ENHANCING HAEMOGLOBIN STATUS OF ANAEMIC SCHOOL GIRLS USING COOKED VEGETABLES ENRICHED WITH BAOBAB POWDER IN KILIFI COUNTY- KENYA

RIZIKI DAMA YAA (A56/6834/2017)

Diploma in Community Health Nursing (Kenya Medical Training College), Bsc. in Food Nutrition and Dietetics (Kenyatta University)

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FACULTY OF FOOD, NUTRITION AND DIETETIC

2020

DECLARATION

This dissertation is my original work and has not been presented for a degree in any other university

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This dissertation has been submitted with our approval as University supervisors.

Dr. Angela. A. Andago

Department of Food Science, Nutrition and Technology

University of Nairobi

Sign..... Date.....

Dr. Catherine. N. Kunyanga

Department of Food Science, Nutrition and Technology

University of Nairobi

Sign..... Date: 1st September, 2020.....

UNIVERSITY OF NAIROBI

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DEDICATION

This work is dedicated to my dear mother who unfortunately did not live to see its end, my dad for his dedication toward baobab supply,

My husband Jared Mogeni and our children Hidaya and Asha for their support, sacrifice and encouragement,

My sister Saumu, for ever lasting support towards this work.

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ACRONYMS

ATP – Adenosine triphosphate

DMT – Divalent metal transporter

EDTA- Ethelene diamine tetraacetic Acid

FFQ- Food frequency questionnaire

HB – Haemoglobin

HCP – Heme-carrier protein

ID – Iron deficiency

IDA – Iron deficiency anaemia

KDHS- Kenya Demographic Health Survey

KMNS – Kenya micronutrient survey

KII- Key informant interview

RDA – Recommended daily allowance

SF- Serum Ferritin

SPSS- Statistical Package for the Social Science

TsfR – Transferrin receptor

WHO – World Health Organization

OPERATIONAL DEFINETIONS

Anaemia: Anaemia is a condition characterized by reduction in the number of red blood cells and/or haemoglobin (Hb) concentration. In men Hb of <13.5g/dl, in women Hb of <12g/dl and Hb of 11.5g/dl in children of age 6 months to 11 years.

Food based interventions: These are interventions that aim to increase the production, availability and access of food nutrients, increase the consumption of nutrient rich food and increase the bioavailability of nutrients diet

Haemoglobin: Conjugated protein, consisting of haem and the protein globin that gives red blood cells their characteristic colour. This protein is responsible for transporting oxygen in the blood

Indigenous vegetables: Indigenous vegetables are vegetables that are native to a specific area and produced through traditional practices and mostly home grown

Iron deficiency: A state where the body does not have enough of the mineral iron for normal physiological processes in the body

Iron status: A state that defines the total range of the entire body's iron stores in all its forms

Morbidity status: A state of being diseased or unhealthy within a population

Serum ferritin: Ferritin is the storage form of iron in the body

Transferrin receptors: Transferrin receptor (TsfR) is an iron related protein that regulates the uptake of iron into all body cells

Vitamin C: Vitamin C is an organic water soluble vitamin essential for humans

ABSTRACT

Anaemia and especially iron deficiency anaemia remain one of the most significant nutritional deficiency in the world affecting approximately 30% of the population. This is more so in countries like Kenya being developing countries. Women of child bearing age and adolescents bear the largest burden. Previous studies have identified inadequate dietary intake and poor absorption of iron as the main causes of anaemia. The study evaluated the effect of consuming cooked vegetables enriched with baobab powder, on haemoglobin status of anaemic adolescent girls in Kilifi, Kenya.

A rapid assessment was conducted to determine knowledge attitude and prevalence of anaemia in Kilifi County through four key informant interviews. A structure questionnaire was used to collect socio-demographic and socio-economic data, morbidity data and food consumption habits of adolescent girls.

Analyses were carried out to determine the iron content of the vegetables *Amaranth* and *Solanum nigram* and the vitamin C content of the baobab grown at the study site. The iron content of raw Solanum nigrum was 5.5mg/100g and of amaranths at 4.4mg/100g. However, the iron content of cooked vegetables in the serving of 225g was 6.2mg and 4.5mg respectively. The vitamin C content of baobab powder was 106mg/100g. Each serving of the mixed vegetable (225g) was enriched with 10g of baobab powder containing 10.6mg of vitamin C.

Systematic random sampling was used to select 112 adolescent girls from the entire school population using the class registers. From the sampled girls 101 were screened for haemoglobin level, after obtaining parental consent during the baseline testing. 'Reagent less' method using a HemoCue machine was used to assess the haemoglobin level of each of the girls. 32 out of the 101 girls had a haemoglobin of < 11.9 g/dl and hence were recruited into the feeding trial.

During the intervention, the 32 anaemic adolescent girls were allocated into two feeding groups consisting of 16 girls in each group. One group was served with mixed vegetables enriched with 10g of baobab powder in each serving of (225g) and the other group with vegetables without baobab powder (placebo) during the scheduled school lunch. The feeding

period lasted 30days, after which 31 adolescent girls who completed the feeding trial were re-evaluated for haemoglobin level.

Data analysis was done using SPSS version 23. Descriptive statistics (frequencies, mean and percentile) were used to describe the study population. Bivariate and multivariable logistic regression were used to determine associated factors (diet consumption habits, age of participant with the haemoglobin level) and T-test was used to compare means of the two feeding groups.

The result show that the prevalence of anaemia among the sampled population at baseline was 31.7%, out of which 9.4% had severe anaemia (<8.0g/dl), 40.6% had moderate anaemia (8.0-10.9g/dl) and 50% mild anaemia (11.0-11.9g/dl). A comparison between the two feeding groups indicated the mean baseline haemoglobin were lower in the intervention group (10.5g/dl) compared to the control group (11.2g/dl). Although the difference was not significant (P=0.052). After the 30 days of feeding trial 14 girls representing 45.2% of the adolescent girls achieved normal Hb (>11.9g/dl). The mean final haemoglobin concentration for the intervention group was 11.6g/dl and for control at 11.8g/dl with a mean change of 1.1g/dl and 0.6g/dl respectively. This was significant at (P=0.045).

In conclusion, indigenous green leafy vegetables are a good source of iron and are availability all year round in the study area. Baobab being a rich source of vitamin C with a shelf life of up to 3 months can be used concurrently with the vegetables to enhance the absorption of iron and hence improve anaemia significantly. Almost half of the adolescent girls who completed the feeding trial 14 out of the 31 achieved normal Hb of >11.9 with an average rate of increase of 1.0g/dl mostly from the intervention group, thus can be concluded that cooked vegetables enriched with baobab powder can effectively improve haemoglobin level of anaemic adolescent girls

CHAPTER ONE

1.1 INTRODUCTION

1.2 Background of the study

Micronutrient deficiency is a state of not having enough of one or more vitamins and minerals required for optimum health. In Kenya the micronutrients of public health significance include: Iron, folate, vitamin A, zinc and iodine, among which iron deficiency is the most common (Drorbaugh & Neumann, 2009). Iron deficiency, is a state of insufficient iron to maintain normal physiological functions of the tissues and can exist with or without anemia. Iron deficiency (ID) is the most prevalent nutritional deficiency in the world with approximately 30.2% suffering from anemia globally. Half of these anemia cases are caused by iron deficiency (WHO, 2016). In Kenya approximately 21.3% non-pregnant women and 15.6% adolescent girls are affected by ID (KMNS, 2011). According to a report by World Health Organization, the main causes of iron deficiency among adolescents and women of reproductive age are: inadequate intake of iron rich foods, poor absorption of dietary iron and a negative iron balance caused by menstrual bleeding (WHO, 2016).

Vegetables, in particular green leafy ones are known to contain significant amounts of iron. Some vegetables like the ones consumed locally have a higher content than animal sources foods often associated with high iron content such as beef (Petre, 2017). However, vegetables contain non-heme iron which is less easily absorbed by the body and- although many green leafy vegetables are rich in vitamin C, which enhance iron absorption their large volume-to-weight ratio means it is easier to meet the daily requirement when eating them cooked rather than raw (Mampholo et al., 2016). Vitamin C is sensitive to heat, hence most or even all of it is lost during the cooking process especially when the vegetables are exposed to very high temperatures for a long time. The addition of vitamin C after cooking and before consumption may enhance iron absorption (Lane & Richardson, 2014). Baobab fruit locally known as *mabuyu*, which is available in abundance in Kenya's coastal region and is a rich source of vitamin C, may enhance absorption of available iron from foods (Elalfy et al., 2016).

Baobab is a fruit from *Adansoniadigitata*, an indigenous tree which grows in the arid and semi-arid regions of Africa, Asia, Madagascar and Australia (Sanchez et al., 2010). In Kenya baobab are grown in Makueni, Taita-taveta and Kilifi counties. Baobab pulp locally known as *mabuyu* are particularly rich in vitamin C and consuming 40g of the pulp offers 84-100% of the recommended daily intake of vitamin C (Assogbadjo et.al., 2012). 100g of baobab pulp is known to give 163mg of vitamin C and the RDA of vitamin C for female of reproductive age is 75mg/day. Some researchers have stated that the vitamin C in baobab is five times more than in orange, which are traditional source of vitamin C in many places (Chadare et. al., 2008). Baobab powder which is obtained from the fruit pulp easily dissolves in water and many foods such porridge, juice, and jams or incorporated in recipes, which make it a potential food for enhancing iron absorption from non- heme iron sources and thus improving iron status of vulnerable populations (Cook & Reddy, 2001).

This study was therefore designed to use vitamin C rich baobab powder to enrich selected indigenous vegetables *Amaranths* and *Solanum nigrum* as a food based intervention to reduce anaemia among adolescent girls in Kilifi County.

1.3 Problem statement

Iron deficiency has been and still is a major nutritional deficiency globally, affecting 32.9- 44.2% of women of reproductive age and adolescent respectively in Africa. Among the most affected are those who live in developing countries such as Kenya, where iron deficiency co-exist with malaria, leading to higher prevalence of ID.

Interventions which have been put in place to prevent and manage anemia have tended to focus on pregnant and lactating women as well as pre-school children and not much has been done for adolescent girls who are also affected by the problem.

Most of the adolescent who are in boarding secondary school, consume diet according to the school menu, which offers limited heme iron in form of animal products. The iron sources offered are largely in form of vegetables and legumes which are rich in non-heme iron. Hence adolescents in these schools are at risk of iron deficiency due to inadequate intake and poor dietary absorption.

Most research on iron deficiency in adolescents focus on prevalence levels and causative factors of ID. Little has been done as far as interventions to alleviate iron deficiency among adolescent girls is concerned hence the focus of this study.

1.4 Justification

The Kenya micronutrient survey (2011) revealed high prevalence rates of Iron deficiency Anemia (IDA) especially among specific vulnerable groups like school going children, women of reproductive age and pregnant and lactating women. This enhanced policies and programs leading to interventions targeting the vulnerable groups. However, existing interventions are inadequate hence there is still a need for more to be done (KMNS, 2011).

The second global nutrition targets for 2025 calls for 50% reduction of anemia among women of reproductive age adolescents included (WHO, 2014) hence this study aim to aid in achieving this goal.

Food based interventions such as this one have been perceived as sustainable strategies to meet nutritional requirements. Adolescence being a transition stage between childhood and adulthood provides an opportunity for interventions which have the potential to improve iron status and thus enable them to develop optimally and live healthier productive lives (Andago, 2015).

Iron deficiency if not managed during adolescent may later lead to poor pregnancy outcome such as low birth weight infants (Hans & Hans, 2016). When teenage pregnancy occurs adolescents are at an even high risk to iron deficiency, this underscores the importance of iron adequacy in adolescent girls.If iron deficiency is curbed in adolescents it effectively reduces government spending on supplements, reducing morbidity and increasing economic productivity. Non-heme iron is less readily absorbed compared to heme iron (Fuqua et al., 2012), hence this study aimed at tackle the absorption issue through the use of -baobab- which is an indigenous fruit, rich in vitamin C and widely available at low cost in the area of study is worth looking into, since its potential for sustainability is high

1.5 Aim of the study

The aim of this study is to contribute towards reduction of iron deficiency and anemia in the Coastal region of Kenya.

1.6 Study purpose

The purpose of the study is to use a food based intervention to reduce anemia in Kilifi County.

1.7 OBJECTIVES

1.7.1 Main objective

The main objective of this study is to evaluate the effect of vegetables enriched with baobab powder in enhancing hemoglobin status of anemic in-school adolescent girls in Kilifi County

1.7.2 Specific objectives

1. To determine the social-demographic characteristics of the adolescent girls
2. To determine the iron content of the vegetables *Amaranth* and *Solanum nigrum* and vitamin C of baobab powder and the shelf life
3. To determine the baseline haemoglobin status of the adolescent girls
4. To determine the consumption pattern and morbidity of the adolescent girls
5. To determine the effects of addition of baobab powder to vegetables to enhance iron absorption on the hemoglobin status of anemic adolescent girls

1.8 Research questions

1. What are the social economic characteristics of adolescent girls?
2. What are the specific mineral content of baobab powder, *Amaranth* and *Solanum nigrum*?
3. What is the dietary consumption pattern, morbidity and haemoglobin status of adolescent girls?
4. Will consumption of vegetables enriched with baobab powder have an effect on the haemoglobin status of adolescent girls?

1.9 Hypothesis

H_1 Addition of baobab powder to vegetables has a positive effect on the haemoglobin status of adolescent girls

1.10 Benefits of the study

The findings of this study will benefit the adolescent girls, school administration, community leaders, government and non-governmental organizations.

