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EDITORIAL

ONE THOUSAND DAYS

" Invest in nutrition now for better feature"

Good nutrition is a basic human right for all people and fundamental for economic, social and human development. In pregnancy good nutrition enhances optimal foetal development and pregnancy outcomes while in early childhood it is crucial for the health and long-term development of a child. Well-nourished children have higher Intelligence Quotients, are better able to concentrate at school and more likely to perform and finish school (UNICEF 2006).

In adulthood good nutrition enhances productivity, wealth generation and economic development. Optimal nutrition is central to health, learning, and human wellbeing.

On centrally Malnutrition is the greatest cause of child deaths in the country contributing to over one third of child deaths every year and a major factor for the high number of maternal deaths. Apart from the disease burden, micronutrient deficiencies severely affect economic and human development leading to an annual loss of USD 518 million each year (or 2.65% of Tanzania's GDP).

Studies based on the new WHO growth standards provide new evidence that decline in height for age for children in the developing world takes place during the "One Thousand Days". The right nutrition during this 1,000 day window can have a profound impact on a child's ability to grow, learn, and rise out of poverty. Investing in better nutrition in the 1,000 day window can help families, communities and country at large break the cycle of poverty and achieve lasting progress in health and development. *"We are guilty of many errors and many faults, but our worst crime is abandoning the children, neglecting the foundation of life. Many of the things we need can wait. The child cannot. Right now is the time his bones are being formed, his blood is being made and his senses are beingddeveloped. To him we cannot answer "Tomorrow." His name is aToday." (Gabriela Mistral, 1948).*

LISHE – TANZANIA FOOD AND NUTRITION JOURNAL
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This journal receives original papers on basic and applied research as well as review articles on food, nutrition and related disciplines of agriculture and development.

Submission of papers to the journal implies it reports original and unpublished work and if is accepted the paper will not be published elsewhere in the same form. All contributions will be in English language.

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Provide a survey of literature and clearly justify the need for the study and objective(s).

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Particular attention should be paid to design, analysis and statistics. Include reference of methods used.

Results

Description of results should be concise avoiding reproducing information already in the tables.

Discussion

This section should indicate clearly the significance and implication of the results obtained and reference should be made to published recent literatures.

References

References to literature in the text should adhere to the Harvard System of citation (journals, books, chapters in books, internet articles, etc.)

CONTENTS

Effects of malting and fermentation on the amount of reducing sugars and soluble proteins and free amino acids in White Macia and Red Tannin Sorghum flours

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Abstract

The purpose of this study was to investigate effects of malting and fermentation methods on the amounts of sugars and proteins in food grade Macia and Red tannin sorghum flours. Measurements to determine the amounts of reducing sugars, soluble protein, and free amino acids, in sorghum flour samples were performed. Grain sorghum kernels (5.2kg) from each sorghum variety were cleaned and kernel hardness tested using Tangential Abrasive Decortication Device (TADD).Half of the kernels (2.6kg) were milled to get regular (Rg) flour samples and the other half (2.6kg) were malted and milled to get malted (mal).flour samples. About 300g of both regular (Rg) and malted (mal) flour samples from both sorghum cultivars (in duplicate) were fermented, dried and milled again to get regular and fermented (Rgfe) and malted and fermented (malfe) flour samples.

Extracts were prepared for all (8) flour samples by weighing about 0.5g of flour into centrifuge tubes, then 10 ml of water was added, vortexes 3 times, boiled for 15min and then centrifuged at 5250 RCF for 10 min. The reducing sugars in the extracted material of the regular, fermented, malted and malted/fermented flours from both food grade white Macia and the red tannin sorghum samples were determined by the (DNS) colorimetric methods with glucose as the standard and the absorbance values were read at 540 mm (Miller, 1959).The quantitative measurement of free amino acids of the supernatant material from all flour samples from both the food grade white macia and red tannin sorghum samples were performed using the ninhydrin reaction (Plummer, 1978). The amounts of soluble proteins in the supernatant material were measured using the Lowry method (Lowry et al, 1951).

Results showed an increase in reducing sugars, soluble proteins and free amino acids in the malted and fermented flour samples compared to the control or regular flour samples, respectively. Malting and fermentation resulted in increased amounts of reducing sugars, soluble proteins and free amino acids in both food grade Macia and Red tannins sorghum flour. Statistical analysis results showed a significant (p < 0.05) difference between malting and fermentation but no significant (p >0.05) difference between the two sorghum varieties (Macia and Red sorghum). Malting and fermentation may be used to improve the nutritional quality of sorghum food products.

Key words: Free amino acids, fermentation, macia, malting, tannins, reducing sugars, soluble proteins, sorghum flour.

Introduction

Sorghum is among the major dependable cereal grains in Tanzania, other cereals include, corn or maize, rice, wheat, millet etc. Compared to all other cereals sorghum exhibits poor digestion, a problem more pronounced in areas of the world that rely on sorghum as a major staple of their diet. Poor digestibility in grain sorghum is caused by many factors including the presence of tannins that in some sorghum varieties tend to bind protein, carbohydrates, and minerals, and presence of kafirins that are protease resistant (Badi *et al*; 1990; Oria *et al*; 1995; Anglani, 1998). Furthermore, the interactions of protein to protein, protein to carbohydrate and protein to (poly) phenol and carbohydrate to (poly) phenol (Axtell; 1981; Hamaker *et al*; 1987; Knudsen *et al*, 1988; Cherney *et al*, 1992; Taylor and Taylor, 2002) have great influence

on sorghum digestion.

Sorghum is regarded as a poor man's grain in part because of poor digestibility, but also because of poor organoleptic quality of foods made with sorghum. This situation creates negativity among consumers and greatly limits sorghum utilization. Utilization of sorghum on a wider scale would improve local economies in arid areas of Africa, and Tanzania in particular, that depend on this grain to support local residents. Malting and fermentation of grains are simple processes known to have positive effects and can be used to change the functional and organoleptic properties of sorghum based foods. (Rooney, et al, 1995)

This study was undertaken to determine the effects of malting and fermentation on sorghum flour composition and functionality. Specifically, the study was carried out to determine the amounts of reducing sugars, soluble protein and free amino acids in food-grade Macia and Red tannin sorghum flours. It is hypothesized that the amount of reducing sugars, soluble proteins and free amino acids in food grade macia and red tannin sorghum flours will change due to the malting and fermentation pre-treatments, and that the composition of food-grade Macia sorghum flour will differ from the red tannin containing sorghum flour.

Materials and Methods

Materials
White (Macia) and red, tannin containing sorghum (T159781) varieties grown and harvested on University of Nebraska-Lincoln research farms in 2008 were used throughout the experiment. Kernel samples were kept in storage at -20°C until use in treatments.

Methods
Sample Cleaning and Grain quality assessment
Grain sorghum kernels from each sorghum variety were cleaned by first manually sorting to remove deformed, small, broken and immature kernels, dust, sand, stones, and other foreign materials. The kernels were then quickly washed by immersion in cold tap water in a 20-L. bucket, stirred by hand and screened out of the water. Following washing the kernels were dried

at room temperature on paper towels. After drying, kernels were kept in plastic bags and held at room temperature for approximately one month before grain quality tests were performed for each of the two sorghum varieties.

Kernel hardness test was conducted using Tangential Abrasive Decortication Device (TADD), with a standard disk No.36, (Model 4E-230, Venable Machine Works, Saskatoon, Canada) and a laboratory electrical seed scarifer (Forsberg, Thief River Falls, MN), as described by Liu (2007). Stenvert hardness hammer mill (Micro hammer Mill 203 Brook dale Maywood. NJ 0767) and Wisconsin Breakage Tester (Grain Research Laboratory, Minneapolis, MN) with a rapidly spinning horizontal disk were used to determine breakage susceptibility of the kernels. These methods were used due to their simplicity, and the major focus was to find a hardness index that could differentiate the kernel integrity differences between the two varieties of sorghum grain (Watson *et al*, 2000).

Milling Procedure
After cleaning and kernel integrity assessment, 2.6 kg of kernels (in duplicate) from the Macia and red, containing tannin sorghum varieties were milled using a Quadrumat Jr. Laboratory mill (Brabender, Duisburg. Germany), to get regular Macia. **(MRg)** and red tannin or T159781 **(TRg)** sorghum flour samples. Regular Flour samples and subsequently treated flour samples were all stored in plastic bags at -20 °C until further analyses or use.

Malting Procedure
Another 2.6 kg of kernels (also in duplicate) from each of the Macia and red tannin or T159781, varieties were placed in bags made of porous canvas. The bags containing kernels were immersed in tepid tap water contained in 20-L plastic buckets and then placed in a controlled environment chamber, set and maintained at 30°C and 98% relative humidity to begin the steeping phase. During the 120-hour steeping stage, the steep water was drained and replaced with fresh water daily.

After steeping, the kernels were removed out of the bags, blotted with towels to remove surface water and placed on aluminum cookie sheets and covered by wet pieces of germination papers. The sheets with covered kernels were

then placed in a controlled environment chamber at 25°C and 98% relative humidity to begin the germination process. During the 72-hour germination process, the covering paper was periodically lifted and the surface of the kernels was sprayed with tap water.

Following germination, the sheets with the kernels were then transferred to a forced air drying oven maintained at 50°C and held for 48 h. Afterwards, kernels were left on the sheets to cool at room temperature and thereafter all rootlets and shoots were removed from the malted kernels by rubbing vigorously between the hands, and then separated by sifting through a 2.5mm sieve. Malted kernels were milled with a Quadrumat Jr. Laboratory mill (Brabender, Duisburg. Germany) to get malted Macia **(Mmal)** and red tannin or T159781 **(Tmal)** sorghum flour samples.

Fermentation procedure
About 300g of both the malted and regular flours (in duplicate) from malted and unmalted kernels of both varieties were fermented. To start the fermentation process, the flour samples were mixed with 600 ml of tap water at ratio of 1:2 (grain(g) to liquid(ml)) and 30g of non-fat yogurt (obtained from a local market containing active cultures including L. acidophilus) to obtain a final mixture of 930 g of slurry.

The slurry was stirred by hand and covered with aluminum foil then fermented at 25°C for 72 h. After fermentation, the slurry was transferred to a glass pan (6:4cm), and spread into a thin layer. The pans were put into a forced draft oven at 65°C for 24 hours. The dried material in the form of fermented cakes was allowed to cool before breaking into small pieces and milling (Quadramat Jr.), into fermented **(Mfe)** and **(Tfe)** on one hand and malted/fermented **(Mmalfe)** and **(Tmafe)** flour samples from regular (Rg) and malted (mal) flour samples respectively.

Determination of reducing sugars
Extracts were prepared for all (8) flour samples (MRg, TRg, Mmal, Tmal, Mfe, Tfe, Mmalfe and Tmafe) by weighing about 0.5g of flour into centrifuge tubes, then 10 ml of water was added, vortexes 3 times, boiled for 15min and then centrifuged at 5250 RCF for 10 min.

The reducing sugars in the extracted material of the regular, fermented, malted and malted/fermented flours from both food grade white Macia and the red tannin or T159781 sorghum samples were determined by the (DNS) colorimetric methods with glucose as the standard and the absorbance values were read at 540 mm (Miller, 1959).

Determination of Soluble Proteins and Free Amino Acids
The quantitative measurement of free amino acids of the supernatant material from above of the regular, fermented, malted and malted/fermented flours from both the food grade white macia and red tannin or T159781 sorghum samples were performed using the ninhydrin reaction (Plummer, 1978). The amounts of soluble proteins in the supernatant material were measured using the Lowry method (Lowry *et al*, 1951).

Data analysis
The experimental design was a split-split plot design. The whole plot factors were the two sorghum varieties, which were at two levels: white macia and red tannin. The split plot factors were the processing methods: milled and malted, while the split-split plot factor was the fermentation process: fermented or non-fermented. There were two replications for each treatment, thus making a total of sixteen replications and each one of them was taken as one block. Statistical analysis system (SAS 1999) was used for all statistical analyses. An analysis of variance (ANOVA) was performed using PROC MIXED procedures ($p \leq 0.05$) for the flour and the bun analysis.

Results and Discussion
Amounts of reducing sugars in sorghum flour samples
The amount of reducing sugars (mg/flours) in flour samples from the food grade white macia and red tannin or T159781 containing sorghum varieties was determined. Results show that there was an increased amount of reducing sugar in the malted flour from both sorghum varieties (Figure 1). Statistical analysis results showed a significant ($p < 0.05$) difference between the two treatments and no significant ($p > 0.05$) difference between the two varieties (macia and red tannin).
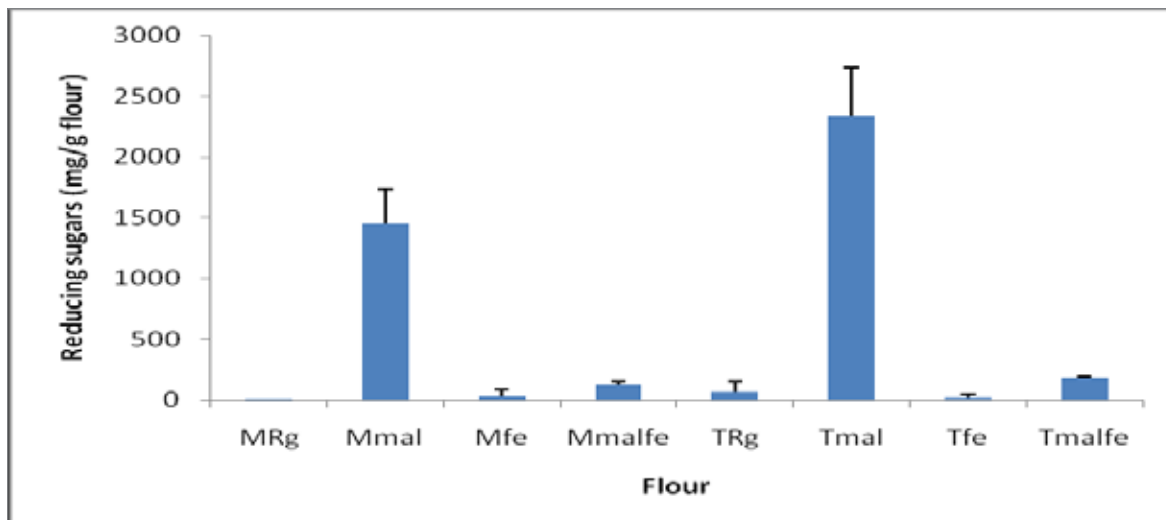
Figure 1. Amount of reducing sugars in sorghum flour samples.

An increase in reducing sugars during malting could be due to starch hydrolysis by hydrolytic enzymes such as α-amylase. These results are in agreement with previous studies, FAO (1995) and Traore et al (2004) which indicated synthesis of hydrolytic enzymes, such as amylases; proteases, and phytases during malting. Miazhar and Chandrasheker, (1993) reported a breakdown of protease resistant prolamines and an increase in the availability of minerals (iron, zinc etc). Essential amino acids principally lysine, tryptophan and methionine (FAO, 1995; Anglani, 1998) and vitamin C content Taur, *et al*, (1984) have been reported to increase during malting.

During the germination stage kernels are first dehydrated, a process that increases both respiration and metabolic activities and enables mobilization of primary and secondary metabolites (Limami *et al*. 2002). It is during this stage when breakdown of protease resistant prolamins occur (Mazhar and Chandrashekar, 1993). Similar findings were reported by Mahgoub *et al*. 1999) and Lorri *et al*, (1993) that a reduction in phytate content corresponded to an improvement in bioavailability of some essential minerals (iron, calcium, zinc, phosphorus etc) in malted cereals. The malting process not only caused a reduction in phytate content, but also increased α- amylase activity and the sweetness in the malt flours (Mallesh

and Desikachar, 1988).

Although some studies showed some negative aspects with this process, especially generation of cyanide, (Traore et al, 2004), the good news is this toxin can be removed either by heating the flour or removing shoots, roots and germs, although removing the germ may reduce the amylase content in the kernel (Traore *et al*, (2004). In African culture, opaque beer and weaning foods are prepared from malted sorghum indicating that malting and other traditional processes can reduce the potential cyanide to lower levels considered nontoxic (Dada and Dendy, 1987) and Laswai *et al*, (2000). Malting process presents an interesting story and could be used to improve energy and nutrient densities of gruels intended for infants and young children.

Amount of soluble proteins and free Amino acids in sorghum flour samples
The amounts of soluble proteins and free amino acids in the white macia and red tannin sorghum varieties were analyzed. Results in Figure 2 show a slight increase in the amount of soluble protein in fermented flours for both sorghum varieties (Mfe&Tfe) although statistical analysis of data showed no significant difference ($p > 0.05$) between the two treatment variables (malting and fermentation) and between the two varieties (macia and red tannin).
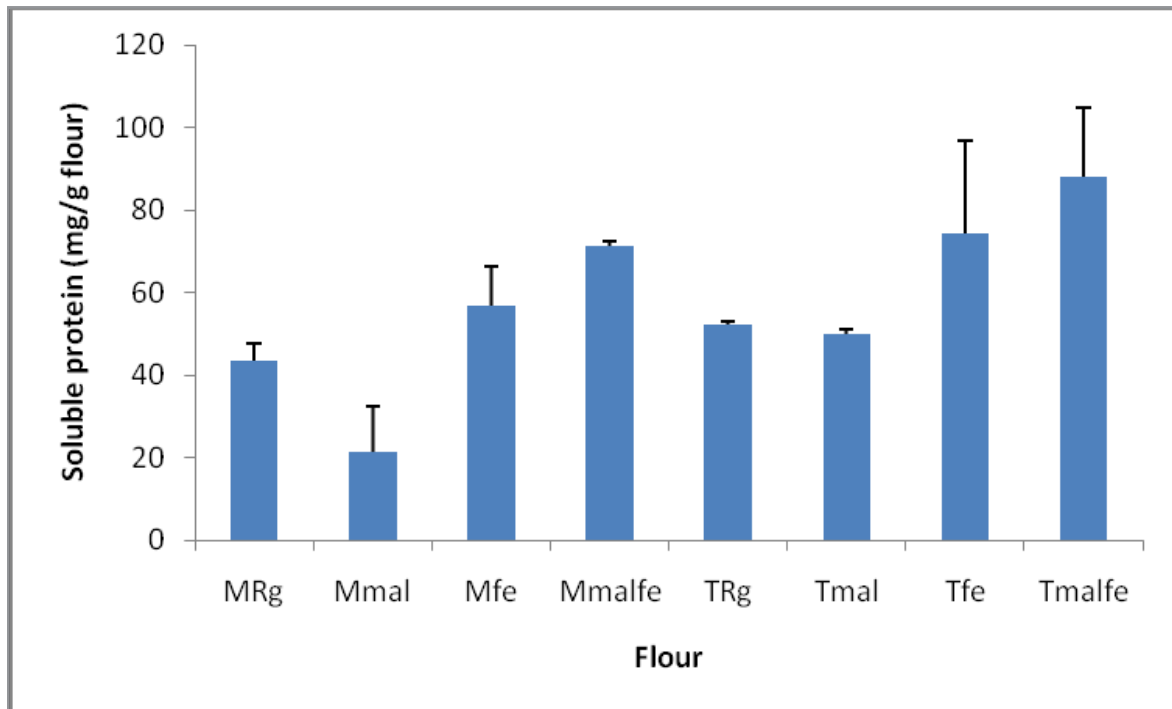
Figure 2: Amount of soluble proteins in sorghum flour samples.

The interaction between the treatments showed a significant effect ($p < 0.05$) on the amount of soluble protein for both varieties. An increase in soluble protein could be due to both solubilization of sorghum flour during fermentation and structural changes in storage protein (prolamines and glutelins) during malting, hence making them available to enzymatic attack.

A study by Taylor and Taylor (2002) supports the above argument whereby their results indicated an increase in vitro protein digestibility during fermentation and a combined treatment effect (malfe) significantly improved digestibility. Also studies by Kazanas and Fields (1981), Mertz et al (1984), Chavan et al (1988), Lorri and Svanberg (1993) and Hassan and El Tinay (1995) all showed an increase in soluble protein during fermentation process.

Although reasons for the increase in an in vitro protein digestibility on lactic acid fermentation are not known, rapid lowering of pH may have an effect on the structure of the proteins thus rendering them more accessible to the pepsin enzymes. Novellie (1968) referred to lactic acid as having a softening effect on the cereal proteins suggesting that the structure of the protein was changed in some way by the effect of the lactic acid. This could explain the improvement in an in vitro protein digestibility coinciding with a rapid drop in pH and the corresponding increase in titratible acidity during fermentation. Generally there was no big variation in the amounts of protein between the two sorghum varieties.

Fermentation as applied in traditional African porridges shows that the process is clear, simple and effective for improving the protein digestibility of cooked sorghum
Malting and fermentation pre-treatments caused an increase in the amounts of Amino acids in the sorghum flour samples.
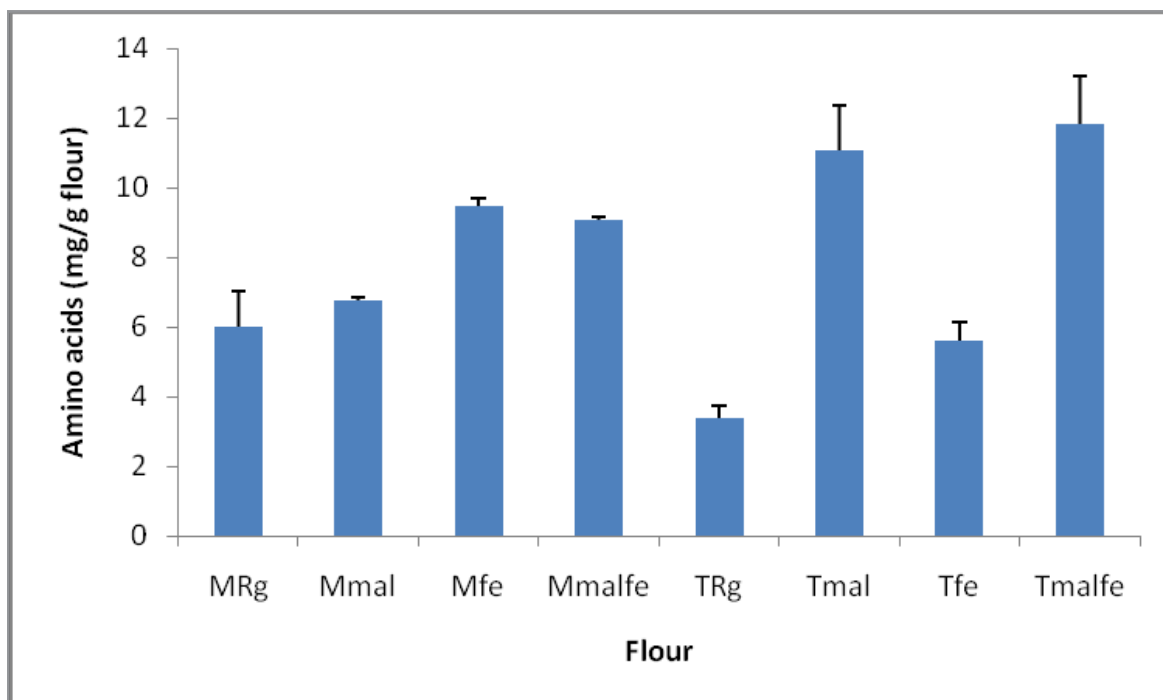
Figure 3. Amounts of amino acids in sorghum flour samples.

Statistical analysis results showed a significant (p < 0.05) difference due to interaction effects (Figure 3). The increase in the free amino acids during malting and fermentation processes is due to a number of reasons. Bhise et al (1988) pointed out that during malting the storage proteins of the grain undergo partial hydrolysis by endogenous proteases to soluble proteins and free amino acids that are more susceptible to pepsin attack. Also the bacteria that are produced during fermentation increased proteolysis and degrade protein into peptides and amino acids that are readily utilized by the bacteria. Zamora and Field (1976) pointed out that during their growth cycle, bacteria can also synthesize amino acids from metabolic intermediates. Chavan, (1988) evaluated the nutritional effects of processing sorghum flour into njera, popular fermented bread in some parts of Africa. In his study he analyzed amino acids and conducted an in vitro (pepsin) protein digestibility during injera processing and found that fermentation increased both.

Conclusion
This study demonstrated that both malting and fermentation do have positive effects on the composition of reducing sugars, soluble proteins and free amino acids in both sorghum flour samples.

