cultural backgrounds. This limitation can restrict the extent to which policymakers can apply the study's findings to broader contexts. The study's focus on a particular community or region raises questions about the representativeness of the sample. If the selected population differs significantly from other populations in terms of demographics, socioeconomic status, or cultural factors, the findings may not be applicable to these other groups. Policymakers rely on research that offers insights into diverse populations to develop inclusive and effective policies.

The second limitation is the intervention or follow-up period was relatively short, the study might not have captured long-term effects on health and academic performance. Some interventions require time to produce measurable changes, and short-term assessments may overlook these impacts. Policymakers may be hesitant to implement interventions based on short-term findings without evidence of sustained effects over time.

The third limitation would be relying on self-reported data, such as dietary intake or academic performance, introduces the potential for biases and inaccuracies. Individuals may overestimate or underestimate their behaviors, leading to

misinterpretations of the data. This limitation could affect the reliability and validity of the study's findings, children and adolescents from different socioeconomic and cultural backgrounds may have unique experiences, lifestyles, and dietary habits. By focusing on a specific community or region, the study may overlook this heterogeneity, potentially missing out on valuable insights into how these factors interact with nutrition intake and academic performance.

5.6 SUGGESTIONS FOR FUTURE RESEARCH

The current study offers recommendations for future research based on the limitations identified in the preceding section. Future research should aim to overcome these challenges by employing larger and more diverse samples, using objective measures whenever possible, implementing rigorous study designs, controlling for confounding variables, and conducting long-term follow-ups to assess sustained effects. By addressing these limitations, policymakers can have greater confidence in applying research findings to policy decisions aimed at improving the health and academic outcomes of children and adolescents in low-income communities.

The second suggestion is, other researchers could consider extending the intervention or follow-up period to capture potential long-term effects on health and academic performance more comprehensively. By prolonging the study duration, researchers can better assess the sustainability and effectiveness of interventions. Additionally, conducting periodic assessments throughout the extended period can provide insights into the evolving impact of interventions over time. This approach would offer policymakers more robust evidence to inform decisions regarding the implementation of interventions with lasting benefits.

The third suggestion is, researchers can employ a combination of methods to collect data, including objective measurements and self-reported information. Objective measurements, such as biochemical assessments or academic assessments administered by trained professionals, can complement self-reported data, providing a more comprehensive understanding of the participants' behaviors and outcomes.

Additionally, researchers can implement strategies to minimize biases and inaccuracies in self-reported data, such as using validated questionnaires, providing clear instructions to participants, and ensuring confidentiality to encourage honest responses. Furthermore, researchers should consider diversifying their study population to capture a broader range of socioeconomic and cultural backgrounds, allowing for a more nuanced analysis of the relationships between nutrition intake, academic performance, and other influencing factors. This approach would enhance the generalizability and applicability of the study's findings across diverse populations, thereby providing more robust evidence for policymakers and stakeholders to inform interventions and policies effectively.

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APPENDIX A: HEALTH DECLARATION FORM

Information Sheet

Name of Principal Investigator	:	Asst. Prof. Dr. Noor Yuslida Binti Hazahari
Name of Organisation	:	International Institute for Halal Research and Training (INHART)
Name of Sponsor	:	Ministry of Higher Education (FRGS-RACER)
Name of Project & Version	:	Resolving Nutrient Deficiencies among Adolescents of the B40 Community in Selected Schools around Gombak, Malaysia, Version 01

I am Nurul Auni Binti Mohd Noor and I am a postgraduate student at International Institute for Halal Research and Training (INHART), International Islamic University of Malaysia (IIUM), Gombak, Kuala Lumpur. This study is Master Degree research under INHART and it is being carried out as part of Master Degree requirement.

Adolescents had been the greatest interest of this study because of little documentation recorded on their health status and cognitive development in previous studies. In fact, this study intends to serve a part of Supplementary Food Programme (SFP), an initiative from Ministry of Education Malaysia to prevent hunger in school for B40 community. The objectives of this study are as follow;

1) To determine healthy bar formulation and its physical and chemical characteristics as part of Supplementary Food Programme (SFP) involving the adolescents of B40 community.
2) To identify the relationship between nutrition intake to health and cognitive performance of the adolescents of the B40 community through basic data cataloguing.
3) To assess the improvement of health and cognitive performance of the adolescents of the B40 community through survey and healthy bar pilot food intervention study.

Lembaran Maklumat Kajian

Nama Ketua Projek	:	Asst. Prof. Dr. Noor Yuslida Binti Hazahari
Nama Organisasi	:	International Institute for Halal Research and Training (INHART)
Nama Penaja	:	Ministry of Higher Education (FRGS-RACER)
Nama Projek dan Versi	:	Resolving Nutrient Deficiencies among Children & Adolescents of the B40 Community in Selected Schools around Gombak, Malaysia, Versi 01

Saya Nurul Auni Binti Mohd Noor merupakan pelajar sarjana di International Institute for Halal Research and Training (INHART), Universiti Islam Antarabangsa Malaysia (UIAM), Gombak, Kuala Lumpur. Kajian ini dijalankan bertujuan untuk memenuhi syarat-syarat program Ijazah Sarjana di INHART.

Kajian ini menitikberatkan kanak-kanak dan juga remaja kerana terlalu sedikit maklumat yang boleh didapati berkaitan status kesihatan dan perkembangan kognitif mereka berdasarkan kajian terdahulu. Tambahan pula, kajian ini bertujuan untuk memenuhi sebahagian daripada Rancangan Makanan Tambahan (RMT), satu inisiatif daripada Kementerian Pendidikan Malaysia (KPM) untuk memperbaiki keadaan kesihatan, fizikal dan amalan pemakanan terutamanya untuk golongan B40.

Objektif-objektif kajian ini adalah seperti berikut;

1) Untuk mengkaji formulasi, ciri-ciri fizikal dan kimia “healthy bar” sebagai sebahagian daripada Rancangan Makanan Tambahan (RMT) yang melibatkan kanak-kanak dan remaja golongan B40.
2) Untuk mengkaji hubung kait di antara pengambilan nutrien yang cukup dengan tahap kesihatan dan perkembangan kognitif kanak-kanak dan remaja golongan B40 melalui pengelasan data yang asas.
3) Untuk mengkaji peningkatan tahap kesihatan dan perkembangan kognitif kanak-kanak dan remaja golongan B40 melalui tinjauan dan juga kajian intervensi awal makanan melibatkan “healthy bar”.