1. This study highlights importance of IDA interventions for school girls/teens hence improve on their dietary intake of iron rich foods to prevent and manage IDA
2. This study might prompt the school administration to look into the diet offered to school adolescent girls for iron adequacy leading to an improved diet rich in iron from green leafy vegetables
3. This study has enlighten the community leaders on sustainable local available foods to prevent anemia and this might trigger them to be more involved in health and nutrition activities in the area to help alleviate anemia.
4. Information from this study can be used by the government and non-governmental organization in planning and targeting interventions programs aiming at alleviating IDA among adolescents and improving community health.

CHAPTER TWO

LITERATURE REVIEW

2.1 Iron deficiency anaemia

Iron is a bio-element that must be supplied by diet to avoid deficiency and is essential for most forms of life, from single celled organisms like bacteria to mammals. Every day, the human body gets iron from dietary absorption (1.0 mg) and from degraded erythrocytes (20mg) to support erythropoiesis (Waldvogel-Abramowski et al., 2014). Well-nourished people have 4 to 5 grams of iron in their bodies. Of this, about 2.5 grams is contained in haemoglobin and the rest in ferritin complexes that are present in all cells, bone marrow, liver and spleen (Indriastuti Kurniawan et al., 2006). The reserve of iron in women of child bearing age and children is lower than men and elderly people. This is because women use their stores to compensate for iron lost through bleeding, pregnancy in supporting foetal development and lactation (Andrews, 2000). The human body require two types of iron; heme iron from animal products like red meat, fish and poultry and non-heme iron from plant products, non-heme iron is not easily absorbed by the body (Fuqua et al., 2012).

Iron deficiency anaemia is a state where the body does not have enough of the mineral iron to perform it normal physiological processes. The stages in the development of iron deficiency are; the reduction of iron stores, interference with biochemical processes in the body and finally anaemia as indicated by low haemoglobin (Camaschella, 2015).

According to WHO, iron deficiency anaemia among women of childbearing age (14-49) are caused by: Inadequate intake, mal-absorption and loss of iron in blood due to heavy menstruation, pregnancy and lactation.

2.2 Prevalence rate of iron deficiency anaemia

According to (WHO), anaemia is present when there is a reduction in number of red blood cell or haemoglobin concentration. It is a global nutrition problem and more so in developing countries. Approximately 30.2% of the world population are affected by anaemia (WHO, 2016). Vulnerable population are affected in different ways depending on: physiological status like illness, sex and age (WHO, 2016). The global prevalence of anaemia among

adolescents is 15% (9% in developing countries and 6% in developed countries). In Kenya, the prevalence of anaemia among the age group of 14–19-year female is 13.8% anaemia, 15.6% ID and 7.6% IDA (KMNS, 2011). The most common types of anaemia are: iron deficiency anaemia, sickle cell anaemia, haemolytic anaemia, aplastic anaemia, pernicious anaemia, thalassemia anaemia and fanconi anaemia (Soundarya, N, 2016).

Adolescence is one of the periods when the risk of iron deficiency increases (Siva et al., 2016). Both boys and girls are affected due to the physiological and physical changes which occur at this stage of life that increases their nutrition requirements especially for iron (Mesías et al., 2013). The changes include: increased blood volume and red cell mass, sharp increase in lean body mass, which leads to increase iron requirements for myoglobin in muscles and Hb in blood (Evans & Lo, 2012). In adolescent girls, this is compounded with the onset of menstruation (Morgan, 2014).

2.3 Functions of iron in the body

2.3.1 Transportation of oxygen

Human body needs iron for oxygen transportation within the body (Dunn, 2016), Oxygen (O_2) is important for the functioning of all body cells. After inhalation, oxygen goes to the lungs, and then to the rest of the body bound to iron called haemoglobin (iron bound protein found in red blood cells). Iron binds myoglobin in the muscles and this regulates its release into the tissues, as it stores and diffuses oxygen in the muscles (Dunn, 2016).

2.3.2 Cellular respiration

Human cells obtain energy in the form of ATP from cellular respiration (Cox, 2012). Iron is required in order for cells to obtain this energy. Iron present in heme group and iron-sulfur cluster of the electron transport chain allow ATP synthase to synthesize ATP which enables the energy to be available to the cells (Cox, 2012).

2.3.3 Bacterial protection

Bacteria need to obtain iron from their environment in order to survive. Pathogenic bacteria obtain iron through various ways, including direct use of iron from haemoglobin or transferrin, absorbing iron from iron binding molecules within their bodies (Cherayil, 2011). This means iron deprived bacteria reproduce more slowly hence reduce the disease virulence.

During an infection, the body withhold iron which is an important defence against bacterial infection (Cherayil, 2011). This explains why people with high level of iron, are more prone to bacterial infections. This system works well in short term bacterial infections as it causes anaemia in long term inflammation as it leaves the body with no enough iron for normal physiological processes.

2.4 Causes of iron deficiency in adolescents

Adolescent, is the transitional phase of growth and development between childhood and adulthood (WHO 2018). Adolescents have increased iron needs because of the expansion blood volume and increased muscle mass characterized in this stage of life. Menstrual blood loss in adolescent girls put them in particular risk of iron deficiency if iron is not replaced in adequate amounts. Iron deficiency affects both cognitive performance and physical endurance in adolescents. The major causes however are:

Nutritional deficiencies: This can result due to consumption of diet that is iron deficient or consumption of iron absorption inhibitors, such as tannins from tea/coffee, phytates from food like beans and calcium.

Increased loss of iron: in adolescents girls may result from menstruation. Bleeding causes a reduction in red cell mass, and increases iron demand for erythrocytes production. Two thirds of iron in the body circulates in the form of haemoglobin each gram of haemoglobin contain 3.47mg of iron, thus each milligram of blood lost results in loss of 0.5mg of iron (Coad & Conlon, 2011).

Diseases: infections like Malaria can leads to iron deficiency through causing haemolysis in the blood vessels, which leads to loss of haemoglobin iron in urine, trigger the immune system to suppress erythropoiesis and restrict iron absorption through increased hepcidin during the liver stage of malaria infection (Portugal et al. 2011).

Helminths (worms) infestation: helminths and especially Hookworms, Trichuris and Ascaris induce iron deficiency leading to anaemia by causing chronic blood loss of about 02-0.15ml per day through releasing anti-coagulating enzymes i.e. coagulase to ensure continuous blood flow for their sustenance (Oguntande Michael, 2011).

Physiological changes in adolescents which lead to Increased demand for iron. Changes such as: rapid growth, increased blood volume and muscle mass.

Mal-absorption of iron: taking of acid reducing medications like omeprazole severely inhibits iron absorption in the intestine.

2.5 Conceptual frame work

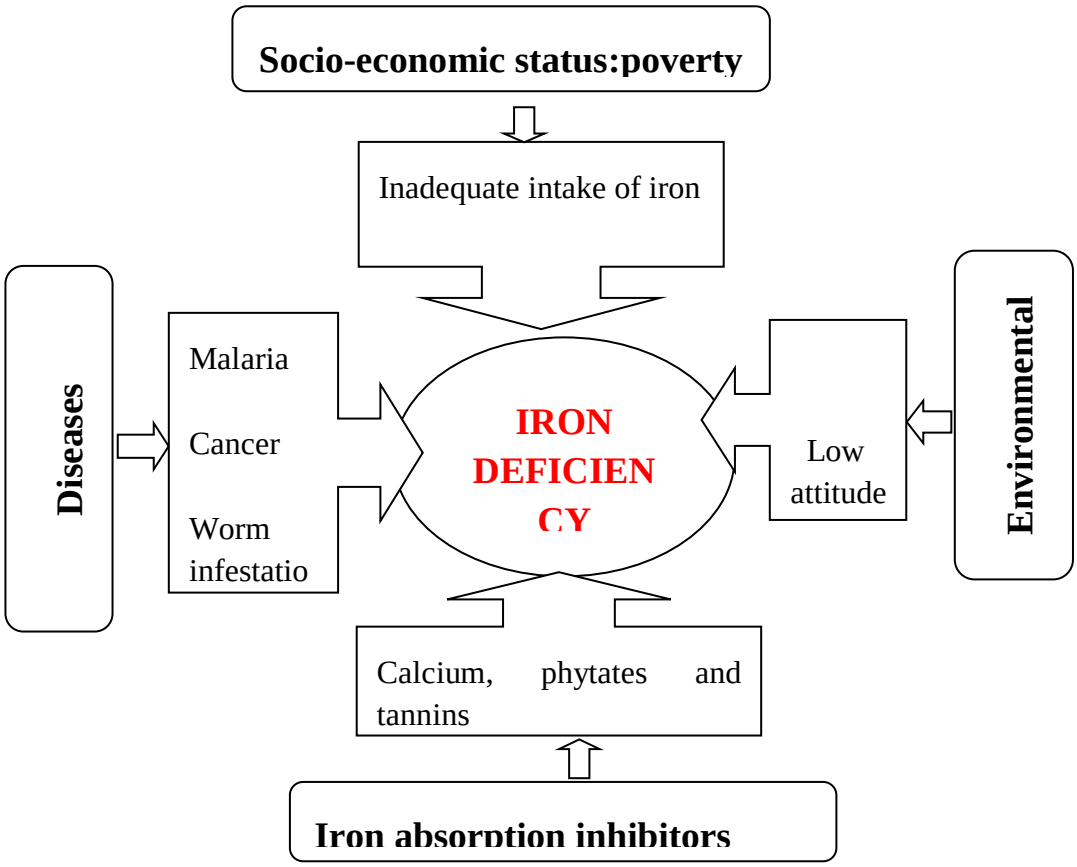


Figure 2.1: Causes of iron deficiency

2.6 Iron metabolism and absorption

Iron absorbed through a complex mechanism in the upper part of the gastrointestinal tract, mostly in the proximal jejunum and the duodenum. Both forms of iron (heme and non-heme) are absorbed through different pathways that is divalent metal transporter (DMT) for non-heme and heme carrier protein (hcp), ferriductase and duodenal cytochrome for heme iron. After absorption, iron is transported into the blood via transferrin (Waldvogel-Abramowski et al., 2014)

Metabolism of iron is a set of chemical reaction that maintains human homeostasis of iron at both the systemic and cellular level (Anderson, Frazer, and McLaren, 2009). Iron metabolism is very important in the body because iron is essential for oxygen transportation as most of iron in the body is in form of haemoglobin, and it help in understanding disease of iron like hemochromatosis and anaemia (Waldvogel-Abramowski et al, 2014).

About 75% of iron is metabolically active, in myoglobin in muscles and enzymes in all body's cells. The remaining 25% is stored iron mainly in the liver in hepatocytes (Anderson et al., 2009). Iron from degraded red blood cells in the serum is bound to transport protein transferrin and can be reused for erythropoiesis, or held in storage bound to protein ferritin. Stored iron in the macrophage system is almost entirely derived from phagocytosis of defective developing erythrocytes. The bone marrow uses recycled and absorbed iron from diet for erythropoiesis (Huong, 2006). Iron absorbed in the intestine is the only mean of regulating iron stores, hence dietary inadequate of iron leads to deficiency. There is no known physiological means of iron excretion (Huong, 2006).

2.7 Some common measures of iron status

2.7.1 Method of measuring haemoglobin

Haemoglobin is the iron containing protein found in all red blood cells that give the cells the characteristic red colour. This test is mostly considered a screening test for iron deficiency anaemia and not used for diagnosis purposes (Agarwal, 2013). The test takes a very short time and it involves drawing blood from the vein or by a finger prick. Haemoglobin test is mostly used to: measure the severity of anaemia, monitor response to an intervention to manage anaemia and help make decision about blood transfusion. Normal haemoglobin level is >12g/dl in female and >14g/dl in male (WHO, 1999)

2.7.2 Serum ferritin

Iron stored in the body is bound to protein Ferritin, thus serum ferritin (SR) is the measure of iron status that can reflect a deficient, excess, or normal iron status (Huong, 2006). Iron deficiency causes lowered iron stores: serum ferritin levels drops continuously as the stores decline; this happen before any changes is detected in serum iron and total iron binding capacity (TIBC). 1µg/L of serum ferritin concentration is equivalent to ~10mgs of storage

iron (Miller, 2013). Serum ferritin concentration interpretation is straightforward as concentrations of <15µg/L reflects highly absent iron stores (Wish, 2006).

There some conditions that may lead to an elevation of serum ferritin levels, in such cases this assessment method is not preferred. Disorders like acute or chronic infections, inflammatory diseases and liver diseases may lead to an increase in ferritin synthesis rate, which is shown by a higher concentration of ferritin in the serum.

2.7.3 Transferrin receptor (TsfR)

These are iron bound protein that regulates iron uptake into all body cells. TfR concentration in a soluble form circulating in human serum is proportional to the total body mass of cellular transferrin receptor, hence is a good indicator of tissue iron deficiency (Wish, 2006). When there is iron deficiency, iron available to tissue is compromised as iron stores are depleted. In such cases TfR expression by the cells increases allowing the cells to compete more effectively for transferrin bound iron. Therefore the level of TfR increases in proportion to the level of iron deficit (Agarwal, 2013).

The main advantages TfR is that, TfR concentration remains normal in any other condition other than iron deficiency hence distinguishing anaemia from iron deficiency and that of chronic diseases. An TfR concentration of (>8.5 mg/L) is an indicator of iron deficiency (Huong, 2006).

2.8 Strategies to manage iron deficiency anaemia

2.8.1 Iron supplementation

Supplementation with iron has been the main strategy for control and management of iron deficiency anaemia in pregnant and lactating women, adolescent girls and children (WHO, 2016). It is recommended in these groups as iron deficiency can lead to poor neuro-development in foetus, infants and pre-school aged children. However, excess iron in the body can lead to toxicity as it has no mechanism for excretion from the body, and make one susceptible to infections as pathogenic microorganisms use iron to multiply (Domellöf, 2010). Blanket supplementation is not recommended, supplementation should only be given in areas with endemic iron deficiency, and in malaria zone areas cautious supplementation is needed based on either screening for malaria first or a combination of iron supplementation and malaria control measures (WHO, 2016b).