Malting process caused an increase in the amounts of reducing sugars in both macia and red tannin or T159781 sorghum flour samples. Fermentation caused an increase in the amounts of soluble proteins and the free amino acids. Therefore malting and fermentation pre-treatments can improve the composition and functionality of sorghum flour in both food grade (Macia) and the red tannin (T159781) sorghum flours.

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Utilization of fortified bean-maize composite meal to improve the nutritional and immune status of HIV+ children in Morogoro, Tanzania

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Abstract

Complications emanating from HIV infection and AIDS lead to poor nutritional and immune status among children. Supplementing HIV+ children with high protein, fortified composite meal may improve the health, which in turn reduces progression from HIV infection state to AIDS and prolongs the time/age at which anti-retroviral drugs need to be initiated. This study investigated the efficacy of an extruded, fortified bean-maize composite meal in improving the nutritional status and motor performance of children infected with HIV/AIDS. A group of 107 HIV+ children (aged between 24 and 180 months) receiving social, medical and/or home based care at two centers - WAVUMO and Faraja in Morogoro district, Tanzania were supplemented with an extruded, fortified bean-maize composite meal for a period of 16 weeks. The composite meal was formulated to meet the WHO/UNICEF recommendations for HIV+ children. Results of the study showed that, 8.9% of the study children aged between 24 and 119 months (n = 45) were wasted, 15.5% were underweight while 28.9% were stunted at the baseline. After the feeding intervention, the proportion of children who were wasted, underweight and stunted decreased significantly (p ≤ 0.05). BMI-for-age of the children aged 109 and 180 months (n = 62) also increased significantly (p ≤ 0.05) during the supplementation period. Fat mass and lean body mass increased slightly (p > 0.05) during the feeding. The HIV/AIDS biomarkers of CD4+ cell count and CD4+/CD8+ ratio increased by more that 50% over the feeding period. This in turn prolonged the time/age at which anti-retroviral treatment would have been initiated to some of the children. This study revealed that supplementation of HIV+/AIDS children with fortified bean-maize composite meal improved the nutritional status, CD4+ cell count and CD4+/CD8+ ratio. Improvement in the CD4+ cell count had the advantage of slowing down the progression from HIV infection to AIDS and prolonging the time/age at which initiation of antiretroviral treatment was needed. It was recommended that, in order for the HIV-infected children to attain normal growth, they should receive well-balanced foods that contain generous amounts of high quality protein, calorie and all macro/micronutrients.

Key Words: HIV infection, weight-for-age, height-for-age, weight-for-height, BMI-for-age, CD4/8+ cell count, lean/fat body mass.

Introduction

It has been hypothesized that appropriate nutrition provides advantages in HIV infected persons. It improves fitness, it maintains body weight and tissues, and it also improves quality of life and maintains body functions and above all replenishes nutrient losses from repeated infections. Promotion of appropriate nutrition to people living with HIV/AIDS is therefore important (Cimoth, 1997). HIV infection increases energy requirements through increase in resting energy expenditure, reduction in food intake, nutrient mal-absorption and loss, and complex metabolic alterations that culminate in weight loss and wasting. The effect of HIV on nutrition begins early in the course of the disease, even before an individual may be aware that he or she is infected with the virus. Asymptomatic HIV-positive individuals

require 10% more energy, and symptomatic HIV-positive individuals require 20-30% more energy than HIV-negative individuals of the same age, sex, and physical activity level (Cimoth, 1997; Babameto and Kotler, 1997; McCallan, 1999).

HIV-positive women have a higher incidence of pre-term and low birth weight deliveries and as a result, HIV-exposed infants may start life with impaired nutrition. HIV-positive infants experience slower growth and are at a greater risk of severe malnutrition. Children living with HIV or born into families affected by HIV are therefore a high-risk group with special needs. Studies (Bakaki et al., 2001; Newell et al., 2003) show that, severe malnutrition in HIV-positive children can be reversed with hospital and home-based therapeutic feeding, though the time to recovery is longer than that of uninfected children. Good nutrition is central to good health and human development and to long-term social, economic and environmental development. Without provision of adequate nutrition, other social and economic initiatives will be severely compromised. People living with HIV/AIDS in Africa often have marginal nutritional status or suffer from varying degrees of malnutrition prior to infection, general medical care and hygiene are inadequate and monies for special nutritional supplements are unavailable (Piwoz and Preble, 2000).

The impact of the pre-existing malnutrition on HIV susceptibility and disease progression is difficult to study, and knowledge in this area is still limited. Early studies demonstrated that, weight loss and wasting were associated with increased risk of opportunistic infections and shorter survival time in HIV positive adults independent of their immune status. Other studies (WHO, 2003) showed that, clinical outcome was poorer and risk of death was higher in HIV-positive adults with compromised micronutrient status. The nutritional aspect of HIV/AIDS has been a neglected dimension in the management and care of HIV/AIDS affected individuals. Most of the attention has been focused on the use of drugs in the treatment of HIV/AIDS. While the role of

drugs, such as anti-retroviral treatment cannot be under-estimated, other more affordable and sustainable alternatives and adjuvant must be explored (WHO, 2003). Globally, reports are showing that a good diet is one of the simplest means of helping people living with HIV/AIDS and may even help delay the progression of the deadly virus (FAO, 2005). By bolstering the immune system and boosting energy levels, balanced nutrition can help the body fight against the ravages of the disease, prevent malnutrition and support drug treatment. Emerging evidence shows that, eating beans contributes to improved health because they reduce the risk of cancers (colon, breast, prostate); reduce the risk of cardiovascular diseases and reduce obesity and thus the risk of Type 2 diabetes. They also provide important nutrients for growth, especially for children (BHA, 2005). Beans are one of the best plant food sources with soluble dietary fiber. Bean protein is capable of bolstering the lean body mass, that is essential for rebuilding the muscle mass that gets lost in advanced stages of HIV.

The aim of this study was to investigate the effects of a bean-maize composite meal in improving the nutritional and immune status of children infected with HIV. Results from this study would be useful for HIV program managers, home based care providers, policy makers and other stakeholders involved in the efforts to mitigate the adverse effects of HIV/AIDS infection on children.

Methodology

Study Population

A group of 107 HIV+ children (aged between 24 and 180 months) receiving social, medical and/or home based care support at WAVUMO and Faraja centers in Morogoro district, Tanzania were selected to participate in the study. Out of the 107 HIV+ children 45 were at the age of 24 – 119 months while 62 children were at the age of 120 – 180 months. Of the 107 children enrolled in the study, 67 (62.6%) were centered at WAVUMO while 40 (37.4%) were centered at Faraja. The children received a fortified extruded bean-maize composite

meal that was formulated to meet the WHO/ UNICEF recommendations (WHO, 2003) for HIV+ children. The expectation was that, the bean-blended composite meal would support growth of more lean body mass and improve the nutritional status of the HIV+ children. The composite bean-blended meal was inexpensive, extruded (ready-to-feed), fortified with multi-vitamins and minerals and were prepared from locally produced food ingredients (Table 1).

Feeding Regime

Each child was provided with 200 g of the composite meal per day. The composite meal was formulated to provide 45% of RDA for calories, 80% of RDA for protein, and 100% of RDA for iron and zinc for every 100 g of food (dry matter) consumed. Each child and the parent/ caregiver were given instructions on how to prepare the product prior to consumption. The product was supposed to be taken as an evening snack preferably at 4:00 pm. This was done in order to avoid substitution of the normal meals with the product. The children received the composite product daily for a period of six months.

Physical measurements

Physical measurements of the subjects were taken at baseline and monthly thereafter for six months. The biomarkers for nutrition improvement included weight, height, CD4+ and CD8+ cell count, lean body mass and motor performance. Height was measured using a pocket stadiometer (CMS Weighing Equipment Ltd; London) and the measurement recorded to the nearest 0.01 m. A digital body composition analyser (Model BF-350, Tanita Corporation of America Inc) scale was used to measure weight and recorded to the nearest 0.1kg. These measurements were taken without shoes on and with minimal clothing. Scales were zeroed before each measurement and were frequently calibrated.

Percentage body fat mass was determined by bioelectrical impedance method using a body composition analyzer (Model BF-350, Tanita Corporation of America Inc.) Lean body mass (LBM) was calculated by subtracting percentage the body fat mass from 100 as follows: LBM = (100 - BF) %, where LBM = Lean Body Mass and BF = Body fat.

Biochemical Assay

Three mL of venous blood were collected from 107 HIV sero-positive children. A trained laboratory technician collected the blood samples between 9.00 – 12.00 hours. All bio-safety precautions were strictly observed. Whole blood samples were processed immediately (within two hours) after collection. The CD4+ and CD8+ were determined by using MultiSET flow cytometric method (BD FACSCount System™, Biosciences, USA) as described by Urassa et al. (2003).

Statistical Analysis

The collected data were entered into the statistical program (Statistical Product and Service Solutions - SPSS) version 11.5 for analysis. Differences in baseline measurements between the age groups and within the study visits were assessed for statistical significance using one-way- ANOVA. Appropriate adjustments for these differences were taken into account during analysis of the data. Anthropometric indices (WAZ, WHZ and HAZ) were calculated by using EPI-INFO Package 2002 and compared with WHO reference population. Paired t-test was used to compare the growth parameters and lean/fat body mass.

Ethics and Confidentiality

Approval to use human subjects was obtained from the National Institute for Medical Research (NIMR) Ethics Committee. Parents/ caregivers signed a consent form to affirm their willingness to allow their children to participate in the study. All subjects were identified through their services centers and assigned identity numbers. There was no use of real names in the data collection, analysis or reporting. Parents/caregivers had the liberty to decline participation or to withdraw from the study at any stage without fear of retribution.

Results and Discussion
Nutritional Status of Children

Nutritional status of the studied children

was determined by using the anthropometric measurements, which were classified, by using standard deviation z-scores. The standard deviation scores were compared with the WHO (1995) standard references for children of the same age and sex recommended. WHO (1995) recommends the use of standard deviation z-scores (WAZ, WHZ and HAZ) for children aged 0 – 119 months and BMI-for-age for children aged 120 – 180 months.

The Weight-for-Age z-score (WAZ)

The weight-for-age z-score (WAZ) reflects the effects of the most current change in the nutritional status. Low weight-for-age indicates a child whose weight for age is below minus two standard deviation (-2 SD) from the median of reference population. Table 2 data summarize the nutritional status of the weight-for-age scores for children aged 24 – 119 months. Table 2 data indicate that, 2.2% (n = 45) of the studied children were severely underweight, 13.3% (n=45) were moderately underweight while 84.4% (n=45) of the children had normal weight for age at the baseline survey. The proportion of severely underweight children of the age between 24 and 60 months was reduced from 2.2% at baseline to zero in the first month, but increased to 2.2% in the second, third and fourth months (Table 2). Prevalence of severe underweight declined to zero percent in the fifth and sixth months of supplementary feeding. There were no cases of severely underweight children for the age group of 61 - 119 months throughout the study period. The proportion of severely underweight children observed was lower than that reported in the Tanzania Demographic and Health Survey (NBS and ICF Micro, 2011). According to NBS and ICF Micro (2011), prevalence of severe underweight at national level was 3.5% for the age group 24 - 60 months and 3.0% for the age group 61 - 119 months (NBS and ICF Micro, 2011). Despite inherent loss of weight among people living with HIV/AIDS caused by deranged metabolism of fats and carbohydrates and low dietary intake of energy, children in this study had WAZ scores higher than the national average. This suggested that the HIV+ children

had not reached the extremes of weight loss (Piwoz and Preble, 2000, Colecraft, 2008).

Proportions of moderately underweight children were 13.3% (n=45) at baseline, 8.9% (n=45) in the first month, 6.7% (n=45) in the second month, 8.9% (n=45) in the third month and zero percent in the fourth, fifth and sixth months of supplementary feeding. For the age group 24 to 60 months (n = 20), proportions of moderately underweight children were 6.7% at baseline, 4.4% in the first month, 4.4% in the second month, 4.4% in the third month and zero percent in the subsequent months. The proportion of moderately underweight children in the age group 61 – 119 months (n = 25) was 6.6% at baseline, 4.4% in the first month, 2.2% in the second month, 4.4% in the third month and zero percent in the fourth, fifth and the sixth month of supplementary feeding. Prevalence of moderately underweight children for both age groups (24 – 60 and 61 – 119 months) was lower than that reported by NBS and ICF MICRO (2011). The Tanzania Demographic and Health Survey reported prevalence of moderate underweight of 16.1% among children aged 24 – 60 months and 12.2% for children aged 61 – 119 months (NBS and ICF Micro, 2011).

Based on sex, more females were underweight compared to their male counterparts. At baseline, 2.2% of females and zero percent males were severely underweight. A similar trend was observed on the second, third and fourth months of supplementation. There were no males who were severely underweight. According to NBS and ICF Micro (2011) report, the proportion of females who were severely underweight was 3.3% while for males was 4.2%. Likewise, more female children were moderately underweight than their male peers. The proportion of children who had normal weight for their age was 84.4% (n = 45) at baseline, and this proportion increased steadily to 100% (n=45) at the end of the six months of supplementary feeding. According to NBS and ICF Micro (2011) report, the proportion of females who were moderately underweight was 14.5% while for males was 17.3%.

The Height-for-Age z-score (HAZ)

The height-for-age z-score (HAZ) reflects achieved linear growth for age. Low height-for-age indicates a child whose height for age is below minus two standard deviation (-2 SD) from the median of reference population. It also reflects chronic under-nutrition referred to as stunting. Table 3 summarizes the nutritional status of the children aged between 24 – 119 months using height-for-age z-score index. Table 3 data indicate that, 11.1% (n=45) of the study children were severely stunted, 17.8% (n=45) were moderately stunted while 71.1% had normal height-for-age at baseline survey. Percentage of the severely stunted children remained almost unchanged for the first, second and third months of supplemental feeding, but declined slightly to 8.9, 6.7 and 8.9 percent during the fourth, fifth and sixth months of supplementation, respectively. Prevalence of moderate stunting was 17.8% at baseline and the proportion declined gradually to 15.6% (second and third months of feeding), 11.1% (fourth month) and 8.9% (fifth and sixth months). The proportion of severely stunted children observed in this study was lower than that reported in NBS and ICF Micro (2011). According to NBS and ICF Micro (2011), prevalence of severely stunted children at national level was 17.9% while for moderately stunted children was 46.5%. The proportion of stunted children observed in this study was higher than the level for Morogoro region in which 18.8% of children at the age range 24 – 119 months were reported as severely stunted while 44.4% were reported to be moderately stunted (NBS and ICF Micro, 2011).

In this study, more females (n = 27) were severely stunted compared to their male counterparts. Prevalence of severe stunting among females was 6.6% at baseline, 6.6% in the first, second and third months and remained at 4.4% n the subsequent feeding months. Conversely, prevalence of severe stunting among males (n = 18) was 4.4% at baseline and remained at this level in the first, second, third, fourth and the sixth month of the study. Prevalence of moderate stunting was similar for males and females at baseline and the first month (8.9%)

but the level remained higher among females (6.6%) than males (2.2%) at the end of the study. According to NBS and ICF Micro (2011), severe stunting at national level was 14.4% and 18.7% for female and male children aged 24 – 119 months, respectively while prevalence of moderate stunting at national level for female and male children of the same age group was 38.5 and 45.6%, respectively (NBS and ICF Micro, 2011). Prevalence levels for stunting reported at national level were higher than those observed in this study.

The proportion of severely stunted children in the age group 24 - 60 months (n = 20) was 8.8% at the baseline survey, 8.8% after the first, second and third months and 6.6, 4.4 and 6.6% during the fourth, fifth and the sixth months, respectively. Prevalence of moderate stunting among children of the same age were 4.4% (baseline), 6.6% (first month), 8.8% (second month), 8.9% (third month) and 4.4% (fourth, fifth and sixth months) (Table 3). According to NBS and ICF Micro (2011), prevalence of severe stunting among children aged 24 –60 months at national level was 17.9%, higher than the levels (4.2 – 8.4%) observed in this study. Regarding moderate stunting, NBS and ICF Micro (2011) reported higher prevalence rate of 46.5% for children of the same age group. Moderate stunting in this study ranged between 4.4 and 8.9%. For the age group 61 – 119 months (n = 25), results revealed that, prevalence of severely stunted children ranged between 0.0 and 2.2%. These proportions were also lower than those reported by NBS and ICF Micro (2011) (15.0%) at national level. Moderate stunting for children aged 61 – 119 months ranged between 4.4 and 13.4%. These values were also lower than those reported by NBS and ICF Micro (2011) at national level (44.2%) for children aged 61 - 119 months.

Overall, only 71.1% (n = 45) of the studied children had normal heights for their ages. This proportion improved modestly on the course of supplementary feeding to 73.3% (second month), 80.0% (fourth month), 84.4% (fifth month), and later declined to 82.2% in the sixth month of supplementation. The rate of

stunting did not change much as a result of the supplementary feeding because the rate of growth in height is generally very slow. Improvement in stunting was only 13.3% for the entire six months of supplementary feeding.

Weight-for-height z-scores (WHZ)

Table 4 summarizes the weight-for-height z-scores (WHZ) for the studied children. The data showed that, 6.7% (n=45) of the studied children were severely wasted at the baseline. The proportion of severely wasted children decreased to zero percent by the third month of supplementation. The proportion of moderately wasted children was 2.2% (n=45) at baseline survey but this proportion increased slightly to 4.4% in the first and third months and decreased to zero percent by the end of the fifth month of supplementation. One case of moderately wasted child emerged in the sixth month of supplementation. Records show that, this child had been receiving treatment for malaria and lower respiratory infections during the same month. This suggested that, in cases where illnesses occurred, the effect of supplemental feeding was masked.

The proportion of severely wasted children in the age group 24 – 60 months decreased from 6.6% (n=45) to zero percent on the course of the study period. There were no children who were severely wasted in the age group 61 – 119 months. The percentage of the severely wasted children observed during the baseline survey was higher than that reported in the Tanzania Demographic and Health Survey (NBS and ICF Micro, 2011) in which prevalence of severe wasting was reported at 0.7% for children aged 24 – 60 months and 0.3% for children aged 61 – 119 months (NBS and ICF Micro, 2011). Weight for height reflects the effects of both acute (wasting) and chronic (stunting) nutritional status. Wasting in children therefore symbolized deficit in tissue and fat mass compared with their peers of the same height. The wasting observed among children in this study could have resulted from failure to gain weight or from actual weight loss due to the complications associated with HIV/AIDS infection. With supplementation with the

bean-maize composite food, children showed noticeable improvement as evidenced by the decrease in the proportion of wasted children to levels below those reported by NBS and ICF Micro (2011).

The proportion of moderately wasted children aged 24 - 60 months was zero percent at the baseline and increased to 2.2% in the first month, thereafter declined to zero percent at the second, third, forth and fifth months (Table 4). For children in the age group 61 – 119 months, prevalence of moderate wasting was 2.2% (n=45) at baseline, first, second and third months but decreased to zero percent in the subsequent months. Although the proportion of moderately wasted children remained constant for the first three months of supplementary feeding, the prevalence declined to levels lower than those reported by NBS and ICF Micro (2011) at the end of the study. Prevalence of severe wasting at national level was reported at 1.25% for children aged 24 - 60 months and 1.0% for children aged 61 – 119 months (NBS and ICF Micro, 2011). HIV/AIDS subjects usually experience loss of appetite, difficulty eating, infections and side effects due to medication, which collectively suppress food intake. HIV subjects also have poor digestion and absorption of nutrients that lead to acute/chronic diarrhea and steatorhea.

At baseline, more females (4.4%, n=45) were severely wasted than males (2.2%, n = 45). This proportion declined to zero percent on the course of the study. The proportions of severely wasted females and males were higher than the national level of 0.8% for females and 1.7% for males (NBS and ICF Micro, 2011). Moderately wasted females in this study were zero percent (n=45) at baseline, increased to 2.2% in the first month and thereafter declined to zero percent for the rest of the study period. For males, the proportion of moderately wasted children was 2.2% (n=45) at baseline and remained constant in the first, second, and third months and thereafter decreased to zero percent. According to NBS and ICF Micro (2011), the proportion of moderately wasted children at national level was 4.0% for females and 5.6% for males. These

results suggested that, the nutrition status of HIV infected children could be improved by consuming the bean-maize composite diets. The proportion of children who were classified as having normal weight for their heights at baseline was 91.1% (n = 45). This proportion increased steadily on the course of feeding to 100.0% at the end of the study.

BMI-for-Age for Children Aged 120 – 180 months

According to WHO (1995), BMI-for-age is recommended for assessing the nutritional status of children aged 120 – 180 months. Table 5 shows the distribution of mean BMI-for-age of the studied children. The data indicated that 6.4% (n=62) of the studied children were severely underweight at baseline survey, but decreased to 1.6% in the first month of supplementation, 3.2% in the second month, and zero percent in the subsequent months. The proportion of children who were moderately underweight were 21.0% (n=62) at baseline survey, 14.5% (n=62) in the first month, 9.7% (n=62) in the second month, 4.8% (n=62) in the third month, 3.2% (n=62) in the fourth month and zero percent (n=62) in the fifth and sixth months, respectively. The proportion of mildly underweight children was 12.9% (n=62) at baseline, 8.1% (n=62) in the first month, 4.8% (n=62) in the second month, 8.1% (n=62) in the third month, 4.8% in the fourth month, 1.6% (n=62) in the fifth month and zero percent (n=62) in the sixth month. The proportion of children classified as having normal BMI-for-age increased from 59.7% (n=62) at the baseline to 100.0% in the sixth month of supplementation. Based on these observations, the supplementary feeding with bean-maize composite food improved the nutritional status of the children by reducing the proportion of mildly, moderately and severely underweight children. Both females and males showed similar improvement.

Changes in the CD4+ Status

The distribution of CD4+, CD8+ and CD4+:CD8+ ratio among the studied children is summarized in Table 6. The CD4+ and CD8+ decreased with increase in age, whereby the younger age groups e.g. 24 – 59 months had higher average CD4+ and CD8+ cell counts compared to their elder age group counterparts e.g. 150 – 180 months. Overall, the supplementary feeding resulted in improvement in both CD4+ and CD8+ cell counts. At baseline survey, the mean CD4+ cell counts was 291 cells/µL and at the end of the six months of supplementary feeding the mean CD4+ cell counts increased to 439 cells/µL, an increase of 51%. The mean CD8+ cell count also increased during supplementary feeding, however, the increase in the cell counts was not consistent. Likewise, supplementary feeding resulted in an increase in both CD4+ and CD8+ cell counts across the feeding period for all age groups. For children aged 24 – 59 months, CD4+ cell counts increased by 52%, while increments for the other age groups were 51% (60 – 89 months), 46% (90 – 119 months), 78% (120 – 149 months) and 71% (150 – 180 months).

The amount of CD4+ cells is used as a surrogate marker for diagnosis of HIV infection, monitoring progression and improvement, and to make decisions to initiate antiretroviral drugs and prophylactic treatment for opportunistic infections. According to CDC (1993) classification system, CD4+ cell count for health (HIV negative) individuals range between 500 and 1600 cells/µL while CD8+ cells range between 375 and 1100 cells/µL. The CD4+/CD8+ ratio for health individuals (HIV negative) range between 0.9 and 1.9. In HIV infection, both CD4+ cells and CD4+/CD8+ ratio drop dramatically, implying that during infection there are usually more CD8+ than CD4+ cells. CD4+ cell count of $\leq$ 200 cells/µL indicates that the individual is HIV positive, the immune system is severely weakened and the individual is at a greater risk of opportunistic infections. At this level of CD4+ cell count, initiation of anti-retroviral treatment (ART) is recommended. CD4+ cell count between 200 and 350 cells/µL indicates some improvement in the immune system, however, the immunity is still weak and the individual may still be at increased risk for infections. At CD4+ range of 350 – 600 cells/µL the immune system of the HIV+ individual is described as very good and

ART may not be indicated. At the baseline, the CD4+ cell counts for the various age groups ranged between 199 and 391 cells/μL. This means that the immunity of most of the children could be classified as weak with increased risk for infections. At the end of the six months of supplementary feeding, the CD4+ cell counts for the various age groups increased to the range 343 - 596 cells/μL. This implied that, the immunity of majority of the children after six months of supplementary feeding could be described as very good and ART might not be needed.

