A COMPARISON BETWEEN GOAT MILK AND COW MILK SUPPLEMENTATION ON NUTRITIONAL STATUS AMONG PAEDIATRICS WITH CEREBRAL PALSY IN KELANTAN

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by

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LIST OF SYMBOLS AND ABBREVIATIONS

AAP	American Academy Pediatrics
ANCOVA	Analysis of covariance
AOAC	Association of Official Analytical Chemists
BAZ	BMI-for-age
BMD	Bone mineral density
BMI	Body mass index
BO	Bowel open
CI	Confidence interval
CP	Cerebral palsy
DHA	Docosahexaenoic acid
DXA	Dual X-ray absorptiometry
EI	Energy intake
G	Goat milk sample
GC	Gas Chromatographic
GDP	Gross domestic product
GMF	Goat milk-based formula
GMFCS	Gross Motor Function Classification System
GOT	Glutamic oxaloacetic transaminase
GPT	Glutamic pyruvic transaminase
H_2SO_4	Sulfuric acid
Hb	Hemoglobin
HCl	Hydrochloric acid

Hct	Hematocrit
HDL	High density lipoprotein
HAZ	Height-for-age
Hospital USM	Hospital Universiti Sains Malaysia
HR	Heart Rate
IL-2	Interleukin-2
MCFA	Medium-chain fatty acids
MDG	Malaysian dietary guideline
MUAC	Mid-upper arm circumference
MUFA	Monounsaturated fatty acids
n	Frequency
N	Nitrogen
N/A	Non-applicable
NA	Not Available
ND	Not detected
NFA	Nutritional ferropenic anaemia
NH_4OH	Ammonium hydroxide
PUFA	Polyunsaturated fatty acids
QOL	Quality of life
RCT	Randomized Clinical Trial
RNI	Recommended nutrient intakes
RTF	Ryles Tube Feeding
SD	Standard deviation

SFA	Saturated fatty acids
SOB	Shortness of breath
SQCP	Spastic quadriplegic CP
T_0	Baseline
T_1	2-months from the baseline
T_2	2-months from the T_1
TEE	Total energy expenditure
TSF	Triceps skinfold
UK	United Kingdom
USA	United States of America
WAZ	Weight-for-age
WHO	World Health Organisation
YOKUK	*Yayasan Orang Kelainan Upaya Kelantan*

PERBANDINGAN DI ANTARA PENGAMBILAN SUSU KAMBING DAN SUSU LEMBU SEBAGAI MAKANAN TAMBAHAN TERHADAP STATUS PEMAKANAN DALAM KALANGAN PEDIATRIK PALSI SEREBRUM DI KELANTAN

ABSTRAK

Susu kambing (GM) boleh digunakan sebagai alternatif sekiranya kanak-kanak palsi serebrum (CP) tidak boleh minum susu lembu (CM). Objektif kajian ini adalah untuk membandingkan pengukuran antropometrik, biokimia, klinikal, dan pengambilan pemakanan antara suplemen susu kambing tepung berbanding susu lembu dalam kalangan kanak-kanak CP di Kelantan, Malaysia. Kajian ini melibatkan 2 Fasa; Fasa 1 ialah penentuan, analisis proksimat, profil asid lemak GM dan CM manakala Fasa 2 ialah kajian intervensi. Bagi Fasa 1, sejumlah 20 sampel GM, 1 sampel GM (rujukan) dan 1 sampel CM telah dianalisis. Kriteria kajian untuk rujukan GM dan CM ialah menggunakan susu tepung penuh krim sebagai salah satu bahan utama atau sebagai jenama yang paling banyak digunakan oleh pengguna. Manakala dalam Fasa 2 kajian (reka bentuk kuasi eksperimen, buta tunggal), seramai 87 kanak-kanak dengan CP secara rawak diberikan sama ada susu kambing (GM, n=43) atau susu lembu (CM, n=44). Kajian ini mempunyai kadar respon 82.1%. Umur 4 hingga 12 tahun adalah kriteria inklusi, tetapi kes teruk CP yang memerlukan keperluan pemakanan khas termasuk penyakit metabolik semulajadi, pemakanan melalui tiub dan alahan protein susu lembu (CMPA) dikecualikan. Purata umur kumpulan intervensi ialah 9.05 ± 2.30 tahun, berbanding 8.27 ± 2.55 tahun bagi kumpulan kawalan dan agihan jantina ialah (GM; 53.5% lelaki, 46.5% perempuan) dan

