academicJournals

Vol. 9(4), pp. 81-88, April 2017
DOI: 10.5897/JAHR2017.0415
Article Number: 7A358F563311
ISSN 2141-2359

http://www.academicjournals.org/JAHR

Journal of AIDS and HIV Research

Full Length Research Paper

Efficacy of amaranth grain consumption on CD4 count and morbidity patterns among adults living with HIV in Nyeri, Kenya

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Received 14 January, 2017; Accepted 20 February, 2017

Human immunodeficiency virus (HIV) is associated with increased nutrient needs and compromised body immunity. Minimal information exists on effect of food-based interventions on health status of people living with HIV (PLHIV) and not on antiretroviral therapy (ART). This study investigated the efficacy of amaranth grain (*Amaranthus cruentus*) consumption on CD4 count and morbidity patterns among PLHIV. A one group pre-test-post-test study design was used on a sample of 66 pre-ART adults living with HIV. The study involved collection of baseline characteristics of the respondents; this was followed by consumption of amaranth grain porridge (100 g) for six months. Post-test data was collected and paired t- test was used to compare pre-test and post-test data. Daily consumption of 100 g of amaranth grain porridge increased nutrient intake. A significant increase (P=0.004) in CD4 count from 498.2±163 SD at baseline to 608 ± 157 SD post-test was observed. There was a significant decline in the number of respondents with any form of illnesses from a total of 52 (78.8%) at baseline to 21 (31.8%) respondents at month six (P=0.031). Amaranth grain increased nutrient intake, CD4 count and consequently reduced the prevalence of illness. The study recommends that nutrition and health practitioners should educate PLHIV on importance of use of amaranth grain to complement usual dietary intake.

Key words: Amaranth grain, CD4 count, morbidity pattern, people living with human immunodeficiency virus (PLHIV).

INTRODUCTION

People living with human immunodeficiency virus (PLHIV) are at a greater risk of malnutrition (Hailemariam et al., 2013). This is because human immunodeficiency virus (HIV) compromises the immune system resulting to increased susceptibility to opportunistic infections (Cahn et al., 2013; Luckheeram et al., 2012). This leads to

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increased energy and nutrient needs, reduced nutrient intake, increased nutrient losses, altered metabolism and poor utilization of nutrients in the body (Rajeswari et al., 2015). This makes both macronutrient and micronutrient deficiencies to be common among PLHIV (Ivers et al., 2009; Rawat et al., 2010). The challenge therefore remains on how to meet the increased nutrient needs amidst compromised intake. If these increased nutrient needs are not met, it leads to incomplete HIV suppression and decline in CD4 count (Tagwira et al., 2006). The number of CD4 cells count is an indicator of how strong immune system is and guides the initiation of antiretroviral therapy (ART) (Hazenberg et al., 2000). According to national ART guidelines, a CD4 count of <350 cells/mm3 is considered low and calls for initiation of antiretroviral (ARVs) (NASCOP, 2011).

The World Health Organization (WHO) recommends use of food based interventions to boost nutrient intake among PLHIV and to prolong the Pre-ART period (WHO, 2003). Studies have demonstrated that intervention with food supplements; including nutrients dense foods and other bio-active food components reconstitute the immune function by suppressing the viral load hence increasing the CD4 cell count (Cahn et al., 2013; Ivers et al., 2009; Rawat et al., 2010). However, the fundamental nutritional concern for HIV infected people remains the availability of adequate and quality diets on a continuous basis. With the raging global HIV epidemic, there is an urgent need to exploit all potential interventions to halt its continued effect on the health and quality of life of those already infected and not on ART. This study therefore assessed the efficacy of locally grown amaranth grain as a food based intervention on the health status of PLHIV.