Health Screening Form

Name :	Age :
Date :	Gender :

INSTRUCTION TO THE PARTICIPANT:

The purpose of this form is to evaluate participant's health condition and allergy issues. Please feel free to ask if you need any of the questions explained to you. Please mark ☑ on related boxes.

1) → Are you allergic to any food?

☐ Yes → → → ☐ No

2) → If Yes, please list down the specific ingredients that can cause the allergic

3) → What would be your reaction if you touch the ingredients?

4) → What would be your reaction if you ingest the ingredients?

5) → Other than ingredients mentioned in (2) do you have any intolerance towards the ingredients listed below?

☐ Nuts → ☐ Legumes

☐ Cereals → ☐ Dairy products

☐ Others:

Borang Pemeriksaan Kesihatan

Nama	:	Umur	:
Tarikh	:	Jantina	:

ARAHAN KEPADA PESERTA:

Borang ini bertujuan untuk mengenalpasti masalah kesihatan dan alahan para peserta. Sila tandakan ☑ pada ruang yang berkenaan.

1) Adakah anda mengalami alahan terhadap mana-mana makanan?

☐ Ya ☐ Tidak

2) Jika Ya, sila senaraikan bahan-bahan yang boleh menyebabkan alahan

3) Apakah tindak balas anda sekiranya anda sentuh bahan-bahan tersebut?

4) Apakah tindak balas anda sekiranya anda telan bahan-bahan tersebut?

5) Selain daripada bahan-bahan yang disebutkan di atas (2) adakah anda mempunyai alahan terhadap bahan-bahan di bawah?

☐ Kacang ☐ Legum/kekacang (kacang soya, kacang hijau, kacang merah, dll)

☐ Bijirin ☐ Produk tenusu

☐ Lain-lain:

Informed Consent Form for Qualitative Study

This Informed Consent Form is for guardians and potential participants participating in the study titled, "Resolving Nutrient Deficiencies among Adolescents of the B40 Community in Selected Schools around Gombak, Malaysia".

Name of Principal Investigator	:	Asst. Prof. Dr. Noor Yuslida Binti Hazahari
Name of Organisation	:	International Institute for Halal Research and Training (INHART)
Name of Sponsor	:	Ministry of Higher Education (FRGS-RACER)
Name of Project & Version	:	Resolving Nutrient Deficiencies among Adolescents of the B40 Community in Selected Schools around Gombak, Malaysia, Version 01

This Informed Consent Form has two parts:

- Part I: Information Sheet (to share information about the study)
- Part II: Consent Form (for approval of participation from guardians)

Part I: Information Sheet

I am Nurul Auni Binti Mohd Noor and I am a postgraduate student at International Institute for Halal Research and Training (INHART), International Islamic University of Malaysia (IIUM), Gombak, Kuala Lumpur. This study is Master Degree research under INHART and it is being carried out as part of Master Degree requirement.

Adolescents had been the greatest interest of this study because of little documentation recorded on their health status and cognitive development in previous studies. In fact, this study intends to serve a part of Supplementary Food Programme (SFP), an initiative from Ministry of Education Malaysia to prevent hunger in school for B40 community. The objectives of this study are as follow;

1) To determine healthy bar formulation and its physical and chemical characteristics as part of Supplementary Food Programme (SFP) involving the adolescents of B40 community.
2) To identify the relationship between nutrition intake to health and cognitive performance of the adolescents of the B40 community through basic data cataloguing

3) To assess the improvement of health and cognitive performance of the adolescents of the B40 community through survey and healthy bar pilot food intervention study.

The participants will take part in pilot food intervention, several assessments and answering questionnaires. The participants are required to consume healthy bar 5 times in each week for 12 weeks (approximately 3 months). Please note that the healthy bar is the highlight of this study to test the improvement of participants' cognitive performance. Meanwhile, the assessments and questionnaires will be given out for every two weeks and they are related to participants' health status and cognitive performance.

There might be no immediate benefit to participants but their participation is likely to help us find out more about the effectiveness of the healthy bar on cognitive performance. The participants will not be provided with any payment. However, token of appreciation will be given in other form.

All information obtained throughout this study will be kept highly private and confidential. Participants' information will not be showed or revealed to other party without guardians' consent. On a side note, the participation in this study is voluntary. The guardians or participants may discontinue the participation at any point and decline to be part of the study.

Part II: Consent Form

To be filled by Guardian

Guardian's name :_____

Guardian's contact number :_____

Can we contact you when need to interview your child?

☐ Yes ☐ No

Guardian's address :_____

_____

_____

Do you give your consent for your child to participate in this study?

☐ Yes ☐ No

I have read the foregoing information, or it has been read to me. I have had the opportunity to ask questions about it and any questions that I have asked have been answered to my satisfaction. I consent voluntarily for my child to participate as a participant in this study.

Print Name of Guardian: _____

Signature of Guardian: _____

Date: _____

Day/month/year

Borang Persetujuan Termaklum untuk Kajian Kualitatif

Borang Persetujuan Termaklum ini adalah untuk penjaga para peserta yang menyertai kajian yang bertajuk, "Resolving Nutrient Deficiencies among Children & Adolescents of the B40 Community in Selected Schools around Gombak, Malaysia".

Nama Ketua Projek	:	Asst. Prof. Dr. Noor Yuslida Binti Hazahari
Nama Organisasi	:	International Institute for Halal Research and Training (INHART)
Nama Penaja	:	Ministry of Higher Education (FRGS-RACER)
Nama Projek dan Versi	:	Resolving Nutrient Deficiencies among Children & Adolescents of the B40 Community in Selected Schools around Gombak, Malaysia, Versi 01

Borang Persetujuan Termaklum ini mempunyai dua bahagian:

- Bahagian I: Lembaran Maklumat (mengandungi maklumat mengenai kajian ini)
- Bahagian II: Borang Persetujuan (bertujuan untuk mendapatkan persetujuan penjaga)

Bahagian I: Lembaran Maklumat

Saya Nurul Auni Binti Mohd Noor merupakan pelajar sarjana di International Institute for Halal Research and Training (INHART), Universiti Islam Antarabangsa Malaysia (UIAM), Gombak, Kuala Lumpur. Kajian ini dijalankan bertujuan untuk memenuhi syarat-syarat program Ijazah Sarjana di INHART.