Body Composition of the HIV+ Children

Table 7 data show the mean lean body mass (percent) of the studied children. The mean lean body mass was not significantly different (p>0.05) among the various age groups and within the visits. This meant that, utilization of the bean-maize composite meal did not alter their percentage lean body mass over the six months of supplementary feeding. This could be associated with high viral load, which usually increases the basal metabolic demands for both protein and energy among HIV-infected children (Bailey et al., 1999). A study on protein utilization by HIV+ children revealed that, lean body mass increases with long-term nutrition rehabilitation (ADA, 2004). Therefore, the increase in the mean lean body mass (%) could have been significant if the feeding would have been done for a period exceeding six months.

For the total body fat mass (Table 8), there were no statistical variations (p>0.05) observed among the various age groups and between the visits made at baseline and in the first, second and third months. Significant variations (p ≤ 0.05) in the total body fat mass were observed after the fourth, fifth and the sixth month of feeding (Table 8). Since percentage body fat mass is the predictor of lean body mass (i.e. Lean Body Mass = 100% - %Body Fat), the percentage body fat mass was expected to decrease with increasing lean body mass of the HIV infected children over a long-term nutrition rehabilitation (ADA, 2004). In this study, significant difference (p≤0.05) started to show up at the fourth month of supplementation, suggesting that longer period of feeding above six months could have resulted in significant changes in both lean body mass and total body fat mass of the studied children.

Conclusion and Recommendation

This study elucidated that supplementation of HIV+/AIDS children with fortified bean-maize composite meal improved the nutritional status; CD4+ and CD8+ cell counts and CD4+/CD8+ ratio of the children. Improvement in the CD4+ count had the advantage of slowing down the progression from HIV infection to AIDS and in prolonging the time/age at which initiation of ART would be needed. It was recommended that, in order for the HIV-infected children to attain normal growth, they should receive well-balanced foods that contain generous amounts of high quality protein, calorie and all macro/micronutrients.

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Table 1: Composition of the bean-maize composite meal (100 g dry matter)

Ingredients	Amount (g)
Maize	21.52
Beans	55.48
Soybeans	5.50
Vegetable oil	4.50
Sugar	4.00
Cassava	5.20
Salt (iodized)	0.30
Mineral/Vitamin premix	3.00
Baking soda	0.50
TOTAL	**100.00**

Table 2. Weight for age z-scores (WAZ) of the studied children[1]

Duration/Sex	Age group (months)	Normal No.	Normal %	Moderate underweight No.	Moderate underweight %	Severe underweight No.	Severe underweight %
Baseline							
Female	24 – 60	8	17.8	3	6.7	1	2.2
	61 – 119	14	31.1	1	2.2	0	0.0
Male	24 – 60	8	17.8	0	0.0	0	0.0
	61 – 119	8	17.8	2	4.4	0	0.0
Total	24 – 119	38	84.4	6	13.3	1	2.2
1st Month							
Female	24 – 60	10	22.2	2	4.4	0	0.0
	61 – 119	15	33.3	0	0.0	0	0.0
Male	24 – 60	8	17.8	0	0.0	0	0.0
	61 – 119	8	17.8	2	4.4	0	0.0
Total	24 – 119	41	91.1	4	8.9	0	0.0
2nd Month							
Female	24 – 60	9	20.0	2	4.4	1	2.2
	61 – 119	15	33.3	0	0.0	0	0.0
Male	24 – 60	8	17.8	0	0.0	0	0.0
	61 – 119	9	20.0	1	2.2	0	0.0
Total	24 – 119	41	91.1	3	6.7	1	2.2
3rd Month							
Female	24 – 60	9	20.0	2	4.4	1	2.2
	61 – 119	13	28.9	2	4.4	0	0.0
Male	24 – 60	8	17.8	0	0.0	0	0.0
	61 – 119	10	22.2	0	0.0	0	0.0
Total	24 – 119	40	88.9	4	8.9	1	2.2
4th Month							
Female	24 – 60	11	24.4	0	0.0	1	2.2
	61 – 119	15	33.3	0	0.0	0	0.0
Male	24 – 60	8	17.8	0	0.0	0	0.0
	61 – 119	10	22.2	0	0.0	0	0.0
Total	24 – 119	44	97.8	0	0.0	1	2.2
5th Month							
Female	24 – 60	12	26.7	0	0.0	0	0.0

Duration/ Sex	Age group (months)	No.	%	No.	%	No.	%
	61 – 119	15	33.3	0	0.0	0	0.0
Male	24 – 60	8	17.8	0	0.0	0	0.0
	61 – 119	10	22.2	0	0.0	0	0.0
Total	24 – 119	45	100.0	0	0.0	0	0.0
6th Month							
Female	24 – 60	12	26.7	0	0.0	0	0.0
	61 – 119	15	33.3	0	0.0	0	0.0
Male	24 – 60	8	17.8	0	0.0	0	0.0
	61 – 119	10	22.2	0	0.0	0	0.0
Total	24 – 119	45	100.0	0	0.0	0	0.0

[1] WAZ scores classification – Normal = -2 SD -- +2SD; Moderate underweight = < -2 SD -- -3SD; Severe underweight = < -3SD.

Table 3. Height for age z-scores (HAZ) of the studied children[1]

Duration/ Sex	Age group (months)	Normal		Moderate stunting		Severe stunting	
		No.	%	No.	%	No.	%
Baseline							
Female	24 – 60	9	20.0	1	2.2	2	4.4
	61 – 119	11	24.4	3	6.7	1	2.2
Male	24 – 60	5	11.1	1	2.2	2	4.4
	61 – 119	7	15.6	3	6.7	0	0.0
Total	24 – 119	32	71.1	8	17.8	5	11.1
1st Month							
Female	24 – 60	9	20.0	2	4.4	2	4.4
	61 – 119	11	24.4	2	4.4	1	2.2
Male	24 – 60	5	11.1	1	2.2	2	4.4
	61 – 119	7	15.6	3	6.7	0	0.0
Total	24 – 119	32	71.1	8	17.8	5	11.1
2nd Month							
Female	24 – 60	9	20.0	2	4.4	2	4.4
	61 – 119	11	24.4	1	2.2	1	2.2
Male	24 – 60	6	13.3	2	4.4	2	4.4
	61 – 119	8	15.6	2	4.4	0	0.0
Total	24 – 119	33	73.3	7	15.6	5	11.1
3rd Month							
Female	24 – 60	8	17.8	3	6.7	2	4.4
	61 – 119	10	22.2	2	4.4	1	2.2
Male	24 – 60	7	15.6	1	2.2	2	4.4
	61 – 119	9	17.8	1	2.2	0	0.0
Total	24 – 119	33	73.3	7	15.6	5	11.1
4th Month							
Female	24 – 60	10	22.2	2	4.4	1	2.2
	61 – 119	11	24.4	1	2.2	1	2.2
Male	24 – 60	8	17.8	0	0.0	2	4.4
	61 – 119	7	15.6	2	4.4	0	0.0
Total	24 – 119	36	80.0	5	11.1	4	8.9
5th Month							
Female	24 – 60	0	22.2	2	4.4	1	2.2
	61 – 119	11	24.4	1	2.2	1	2.2
Male	24 – 60	9	20.0	0	0.0	1	2.2
	61 – 119	8	17.8	1	2.2	0	0.0

otal	24 – 119	38	84.4	4	8.9	3	6.7
6th Month							
Female	24 – 60	10	22.2	2	4.4	1	2.2
	61 – 119	11	24.4	1	2.2	1	2.2
Male	24 – 60	8	17.8	0	0.0	2	4.4
	61 – 119	8	17.8	1	2.2	0	0.0
Total	24 – 119	37	82.2	4	8.9	3	8.9

[1] HAZ scores classification – Normal = -2 SD -- +2SD; Moderate stunting = < -2 SD -- -3SD; Severe stunting = < -3SD.

Table 4. Weight for height z-scores (WHZ) of the studied children[1]

Duration/Sex	Age group (months)	Normal		Moderate wasting		Severe wasting	
		No.	%	No.	%	No.	%
Baseline							
Female	24 – 60	11	24.4	0	0.0	2	4.4
	61 – 119	13	28.9	0	0.0	0	0.0
Male	24 – 60	7	15.6	0	0.0	1	2.2
	61 – 119	10	22.2	1	2.2	0	0.0
Total	24 – 119	41	91.1	1	2.2	3	6.7
1st Month							
Female	24 – 60	11	24.4	1	2.2	1	2.2
	61 – 119	13	28.9	0	0.0	0	0.0
Male	24 – 60	7	15.6	0	0.0	1	2.2
	61 – 119	10	22.2	1	2.2	0	0.0
Total	24 – 119	41	91.1	2	4.4	2	4.4
2nd Month							
Female	24 – 60	13	28.9	0	0.0	0	0.0
	61 – 119	13	28.9	0	0.0	0	0.0
Male	24 – 60	7	15.6	0	0.0	1	2.2
	61 – 119	10	22.2	1	2.2	0	0.0
Total	24 – 119	43	95.6	1	2.2	1	2.2
3rd Month							
Female	24 – 60	13	28.9	0	0.0	0	0.0
	61 – 119	12	26.7	1	2.2	0	0.0
Male	24 – 60	7	15.6	0	0.0	1	2.2
	61 – 119	10	22.2	1	2.2	0	0.0
Total	24 – 119	42	93.4	2	4.4	1	2.2
4th Month							
Female	24 – 60	13	28.9	0	0.0	0	0.0
	61 – 119	13	28.9	0	0.0	0	0.0
Male	24 – 60	8	17.8	0	0.0	0	0.0
	61 – 119	11	24.4	0	0.0	0	0.0
Total	24 – 119	45	100.0	0	0.0	0	0.0
5th Month							
Female	24 – 60	13	28.9	0	0.0	0	0.0
	61 – 119	13	28.9	0	0.0	0	0.0
Male	24 – 60	8	17.8	0	0.0	0	0.0
	61 – 119	11	24.4	0	0.0	0	0.0
Total	24 – 119	45	100.0	0	0.0	0	0.0
6th Month							

Female	24 – 60	12	26.7	1	2.2	0	0.0
	61 – 119	13	28.9	0	0.0	0	0.0
Male	24 – 60	8	17.8	0	0.0	0	0.0
	61 – 119	11	24.4	0	0.0	0	0.0
Total	24 – 119	44	97.8	1	2.2	0	0.0

[1] WHZ scores classification – Normal = -2 SD -- +2SD; Moderate wasting = < -2 SD -- -3SD; Severe wasting
 = < -3SD.

Table 5. Body mass index (BMI) for age distribution for children aged 120 – 180 months[1]

Duration/ Sex	Normal		Mild underweight		Moderate underweight		Severe underweight	
	No.	%	No	%	No.	%	No.	%
Baseline								
Female	20	33.3	3	4.8	6	9.7	3	4.8
Male	17	27.4	5	8.1	7	11.3	1	1.6
Total	37	59.7	8	12.9	13	21.0	4	6.4
1st Month								
Female	26	41.9	1	1.6	4	6.5	1	1.6
Male	21	33.9	4	6.5	5	8.1	0	0.0
Total	47	75.8	5	8.1	9	14.5	1	1.6
2nd Month								
Female	27	43.5	1	1.6	2	3.2	1	1.6
Male	24	38.7	2	3.2	4	6.5	1	1.6
Total	51	82.3	3	4.8	6	9.7	2	3.2
3rd Month								
Female	29	46.8	1	1.6	1	1.6	0	0.0
Male	25	40.3	4	6.5	2	3.2	0	0.0
Total	54	87.1	5	8.1	3	4.8	0	0.0
4th Month								
Female	29	46.8	1	1.6	1	1.6	0	0.0
Male	28	45.2	2	3.2	1	1.6	0	0.0
Total	57	91.9	3	4.8	2	3.2	0	0.0
5th Month								
Female	30	48.4	1	1.6	0	0.0	0	0.0
Male	31	50.0	0	0.0	0	0.0	0	0.0
Total	61	98.4	1	1.6	0	0.0	0	0.0
6th Month								
Female	31	50.0	0	0.0	0	0.0	0	0.0
Male	31	50.0	0	0.0	0	0.0	0	0.0
Total	62	100.0	0	0.0	0	0.0	0	0.0

[1] BMI categories – Normal = BMI range 18.5 - 25; Mild underweight = BMI range 17.5 – 18.4; Moderate underweight = BMI range 16 – 17.4; Severe underweight = BMI < 16.

Table 6. Distribution of CD4+, CD8+ and CD4:CD8 ratio (cell/µL) among the studied children[1]

Duration	Age group (months)					Overall
	24 – 59 (n = 11)	60 – 89 (n = 23)	90 – 119 (n = 11)	120 – 149 (n = 27)	150 – 180 (n = 35)	(N = 107)
Baseline						
CD4	391 ± 117[d]	368 ± 210[bc]	276 ± 110[c]	220 ± 189[dc]	199 ± 125[c]	291 ± 150[c]
CD8	660 ± 312[d]	742 ± 380[b]	831 ± 385[a]	910 ± 310[a]	720 ± 442[c]	73 ± 366[b]
CD4/CD8	0.59 ± 0.38[b]	0.50 ± 0.55[ab]	0.33 ± 0.29[b]	0.24 ± 0.61[b]	0.28 ± 0.28[ab]	0.38 ± 0.41[a]
1st Month						
CD4	478 ± 108[c]	331 ± 310[c]	381 ± 211[a]	232 ± 210[c]	217 ± 120[c]	328 ± 192[bc]
CD8	615 ± 387[d]	819 ± 390[a]	843 ± 302[a]	850 ± 441[b]	996 ± 313[a]	825 + 367[a]
CD4/CD8	0.78 ± 0.28[ab]	0.40 ± 0.79[b]	0.45 ± 0.70[ab]	0.27 ± 0.48[b]	0.22 ± 0.38[b]	0.40 ± 0.52[a]
2nd Month						
CD4	501 ± 312[bc]	360 ± 339[bc]	315 ± 220[bc]	277 ± 303[c]	258 ± 286[b]	342 ± 292[b]
CD8	792 ± 414[a]	779 ± 412[ab]	835 ± 361[a]	873 ± 542[ab]	969 ± 345[a]	850 ± 415[a]
CD4/CD8	0.63 ± 0.75[ab]	0.46 ± 0.82[ab]	0.38 ± 0.61[ab]	0.32 ± 0.56[ab]	0.27 ± 0.83[ab]	0.40± 0.70[a]
3rd Month						
CD4	511 ± 304[bc]	372 ± 351[bc]	365 ± 272[a]	363 ± 209[ab]	389 ± 267[a]	400 ± 281[a]
CD8	737 ± 501[b]	743 ± 440[b]	844 ± 419[a]	832 ± 403[bc]	1010 ± 502[a]	833 ± 453[a]
CD4/CD8	0.69 ± 0.61[ab]	0.50 ± 0.80[ab]	0.43 ± 0.65[ab]	0.44 ± 0.52[ab]	0.39 ± 0.53[ab]	0.48± 0.62[a]
4th Month						
CD4	536 ± 330[b]	382 ± 276[b]	342 ± 109[b]	335 ± 207[b]	283 ± 238[b]	376 ± 232[ab]
CD8	719 ± 400[c]	735 ± 347[b]	764 ± 399[b]	799 ± 483[b]	788 ± 402[b]	761 ± 406[b]
CD4/CD8	0.75 ± 0.83[ab]	0.52 ± 0.80[ab]	0.45 ± 0.27[ab]	0.42 ± 0.43[ab]	0.36 ± 0.59[ab]	0.49± 0.57[a]
5th Month						
CD4	541 ± 217[b]	396 ± 221[b]	347 ± 204[b]	335 ± 207[b]	289 ± 206[b]	382 ± 211[ab]
CD8	755 ± 412[ab]	749 ± 409[b]	764 ± 311[b]	798 ± 509[c]	784 ± 445[b]	770 ± 417[b]
CD4/CD8	0.72 ± 0.53[ab]	0.53 ± 0.54[ab]	0.45 ± 0.66[ab]	0.42 ± 0.41[ab]	0.37 ± 0.46[ab]	0.50 ± 0.51[a]
6th Month						
CD4	596 ± 247[a]	464 ± 278[a]	402 ± 228[a]	393 ± 201[a]	343 ± 217[a]	439 ± 234[bc]
CD8	719 ± 510[c]	762 ± 473[b]	762 ± 398[b]	798 ± 408[c]	788 ± 456[b]	766 ± 449[b]
CD4/CD8	0.83 ± 0.48[a]	0.61 ± 0.59[a]	0.53 ± 0.57[a]	0.49 ± 0.49[a]	0.44 ± 0.47[a]	0.57 ± 0.52[a]

[1] Values of CD4, CD8 and CD4/CD8 in a column with different superscripts are significantly different at $p \leq 0.05$.

Table 7. Mean lean body mass (%) of the studied children

Duration	Age group (months)					Overall	One way ANOVA
	24 – 59 (n = 11)	60 – 89 (n = 23)	90 – 119 (n = 11)	120 – 149 (n = 27)	150 – 180 (n = 35)	F (N = 107)	Combined)
Baseline	93.2	88.2	86.4	88.9	85.8	88.5	1.755 (ns)
1st Month	96.9	87.6	87.8	87.1	86.9	89.3	2.202 (ns)
2nd Month	95.3	88.2	87.3	87.5	88.4	89.3	1.361 (ns)
3rd Month	96.5	85.5	86.5	86.3	86.7	88.3	1.233 (ns)
4th Month	95.6	86.2	88.8	80.9	86.3	87.6	0.930 (ns)
5th Month	95.2	86.1	86.3	85.4	85.4	87.7	1.056 (ns)
6th Month	94.9	85.9	86.2	84.5	85.3	87.4	0.901 (ns)

** $p \leq 0.05$;   *** $p \leq 0.01$;   ns = not significant ($p > 0.05$)

Table 8. Mean total body fat mass (%) of the studied children

Duration	Age group (months)					Overall	One way ANOVA
	24–59 (n = 11)	60–89 (n = 23)	90–119 (n = 11)	120–149 (n = 27)	150–180 (n = 35)	F (N = 107)	(Combined)
Baseline	8.8	11.7	13.6	11.2	14.2	11.9	2.276 (ns)
1st Month	3.1	12.5	12.3	12.7	13.1	10.7	1.320 (ns)
2nd Month	4.7	11.8	12.9	12.3	11.9	10.7	1.386 (ns)
3rd Month	3.5	14.3	13.5	13.7	13.4	11.7	2.103 (ns)
4th Month	4.4	13.8	11.2	19.0	13.8	12.4	2.946**
5th Month	4.8	13.7	13.8	14.7	14.7	12.3	2.758**
6th Month	5.1	14.2	13.9	15.3	14.9	12.7	3.129**

** $p \leq 0.05$;   *** $p \leq 0.01$;   ns = not significant ($p > 0.05$)

Effect of Highly Active Antiretroviral Therapy and Multi-vitamins-minerals Supplement on the Nutritional Status and Growth Pattern of HIV-infected Children

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Abstract

Use of multivitamins-minerals supplement and highly active antiretroviral therapy (HAART) has been reported to improve the immunity, restore metabolism of lipid, protein and carbohydrate and enhance growth of HIV+ children. This study assessed the nutritional status and growth pattern of HIV+ children receiving multivitamins-minerals supplement with and without HAART in Dar es Salaam, Tanzania. All children involved in the study were supplemented with a daily dose of soft gel capsule of multivitamins and minerals. Anthropometric measurements of weight and height and biomarkers of HIV status - CD4+ cell count were taken at baseline, after three months and at the end of five months of a longitudinal study.

Results showed that, HIV+ children who were receiving HAART had higher (p < 0.05) CD4+ cell count than their peers not receiving HAART. Also, HIV+ children receiving the multivitamins-minerals supplement and HAART were growing slightly better (p > 0.05) in WAZ, WHZ and HAZ than their counterparts receiving only multivitamins-minerals supplement. HIV+ children receiving and not receiving HAART had growth patterns below the standard reference patterns for children of their age, although on average they gained more weight than the standard (0.34 kg/month). Boys and girls receiving HAART had an average weight gain of 0.43 and 0.51 kg/month, while those not receiving HAART had an average weight gain of 0.42 and 0.43 kg/month, respectively. It was concluded that, nutrition support of HIV+ children especially with multivitamins/ minerals is essential for restoring normal growth. It was recommended that, dietary/nutrition support should remain a cardinal aspect in the management of HIV+ children and administration of HAART should be done in tandem with nutritional support.

Key Words: Nutritional status, Weight/height-for-age, Weight-for-height, CD4+ cells count, Highly-active-anti-retroviral therapy (HAART), multivitamins/minerals supplement, growth patterns

Introduction

It has been hypothesized that appropriate nutrition provides advantages in HIV infected persons. It improves fitness, it maintains body weight and tissues, and it also improves quality of life and maintains body functions and above all replenishes nutrient losses from repeated infections. Therefore promotion of appropriate nutrition to people living with HIV/AIDS becomes of crucial importance (Cimoth, 1997). Alterations in the function of the gastrointestinal tract and the ability to use food in an efficient way increase the use of body fat stores, recurrent fevers and infections causing a rise in metabolic rates and depletion of vitamin and mineral stores.

Metabolic problems such as glucose deregulation and lipid abnormalities may originate from immune dysfunction, medication side effects, opportunistic infections, hormonal alterations, or the direct effects of HIV itself (Ayoob, 2000). In children, early growth failure is an important indicator of the metabolic derangement of protein, lipid and carbohydrate. HIV infection increases energy requirements through increase in resting energy expenditure, reduces

food intake, causes nutrient mal-absorption and nutrient losses, and complex metabolic alterations that culminate in weight loss and wasting.

The effect of HIV on nutrition begins early in the course of the disease, even before an individual may be aware that he or she is infected with the virus. Asymptomatic HIV-positive individuals require 10% more energy, and symptomatic HIV-positive individuals require 20-30% more energy than HIV-negative individuals of the same age, sex, and physical activity level (Cimoth, 1997; Babameto and Kotler, 1997; McCallan, 1999). Studies (Bakaki et al., 2001; Newell et al., 2003) show that, severe malnutrition in HIV-positive children can be reversed with hospital and home-based therapeutic feeding, though the time to recovery is longer than that of uninfected children. Good nutrition is thus central to normal growth and development and without adequate nutrition, growth is highly impaired and may result in underweight, stunting and/or wasting.

Early studies demonstrated that, weight loss and wasting were associated with increased risk of opportunistic infections and shorter survival time in HIV+ subjects independent of their immune status (Suttmann et al., 1995;). Other studies (National Academy of Sciences, 2001; Semba and Tang, 1999) showed that, clinical outcome was poorer and risk of death was higher among HIV+ adults with compromised micronutrient status. In the management of HIV+ individuals, emphasis has been placed on the use of drugs and little attention was placed in the nutritional aspects. While the role of drugs, such as anti-retroviral treatment cannot be under-estimated, other more affordable and sustainable alternatives and adjuvant must be explored (WHO, 2005).

According to WHO (2006) and Castleman et al. (2004), lack of good nutrition and access to affordable child-friendly highly active antiretroviral therapy (HAART) exacerbates the problem in children. In Tanzania, an ongoing supply of HAART has assisted to some extent to prolong the lives of infected adults but few children are receiving HAART and yet for those receiving HAART it is not clearly known if the HAART improves their growth pattern to normal.

This study was designed to assess the nutritional status and growth patterns of HIV+ children receiving multivitamins/minerals with and without antiretroviral therapy. Specifically, this study aimed at determining the weight for age, height for age and weight for height and the growth patterns of HIV+ children aged 5 – 10 years receiving multi-vitamins-minerals with and without HAART in Dar es Salaam, Tanzania. This study would be useful in determining the potential of multi-vitamins-minerals and antiretroviral therapy in restoring to normal the nutritional status and growth patterns of HIV-infected children.

Materials and methods
Study Population
A longitudinal study involving 174 HIV+ boys and girls aged 5 – 10 years was conducted at Mwananyamala Hospital in Dares Salaam. The study was conducted for five consecutive months between October and March 2011.

Sampling population and technique
Sampling population comprised all children aged 5 - 10 years who were receiving medical care at Mwananyamala Hospital, Dar es Salaam and enrolled into the Sokoine University of Agriculture – Beans for Health Alliance nutrition support project. Subjects were stratified in two groups based on the CD4+ cell count. The first group comprised children who classically had been diagnosed to be HIV+ and were not receiving HAART while the second group comprised all children who classically had been diagnosed to be HIV+ but were receiving HAART (even if at the study time the CD4+ cell counts were above or below 200 mm^3). Using a random sampling technique (table of random numbers) a representative sample of children was drawn from each group.

Sample size
The sample size was determined by using a formula (n = Z^{2}pq /d^2) by Fischer et al. (1991).