Amaranth grain has been consumed throughout history as a staple food in most Mexican region (Kauffman et al., 1990). An increased interest in amaranth grain appeared in the 1980s, when the United States National Academy of Sciences performed research on the grain and described its high nutritional and health benefits (Caselato-Sousa et al., 2012). Amaranth grain has higher quality and quantity of protein than most staples (Tibagonzeka et al., 2014). Amaranth grain contains twice the level of calcium in milk, five times the level of iron in wheat, higher potassium, phosphorous, zinc, vitamin E and folic acid than cereal grains. Amaranth grain also consists of 6 to 10% oil, which is predominantly unsaturated and is high in linoleic acid, an essential fatty acid (Mburu et al., 2012). The varieties grown in Kenya have been found to have very high content of lysine (3.2 to 18%) an essential amino acid that is so low in most other grains (Mburu et al., 2012). Lysine has been used to manage infections with strains of the herpes virus along with other viral infections including HIV that causes AIDS (Gaby et al., 2006). The starch in amaranth grain consists mainly of amylopectin (94.3%) which are easy to digest (Tibagonzeka et al., 2014). The levels of nutrient inhibitors such as tannins (0.1 mg/100 g) and phytates (0.2 mg/100 g) in amaranth grain have been reported to be within the non-critical range (Mburu et al., 2012).

The high amounts of micronutrients in amaranth grain are beneficial to PLHIV in boosting the immunity and for energy metabolism (Onyango et al., 2015). Grain amaranth would, if adopted for consumption, therefore, enrich local diets and increase nutrient intake especially among vulnerable populations such as PLHIV (Tibagonzeka et al., 2014). However, consumption of amaranth grain in Kenya is still low especially in Central Kenya. This is due to minimal awareness of its nutritive value (Mwangi, 2003). Restoring both the macro and the micronutrient supply with amaranth grain could be one of the most important strategies for improving health status among PLHIV. This study therefore sought to establish the contribution of amaranth grain consumption on dietary intake, CD4 cell count and morbidity patterns of adults living with HIV in Nyeri, Kenya.

MATERIALS AND METHODS

Study design and sampling method

The study adopted a one group pre-test post-test experimental design (Dimitrov and Rumrill, 2003) to conduct a study in Nyeri County. Due to ethical reasons the study did not have a control group. The study targeted adults living with HIV attending home-based care groups in Mweiga ward, Nyeri County. At the time of study, Mweiga ward had three home based care groups and Mary Immaculate Home Based care group (HBCG) was randomly selected. The group had a total of 149 members. This study focused on PLHIV not on ARVs. According to national guidelines, initiation of ARVs is recommended when CD4 count falls below 350 cells/mm^3 (NASCOP, 2011).

The study also excluded PLHIV who were beyond 60 years of age, pregnant and lactating mothers. This was because physiological status such as old age pregnancy and lactation have been associated with immune suppression and decline in CD4 count (Hargrove and Humphrey, 2010; High et al., 2008). For ethical purposes all the 149 members of the group benefited from the food intervention but for the purpose of monitoring the effect of the intervention on CD4 count and morbidity pattern, the study focused only on the 83 who met the inclusion criteria. Data from seventeen (17) respondents was not analyzed due to various reasons such as relocation from the study area, missing data on CD4 count, inconsistencies in daily consumption of the amaranth grain porridge and any respondent who had no data on dietary intake and morbidity patterns for at least one single month.

Description of the study intervention

Baseline data on demographic and socio-economic characteristics, dietary practices, CD4 count and morbidity patterns among PLHIV was collected before the start of the study in January 2011 using a structured questionnaire. This was then followed by a food-based intervention from February to July 2011. The intervention involved consumption of 100 g amaranth (*Amaranthus cruentus*) grain in form of porridge. The nutrient content of the amaranth flour (Table 1) was established at Kenyatta University laboratory as the first phase of this study (Mburu et al., 2012).

The researchers demonstrated on how to prepare the amaranth grain porridge. Every respondent was provided with 4 kg of amaranth grain flour fortnightly. Also given was a standard cup to measure 100 grams of amaranth flour and a calibrated jug for measuring water. The respondents consumed the porridge daily for six months. Extra amaranth grain flour was issued to the respondents with other infected family members or under five children to avoid food leakage. To

Table 1. Nutrient content of amaranth grain used in this study.

Nutrient	Amaranth grain per 100 g
Energy (Kcal)	402.4
Protein (gms)	16.7
Lysine (gms)	0.59
Fat (gms)	7.0
Zinc (gms)	4.8
Iron (gms)	13.0
Calcium (gms)	189.1
Pyridoxine (mg)	0.4
Vitamin C (mg)	0.4
Potassium (mg)	324.4
Niacin (mg)	0.9
Riboflavin (mg)	0.5
Thiamine (mg)	0.2
Sodium (mg)	8.0
Magnesium(mg)	219
Vitamin E (mg)	44.4
Vitamin A (µg)	Trace

enhance adherence, every respondent was assigned a trained Community Health Worker for follow up and monitoring process to adherence on consumption at the household's level. Respondents were also adequately sensitized on nutrition and health benefits of amaranth grain to enhance consumption.