2.8.2 Food based interventions

These are various interventions that aims to improve the production, access and availability of foods rich in iron, enhance bioavailability of iron in diet and increase the consumption in general of iron rich foods. The common food based interventions include: food fortification, food bio-fortification and dietary diversification.

Fortification is normally done to staple foods to ensure acceptability and improve sustainable. Food fortification is cost effective; delivers iron in an absorbable form, can reach a large population and can be a permanent long term approach to reducing prevalence of iron deficiency (Huong, 2006). Fortified food can generally be recommended as there less chance of toxicity (Dwyer et al., 2015). However, the major challenge is to identify a form that is easily and adequately absorbed and yet does not alter the taste or appearance of food as iron has the potential of causing unwanted colour and flavour in the vehicle food (Dwyer et al., 2015). NaFeEDTA use has recently been approved as a food additive by the international Nutritional Anaemia Consultative Group as the most suitable to be used in developing countries (Mannar and Wesley, 2016). Its major advantage is that it prevents iron from binding with phytic acid found in many food vehicles like cereals and legumes grain. The major disadvantage is its high cost as compared to ferrous sulphate which can be as much as 6 times more expensive (Horton, 2006). Breakfast cereals, maize flour and wheat flour are the most common food vehicles used currently for iron fortification.

Iron bio-fortification is a technique to increase the concentration of iron in grains and cereals which improves the availability of iron to the body. Bio-fortification is done through application of the nutrient to the soils and through plant breeding where only the varieties with high levels of iron are selected and given to the farmers to plant (Naz et al., 2015).

Food diversification is an intervention that aims at changing food consumption at house- hold level, such as increasing the consumption of animal source foods, fruits and vegetables (Anderson, 2009). Lack of dietary diversification is normally caused by culture, religion and economic constrains. This can be achieved through social and behaviour change activities, increasing production of nutrient rich foods and improve access to diverse foods through the promotion of income generating activities.

2.9 Factors enhancing iron absorption

2.9.1 Vitamin C

Vitamin C is an organic water soluble vitamin essential for humans. Humans are not able to synthesis the vitamins as they lack enzyme L-gulono-y-lactone oxidase which is essential for it synthesis and must be obtained from dietary sources (Lane and Richardson, 2014). Vitamin C exists in two biological forms; the reduced form (ascorbic acid) and the oxidised form (dehydroascorbic acid). Ascorbate in humans enhance iron absorption in the gut and regulates cellular iron uptake and metabolism (Cook and Reddy, 2001). Vitamin C regulates iron metabolism through stimulating ferritin synthesis which inhibits lysosomal ferritin degradation hence decrease cellular iron reflux, and stimulate iron uptake by stimulating transferrin- dependent iron uptake through an intracellular reductive mechanism. Ascorbate is also a key modulator of the transferrin-iron uptake pathway, which provides almost all iron for cellular demand and for erythropoiesis. When vitamin C rich foods are taken at the same time with non-heme iron rich foods may increase the absorption of iron buy up to 300% (Elalfy et al., 2016). Common sources of vitamin C in the study area include: oranges, papaya, mangoes, pineapples, watermelon, guavas and tomatoes.

2.10 Indigenous vegetables

Indigenous vegetables are native to a specific area and produced through traditional practices and mostly home grown. Africa indigenous vegetables such as: amaranths, solanum, spider plant, nightshade, cowpeas leaves, pumpkin leaves, slender leaf, are superior compared to exotic one like spinach in terms of content carotene, iron, zinc, calcium and magnesium (Mbugua et al., 2011). However, these vegetables are mostly neglected and most of them are treated as weeds and therefore face being eradicated or genetic erosion. Owing to socio-economic changes in Africa, consumption of indigenous vegetable is widely regarded as primitive culture and associated with poor lifestyle (Orech et al., 2007). In resent past the long overlooked Africa indigenous vegetables have gained attention for their nutrition and impact in elimination of micronutrient deficiencies (Cernansk, 2015). The attention is due to numerous studies which have been done on indigenous vegetables which have shown that they are highly nutritious; they contain high levels of both minerals and vitamins, and have the potential to counter food insecurity since most are well adapted to the local environment, enabling them to resist pest, drought and diseases (Venter and Witkowski, 2013). In the study

area indigenous vegetables are mostly consumed, owing to their ease of availability compared to exotic vegetables like kales, spinach and cabbages which are not widely grown in the area and have to be transported to the area hence making them expensive and not available to many especially the rural population. Some of the common indigenous vegetables in the study area include: amaranths, solanum, spider plant, nightshade, cowpeas leaves, pumpkin leaves, slender leaf,

2.11 Baobab

2.11.1 Description of baobab tree

The baobab tree is from species deciduous in genus Adansonia found in tropical Savana regions (arid and semi-arid) of Africa, Australia, Arabia and Madagascar. Michel Adanson a French naturalist and explorer described the tree hence the genetic name Adansoniadigitata in his houner (Abdulkarim and Bamalli , 2014). In Kenya baobab trees are found along the coast region, Makueni and Taita-Taveta counties locally known as *mbuyu*. The tree adapts to its environment by being succulent where it absorbs water during the rainy season and stores it in its trunk which enable the tree to produce fruits during the dry season, hence its association with the Savannah dry-lands of sub-Sahara Africa. Almost all the parts of this indigenous tree can be utilised; leaves, pulp, tree buck and seed are utilised as a source of food, medicine and for income generation (Christine et al., 2010).

Baobab tree is massive, up to 20-30metre tall with a diameter up to 2-10 metres at adult age. The tree has smooth reddish brown to grey coloured bark, with longitudinal fibres. The tree has extensive roots lateral roots system until 50metres from the trunk. At the beginning of each season, adult trees begin by producing simple leaves followed by 2-3 leaflet leaves; mature leaves appears later. Flowering begins at the end of the dry season or at the beginning of the rainy season. The flowers are either solitary or paired, situated at the axils of the leaves; they are white in colour, pendulous and they open in late afternoon and fall off the next day at dawn. Pollination is manly done by bats that are attracted by the sulfur fragrance emitted by the flowers (Christine et al., 2010)

Figure 2.2: Image of baobab tree in Kilifi

The fruits of a baobab tree are the only ones in the world that naturally dries on its branch, they don't drop down and spoil instead they stay on the branch and bake in the sun for 6 months- changing colour from green velvet like coating to grey-brown coloured coconut-like shell (Gebauer et al., 2016). Through this process the pulp completely dries out. Baobab fruit has shelf life of 24 months without preservatives or additives added to it (Aluko et al, 2016).

Image of a green baobab fruit	Image of a dry baobab fruit	Image of an open baobab fruit
		

Figure 2.3 images of baobab fruit at different stages of maturity source: http://highvibe.com/unique-fruit-of-the-baobab-three

2.11 Nutritional components of baobab pulp

Most of the research done shows that baobab pulp is rich in vitamin C and dietary fibre. It also has other vitamins, macronutrients like protein and carbohydrates, micronutrients; iron, sodium, potassium among others and very rich in dietary fibre (Ndabikunze et al., 2010). Table 2.1 gives the nutritional profile of baobab pulp as per (Aluko et al., 2016).

Table 2.1 Nutrition composition of dried baobab fruit pulp/ 100g

Macronutrients in mg/100g		**Micronutrients mg/100g**		**Vitamins mg/100g**	
Protein	2.04-3.24	Sodium	7-31.1	Vitamin C	74-163
Fats	0.4-0.7	Potassium	2010-2390	Thiamine	0.01-0.09
Carbohydrates	78.3-78.9	Calcium	257-370	Riboflavin	0.01-0.03
Glucose	16.9-25.3	Magnesium	126-179		
Fibre	45.8-53.9	Phosphorus	56.1-73.3		
Ash	3.95-9.13	Iron	3.95-9.13		
		Copper	0.53-0.75		
		Zinc	0.7-1.02		
		Manganese	0.65-1.3		

2.13.1 Uses of baobab

Baobab *Adansoniadigitata L* is widely distributed throughout sub-Sahara Africa with many uses, and has been used extensively since ancient times for medicinal, nutritional and beauty purposes (Lisao et al, 2017). Several studies on the biological activities of baobab have been done revealing anti-oxidant, anti-inflammatory and anti-viral properties. Baobab is a multi-purpose tree with fruits, leaves, flowers, twigs, seeds and roots that are edible. However the fruit pulp is one of the most important part of the tree that is used for food owing to its numerous nutritional benefits (Abdulkarim and Bamalli, 2014). The vitamin C content and it anti-oxidant properties contribute to most of the health benefits associated with baobab. The leave contain minerals and a good source of vitamin A and the seed have been used to produce natural oil which has been used for topical applications and pharmaceutical industries (Aluko et al., 2016). The fatty acid composition in baobab oil are linoleic and oleic acid, due to high level of oleic acid it is more oxidative stable during shelf life and frying

hence can be used as a premium oil in place of vegetable oil (Abdulkarim and Bamalli, 2014). As a result of its multiple uses, nutritional value, medicinal value, ease of cultivation and drought tolerance, baobab has been identified as an important edible forest tree to be domesticated and conserved in Africa (Sanchez et al., 2010). Baobab fruit can be a significant contributor to daily intake of important nutrients and non-nutrient compounds. In the study area dried fruit pulp are eaten raw or coated with sugar and food colour and sold as sweets, dissolved in water; stirred into a milky like mixture, seeds sieved off and the juice is used as a sauce, added to porridge or to milk to ferment it. The seeds are roasted like ground nuts and eaten as snacks and young leaves are used as vegetables when fresh and as sauce thickener when dried (Lisao et al., 2017).

2.14 Gaps in knowledge

Baobab is largely used in the Kenyan coastal region though not as a source of vitamin C but as a candies where it's prepared in sugar and food colour and served as a snack. The nutritional potential of baobab is largely unknown to the locals.

In Kenya, national policies have been implemented to provide iron supplementation to pregnant and lactating women though iron and folic acid supplementation program and to a lesser extent to pre-school children as the primary strategy to prevent and manage iron deficient anaemia. Not much has been done to the adolescents who are a critical stage of development.

There is need for more to be done and especially on food base strategies which are viewed as economical and sustainable.

CHAPTER THREE

METHODOLOGY

3.1 Study design

This study was a Randomised controlled intervention study with analytical component, comprising of feeding trial and analysis of baobab powder for vitamin C and shelf life as well as iron content of *amaranths* and *Solanum nigram*.

3.2 Study setting

The study was carried out in Kilifi County located in the coastal region of Kenya. Kilifi County was formed in 2010 as a result of merging Kilifi and Malindi districts. The county headquarter is Kilifi and the largest town is Malindi. The county has an area of 12,609km^2. Kilifi is located about 60km North of Mombasa and about 420km South-East of the capital Nairobi.

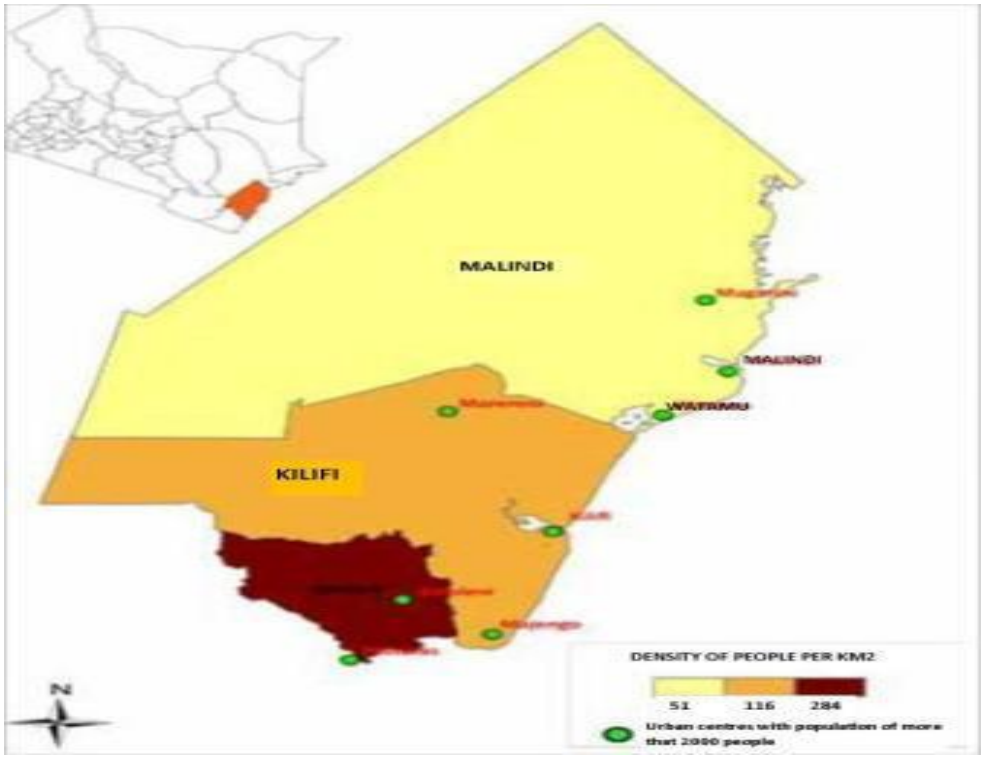


Figure 3.1 Map of Kilifi County source: https://google.co.ke/wellcomeopenresearch.org

The estimated population of Kilifi County was 1,109,735 people according to the 2009 census, with a male female ratio of 48% and 52% respectively. The study location was Malindi constituency which has a population of 207,253 (2009).

The average annual rainfall in Kilifi range between 300mm in the inland area to 1,300mm at the coastal belt. Areas with highest rainfall include Mtwapa and to the North of the coastal strip around Arabuko-Sokoke forest. There are two rainy seasons April - May (long rains) and October - December (short rains). The annual temperatures in the county range from 21^0c to 30^0c in the coastal belt and between 30^0c and 34^0c in the inland area.