Kajian ini menitikberatkan kanak-kanak dan juga remaja kerana terlalu sedikit maklumat yang boleh didapati berkaitan status kesihatan dan perkembangan kognitif mereka berdasarkan kajian terdahulu. Tambahan pula, kajian ini bertujuan untuk memenuhi jangka masa yang panjang dalam Matlamat Pembangunan Mampan/Lestari Nombor 1: Tiada Kemiskinan dan Nombor 3: Kesihatan Baik dan Kesejahteraan terutamanya untuk golongan B40.

Objektif-objektif kajian ini adalah seperti berikut;

1) Untuk mengkaji formulasi, ciri-ciri fizikal dan kimia "healthy bar" sebagai sebahagian daripada kajian intervensi yang melibatkan kanak-kanak dan remaja golongan B40.

2) Untuk mengkaji hubung kait di antara pengambilan nutrien yang cukup dengan tahap kesihatan dan perkembangan kognitif kanak-kanak dan remaja golongan B40 melalui pengelasan data yang asas.
3) Untuk mengkaji peningkatan tahap kesihatan dan perkembangan kognitif kanak-kanak dan remaja golongan B40 melalui tinjauan dan juga kajian intervensi awal makanan melibatkan "healthy bar".

Para peserta akan diminta untuk menyertai beberapa aktiviti dalam kajian ini termasuk kajian intervensi awal makanan, beberapa ujian dan juga menjawab borang soal selidik. Mereka juga perlu mengambil "healthy bar" sebanyak 7 kali setiap minggu selama 8 minggu (± 2 bulan). Untuk makluman, "healthy bar" ini merupakan fokus utama untuk mengkaji perkembangan tahap kognitif para peserta. Manakala, ujian dan juga borang soal selidik yang berkaitan dengan status kesihatan dan perkembangan kognitif para peserta akan diberikan setiap dua minggu.

Kajian ini berkemungkinan tidak akan memberi manfaat secara langsung kepada para peserta tetapi penyertaan mereka akan menyumbang kepada impak yang lebih besar terutamanya terhadap keberhasilan "healthy bar" ini terhadap perkembangan kognitif. Para peserta tidak akan diberikan sebarang bayaran, namun, token apresiasi akan diberikan dalam bentuk yang lain.

Segala maklumat yang diperoleh daripada kajian ini akan disimpan secara sulit. Maklumat para peserta tidak akan dibocorkan atau ditunjukkan kepada pihak ketiga tanpa persetujuan penjaga. Selain itu, untuk makluman penyertaan dalam kajian ini adalah bersifat sukarela dan para peserta serta penjaga boleh membuat keputusan untuk menarik diri pada bila-bila masa.

Bahagian II: Borang Persetujuan

Untuk diisi oleh Penjaga

Nama Penjaga :_____

No. Telefon Penjaga :_____

Adakah kami boleh menelefon pihak Tuan/Puan untuk menemuramah anak Tuan/Puan?

☐ Ya ☐ Tidak

Alamat Penjaga :_____

_____

_____

Adakah pihak Tuan/Puan memberi kebenaran kepada anak Tuan/Puan untuk menyertai kajian ini?

☐ Ya ☐ Tidak

Saya telah membaca atau telah dibacakan segala maklumat. Saya telah diberikan peluang untuk bertanyakan soalan mengenai kajian ini dan juga telah mendapat jawapan yang sesuai untuk semua soalan saya. Saya dengan ini memberi persetujuan kepada anak jagaan saya untuk menyertai kajian ini.

Nama Penjaga :_____

Tandatangan Penjaga :_____

Tarikh :_____

APPENDIX B: ACCEPTANCE TEST USING 5-POINT HEDONIC SCALE

Sensory Test using 5-points Hedonic Scale

Participant's code: _____

INSTRUCTION TO THE PARTICIPANT:

You will be given two (2) healthy bar samples with different codes. Please taste each of the sample and circle the face that describes the taste of the healthy bar you have just had

Example;

432

571

Ujian Sensori menggunakan Skala Hedonik 5-poin

Kod Peserta: _____

ARAHAN KEPADA PESERTA:

Anda akan diberikan dua (2) sampel "healthy bar" yang mengandungi kod yang berbeza. Sila rasa dan tandakan muka yang menggambarkan rasa "healthy bar" sebentar tadi

Contoh:

432

571

APPENDIX C: FOOD LOGS

Borang Soal Selidik Kekerapan Pengambilan Makanan

ARAHAN KEPADA PESERTA:

Sila lengkapkan soalan kaji selidik kekerapan pengambilan makanan ini. Isi kekerapan pengambilan makanan pada ruang pilihan dan isikan jumlah sajian yang diambil setiap

Kod	**Jenis makanan**	**Kekerapan pengambilan**				**Ukuran sajian** (pilih satu jenis ukuran sahaja)	**Jumlah sajian (setiap kali makan)**
	A. Bijirin dan hasil bijirin	Berapa kali sehari	Berapa kali seminggu	Berapa kali sebulan	Tidak makan		
	Contoh						
	Nasi putih	2				Pinggan	1/2
A1	Nasi putih					Pinggan	
						Mangkuk cina	
						Cawan	
						Senduk	
A2	Nasi beras perang					Pinggan	
						Mangkuk cina	
						Cawan	
						Senduk	
A3	Nasi berperisa (Nasi biryani, nasi goring dsb)					Pinggan	
						Cawan	
						Senduk	
A4	Bubur nasi					Mangkuk sedang	
						Cawan	
						Senduk	