A 24 h recall questionnaire was used to monitor monthly food intake. Three 24-hour recalls were administered to the respondents on the fourth week of every month during the intervention. This included 2 week days and one weekend day. All food items consumed in the previous 24 h were assessed. To minimize on systematic errors, food photographs and food models which depicted food portion sizes were used. A 24h multiple pass recall method was used to probe for complete description of foods and to overcome the recall bias which is a limitation of using 24 h recall questionnaires. Morbidity data was collected on monthly basis based on 2 weeks recall where respondents were asked if they had suffered from any illness in the previous two weeks. The CD4 count was done at the baseline, at the third month and at sixth month at the Nyeri County Referral Hospital laboratories.

Data analyses

Quantitative data were entered, cleaned and analyzed by use of statistical package for social sciences software (version 16.0). Mean, frequencies and percentages were used to summarize descriptive statistics of the data. The amounts in grams of ingredients from foods consumed were entered into Nutri-survey software to generate the actual amount of selected nutrients consumed per day from daily usual food intake and from amaranth grain porridge. These were then compared with the recommended daily allowances (RDAs) for PLHIV as provided by NASCOP (2006).

Pearson product moment correlation (r) was used to determine the relationship between amount of nutrient intake and CD4 count. The t–test for non-independent samples was used to determine if there was a significant difference between the dietary practices, morbidity patterns and CD4 count for the pre-test and post-test data. Logistic regression was used to calculate the association between CD4 count and presence of illness as an index of odds ratio. Multiple regressions was used to determine the contribution of nutrients from amaranth grain to CD4 count while adjusting for confounding factor namely sickness status and nutrients from other foods.

Ethical considerations

The research protocol was approved for implementation by Ethical Review Committee (ERC) of the Kenya Medical Research Institute (ERC No: KEMRI/RES/7/3/1). A consent form was signed by the respondents prior to beginning the study. This included the nature and purpose of the study, what would occur during the intervention, any risk, assurance that all data collected would be coded to protect their identity and privacy, thus confidentiality was assured.

RESULTS

Characteristic of the respondents

The study had recruited 83 respondents at the beginning of the intervention, however, due to attrition data is reported for 66 respondents. Slightly more than half (53.0%) were females (Table 2). The mean age was 34.30±1.2 SD. The majority of the respondents (69.7%) were farmers. The highest educational level attained by about half of the study respondents was secondary education (51.5%). Close to half (48.5%) of the respondents were married. The mean income of the respondents was 66.75 ±23.50 US dollars. There was no significant change in mean monthly income (P=0.06) between baseline and month six.

Change in nutrient intake during intervention

The mean nutrient intake was below the RDA for most of the nutrient at baseline. This increased significantly with introduction of amaranth grain in the diet, enabling the respondents to achieve the required dietary intake for energy, protein and selected micronutrients (Table 3).

The proportion of respondents who met the RDAs for energy increased from 27.3% at baseline to 92.4% at month six. For protein the increase was from 21.2 to 95.5%. Over 70% of the respondents were found to consume adequate micronutrients at month six that was 97% iron, 92.4% zinc, 77.3% calcium, 95.5% magnesium, 89.4% vitamin B1, 86.4% B2, 92.4% B3, 72.7% B6 and 100% vitamin E compared to an average of below 40% of the respondent at baseline (Table 4).

Change in CD4 count during intervention

The mean CD4 count (cells/mm^3) was assessed at baseline, month three and at month six. Figure 2 shows the change in mean CD4 count (cells/mm^3) during the six months of amaranth grain consumption. The mean CD4 count increase in the first three months was 42 ± 4.4 SD (cells/mm^3) and 63 ± 7.1 SD (cells/mm^3) from month three to month six. Total CD4 count increase was 105 ± 25.8 SD (cells/mm$^{3)}$ of blood. There was a significant difference in CD4 count between baseline and month six (P=0.041).