A total of 174 children were randomly selected into the study (124 children were receiving HAART while 50 were not receiving HAART). The distribution by gender was - boys receiving HAART (62), boys not receiving HAART (26), girls receiving HAART (62) and girls not receiving HAART (24).

Interventions

One group of HIV+ children (those with CD4+ cell count below 200 mm^3) received antiretroviral drug that was administered daily according to body weight. Children on HAART received the first line antiretroviral therapy comprising a combination of stavudine, nevirapine and lamivudine. The antiretroviral drug was available either as tablets or syrup. The second group of children (those with CD4+ cell count above 200 mm^3) did not receive antiretroviral therapy. All children in both groups received a daily dose of soft gel capsule of multivitamins and minerals (Vitacap®, Mega Lifesciences Ltd, 384 Pattana 3 Rd, Samutprakarn 10280, Thailand). Each capsule of multivitamin and mineral contained vitamin A (palmitate) – 5000 IU; vitamin B1 (thiamine mononitrate) – 5 mg; vitamin B2 (riboflavin) – 5 mg; vitamin B6 (pyridoxine HCl) – 2 mg; vitamin B12 (cyanocobalamin) – 5 μg; vitamin C – 75 mg; vitamin D3 (cholecalciferol) – 400 IU; vitamin E (dl- -tocopheryl acetate) – 15 mg; nicotinamide – 45 mg; d-panthenol – 5 mg; folic acid – 1000 μg; ferrous fumarate – 50 mg; di-basic calcium phosphate – 70 mg; copper sulphate – 0.1 mg; manganese sulphate – 0.01 mg; zinc sulphate – 50 mg; potassium iodide – 50 mg and magnesium oxide – 0.5 mg.

Data Collection

Construction of a Questionnaire: A structured questionnaire was constructed to solicit information about the parents/guardian characteristics, nutritional status and growth patterns of HIV+ children receiving multivitamins/mineral supplement with and without HAART. The questionnaire was pre-tested at Morogoro Government Hospital and unclear or ambiguous questions were corrected accordingly.

Training of enumerators: Before administering the questionnaire, enumerators were intensively trained on how to ask and interpret the questions correctly. Researchers and the enumerators went through the questions to ensure that all the questions were clear and correct.

Administration of the questionnaire: The questionnaire was administered by face–to–face interviews with the mothers or guardians/ care providers during visits to the Mwananyamala Hospital. Questionnaires were administered during the morning hours.

Measurements of Weight and Height: Weight was measured by using a digital scale and recorded to the nearest 0.1 kg while height was measured by using a stadiometer and recorded to the nearest 0.1cm. These measurements were taken without shoes on and with minimal clothing. A scale was zeroed before each measurement and was calibrated twice. Weight-for-height, weight-for-age and height for age z-scores were calculated to determine the extent of wasting, underweight and stunting, respectively. The children were classified according to the WHO (1995) standard references for children.

Determination of CD4+ and CD8+ cell counts

The CD4+ and CD8+ cell counts were determined by Fluorescence Activated Cell Sorting (FACS) method involving the use of whole blood in sample processing (Hulsta et al., 1994). Whole blood was drawn from the vein of each child involved in the study and added to a pair of test tubes containing a reagent. Fifty mL of whole blood was pipetted after gently mixing into each tube, then vortexed and incubated for 60 to 120 minutes at room temperature in the dark. Then 50 mL of fixative solution was pipetted into each tube and vortexed. The fluorochrome label antibodies were bound specifically to antigens on the surface of the lymphocytes – CD3+, CD4+/CD8+. The FACS count instrument detected two colors and the relative cell size was measured. The CD3+ cells fluoresced red and the CD4+ and CD8+ fluoresced yellow. Reference beads functioned as – fluorescence quantification standard for

calculating the absolute counts of CD3+, CD4+ and CD8+ T- lymphocytes. Fixative was added to preserve the integrity of the antibody binding. No lysis of cells was necessary (Hulsta *et al.*, 1994).

Statistical Analysis

The collected data were summarized and analyzed using Statistical Product and Service Solutions (SPSS) version 11.5 computer programme. Anthropometric indices -Weight for age, Weight for height and Height for age Z-scores were calculated using the EPI INFO7™ (2008) and compared with WHO (1993) reference population. Differences in baseline measurements between the two groups (those receiving and not receiving HAART) were determined.

Confidentiality

All subjects were identified and assigned identity numbers. Those numbers were used to identify the subjects during data collection. There was no use of names in the data entry, analysis or writing of the report.

Ethical Clearance

Permission to use human subjects for this study was obtained from the Ethics Committee of the National Institute for Medical Research, Dar es Salaam. Parents, guardians or care providers signed a consent form to affirm their willingness to allow their children or children under their jurisdiction to participate in the study.

Results and Discussion
Socio-economic and demographic characteristics of the parents/caregivers

Table 1 shows the socioeconomic and demographic characteristics of the parents/ guardians. About 29.3% (n = 174) of the parents/guardians were 19 years or less, 52.9% were 20 to 35 years while 17.8% were above 35 years. Majority of the parents/guardians (70.7%; n = 174) were adults above 20 years. Most of the parents/guardians (51.7%; n = 174) were married, while 24.7% were widowed, 13.8% were divorced/ separated and 9.8% (n = 174) were single. Results also showed that, 56.3% of the parents/guardians had attained primary

school education, 25.9% (n = 174) had attained secondary school education, while only 10.3 and 3.5% had attained vocational training and university education levels, respectively. About 4% (n = 174) of the parents/guardians had not attended any formal school. On the basis of this, most of the parents/guardians (96%; n = 174) had attained formal education and were thus literate. Education level is an important social factor that determines the quality of care that the care provider would offer to the HIV infected child. An educated care provider has a better understanding of the nutritional, medical and social needs; with a wider knowledge about the importance of HAART and nutrition support to an HIV infected person. In this study, majority of the care providers had only primary education while only a handful had secondary and post-secondary level education. According to Kavishe (1993), parents/guardians who have attained even the basic education are more articulate in addressing the nutritional and health problems of their families than their uneducated peers.

Table 2 shows the distribution of CD4+ and CD8+ cell counts for HIV+ children receiving and not receiving HAART. At baseline, the mean CD4+ cell count for boys receiving HAART was 399 mm^3 while those not receiving HAART had mean CD4+ count of 406 mm^3. For the HIV+ girls receiving HAART at baseline, the mean CD4+ cell count was 413 mm^3 while their peers not receiving HAART the mean CD4+ cell count was 411 mm^3. During the third month of study, the mean CD4+ cell count for HIV+ boys and girls receiving and not receiving HAART increased considerably (p > 0.05). The mean CD4+ cell count distribution was 424 mm^3 (boys receiving HAART), 418 mm^3 (boys not receiving HAART), 440 mm^3 (girls receiving HAART) and 427 mm^3 (girls not receiving HAART). At the fifth month of the study, the CD4+ cell counts for all groups increased significantly (p < 0.05). The distribution of the CD4+ cell count was – boys receiving HAART (462 mm^3), boys not receiving HAART (437 mm^3), girls receiving HAART (477 mm^3) and girls not receiving HAART (441 mm^3). The trend

of the CD4+ cell counts indicated a general increase in the cell counts, suggesting that, the immunity improved significantly on the course of multivitamins-minerals supplementation. Boys and girls receiving HAART had a bigger increment ($p < 0.05$) in the CD4+ cell count ($63 - 64$ mm^3) than their peers not receiving HAART ($30 - 31$ mm^3). Likewise, girls had higher average ($p < 0.05$) CD4+ cell counts ($411 - 477$ mm^3) than their male counterparts ($399 - 462$ mm^3). The CD8+ cells (T-suppressor or killer T cells) normally range between $300 - 1000$ cells in non-HIV infected people, however, for unclear reasons, the CD8+ cell count increases over time in HIV+ people (CDC, 2008). This trend was also observed in this study for boys and girls receiving and not receiving HAART. The CD8+ cell counts were $665 - 924$ mm3 (boys receiving HAART), $810 - 1093$ mm^3 (boys not receiving HAART), $826 - 954$ mm^3 (girls receiving HAART) and $822 - 1103$ mm^3 (girls not receiving HAART). The increment in CD8+ cell count was higher ($p < 0.05$) among boys (283 mm^3) and girls (281 mm^3) not receiving HAART than their counterparts receiving HAART (boys – 259 mm^3 and girls – 128 mm^3).

CD4+ cell count is used as a surrogate marker for diagnosis of HIV infection, for monitoring progression and improvement, and for making decisions to initiate antiretroviral therapy and prophylactic treatment for opportunistic infections. According to CDC (2008) classification system, CD4+ cell count for health (HIV negative) individuals range between 500 and 1600 cells/mm^3 while CD8+ cells range between 375 and 1100 cells/mm^3. The CD4+/CD8+ ratio for health individuals (HIV negative) range between 0.9 and 1.9. In HIV infection, both CD4+ cell count and CD4+/CD8+ ratio drop dramatically, implying that during infection there are usually more CD8+ than CD4+ cells (Zijenah et al., 2005). CD4+ cell count of ≤ 200 cells/mm^3 indicates that the individual is HIV positive, the immune system is severely weakened and the individual is at a greater risk of opportunistic infections. At this level of CD4+ cell count, initiation of anti-retroviral therapy is recommended. CD4+

cell count between 200 and 350 cells/mm^3 indicates some improvement in the immune system, however, the immunity is still weak and the individual may still be at increased risk of infections. At CD4+ range of $350 - 600$ cells/mm^3, the immune system of the HIV+ individual is described as very good and HAART may not be indicated. At the baseline of this study, the CD4+ cell counts for the children receiving and not receiving HAART ranged between 399 and 413 cells/mm^3. At the end of the five months of multivitamins/ mineral supplementation, the CD4+ cell counts for the children receiving and not receiving HAART increased to the range 437 - 477 cells/mm^3. This implied that, the immunity of most of the children (receiving and not receiving HAART) after five months of multivitamins/mineral supplementation could be described as very good although there was still a risk, as the underlying HIV-infection still existed.

Weight for Age Z-scores (WAZ)
Table 3 summarizes the distribution of WAZ- scores for children receiving multi-vitamins/mineral supplement with and without HAART. At baseline 12.9% (n = 62) of boys taking HAART versus 15.4 % (n = 24) of their counterparts not taking HAART were severely underweight. For girls who were taking HAART, only 9.7% (n = 62) were severely underweight while 8.3 % (n = 24) of girls not using HAART were severely underweight. There were no significant differences in the average weights of boys ($p = 0.095$) and girls ($p = 0.811$) receiving and not receiving HAART at baseline. After the first month of multivitamins-minerals supplementation, prevalence of severe underweight was 8.1% (n = 62) for boys receiving HAART, 11.5% (n = 24) for boys not taking HAART, 3.2% (n = 62) for girls receiving HAART and 8.3% (n = 24) for girls not receiving HAART. There were no differences in the average weights of boys ($p = 0.097$) and girls ($p = 0.661$) receiving and not receiving HAART after the first month of study.

After the second month of multivitamins-minerals supplementation, the proportions

of moderately and severely underweight boys receiving the HAART were 7 and 5%, respectively, while those not receiving HAART were 2 and 3%, respectively. The proportions of girls classified as moderately or severely underweight were 4% (receiving HAART) and 2% (not receiving HAART). During the third month of multivitamins-minerals supplementation, 1.6% (n = 62) of boys receiving HAART remained severely underweight, while 7.7% (n = 26) of their counterparts not receiving HAART were severely underweight. For the girls receiving HAART, only 3.2% (n = 62) were severely underweight while for those not receiving HAART, none was severely underweight (0%, n = 24). During the fourth month, none of the boys receiving HAART was severely underweight (0%, n = 62), while only 3.8% of their peers not taking HAART were severely underweight (Table 3). For girls receiving HAART, only 1% (n = 62) were severely underweight, while 4.2% (n = 24) of their counterparts not receiving HAART were severely underweight. During the fifth month of multivitamins-minerals supplementation, 0 % (n = 62) of boys and 3.2% (n = 62) of girls receiving HAART were severely underweight while 2% (n = 26) of boys and 0% (n = 24) of girls not receiving HAART were severely underweight. There were no significant differences in the average body weights for boys (p = 0.210) and girls (p = 0.143) receiving HAART and not receiving HAART during the fifth month of study.

Overall, prevalence of severe underweight for boys not receiving HAART was higher than that of their peers receiving HAART. For boys receiving HAART, prevalence of severe underweight decreased from 12.9% at baseline to 0% at the end of the study, while for their peers not receiving HAART, the prevalence of severe underweight decreased from 15.4% (baseline) to 7.7% (end of study). Improvement of severe underweight led to increase in the number of children classified as moderately and mildly underweight. Prevalence of moderate underweight for boys receiving HAART increased from 9.7 at baseline to 12.9% at the end of the study period, while their counterparts

not receiving HAART, prevalence of underweight increased from 7.7% at baseline to 11.5% at the end of the study. For girls receiving HAART, prevalence of moderate underweight remained almost stable from baseline (6.5%) to the end of the study (6.1%), while their peers not receiving HAART, prevalence of moderate under-nutrition decreased dramatically from 20.8% at baseline to 8.3% at the end of the study. The changes in the prevalence of severe and moderate underweight cases were reflected in the proportion of the children who changed to normal nutritional status. For boys receiving HAART, the proportion of children classified as normal, increased from 48.4% (baseline) to 71.0% (end of study) while for their peers not receiving HAART, the proportion increased from 50.0% at baseline to 53.8% at the end of study. For girls receiving the HAART, the proportion of children classified as normal increased from 43.5% at baseline to 61.3% at the end of the study, while their peers not receiving HAART, the proportion increased from 25.0% (baseline) to 41.7% (end of the study). Although both groups of children receiving and not receiving HAART showed improvement of weight for age over the study period, those receiving HAART had significantly superior weight for age compared to those not receiving HAART.

The proportion of severely underweight children observed in this study was higher than that reported in the Tanzania Demographic and Health Survey (NBS and ICF Micro, 2011). According to NBS and ICF Micro (2011), prevalence of severe underweight at national level was 0.4% for children aged 24 - 60 months and 0.3% for children aged 61 - 119 months (NBS and ICF Micro, 2011). High proportions of underweight children observed in this study could be associated with alterations in the metabolism of lipid; carbohydrate and protein inherent in HIV infected subjects; which is the major cause of weight loss among people living with HIV/AIDS (Piwoz and Preble, 2000, Colecraft, 2008). Prevalence of moderate underweight for boys and girls receiving (1.5 – 17.7%) and not receiving (7.7 – 20.8%) HAART was, however, lower than

that reported by NBS and ICF Micro (2011). The Tanzania Demographic and Health Survey reported prevalence of moderate underweight of 21.0% among children aged 24 – 60 months and 22.2% for children aged 61 – 119 months (NBS and ICF Micro, 2011).

Weight for Height Z-scores (WHZ)

Table 4 summarizes the distribution of WHZ-scores for children receiving multi-vitamins/mineral supplement with and without HAART. At baseline, 6.5% (n = 62) of girls taking the HAART were severely wasted compared to 8.3%, (n = 24) of their peers not taking HAART. Likewise, wasting was more prevalent among boys not taking HAART (3.8%, n = 26) than those receiving the therapy (3.2%, n = 62). There were no children receiving HAART who were severely wasted and only few boys (3.2%, n = 62) and girls (4.8%, n= 62) were classified as moderately wasted. At the end of the study, none of the children receiving and not receiving HAART were severely wasted. However, 1.6% (n = 62) of boys and 3.2% (n = 62) of girls receiving HAART and 3.8% (n = 26) of boys and 0% (n = 24) of girls not receiving HAART were moderately wasted.

Prevalence of wasting was generally low for both groups and there was only a small change over the five months period of multivitamins/mineral supplementation. For severe wasting, both boys and girls receiving and not receiving HAART showed a similar trend and none of the children in either group were severely wasted at the end of the study. Prevalence of moderate wasting observed in this study was inconsistent for both boys and girls receiving and not receiving HAART; but ranged from 0.0 to 3.8% (boys) and 0.0 to 8.3% (girls). Prevalence of moderate wasting at national level was reported at 2.7% for females and 3.3% for males (NBS and ICF Micro, 2011). The percent of children classified as normal (not wasted) increased from 88.7% at baseline to 96.8% at the end of the study for boys receiving HAART, 73.1 – 92.8% (boys not receiving HAART), 87.1 – 96.8% (girls receiving HAART) and from 75.0 – 91.7% for girls not receiving HAART. Overall, the use of HAART appeared to have minimal (p

> 0.05) influence on the prevalence of either moderate or severe wasting between boys and girls receiving antiretroviral.

The percentage of the severely wasted children observed during the baseline survey was higher than that reported in the Tanzania Demographic and Health Survey (NBS and ICF Micro, 2011) in which prevalence of severe wasting at national level was 3.7% for children aged 24 – 60 months and 3.2% for children aged 61 – 119 months. Weight for height reflects the effects of both acute (wasting) and chronic (stunting) nutritional status. Wasting in children therefore symbolized deficit in tissue and fat mass compared with their peers of the same height. The wasting observed among children in this study could have resulted from failure to gain weight or from actual weight loss due to the complications associated with HIV/AIDS infection. With multivitamins/mineral supplementation, children showed noticeable improvement as evidenced by the decrease in the proportion of wasted children to levels below those reported by NBS and ICF Micro (2011).

Height for Age Z-scores (HAZ)

Distribution of HAZ-scores for children receiving and not-receiving the HAART (n = 174) indicated that, at baseline 17.7% (n = 62) of boys taking HAART were severely stunted (HAZ< -3SD) while 19.2% (n = 26) of their peers not receiving HAART were severely stunted. For girls taking HAART, 25.8 % (n = 62) were severely stunted while about 16.7% (n = 24) of those not receiving HAART were severely stunted. During the first month of study, prevalence of severe stunting remained at 17.7% and 19.2% (n = 26) for boys receiving and not receiving HAART, respectively and 24.2% (n = 62) and 16.7% (n = 24) for girls receiving and not receiving HAART, respectively. During the second month of study, prevalence of severe stunting decreased only among the girls receiving HAART (17.7%) but remained unchanged for the other groups. A similar trend was also observed during fourth and fifth months of study whereby the prevalence of severe stunting decreased slightly among girls

receiving HAART but remained unchanged for their boy counterparts. Likewise, for boys and girls not receiving HAART, prevalence of severe stunting remained unchanged from the baseline to the fourth month and decreased only slightly ($p > 0.05$) among the girls in the fifth month of study.

According to NBS and ICF Micro (2011), severe stunting at national level was 12.0 and 13.6% for female and male children aged 24 – 119 months, respectively while prevalence of moderate stunting at national level for female and male children of the same age group was 36.8 and 38.6%, respectively. Prevalence levels for severe stunting observed in this study were higher than those reported at national level. Prevalence of severe stunting among boys in this study ranged between 17.7 and 19.2% while for girls it ranged between 12.5 and 25.8%. Prevalence of moderate stunting among boys in this study ranged between 10.0 and 30.8% while for girls it ranged between 14 and 33.3%. Prevalence rate for stunting did not change significantly on the course of multivitamins/mineral supplementation because the rate of growth of linear growth is usually very slow (King and Burgess, 1993).

The growth patterns
Figure 1 indicates the growth pattern (change in weight per month) for HIV+ boys and girls receiving and not receiving HAART. Both boys and girls who received multivitamins/mineral supplement progressively gained weight from the baseline to the fifth month of study. The average rate of weight gain, however, differed between boys and girl with girls gaining more weight overall. Girls receiving HAART had an average weight gain of 0.51 kg/month, while their peers not receiving HAART gained slightly lower weight (0.43 kg/month)($p > 0.05$). Likewise, the boys who were receiving HAART gained more weight (0.43 kg/month) than their peers not receiving HAART (0.42 kg/month). Both boys and girls receiving and not receiving HAART followed a similar pattern of growth in weight and they all grew up below the average reference weight for their age. The gap between the actual growth in weight and

the reference weight decreased progressively on the course of the study as more children who were mildly and moderately underweight moved into normal weights for their ages. It was also observed that, both boys and girls receiving multivitamins/mineral supplement (with or without HAART) gained more weight on average compared to the standard reference weight gain. Standard reference weight gain for normal health children of the same age is 0.34 kg/month while the average weight gain for the study children were 0.51 kg/month (girls receiving HAART), 0.43 kg/month (girls not receiving HAART), 0.43 kg/month (boys receiving HAART) and 0.42 kg/month (boys not receiving HAART) (WHO, 1995).

Figure 2 indicates the growth pattern (change in height per month) for HIV+ boys and girls receiving and not receiving HAART. For the entire study period, there was only slight ($p > 0.05$) improvement in the linear growth of both boys and girls receiving and not receiving HAART. This could be due to the fact that, linear growth usually takes place very slowly and it takes a long time for any increase in height to be noticed (King and Burgess, 1993). Girls receiving HAART had an average height gain of 0.21 cm per month while their peers not receiving the HAART had an average height gain of 0.22 cm per month. Boys receiving and not receiving HAART had a similar average height gain of 0.18 cm per month. Like for weight, both boys and girls receiving and not receiving HAART followed the same pattern of growth in height and they also grew up below the standard reference average height for their age. Both boys and girls in this study gained slightly lower average heights compared to the standard reference height gain. The standard reference height gain for healthy children of their age was 0.23 cm per month (WHO, 1995), while the average heights gained by children in this study were 0.18 cm/month (boys receiving and not receiving HAART), 0.21 cm/month (girls receiving HAART) and 0.22 cm/month (girls not receiving HAART).

The growth patterns observed in this study were similar to trends in weight and height gain

reported from other studies of HIV positive children (Gwenda et al., 2002; Guillen et al., 2007; Nachman et al., 2005). HAART has shown to have a positive effect on the growth of HIV infected children (Gwenda et al., 2002). Height and weight were favorably influenced in HIV-infected children in whom HAART also increased the CD4+ cell count (Gwenda et al., 2002). A similar study by Nachman et al. (2005) showed that, HAART improved the average weight gain of HIV-infected children from subnormal to normal after one year and also improved the average height growth to nearly normal after two years. A study of the impact of HAART on weight and height of HIV infected children showed that, the children experienced catch-up growth in weight and height five years after starting the therapy (Guillen et al., 2007). According to Lowenthal and Millon (2000), children receiving HAART in Netherlands demonstrated a significant increase in height and weight while in Tanzania, a study involving multivitamin supplementation of children aged 6 – 10 years showed significant gains in weight and height after six months (Fawzi et al. 2005).

A multivitamins - multiminerals supplementation study involving children aged 5 – 11 years in Botswana showed significant improvement in weight-for height z-scores after eight weeks. A ten-year follow-up study of HIV infected children indicated that, HIV+ children grew below the reference weight and height for age of their peers of the same age and sex and were on average 7 kg lighter due to wasting and 7.5 cm shorter than their uninfected peers of the same age and sex (Lowenthal and Millon, 2000). In a separate study, Moye et al. (1996) also observed that, 18-month old HIV infected children were 0.7 kg lighter and 2.2 cm shorter than their healthy uninfected peers. Lowenthal and Millon (2000) reported further that, children with HIV infection grow slower than uninfected children, a difference that becomes more significant with age. Asymptomatic infected children have similar growth patterns as mildly or moderately underweight children while increased levels of opportunistic infections decreased linear growth. Likewise, growth failure in children has been shown to accelerate progression from asymptomatic HIV infection to AIDS. Fawzi et al. (2005) reported that, early nutrition intervention of HIV+ children improve the immunity, reduce opportunistic infections, delay the progression of HIV to AIDS, delay the initiation of HAART and restores growth. Also, treatment with HAART along with nutritional support significantly improved the weight, weight-for-height ratio and had a marginal improvement on height.

Conclusion and Recommendation

This study showed that, use of HAART in HIV+ children resulted in significant increase in the CD4+ cell count and slightly higher gain in weight relative to children who were using multivitamins-minerals supplement alone. The weight-for-age, weight-for-height and height-for-age z-scores of the HIV+ children receiving HAART were slightly higher ($p > 0.05$) than those of their peers not receiving HAART. Both children receiving and not receiving the HAART had growth patterns that were below the standard reference pattern for children of the same age and sex. It was concluded that, nutrition support for HIV+ children especially with multivitamins and minerals is essential for restoring normal growth and using HAART is essential for boosting the CD4+ cell count. It was recommended that, dietary/nutrition support should remain a cardinal aspect in the management of HIV+ children and administration of HAART should be done in tandem with nutritional support.