A5	Pulut					Mangkuk cina	
						Cawan	
						Senduk	
A6	Mee kuning/ mee siput/ mee segera					Pinggan lengkung	
						Pinggan	
						Mangkuk cina	
						Senduk	
A7	Mihun/ kueh teow/ laksa/ laksam					Pinggan lengkung	
						Pinggan	
						Mangkuk cina	
						Senduk	
A8	Pasta					Pinggan	
						Senduk	
A9	Sagu/ ambuyat/ linut					Potong	
						Cawan	
						Sudu	
A10	Roti					Keping	
A11	Roti bijirin penuh					Keping	
A12	Roti bun					Biji	
A13	Roti canai (termasuk roti telur, roti sardine, roti bawang, roti pisang, murtabak)					Keping	
A14	Capati					Keping	
A15	Tosai					Keping	
A16	Bijirin sarapan pagi (cornflakes, koko crunch,					Cawan	
						Mangkuk cina	

	hineystar dsb)						
A17	Bijirin tersedia perlu dibancuh (nestum, quaker oats dsb)					Mangkuk cina	
						Cawan	
A18	Jagung					Tongkol	
						Cawan	
A19	Burger					Biji	
A20	Ayam goreng					Ketul	
A21	Pizza					Keping	
A22	Kentang goreng					Hidang medium	
A23	Kentang lenyek					Bekas kecil	
A24	Coleslaw					Bekas kecil	
A25	Sosej/ hotdog/ frankfurter					Keping	
A26	Nugget					Ketul	

Kod	**Jenis makanan**	**Kekerapan pengambilan**				**Ukuran sajian** (pilih satu jenis makanan sahaja)	**Jumlah sajian (setiap kali makan)**
	B. Daging dan hasil daging	Berapa kali sehari	Berapa kali seminggu	Berapa kali sebulan	Tidak makan		
B1	Ayam					Ketul	
B2	Burung puyuh					Ekor	
B3	Itik					Ketul	
B4	Lembu/ kerbau					Kotak mancis	
B5	Kambing					Kotak mancis	
B6	Organ dalaman					Kotak mancis	

	(hati, limpa, paru)						
B7	Bebola ayam/daging					Ketul	
B8	Ham (bagi bukan Islam)					Keping	
B9	Bacon (bagi bukan Islam)					Keping	
B10	Luncheon meat (bagi bukan Islam)					Keping	
B11	Babi (bagi bukan Islam)					Kotak mancis	

Kod	**Jenis makanan**	**Kekerapan pengambilan**				**Ukuran sajian** (pilih satu jenis makanan sahaja)	**Jumlah sajian (setiap kali makan)**
	C. Ikan dan makanan laut	Berapa kali sehari	Berapa kali seminggu	Berapa kali sebulan	Tidak makan		
C1	Ikan laut					Keping	
						Ekor	
C2	Ikan air tawar					Keping	
						Ekor	
C3	Ikan bilis					Sudu makan	
C4	Ikan dalam tin					Ekor	
C5	Kekerang (kerang, lalla, remis, kupang, mentarang dsb)					Sudu makan	
C6	Udang basah					Ekor sederhana	
C7	Sotong basah					Ekor sederhana	
						Potong sederhana	

C8	Sotong kering					Keping sederhana	
						Potong sederhana	
C9	Ketam					Ekor	
C10	Ikan kering					Keping	
						Ekor	
C11	Bebola/ kek ikan/ udang/ sotong/ ketam					Bebola	
						Ketul	
C12	Keropok lekor					Keping	
C13	Keropok ikan/udang/ sotong/ ketam					Keping	
C14	Ikan jeruk/ pekasam					Keping	
C15	Siput sedut (belitung, siput buluh dsb)					Sudu makan	

Kod	**Jenis makanan**	**Kekerapan pengambilan**				**Ukuran sajian** (pilih satu jenis makanan)	**Jumlah sajian (setiap kali makan)**
	D. Telur	Berapa kali sehari	Berapa kali seminggu	Berapa kali sebulan	Tidak makan		
D1	Telur ayam (mata kerbau, telur dadar, telur rebus, telur masak sambal, telur pindang)					Biji	
D2	Telur itik (masak lemak/gulai, telur dadar)					Biji	
D3	Telur puyuh (rebus, masak sambal)					Biji	
D4	Telur masin					Biji	

Kod	Jenis makanan	Kekerapan pengambilan				Ukuran sajian (pilih satu jenis makanan)	Jumlah sajian (setiap kali makan)
	E. Kekacang dan hasilnya	Berapa kali sehari	Berapa kali seminggu	Berapa kali sebulan	Tidak makan		
E1	Kekacang (kacang hijau, kacang parang, kacang kuda, kacang merah dsb)					Sudu makan	
E2	Tauhu					Keping	
E3	Tempe					Keping	
						Sudu makan	
E4	Kacang tanah					Sudu makan	
E5	Taufufa					Sudu makan	

Kod	Jenis makanan	Kekerapan pengambilan				Ukuran sajian (pilih satu jenis makanan)	Jumlah sajian (setiap kali makan)
	F. Susu dan hasil tenusu	Berapa kali sehari	Berapa kali seminggu	Berapa kali sebulan	Tidak makan		
F1	Susu segar (yang tidak diproses)					Cawan	
						Gelas	
F2	Susu tepung					Sudu makan	
F3	Susu sejat/ cair					Sudu makan	
F4	Susu komersial					Cawan	
F5	Yogurt/ dadih/ lassi/ tairu					Cawan	
						Sudu makan	

F6	Keju					Keping	

Kod	**Jenis makanan**	**Kekerapan pengambilan**				**Ukuran sajian** (pilih satu jenis makanan)	**Jumlah sajian (setiap kali makan)**
	G. Sayur-sayuran	Berapa kali sehari	Berapa kali seminggu	Berapa kali sebulan	Tidak makan		
G1	Sayuran berdaun hijau (bayam, kangkung, kalian dsb)					Cawan	
G2	Bendi					Cawan	
G3	Sayuran kekacang lain (kacang panjang, kacang buncis, kacang botol dsb)					Cawan	
G4	Sayuran berubi (kentang, keladi, keledek)					Cawan	
G5	Sayuran kobis (kobis bulat, brokoli, kobis cina, bunga kobis)					Cawan	
G6	Cili					Sudu makan	
G7	Tomato					Sudu makan	
G8	Terung					Sudu makan	
G9	Sayuran berbuah lain (Petola/ labu/ timun/ putik jagung					Cawan	
G10	Sayuran asin/ kering (pucuk soo hon dsb)					Cawan	
G11	Ulam-ulaman					Cawan	