Table 2. Characteristic of the respondents

Respondent's characteristics (n=66)		n	%
Sex	Males	31	47.0
	Females	35	53.0
Age category	20-29	22	33.3
	30-39	28	42.4
	40-49	9	13.6
	50-59	7	10.6
Occupation	Farmer	46	69.7
	Casual labor	10	15.2
	Formal employment	5	7.6
	Small business	5	7.6
Education level	Primary	26	34.9
	Secondary	34	51.5
	Tertiary	6	9.1
Marital status	Married	32	48.5
	Separated	15	22.7
	Single parent	11	16.7
	Widow/ widower	8	12.1
	Baseline	**At six months**	**t test P Value**
Monthly income	66.75 ± 23.50 USD	68.09 ± 22.29 USD	0.066

Table 3. Energy and nutrient intake at baseline and at month six of intervention.

Nutrients	Baseline		Month 6	
	Female	Male	Female	Male
Energy (Kcals)*	2479± 312	3139± 365	2892± 330	3549± 386
Protein (gms)*	39.3 ± 2.3	41.9± 4.2	54.8 ± 2.7	58.8 ± 2.6
Vitamin B1 (mg)[€]	1.2± 0.1	1.3 ± 0.2	1.4 ± 0.2	1.5 ± 0.2
Vitamin B2(mg) [€]	1.0 ± 0.1	1.1 ± 0.1	1.3 ± 0.2	1.4 ± 0.1
Vitamin B3 (mg) [€]	16 ± 0.3	17.1 ± 0.3	16.7 ± 0.2	17.8 ± 0.4
Vitamin B6 (mg)*	1.0 ± 0.2	1.1 ± 0.1	1.4 ± 0.2	1.5 ± 0.1
Calcium (mg)*	836 ± 7	889 ± 83.0	1102 ± 9	1023 ± 79.0
Iron (gms)*	11.6± 2.8	10.6 ± 2.5	22.6 ± 2.6	21.4 ± 2.1
Zinc (gms)*	4.3 ± 2.4	5.8 ± 2.9	8.6 ± 2.8	10.5 ± 2.2
Magnesium (mg)*	190 ± 75.0	201 ± 82.3	350± 76.2	371 ± 74.8
Vitamin E (mg)*	9 ± 2.2	8 ±0.3	42 ± 3.3	46 ± 5.1
Vitamin A (µg)[đ]	413 ± 26.0	483 ±19.0	430 ± 43.0	471 ± 22.0
Selenium (mg)[đ]	19 ± 1.7	22 ± 2.5	22 ± 1.9	24 ± 2.3

*Nutrients where significant increase was observed after the diet was supplemented with nutrient dense amaranth grain; [đ]Nutrients where no significant differences were observed even after introduction of amaranth grain in the diets of the respondents; [€]Nutrients where respondents had adequate intake at baseline even without amaranth grain.

Relationship between nutrient intake and CD4 count

The amount of CD4 count and amaranth grain consumption had significant ($P < 0.001$), positive moderate correlation (R^2=0.63) (Table 5). From simple regression iron intake contributed about 13.3% to CD4 count, calcium (11.2%) vitamin B6 (16.8%), vitamin C (12.0%), zinc (17.6%), magnesium (11.3%), vitamin E (20%), protein 8.7% and Kcals 16.9%. From multiple regression, nutrients intake from amaranth grain

Table 4. Proportion of respondents consuming adequate nutrients.

Nutrient	Baseline (n=66)		At month 6 (n=66)	
	n	%	n	%
Energy (Kcals)	18	27.3	61	92.4
Protein (g)	14	21.2	63	95.5
Iron (g)	17	25.8	60	90.9
Zinc (g)	18	27.3	61	92.4
Calcium (g)	25	37.9	51	77.3
Magnesium (g)	23	34.8	63	95.5
Vitamin C (g)	25	37.9	33	50.0
Vitamin B1 (mg)	49	74.2	59	89.4
Vitamin B2 (mg))	50	75.8	57	86.4
Vitamin B3 (mg))	50	75.8	61	92.4
Vitamin B 6 (mg)	26	39.4	48	72.7
Vitamin E (g)	36	54.5	66	100.0
Vitamin A (µg)	24	36.4	28	42.4
Selenium (mg)	23	34.8	33	50.0

Table 5. Determinant of CD4 count.