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Table 1: Socio-demographic and demographic characteristics of the respondents (n = 174)

Characteristic	No. of respondents	Percent
Age category (years)		
≤ 19	51	29.3
20 – 35	92	52.9
> 35	31	17.8
Marital Status		
Single	17	9.8
Married	90	51.7
Widowed	43	24.7
Divorced/Separated	24	13.8
Occupation		
Businesswomen/Petty traders	44	25.3
Farmers	17	9.8
Employed for wage	79	45.4
Housewives	21	12.0
Unemployed	13	7.5
Family size		
1 - 2	16	9.2
3 - 4	109	62.6
5 - 6	35	20.1
> 6	14	8.1
Educational level		
Uneducated/Informal	7	4.0
Primary	98	56.3
Secondary	45	25.9
Post-secondary/Vocational training	18	10.3
University graduate	6	3.5
Average income per month (Tanzanian Shillings)		
10,000 – 50,000	26	14.9
51,000 – 100,000	71	40.8
101,000 - 300,000	45	25.9
301,000 – 500,000	19	10.9
> 500,000	13	7.5
Head of Household		
Male	124	71.3
Female	50	28.7

Table 2: Changes in CD4⁺ and CD8⁺ cell counts (mm³) of children receiving and not-receiving HAART during the study

Gender/Duration	CD4⁺	CD8⁺	CD4⁺/CD8⁺ Ratio
Boys receiving HAART			
Baseline	399[c]	665[e]	0.6[a]
3rd month	424[c]	707[d]	0.6[a]
5th month	462[a]	924[b]	0.5[a]
Boys not-receiving HAART			
Baseline	406[c]	810[c]	0.5[a]
3rd month	418[c]	836[c]	0.5[a]
5th month	437[b]	1093[a]	0.4[a]
Girls receiving HAART			
Baseline	413[c]	826[e]	0.5[a]
3rd month	440[b]	880[d]	0.5[a]
5th month	477[a]	954[c]	0.5[a]
Girls not-receiving HAART			
Baseline	411[c]	822[e]	0.5[a]
3rd month	427[c]	1068[b]	0.4[a]
5th month	441[b]	1103[a]	0.4[a]

[a,b,c,d,e] CD4⁺, CD8⁺ and CD4⁺/CD8⁺ values in a column with different superscripts are significantly different at $p \leq 0.05$.

Table 3: Distribution of weight for age Z-scores for children receiving and not receiving HAART (n = 174)[1]

Duration/status	Receiving HAART						Not-receiving HAART					
	Boys		Girls		Total		Boys		Girls		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Baseline												
Normal	30	48.4	27	43.5	57	45.0	13	50.0	6	25.0	19	38.0
Mild	18	29.0	25	40.3	43	34.0	7	26.9	11	45.8	18	36.0
Moderate	6	9.7	4	6.5	10	8.0	2	7.7	5	20.8	7	14.0
Severe	8	12.9	6	9.7	14	11.2	4	15.4	2	8.3	6	12.0
Overall	62	100.0	62	100.0	124	100.0	26	100.0	24	100.0	50	100.0
First Month												
Normal	31	50.0	28	45.2	59	47.5	13	50.0	6	25.0	19	38.0
Mild	18	29.0	25	40.3	43	34.6	8	30.8	11	45.8	19	38.0
Moderate	8	12.9	7	11.3	15	12.5	2	7.7	5	20.8	7	14.0
Severe	5	8.1	2	3.2	7	5.6	3	11.5	2	8.3	3	10.0
Overall	62	100.0	62	100.0	124	100.0	26	100.0	24	100.0	50	100.0
Second Month												
Normal	35	56.5	32	51.6	67	54.0	12	46.2	8	33.3	20	40.0
Mild	15	24.2	24	38.7	39	31.4	9	34.6	12	50.0	21	42.0
Moderate	7	11.3	2	3.2	9	7.3	2	7.7	2	8.3	4	8.0
Severe	5	8.1	4	6.5	9	7.3	3	11.5	2	8.3	5	10.
Overall	62	100.0	62	100.0	124	100.0	26	100.0	24	100.0	50	100.0
Third Month												
Normal	40	64.5	33	53.2	73	58.0	13	50.0	8	33.3	21	42.0
Mild	10	16.1	23	37.1	33	26.0	8	30.8	12	50.0	20	40.0
Moderate	11	17.7	4	6.5	15	12.0	3	11.5	4	16.7	7	14.0
Severe	1	1.6	2	3.2	3	2.4	2	7.7	0	0.0	2	4.0
Overall	62	100.0	62	100.0	124	100.0	26	100.0	24	100.0	50	100.0

Duration/status	Boys No.	Boys %	Girls No.	Girls %	Total No.	Total %	Boys No.	Boys %	Girls No.	Girls %	Total No.	Total %
Fourth Month												
Normal	42	67.7	29	46.8	71	57.3	13	50.0	8	33.3	21	42.0
Mild	10	16.1	28	45.2	38	30.6	9	34.4	12	50.0	21	42.0
Moderate	10	16.1	4	6.5	14	11.3	3	11.5	3	12.5	6	12.0
Severe	0	0.0	1	1.6	1	0.8	1	3.8	1	4.2	2	4.0
Overall	62	100.0	62	100.0	124	100.0	26	100.0	24	100.0	50	100.0
Fifth Month												
Normal	44	71.0	38	61.3	82	66.1	14	53.8	10	41.7	24	48.0
Mild	10	16.1	21	33.9	31	25.0	7	26.9	12	50.0	19	38.0
Moderate	8	12.9	1	1.6	9	7.3	3	11.5	2	8.3	5	10.0
Severe	0	0.0	2	3.2	2	1.6	2	7.7	0	0.0	2	4.0
Overall	62	100.0	62	100.0	124	100.0	26	100.0	24	100.0	50	100.0

[1] Normal weight for age = SD > - 1.0; Mild underweight = SD -1 -- -1.9; Moderate underweight = SD –2 -- -2.9; Severe underweight = SD < -3.

Table 4: Distribution of weight for height Z-scores for children receiving and not receiving HAART (n=174)[1]

Duration/status	Receiving HAART						Not-receiving HAART					
	Boys		Girls		Total		Boys		Girls		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Baseline												
Normal	55	88.7	54	87.1	109	87.9	19	73.1	18	75.0	37	74.0
Mild	5	8.1	4	6.5	9	7.2	6	23.1	4	16.7	10	20.0
Moderate	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Severe	2	3.2	4	6.5	6	4.8	1	3.8	2	8.3	3	6.0
Overall	62	100.0	62	100.0	124	100.0	26	100.0	24	100.0	50	100.0
First Month												
Normal	55	88.7	53	85.5	108	87.1	19	73.1	17	70.8	36	72.0
Mild	5	8.1	6	9.7	11	8.8	6	23.1	6	25.0	12	24.0
Moderate	2	3.2	2	3.2	4	3.2	0	0.0	1	4.2	1	2.0
Severe	0	0.0	1	1.6	1	0.8	1	3.8	0	0.0	1	2.0
Overall	62	100.0	62	100.0	124	100.0	26	100.0	24	100.0	50	100.0
Second Month												
Normal	56	90.3	53	85.5	109	87.9	23	88.5	19	79.2	42	84.0
Mild	4	6.5	6	9.7	10	8.1	2	7.7	4	16.7	6	12.0
Moderate	2	3.2	3	4.8	5	4.0	0	0.0	1	4.2	1	2.0
Severe	0	0.0	0	0.0	0	0.0	1	3.8	0	0.0	1	2.0
Overall	62	100.0	62	100.0	124	100.0	26	100.0	24	100.0	50	100.0
Third Month												
Normal	61	98.4	54	87.1	115	92.7	20	76.9	20	83.3	40	80.0
Mild	1	1.6	6	9.7	7	5.6	5	19.2	3	12.5	8	16.0
Moderate	0	0.0	2	3.2	2	1.6	1	3.8	1	4.2	2	4.0
Severe	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Overall	62	100.0	62	100.0	124	100.0	26	100.0	24	100.0	50	100.0
Fourth Month												
Normal	60	96.8	56	90.3	116	93.5	21	80.8	18	75.0	39	78.0
Mild	1	1.6	2	3.2	3	2.4	4	15.4	4	16.7	8	16.0
Moderate	1	1.6	4	6.5	5	4.0	1	3.8	2	8.3	3	6.0
Severe	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Overall	62	100.0	62	100.0	124	100.0	26	100.0	24	100.0	50	100.0
Fifth Month												

Normal	60	96.8	60	96.8	120	91.0	24	92.3	22	91.7	46	92.0
Mild	1	1.6	0	0.0	1	0.8	1	3.8	2	8.3	3	6.0
Moderate	1	1.6	2	3.2	3	2.4	1	3.8	0	0.0	1	2.0
Severe	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Overall	62	100.0	62	100.0	124	100.0	26	100.0	24	100.0	50 100.0

[1] Normal weight for height = SD > - 1.0; Mild wasting = SD -1 -- -1.9; Moderate wasting = SD –2 -- -2.9; Severe wasting = SD < -3.

Figure 1: Changes in weight of the HIV+ children receiving and not receiving HAART

Figure 2: Changes in height of HIV+ children receiving and not receiving HAART
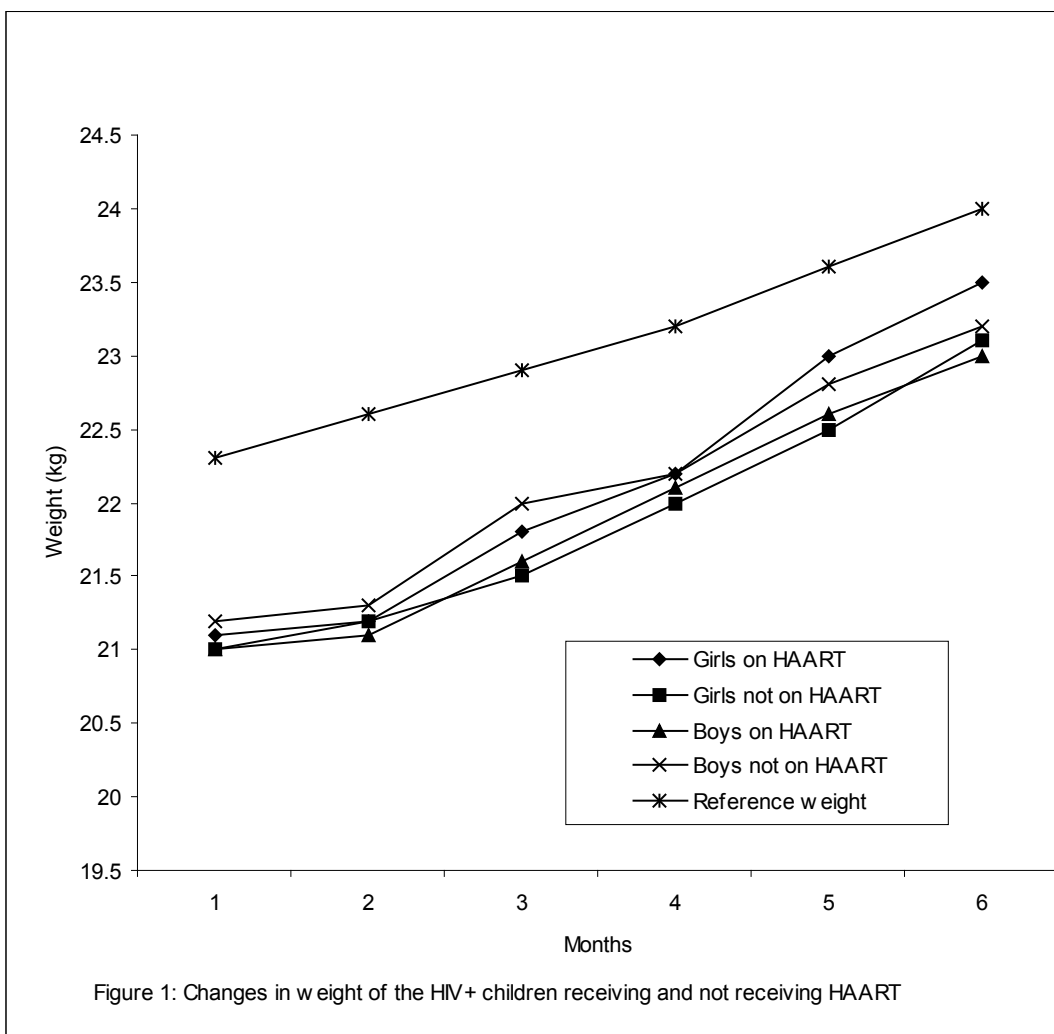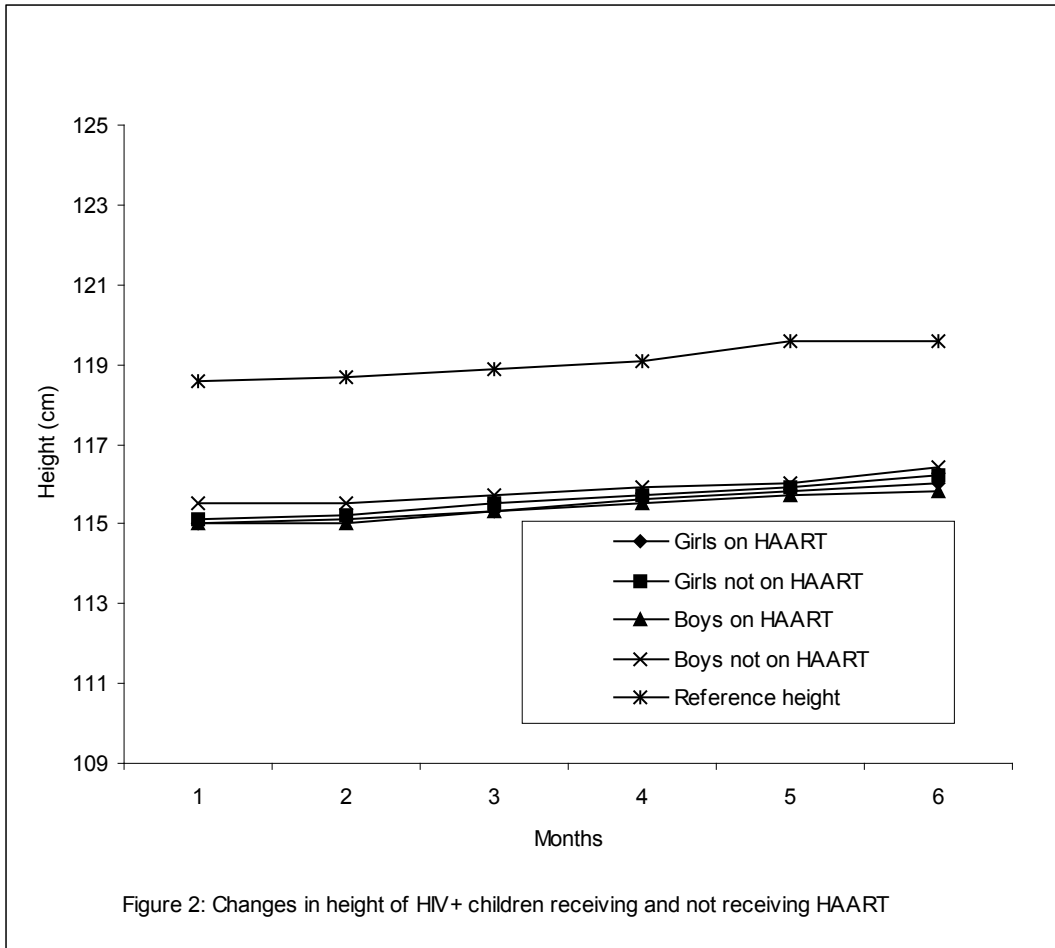
Use of small grains and rice husks as physical control measures for post-harvest maize losses during storage

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Abstract

During storage, maize is susceptible to post-harvest losses, especially by insects. The use of synthetic insecticides is currently expensive, poses some health risks and pollutes the environment. This study was therefore conducted to evaluate effectiveness of small grains (finger millet and sorghum), sunnhemp (Crotalaria ochroleuca) seeds and rice husks in controlling post-harvest losses during maize storage. Actellic super dust, a synthetic insecticide was used as a control. This experiment was conducted for 3 months, using Prostephanus truncatus and Sitophilus zeamais as study insect pests. The effectiveness of the treatments was of the order: actellic super dust > sunnhemp seeds > rice husks > finger millet > sorghum for P. truncatus and S. zeamais. Survivor rates for P. truncatus in maize after 3 months of storage were; actellic super dust (2.33), sunnhemp seeds (3.83), rice husks (5.67), finger millet (6.83) and sorghum (7.67). Survivor rates for S. zeamais were; actellic super dust (2.17), sunnhemp seeds (3.66), rice husks (4.83), finger millet (5.83) and sorghum (6.83). Irrespective of treatment, P. truncatus caused more grain damage than S. zeamais during storage. This study calls for more investigations on possibility of using sunnhemp seeds (both in ground and unground state) in maize storage.

Key words: Crotalaria, insects, post-harvest losses, small grains

Introduction

The production of grains that is mostly for human consumption and feeding of farm animals requires the storage of these grains for varying periods, depending on the market demand and yearly production. Insects, rodents and mites are the common pests of these grains. Damage caused by the pests results in great grain losses, in terms of quality and quantity. Potential losses world-wide have been estimated to be about 35% in the field and 14% in storage, bringing the total grain loss to about 50%. In Eastern and Southern Africa, grain losses are even higher (Odhiambo, 1985; Kaitisha, 1995). According to Mngodo *et al.* (1997), losses in Tanzania are estimated to be between 35 and 50%. Post-harvest losses are often significantly higher than the losses that occur in the field (FAO, 1985).

The only solution to cope with increasing world population is to improve food storage by reducing post-harvest losses (FAO, 1997). Reduction of post-harvest crop losses caused by pests will improve the food security, which will in turn improve the economy of developing countries (Saxena, 1993). Without pesticides, an estimated two thirds of all crops would be lost, depriving millions of people of valuable food. These pesticides have, undesirable side effects on health, which have been reported due to long term use of some of them (MacEwen and Stephenson, 1979).

The commonest method of control for these pests has been chemicals. This method has serious drawbacks in relation to cost, availability and toxicity, especially to the subsistence farmers. Most of the farmers store more than 70% of their grains in the household. They need

low-cost non-polluting pest control agents if they are to achieve sustainable management of insect pests (Mugoya, 1995). The insect pests mentioned above being aerobic organisms, could be easily eradicated by storage of the grains in an anaerobic environment, especially if the grains would not be used as seeds. Alternatively, minimising the entrapped air in the grains that are intended for seed, and malting are another practical options. The use of small grains like millet, sorghum and sunnhemp seeds in maize storage could help in minimizing the air available for the insect pests thus suffocating them. This in turn will help in extending the shelf life of maize.

Several insect species that attack grains are common in developing countries (Gahukar, 1994). In Tanzania, the common insect pests of maize are the larger grain borer (*P. truncatus*) and maize weevil (*S. zeamais*). According to Hodges *et al*., (1983), maize losses of up to 34% (mean 8.7%) have been reported to be caused by *P. truncatus* in maize stored at the farm conditions for 3-6 months. The losses reported for *S. zeamais* are much lower under similar farm conditions.

In a study conducted in Benin, most of the grain losses were attributed to the larger grain borer (*P. truncatus*) (Borgemeister *et al*., 1998, Meikle *et al*., 1998). Maize losses in Ghana have been reported at 25.3% mostly caused by rodents, insects, rain water, birds, fire and moulds, in addition to improper grain handling, drying and storage methods (Bani, 1991), weight loss due to insect infestation in sorghum stored for 6 months in rural India was 4.88% (Girish *et al*., 1974) while loss of maize stored for 10 months in Kenya was 4.45% (De Lima, 1979).

Maize is reported to be severely attacked in storage by many insects including *Sitophilus spp*. Among these, S. *zeamais* and S. *oryzae* are the most frequently encountered in the tropics. The damage inflicted by pests include consumption of the kernels, loss or conversion of nutrients, reduced germination power of seeds and contamination with filthy materials, eg., insect fragments, excreta and moulds (Enobakhare and Obasuyi, 1993). The attack results in quantitative and qualitative losses (Salunkhe *et al*., 1985).

Providing adequate supply of food and improving the health of a rapidly increasing population are the two greatest challenges of today. The increase in annual rate of food production in tropical developing nations is less than 1%, while the population is growing at an annual rate of around 2 % (Youdeowei and Service, 1983, http://www.indexmundi.com/tanzania/population_growth_rate.html). Thus, there is a serious gap between food supply and demand. The gap is increased by the post-harvest losses associated with insect pests. The objective of this study was therefore to evaluate the effectiveness of small grains and rice husks in controlling post-harvest losses caused by insects during maize storage.

Materials and Methods

Materials

Materials used in this study were maize grains, finger millet, sorghum, sunnhemp seeds and rice husks, sixty sisal bags (0.5 kg capacity), actellic super dust and two insect pests, P. *truncatus* and *S. zeamais*.

Methods

Sample collection and preparation

Freshly harvested, untreated and undamaged grains were purchased from farmers in Lugala and Mlali villages in Morogoro region. Dry rice husks were obtained from paddy mills in Morogoro municipal. Prior to the experiment, the grains and sunnhemp seeds were cleaned to remove any contaminants and deep-frozen for one week to kill all live insects and their larvae or eggs. Thereafter, the grains were sun- dried for two consecutive days. Two hundred grams of the dried maize were separately mixed with 50 g of each of the finger millet, sorghum or rice husks and sunnhemp seeds. Actellic super dust, which was used as a control, was applied to maize at 0.1%. For each combination, six bags each containing o.5 kg of grain were inoculated with P. *truncatus* and the other six with *S. zeamais*. The control samples were treated in the same way, but were not inoculated with insects.

Laboratory culturing of study insects

Adult insects (*P. truncatus* and *S. zeamais*) were collected from SAI and Ladwa cereal milling machines in Morogoro municipality. The collected insects were incubated in two separate jars containing maize, (previously deep-frozen and equilibrated at ambient temperature), for each genera. After 2 weeks, the adult insects were removed leaving behind the eggs and larvae. As soon as adults emerged, they were used to inoculate the maize bags containing different treatments. Seven and five pairs of male and female insects of *S. zeamais* and *P. truncatus*, respectively, were introduced into each treatment bag. The experiment was conducted for 3 months, with sampling every fortnight. The storage was done at room temperature ($26\pm2°C$) and 80 % relative humidity. The numbers of dead insects, survivors, together with that of damaged grains were recorded. Weight loss was determined at the end of the experiment.

Statistical analysis

Analysis of variance was employed to determine variation in the effectiveness of the different treatments. Duncan's Multiple Range Test (DMRT) was used to compare the means at 5% level of probability (Steel and Torrie, 1980). Excel for Windows™ was also used for descriptive analysis of the data (Chester, 1995).

Results and Discussion

Table 1 summarizes the means of live *P. truncatus* observed in maize at different times during storage. Actellic super dust was the most effective in controlling the numbers of insect pests in the maize. Generally, the average number of *P. truncatus* survivors for samples treated with actellic super dust was significantly lower (P£0.05) than in the other treatments, during the first eight weeks of the experiment. However, after twelve weeks, the trend was similar the mean survivors in the treatments involving actellic super dust and sunnhemp seeds, which was not significant (P³ 0.05). Overall, sunnhemp seeds showed promising effectiveness against *P. truncatus* but not as good as that shown by actellic super dust. In terms of effectiveness, the use of sorghum grain was the least effective in controlling *P. truncatus*. Generally, the effectiveness of the studied treatments against *P. truncatus* was of the order: actellic super dust > sunnhemp seeds > rice husks > finger millet > sorghum.

Effectiveness of the studied treatments against *S. zeamais* is shown in Table 2. Throughout the experimental period, the mean survivors in the treatment involving actellic super dust were significantly lower (p<0.05) than in the other treatments. Although the mean survivors for maize grain treated with sunnhemp were significantly higher (p£0.05) than for the maize grains treated with actellic super dust, the use of sunnhemp seeds gave significantly better results than the other treatments at the end of the storage period. As was observed for *P. truncatus*, a similar trend of effectiveness of the treatments was observed for the *S. zeamais*, with actellic super dust being the most effective and the sorghum grain being the least effective.

Figure 1 shows the average percentage of maize grains damaged by *P. truncatus* and *S. zeamais* during storage under different treatments. The maize grains treated with actellic super dust were the least damaged, followed by those treated with sunnhemp seeds, rice husks, and finger millet. The maize grains treated with sorghum were highly damaged, indicating the failure of sorghum in providing physical barrier to maize grains, against insects' damage during storage. Instead, sorghum proved to behave as more of food to the insects than protectant. Throughout the storage period, irrespective of the treatment, *P. truncatus* caused more damage than *S. zeamais*.