G12	Cendawan basah					Cawan	
G13	Cendawan kering					Cawan	
G14	Taugeh					Cawan	

Kod	**Jenis makanan**	**Kekerapan pengambilan**				**Ukuran sajian** (pilih satu jenis makanan)	**Jumlah sajian (setiap kali makan)**
	H. Buah-buahan	Berapa kali sehari	Berapa kali seminggu	Berapa kali sebulan	Tidak makan		
H1	Betik					Potong	
H2	Jambu batu					Keping	
H3	Limau manis tempatan					Biji	
H4	Mangga					Potong	
H5	Nanas					Potong	
H6	Pisang (pisang segar, pisang goreng, pengat pisang, pisang salai dsb)					Biji	
H7	Tembikai					Potong	
H8	Belimbing					Biji	
H9	Nangka/ cempedak					Ulas	
H10	Epal					Biji	
H11	Oren/mandarin					Biji	
H12	Pir/lai					Biji	
H13	Anggur					Biji	
H14	Durian					Ulas	

Kod	Jenis makanan	Kekerapan pengambilan				Ukuran sajian (pilih satu jenis makanan)	Jumlah sajian (setiap kali makan)
	I. Minuman	Berapa kali sehari	Berapa kali seminggu	Berapa kali sebulan	Tidak makan		
I1	Air kosong					Gelas	
I2	Teh					Cawan	
I3	Kopi					Cawan	
I4	Minuman bercoklat (van houten, Cadbury dsb)					Cawan	
I5	Minuman bermalt (milo, horlick dsb)					Cawan	
I6	Minuman pra campuran 2 in 1/ 3 in 1 dsb (kecuali botani/ herba)					Cawan	
I7	Minuman ready-to-drink seperti air tin/ air kotak (kecuali botani/ herba)					Gelas	
I8	Sirap kordial					Cawan	
I9	Jus buah-buahan					Gelas/ tin	
I10	Minuman bergas (termasuk isotonik)					Gelas	
I11	Air kacang soya					Kotak	
I12	Minuman botani/herba 2 in 1/3 in 1 dsb (pra campuran)					Gelas	
						Kotak	
I13	Minuman botani/herba seperti dalam tin/kotak (ready-to-drink)					Gelas	
						Kotak	
I14	Minuman air rebusan botani/herbal					Cawan	
I15	Minuman bertenaga (red bull, livita)					Cawan	
						Tin	
I16	Minuman yogurt					Cawan	

Kod	Jenis makanan	Kekerapan pengambilan				Ukuran sajian (pilih satu jenis makanan)	Jumlah sajian (setiap kali makan)
	J. Minuman beralkohol (bagi bukan Islam)	Berapa kali sehari	Berapa kali seminggu	Berapa kali sebulan	Tidak makan		
J1	Syandi					Tin	
J2	Bir/ lager/ ale/ stout					Gelas	
						Tin	
						Botol	
J3	Todi (tuak kelapa/ bahar)					Gelas	
J4	Wain/cider/ champagne/ peri					Gelas wain	
J5	Wain beras/ tuak beras/ lihing					Gelas	
J6	Brandi/ rum/ wiski/ vodka/ gin/ samsu/ sam cheng/ montoku/ langkau					Gelas	

Kod	Jenis makanan	Kekerapan pengambilan				Ukuran sajian (pilih satu jenis makanan)	Jumlah sajian (setiap kali makan)
	K. Konfeksi	Berapa kali sehari	Berapa kali seminggu	Berapa kali sebulan	Tidak makan		
K1	Kuih-muih tempatan					Ketul	
K2	Kek					Potong	
K3	Gula-gula					Ketul	
K4	Coklat bar					Bar kecil	
K5	Aiskrim (susu)					Cawan	
						Scoop	
K6	Aiskrim (tanpa susu)					Potong	
K7	ABC (air batu campur/ ais pop)					Mangkuk	
						Batang	
K8	Agar-agar/ jeli/					Cawan	

	kastard					Potong	
K9	Biskut tawar/ krim kraker					Keping	
K10	Biskut berperisa/ berkrim/ berinti					Keping	
K11	Pastri (pai, croissant)					Keping	
K12	Snek / kerepek					Keping	

Kod	**Jenis makanan**	**Kekerapan pengambilan**				**Ukuran sajian** (pilih satu jenis makanan)	**Jumlah sajian (setiap kali makan)**
	L. Sapuan roti	Berapa kali sehari	Berapa kali seminggu	Berapa kali sebulan	Tidak makan		
L1	Jem					Sudu teh	
L2	Seri kaya					Sudu teh	
L3	Mentega					Sudu teh	
L4	Marjerin					Sudu teh	
L5	Mentega kacang					Sudu teh	
L6	Krim keju					Sudu teh	
L7	Sapuan coklat					Sudu teh	
L8	Sapuan bawang putih					Sudu teh	

Kod	**Jenis makanan**	**Kekerapan pengambilan**				**Ukuran sajian** (pilih satu jenis makanan)	**Jumlah sajian (setiap kali makan)**
	M. Perencah/ perisa	Berapa kali sehari	Berapa kali seminggu	Berapa kali sebulan	Tidak makan		

M1	Gula (putih, perang, Melaka)					Sudu teh	
M2	Madu					Sudu teh	
M3	Sambal (lada, belacan, tempoyak, bambangan)					Sudu makan	
M4	Budu					Sudu teh	
M5	Cencaluk					Sudu teh	
M6	Kicap					Sudu teh	
M7	Sos cili					Sudu teh	
M8	Sos tomato					Sudu teh	
M9	Sos tiram					Sudu teh	
M10	Sos ikan					Sudu teh	
M11	Petis/ heko/ otak udang					Sudu teh	
M12	Susu pekat manis (susu isian pekat manis/ krimmer pekat manis)					Sudu makan	
M13	Jeruk (bawang, tuhau)					Sudu teh	
M14	Belacan					Sudu teh	
M15	Cili kering					Sudu teh	
M16	Salad dressing					Sudu teh	

APPENDIX C: PEDIATRIC QUALITY OF LIFE (PedsQL 4.0)

Pediatric Quality of Life Inventory 4.0 (PedsQL 4.0) to Assess Health-related Quality of Life (HRQoL) (Pre-intervention and Post-intervention)