(CM; 70.5% lelaki, 29.5% perempuan) masing-masing. Susu dalam bentuk tepung diberikan dalam paket (21-23 gram, dua kali sehari) disediakan daripada peringkat awal sehingga 4 bulan kajian (3 kali pertemuan; permulaan, 2-bulan dan 4-bulan). Data antropometrik (berat, ketinggian, IJT, MUAC, ukuran lipatan kulit triseps dan subskapular, peratus lemak badan), data biokimia (hemoglobin dan hematokrit), data klinikal (sistolik dan diastolik tekanan darah dan kadar denyut jantung), dan pengambilan diet diukur daripada permulaan kajian sehingga 4 bulan. Hasil kajian Fasa 1 menunjukkan hanya sembilan sampel susu kambing daripada 20 sampel mengandungi susu kambing asli (berdasarkan label kandungan) dan sampel G17 dipilih sebagai susu kambing untuk kegunaan Fasa 2 kerana mengandungi paling tinggi kandungan asid lemak rantaian sederhana (MCFA) iaitu 2803.9 mg (12.97%) berbanding susu lembu iaitu 765 mg (7.19%) dan juga sampel susu kambing yang lain. Hasil kajian Fasa 2, GM menunjukkan peningkatan yang lebih baik, terdapat perbezaan yang ketara bagi ukur lilit triseps (0.33 mm vs -0.20 mm, p=0.024) dan vitamin B1 (p=0.043), manakala bagi parameter yang lain tidak terdapat perbezaan yang ketara di antara GM dan CM selepas intervensi kajian (p>0.05). Selain itu, terdapat juga penurunan bagi parameter kalsium (p=0.040) dan vitamin B12 (p=0.022), di antara GM dan CM. Kesimpulannya, berdasarkan analisis makmal, kandungan MCFA GM adalah lebih tinggi daripada CM. Manakala bagi kajian intervensi, GM boleh dijadikan alternatif kepada CM sebagai suplemen ia juga boleh diterima oleh kanak-kanak CP tetapi terdapat perbezaan ketara untuk parameter ukur lilit triseps dan vitamin B1 sahaja. Selain itu, berlaku penurunan kalsium dan vitamin B12 daripada pengambilan diet seharian di antara GM dibandingkan CM. Kajian masa depan diperlukan untuk mengesahkan dan mengkaji isu ini secara intervensi jangka masa

panjang serta ujian darah perlu dilakukan untuk menilai pengurangan kalsium dan vitamin tertentu dalam diet seharian.

A COMPARISON BETWEEN GOAT MILK AND COW MILK SUPPLEMENTATION ON NUTRITIONAL STATUS AMONG PAEDIATRICS WITH CEREBRAL PALSY IN KELANTAN

ABSTRACT

Goat milk (GM) can be used as an alternative if cerebral palsy (CP) children are unable to tolerate cow milk. The purpose of this study was to compare the anthropometric, biochemical, clinical, and dietary intake of powdered GM versus CM among CP children in Kelantan, Malaysia. The study consists of two phases: Phase 1 focuses on determining and analysing the proximate and fatty acids profile of GM and CM, while Phase 2 involves the intervention study. In Phase 1, a grand total of 20 GM samples were analysed, along with 1 GM sample (reference) and 1 CM sample. The study's criteria for references on GM and CM involved the use of powdered full cream milk as a primary ingredient or the most popular brand among consumers. Meanwhile, during Phase 2 of the study (quasi-experimental design, single blind), a total of 87 children with CP were randomly assigned to either goat milk (GM, n=43) or cow milk (CM, n=44). The research achieved an 82.1% response rate. The study included children between the ages of 4 and 12, but excluded those with severe cases of CP who needed special nutritional requirements such as inborn error metabolism, tube feedings, and cow milk protein allergy (CMPA). In the intervention group, the mean age was 9.05 ± 2.30 years, while in the control group, it was 8.27 ± 2.55 years. The gender distribution was as follows: in the GM group, 53.5% were male and 46.5% were female, while in the CM group, 70.5% were male and 29.5% were female. Milk powder in the form of a sachet (21-23 grams, twice a day) was provided

from the start of the study until the end of the 4 months (3 meetings; baseline, 2-months, and 4-months). Anthropometric data (weight, height, BMI, MUAC, triceps and subscapular skinfold measurements, body fat percentage), biochemical data (hemoglobin and hematocrit), clinical data (systolic and diastolic blood pressure and heart rate), and dietary intake were gathered from baseline to 4-months. The Phase 1 study found that only nine GM samples out of 20 contained pure GM (based on the ingredient label), and sample G17 was chosen as goat milk for Phase 2 because it contained the highest medium-chain fatty acid (MCFA) content of 2803.9 mg (12.97%) compared to CM, 765 mg (7.19%), and the other goat milk samples. Phase 2 results show that GM showed greater improvements. There were significant differences in triceps skinfold measurement (0.33 mm vs -0.20 mm, p=0.024) and vitamin B1 (p=0.043), while other parameters did not show significant differences between GM and CM after the intervention (p>0.05). Furthermore, there was a reduction in calcium (p=0.040) and vitamin B12 (p=0.022) levels between GM and CM. In conclusion, laboratory analysis shows that GM has a higher MCFA content than CM. Meanwhile, for the intervention study, GM can be used as a tolerable supplement for CP children based solely on significant differences in triceps skinfold measurement and vitamin B1 levels. Moreover, calcium and vitamin B12 intake decreased in the daily diet of GM in comparison to CM. Further research is needed to confirm and explore this matter over a longer duration, with the necessity of conducting blood tests to assess the decrease in calcium and vitamins from the daily diet.

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Cerebral palsy (CP) is the most common type of disability among children, and they are at risk of malnutrition, with 50% of them being undernourished (Almuneef et al., 2019). CP is defined as a neurological lesion in the brain that impairs oral motor function and causes feeding dysfunction (Sigan et al., 2013). They may also have dysphagia, or difficulty swallowing, as well as coughing, choking, vomiting, sensory impairment, constipation, seizures, or dehydration (Speyer et al. 2019). CP occurs in approximately 2.08 out of every 1000 live births (Sadowska et al., 2020).