Simple regression	**r**	**r^2**	**%**	**P-value**
Iron	0.365	0.133	13.3	0.003
Calcium	0.335	0.112	11.2	0.002
Vitamin B6	0.410	0. 168	16.8	0.001
Vitamin C	0.346	0.120	12.0	0.004
Zinc	0.420	0.176	17.6	0.000
Magnesium	0.336	0.113	11.3	0.008
Vitamin E	0.447	0.200	20.0	0.001
Protein	0.432	0.187	18.7	0.001
Kcal	0.411	0.169	16.9	0.001
Multiple regression	R	**R^2**		
Iron, calcium, vitamin B6, vitamin C, zinc, magnesium, Kcal, proteins	0.630	0.397	39.7	0.000

contributed to 39.7% of CD4 count (R=0.630; R^2=0.397; P=<0.001). This was when intake of nutrients from other foods and sickness status were adjusted for.

Presence of illnesses among respondents

At baseline upper respiratory tract infections (URTI), diarrhea, loss of appetite and oral thrush were the most common opportunistic infections (Figure 1).

There was a significant decline in the number of respondents with either of the illnesses from a total of 52 (78.8%) at baseline to 21 (31.8%) respondents at month (P=0.031). The prevalence of URTI, diarrhea, oral thrush, loss of appetite was 27.3, 13.6, 19.7 and 18.2%, respectively. This significantly reduced to 12.1, 7.6, 1.5 and 10.6% respectively by the sixth month. Significant association was observed between CD4 count and presence of illness [OR] 2.4, 95% confidence interval [CI] 2.16-2.67), (P= 0.018**)** where respondents with low CD4 count were 2.3 times more likely to become ill compared to those with high CD4 count.

DISCUSSION

Households with PLHIV are mainly food insecure and have challenges of meeting their increased energy and nutrient requirements (Tibagonzeka et al., 2014). This is compounded by presence of opportunistic infections which further increase nutrients requirements while compromising intake and utilization. Therefore,

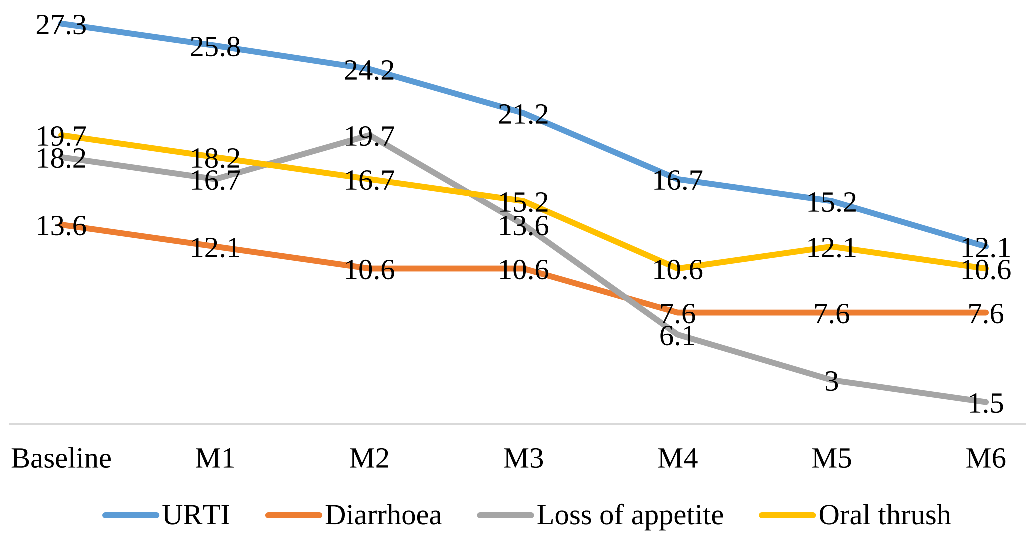

Figure 1. Morbidity pattern among adults living with HIV in Mweiga.