Participant's name: _____

Date : _____

INSTRUCTION TO THE PARTICIPANT:

The following is a list of things that might be a problem for you. Please tell us how much of a problem each one has been for you for the past **ONE month** by circling:

0 If it is never a problem
1 If it is almost never a problem
2 If it is sometimes a problem
3 If it is often a problem
4 If it is almost always a problem

In the past **ONE month**, how much of a problem has this been for you

About my health and activities (problems with…)	Never	Almost Never	Sometimes	Often	Almost always
1. It is hard for me to walk more than one block	0	1	2	3	4
2. It is hard for me to run	0	1	2	3	4
3. It is hard for me to do sports activity or exercise	0	1	2	3	4
4. It is hard for me to lift something heavy	0	1	2	3	4
5. It is hard for me to take a bath or shower by myself	0	1	2	3	4
6. It is hard for me to do chores around the house	0	1	2	3	4
7. I hurt or ache	0	1	2	3	4
8. I have low energy	0	1	2	3	4

About my feelings (problems with…)	Never	Almost Never	Sometimes	Often	Almost Always
1. I feel afraid or scared	0	1	2	3	4
2. I feel sad or blue	0	1	2	3	4
3. I feel angry	0	1	2	3	4
4. I have trouble sleeping	0	1	2	3	4
5. I worry about what will happen to me	0	1	2	3	4

How I get along with others (problems with…)	Never	Almost Never	Sometimes	Often	Almost Always
1. I have trouble getting along with other teens	0	1	2	3	4
2. Other teens do not want to be my friend	0	1	2	3	4
3. Other teens tease me	0	1	2	3	4
4. I cannot do things that other teen my age can do	0	1	2	3	4
5. It is hard to keep up with my peers	0	1	2	3	4

About school (problems with…)	Never	Almost Never	Sometimes	Often	Almost Always
1. It is hard to pay attention in class	0	1	2	3	4
2. I forgot things	0	1	2	3	4
3. I have trouble keeping up with my schoolwork	0	1	2	3	4
4. I miss school because of not feeling well	0	1	2	3	4
5. I miss school to go to the doctor or hospital	0	1	2	3	4

Inventori Kualiti Hidup Pediatrik 4.0 (PedsQL 4.0) untuk Mengkaji Kualiti Hidup yang Berkaitan dengan Kesihatan (HRQoL)

Nama Peserta: _____

Tarikh : _____

ARAHAN KEPADA PESERTA:

Berikut merupakan senarai perkara yang mungkin menjadi masalah atau mengganggu anda. Sila ceritakan bagaimana anda terganggu dengan perkara tersebut sepanjang tempoh **1 bulan** yang lalu dengan membulatkan:

0 sekiranya tidak pernah menjadi masalah
1 sekiranya hampir tidak pernah menjadi masalah
2 sekiranya kadang-kadang menjadi masalah
3 sekiranya hampir kerap menjadi masalah
4 sekiranya terlalu kerap menjadi masalah

Dalam tempoh **1 bulan** yang lalu, bagaimanakah perkara ini mengganggu anda

Masalah mengenai kesihatan dan aktiviti saya	Tidak pernah	Hampir tidak pernah	Kadang-kadang	Hampir kerap	Kerap
1. Sukar untuk berjalan lebih satu blok	0	1	2	3	4
2. Sukar untuk berlari	0	1	2	3	4
3. Sukar untuk bersukan atau bersenam	0	1	2	3	4
4. Sukar untuk mengangkat benda yang berat	0	1	2	3	4
5. Sukar untuk mandi sendiri	0	1	2	3	4
6. Sukar untuk melakukan kerja-kerja rumah	0	1	2	3	4
7. Berasa sakit atau sengal-sengal	0	1	2	3	4
8. Sentiasa berasa kurang bertenaga	0	1	2	3	4

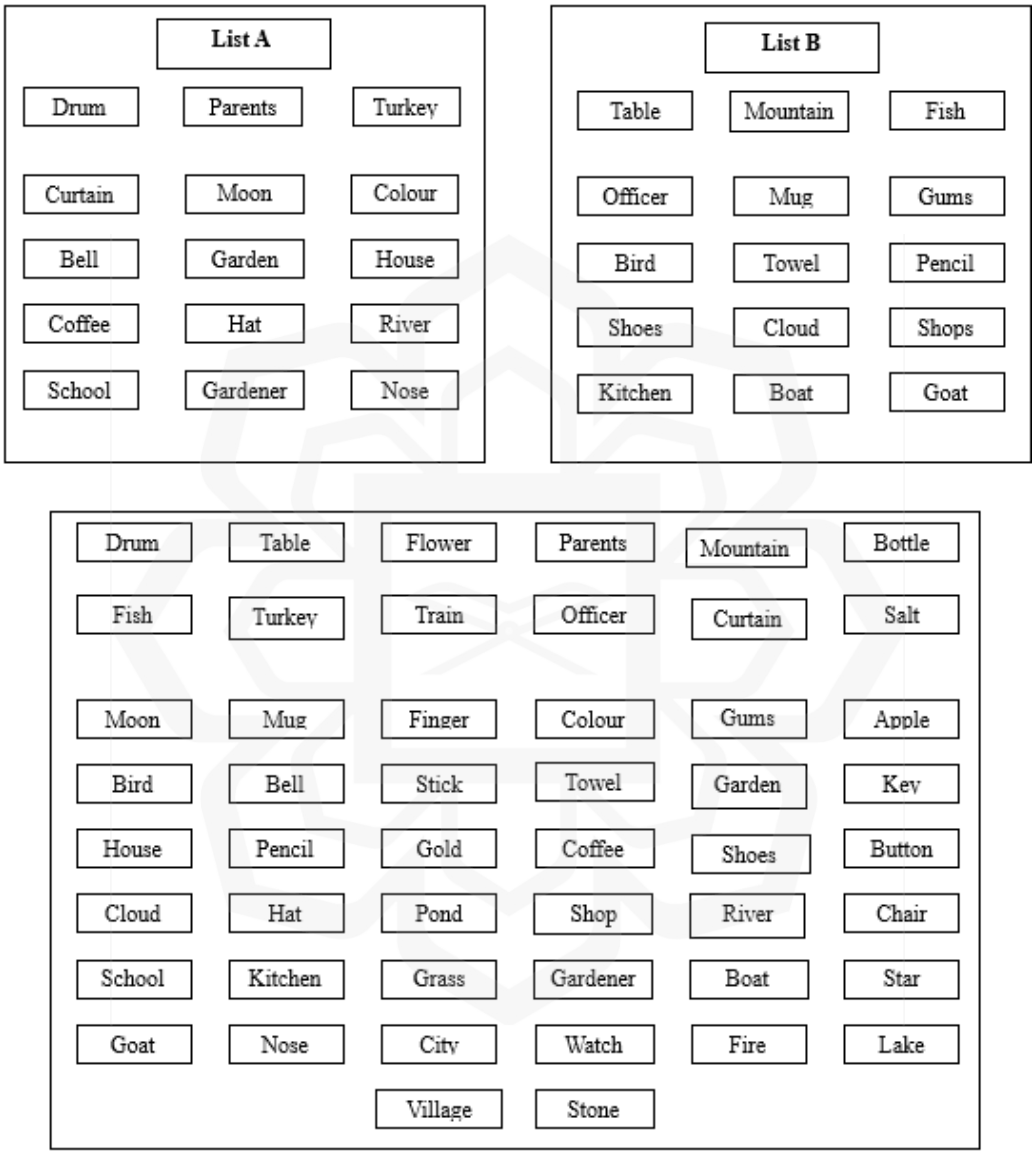
Masalah mengenai perasaan saya	Tidak pernah	Hampir tidak pernah	Kadang-kadang	Hampir kerap	Kerap
1. Saya berasa takut	0	1	2	3	4
2. Saya berasa sedih	0	1	2	3	4
3. Saya berasa marah	0	1	2	3	4
4. Saya mengalami kesukaran untuk tidur	0	1	2	3	4
5. Saya risau mengenai masa hadapan	0	1	2	3	4