Currently, there are no recent or national data regarding the prevalence of CP in Malaysia. Based on the population-based survey, overall prevalence of physical disability was 2.8 per 1000 population among Malaysian school age-children between 7 and 18 years old and most of them are totally reliant on their caregiver in term of self-care and movement (Khoo et al., 2009). Meanwhile, Tan and Yadav (2008) reported that from 900 children in their cross-sectional study, it is said that children with disability registered with primary health care clinics in Malaysia, 22.2% were CP (Tan & Yadav, 2008). In 2012, the Malaysian Ministry of Health recorded 2766 children with special needs, 215 of whom were diagnosed with cerebral palsy (UNICEF, 2014).

A child with cerebral palsy is recognised as a disabled child and requires additional attention similar to non-disabled children. Malnutrition among children can potentially lead to further health problems or complications, thus impacting the child's emotional and financial well-being (Neyestani et al., 2010). It is important to address malnutrition as a significant issue among disabled children, particularly those with CP. Providing them with appropriate food like goat milk can help with absorption and enhance their nutritional status (He et al., 2022; López-Aliaga et al., 2010).

In Malaysia, children with cerebral palsy often experience malnutrition, especially undernutrition (Ahmad et al., 2020; Zainah et al., 2001). In addition, children with CP, especially those facing feeding challenges, experience inadequate nutritional status (Rajikan et al., 2018). According to a recent systematic review and meta-analysis, a significant prevalence of malnutrition was found in individuals with CP (da Silva et al., 2022).

Malnutrition in children with CP can be attributed to inadequate oral-motor function, hindering their ability to consume essential calories and nutrients required for growth (Fung et al., 2002). Children with CP may benefit from goat milk to help alleviate constipation and promote softer stool. The variations in digestibility between the two formulas are attributed to the different curd textures produced by goat milk and cow milk (Joon et al., 2017). It is possible that the varying whey and casein ratio in goat milk and cow milk could be the reason, as goat milk has a higher whey to casein ratio compared to

cow milk (Roy et al., 2020). Therefore, this study can contribute evidence about the digestibility of milk and offer children an alternative to cow milk.

Based on a study carried out in spastic and rehabilitation centres in Kuala Lumpur, Johor, and Pulau Pinang, cow milk was identified as the primary source of energy and nutrients for children with severe cerebral palsy (Rajikan et al., 2018). Moreover, research conducted in Indonesia examined food consumption and nutritional adequacy in relation to nutritional status among CP children aged 5 to 18 years. The study showed that cow milk (60%) is the most consumed dietary source of animal protein (Indriasari et al., 2019).

Advances in health awareness among society that increasingly concern about health issues and quality of life, have led nutritional science to search new foods that offer added value and health benefits, and help delay or even prevent the occurrence of certain diseases (López-Aliaga et al., 2010). In this context, goat milk has been studied as the natural food with excellent nutritional properties. Goat milk has been identified as a great substitute for cow milk in this study due to its numerous nutritional benefits. One of the advantages highlighted is that goat milk, which is high in MCFA, has been proven to be effective in treating various clinical issues like malabsorption syndromes, intestinal resection, premature newborn feeding, non-thriftiness of children, or infant malnutrition (Kumar et al., 2012). Even though the consumption of goat milk and its products was low, it is generally accepted by young adults (Nishitani et al., 2008). Asia contributes around 60% to the global goat milk production, with the demand for animal products in Asia rising rapidly due to growing populations and disposable incomes (Miller & Lu,

2019). Goat milk is crucial for the nutrition and economic stability of developing and underdeveloped nations. It offers essential sustenance to rural populations, who make up the majority of these countries (Park & Haenlein, 2007).

Based on a previous study, goat milk contains 40% more medium-chain fatty acids than cow milk, which is advantageous for health. When stated as mg/100 g of milk, the difference can be as high as 115% (Ceballos et al., 2009). MCFA are broken down faster than LCFA, providing a sudden burst of energy (Velázquez et al., 1996). Goat milk fat contains a significantly greater quantity of short and medium chain fatty acids. These treatments have been widely accepted in the medical field for various malabsorption conditions. They have shown positive effects in reducing cholesterol levels, improving digestion, and addressing sleep issues, especially in children (Haenlein, 2001). Furthermore, medium chain fatty acids (MCFA) are widely acknowledged for their positive impact on human health, specifically in terms of cardiovascular health (Haenlein, 2004) and their ease of digestion (Alferez et al., 2001).

Many past human studies have examined the impact of goat milk on infants or children who are in good health (Grant et al., 2005; Razafindrakoto et al., 1994; Tannock et al., 2013; Xu, Wang, et al., 2015; Zhou et al., 2014). No studies were found regarding the effectiveness of goat milk on children with disabilities, specifically those with CP. Thus, the study aimed to investigate whether there were significant differences in nutritional status among children with CP who consumed goat milk versus cow milk. We hypothesised that children with CP who were fed goat milk would show notable variations

in nutritional status (including anthropometry, body fat, biochemical markers, and dietary intake) in comparison to those who were fed cow milk.