The non-food protectants (actellic super dust, sunnhemp seeds and rice husks) gave more promising results than the food protectants (finger millet and sorghum), i.e., low number of survivors and small percentage of damaged maize.

Sorghum was a good source of nutrients and was used as alternative source of food, instead of maize, to the insects. This may explain why maize samples treated with sorghum were the most attacked confirming the failure of sorghum to provide physical barrier against the insect pests.

Finger millet is not easily attacked by insects due to the small grain size, which makes insects unable to complete their life cycles in the grain. Guiragossian and Mukuru (1993) reported that, finger millet stores well and is often free from major storage pests. The effectiveness of the rice husks originate from the fact that, rice husks tend to fill the inter-granular spaces, thus eliminating air and consequently increasing oxygen demand for the insect pests.

Sunnhemp seeds are of size comparable to finger millet. They proved to be more protective to maize that the finger millet due to the fact that, in addition to the physical protection, they also have insect repellant properties. This was the mechanism by which they kept away the *P. truncatus* and *S. zeamais* (Coburn and Russell, 1987; Leitner *et al.*, 1990; Manavalan *et al.*, 1979) Actellic super dust performed as expected by giving the lowest damage and highest insects mortality. This is a commercial insecticide recommended for maize storage.

Conclusions and Recommendations

From this study, sunnhemp seeds showed potential for use as treatment in the storage of maize next to the actellic super dust, which is usually used for controlling insect pests in maize grains during storage. Therefore, seeds could be recommended as an alternative to the synthetic insecticide (actellic super dust) in controlling insect pests in stored maize. It is recommended that further studies involving ground sunnhemp seeds should be done to determine the effect of both physical and the repelling effects of the sunhemp seed flour. However, effective separation of the sunnhemp seeds and flour from the maize grain is essential before milling the maize grains into flour.

Acknowledgements

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Table 1. Mean number of survivors of *P. truncatus* in maize storage under different conditions

Treatment	Duration of storage (days)					
	14	28	42	56	70	84
Actellic Super	0.5 ± 0.55	0.83 ± 0.75	1.00 ± 0.89	1.83 ± 0.75	2.17 ± 0.75	2.33 ± 0.52
Crotalatia seeds	1.67 ± 0.52	2.00 ± 0.75	2.50 ± 0.55	3.17 ± 0.98	3.50 ± 0.55	3.83 ± 0.75
Rice husks	2.33 ± 0.82	3.17 ± 0.75	3.67 ± 0.82	4.50 ± 1.05	5.17 ± 0.98	5.67 ± 1.37
Finger millet	3.00 ± 0.89	3.83 ± 0.75	4.33 ± 0.82	5.17 ± 0.98	6.33 ± 1.37	6.83 ± 1.17
Sorghum	3.00 ± 0.89	4.00 ± 1.26	4.67 ± 1.51	6.00 ± 1.26	7.16 ± 1.60	7.67 ± 1.51

Table 2. Mean number of survivors of *S. zeamais* in maize storage under different conditions

Treatment	Duration of storage (days)					
	14	28	42	56	70	84
Actellic Super	033 ± 0.52	0.83 ± 0.75	0.83 ± 0.75	1.50 ± 1.05	2.17 ± 0.75	2.17 ± 0.75
Crotalatia seeds	1.50 ± 1.05	1.83 ± 1.17	2.50 ± 1.05	3.00 ± 0.89	3.50 ± 0.55	3.66 ± 0.52
Rice husks	2.00 ± 0.63	2.50 ± 0.55	2.83 ± 0.98	3.83 ± 0.75	4.17 ± 0.98	4.83 ± 0.75
Finger millet	2.17 ± 0.75	2.83 ± 0.75	3.67 ± 0.52	4.17 ± 0.75	5.33 ± 1.03	5.83 ± 1.17
Sorghum	3.00 ± 0.89	3.83 ± 0.75	4.33 ± 0.82	5.33 ± 1.03	6.17 ± 1.17	6.17 ± 1.17

Figure 1.Percentage of maize grains damaged by P.truncatus and S.zeamais during storage under different treatments
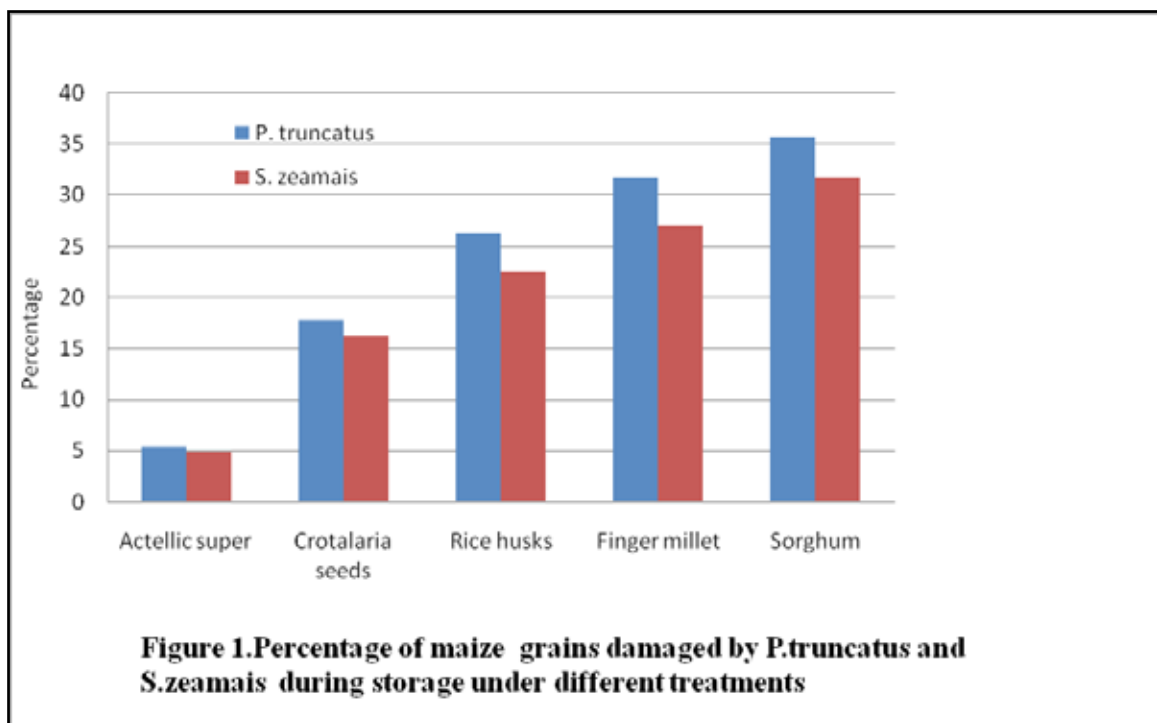
Socio-economic impact of
HIV/AIDS on household livelihoods

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Abstract

Socio-economic impacts (affordability on costs of education, health and food as basic need) of HIV/AIDS on household livelihoods have been assessed in Dar es Salaam City. A cross sectional study design was used. Snow –ball (chain referral) and purposive sampling technique was used to select 45 affected households' while multistage sampling techniques were used to select 45 non-affected households. Data were collected by using structured questionnaires with open and closed ended questions. Checklist was used to collect data from key implementers in the organizations dealing with care and treatment for people with HIV/AIDS. The data were analysed by using SPSS Version 11.5 computer program. Results showed that there was a significant difference on the socio-economic impact of HIV/AIDS between the affected and non-affected households. Nearly 75% of non-affected households afforded to pay medical expenses compared to 30% in the affected households. The data also show that nearly 50% of children in affected households and only 27% in non-affected households drop out school because of failure to pay school fees. About 80% of non-affected households and only 38% in affected households afford to eat three meals per day. Coping mechanisms commonly used were selling of assets, going for the cheaper food stuff, sending children to relatives and reducing the number of meals.

Key words: HIV/AIDS, affected households, non-affected households, livelihoods, coping mechanism and household assets.

Introduction

HIV infection is not an immediate death sentence but it depends upon individual's living conditions, rates and types of current infection and diet among the infected persons (UNAIDS, 2000). Many opportunistic infections and diseases associated with AIDS can be treated or prevented at relatively low cost, thus prolonging life.

The spread of HIV has been greater than predicted and its impact on social capital, population structure and economic growth is high to the extend of threatening the livelihood of many active population groups and hence those who depend on them (fathers, mothers, sisters and or brothers) and weakening the national economies (UNAIDS, 2005). HIV affects food security and livelihoods in different ways for different households. Its impact varies according to assets available in the households, demographic composition and the circumstances in question, such as chronic illness of a member, recent death or whether they are supporting orphans (Donnell, 2004).

Livelihood approaches offer a holistic way of addressing the HIV/AIDS epidemic which promotes joint thinking across sectors and disciplines, that can look not just at the impact on health but also at the impact on social support, finances, housing, land use and land tenure (FAO, 1997). The mechanisms by which households are affected are best understood using a sustainable livelihoods framework, and considering impact on each of the different types of assets available to the household.

This paper presents information on socio-economic impact of HIV/AIDS on household livelihood in Dar es Salaam city which will help

to control household resources such as human, financial, infrastructure and expertise in the family, also in policy making and planning of activities that will help the government to find ways of harnessing its leadership to the energy and creativity of community organization.

Methodology

This study was conducted in Dar es Salaam city in the year 2007. This is because the city is full of people with mixed cultures from rural areas (due to rural-urban and urban-rural migration) whereby such people often return to rural areas after being affected by HIV/AIDS and or vice versa.

Furthermore, it was leading in commercial sex (prostitution), number of children living in street, orphans, third most HIV prevalent in Tanzania (11%) and leading cases of child labour especially among young girls as domestic workers and who are later exposed to HIV/AIDS which is the leading cause of death in the city.

A cross sectional study design was used in this study. A total of ninety households were collected by the researcher through structured questionnaire to represent the whole population in Dar-es-Salaam City. Forty five affected out of which fifteen were selected from each municipal council (Ilala Kinondoni and Temeke) were collected by using *purposive* and *snow ball* (referral) sampling technique from three Institutions dealing with care and support for people dealing with HIV/AIDS, namely SHIDEPHA+, *Walio katika Mapambano na Ukimwi Tanzania* (WAMATA) and Pastoral Activities and Services for people with AIDS Dar es Salaam Archdiocese (PASADA) respectively.

Multistage sampling technique was used to select forty five non-affected households, fifteen from each municipal council.

The researcher also used the checklist with open and closed-ended questions (key informants' approach) to collect primary data from key informants in the organizations and local government authorities in order to ensure validity and reliability of the study.

The data were coded and analysed using SPSS version 11.5-computer programme. Validity check for each variable under study was made for inconsistencies, illogical entries and improbable values. Descriptive statistics particularly means, frequencies and percentages were computed. Cross tabulations involving chi-square test were used for bivariate analysis to test associations and relationships between different pairs of variables of the HIV/AIDS affected and unaffected households. 5% level of significance was used for testing hypotheses which stated that "Livelihoods of affected and non-affected households by HIV/AIDS do not differ significantly". The researcher also used composite variable for multiple indicators (medical expenses, number of meals per day, mode of owning the house, availability and access to pay for electricity, mode of owning the plot, radio, table, metal bed, clothes cupboard, utensils cupboard, television, wrist or table watch, refrigeration, bicycle, kerosene lamp, mattress, public water, public well, well in a residence, tape in a residence, wall, burnt bricks and concrete blocks; thatched, asbestos tiles and corrugated iron sheets; sand, wood plank, cement floor and motor car) to construct one indicator which is household livelihood.

Results and discussion

The socio-economic impact of HIV/AIDS on household livelihoods

The socio-economic impact discussed here are ability of the household to afford medical expenses; education and household food security (number of meals per day). These were the main indicators which showed a significant difference on socio-economic impacts of HIV/AIDS between affected and non-affected households.

Medical cost

Members of the household were asked to give their opinion as to whether they are able to afford medical expenses or not. This was to assess the economic stability of the households and the responses were based on two durations i.e. during the study and five years before the study (assumed not all respondents were affected).

Table 1: Ability of the household to afford medical expenses (%) N=90

Affordability of medical Expenses	Non-affected households	Affected households	Total	X²
During the study				0.000*
Afford	73.3	31.1	52.2	
Didn't afford	26.7	68.9	47.8	
Past	**100.0**	**100.0**	**100.0**	
Afford	100.0	60.0	80.0	
Didn't afford	0.0	40.0	20.0	
Total	**100.0**	**100.0**	**100.0**	

ns not statistically significant   * *statistically significant (p≤0.05*

The results show that more than three quarters of non-affected households afford medical expenses during the survey compared to 30% for the affected households, while in the past five years 80% of both affected and non-affected households afforded medical expenses and only 20% didn't afford medical expenses.

Furthermore, during the survey the situation was worse in affected households than in non-affected households, which is to say the situation might be aggravated by HIV/AIDS. The variation of the past five years and during the study for all respondents might be caused by changes on life expenses. Therefore HIV/AIDS have high cost-effective impacts on households' livelihoods. Related study in Uganda shows that, health expenses reduce available capital since cash may be used for drugs, healthcare, hospital drugs and special nutritious foods that are recommended to be eaten with HIV drugs C., Kathy. H, and Maction. K, 2009)

HIV/AIDS and education

The key determinant of lifestyle and status of an individual is education. It affects many aspects of human life, including demographic and health aspects (TACAIDS *et al.,* 2003). In this study education factor was assessed in terms of school dropout as shown in Table 2. The dropout rates show the percentage of pupils who were in school and during the time of the interview was no longer at school. The study further assessed the reasons for school dropout as shown in Table 3.

Table 2: HIV/AIDS and school dropout (%) N=90

School dropout	Non-affected hh n=45	Affected hh n=45	Total N=90	X²
Drop out	26.7	66.7	46.7	0.000*
Attend	73.3	33.3	53.3	
Total	**100.0**	**100.0**	**100.0**	

ns not statistically significant   * statistically significant(p≤0.05)

The results showed that more than half of children in the affected households dropped out school. On the other side about a quarter of non-affected households dropped out and nearly three quarter continued attending school. This has been supported by the study conducted in Ethiopia which shows a significant difference of children from affected household on drop out school as compared to children from non-affected household (WFP, 2008).

The follow up response has been shown in Table 3.

Table 3: Reasons for school dropout (%) N=90

Reasons for School dropout	Non-affected hh n=45	Affected hh n=45	Total N=90	X^2
No reason	73.3	33.3	53.3	0.001*
Stationers	0.0	2.2	1.1	
Uniform	0.0	15.6	7.8	
School fees	26.7	48.9	37.8	
Total	**100.0**	**100.0**	**100.0**	

ns not statistically significant   * statistically significant (p≤0.05)

The study revealed that nearly half (48.9%) of children in the affected households failed to attend school because of school fees and approximately 16% failed to attend school because of lack of uniforms, more than a quarter had no reason and only 2% because of lack of stationeries. This implies negative impact of HIV/AIDS on education. Affected households suffer more on matters relating to lack of inadequate family income to meet schooling expenses.

Food is a basic need for all people. Figure 1 presents the number of meals per day as an indicator of food security for HIV/AIDS affected, non-affected and the total households. It is also one of the indicators and measures of household welfare. Respondents were asked about number of meals per day taken.

Figure 1: HIV/AIDS and household food security
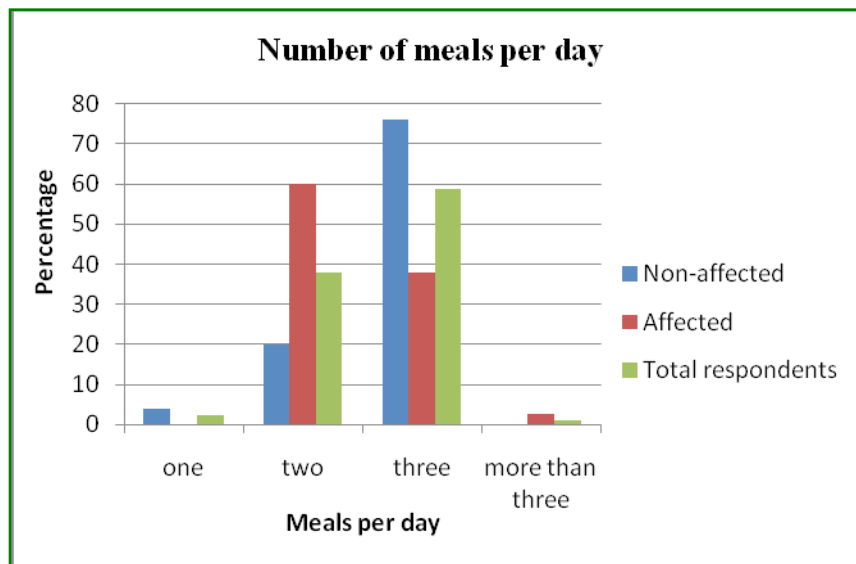
Results in figure 1, show that there were very few respondents (2.2%) who took one meal per day together with those who took more than three meals per day (1.1%). The variation has been

observed on taking two and three meals per day. About two third (60%) of HIV/AIDS of individuals in the affected households took two meals per day while one third (37.5%) of them took three meals per day. Three quarter (76%) of HIV/AIDS non-affected households took three meals per day while only 20% took two meals per day. HIV/AIDS affected households experienced a decline in food consumption (in terms of quantity i.e. reduces the amount) and in quality (go for cheaper foods regardless of their nutritive value) compared to non-affected households. This may effect an individual as HIV/AIDS and food security is a bi-direction in the fact that HIV/AIDS contributes to food insecurity; and physiological susceptability to HIV/AIDS.

Quality of life during the past and to date

Respondents were also asked to compare the quality of life during the past (recall) and to date (during the survey). Quality of life was used as a standard indicator of not only the wealth and employment, but also the built environment, physical and mental health, education, recreation and leisure time; and social belonging.

Respondents were asked to recall their quality of life in the past five years (i.e. from year 2006 to year 2001). Results showed that 60% of HIV/AIDS non-affected households had moderate quality of life while HIV/AIDS affected households were 25%. For the case of bad quality of life nearly a quarter (27%) of affected household experienced that as compared to 7% of non-affected households. Other component of quality of life (pretty good, good and pretty bad) has not shown any significance difference, see figure 2.

Figure 2: Quality of life during the past five years

Quality of life during the survey

Respondents rated their quality of life during the survey (year 2006) and results in figure 3 shows that HIV affected households experienced lower quality of life as 74% had bad quality of life during the survey compared to 27% in the past.

Figure 3: Quality of life during the survey
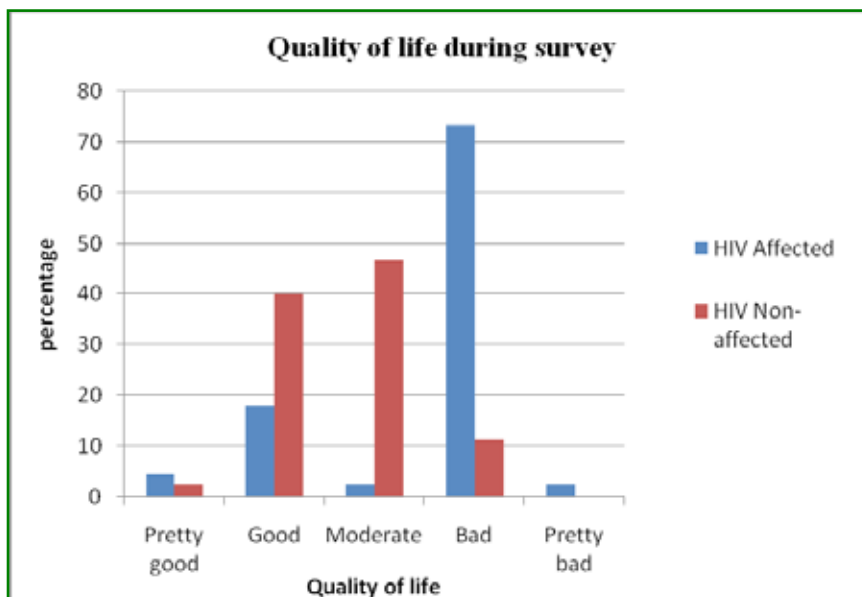
HIV non-affected household didn't experience bad situation as affected household. Instead they had good quality of life as 40% had good and 45% had moderate quality of life during the survey while in the past five years 32% had good and 60% had moderate quality of life. Therefore HIV/AIDS exacerbate the economic hardship of the household hence worsening the quality of life. For that reason, the study also identified how the affected individuals try to devise strategies to cope with the bad situation.

Household coping mechanism for affected and non-affected households

Coping mechanisms such as changing food consumption patterns, substituting cheaper commodities, selling of household assets and livestock, child labor and sending children to live with relatives were identified during the study as depicted in Figure 1 above.

Respondents were asked; when they have food shortage, which coping mechanism(s) do they use to meet household requirements. The study revealed that, more than half of non-affected households had no food shortage hence no permanent coping mechanisms instead they go for cheaper foods in such situation. About 40% coped by reducing the number of meals per day and only 4% coped by selling household assets and send children to live with relatives. In affected households more than three quarters coped by reducing the number of meals per day. Nearly 15% coped by selling of household assets and about 7% by child labour. Basing on results in Figure 1 most of affected households observed to have a number of coping mechanism than non-affected households (p<0.05). This implies that reducing consumption and switching strategies are generally the households' first line of defence against food shortage in affected households. Switching strategies include consumption of food not normally consumed and low costly foods such as green vegetables, meal without animal protein such as meat, selling of household assets such as refrigerator; cup boards and jewelleries. Other coping strategies were doing small businesses for example selling of ice cream and *ubuyu* (wild fruit) which normally was done by children. Therefore child labour was among the coping strategies used to cope with food shortage.

Selling of household assets

The study dealt with households' durable assets as an indication of the household's socio-economic status. Having access to a radio or television exposes household members to innovative ideas, refrigerator prolongs the wholesomeness of foods and means of transport allows greater access to services away from the local area. Households' assets owned included radio, table, TV, refrigerator, metal bed, wood

bed, utensils cupboard, clock, and kerosene lamp, and bicycle and cotton mattress.

Household condition was also used to assess household livelihoods. These include source of drinking water which include piped water into a house, public tape, well in residence, public well, rainfall, open well; and flooring material which include earth/sand/dang floor, cement/ceramic tiles, wood planks; and doors which include wood, corrugated iron sheet; and source of energy i.e. availability and ability to pay for electricity; roof which include oil cans, asbestos tiles and corrugated iron sheets; walls which included sun dried bricks, burnt bricks, concrete blocks and iron sheets. A total of 32 variables were used to find a mean for affected and non-affected households.

In the study area ownership of a plot was not common in Dar es Salaam instead the renting of houses was generally common, followed by own house and lastly by inheriting. Therefore most of household sold were movable assets such radios TVs, and not land or houses as depicted in Table 4, that nearly a quarter of affected household selling household assets as a coping mechanism to get food and cover medical expenses. Some of the assets sold include refrigerator, furniture such as cupboards and jewelleries hence the decrease selling of household assets is an important impact of HIV/AIDS pandemic.

Conclusion and recommendations

HIV/AIDS was found to impact negatively on both social and financial capital of the sustainable livelihood framework in the studied area. HIV/AIDS households faced difficulties to pay cost of education, food and medical expenses. Therefore it adds stress to the lives of family members and it robs the lives of the caregivers. On the other hand, there was a significant difference in terms of the coping mechanisms employed by HIV/AIDS affected and non affected households. HIV/AIDS affected households coped by reducing the number of meals, selling of household assets and child labour while non-affected household coped by changing type of food (go for cheaper food), reducing the number of meals and selling of household assets. Therefore households of the HIV affected individuals experienced more shock on socio-economic welfare than in non-affected households.

Limitation of the study includes the fact that it was conducted with limited funds therefore less number of respondent were interviewed and these can not represent the whole population of Dar es Salaam city as well as population of Tanzania.

Therefore there is a need for further research on socio-economic impacts of HIV/AIDS on household livelihoods in the large population of Dar es Salaam city as well as in other part of the country. Only two variables (social and financial capital) of sustainable livelihood framework were used to study the impacts of HIV/AIDS in Dar es Salaam city, the other three namely natural, human and physical capitals were not used.