Masalah bergaul bersama rakan-rakan	Tidak pernah	Hampir tidak pernah	Kadang-kadang	Hampir kerap	Kerap
1. Saya mempunyai masalah untuk bergaul dengan rakan-rakan yang lain	0	1	2	3	4
2. Rakan-rakan tidak mahu berkawan dengan saya	0	1	2	3	4
3. Rakan-rakan mengejek saya	0	1	2	3	4
4. Saya tidak mempunyai keupayaan untuk melakukan perkara seperti rakan sebaya saya lakukan	0	1	2	3	4
5. Saya tidak setanding dengan rakan-rakan yang lain	0	1	2	3	4

Masalah berkaitan sekolah	Tidak pernah	Hampir tidak pernah	Kadang-kadang	Hampir kerap	Kerap
1. Sukar untuk fokus di dalam kelas	0	1	2	3	4
2. Saya sering lupa	0	1	2	3	4
3. Kerja sekolah terlalu sukar untuk saya	0	1	2	3	4
4. Saya tidak hadir ke sekolah kerana tidak sihat	0	1	2	3	4
5. Saya tidak hadir ke sekolah kerana pergi ke klinik atau hospital	0	1	2	3	4

APPENDIX C: REY'S AUDITORY VERBAL LEARNING TEST (RAVLT)

Rey's Auditory-verbal Learning Test (RAVLT) for Cognitive Performance Evaluation
(Pre-intervention and Post-intervention)



Rey's Auditory-verbal Learning Test (RAVLT) untuk Mengkaji Perkembangan Kognitif

Senarai A

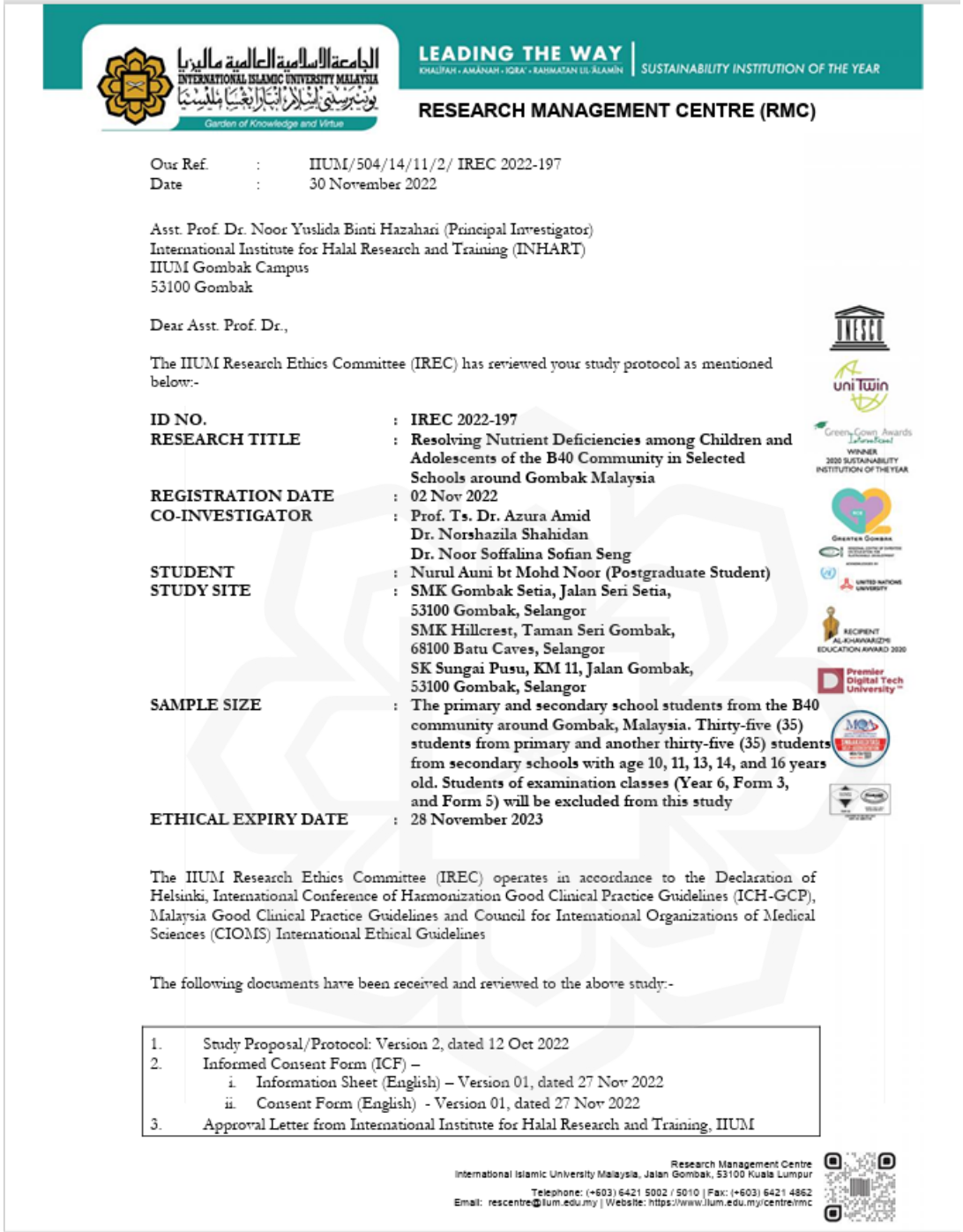
Drum	Ibu bapa	Ayam belanda
Langsir	Bulan	Warna
Loceng	Taman	Rumah
Kopi	Topi	Sungai
Sekolah	Pekebun	Hidung