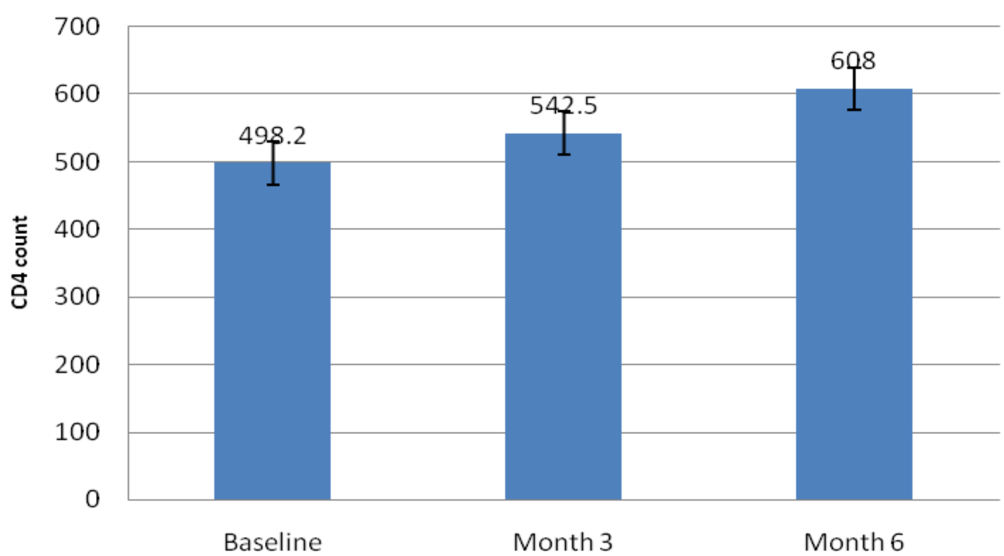

Figure 2. Mean CD4 count among respondents in MHBCG

intervention aimed at supplementing diet for vulnerable PLHIV in such households has been shown to improve nutrient intake (USAID, 2015). Despite this growing recognition of integrating targeted food assistance to PLHIVs, there have been few studies to evaluate the health and nutritional impact of these interventions especially using locally available nutrient and energy dense food products. From the findings of our study, supplementing the diet of PLHIV with amaranth grain led to increased intake of calcium, iron, zinc, vitamin B6, Vitamin E, magnesium, protein and energy. This study finding demonstrates that an aggressive, individualized intervention that promotes daily optimal energy, protein and micronutrient intake is feasible and effective in increasing the CD4 count hence reduction of opportunistic infections. Nutrients intake among the respondents at baseline was below the RDAs while morbidity profile was high. The consumption of amaranth grain significantly raised nutrients intake and contributed to 39.7% of the CD4 count ($R=0.630$; $R2=0.397$; $P=<0.001$) when nutrient intake from other foods and sickness status were adjusted for. The respondent CD4 count continued to rise during the intervention period which was an indication of improved immune system.

This was also confirmed by reduction in proportion of respondents with various illnesses by the end of the study.

An increase in CD4 count after increased intake of micronutrient in HIV-infected persons has previously been reported (Fawzi et al., 2004). A study by Palermo et al. (2013) and Rawat et al. (2010), confirmed positive relationship between consumption of nutrient rich diets and increase in CD4 count. Consumption of micronutrients showed a potential to increase the CD4 count by mean of 65 cells/mm^3 after three months in a study in USA (Kaiser et al., 2006). Other similar studies suggested that food based intervention improved nutrient intake and hence the outcome of health status of PLHIV (Koethe at al., 2009). A study conducted in the United States further showed that focus on food rations to increase energy and protein was more effective in management of opportunistic infections associated with HIV and AIDS (Mcdermott et al., 2003). There is also growing scientific consensus that nutrient adequacy is a critical component of the treatment of both malnutrition and malnutrition-mediated disease outcomes among PLHIV (Palermo et al., 2013; Thapa et al., 2015). Another study by Piwoz and Preble (2000) showed that intake of zinc improved immune status and reduced diarrhea among PLHIV. Moreover, in the same study vitamins E was found to reduce oxidative stress and HIV viral load. Zinc reduced incidence of opportunistic infections, stabilized weight, improved CD4 counts in adults with AIDS while iron was found to reverse anemia thus slowed down HIV progression and improved survival (Guarino et al., 2002).

Association of nutrient intakes with disease outcomes can be difficult to detect, especially in studies without a control group which was as a limitation in this study. However, since the entire respondent received the same treatment and monitoring during the experiment, any changes observed across the group of the participants was associated with the study treatment. However, other confounding factors that are likely to influence the outcome like usual dietary intake and sickness status were monitored and controlled for during data analyses. Previously food based intervention among PLHIV in Kenya has been donor based and has lacked sustainability and created dependency on food donations. The strength of our study lies on the fact that we explored use of locally grown amaranth grain which can be incorporated in the daily diets of PLHIV. Considering the climatic conditions of the research setting, amaranth grain can be easily grown locally. Due to its superior nutritional profile compared to other locally grown cereals, amaranth grain can easily solve the problem of inadequate dietary intake among vulnerable populations which will translate to improved health outcome.