Research should also be done on how the local government and institutions (dealing with HIV/AIDS) handle the problem of impacts of HIV/AIDS on household livelihoods (micro-level) to the governmental level (macro). Likewise, further research needs to be conducted to find out appropriate coping mechanisms to people living with HIV and AIDS both in rural and urban settings.

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A review of sorghum utilization in Tanzania

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Abstract

Utilization of sorghum as a human food occurs mostly in Africa, India and Asia, and little amount in the United States as an alternative for people with celiac disease who can't handle wheat and gluten. Larger amounts of sorghum produced in USA and other developed countries are mainly used for syrup, animal feeds and ethanol production.

Approximate 21.6 million metric tons of sorghum and millet are produced in Africa each year (FAO, 1995). The most commonly grown cultivars include white sorghums and red sorghums. Red sorghums are normally bitter and are manly used for fodder and brewing, whereas the white sorghums are sweeter and usually used for making porridge and syrup.

In Tanzania, both improved and local cultivars are produced in all dry land regions on subsistence bases with an average yield less than 1000 tons per year, an amount considered too little to sustain an average farm family for 12 months Rohrhach et al,(2007). When used as food sorghum is consumed as whole grain or processed into flour from which traditional meals and beverages are prepared.

The overall acceptability of sorghum as human food compared to other cereals is still low even in regions showing promising potential for its production and utilization. This situation is partly due to sorghum having poor starch and protein digestibility on one hand and inadequate knowledge among the people on its nutritional and health benefits on the other hand, thus negative perception on its nutritional value. However studies have now shown that processing methods including malting and fermentation can have positive effects on the digestibility of sorghum and therefore improve its nutritional quality (Chavana et al; 1989).

Key words: Acceptability, celiac disease, digestibility, fermentation, malting, attitude.

Introduction:

Sorghum is a cereal native to sub-Saharan Africa and grows well in temperate and tropical areas of the world where other staple cereals such as maize, wheat and rice cannot grow well. About forty five million hectares of sorghum are cultivated in the world (FAO, 2005) and USA is the number one producer followed by Nigeria, India, Mexico, China, Argentina, Sudan, Ethiopia, Somalia, Australia, Burkina Faso, and Brazil (Murty and Kumar, 1995; Dicko *et al* 2005; FAO, 2005).

Approximate 21.6 million metric tons of sorghum and millet are produced in Africa each year (FAO, 1995). The most commonly grown cultivars include white sorghums and red sorghums. Red sorghums are normally bitter and are manly used for fodder and brewing, whereas the white sorghums are sweeter and usually used for making porridge and syrup.

In Tanzania, small-scale farmers, produce sorghum on subsistence basis with an average yield less than 1000 tons per year, an amount considered too little to sustain an average farm family for 12 months Rohrhach et al (2007).

Basically sorghum is produced in all regions of mainland Tanzania, but the major producing areas are Singida, Dodoma and Tabora in the Central zone, Mwanza, Shinyanga and Mara in the lake zone, Lindi and Mtwara in the Southern zone, and some parts of Morogoro region in the Eastern zone (MAC, 1998). Commonly grown cultivars include *macia, tegemeo, pato,* and *Serena* (improved cultivars) and *Lugugu, Udo, Ichicha,* (*Tundu* and *Weigita* (local cultivars) (Mufuru *et al*; 2007). *Marcia* and *tegemeo* (white/*khaki* in colour with a sweet taste and considered low in tannins), are grown mainly in the southern, eastern and central zones (Lindi, Mtwara,

Morogoro, Dodoma and Singida. *Serena*, *gundu* and *weigita* cultivars that are bitter with high tannin content and mainly used for making local brews are grown in Lake Zone regions of Shinyanga, Tabora, Mwanza, and Mara (Minde *et al*; 1993).

Sorghum farm (macia) in Mvomero district–Morogoro region

Sorghum is consumed as whole grain or processed into flour, from which traditional meals are prepared. These foods include thin or thick fermented or unfermented porridge, boiled products similar to maize grifts or rice, boiled whole kernels and popped sorghum. Moreover, sorghum and wheat composite flour is now commonly used for making flat bread (chapatti) and other deep fried preparations such as buns from fermented or unfermented dough. Other uses include prepared of alcoholic and non- alcoholic beverages.

In recent years, Tanzania Food and Nutrition Centre, Sokoine University of Agriculture and University of Nebarska-Linkoln (UNL), conducted some trainings on sorghum processing and entrepreneurship to a number of small-scale processors, both individually and in groups, who are now fully engaged in the business of processing sorghum food products for selling. One of the products that have expanded its presence in the market is the sorghum flour, popularly known as Unga Bora wa Lishe. The

product, usually packaged at different weights is being sold in supermarkets, food stores and grocery shops in the eastern Africa region. *Unga bora wa Lishe* product is viewed not only as the best supplementary food for children, but also used by people with diabetes and high blood pressure and other health conditions especially opportunistic diseases associated with HIV/AIDS.

Different studies have shown that overall acceptability of sorghum as human food compared to other cereals such as maize, rice, wheat etc. is still low even in regions showing promising potential for its production and utilization. There are a number of reasons for low acceptability. One is poor starch and protein digestibility. Second, is inadequate knowledge on the nutritional and health benefits of sorghum, negative attitude and limited product development expertise. Due to these and other reasons, sorghum is categorized as a low nutritional value food and a food for the poor, however, there are several methods of processing that are known to have some effects on the digestibility of sorghum and if used can solve the problem of poor starch and protein digestibility in sorghum therefore improve its nutritional quality (Chavana *et al;* 1989).

Sorghum Grain Composition and Functionality

Like all other cereals, the sorghum kernel is composed of three main anatomical parts, namely the pericarp (bran), germ and endosperm (Hoseney, 1994). The pericarp is the outer protective layer making up to 5-6 % of the kernel weight and a rich source of dietary fiber, minerals and vitamins. The endosperm is the storage tissue and the largest part of the kernel and a major source of both starch and protein. The relative proportion of protein and starch in the endosperm is the most important factor affecting grain hardness and density.

The germ contains two major parts, the embryonic axis and the scutellum making up to 10-14 % of the kernel weight. It is a rich source of lipids similar to corn oil (Rooney et al, (1978). The scutellum on the other hand is a storage tissue and rich in lipids, proteins, enzymes and minerals.

Non-starch polysaccharides (NSPs) constitute about 2-7% of the kernel weight, and are the main cause for the insolubility and resistance nature of sorghum starch. Most NSPs are located in the pericarp although some can be found in endosperm cell wall (Hoseney, 1994). Cellulose, hemicellulose, minerals, protein, phosphorus, phytates, fat, niacin, thiamine and riboflavin are also found in the bran (Hoseney, 1994; Serna-Saldivar and Rooney, 1995). The most important non-starch polysaccharides include arabinoxylans and β-glucans. While arabinoxylans are said to play an important role in the processing of sorghum for baking and brewing, the β-glucans are associated with processing problems such as poor wort and beer filtration rate (Serna-Saldivar and Rooney, 1995).

Carbohydrates, in the form of starch, are located in the endosperm and are most abundant (60-80%) in the sorghum kernel (Hoseney, 1994). Starch is the main source of energy required for germination and is made of two large molecules namely amylopectin, a branched-chain of α-glucose units joined by (1-4) and (1-6) glycosidic bonds with content in sorghum starch ranging from 45-54%, and amylose, a straight-chain polymer, with α-glucose units held together by (1-4) glycosidic bonds (Duodu et al,2003). Amylose that constitutes about 10-17% of sorghum starch is capable of forming helicoidal structure in solutions. The interior of the helix is hydrophobic allowing amylose to form a complex with free fatty acids and iodine. It has a higher gelatinization temperature (70-75^0 C) than amylopectin (Dufour et al; 1992; Taylor, 1983) and is more susceptible to retro-gradation than amylopectin (Gomez et al; 1988).

Low amylose-containing sorghum varieties are suitable for brewing and extrusion cooking and are also recommended for infant formulations and preparations. Preparation of thick paste for noodles requires high amylose content. The majority of the carbohydrates in sorghum are starch with low amylose content and therefore suitable for brewing and preparation of infant formulations.

Protein is the second major component (7-15%) of the sorghum kernel. It is located mainly in the endosperm and divided into kafirins, albumin, globulins and glutelins. Kafirins (prolamins) constitute the major protein fraction in sorghum with about 50-70% of protein mass followed by glutelins (FAO, 1995; Hamaker et al; 1995; Oria et al; 1995; Duodu et al; 2003).

These protein fractions are within the protein bodies and protein matrix of the starchy endosperm. Kafirins are further subdivided into three types α, $_β$ and γ-kafirins, with α kafirin (80%) being the principle storage proteins of sorghum. The $_β$ and γ-kafirins account for about 5 and 15% of the total kafirins, respectively (Jambunathan et al; 1975). The nutritional quality of sorghum is poor because these kafirins (prolamins) are protease resistant**.** This is a big challenge especially for developing countries (including Tanzania) where protein quality is critically important yet the human diets consist mainly of cereals.

Lipid content of sorghum, averaging about 3%, is higher than that of wheat and rice but lower than that of corn and pearl millet (Hulse et al; 1980; Serna-Saldivar and Rooney, 1995). Most of the lipids of sorghum are located in the scutellum and therefore can be significantly reduced when kernels are decorticated and de-germed. Fatty acid composition of sorghum oil is similar to that of corn oil, with high concentrations of polyunsaturated fatty acids including linoleic (49%), oleic (31%), and palmitic (14%) acids. In addition, the oil contains linoleic (2.7%) and stearic acids (2.1%). (Hoseney, 1994, Hulse et al, 1980).

Both vitamins and minerals in sorghum kernel are concentrated in the aleuronic and germ and therefore the removal of these tissues by decortications will result into getting a refined sorghum product that has lost a major part of these important nutrients.

Sorghum is the only cereal that contains a significant amount of β-carotene, the provitamin

of vitamin A, which is an important vitamin for human physiology, and a good source of lipid soluble vitamins A, D, E and K (Hoseney, 1994), B-vitamins (thiamin, riboflavin, and pyridoxine), and tocopherols (Dykes and Rooney, 2004). Whole grain sorghum is considered rich in minerals such as magnesium, iron, zinc, copper, calcium, phosphorus and potassium found in the pericarp, aleurone layer and germ, (Anglani, 1998).

Health and Nutritional Benefits of Sorghum

Apart from having substantial amounts of both macro and micro nutrients, some sorghum contains high amounts of phenolic acids, flavonoids, and condensed tannins. Different studies have shown that, these compounds have numerous health benefits to humans including the ability to decrease the risk of cardiovascular diseases by improving endothelial function and inhibiting platelet aggregation (Carr et al; 2005; Dykes and Rooney, 2006), and known to have anti-carcinogenic properties (Chen et al; 1993).

After studying populations consuming sorghum and millet, Chen et al (1993), found that, individuals from the respective study populations had a lower incidence of esophageal cancer compared to other populations consuming wheat or maize and therefore concluded that, these cereals have anti-carcinogenic properties. Morton (1970; 1972) on the other hand, reported that, there was an association between high tannin sorghum consumption and human esophageal cancer. Grimmer et al. (1992) showed that, polymeric tannins from sorghum had higher anti-mutagenic properties, and that, a reduction in colon carcinogenesis could be due to the antioxidant activity of the black and tannin sorghum bran.

Some sorghum with a pigmented pericarp provides a unique opportunity to produce special food products with high levels of dietary fiber, antioxidants and a variety of phenols. Tannin sorghums with red or brown pericarps are often used in the production of opaque beers, since the dark color imparted to the beer by the pericarp pigments is a desirable attribute. Black and tannin sorghum bran can be added into- yeast-leavened bread formulas to produce food products with potential health benefits like good-quality breads containing tannin sorghum

bran, high phenols, antioxidant activity, and dietary fiber levels with a natural dark-brown color and excellent flavor (Rooney and Waniska, 2000; Gordon, 2001).

Starch and protein digestibility

Regardless of its nutritional and health benefits, sorghum is among the cereals with poor starch and protein digestibility. Sorghum possesses low starch digestibility (Zhang and Hamaker, 1998) that has been shown to affect the feeding value in livestock (Axtell et al; 1981), and to cause a higher loss of energy in humans (MacLean et al; 1981). Factors affecting the digestibility of sorghum starch include cultivars, the extent of starch-protein interaction, and the physical form of the starch granules, presence of inhibitors such as tannins, and the type of starch.

According to Pflugfelder and Rooney (1986), the starch in the endosperm of the sorghum kernel is surrounded by a dense, hard peripheral endosperm layer that resists water penetration, prevents both physical and enzymatic digestion and mechanical disruptions (Rooney and Sullin, 1977). The layer is largely responsible for restricting the availability of starch to enzymatic hydrolysis. Starch granules of the sorghum endosperm are embedded in a dense protein matrix; with high levels of prolamin-containing protein bodies that surround starch granules thus acting as barrier to starch gelatinization and starch-protein interactions. All these factors are known to contribute to the lower starch digestibility of sorghum.

Another nutritional constraint to the use of sorghum as food is the poor digestibility of sorghum proteins after cooking. Proteins of wet cooked sorghum are significantly less digestible than the proteins of other similarly cooked cereals like wheat and corn. According to Doudu et al, (2002; 2003) poor protein digestibility is caused by both non-protein components (polyphenols, phytic acids, and starch and non-starch polysaccharides) and protein components (disulfide and non-disulfide cross linking, hydrophobicity and changes in protein secondary structure).

Protein cross-linking is the greatest factor that influences the low quality of sorghum digestibility (Duodu, 2002). Tannin-protein

interaction in sorghum involving hydrogen bonding and hydrophobic interactions whereby tannins are capable of binding and precipitating at least 12 times their own weight of protein (Butler et al; 1984). Tannins, associated with pericarp or endosperm cell walls in sorghum kernels lower protein digestibility either by reducing the accessibility to enzymes or by forming indigestible complexes (Glennie, 1984; Taylor 2002). Another cause of poor sorghum protein digestibility is the presence of higher proportions of cross-linked kafirins that causes intermolecular disulfide-cross linking among kafirins (Hamaker, 1986; 1987).

Poor starch and protein digestibility limits the use of sorghum flour for the preparation of supplementary foods, and therefore any processing method that can expose the starch granules and protein matrix to digestion may help overcome the digestibility problem. There is evidence that malting and fermentation can increase the digestibility of protein in sorghum and therefore an improvement in its nutritional value. Kazanas and fields (1981) reported an improvement in the in-vitro digestibility of protein and starch, while Chavan et al. (1988), and Au and Fields (1981) indicated an improvement in the composition and content of essential amino acids, and an increased absorption of minerals such as zinc, iron, potassium, magnesium, and calcium in malted or fermented products. A decrease in tannin content and increase in the vitamin B6 and C contents during malting and or fermentation procedures were also reported by Hassan and El Tinay (1995).

Processing Methods

Malting and fermentation are among the traditional processing methods that are widely used in Africa for the preparation of foods and beverages. Malting is the controlled germination followed by controlled drying of the kernels. The main objective of malting is to promote the development of hydrolytic enzymes, which are not present in non-germinated grain (Dewar, 2003).

In-vitro studies on digestion of sorghum show that, malting caused an improvement in protein digestibility and other protein quality characteristics, including percentage of soluble protein, nitrogen solubility index and content of the most limiting amino acid, lysine (Dewar et al; 1995; 2003; Taylor, 1983). Other benefits of malting process in sorghum include, an increased vitamin C content, phosphorus availability, and synthesis of lysine and tryptophan. Also, during malting, both starch and protein are partially degraded allowing for better digestibility. Furthermore, amylases are elaborated and as a result, the viscosity of gelled starch decreases.

Furthermore malting has produced improvement in flavor profile and color of sorghum food product (Rooney and Waniska, 2004; Gordon, 2001). Research conducted on the improvement of the protein quality of sorghum and its introduction into staple food products for southern and eastern Africa showed that malting apart from improving the malt quality characteristics, also improved the digestibility and quality of the protein, which generally increased with increased malting time (Carnovale et al; 1988; Dewar et al; 1997). Therefore, in view of these multiple benefits, use of a malting processing method needs to be well studied and advocated. The process of malting comprises three unit operations which are: steeping, germination and drying.

During steeping phase, kernels are immersed in water until imbibed with sufficient water to start the metabolic processes of germination and at the same time dirt, chaff and broken kernels are removed by washing and flotation. The germination phase begins after the kernels have absorbed enough water to start enzyme production and starch hydrolysis. Conditions that are necessary during the germination phase are moisture content, temperature, length of germination time, and oxygen availability. Germination takes about 4-6 days and occurs rapidly between 20^0C and 30^0C with an optimum temperature of 25^0C to 28^0C. (Hoseney, 1994).

The most important physiological processes associated with the germination phase are the synthesis of amylases, proteases and other endogenous hydrolytic enzymes (Hoseney, 1994). During the process, the hydrolytic enzymes migrate from the germ into the endosperm where starch and protein are hydrolyzed to sugars and amino acids,

respectively. These are then transported into the germ where they are further metabolized by the growing seedling (Hoseney, 1994; Leder, 2004).

Drying is the final phase of the malting process and is required for stopping further growth of the kernels, reducing the moisture content and water activity, hence producing a shelf-stable product with active enzymes (Hoseney, 1994). Kernels are dried at a temperature of about 500C for 24 hours (Hoseney, 1994). After drying the roots and shoots are removed and the kernels milled into malted flour ready for use in the preparations of different food products. Elaboration of amylases during malting has been taken advantage of in the development of supplementary foods and different infant and young child formulations.

Fermentation, on the other hand, is a microbial metabolic, aerobic process, involving carbohydrate as the substrate and can be done either by yeast to produce alcoholic beverages or by bacteria to produce non-alcoholic products. Like malting, fermentation has been used to improve the flavor, texture, and palatability of foods. Various studies have shown that, fermentation can increase the concentrations of vitamins, minerals and protein (Taylor et al; 2000), soluble protein (Chavan et al; 1988) and provide better essential amino acids composition as a result of de novo production of important amino acids (Au and Fields, 1981), fermentation causes changes in food quality indices including texture, flavor, appearance, nutrition and safety (Rooney, 1995).

Fermentation can also improve mineral availability and increase vitamin B content particularly thiamine (Manning, 1970; Mugula et al; 2003). Furthermore fermentation can improve microbiological safety and keeping quality of foods (El Tinay and El Hidai, 1979), increase in vitro carbohydrate availability and starch digestibility (Manning, 1970) and improve in vitro protein digestibility (Carnovale et al; 1988; Oria et al; 1995).

According to Kazanas and Fields (1981), fermentation processing method can help enrich the nutritive content of essential nutrients through microbial synthesis and improvement in protein and carbohydrates

digestibility (Taur et al; 1984). This is probably due to both the enzymatic breakdown of the proteins by microorganisms in the fermentation medium and the effects of decreased pH during fermentation (Carnovale et al, 1988). Other studies also showed that, fermentation could help to remove ant-nutrients, natural toxicants and mycotoxins (Hassan and El Tinay, 1995). It can improve nutrient density and increase the amount and bioavailability of nutrients through degradation of anti-nutritional factors, pre-digestion of certain food components, synthesis of compounds that improve absorption and by influencing the uptake of nutrients in the intestine (Leder, 2004).

Conclusion

There is clear evidence that sorghum is a food of nutritional and health benefits to humans and a dependable food security crop in Tanzania. Issues of poor digestibility can be solved by deploying methods such as malting and or fermentation. These processing technologies if used properly can help improve food availability, accessibility and its bioavailability. Since malting and fermentation process can change the composition and functionality in sorghum kernel components. Therefore can be relied to improve the nutritional quality of sorghum food products. This way the two processes may help to increase the consumption of sorghum based food products in the country. Increased consumption will translate into increased production. Increased production on the other hand, will result into more harvest and thus enough food for use as food and surplus for sale, eventually an improvement in the household income and nutrition status followed by a reduction of poverty and malnutrition.

Further studies on improvements of sorghum food products including product development and recipe formulations are warranted. Such study would shed light on the health and nutritional benefits of sorghum and therefore change people's negative attitude towards this precious crop. Furthermore, functional property analyses like hardness, springiness and color of sorghum products such as buns, donates etc. as well as oil uptake during frying those products and other pre-treatments on sorghum flours needs to be studied.

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Contribution of care, hygiene and sanitation to maternal and child nutrition status in Kilosa district

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Abstract

Under-nutrition is a multifaceted problem. However emphasis has been on food availability when designing intervention strategies, leaving aside other factors which are equally important. Neglected factors include care and sanitation and this has partly been caused by little appreciation of their contribution to under-nutrition. A study was conducted in Kilosa district to examine under-nutrition determinant factors and their relationships. Face to face household interviews were administered to mothers using a structured questionnaire to assess various under-nutrition risk factors while nutrition status was assessed using anthropometric indicators. Results showed that inadequate care and sanitation were important factors in maternal and child nutrition. Little time (2.6 ±1.7 hours per day) was spent by mothers to attending to their young children care needs due to heavy workload of other activities. Provision of care by sibling was 5.1 ± 1.1 hours per day. Hygiene and sanitation was found to be poor. Care quality score was positively and significantly correlated to adequacy of food consumption score (r = 0.17, p < 0.05). Hand washing score correlated positively and significantly with toilet quality score (r = 0.38, p < 0.01). Hand washing score was also important contributor to women nutrition status as it correlated positively and significantly with women BMI (r = 0.2, p < 0.05). Households with poor toilet quality were more likely to have sanitary related ailments (p = 0.03). Care, hygiene and sanitation practices are recommended to accompany nutritional problems intervention.

Key words: maternal and child care; hygiene and sanitation; nutrition status

Introduction

Under-nutrition in humans is a multifaceted problem and causes vary depending on groups affected (infants, children, women or men). Care accorded to members of the household and sanitation levels do vary also from one household and the community to the other. Care, hygiene and sanitation are important factors in determining maternal and child nutrition status in rural communities. However, documentation of details of the relationship among care and sanitation factors and their contribution to observed under-nutrition has been scanty. Inadequate or inattentive care is known to be important factor behind child under-nutrition (WHO, 2008). However, this depends on context as importance of their contribution may sometimes be insignificant (Butteheim, 2008).

Adequate care is defined as sufficient time, attention, support and skills provided in the household and in the community to meet the physical, mental and social needs of growing children and other members of the household. Personal hygiene scores have been seen to be significantly higher among well nourished and healthy children than for those who were undernourished and those who reported morbidity in the two weeks prior to the study (Deb *et al,*. 2010). Similarly, sanitation and water accessibility independently contribute to infant, child and maternal mortality globally (Cheng *et al,* 2012) but data from local situation may portray different picture. In addition, 50% of under-nutrition has been associated with repeated diarrhea as a result of unsafe water, inadequate sanitation or insufficient hygiene (UNICEF and WHO, 2009). Diseases are known to contribute to poor nutrients utilization in the body and can lead to under-nutrition (Arimond and Ruel, 2004) but pathways of relationship vary widely among communities. Therefore, understanding of

specific factors interacting to cause the observed under-nutrition in a particular location or culture is imperative in order to better inform relevant intervention strategies formulation for that particular area and similar situations.

This study was carried out to examine contribution of care, hygiene and sanitation to maternal and child nutrition status and their interrelationships in a local community in Tanzania.

Methods

This was a cross sectional study design and a multistage random sampling was used to get sample representing Kilosa district. All divisions (9) in Kilosa district were listed and one division selected randomly (Kimamba division selected). The same procedure was employed to obtain one ward (Rudewa ward) from the list of all wards in Kimamba division and then one village (Rudewa-Mbuyuni) was selected out of 4 villages in that ward. Villages in Tanzania are divided in hamlets (*vitongoji*) or clusters / communities. A hamlet can have about 50 to more than 200 households depending on the population density of the area hence requiring proportionate consideration when selecting households. Therefore, households were randomly selected proportional to the population size in each hamlet. A systematic random sampling was employed using village register and sample of households to be included in the study obtained. All members in each sampled household had their anthropometric measurements taken for assessing nutrition status.

Study population, inclusion and exclusion criteria

The study population was children under five years of age and mothers between 15 and 49 years. Pregnant women and women outside that age range were excluded in the analysis. Those who were sick during the interviews were also excluded.

Sample size determination

A formula, $N=4Za^2$ pq/d^2 (Hulley and Cummings, 1988) was used to determine sample size. The formula gave 349 preschool children, then assuming 1.5 children per household

and adding 10% to take care of no response approximated the sample to 256 households.