The County has seven constituencies: Kilifi north, Kaloleni, Kilifi south, Ganze, Rabai, Magarini and Malindi. The county's top leadership includes the Governor, county commissioner, senator, women representative, Member of Parliament (MP) and members of county assembly (MCA).

The major communities living in the County are the Mijikenda, Indians, Bajuni, Swahili, Arabs and European settlers. Although, there are others communities from all over the country living in the county as well. Kiswahili and Mijikenda languages are widely spoken in the county.

The main economic activities in the County are: tourism, fishing and agriculture. However, Tourism and fishing are more popular than agriculture because of poor rainfall as well as a booming hotel industry in the County. Cash crops grown include: sisal, coconut palms, cashew nuts, mangoes, baobab and pineapples.

This study was undertaken at Ngala memorial secondary school (girl's boarding school) situated in Malindi sub- County, Watamu location and Dabaso sub-location. It was established in 1986 with 8 students as a community school through the district development committee. The school cover approximately 7.4 acres of land. The school has total number 824 students: form I; 240, form II; 234, form III; 177 and form IV; 144 students respectively. The school has 6 kitchen staff all employed for casual labour.

3.3 Study population

The main study population were adolescent girls attending (Ngala memorial secondary school) in Malindi sub-county. Others include: the school principal, school nurse, cateress, county nutritionist and county health officer.

3.3.1 Inclusion criteria

- Adolescent girls who are not on treatment for malaria or anaemia
- Adolescent girls with a HB of <11.9 mg/dl
- Adolescent girls who have consented to participate in the study

3.3.2 Exclusion criteria

- Adolescent girls with Hb of >11.9 mg/dl
- Adolescent girls who are on current malaria treatment and those on iron supplements
- Adolescent girls who are not willing to participate in the study

3.4 Sampling

3.4.1 Sample size determination

The sample size will be calculated using the Fisher et al. (1991) formula as follows:

$$N = \frac{z^2 pq}{d^2}$$

Where:

N- Desired sample

z- Standard normal deviation set at 1.96 of 95% confidence interval

p- Prevalence of iron deficiency in adolescent according to (KMNS, 2011). 15.6%=0.156

q- Proportion of adolescents expected not to be iron deficient is (1-p) = 1- 0.156= 0.884

d- Sampling error at 5%= 0.05

Therefore, $N = (1.96)^2(0.156)\ (0.884)/0.05^2 = 212$

This was then adjusted to fit the sample size of a small population<10,000 individuals which consisted of 840 adolescent girls with anaemia rate of 24% in the selected secondary school (Ngala memorial secondary school).

$$nf = \frac{N}{1 + (N/n)}$$

Where:

nf- minimum desired sample

N- The estimated sample calculated using Fisher et al. (1991) formula

n- Estimated study population which is the number of adolescent with anaemia in Ngala girls secondary school is 240

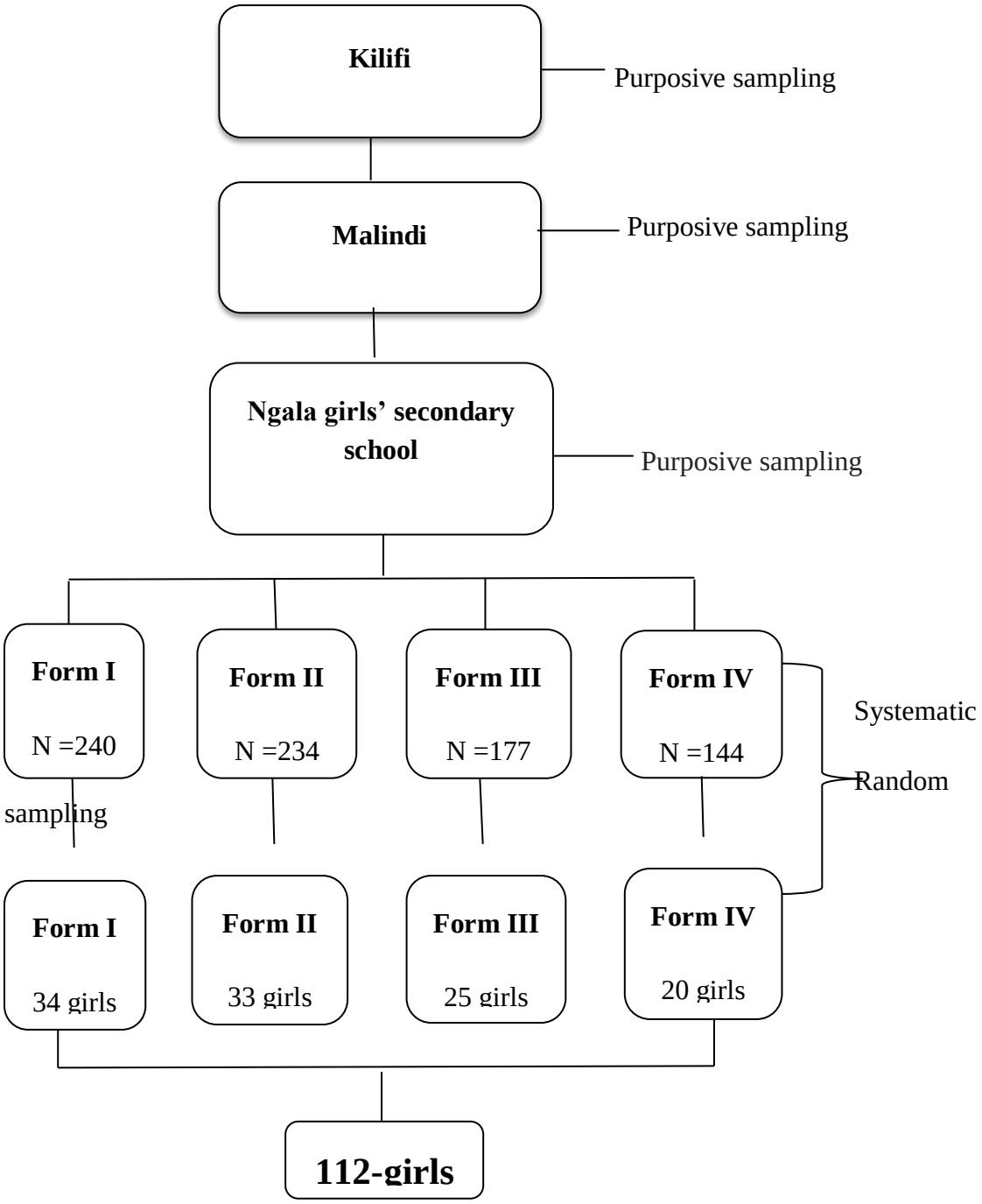
$nf = 212 / 1+(212/240) = 112$

The 112 adolescent girls will undergo the baseline Hb test.

3.4.2 Sampling procedure

Purposive sampling was used to select the school (Ngala memorial secondary school). Systematic random sampling was used in selection of the individual adolescent girls into the study from the entire school population using the class register as a sampling frame as per the class ratio. Then exhaustive sampling was used to select girls into the feeding trial after baseline haemoglobin test where all girls with Hb of <11.9 g/d were included.

3.4.3 Sampling flow chart



3.5 Data collection

3.5.1 Recruitment and training of research assistants

Two field assistants were recruited to assist with data collection. They were required to have at least a form four certificate and speaking fluent Kiswahili and English. Two day of training was conducted to equip them with knowledge and skills on how to conduct the interview during questionnaire administration: create rapport with the respondents, how to interview the respondents and administer and correctly filled questionnaire. By the end of the training they were expected to: understand the questionnaire and extract the correct response from the respondents; they also obtain knowledge on ethics of research. They signed confidentiality form to ensure privacy and security of all participants' information that was collected. The school nurse was trained on the expected side effect which is mild heartburn and how to manage it. There are no severe allergic reaction reported with direct used of baobab products so this is highly not expected and just in case it happen the nurse was trained on the referral procedure to the Malindi general hospital.

3.5.2 Pre-testing of questionnaires

Pre-testing was carried out at a nearby secondary school (Barani secondary school) with 10 girls. The information was used to improve the questionnaire where needed. The information from pre-test was used to make necessary corrections on the questionnaire.

3.5.3 Data collection tools and methods

key informant interview guide Semi-structured questionnaire and food frequency table were used to collect data on prevalence of anaemia, demographic characteristics, morbidity and consumption pattern.

3.5.3.1 Key informant interview

Four Key informant interview (KII) were done, the key informants were: the school principle and the school cateress, the County Nutritionist, and the County health officer were interviewed. Rapport was created before explaining to the respondent what the research entailed; nature of the study, purpose, its benefits and any risk/discomfort expected. The interview were done using question guide, to obtain information on school menu, gaps in

feeding practice, common sources of iron in the adolescent diet, prevalence of iron deficiency anaemia among adolescents and common causes of anaemia in Kilifi county. The information was manually recorded during the interview.

3.5.3.2 Study questionnaire

A pre-tested structured questionnaire was used to collect qualitative and quantitative data. The questionnaire was divided into three parts. The first part covered questions regarding variables: socio-demographic characteristics, dietary consumption pattern and morbidity. The second part covered key informant guide and the third part the food frequency table. The interview was conducted by the enumerators.

3.5.3.3 Food Frequency Questionnaire

The food frequency questionnaire consisted of a table of possible food sources of iron as well as other foods that promote or hinder iron absorption and associated set of frequency of use at the time of research. The list was sufficiently extensive to enable a good estimation of the dietary pattern as far as iron consumption is concerned.

3.5.4 Haemoglobin status: The adolescent girl's haemoglobin was assessed using a 'Reagent less 'method, using a HemoCue machine, which was conducted on each individual girl in the sample. Where 10 micro-litre of non-fasting blood was collected via venepuncture from each adolescent girl by the lab technician using a BD contact activated lancets (BD microtainer). Micro curvets was used to collect the blood sample which was inserted into the HemoCue Hb analyser and the haemoglobin level read and recorded immediately. A battery powered HemoCue machine (Mission plus Hb, Germany) was used. Adolescent girls with Hb of <11.9g/dl were enrolled into the feeding trial.

3.6 Analytical methods

3.6.1 Mineral analysis

The iron content of the vegetables *amaranth* and *solanum nigrum* and baobab were analysed using atomic absorption spectrometry technique. The samples were first digested with hydrochloric acid and the digest used for analysis. The concentration of minerals was read from atomic absorption spectrophotometer (Buck scientific, 210 VGP, USA) at their specific wavelengths.

3.6.2 Determination of reduced ascorbic acid

Vitamin C was determined as reduced ascorbic acid by titration with 2, 6 Dichlorophenol indophenols as described by Seki (1990). Standard indophenols was prepared by dissolving 0.042g NAHCO3 in 50ml of distilled water followed by 0.05g of 2, 6 dichlorophenol and made to 200ml, then filtered and stored in a brown bottle. 5g of baobab powder was put in a glass wash then 25ml of trichloroacetic acid (TCA) 10% solution was added then filtered immediately. The sample was quantitatively transferred into a 100ml volumetric flask and made to volume with 10% TCA solution. 10ml of the sample was transferred into a conical flask and titrated with indolphenol solution until pick colour appears. For the blank, 10ml of 10% TCA solution was measured into a conical flask followed by equal volume of water to indolphenol solution and titrated against indolphenol solution until pink colour appears.

3.6.3 Shelf life evaluation of the baobab powder

Accelerated shelf life was also done (1 day equivalent to 1 month). Sixteen samples packaged in four different packaging materials were placed in an air oven at 55^0c where one set of each packaging material was removed and analysed for moisture content after every 24 hours for 3 days. Baobab powder was subjected to shelf life evaluation to determine the stability of vitamin C during storage. This was done at the DFSNT of University of Nairobi. The baobab powder was divided into 12 portions of 100g each. Four of these portions were packaged in 3 different packaging material; plastic jar, glass jar and polythene bag. A set of three of the different packaging materials were stored in two different thermostatically controlled air ovens set at temperatures of 25^0C and 35^0c for a period of three months. Every month a sample from each packaging material is removed and analysed for change in vitamin C content according to (Seki, 1990) titration method.

3.6.4 Sensory evaluation of the vegetables

Sensory evaluation was done to determine the amount of baobab powder to be used for the feeding trial. The panellist were adolescent girls from (Barani secondary school) a school near the study site. 30 panellist were involved in the evaluation and they were asked to rinse their mouths with clean water before testing the next sample. The vegetables was evaluated for colour, taste, level of sourness and overall acceptability using six rating scale, where 1=dislike very much and 6=like very much. The sample with most acceptable amount of baobab powder was used for the feeding trial. The vegetables *amaranth* and *solanum nigrum*

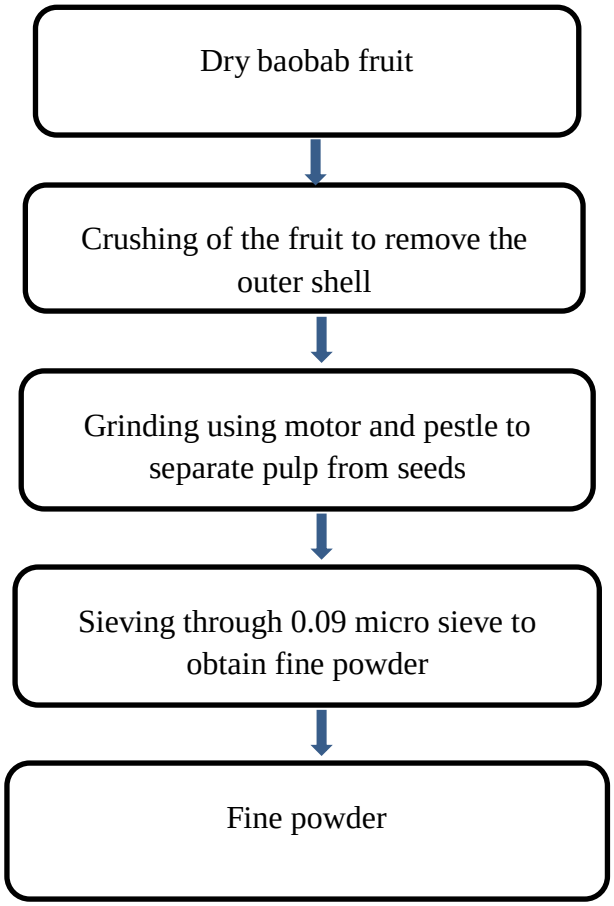
were washed then chopped into small pieces the cooked together at the ratio of 1:1 in onions and tomatoes till tender for about 10-15 minutes. The cooked vegetables were allowed to cool to a temperature of approximately 30^0C, before amounts of baobab powder (10g, 15g and 20g) was added as a sprinkle to each serving of 225g of the mixed vegetables.