Conclusion

This study has demonstrated that grain amaranth has a potential to contribute to the alleviation of inadequate dietary intakes among PLHIV. Consumption of amaranth grain porridge was found to enhance levels of the nutrients previously reported to be inadequate in the diets of PLHIV from the baseline data. The intake of amaranth porridge was not only able to fill the nutritional gaps but was also found to boost the immunological status of the respondents as evidenced by increased CD4 count which resulted to reduced prevalence of common illnesses.

This important outcome is entirely plausible, given that amaranth grain is high in zinc, iron, calcium, vitamin E, B vitamins and essential amino acids which play a vital role in immune system. Since there was no significant change in dietary intake from the usual food intake in the study population, the change in CD4 count, morbidity patterns between the pre-test and post-test data is attributed to amaranth grain consumption. In addition, it was observed that none of the respondents CD4 count fell below 350 (cells/mm^3) which is the recommended level for initiating ARV (NASCOP, 2011). This was a very crucial outcome and shows the need for early nutrition intervention among PLHIV to delay initiation of ARVs.

RECOMMENDATION

The study recommends that nutrition and health practitioners to educate PLHIV on importance of use of amaranth grain to complement usual dietary intake for improved health outcomes.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

ACKNOWLEDGEMENTS

The author of this paper wishes to acknowledge Kenya Agricultural Kenya Agricultural Productivity Project (KAPP), project number KAPP06/PRC-SECBCCI-06-FP2006023 which supported this research and Kenyatta University for knowledge provided; all grain companies that helped in processing and packaging of amaranth grain flour. Research assistants and especially Henery Ngethe are thanked for their assistance in data collection. The management of Mary Immaculate hospital which hosted the Mweiga Home based care support Group that formed the sample for this study.

REFERENCES

Cahn P, Ruxrungtham K, Gazzard B, Diaz RS, Gori A, Kotler DP, Vriesema A, Georgiou NA, Garssen J, Clerici M, Lange JM (2013). The immunomodulatory nutritional intervention NR100157 reduced CD4+ T-cell decline and immune activation: a 1-year multicenter randomized controlled double-blind trial in HIV-infected persons not receiving antiretroviral therapy (The BITE Study). Clin. Infect. Dis. 57(1):139-146.

Caselato-Sousa VM, Amaya-Farfán J (2012). State of knowledge on amaranth grain: a comprehensive review. J. Food Sci. 77(4):93-104.

Dimitrov DM, Rumrill Jr PD (2003). Pretest-posttest designs and measurement of change. Work 20(2):159-165.

Fawzi WW, Msamanga GI, Spiegelman D, Wei R, Kapiga S, Villamor E, Mwakagile D, Mugusi F, Hertzmark E, Essex M, Hunter DJ (2004). A randomized trial of multivitamin supplements and HIV disease progression and mortality. N. Engl. J. Med. 351(1):23-32.

Gaby AR (2006). Natural remedies for Herpes simplex. Altern. Med. Rev. 11(2):93.

Guarino A, Spagnuolo MI, Giacomet V, Canani RB, Bruzzese E, Giaquinto C, Roggero P, Plebani A, Gattinara GC (2002). Effects of nutritional rehabilitation on intestinal function and on CD4 cell number in children with HIV. J. Pediatr. Gastroenterol. Nutr. 34(4):366-337.

Hailemariam S, Bune GT, Ayele HT (2013). Malnutrition: Prevalence and its associated factors in People living with HIV/AIDS, in Dilla University Referral Hospital. Arch. Public Health 71(1):13.

Hargrove JW, Humphrey JH, (2010). ZVITAMBO Study Group. Mortality among HIV-positive postpartum women with high CD4 counts in Zimbabwe. AIDS 24(3):11-14.

Hazenberg MD, Hamann D, Schuitemaker H, Miedema F (2000). R EVIEWS T cell depletion in HIV-1 infection : how CD4 + T cells go out of stock. Natl. Immunol. 1(4):285-289.