1.2 Problem Statement

The issue of malnutrition impacts the nutritional status of children with CP and has been linked to increased use of healthcare services such as hospitalisation and doctor visits, restricted social involvement, and reduced participation in outdoor activities (Fortin et al., 2021; Lisa Samson-Fang et al., 2002; Shikako-Thomas et al., 2008). Children with CP also need specialized education, nutritional, and emotional support from parents or caregivers. Nutritional issues are receiving attention because children with disabilities are struggling to meet their calorie requirements when it comes to feeding and achieving them (Jones et al., 2007).

There is a growing issue of malnutrition that requires an improvement in dietary intake. Children with CP may need additional calories from supplements (Trivić & Hojsak, 2019). Problems with eating are often seen in children with neurodevelopmental disorders like CP, leading to poor nutrition and a risk of malnutrition. They are typically given ONS as a treatment option (Hill, 2017). Boosting calorie, protein, and micronutrient intake can be crucial by consuming oral nutrition supplements like heavy cream, whole milk, or complete enteral nutrition formulas, which are favoured by dietitians for meeting essential nutrient needs (Brown et al., 2015; Jesus & Stevenson, 2020). At present, children with cerebral palsy are consuming oral nutritional supplements (ONS) or cow milk as part of their diet. Nevertheless, the cost of ONS was deemed excessive by Norman

et al. (2011), and there is also a requirement for alternatives to cow milk because of digestibility concerns, as highlighted by Araújo et al. (2012). Problems with digestion are common among individuals with CP due to neurological issues affecting the digestive system (Araújo et al., 2012).

Because of challenges with feeding, many parents or caregivers give children cow milk supplements to meet their energy needs (Nur et al., 2019; Rajikan et al., 2018). Nevertheless, children with CP often experience constipation and digestive issues (Araújo et al., 2012). As per Araújo et al., (2012), individuals with CP may be at a higher risk of developing eating disorders because of structural abnormalities in the central and peripheral nervous systems. The most common disorders of the digestive tract are dysphagia, gastroesophageal reflux disease, and constipation (Araújo et al., 2012). Children who have CP often experience constipation. This occurs due to a neurological condition that harms the central nervous system, which is a primary risk factor for constipation (Veugelers et al., 2010). Constipation can exacerbate feeding issues, leading to frequent vomiting, persistent nausea, and early satiety (Borowitz & Sutphen, 2004), which could potentially decrease calorie intake. The higher medium chain fatty acids (MCFA) in goat milk compared to cow milk aid in digestibility, fast and efficient digestion and more gut friendly may improve the constipation problems among CP children.

Therefore, it is important to offer different approaches that could enhance digestion and dietary consumption in this particular group of children. Currently, there is a lack of intervention studies addressing these nutritional issues. All of these highlight the

importance of having a different supplement besides cow milk to enhance the nutritional status of children with CP.

At the moment, only seven Randomized Clinical Trials (RCTs) have been conducted and published. The results were mixed findings. Hence, it is essential to carry out this study to gather more evidence on the benefits of consuming goat milk. This material can serve as a valuable resource for parents or caregivers of children with special needs or typical development, as well as for the general public, policymakers, researchers, and healthcare providers. It offers guidance on the benefits of incorporating powdered goat's or cow's milk into a regular diet.

In such scenarios, it is essential to supplement goat milk among CP children as part of nutritional intervention for this vulnerable population. By doing that, children with cerebral palsy can better consume and digest milk, which can enhance their dietary intake.

1.3 Significance of the Study

This study is crucial because of the high rate of malnutrition among children with CP. Moreover, children with cerebral palsy frequently face feeding issues that can affect various aspects of their well-being, including growth, nutrition, health, social interactions, behavior, and development. Feeding issues can lead to insufficient nutritional consumption, increasing the likelihood of malnutrition, especially undernutrition.

Typically, children with cerebral palsy incorporate oral nutritional supplements (ONS) or cow milk into their daily diet. However, due to the increased cost and parents' ongoing search for alternatives, such as goat milk in this case, conducting this study is necessary.

Due to gastrointestinal problems, constipation was a frequent issue among children with severe neurological disabilities, and a larger proportion of these children had lower intake of fibre and fluids (Veugelers et al., 2010). There was a discussion about how younger age, increased spasticity, higher severity, and reliance on caregivers could raise the likelihood of constipation. Furthermore, inadequate fluid, calorie, and fibre consumption also played a role in causing constipation (Nadeem & Waqar, 2019).

Furthermore, while social media has documented the nutritional and medicinal advantages of goat milk, there is a paucity of research that has been conducted and published in scholarly journals on the subject. In contrast to cow milk, goat milk offers numerous nutritional and health benefits, as evidenced by scientific studies pertaining to goat nutrition. However, research examining the nutritional status of children in relation to goat milk as an alternative to cow milk is limited.