Senarai B

Meja	Gunung	Ikan
Pegawai	Gelas	Gusi
Burung	Tuala	Pensel
Kasut	Awan	Kedai
Dapur	Bot	Kambing

Drum	Meja	Bunga	Ibu bapa	Gunung	Botol
Ikan	Ayam belanda	Keretapi	Pegawai	Langsir	Garam
Bulan	Gelas	Jari	Warna	Gusi	Enal
Burung	Loceng	Kayu	Tuala	Taman	Kunci
Rumah	Pensel	Emas	Kopi	Kasut	Butang
Awan	Topi	Kolam	Kedai	Sungai	Kerusi
Sekolah	Dapur	Rumput	Pekebun	Bot	Bintang
Kambing	Hidung	Bandar	Jam	Api	Tasik
		Kampung	Batu		

APPENDIX C: IREC ETHICAL APPROVAL



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RESEARCH MANAGEMENT CENTRE (RMC)

Our Ref. : IIUM/504/14/11/2/ IREC 2022-197
Date : 30 November 2022

Asst. Prof. Dr. Noor Yuslida Binti Hazahari (Principal Investigator)
International Institute for Halal Research and Training (INHART)
IIUM Gombak Campus
53100 Gombak

Dear Asst. Prof. Dr.,

The IIUM Research Ethics Committee (IREC) has reviewed your study protocol as mentioned below:-

ID NO.	:	**IREC 2022-197**
RESEARCH TITLE	:	**Resolving Nutrient Deficiencies among Children and Adolescents of the B40 Community in Selected Schools around Gombak Malaysia**
REGISTRATION DATE	:	**02 Nov 2022**
CO-INVESTIGATOR	:	**Prof. Ts. Dr. Azura Amid** **Dr. Norshazila Shahidan** **Dr. Noor Soffalina Sofian Seng**
STUDENT	:	**Nurul Auni bt Mohd Noor (Postgraduate Student)**
STUDY SITE	:	**SMK Gombak Setia, Jalan Seri Setia, 53100 Gombak, Selangor** **SMK Hillcrest, Taman Seri Gombak, 68100 Batu Caves, Selangor** **SK Sungai Pusu, KM 11, Jalan Gombak, 53100 Gombak, Selangor**
SAMPLE SIZE	:	**The primary and secondary school students from the B40 community around Gombak, Malaysia. Thirty-five (35) students from primary and another thirty-five (35) students from secondary schools with age 10, 11, 13, 14, and 16 years old. Students of examination classes (Year 6, Form 3, and Form 5) will be excluded from this study**
ETHICAL EXPIRY DATE	:	**28 November 2023**

The IIUM Research Ethics Committee (IREC) operates in accordance to the Declaration of Helsinki, International Conference of Harmonization Good Clinical Practice Guidelines (ICH-GCP), Malaysia Good Clinical Practice Guidelines and Council for International Organizations of Medical Sciences (CIOMS) International Ethical Guidelines

The following documents have been received and reviewed to the above study:-

1. Study Proposal/Protocol: Version 2, dated 12 Oct 2022
2. Informed Consent Form (ICF) –
   i. Information Sheet (English) – Version 01, dated 27 Nov 2022
   ii. Consent Form (English) - Version 01, dated 27 Nov 2022
3. Approval Letter from International Institute for Halal Research and Training, IIUM

Research Management Centre
International Islamic University Malaysia, Jalan Gombak, 53100 Kuala Lumpur
Telephone: (+603) 6421 5002 / 5010 | Fax: (+603) 6421 4862
Email: rescentre@iium.edu.my | Website: https://www.iium.edu.my/centre/rmc

4.	Principal Investigator's CV

Decision by IIUM Research Ethics Committee (IREC):

(√) Approved
( ) Disapproved **Date of Approval: 28 November 2022**

The investigator(s) are required to:

a) submit the 'Continuing Review Form' 30 days before EXPIRY DATE to renew Ethical Approval.
b) notify IREC of any change in protocol and obtaining further ethical approval as appropriate.
c) report any adverse incident during the course of a study to IREC even if the incident is not directly related to the study.
d) report to the IREC within 72 hours for all internal SAEs (occurring in IIUM PI site).
e) report in a prompt manner if the information impacts the continued ethical acceptability of the trial for external SAEs (occurring in participants at other sites).
f) report any major protocol deviation occurs within 5 working days.
g) complete and submit the End of Project Report Form to the IREC Secretariat's Office.
h) All records and data subjects are CONFIDENTIAL and used only for the purposes of this study and all issues and procedures on data confidentiality must be observed.

Yours sincerely,

PROF. DR. NASSER MUHAMMAD AMJAD
Chairman,
IIUM Research Ethics Committee (IREC)

Copy : File –IREC 2022-197

DISCLAIMER: The approval letter only covers the ethical aspect of your study only. Any other permission/approval to use any facilities, data or human resource should fall under applicant's responsibility.