High KP, Effros RB, Fletcher CV, Gebo K, Halter JB, Hazzard WR, Horne FM, Huebner RE, Janoff EN, Justice AC, Kuritzkes D (2008). Workshop on HIV infection and aging: what is known and future research directions? Clin. Infect. Dis. 15(47):542-553.

Ivers LC, Cullen KA, Freedberg KA, Block S, Coates J, Webb P (2009). HIV / AIDS , Undernutrition , and Food Insecurity. Clin. Infect. Dis. 49:1096-102.

Kaiser JD, Campa AM, Ondercin JP, Leoung GS, Pless RF, Baum MK (2006) Micronutrient supplementation increases CD4 count in HIV-infected individuals on highly active antiretroviral therapy: a prospective, double-blinded, placebo-controlled trial. J. Acquir. Immune Defic. Syndr. 15(42):523-528.

Kauffman CS, Weber LE (1990). Grain amaranth. Adv. New Crops 127-39.

Koethe JR, Chi BH, Megazzini KM, Heimburger DC, Stringer JS (2009). Macronutrient supplementation for malnourished HIV-infected adults: a review of the evidence in resource-adequate and resource-constrained settings. Clin. Infect. Dis. 49:787-98.

Luckheeram RV, Zhou R, Verma AD, Xia B (2012). CD4 + T Cells: Differentiation and Functions. Clin. Dev. Immunol.10(1155):1-12.

Mburu MW, Gikonyo NK, Kenji GM, Mwasaru AM (2012). Nutritional and functional properties of a complementary food based on Kenyan amaranth grain (*Amaranthus cruentus*). Afr. J. Food Agric. Nutr. Dev. 12:5959-77.

McDermott AY, Shevitz A, Must A, Harris S, Roubenoff R, Gorbach S (2003). Nutrition treatment for HIV wasting: a prescription for food as medicine. Nutr. Clin. Pract. 18:86-94.

Mwangi D (2003). Introduction to Amaranth. Joypet Services and Printers. Nairobi, Kenya. pp. 51-56.

National AIDS/STI Control Program (NASCOP) (2011). Guidelines for antiretroviral therapy in Kenya; 4th edition.

National AIDS/STI Control Program (NASCOP), (2006). Kenyan National Guidelines on Nutrition and HIV / AIDS.

Onyango AC, Walingo MK, Mbagaya G, Kakai R (2015). Nutrient Intake and Immune Status of HIV Sero-positive Patients in a Comprehensive Care Clinic at Chulaimbo. J. Food Nutr. Sci. 3:209-15.

Palermo T, Rawat R, Weiser SD, Kadiyala S (2013). Food access and diet quality are associated with quality of life outcomes among HIV-infected individuals in Uganda. PloS one 18:8e62353.

Piwoz EG, Preble EA (2002). HIV/AIDS and nutrition: a review of the literature and recommendations for nutritional care and support in sub-Saharan Africa.

Rajeswari G, Gopal PS, Suresh E, Prasad GBVVS V (2015). Biochemical Changes in HIV Related Malnutrition in Children. J. Dent. Med. Sci. 14:53-7.

Rawat R, Kadiyala S, Mcnamara PE (2010). The impact of food assistance on weight gain and disease progression among HIV-infected individuals accessing AIDS care and treatment services in Uganda. BMC Public Health 10:1-8.

Tagwira M, Tagwira F, Dugger R, Okum B (2006). Using grain amaranth to fight malnutrition. RUFORUM Working Document. 2006. pp. 201-6.

Thapa R, Amatya A, Pahari DP, Bam K, Newman MS (2015). Nutritional status and its association with quality of life among people living with HIV attending public anti-retroviral therapy sites of Kathmandu Valley, Nepal. AIDS Res. Ther. 3(12):14.

Tibagonzeka J, Wambete J, Muyinda AM, Nakimbugwe D, Muyonga JH (2014). Acceptability and nutritional contribution of grain amaranth recipes in Uganda. Afr. J. Food Agric. Nutr. Dev. 14(3).8979-8997.

USAID (2015). Nutrition , Food Security and HIV-Multi-Sectoral Nutrition Strategy 2014-2025.

WHO (World Health Organisation) (2003). Nutrient requirements for people living with HIV / AIDS Report of a technical consultation.

Wrieden W, Peace H, Armstrong J, Barton K (2003). A short review of dietary assessment methods used in National and Scottish Research Studies [Internet]. dietary assessment methods used in National and Scottish Research Studies.