Furthermore, this study is necessary due to the unique characteristics of goat milk regarding medium chain fatty acids (MCFA). This could serve as a substitute for cow's milk for children with CP. Moreover, there has been a rise in demand for goat milk as many nutritional companies in Malaysia have begun producing it. The rising demand for

goat milk is due to the perception of these foods as *sunnah* foods. An analysis is needed to evaluate the proximate and fatty acid analyses of powdered goat milk. Afterwards, the goat milk with the highest MCFA content was chosen for the intervention study to evaluate the effects of goat milk and cow milk on the nutritional status of children with CP. The results could contribute valuable information on nutrient analysis, particularly proximate and fatty acids analysis.

This study made a contribution to the field by comparing the nutritional status of children with CP in response to supplementation with goat milk and cow milk. The information provided may prove beneficial to researchers, healthcare professionals (particularly dietitians or nutritionists), or parents when making decisions regarding supplement alternatives for children with cerebral palsy as part of their dietary management. This information has the potential to enhance the body of literature in Malaysia by providing additional evidence.

Ultimately, malnutrition imposes a strain on the family due to its substantial impact on health deterioration (Krick et al., 1996; Mushta et al., 2021). Recognizing signs of malnutrition early and intervening promptly in children with CP can support them in attaining sufficient nutrition essential for optimal growth and development, ultimately leading to an improved quality of life. Furthermore, there were conflicting results in typical children and a lack of research on nutritional intervention comparing goat milk and cow milk among CP children, which supports the need for this study. Hence, conducting this study is crucial.

1.4 Theoretical Framework

Figure 1.1 depicts the theoretical framework for the current investigation. This theoretical framework refers to the research conducted by Ceballos and colleagues (Ceballos et al., 2009). The study explained the advantages of goat milk containing more Medium Chain Fatty Acids (MCFA) than cow milk. The MCFA is made up of C6:0 (Caproic acid), C8:0 (Caprylic acid), and C10:0 (Capric acid). It is advantageous because MCFA is easily hydrolyzed in the digestive tract. Aside from that, MCFA can be absorbed without re-esterification (Zenebe et al., 2014). Subsequently, a rapid and effective digestion process ensued, accompanied by superior energy sources and enhanced digestibility. Based on this theoretical framework, it was hypothesized that the exceptional properties of MCFA would enhance digestion and absorption, thereby contributing to the weight gain and nutritional improvement of children with cerebral palsy in comparison to cow milk.

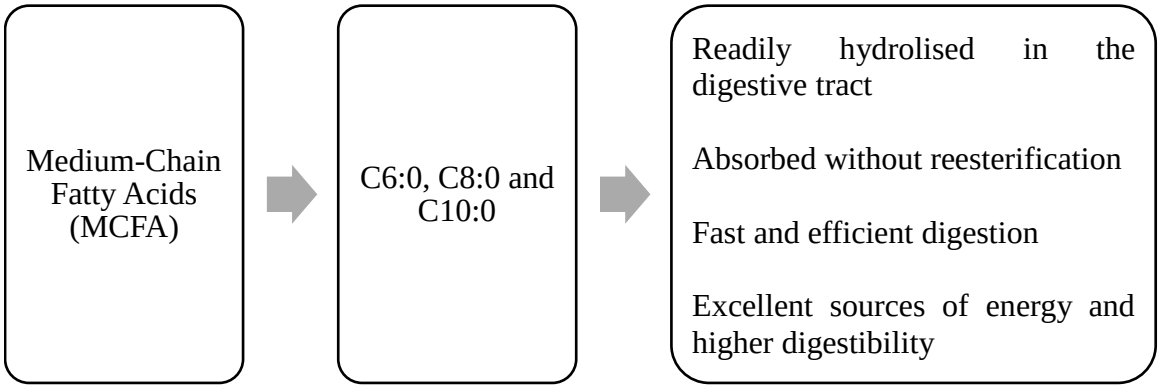

Figure 1.1 Theoretical Framework of the study (Rai et al., 2022; Zenebe et al., 2014)

1.5 Conceptual Framework

Figure 1.2 depicts the conceptual framework for the current study. The independent variables were the intervention groups that consumed powdered goat milk and the control groups that consumed powdered cow milk, while the dependent variables were anthropometric measurements, body fat measurements, biochemical measurements (hemoglobin, hematocrit), clinical measurements (systolic blood pressure, diastolic blood pressure, and heart rate), and dietary consumption.

The study was split into two phases: Phase 1 focused on food analysis, while phase 2 involved a quasi-experimental design. This study aimed to compare the effectiveness of goat milk and cow milk supplementation on the nutritional status of children with cerebral palsy in Kelantan, Malaysia. In the first phase of the study, an analysis was conducted on 20 samples of goat milk from the Malaysian market to determine their proximate and fatty acid content. By the end of Phase 1, a single goat milk sample containing the highest concentration of medium chain fatty acids (MCFA) was selected for Phase 2, with cow milk being used as the control group's standard for comparison.

During this time, a crucial aspect of Phase 2 involved comparing the effectiveness of goat milk and cow milk supplementation on the nutritional status of children with cerebral palsy. The study was conducted in Kelantan, Malaysia, using home visitation. When it came to supplementation, the goat milk supplement was provided in a 21-gram sachet twice a day, while the cow milk supplement was given in a 23.4-gram sachet twice a day.