3.7 Preparation of baobab powder and Vegetables

3.7.1 Preparation of baobab powder

Dry baobab fruit in its shell was harvested from the study area, then transported in a suck while still in the shell to preserve vitamin C content and sent to the DFSNT laboratory for analysis.

3.7.2 Flow chart diagram of baobab powder preparation



3.8 Preparation of vegetables for the feeding trial

Fresh vegetables *Amaranths* and *Solanum nigrum* approximately 10 kilograms 5kg of each vegetable were obtained from the local market in Malindi and delivered to the school kitchen daily for the 30 days at around 10 o'clock. The vegetables were washed under running water and drained off the excess water on a rack, then chopped into small pieces and cooked together at the ratio of 1:1 in tomato 1kg, onion 1/2kg and vegetable oil 0.5 litre till tender for 10-15 minutes by a trained assistant. This was closely supervised by the researcher to ensure all the ingredients were measured as required. Once ready they were allowed to cool to a temperature of 30^0 C, then 10g of baobab powder as per sensory evaluation test was added to each serving of 225g as a sprinkle and stirred in to dissolve before served to the girls.

3.9 Feeding trial

At the beginning of the feeding trial each of the adolescent girl was randomly allocated to one feeding group, either the intervention or the control group. The girls were blinded so they did not know that they belong to two separate groups. The grouping was done at the ratio of 1:1. Each girl was allocated a unique number for the purpose of the study. The girls were served with the vegetables (225g of mixed cooked vegetables) during scheduled school lunch together with the meal offered by the school for 30 day consecutively. The mixed vegetables with baobab powder offered 10.7mg of iron and 33% of vitamin C of the RDA for adolescent girls. Close supervision by the researcher was done to monitor consumption and to prevent girls from exchanging portions with each other and recorded on daily basis. At the end of the feeding period the adolescent girls were re-evaluated for anaemia using Hb level testing. Sourcing and supplying of the vegetables and the baobab powder was done by the researcher.

3.10 Data quality control/assurance

Laboratory results were immediately entered in preformed dummy tables then in the computer using SPSS software. Calibration of instruments (kitchen scale) to ensure reliability before data is collected. To achieve quality of data, the research assistants were adequately trained by the principle investigator; pre-test of the questionnaire was also carried out to enable familiarization with questions and method of interviewing in order to avoid recording errors. The completed questionnaires were cross-checked to ensure completeness of data and

consistency of answers. Data cleaning to remove outliers and wrong entries was done during data entry for analysis. Close supervision of the feeding trial was done by the principle investigator to ensure feeding is done as prescribe.

3.11 Data analysis

Data analysis was done using IBM SPSS, version 23 and Nutrisurvey software. Descriptive statistics such as mean, median and percentile was used to describe socio-demographic status, Chi-square was used to compare mean of variables, correlation was used to determine the association between dietary intake/ morbidity status and iron status, paired t-test was used to assess change in mean of iron status (before and after the intervention), logistic regression was used to determine the probability of the intervention affecting the iron status and ANOVA was used to compare mean between the two groups(the intervention and the controls). Data for food consumption was analysed using Nutrisurvey.

3.12 Ethical consideration

Ethical clearance was obtained from the ethics committee of Kenyatta National Hospital and the University of Nairobi, Department of Food science, Nutrition and Technology. Permission was also obtained from Kilifi County and Sub-County health offices and the school administration of Ngala memorial secondary school. Written informed consent was obtained from the parents of individual girls. The sampled girls were given the written consent to take home with them during the midterm break for the parent to sign. All information and data collected was kept confidentially by the researcher and the information was not shared with anyone other than the research team members.

Monitoring of adverse effects was closely monitored by the school nurse. In case a referral was needed the affected students was to be referred to the Malindi general hospital by the school nurse to the clinician on duty as per ethical requirements.

Care was taken to minimize risk and injuries as much as possible and maximize on the benefits. Training on good professional and good clinical practice was done to all the study personnel by a qualified clinician.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Socio- demographic characteristics

Socio- demographic characteristics were compared according to the feeding groups to determine the extent to which the control or the intervention group were similar or different.

Table 4.1: Socio-demographic characteristics of adolescent girls (%) by feeding group

Characteristics	Intervention Group n=16	Control group n=15	Total %	P value
Religion				
Christians	87.5	93.3	89.2	1.00
Muslims	12.5	6.7	10.8	
Parent's occupation				
Formal employment	37.5	33.3	37	0.52
Informal employment	56.3	73.3	63	

The respondent's age group range was 14-22 years which was normal according to population of secondary school students. Most of the respondents were Christians representing 89.2% and the others were Muslims at 10.8%. Despite the fact that majority of the coastal population are Muslims the results on religion distribution showed that >89% of the sampled girls are Christians. These findings were contrary to the expected results Majority of the parents were in informal employment representing 63%, with most of the parents employed in the hotel industry since tourism is major economic activity in the area. The results indicated that the socio-demographic characteristics in the two groups were not significantly different.

4.2 Iron content of Amaranth leaves solanum nigram

The results of iron content of vegetables *amaranth* and *solanum nigrum* raw and cooked are shown in table 4.2

Table 4.2: Iron content of amaranth and solanum nigrum raw and cooked

Vegetables	Raw (mg/100g)	Cooked (serving of 225g)
Amaranth	4.4	4.5
S. nigrum	5.5	6.2

The iron content of the vegetables *amaranth* and *solanum nigrum* was higher than of spinach a common exotic vegetable at 2.1 mg/100g when raw and 3.5 mg/100g when stewed according to the Kenya food composition table (2018). These results are similar to findings from other regions of the Country on nutritional components of indigenous vegetables, which have shown them to be superior in nutrients (Mbugua et al., 2011).

4.2.1 Iron and vitamin C content of baobab powder

The results of iron and vitamin C content are given in the table below

Table 4.3: Vitamin C and iron content of baobab powder

Micronutrients	Baobab powder (mg/100g)
Vitamin C	106.0
Iron	6.5

The vitamin C content of baobab was 106mg/100g which was within the range of 74-163mg/100g (Aluko et al., 2016). However, in the result the vitamin C content increased with decrease in moisture content of the powder as indicated in figure 4.1.

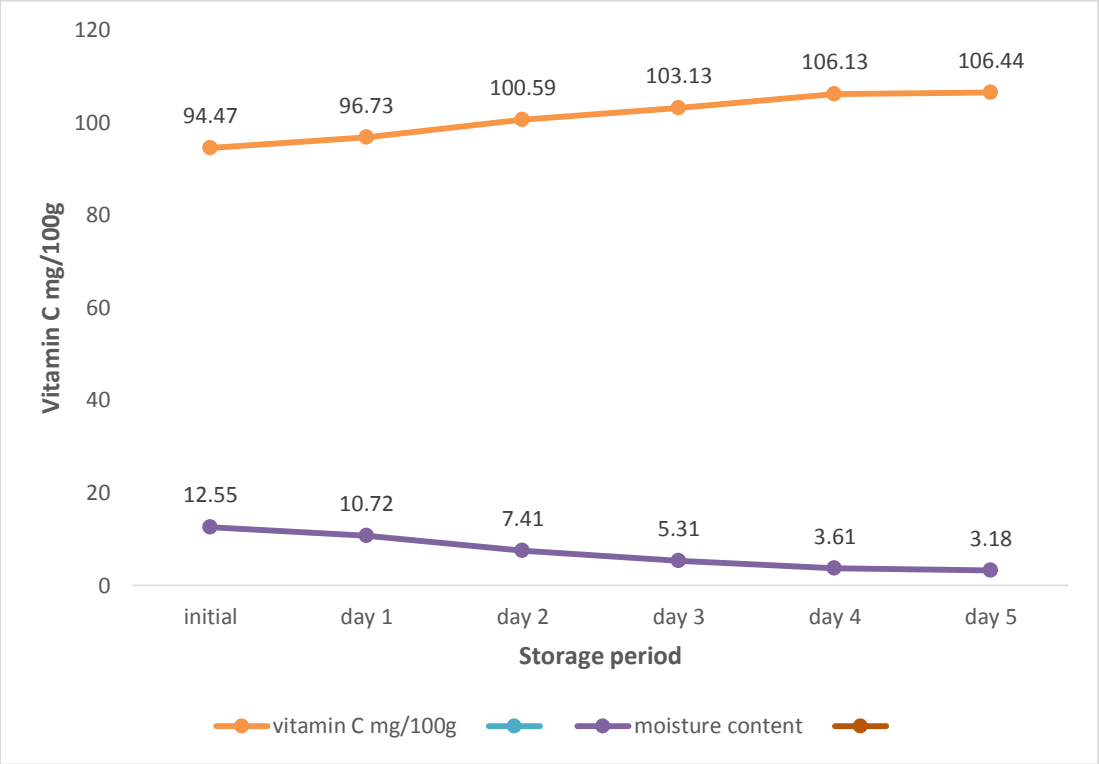


Figure 4.1: Vitamin C content of baobab powder in relation to moisture content

The result of vitamin C content of baobab powder at 106 mg/100g was slightly lower than most varieties in the world but still within the range of 74-163 mg/100g (Aluko et al., 2016). Most of the residence in Kilifi County were not aware that baobab is a rich source of vitamin C. As much as baobab is consumed widely in the area but not as a source of vitamin C but as a snack or a flavour enhancer in sauces and porridge (Donatien Kaboré, 2011).

4.3 Shelf life evaluation of baobab powder in three different packaging material

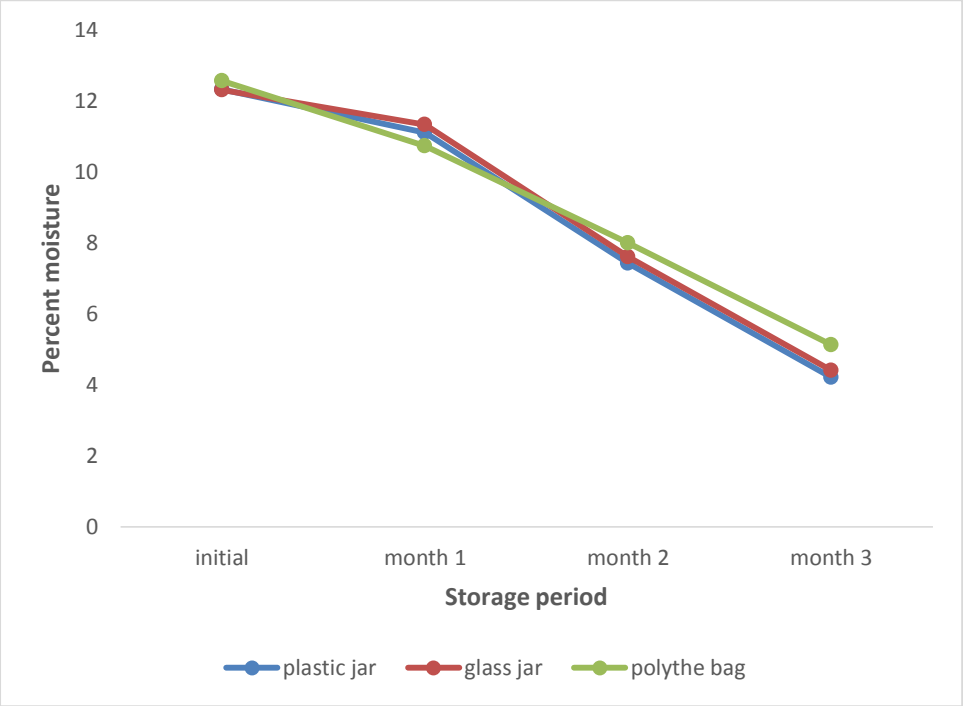


Figure 4.2: Moisture content of baobab powder during the three months of storage

The shelf-life evaluation was based on changes in moisture content during storage. The moisture content of the baobab powder was 4.5% after the three months of storage. The initial moisture content of the baobab powder was 12.55%. There was a significant reduction in the moisture content of the baobab powder $P<0.05$ during the three months of storage. The reduction was significant during the second and third month of storage but not significant during the first month of storage (figure 4.2). However, there was no significant difference of the change in moisture in the different packing materials used at $P>0.05$. The result on the shelf evaluation indicated that the baobab powder can be stored for up to 3 months with the vitamin C being stable and not altered in terms of the levels. With the plastic and glass jar being the most preferred storage container since the baobab powder stored in polythene bag retained more moisture than the others packaged in plastic and glass jar (figure4.2). In the community baobab was stored in its shell and only opened when just about to be used, this was reported that it can last up to one year according to the locals. These findings are in agreement with a report by (Lisao et al., 2017) which reported the shelf life of baobab as 24

months when stored in its shell. The powder form of baobab is rarely used mostly the pulp is used whole or socked to produce a solution that is added to food either during cooking or during consumption.