Data collection

Information was collected on socio-demographic; household care; primary health care; infant and child feeding practices (time of breastfeeding, colostrums feeding, complementary feeding). This was done by administering a face to face interview to mothers in each of the sampled households. For anthropometric assessment, electronic scale (SECA, Hamburg) with a digital screen was used for weighing and a stadiometer (Shorr Productions 17802 Shorley Bridge, Maryland) for use in survey settings was used for measuring heights.

Height

For children less than two years of age, recumbent length was measured (lying down on the board). The board was positioned on a hard flat surface, and with the mother's help the child was placed on the board facing upward with the head towards the fixed end and the body parallel to the long axis of the board. Child's knees were pressed onto the board so that the legs were straight and the toes pointing directly upwards, then the movable footboard was brought to rest firmly against the heels and measurement was taken to the nearest 0.1cm. For children above two years of age and mothers, stadiometer was placed against a wall firmly for measuring height. Subjects were asked to stand straight with the head positioned such that the Frankfurt plane is horizontal, feet together, knees straight and heels, buttocks and shoulder blades in contact with the vertical surface of the stadiometer, hands hanging loosely with palms facing the thighs. The movable headboard was then lowered until it touched the crown of the head.

Weight

The SECA weighing scale was used for both women and children. The scale was placed on a hard flat surface ensuring that the display window is blank. Thereafter, the scale was turned on and given time (5 seconds) to adjust it to zero. To measure an adult, a person was asked to step on the scale and stand still to allow for weight to be

displayed. Then the measurement was recorded to the nearest 0.1kilogrammes. After measuring weight of an adult this electronic weighing scale is able to store the weight of adult in memory if taring is done.

After measuring weight of mother the weighing scale was tarred, then handing an infant or young child to the mother was done while she is standing on the weighing scale. The scale was eventually able to show weight of infant or young child held by the mother on scale indicator. Each subject was weighed with minimum clothing and with no foot ware. Measurements were taken to the nearest 0.1kg. Age and sex were also recorded.

Food consumption assessment methods

Twenty four hour recall (24-h recall) and food frequency questionnaire (FFQ) methods were used to assess food consumption adequacy. First, respondent were asked to recall what they ate during the previous 24 hours. Then, a food frequency questionnaire was administered to the same respondent. The questionnaire had daily, weekly, monthly or rarely categories and mothers were asked how often they consumed each item of food. The responses were scored in such a way that rarely or yearly received 1 point monthly 2 points score of 2, weekly 3 point and almost every day 4 points.

Then a combined scoring system was devised for food consumption adequacy determination (combination of diversification of meals and frequency of meals in a day) If the respondent reports less than three meals a day and single type of meal then 1 point was allotted; if two types of meals/foods but less than three meals a day 2 points allotted; if two types of meals/foods and three meals 3 points and 4 points was given to those with good diversified meals, balanced in terms of food groups and meal frequency exceeding 3. Scoring enabled assessment of quality of diet and also linking to other variables (socioeconomic, food availability, care and sanitation related variables).

Assessment of perception of respondents on care

This assessment was based on understanding that care quality is a function of many factors including traditions and what people believe. Therefore, Likert type of summated scale was employed to assess perception of respondents on conventional caring practices in order to get reasons to the observed quality of care. Respondents were asked to give opinions regarding conventional caring practices as presented to them in form of ten care statements in the questionnaire. Their opinion regarding conventional caring practices were captured through their opinion on whether they strongly agree, disagree or were indifferent (neutral) with what professionals advocate regarding conventional caring practices. Therefore, the responses were scored on 50-point scale meaning that possible results of the scoring of conventional caring practices statements on summated scale were: strongly agreeing = 5 x 10 hence 50; agreeing score = 4 x 10 hence 40; neutral = 3 x 10 hence 30 and anything below 30 is disagreeing i.e. 2 x 10 and 1 x 10.

Assessment of sanitation

Two types of scoring system were employed to assess sanitation. Scoring of hand-washing practices based on mothers' response to questions relating to hand-washing and scoring of environmental sanitation (garbage disposal, water treatment and quality of household toilet facility). Mothers were asked to tell when do they normally wash hands and their responses were judged based on coverage of critical points that need hand washing namely before eating, before feeding babies, after cleaning baby's bottom and after going to toilet. They were also asked to tell how they dispose baby' faeces, garbage from households and whether they do anything for drinking water to ensure safety. Overall household sanitation was assessed by combining hand washing practice, garbage disposal and quality of toilet the household use. Toilet quality assessment was based on observation to ascertain presence of toilet facility and rating its quality by assigning points (no toilet = 0 point, temporary toilet = 2 points; semi- permanent toilet due to unroofed structure = 3 points, permanent toilet but dirty = 4 points and permanent toilet and clean = 5 points.

Statistical analysis

WHO Anthro (3.1) software was used to compute nutritional indices and SPSS program version 16 was used for analysis of data. Regression analysis was done to quantify contribution of key factors to the observed nutrition status as represented by the following equations:

$$Y = a_1 + b_1 x_1$$

where:

Y is nutrition status index like women BMI and x_1 is independent variable such as sanitation score, morbidity and care

Results

Demographic and socioeconomic status of the studied population

A total of 206 mother-child pairs participated in the study. About 50 percent of the women had attained primary school education fully, about 8 percent had partial primary education, 30 percent had no formal education and 12 percent had education above primary school (secondary school and college education). Most of the houses were of low quality. Earth floor was found in 93.8 percent of the households, and about 57.0 percent of the households used grass as roofing materials while 42.0 percent used galvanized iron sheet as roofing materials. Burnt bricks were used by 64.0 percent of the households and 23.0 percent used poles for construction of walls. Mean family size was 4.4 ±2.3.

Nutrition status

Acute child under-nutrition was not a public health problem based on weight-for-height index. However, prevalence of chronic under-nutrition based on height-for age index in children was high in all five communities with highest prevalence in Kigenge and Mkoroshini hamlets (46.7 and 47.6 percent respectively) (Table 1). Similarly, low BMI in women was not as serious as overweight (5.8 vs 22.7 percent).

Table 1: Household characteristics and prevalence of stunting in children under five years of age in studied communities (hamlets)

Particular	Shuleni		Muungano		Kigenge		Mkoroshini		All	
	n	%	n	%	n	%	n	%	n	%
Family size										
Below 3	9	20.9	12	23.1	6	16.2	10	21.7	37	20.8
3-4	11	25.6	19	36.5	10	27.0	16	34.9	56	31.5
5-6	11	25.6	16	30.7	17	46.0	14	30.4	58	32.5
7 and above	12	27.9	5	9.7	4	10.8	6	13.0	27	15.2
Stunted	30	37.0	15	30.0	38	46.7	20	47.6	91	39.0
Sample underfives(N)	81		50		45		42		234	100

Children aged 24-35 months had the highest percentage of stunted children (Table 2) and stunting increased with age, climaxed before the age of three and dropped thereafter (Fig.1). Before six months of age undernourishment was not evident.
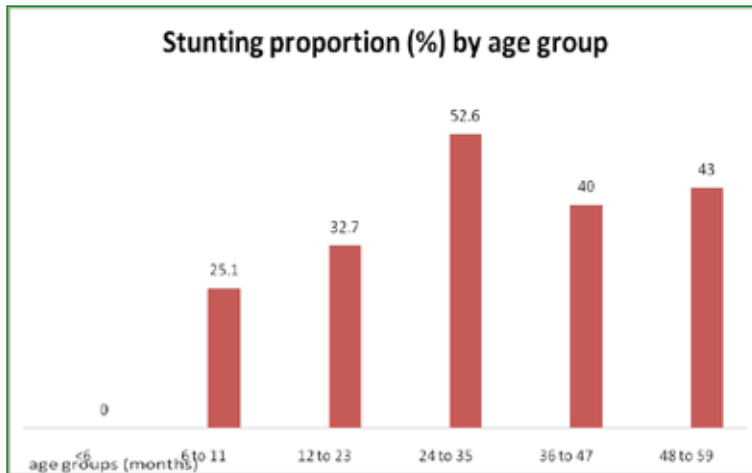
Fig. 1: Prevalence of stunting by age categories

About 4 percent of all children under the age of five years were obese. Similarly, prevalence of obesity in women was high (7.1%).

Table 2: Prevalence of stunting by age categories in children under the age of five years

Nutritional status	Age categories (Months)											
	0-5.9		6-11.9		12-23.9		24-35.9		36-47.9		48-59	
	n	%	n	%	n	%	n	%	n	%	n	%
Moderate stunting	0	0	3	18.8	8	14.5	23	39.0	15	30.0	13	31.0
Severe stunting	0	0	1	6.3	10	18.2	8	13.6	5	10.0	5	12.0
Total stunting	0	0	4	25.1	18	32.7	31	52.6	20	40.0	18	43.0

Table 3 presents detailed results of nutritional status assessment for children under the age of five years and women as assessed through anthropometric indices. Mean z-score and mean BMI showed again that unlike acute under-nutrition which was not a significant problem in this population, stunting in children under the age of five was a significant problem.

Table 3: Prevalence of malnutrition, mean z-score and mean BMI for children and women

Group	n	%	mean (z-score / BMI)
Children under five yrs			
Height-for-age index			
Stunted	91	39.0	-0.55 ± 2.3
Normal	143	61.0	
All	234	100.0	
Weight-for-age index			
Underweight	35	15.0	-0.45 ± 1.9
Overweight	11	4.7	
Normal	188	80.3	
All	234	100.0	
Weight-for-height index			
Wasted	4	1.7	-0.16 ± 1.1
Overweight	9	4.0	
Normal	221	94.3	
All	234	100.0	
Women			
Low BMI	9	5.8	19.8 ± 4.5
Over-weight	46	29.9	
Normal	99	64.3	
All	154	100	

Food consumption

Results showed that the number of meals per day had a mean of 2.9±0.6 and diversification of diets was low. Proportion of respondents with poorest quality was 15.5% and proportion with best quality diets was 50.8%.

Consumption of animal source foods (ASF) was low as the only substantial consumption was that of sardines which was eaten weekly (score of 3.0), while consumption of beef, fish and milk were rare, eaten monthly (scored 2.3, 2.2 and 2.1 respectively). The same low consumption was found in fruits where highest score were that of banana, pawpaw and citrus which were 2.8, 2.4 and 2.1 respectively. Vegetables and legumes were frequently consumed, (score of 3.5 and 3.4 respectively).

Only 44.0% of respondents had adequate consumption the day before the study as captured by the 24-hour recall. Mean for diet quality score was 2.4 ±0.8. Mean for number of meals per day was 2.9±0.6 and about 16.5% of the households had less than 3 meals per day.

Food consumption adequacy score correlated positively with household income (r=0.28, p<0.01); quantity of maize produced by the household in that particular season (r=0.25, p<0.01); quantity of paddy produced by the household in that particular season (r=0.15, p<0.05) and household care adequacy score (r=0.17, p<0.05). Households with higher income, higher yield of maize and higher yield of paddy in that particular season were more likely to have adequate number of meals per day (r=0.20, p<0.01; r=0.25, p<0.01 and r=0.14, p<0.05 respectively).

Food secure households had significantly higher food consumption (r=0.30, p<0.001) and significantly (p<0.05) higher mean BMI than household with food shortage (23.7±3.6 versus 21.8±3.5). Women BMI was positively and significantly (p<0.05) correlating (r=0.25) with the household annual incomes and women from food sufficient households had significantly (p<0.001) higher BMI.

Maternal care

Mothers seem to know why they should attend antenatal care throughout the schedule but their attendance does not match the knowledge. They were asked about duration of their attendance to antenatal care for the last pregnancy and their understanding on importance. Attendance of antenatal care (for the whole pregnancy period) had a mean of 4 visits (Table 4). Almost half (49.7%) of men do not provide support to their spouses for attending antenatal and postnatal care, while about 29% do not perceive that to be their responsibility. About 7% do not set aside any budget for their wives pregnancy care.

Table 4: Antenatal care attendance performance, knowledge and reported birth outcomes

Performance	n	min	max	mean±sd
Duration (months) of attending antenatal care by respondents (women)	137	1.0	9.0	4.6 ±.2.1
Gestation age (months of pregnancy) known by respondents (women) as appropriate for the first visit to an antenatal care facility	86	1.0	6.0	3.16 ± 0.9
Birth weight (kg) recorded (clinic cards record)	50	2.1	4.0	3.15 ± 0.4
Number of still birth that occurred to respondents' life	22	1.0	5.0	1.63 ± 1.1

Child care

Breastfeeding
Mothers were asked about the status of breastfeeding of their youngest child and it was observed that 59% of them initiated breastfeeding immediately after delivery (within the first hour after delivery). About 36% initiated breastfeeding beyond one hour and 4.5% initiated one day after delivery. Only 15.5% of infants under 6 months are exclusively breastfed. Reasons given by the majority (63.5%) for not breastfeeding exclusively for six months relates to mothers' assumption that breast milk was no longer sufficient. Others (13.1%) gave genuine reasons approved by professionals like abnormalities and ailments (12.4%) and others mentioned cultural reasons (barriers or norms). Few (9.5%) indicated that they were too busy with other activities (farming activities, petty business and household chores like firewood collection and fetching water) hence obliged to introduce solids before the recommended age.

Complementary feeding

Generally complementary feeding is not done properly. Complementary foods were often introduced when the baby was hungry or crying or when the baby show interest in foods. Professional guidance is seldom followed because of tendency to follow traditions and being too busy (heavy workloads) with other obligations. Feeding frequency for children under the age of five years and quality of complementary foods were low (mean of 2.5±0.9) and bulky porridge of low quality dominated as complementary food. Maize porridge was the most (58.0%) important complementary foods fed to infants. Other complementary foods that are used include mashed potato and vegetables.

Psychosocial stimulation

Another child care aspect explored was psychosocial stimulation and support in early childhood. Children need time to play and stimulate or exercise their intellectual faculty and these child activities need to be guided by care providers by allocating sufficient time for guided or monitored playing. In the present study it was observed that only 33% of the respondents allocated time for children to play. For those who do not allocate time for guided playing had the following as reasons: insufficient time (55%), not necessary (24%), and unable to cope with children activities (17%).

Mean time spent by mothers to stay with children was 2.6 ±1.7 hours and sibling care was availed most as a mean of 5.1 ± 1.1 hours per day was observed (time spent by siblings to stay with young children). This kind of extended family arrangement for giving care to children was in about 56% of the households. In about 33% of households care is solely parents (mother and father) responsibility.

Results of assessment of perception of respondents on conventional care showed community members disagreed (29.5 score) with the currently advocated care to children and women. However, the respondents agreed with need to reduce women's workload. They were undecided with restriction of children freedom; denying women deserved care and family planning. They disagreed with advocated psychosocial stimulation and support (early stimulation and play support to children) and were in favor of harsh punishments to children.

Morbidity and Health Care Seeking behavior

Generally, morbidity was high as almost half (47.0%) of the respondents reported illness in their household in the two weeks previous to the survey. Prevalence of morbidity in children was 26.7%. Some weaknesses were also identified with service seeking behavior and these weaknesses had some links to poor knowledge and negative attitude towards kinds of services availed. About half (52%) of the respondents do not normally send their sick children to the health facility. Reasons were that the facilities are not equipped with adequate supplies (medicines and working tools), they cannot afford financially and service providers are irresponsible in that order of importance. This was also reflected in the proportion (8%) using medicine without prescription and proportion(4%) using traditional healer's services (Table 5).

Table 5: Health service seeking behavior and perception of respondents on quality of health care services provided, constraints faced and attitude towards professional advice

Index	n	%
Health service seeking behavior (n=206)		
Regular seekers of conventional medical services	181	87.8
Self medication practicing	17	8.3
Regular users of alternative medicine (traditional)	8	3.9
All	206	100
Respondent's perception on constraints of services		
Affordability by respondent as perceived constraint	80	24.2
Medicine supply as perceived constraint	169	51.2
Personnel shortage/conduct as perceived problems	76	23.0
All	325	100
Practice or outcome (n=104)		
Home deliveries (including TBAs homes)	14	13.4
Gvt hospital facilities deliveries	86	82.8
Other facilities deliveries	4	3.8
All	104	100
Respondents trusting professional advice	44	42.3

Water, hygiene and sanitation

Majority of the respondents do not maintain proper water treatment, hand washing, garbage disposal and clean toilets. About 87 percent of households interviewed do nothing to ensure water is safe for drinking. The mean distance to a water source was 0.61 kilometers and the average time taken to fetch water was 13 minutes. About 11% of households had no toilets, and this was attributed to lack of resources for construction for the major (75%) and negligence (25%) i.e. lack of desire to construct one. Moreover, about 22% of the respondents do not use any washing agents in household utensil washing and hand-washing. In about 72% of the households there were at least a member who had happened to be afflicted with disease related to poor sanitation in the two weeks period preceding the study while the common diseases in these communities were malaria, acute respiratory tract infections and diarrhea.

Sanitation score (involving hand-washing practices, toilet quality, baby bottom cleaning and garbage disposal) correlated positively and significantly ($r = 0.2, p < 0.05$) with women BMI. Hand washing score also correlated positively and significantly with toilet quality score ($r = 0.38, p < 0.01$). On the other hand, households with poor toilet quality were more likely to have sanitation related ailments ($p = 0.033$). Also, each unit improvement in sanitation had more than unit improvement in nutrition status (BMI).

Table 6 shows that food availability, food consumption and sanitation contributed significantly to nutrition status. Also, sanitation, toilet quality and income contributed significantly ($p<0.05$) to the observed morbidity.

Table 6: Contribution of food variables, care variables and sanitation variables to nutrition status (women BMI) based on simple regression analysis

Independent variables	Regres coeff. or slope (b)	Intercept (a)	Conf level for (b)%
Food consumption score	2.78	16.195	>95
Sanitation & hygiene	1.03	21.122	>95
Food shortage score	- 0.328	16.195	>95
Maternal care	0.179		<20

The following were equations reflecting results of regression analysis:

Nutrition status as a function of food consumption

BMI = 16.195 + 2.78 food consumption (t =2.9, p =0.004)

Food consumption as a function of income and food availability

Food consumption adequacy score = 3.051 + 0.260 income − 0.328 food   shortage

Nutrition status as a function of food consumption and care

BMI = 16.19 + 2.7 food consumption adequacy score x 0.179 care

Nutrition status as a function of sanitation

BMI = 21.122 + 1.03 sanitation; t = 2.2, p = 0.02

Table 7 presents relationship of sanitation to morbidity. It was found that disease prevalence is a function of level of sanitation and quality of toilet (Morbidity score = 0.79 - 0.294 sanitation score + 0.008 toilet quality). About 40% of the variation of morbidity in the household around its mean is explained collectively by sanitation and toilet quality.

Table 7: Regression of morbidity (disease prevalence) in the household against sanitation variables

Ind. variables	Regr coeff (b)	R square	Std error	Intercept (a)	t	sig
Sanitation score	0.294	0.1	0.06	0.790	4.5	.000
Quality of toilet the household has/use	0.299	0.1	0.03	0.805	4.3	.000

R^2= 0.4

Discussion

Results of this study demonstrated association of under-nutrition to a number of factors ranging from socioeconomic characteristics like incomes, education level to food consumption, care and sanitation. Insufficient care, poor knowledge of health and nutrition including proper child feeding knowledge and insufficient support to pregnant women were key contributors to the observed under-nutrition in women and children. Major weakness in child care and serous negative implication were observed from six month of age to 35 months (Fig. 1). This implies among others that child feeding at the age of six months to two years is a critical window of weakness that needs to be corrected for prevention of the observed stunting in this community. A mean of 2.5 $\pm$ 0.9 meals per day is obviously low and this low feeding frequency coupled with low quality complementary food (mainly unfortified maize porridge) compromised child nutrition status.

Care and nutrition linkages

Correlation between care and food consumption adequacy score was positive and significant (r = 0.17, p < 0.05). This implies that maternal and child care was important contributor to food consumption levels. A child's chance of survival and well-being drops dramatically when deprived of a mother's care. Stunting is normally a characteristic of low socioeconomic status hence an outcome of consistent failure to receive adequate nutrition over time - normally associated with poor overall economic conditions, chronic or repeated infections and consistently inadequate nutrient intake. An important question here is why such shortfalls and what could be done to redress.

Inattentive care of young children coupled with unhygienic condition emanating from insufficient health and nutrition knowledge contributed significantly to the observed under-nutrition. Implications include the fact that intervention to prevent stunting should be directed to maternal care and child care in the first 1000 days. During this period children have proportionately higher nutritional requirements than other period because they are growing more rapidly, less able to express their needs and are more susceptible to disease. This is consistent with recently findings that globally the prevalence of stunting increases rapidly during the first 18 months (World Bank, 2006). Areas of emphasis in intervening according to the reasons behind inadequate care found in this study include: reducing women's workload by campaigning for change of attitudes particularly relating to spouse support (increasing men support to their spouses in care). Pregnant women need adequate rest, psychological and nutritional support, but all these are poorly provided. Similarly, children need psychosocial support quality breastfeeding (early initiation of breastfeeding, exclusive breastfeeding during the first 6 months of life, continued breastfeeding up to age 2 and beyond, timely introduction of complementary feeding) adequate feeding frequency with diverse food groups and sanitation (to control for infectious diseases).

Breastfeeding, complementary feeding and psychosocial support

Poor quality of feeding implies obvious risk of under-nutrition and reasons behind the observed shortfalls are those determined by the assessment of attitudes towards conventional care (disagreement with advocated conventional care is evidence of attitude gap).

Improper breastfeeding may have elevated risk of under-nourishment. The proportion (36%) of mothers who delay initiation of breastfeeding between 1 hour and 23 hours may affect production of milk negatively as early suckling stimulates the release of prolactin, which helps in the production of milk and oxytocin which is responsible for ejection of milk. Moreover, the first liquid to come from the breast, known as colostrums is produced in the first few days after delivery and provides natural immunity to the infant. The fact that they normally initiate breastfeeding late may explain why there were 'milk insufficiency' perceptions (which is frustrated milk flow rather than real insufficiency) and increased childhood morbidity (half of all women and a quarter of all children in the current study had episode of

illness in the two weeks preceding the study). This is in line with what was found in previous studies by Gijsbers *et al.* (2005) and Synontt *et al.* (2007).

Results of this study are also similar to the previous results of Tanzania Demographic and Health Surveys (NBS and ICF Macro, 2011) to a great extent except for some few which differ a bit from the national averages. These are observed low proportion (15.5%) of children under 6 months exclusively breastfed compared to the national average of 50.0%, prevalence of low BMI in non pregnant women (5.8%) which was far less than the national average of 11%.

Morbidity and health seeking behavior

The fact that more than ten percent of the respondents were not regular users of available conventional medical services (Table 5) implies poor health service seeking behavior. This partly is due to low level of education as literacy rate was found to be low. The low education definitely have negative implication because previous studies (NBS and ORC Macro, 2005) found that Tanzania women in the poorest quintile had list education and had least influence on decision making. This normally undermines their ability to adopt new behaviors that can prevent disease, ensure fast treatment of sick children, improved breastfeeding quality and other care choices. These need to be rectified for improving care elements for health and nutrition of women and children which include access to health facilities, quality of services, and professional conduct of health care providers. Antenatal care from a trained provider is important for monitoring of pregnancy in order to minimize risks of delivery complications hence safety of mother as well as the newborn. Other elements include knowledge and skills for care and feeding (Mayer, 2007).

Water, sanitation and nutrition linkage

The fact that majority (87%) do not care for water safety and significant proportion (11%) do not have toilets make unsanitary environment and related infectious diseases serious issues in the area. Moreover significant proportion (22%) does not observe proper hygiene (hand-washing). No wonder poor sanitation in the households contributed significantly to the observed disease prevalence (Table 7). Increased morbidity definitely increases under-nutrition risk. The poor sanitation observed in this study is similar to the national statistics which showed that sixteen percent of households in rural areas had no proper sanitation facilities (NBS and ORC Macro, 2005) implying need for a countrywide or national scale intervention.

Conclusion and recommendation

Care, hygiene and sanitation have significant contribution to the observed under-nutrition in Kilosa warranting serious attention when formulating strategies for improvement of nutrition status in the area and similar situations. Also competing demand on household members' time has compromised attentive care including ability to secure, prepare and serve food in the household. Nutrition education intervention is recommended to bridge the attitude, knowledge and practice gaps in the study community and support to enable devotion of more time on improving care. Educating people would promote their knowledge and attitude about food, dietary customs and care including maternal care. Even at minimum food resource availability, enhanced nutritional knowledge may maximize fairness in food distribution among household members, increase variety of food in meals and improve ways of preparing meals hence enhancing nutrition.

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