Goat milk was consumed by the intervention group in this quasi-experimental design, while the control group consumed cow milk. Results were measured at the study's baseline, 2-months, and 4-months. It is essential to provide powdered goat milk supplementation to children with CP for nutritional support. According to previous research, the Medium-Chain Fatty Acids (MCFA) content in goat milk is 40% higher than that in cow milk (Ceballos et al., 2009). The structure analysed in this study includes Caproic acid (C6:0), Caprylic acid (C8:0), and Capric acid (C10:0). Reports indicate that the significant MCFA content in goat milk aids in digestion and absorption, potentially benefiting weight gain in undernourished children.

The study included various measurements such as anthropometric measurements (weight, height, BMI, weight for age Z-score, height for age Z-score, and BMI for age Z-score), body fat measurements (triceps and subscapular skinfold thickness, body fat percentages), biochemical measurements (hemoglobin, hematocrit), clinical measurements (systolic blood pressure, diastolic blood pressure, and heart rate), and dietary intake (calories, carbohydrate, protein, fat, and micronutrient).

The anticipated result of this study involving the supplementation of goat milk to the diet of children with CP included an increase in body weight and body fat, enhancement of biochemical parameters such as hemoglobin and hematocrit levels, and improvement in dietary intake by boosting the intake of calories, protein, carbohydrates, fats, and other essential micronutrients. By supplementing with goat milk, the nutrition

intervention could enhance the nutritional status of children with cerebral palsy in Kelantan, Malaysia.

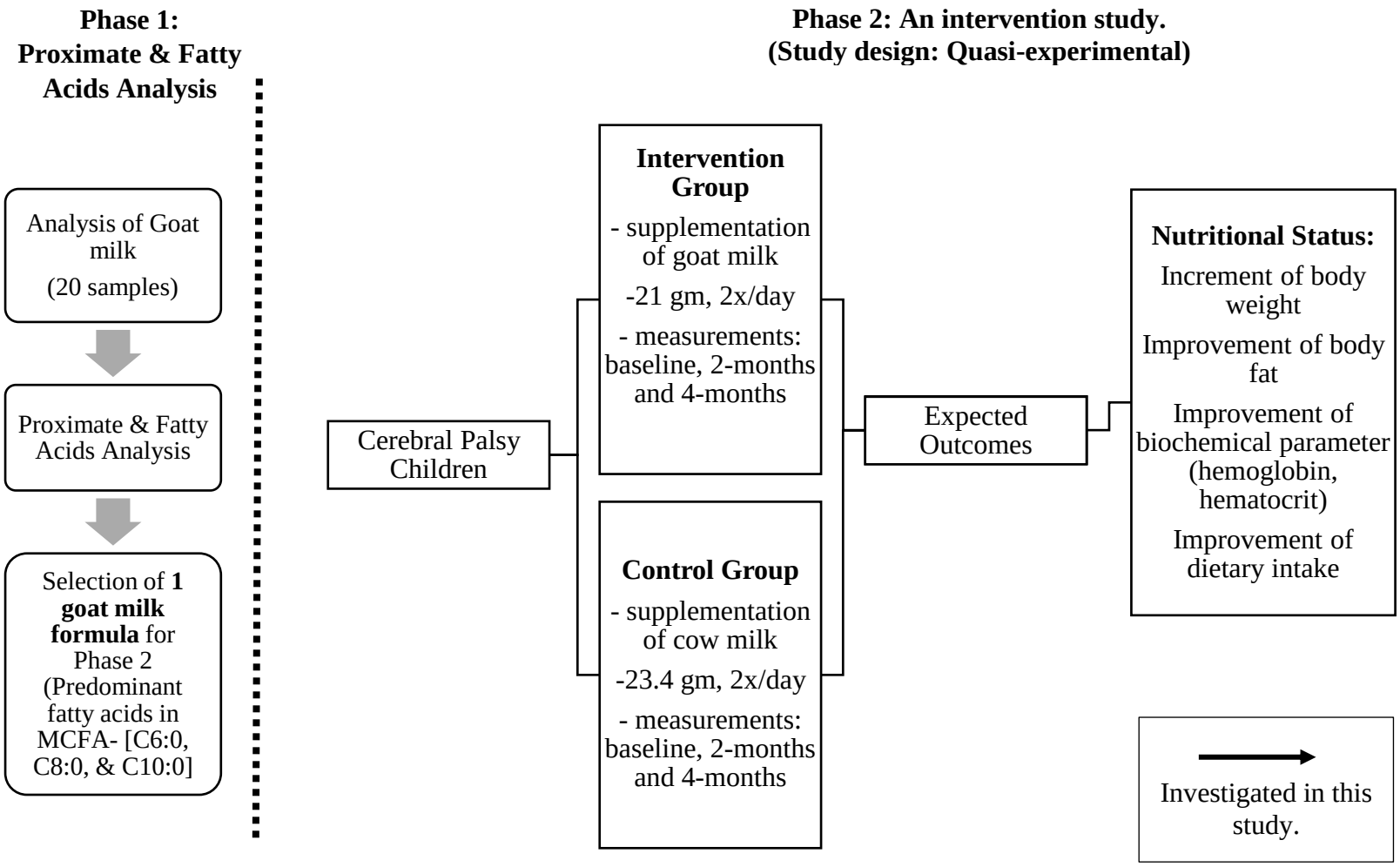

Figure 1.2 Conceptual Framework of the study (Phase 1 & 2)

1.6 Research Questions

This study addresses several research questions as follows:

Phase 1

1. What is the availability of goat milk formulas for children in Malaysia?
2. What are the values of proximate and fatty acids of 20 selected powdered goat milk.
3. Which sample had the highest medium chain fatty acids (MCFA) content out of the 20 selected powdered goat milk samples?