4.4 Sensory evaluation of the vegetables

Sensory evaluation was done to select the most preferred combination of baobab powder and vegetables. The samples had 10mg, 15mg and 20mg respectively of baobab powder added to mixed vegetable (amaranth and solanum nigrum) serving of 225g. The results of sensory evaluation of the three vegetable samples are shown in table 4.4. The most acceptable vegetable sample was VS1 (vegetable sample one).

Table 4.4 Sensory attributes score of the vegetable samples

Sample	Colour	Taste	mouth feel	General acceptability
VS1(10mg)	5.0	5.0	5.0	5.0
VS2(15mg)	5.0	5.0	4.0	4.0
VS3(20mg)	5.0	4.0	3.0	4.0

VS1- Vegetable sample one

VS2- Vegetable sample two

VS3- Vegetable sample three

VS1 had the highest score compared to the lowest which was VS3. However VS3 was not significantly different from VS2. The colour and taste attributes had almost the same results in all the samples. However, in terms of mouth feel and general acceptability there was some slight difference though not significant especially for VS2 and VS3. VS3 had the lowest score in mouth feel, this can be attributed by the fact the higher the amount of baobab powder added the higher the vitamin C content which in return made the sample more acidic. Based on the results of sensory evaluation VS1 was selected for the study and 10mg of baobab powder was added to the serving during the study.

4.5 Food frequency and dietary diversity score

The food frequency and diversity score was not significant different in the two feeding groups at a P>0.05, since all the girls consumed foods from the same menu. What brought about the difference is food allergies which prevent some of them from consuming certain food groups like legumes, animal products and dairy products.

Table 4.5: food frequency (%) and dietary diversity score based on weekly consumption (N=31)

Food groups	**Intervention group %consumption**	**Control group %consumption**	**Total**
Cereals	48.2	51.8	100
Legumes	52.3	47.7	100
Vegetables	70.1	70.2	70.2
Fruits	24.3	25.1	24.7
Dairy products	86.4	92.2	89.3
Meat	19.6	23.5	21.6
Fats	74.5	82.4	78.4

Food frequency: The food frequency data indicated that cereals based food and pulses mostly beans and green grams were the most commonly consumed food by the adolescent girls at 90% with most of them consuming them at least once a day. Consumption of animal source food was low with beef and chicken being consumed each once weekly. The dairy product offered was milk which was consumed daily as part of tea. Fat consumption was adequate as it is used in preparation of most foods that the girls consumed. Consumption of fruits was low at twice a week and the fruits offered were bananas and water melon,

consumption of green leafy vegetable was low as the vegetable offered in the school menu was cabbage.

Diet diversity: Most of the adolescent girls (89.1%) consumed up to six food groups weekly, which was adequate. Only 0.9% of adolescent girls in both feeding groups consumed less than four food groups weekly. The mean diversity score was 5.8 and 5.9 for the intervention and the control group respectively, with the food groups' considered being cereals, legumes, vegetables, fruits, dairy products and fat/oil. There was no significant difference in dietary diversity between the two groups at $P>0.05$.

The iron intake of the adolescent girls was not adequate. As from the findings of the study the major sources of iron in the school diet was beans which were taken at least once a day either with rice, ugali of mixed with maize commonly known as *Githeri*. Beans are a good source of iron with iron content of 3.93mg/100g (Messina, 2014) but poorly absorbed due to phytates and tanning content which hinders its absorption (Glahn et al., 2017). The other sources of iron like animal product and green leafy vegetable were not adequately consumed, as the only vegetable being offered was cabbage which offers 0.4mg/100g of iron (Bosiacki & Tyksiński, 2013).

4.6 Morbidity among the adolescent girls

Results of the 14 day morbidity recall indicated 22.5% of the girls had been sick in the previous two weeks period before the study.

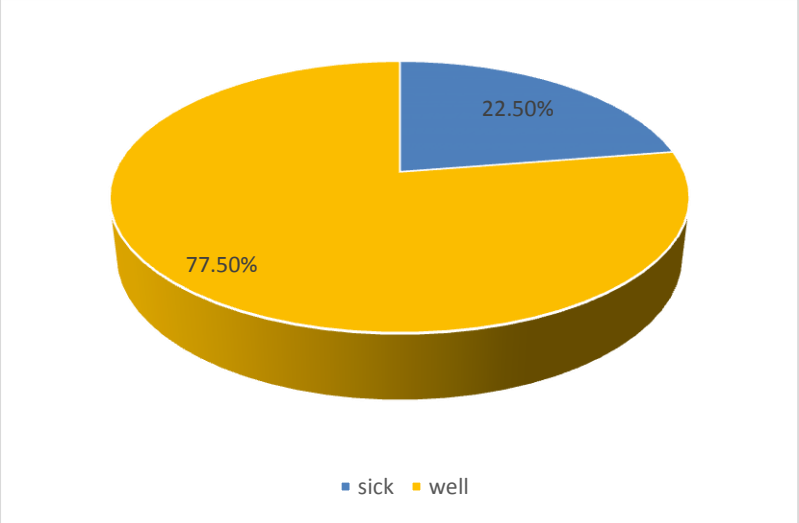


Figure 4.3: morbidity among the adolescent girls

Comparing the two feeding groups 6.6% of the intervention group had been sick and 9.7% of the control group**.** The top three illnesses were upper respiratory tract infections, stomach infections including stomach ulcers and diarrhoea and malaria at 8.1%, 3.6% and 1.8% respectively. Worm infestation was reportedly not common among the adolescent girls. There were no significant difference in morbidity status among the adolescent girls on the two intervention groups P>0.05.

4.7 Haemoglobin status of the adolescent girls (basal)

The baseline Hb test done on 101 girls indicated that 31.7% of them had Hb <11.9 g/dl representing 32 girls with a mean Hb of 12.1 g/dl. The mean Hb for the intervention group was 10.5 g/dl compared to 11.2 g/dl for the control group. The difference was not significant (P-0.052) though almost significant. Table 4.6 show the distribution of anaemia as per classification in percent among the 31.7% girls with Hb <11.9 g/dl.

Table 4.6 Baseline haemoglobin of the adolescent girls

Anaemia classification	**Total girls in %**
Severe anaemia <8.0 g/dl	9.4
Moderate anaemia 8.0- 10.9 g/dl	40.6
Mild anaemia 11.0- 11.9 g/dl	50.0

The result of 31.7% of the girls being anaemic, is in agreement with the result from the key informant interview at the county health office which gave the prevalence of anaemia for adolescents as 32%. Comparing with the national results according to (KMNS, 2011) the result were slightly low as the Country's prevalence for adolescent stand at 37%. The major causes of anaemia among adolescents were given as poor dietary intake of iron rich food, poor absorption and heavy menstrual flow. These finding are in agreement with other studies in the Country and a report by WHO (2016) on causes of anaemia, which has likewise indicated the same factors as the major causes of anaemia.

4.8 Outcome of the randomized control trial

The randomized control feeding trial lasted 30 days (7 days a week) from March to April 2019. Both the intervention and control group consumed similar amount of the vegetables (amaranth and solanum nigrum) mixed at the ratio of 1:1 during preparation, 108,000g and 101,250g respectively P >0.05. At the end of the study the mean Hb in the intervention was 11.6 g/dl from 10.5 g/dl while that of the control group was 11.8 g/dl from 11.2 g/dl. This increase in the intervention group was significant (p=0.001). The mean change (Δ) in Hb concentration in the intervention group was 1.1 g/dl compared to 0.6 g/dl the control group. 56.3% of the adolescent girls from intervention group had normal Hb level (>11.9 g/dl) compared to 46.6% in the control group at the end of the study.

Table 4.7: Effect of vegetable enriched with baobab powder on haemoglobin level of anaemic Adolescent girls

	Intervention group (n=16)	**Control group (n=15)**	**P value**
Total mean vegetable consumption (g)	108,000	101,250	0.102
Mean basal Hb concentration (g/dl)	10.5	11.2	0.052
Mean final Hb concentration (g/dl)	11.6	11.8	0.045
Mean change (Δ) in Hb concentration	1.1	0.6	0.001
Anaemia (%) final	43.4	53.4	0.057

The finding of the study show, there was an improvement on the haemoglobin status of the adolescent girls after consumption of the vegetables for 30 days and to a higher margin in the intervention group. The main strength of this study is that indigenous vegetables and baobab are widely available and affordable and thus can easily be used at household level once sensitization has been done. No industrial or chemical preparation is required just domestic preparation of the vegetables and obtaining of the powder from the baobab using motor and pestle then sieving which can easily be done at any household kitchen. Randomization was successful as there was no significant difference in the baseline characteristics of the adolescent girls in the two feeding groups. This allowed for truly assessing the effect of the vegetables enriched with baobab powder on the haemoglobin level and anaemia in general.

CHAPTER FIVE

CONCLUSSION AND RECOMMENDATIONS

5.1 Conclusion

The sampled population comprised of adolescent girls in boarding secondary school, who majority were Christians. Their parent's main source of income was from informal employment in the hotel industry.

The vegetables *amaranth* and *solanum nigrum* are a good source of iron which when included in the school diet can lead to increased adequacy of the nutrient intake. Baobab powder a rich source of vitamin C which was obtained from the pulp in limited setting using simple procedure and thus has a high possibility of adoption as an intervention in the community. Vitamin C in the baobab powder is stable during storage and can last up to three months in an air tight container. The acidity of the baobab powder may be a deterrent and an important factor to be considered when it incorporated in foods such as vegetables in term of amount to be added, and therefore suitable foods must thus be carefully selected.

Moderate and mild anaemia was the major category in the sample population with less than 10% with severe anaemia and hence simple food based intervention can be used to solve this problem.

The main objective of the study to enhancing haemoglobin status of anaemic adolescent girls was achieved as 48.4% had improved anaemia status and had normal Hb.

6.2 Recommendation

There is need for promotion efforts in adapting green leafy vegetables in school menus given its potential impact and as a credible iron source to improve the nutrient intake.

Research on the potential of baobab powder in effectively enhancing iron absorption in other foods rich in non-haem iron.

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APPENDIX I: TRAINING MODULE FOR TRAINING FIELD ASSISTANT

Topic:

- Research ethics
- Administering questionnaire
- Conducting interview
- Administering food frequency questionnaire
- Professional and good Clinical practice

Objectives

The main objective of the training is to be able to collect good quality data that is reliable by ensuring the field assistants are thoroughly trained.

The specific objectives of the training are as follows:

- To make the field assistants aware of the ethics to be followed in the field including: positive attitude and morals to observe during field work
- To orient and make field assistants aware of respondent's interests and welfare, through confidentiality and data collected
- To make field assistants familiar with data collection techniques using questionnaire
- To make field assistants competent in administering food frequency questionnaire
- To ensure the lab procedures are done within the accepted scope

Teaching and learning methods

- One on one
- Assignments
- Demonstration
- Practicle

Learning materials

- Pens
- Note books
- Pencils and hand outs

APPENDICE II: FIELD ASSISTANTS CONSENT FORM

Title of the study: Enhancing haemoglobin status of anaemic adolescent girls using vegetables enriched with baobab powder

Principal investigator: Riziki Dama Yaa

Introduction

The purpose of this consent form is to give information you will need to help you decide whether or not to be part of this study. Feel free to ask any questions about the purpose of the research and any possible risk and benefits. Once you have understood and agree to be part of the research team, I will request you to sign your name on this form. I will give you a copy of this form for your record.

Roles and responsibilities

- To conduct interviews through administering of questionnaires
- Be professional and respect participant's opinion during the interview
- Be confidential with all the information collected in the course of the study
- Respect other field assistance views
- Respond promptly to any query raised by participants and or contact the principal investigator on any issue not clear
- Minimize any harm or injury to the participants by being professional and consulting where necessary
- Be punctual at all times

Payments terms

You a contracted on temporary bases only for the duration that the study will last which is approximately six weeks. You will be paid on daily bases at the end of each day, Kshs.....

I agree to be a field assistant in this research

Printed name: **Date:**

Signature/ thumb stamp:

Researchers statement

I, the undersigned, have fully explained details of the roles and responsibilities to the research assistant named above and believe that he/she has understood and willingly given his/her consent.

Researchers name: **Date:**

Signature:

APPENDICE III: CONSENT FORM

Title of Study: Enhancing haemoglobin status of anaemic adolescent school girls in Kilifi County using vegetables enriched with baobab powder

Principal Investigator \ and institutional affiliation: Riziki Dama Yaa/ University of Nairobi

Introduction:

I would like to tell you about a study being conducted by the above listed researcher. The purpose

of this consent form is to give you the information you will need to help you decide whether or not

Your child should participate in the study. Feel free to ask any questions about the purpose of the

research, what happens if your child participates in the study, the possible risks and benefits, the

Rights of your child as a volunteer, and anything else about the research or this form that is not clear.

When we have answered all your questions to your satisfaction, you may decide if you want your

Child to be in the study or not. This process is called 'informed consent'. Once you understand and

agree for your child to be in the study, I will request you to sign your name on this form. You

should understand the general principles which apply to all participants in a medical research:

- Your child decision to participate is entirely voluntary
- Your child may withdraw from the study at any time without necessarily giving a reason for his/her withdrawal
- Refusal to participate in the research will not affect the services your child is entitled to in this school

May I continue? YES / NO

For children below 18 years of age we give information about the study to parents or guardians. We will go over this information with you and you need to give permission in order for your child to participate in this study. We will give you a copy of this form for your records. Since your child is at an age that she can appreciate the study we will also require her to agree to participate after being fully informed.

The purpose of the study

The researcher listed above will interview individuals adolescent girls in this school. The purpose of the interview is to find out their dietary intake as far as iron rich foods are concerned. Participants in this research study will be asked questions about their day to day dietary intake. Participants will also have the choice to undergo a **Haemoglobin test** to check for their anaemia status. The participants that will be anaemic will be recruited to a feeding trial (vegetables enriched with baobab powder) for six weeks.There will be approximately **112** participants in this study randomly chosen. We are asking for your consent to consider your child to participate in this study.