Phase 2

1. What are the socio-demographic characteristics of children with CP in Kelantan, Malaysia?
2. What is the prevalence of malnutrition among CP children in Kelantan, Malaysia?
3. Is there a significant difference in the effects of supplementing powdered goat milk versus powdered cow milk on anthropometric and body fat measurements in children with cerebral palsy in Kelantan, Malaysia?
4. Is there a significant difference in the effects of supplementing powdered goat milk versus powdered cow milk on CP children in Kelantan, Malaysia, specifically in terms of biochemical measurements?
5. Is there a significant difference in the effects of supplementing powdered goat milk versus powdered cow milk on CP children in Kelantan, Malaysia, specifically in terms of clinical measurements?

6. Is there a significant difference in the effects of supplementing powdered goat milk versus powdered cow milk on dietary intake among CP children in Kelantan, Malaysia?

1.7 Objectives of the Study

1.7.1 General Objective

To compare the nutritional status of Kelantan children with CP who were supplemented with powdered goat milk or cow milk.

1.7.2 Specific Objectives

There are two phases to this study.

The specific objectives for Phase 1 are:

1. To explore the goat milk availability in Malaysia's marketplace (goat milk formula for children).
2. To analyse the macronutrients in selected goat milk formula and raw goat milk i.e. carbohydrate, protein, fat, water and ash.
3. To determine the fatty acids composition using gas chromatographic methods (GC).

The specific objectives for Phase 2 include:

1. To assess the socio-demographic characteristics of CP children in Kelantan, Malaysia.

2. To determine the prevalence of malnutrition among CP children in Kelantan, Malaysia.
3. To compare anthropometric (weight, height, BMI, weight for age Z-score, height for age Z-score and BMI for age Z-score) and body fat measurements (triceps and subscapular skinfold, body fat percentages) between children with CP in the intervention group who consume goat milk and control group who consume cow milk.
4. To compare biochemical measurements (hemoglobin, hematocrit) between children with CP in the intervention group who consume goat milk and control group who consume cow milk.
5. To compare clinical measurements (systolic blood pressure, diastolic blood pressure and heart rate) between children with CP in the intervention group who consume goat milk and control group who consume cow milk.
6. To examine the differences in dietary intake (calories, carbohydrate, protein, fat, and micronutrients) between children with CP in the intervention group who consume goat milk and the control group who consume cow milk.

1.8 Hypotheses

The study tested the following hypotheses that are relevant to Phase 2:

H_{O1}: There is no difference between anthropometric (weight, height, BMI, weight for age Z-score, height for age Z-score and BMI for age Z-score) and body fat measurements (triceps and subscapular skinfold thickness, body fat percentages) between children with

CP in the intervention group who consume goat milk compared to the control group that consume cow milk.

Ha_1: There is a difference between anthropometric (weight, height, BMI, weight for age Z-score, height for age Z-score and BMI for age Z-score) and body fat measurements (triceps and subscapular skinfold thickness, body fat percentages) between children with CP in the intervention group who consume goat milk compared to the control group that consume cow ‘s milk.

H_{O2}: There is no difference between biochemical measurements (hemoglobin, hematocrit) between children with CP in the intervention group who consume goat milk compared to the control group that consume cow milk.

Ha_2: There is a difference in biochemical measurements (hemoglobin, hematocrit) between children with CP in the intervention group who consume goat milk and the control group that consumes cow milk.

H_{O3}: There is no difference in clinical measurements (systolic blood pressure, diastolic blood pressure and heart rate) between children with CP in the intervention group who consume goat milk compared to the control group that consume cow milk.

Ha_3: There is a difference in clinical measurements (systolic blood pressure, diastolic blood pressure and heart rate) between children with CP in the intervention group who consume goat milk compared to the control group that consume cow milk.

H_{O4}: There is no difference in dietary intake (calories, carbohydrate, protein, fat and micronutrient) between children with CP in the intervention group who consume goat milk compared to the control group that consume cow milk.

Ha_4: There is a difference between dietary intake (calories, carbohydrate, protein, fat and micronutrients) between children with CP in the intervention group who consume goat milk and the control group that consume cow milk.

1.9 Definition of Terms

1. Caregiver: parents or guardian (Eifert et al., 2015).
2. Anthropometry: measurements of the human body (Norton, 2018).
3. Medium-Chain Fatty Acids (MCFA): Fatty acids with two or three fatty acids having an aliphatic tail of 6–10 carbon atoms; C6:0 (Caproic acid), C8:0 (Caprylic acid) and C10:0 (Capric acid) (Marten et al., 2006).
4. Malnutrition: refers to deficiency, excess or imbalance in a person's intake of energy and or nutrients (Dipasquale et al., 2020). The term malnutrition covers two broad groups of conditions. One is 'under nutrition' which includes stunting (low height for age), wasting (low weight for height), underweight (low weight for age) and micronutrient deficiencies or insufficiencies (a lack of important vitamins and

minerals). The other is overweight, obesity and diet-related non-communicable diseases (such as heart disease, stroke, diabetes, and cancer) (Ntenda, 2019).

5. Proximate analysis: the analysis of moisture, ash, protein, fat, and carbohydrate (AOAC, 2000).
6. Fatty acids analysis: the process of fat and fatty acids is extracted from food by hydrolytic method (Christie, 1989).
7. Supplementation: the additional of special foods in addition to regular diet (Domínguez Díaz et al., 2020). In this study, the special foods are powdered goat milk.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The chapter started by introducing children with CP globally and in Malaysia. Following that, the issues of malnutrition among children with CP are discussed in detail, with a focus on growth reference, feeding, and common nutritional problems. The following section examines nutrition assessments, which involve evaluating the nutritional status of children with cerebral palsy and determining the necessity for intervention. This study focuses on supplementing goat milk for children with CP and reviews the available analysis of goat milk's proximate and fatty acids. A key point to note is that this chapter ends with the comparison between goat milk and cow milk in the earlier research.

2.2 Cerebral Palsy (CP)

2.2.1 Introductions (Definition, Incidence and Classifications)

Cerebral Palsy (CP) is the most common cause of children's motor disability. CP is a collection of lasting movement and posture impairments that result in activity limitations. These issues stem from non-progressive complications in the developing fetus or infant brain (Sadowska et al., 2020). Moreover, it can be described as a set of neurological conditions referred to as cerebral palsy that affect the body's movement and muscle

coordination permanently and usually appear in infancy or early childhood (Olusanya et al., 2022).

Based on population-based research, global estimates of the prevalence of CP cases range from 1.7 to 3.6 per 1000 live births or children of a given age group (Bhasin et al., 2006; Ann Johnson, 2002; Winter et al., 2002). From 2011 to 2017, there were 5840 registered children with cerebral palsy in Malaysia (Ying et al., 2021). The most common types of CP are classified according to motor type, topography, or gross motor function classification (GMFCS) (McIntyre et al., 2011). Table 2.1 outlines classification by motor form, while Table 2.2 shows topography. The GMFCS is considered the gold standard for accurately defining motor function in CP (Palisano et al., 1997). Piscitelli et al. (2023) describe GMFCS as a five-level classification system for gross motor control. The classification is based on an individual's ability to initiate movement independently, with a focus on sitting, moving, and mobilising (Table 2.3). Based on all of the classifications, the GMFCS was the most important for children with CP.

Table 2.1 Classification by Motor Type

Type	Definitions	Prevalence
Spasticity	Overactive muscles displaying a speed-dependent stretch resistance. Spasticity can lead to secondary deteriorations, including muscle length loss, dislocation of the joint and pain.	20-40%
Dyskinesia	Dyskinesia is either athetosis or dystonia. Athetoid CP is hypotonic with hyperkinesia characterized by involuntary writhing-stormy movement and can co-occur with chorea. In contrast, dystonic CP is hypokinetic, involving involuntary, abnormal twisting postures or repetitive movements with hypertonia. Tone is typically fluctuating.	10-15%
Ataxia	Ataxia leads to unstable consistency tremors. Ataxic is a muscle coordination failure where the action shows irregular strength, rhythm and precision.	5-10%

Sources: McIntyre et al., 2011 and Gulati & Sondhi, 2018

Table 2.2 Classification by Topography

Type	Definitions
Hemiplegia	Hemiplegia/monoplegia is the involvement of one side of the body. The upper limb is usually more affected than the lower limb. Strong early hand preference or hand disregard is sometimes the first sign of a problem.
Diplegia	Diplegia is where both the legs are affected and are more affected than the upper limbs.
Quadriplegia (Tetraplegia)	Quadriplegia refers to the presence of spasticity in all four limbs; where the effect on the arms is equal or more than the legs. Trunk and oro-facial involvement are also to be expected. In rare cases, one limb is spared, and this is referred to as triplegia.

Source: McIntyre et al., 2011

Table 2.3 Summary Classification by Gross Motor Function Classification System (GMFCS)

Level	Description
I	Can walk without limitations
II	Walk with limitations
III	Walk with assistive mobility device
IV	Walking ability severely limited even with assistive devices. Use of power wheelchair
V	Transported by manual wheelchair

Sources: Palisano et al., 1997 and Compagnone et al., 2014

2.2.2 Risk Factors

Risk factors for CP are typically multifactorial and can be recognised as prenatally, perinatally and postnatally or mixed (Reddihough & Collins, 2003).

The perinatal period encompasses brain malformations, in utero stroke, and congenital cytomegalovirus infection. It covers conditions like hypoxic ischemic encephalopathy, viral encephalitis, or meningitis for perinatal use (Dodge, 2008). Examples after birth include accidental head trauma, lack of oxygen, or child abuse (Dodge, 2008). Despite the reported key risk factors for CP, such as low birth weight, intrauterine infections, and multiple gestation, a child's likelihood of experiencing cerebral palsy increases significantly if their birthweight falls below the 10th percentile. (Odding et al., 2006).