What will happen if you decide you want your child to be in this research study?

If you agree for your child to participate in this study, the following things will happen:

The child will be interviewed by a trained interviewer in a private area where she feel comfortable answering questions. The interview will last approximately **15minutes** minutes. The interview will cover topics such as dietary intake, disease status and general hygiene. After the interview has finished, a qualified lab technician from Malindi general Hospital draw a few drops of blood from your child which will immediately be used to anlyse for Haemoglobin level of your child. You will be informed about the results. We will ask for

a telephone number where we can contact you if necessary. If you agree to provide your contact information, it will be used only by people working for this study and will never be shared with others. The reasons why we may need to contact you include: inform you on the results.

Risks, harms, discomforts associated with this study

We will keep everything your child tell us as confidential as possible. We will use a code number to identify your child and will keep all of our paper records in a locked file cabinet. However, no system of protecting confidentiality can be absolutely secure so it is still possible that someone could find out your child was in this study and could find out information about your child. Also, answering questions in the interview may be uncomfortable for your child. If there are any questions she does not want to answer, she can skip them. She has the right to refuse the interview or any questions asked during the interview. Your child may feel some discomfort when blood is being drowned and may have a small bruise which will heal in a few hours.

In case of an injury, illness or complications related to this study, contact the study staff right away at the number provided at the end of this document. The study staff will treat your child for minor conditions or refer the child for treatment for conditions that require more extensive care.

Benefits of this study

Your child may benefit by receiving free Haemoglobin testing, and if recruited to the feeding trial your child will benefit from iron rich diet in addition to the normal school diet. We will refer your child to a hospital for care and support if necessary. Also the information she provide will help us better understand the major cause of anaemia in school girls. This informationwil be a major contribution to science.

Will being in this study cost you anything?

You are not required to pay anything for you child to be in this study

Is there reimbursement for participating in this study?

There will be no reimbursement of any kind to the participants of this study

What if you have questions in future?

If you have further questions or concerns about your child participating in this study, please call or

send a text message to the study staff at the number provided at the bottom of this page.

For more information about your child's rights as a research participant you may contact the

Secretary/Chairperson, Kenyatta National Hospital-University of Nairobi Ethics and Research

Committee Telephone No. 2726300 Ext. 44102 email uonknh_erc@uonbi.ac.ke.

The study staff will pay you back for your charges to these numbers if the call is for study-related

Communication.

What are your other choices?

Your decision to have your child participate in this research is voluntary. You are free to decline or withdraw participation of your child in the study at any time without injustice or loss of benefits. Just inform the study staff and the participation of your child in the study will be stopped. You do not have to give reasons for withdrawing your child if you do not wish to do so. Withdrawal of your child from the study will not affect the services your child is otherwise entitled to in this school.

For more information contact Riziki Dama Yaa **at** 0722-328539 from **8 am** to **5 pm**

Statement of consent

The person being considered for this study is unable to consent for him/herself because he or she is

a minor (a person less than 18 years of age). You are being asked to give your permission to include

your child in this study.

Parent/guardian statement

I have read this consent form or had the information read to me. I have had the chance to discuss

this research study with a study counselor. I have had my questions answered by him or her in a

language that I understand. The risks and benefits have been explained to me. I understand that I

will be given a copy of this consent form after signing it. I understand that my participation and that

of my child in this study is voluntary and that I may choose to withdraw it any time. I understand that all efforts will be made to keep information regarding me and my child's personal

identity confidential. By signing this consent form, I have not given up my child's legal rights as a participant in this research study.

I voluntarily agree to my child's participation in this research study:

Yes No

I agree to have my child undergo Haemoglobin testing: Yes No

I agree to provide contact information for follow-up: Yes No

Parent/Guardian signature /Thumb stamp: _____ Date _____

Parent/Guardian printed name: _____

Researcher's statement

I, the undersigned, have fully explained the relevant details of this research study to the participant

named above and believe that the participant has understood and has knowingly given his/her

consent.

Printed Name: _____ Date: _____

Signature: _____

Role in the study: _____ [i.e. study staff who explained informed

consent form.]

Witness Printed Name (If witness is necessary) _____

Signature: _____ Date; _____

FOMU YA RIDHAA

Kichwa cha somo: Kuimarisha hali ya hemoglobini ya wasichana shule ya ayoni ya vijana katika Kaunti ya Kilifi kutumia mboga yenye kutajirishwa na poda ya mbuyu

Mchunguzi mkuu \ na uhusiano wa kitaasisi: Riziki kampuni ya Dama Yaa / Chuo Kikuu cha Nairobi

Utangulizi:

Ningependa kukuambia kuhusu utafiti uliofanywa na mtafiti zilizoorodheshwa hapo juu.Madhumuni

ya idhini hii fomu ni kutoa habari unahitaji kukusaidia kuamua kama au si

Mtoto wako wanapaswa kushiriki katika utafiti. Jisikie huru kuuliza maswali yoyote kuhusu madhumuni ya ya

utafiti, nini kinatokea kama mtoto wako anashiriki katika utafiti, hatari na faida, na

haki za mtoto wako kama kujitolea, na chochote kingine kuhusu utafiti au fomu hii si wazi.

Wakati sisi kujibu maswali yako yote ameshiba, unaweza kuamua kama unataka yako

mtoto kuwa katika utafiti au la. Mchakato huu inaitwa 'idhini'. Mara baada ya kuelewa na

kukubaliana kwa mtoto wako kuwa katika utafiti, itakuwa nawaomba kuingia jina lako kwenye fomu hii. Wewe

wanapaswa kuelewa kanuni za jumla ambayo Tekeleza kwa wahusika wote katika utafiti na matibabu:

- Uamuzi wako mtoto kushiriki ni hiari kabisa
- Mtoto wako inaweza kuondoa kutoka kwa kujifunza wakati wowote bila ya kutoa sababu kwa ajili ya uondoaji wake lazima

- Kukataa kushiriki katika utafiti si kuathiri huduma za mtoto wako anastahili kupata katika shule hii

Huenda mimi kuendelea? NDIO / HAKUNA

Kwa watoto chini ya umri wa miaka 18 sisi hutoa taarifa kuhusu mafunzo kwa wazazi au walezi. Tutaenda juu ya habari hii na unahitaji kutoa ruhusa ili mtoto wako kushiriki katika utafiti huu. Tutakupa nakala ya fomu hii kwa ajili ya kumbukumbu. Tangu mtoto wako ni katika umri kwamba yeye kufahamu kujifunza sisi pia zinahitaji yake kukubaliana kushiriki baada ya kuwa kikamilifu taarifa.

Madhumuni ya mafunzo

Mtafiti yaliyoorodheshwa hapo juu itawahoji watu mabaleghe wasichana katika shule hii. Madhumuni ya mahojiano ni kujua ulaji wao mbali kama chuma tajiri vyakula husika. Washiriki katika utafiti huu itakuwa kuulizwa maswali kuhusu ulaji yao siku kwa siku. Washiriki pia kuwa uchaguzi kufanyiwa na **hemoglobini mtihani** kukagua hali yao ya anemia. Washiriki kwamba ayoni itakuwa kuajiriwa kwa kesi ya ulishaji (mboga yenye kutajirishwa na poda ya mbuyu) kwa wiki sita. Kutakuwa na takriban washiriki **112** katika utafiti huu nasibu waliochaguliwa. Tunaomba ruhusa yako kufikiria mtoto wako kushiriki katika utafiti huu.

Nini kitatokea kama kuamua unataka mtoto wako kuwa katika hili utafiti?

Kama unakubali kwa mtoto wako kushiriki katika utafiti huu, mambo yafuatayo yatatokea:

Mtoto itakuwa waliohojiwa na mtafiti mafunzo katika eneo la binafsi ambapo yeye kujisikia starehe ya kujibu maswali. Mahojiano ya mwisho takriban dakika **15minutes** . Mahojiano itafikia mada kama vile ulaji, hali ya ugonjwa na usafi wa jumla. Baada ya mahojiano kukamilika, fundi maabara waliohitimu kutoka hospitali ya kuu ya Malindi kuchora matone machache ya damu kutoka mtoto wako mara moja kutumika hadi anlyse kwa kiwango cha hemoglobini ya mtoto wako. Unaweza kuwa taarifa kuhusu matokeo. Tutaomba kwa namba ya simu ambapo sisi inaweza kuwasiliana na wewe kama ni muhimu. Kama unakubali kutoa maelezo yako ya mawasiliano, ni kutumiwa tu na watu kufanya kazi kwa ajili ya utafiti huu

na kamwe kugawizwa na wengine. Sababu kwa nini sisi kuhitaji kuwasiliana na wewe kujumuisha: taarifa na matokeo.

Hatari, madhara makubwa, usumbufu yanayohusiana na somo hili

Sisi kuweka kila kitu mtoto wako Tuambie siri kama iwezekanavyo. Kutumia idadi ya msimbo kutambua mtoto wako na kuweka rekodi yetu yote katika kikabati zilizofungwa. Hata hivyo, hakuna mfumo wa kulinda usiri inaweza kuwa salama kabisa hivyo inawezekana bado kwamba mtu anaweza kupata nje mtoto wako katika utafiti huu na anaweza kupata habari kuhusu mtoto wako. Pia, kujibu maswali katika mahojiano inaweza kuwa na wasiwasi kwa ajili ya mtoto wako. Kama kuna maswali yoyote yeye hataki kujibu, yeye Ruka wao. Yeye ana haki ya kukataa mahojiano au maswali yoyote aliuliza wakati wa mahojiano. Mtoto wako anaweza kuhisi baadhi ya usumbufu wakati wa damu ni kuwa kuzama na huenda inayofanana ndogo ambayo kuiponya kwa masaa machache.

Katika kesi ya kuumia, maradhi au matatizo yanayohusiana na utafiti huu, wasiliana na wafanyakazi kujifunza haki mbali kwenye namba zinazotolewa katika mwisho wa waraka huu. Wafanyakazi wa kujifunza kutibu mtoto wako kwa hali ya madogo au rejea mtoto kwa ajili ya matibabu kwa hali ambazo zinahitaji utunzaji wa kina zaidi.

Faida ya somo hili

Mtoto wako wanaweza kufaidika kwa kupokea upimaji wa hemoglobini huru, na kama wakipata mafunzo ya kesi kulisha mtoto wako watafaidika chuma tajiri chakula pamoja na mlo wa shule ya kawaida. Rejea mtoto wako hospitali kwa ajili ya huduma na msaada kama ni muhimu. Pia taarifa yeye kutoa atatusaidia sisi kuelewa Kisababishi kikuu cha anemia katika shule ya wasichana. Yatahakikisha hii taarifa kuwa mchango mkubwa katika sayansi.

Itakuwa kuwa katika somo hili gharama wewe chochote?

Wewe si required kulipa chochote kwa ajili ya mtoto wako kuwa katika somo hili

Kuna kuwarudishia kwa kushiriki katika utafiti huu?

Kutakuwa na kuwarudishia hakuna wa aina yoyote kwa washiriki wa utafiti huu

Vipi kama una maswali katika siku zijazo?

Kama una zaidi maswali au wasiwasi kuhusu mtoto wako kushiriki katika utafiti huu, tafadhali piga simu au

kutuma ujumbe wa matini kwa watumishi kujifunza kwa namba zinazotolewa chini ya ukurasa huu.

Kwa maelezo zaidi kuhusu haki za mtoto wako kama mshiriki wa utafiti unaweza kuwasiliana Katibu/Mwenyekiti, hospitali ya Taifa ya Kenyatta-Chuo Kikuu cha Nairobi maadili na utafiti kamati simu No. 2726300 Ext. barua pepe 44102 uonknh_erc@uonbi.ac.ke. Wafanyakazi kujifunza kulipa wewe nyuma kwa ajili ya mashtaka yako kwa namba hizi kama wito ni kwa ajili ya mawasiliano yanayohusiana na masomo.

Chaguo zako ni zipi?

Uamuzi wako wa kuwa na mtoto wako kushiriki katika utafiti huu ni hiari. Uko huru kushuka au kuondoa ushiriki wa mtoto wako katika kujifunza wakati wowote bila dhuluma au kukosa faida. Tu kuwajulisha wafanyakazi kujifunza na ushiriki wa mtoto wako katika utafiti itakuwa kusimamishwa. Huna Toa sababu za kujitoa mtoto wako kama hupendi kufanya hivyo. Uondoaji wa mtoto wako kutoka utafiti si kuathiri huduma za mtoto wako vinginevyo haki katika shule hii.

Kwa taarifa zaidi wasiliana Riziki kampuni ya Dama Yaa **katika** 0722-328539 kutoka **8 juu** hadi **5 pm**

Taarifa ya ridhaa

Mtu kuwa kuchukuliwa kwa ajili ya utafiti huu ni haiwezi ridhaa kwa waliojitokeza kwa sababu yeye ni

mdogo (mtu mwenye umri wa miaka chini ya 18). Wewe ni kuulizwa kutoa kibali chako kujumuisha

mtoto wako katika utafiti huu.

Taarifa ya mzazi au mlezi

Soma fomu hii idhini au alikuwa taarifa kusoma kwangu. Kuwa na nafasi ya kujadili

Utafiti huu kujifunza na mshauri wa kujifunza. Nimekuwa na maswali yangu akajibu kwa yake katika ya

lugha ambayo mimi kuelewa. Hatari na faida imekuwa alielezea kwangu. Nafahamu kwamba mimi

itakuwa kupewa nakala ya fomu hii ya kibali baada ya kutia saini yake. Nafahamu kwamba ushiriki wangu na kwamba

mtoto wangu katika utafiti huu ni wa hiari na kwamba mimi kuchagua kuondoka wakati wowote. Ninaelewa kwamba jitihada zote yatatolewa kwa kuweka maelezo kuhusu mimi na mtoto wangu wa kibinafsi

utambulisho siri. Na kusaini fomu hii ya kibali, kutokana na haki ya kisheria ya mtoto wangu kama mshiriki katika utafiti huu.

Hiari nakubaliana mtoto wangu kushiriki katika utafiti huu:

Ndiyo Hapana

Nakubaliana kuwa mtoto wangu kufanyiwa upimaji wa hemoglobini: Ndiyo Hapana

Nakubaliana na kutoa taarifa ya mwasiliani kwa ajili ya kufuatilia: Ndiyo Hapana

Mzazi au mlezi saini /Thumb muhuri: ___ tarehe ___

Mzazi au mlezi Piga Chapa jina la: ___

Taarifa ya mtafiti

Mimi, tumeyatia, kuwa kikamilifu alielezea maelezo husika ya utafiti huu kwa mshiriki

iliyotajwa hapo juu na kuamini kuwa mshiriki ameelewa na wanajua kupewa yake

idhini.

Piga Chapa jina la: ___ tarehe: ___

Saini: ___

Jukumu katika utafiti: ___ [yaani kujifunza wafanyakazi ambaye alieleza taarifa

idhini ya fomu.]

Kushuhudia jina kuchapishwa (kama ushahidi ni muhimu) ___

Saini: ___ tarehe; _____

APPENDICE IV: ASSENT FORM

Project Title: Enhancing haemoglobin status of anaemic adolescent girls using vegetables enriched with baobab powder

Investigator(s): Riziki Dama Yaa

I am doing a research study about the use of food base intervention to reduce anaemia.

Permission has been granted to undertake this study by the Kenyatta National Hospital-University

of Nairobi Ethics and Research Committee (KNH-UoN ERC Protocol No. _____p360/05/2018_____)

This researchstudy is a way to learn more about anaemia. At least 112 children will be participating in this research study with you.

If you decide that you want to be part of this study, you will be asked (your age, religion, home sub-County, feeding pattern, illness history and take part in feeding trial involving vegetables(mchicha and mnavu) mixed with baobab(mabuyu) powder for six weeks).

There are some things about this study you should know. These are:

There will be a blood test which will be done by qualified lab technician to check for your Hb level. A few drops of your blood will be drawn causing a slight discomfort and a bruise which will disappear in few hours.

The feeding trial will involve you taking the mixed vegetables (mchicha and mnavu) with baobab powder every day for 6weeks

There are no known allergic reactions associated with baobab consumption but in case you experience anything unusual after consumption of the baobab, please report to the school nurse immediately

Note:everyone who takes part in this study will benefit. A benefit means that something good

Happens to you. These benefits might be:

- you will be able to know your Hb status
- you will be exposed to iron rich food other than your normal school diet for the entire period of the study
- you might have an improved Hb status

If you do not want to be in this research study, it's ok and you will still benefit from the findings of the study once it over

Participant unique number……

Sign…….

APPENDICE V: QUESTIONNAIRE

Researchtitle: Enhancing haemoglobin status of anaemic adolescent girls using vegetables enriched with baobab powder

SECTION A

Socio-demographic characteristics

Tick where applicable

1. Participant unique number**.....** **Date.....**

2. Respondent's age

14-19 ☐ 20-25 ☐ >25 ☐

3. Religion

Christian ☐ Muslim ☐ others ☐

If others, specify.....

4. Marital status

Married ☐ single ☐ divorced ☐ N/A ☐

5. Education

Form one ☐ form two ☐ form three ☐ form four ☐

6. Occupation of parent/ guardian.....

SECTION B

Morbidity status

1. Have you been sick the last two weeks?

Yes ☐ No ☐

If yes, what where you suffering from?

_____

- Did you visit the hospital for treatment?

Yes ☐ No ☐

2. Do you know what is anaemia?

Yes ☐ No ☐

Have you ever suffered from anaemia?

Yes ☐ No ☐

If yes, how long ago?

_____

Are you on anaemia treatment currently?

Yes ☐ No ☐

Are worm infestations common in the school?

Yes ☐ No ☐

Are you given medicine to prevent worms by the school?

Yes ☐ No ☐

If yes how often

_____

SECTION C

Hb assessment

1st Hb test results (g/dl)

_____

2nd Hb test results (g/dl)

_____

SECTION C

Dietary consumption pattern

1. How many meals do you take per day?

   _____

2. Do you get food outside the school menu?

   _____

3. How often do you take vegetables?

   _____

4. List the common vegetables that you take:

   -
   -
   -
   -
   -
   -

5. How often do you take fruits?

   _____

5. List common fruits that you take:

   -
   -
   -
   -
   -

5. How often do you take tea or coffee?

   _____

6. Do you take tea/coffee with meals?

Yes ☐ No ☐

APPENDICE VI: FOOD FREQUENCY QUESTIONNAIRE

Please indicate how many times each food in the list has been consumes (NB- for each indicate only one frequency e.g. Beef ×1 weekly (in weekly column)

SN	Food eaten	Frequency of consumption (No. Of times the food consumed by the adolescent girls)				Reasons why not consumed 1=expensive, 2=not locally available, 3=not provided in the school menu,4=taboo,5=doctors instructions, 6=allergy, 7=others(specify)
		Daily	Weekly	Monthly	Occasionally	
1	Beef					
2	Fish					
3	Eggs					
4	Chicken					
5	Liver					
6	Pulses					
7	Green leafy vegetables					
8	Whole milk					
9	Tea					
10	Cocoa					

11	Oranges					
12	Lemons					
13	Mangoes					
14	pineapples					
15	Others					

APPENDICE VII: KEY INFORMANT INTERVIEW GUIDE (Non-Health workers)

INTRODUCTION

My name is Riziki Dama a student at The University of Nairobi doing masters in applied human nutrition. You are being invited to take part in an interview. All information you give will be confidential. The information will be used to prepare general report but will not include any specific name. I encourage you to participate in this study and your participation will be highly appreciated.

PART B

I agree to participate in this research. The purpose is to specify terms of my participation in the interview. I have been given sufficient information about this research and the purpose of my participation has been explained to and is clear. Participation will involve being interviewed; the interview will take approximately 15 minutes. I allow the researcher to take written notes during the interview. I have the right to not answer any of the questions and if I feel uncomfortable in any way during the research I have the right to withdraw. I have been guaranteed that my confidentiality as a participant in this study will remain secure.

Participant signature——————— Date———————

Name of the respondent.....

Date: .....

Sex: .....

Age: .....

Title: .....

1. Which year did the school start operating?

2. How many meals are served to the students per day?

3. What is the composition of each meal?
   Breakfast
   Lunch
   Supper
4. What vegetables are part of the school menu?
5. Does the school menu change? If yes how often?
6. What is the source of the food consumed at the school?
7. How many cooks does the school have?
8. What the most common cooking methods used?
9. What is the source of water used for food preparation?
10. What are the common diseases often suffered by the school girls

Researcher's statement

I appreciate your participation in this interview and your views are highly appreciated and useful in this study.

Signature _____ Date _____

APPENDICE VII: KEY INFORMANT INTERVIEW GUIDE (Health workers)

INTRODUCTION

My name is Riziki Dama a student at The University of Nairobi doing masters in applied human nutrition. You are being invited to take part in an interview. All information you give will be confidential. The information will be used to prepare general report but will not include any specific name. I encourage you to participate in this study and your participation will be highly appreciated.

PART B

I agree to participate in this research. The purpose is to specify terms of my participation in the interview. I have been given sufficient information about this research and the purpose of my participation has been explained to and is clear. Participation will involve being interviewed; the interview will take approximately 15 minutes. I allow the researcher to take written notes during the interview. I have the right to not answer any of the questions and if I feel uncomfortable in any way during the research I have the right to withdraw. I have been guaranteed that my confidentiality as a participant in this study will remain secure.

Participant signature——————— Date———————

Name of the respondent.....

Date: .....

Sex: .....

Title: .....

What are the top five diseases in the County?

What is the prevalence of anaemia in the County?

What is the mortality rate for anaemia in the County?

What are common causes of anaemia among school girls and adolescents?

How is the County health team deal with prevention of anaemia to this particular group?

Is iron supplementation done routinely in schools? If yes how often

Are there school de-worming programmes in the County? If yes how often

Researcher's statement

I appreciate your participation in this interview and your views are highly appreciated and useful in this study.

Interviewer's Signature_____ Date _____

APPENDICE VIII: SENSORY EVALUATION FORM

Form number: …….

Participant's unique number: …….. **Date**: ……..

Instructions

- Read the instructions carefully before the exercise
- Grade the samples according to the codes given for colour, taste, level of sourness and general acceptability attributes.
- Rise your mouth after examining each product

sample	colour	Taste	Level of sourness	General acceptability	Comment
001					
002					
003					

1= dislike

2= dislike moderately

3= dislike slightly

4= neither like nor dislike

5= like moderately

6= like very much

APPENDICE IX: MATRIX FOR DATA ANALYSIS PLAN

OBJECTIVE 1: To determine the socio-demographic characteristics of the adolescent girls
Variables: age, religion, marital status, education and occupation of parents
Initial processing:categorizing data by cluster, religion type, level of education, age groups
basic statistics: frequencies, mean median, mode and percentages
Advanced statistics: regression correlation, X^2
OBJECTIVE 2: to determine dietary intake adequacy for iron, and morbidity
Variables:number of iron rich variety consumed, amount per meal and number of days per week and disease status
Initial processing: categories data by number of varieties and number of hospital visits
Basic statistics: frequencies, mean and percentages
Advanced statistics: correlation and regression
OJECTIVE 3: To determine the proximate vitamin C content of baobab powder and iron content in the vegetables9amarunth and solunam)

Variables:level of vitamin C
Initial processing: Record results on the templates
Basic statistics:mean and percentages
Advanced statistics:correlation
OBJECTIVE 4: To determine the iron status of adolescent girls before and after intervention
Variables: Hb level
Initial processing:recording results on the templates
Basic statistics:mean and percentages
Advanced statistics:ANOVA, correlation, regression

APPENDICE X: MATRIX SHOWING CONVERSION OF OBJECTIVES INTO VARIABLES, OUTPUT AND ACTIVITIES

Specific objective	Variables	Type of variable	tool	activity	indicator	Statistical test
To determine socio-demographic characteristics of adolescent girls	Age Education Religion Marital status Occupation of parent	Continuous Ordinal Nominal Nominal nominal	questionnaire	interview	- income	Mean Median Mode percentile
To determine dietary intake for iron and morbidity of the adolescent girls	Iron intake Disease state	ordinal	-Food frequency table -14 day recall guide	-Administering food frequency table Conducting a 14 day recall for morbidity	-amount of iron taken in 7days Number of hospital visits	Chi-square
To determine iron status before and after the intervention	Iron status	continuous	Hb metre	Drowing blood and testing for iron status	Hb reading recorded	correlation

To determine proximate vitamin C content in baobab powder	Content of vitamin C	Nominal	Motor and pestle, test tubes, glass jar, beaker, reagents, dry baobab pulp	Laboratory analysis for proximate vitamin C content	Data recorded	Correlation regression

ADVERSE EVENTS REPORTING FORM

REPORT ON SUSPECTED SERIOUS ADVERSE DRUG REACTION

- ☐ **Initial report**
- ☐ **Follow –up report**

PARTICIPANTS PARTICULARS

Name of participant.....

Age: ..... Weight (kg:.....) Participant address :.....

Sex: Male.....

Female.....

Pregnant: Yes....., No....., Not applicable.....

Relevant Medical History: .....

.....
.....
.....

SEVERITY OF THE REACTION:

- ☐ Mild
- ☐ Moderate
- ☐ Severe
- ☐ Fatal
- ☐ Unknown

ACTION TAKEN:

- ☐ Drug withdrawn
- ☐ Dose increased
- ☐ Dose reduced
- ☐ Dose not changed

☐ unknown

ADVERSE EVENT REASON FOR REPORTING

☐ Requires or prolongs hospitalization
☐ Life threatening Death
☐ Permanently disabling or incapacitating
☐ Congenital anomaly
☐ Overdose

Other (Please Specify).....

.....

SUSPECTED DRUG/FOOD PRODUCT(S)

Name of suspected Drug/food product(s).....

Name of manufacturer.....

Date of occurrence..... Duration of consumption.....

Starting date of consumption.....

Route of administration.....

Discontinuation of Drug because of event No.... Yes.... Dated:.....

Any other comment(s).....

.....
.....

REPORTING DOCTOR'S / PHARMACIST'S / NURSE'S

NAME: ..... SIGNATURE: .....

INSTITUTION: ..... DATE: .....

EXPLANATORY NOTES

CONFIDENTIALITY

All information collected in this form, identity of the reporter and participant will remain confidential

WHO CAN REPORT

All healthcare professionals(clinicians, dentist, nurses, pharmacist etc), patients or their next of kin may also report.

WHAT HAPPENS TO THE SUBMITTED FORM

All information submitted is handled in strict confidence. The pharmacy and poison board will assess causality and statistical analysis on each form. Data will periodically be used for review and suggest any intervention that may be required to the ministry of health. Data will also periodically be submitted to WHO collaboration centre for International Drug Monitoring.

SUBMISSION OF INITIAL OR FOLLOW-UP REPORTS

It is important to tick the appropriate box on the top right corner of the first page if the report is initial or follow-up so that follow –up reports are identified and linked to the original report.

WHERE TO REPORT TO

After completing the form please forward the same to your pharmacy department for onwards submission or mail directly to:

THE PHARMACY AND POISON BOARD

LENANA ROAD.

P.O BOX 27663-00506 NAIROBI

E-mail:pv@pharmacyboardkenya.org