ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 17 No. 3
July 2017
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Afr. J. Food Agric. Nutr. Dev. 2017; **17(3):** 12343-12361 **DOI: 10.18697/ajfand.79.15350**

EFFECT OF NUTRITION EDUCATION AND DAIRY GROUP MEMBERSHIP ON NUTRITION KNOWLEDGE, PRACTICES AND DIET QUALITY FOR RURAL KENYAN FARM WOMEN

Walton C[1*], VanLeeuwen J[2], MacLellan D[1], Taylor J[1] and S Mbugua[3]

Walton Colleen

*Corresponding author email: cwalton@upei.ca

[1] University of Prince Edward Island, Department of Applied Human Sciences, 550 University Avenue, Charlottetown Prince Edward Island, Canada C1A 4P3

[2] Atlantic Veterinary College, University of Prince Edward Island, 550 University Avenue, Charlottetown Prince Edward Island, Canada C1A 4P3

[3] Egerton University, Department of Human Nutrition, P. O. Box 536, Egerton, Kenya.

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 17 No. 3
July 2017
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

ABSTRACT

The typical high-starch, low diversity diet in developing countries is associated with undernutrition, morbidity and mortality. Previous research with households in Mukurwe-ini Division (Central Kenya) found that members of a community-based dairy development group were more food secure and had higher intake of certain micronutrients compared with non-members; however, the prevalence of inadequate intake of multiple micronutrients was high among all women. A nutrition education intervention was developed to enhance women's nutrition knowledge and food skills to ultimately improve diet quality and micronutrient intakes for women and their families. In addition, it was proposed that the intervention effects would be greater for dairy group members. The Mukurwe-ini study group consisted of 88 women in four dairy membership-duration categories (n=4 x 22) and non-member women (n=23). The study group was previously selected using chain referral sampling. For the intervention, women from each duration-group and non-member women were randomly allocated to intervention (n=55) and control (n=56) groups. Nutrition knowledge and dietary intake (24-hour recall) data were collected from all women over three weeks immediately prior to the intervention (baseline) and again, six months post-intervention, in individual face-to-face interviews. The intervention encouraged food-based strategies to improve intake of vitamin A, iron and zinc and was developed and delivered in collaboration with a Kenyan dietitian. WFood2 was used to compute food and nutrient intakes, dietary diversity and the phytate:zinc molar ratio. Descriptive statistics and linear and logistic regressions analyses were performed using Stata10. Independent of dairy-group membership, a larger proportion of intervention group women, compared to control group women, had the targeted nutrition knowledge and practiced the strategies to improve intake of vitamin A (76% vs 67%, respectively) and zinc and iron (soaked beans and maize 80% vs 13%; avoided tea with meals 67 % vs 5%, respectively). A positive effect of the intervention on dietary diversity was dependent on dairy-group membership status. Positive intervention effects on intake of vitamin A and C were found for non-member women. This study provided evidence that certain intervention effects were dependent on poverty reduction and that all women were able to make positive dietary changes when informed. There is a need to examine longer-term impacts of nutrition education interventions and to explore effective methods to disseminate nutrition information and food-based strategies.

Key words: nutrition intervention, micronutrients, food-based strategy, rural, women, dairy, smallholder farmer

DOI: 10.18697/ajfand.79.15350

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 17 No. 3 July 2017 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

BACKGROUND

Maternal and child under-nutrition is the underlying cause of 3.5 million deaths annually [1]. The majority of the world's poor live in rural areas of developing countries, and many rely on their small farms for income and food [2]. The typical plant-based high-starch diet lacks diversity due to limited consumption of vegetables, fruit and animal source food and places individuals at risk of inadequate intake of multiple micronutrients [3]. Inadequate micronutrient intake is associated with limited immune function, impaired physical and cognitive development, and reduced caring and working capacity [1, 4, 5].

In sub-Saharan Africa, including Kenya, many rural households are challenged by low agricultural productivity, inadequate resources and food insecurity [6]. Building capacity to increase food production is considered a holistic way to improve nutritional outcomes [7]. However, agricultural projects with specified nutritional objectives are associated with greater nutritional outcomes than agricultural projects alone [8,9,10,11]. To prevent micronutrient deficiencies, food-based strategies are considered more appropriate and sustainable than fortification and supplementation particularly in resource-poor areas with limited access to health services, including supplement distribution [11,12]. Berti [9] recommended complementary strategies to support dietary modifications and community- and agricultural-based interventions with simultaneous efforts to improve the capacity and reach of food fortification.

Wakulima Dairy Ltd. (WDL) is located within the Mukurwe-ini Division of Central Province, Kenya, and was established in 1992. Members of the dairy group are smallholder farmers with 1–2 acres of land and 1–2 dairy cows. Women grow and provide feed to the cows (for example, Napier grass) and grow and prepare food for the family (for example, maize, beans, kale, onions, tomatoes and squash) [13].Many households have chickens and sell the eggs. Belonging to WDL enables the women to purchase dry staples (for example, maize meal, wheat flour, cooking fat) on credit. Additional details of the agroecology and demographics are in VanLeeuwen [14] and Walton [15]. In 2008, WDL members included approximately 6000 independent farm families who lived throughout the Mukerwe-ini Division (population 80,000).

Efforts by WDL to improve dairy herd management and milk production were enhanced as a result of partnerships with Farmers Helping Farmers (FHF; a Canadian non-government organization) beginning in 1996 and with the Atlantic Veterinary College of the University of Prince Edward Island, Canada (beginning in 2003). Stemming from these efforts, significant improvements in dairy animal feeding, reproduction, mastitis control, [14] and milk production were reported [15]. As well, WDL members had higher dairy income, greater household food security, consumed more milk, and had better quality homes, water access and social support compared to non-members [16]. However, average dietary diversity (DD) was low (less than five) for member and non-member women. Low DD is associated with inadequate intake of multiple micronutrients for women [3]. Correspondingly, member and non-member women had inadequate intake of iron (65% of member women and 70% of non-

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 17 No. 3 July 2017 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

member), zinc (20% and 14% of member and non-member women, respectively) and vitamin A intake (28% of member and 65% of non-member women) [16].

Food choices are influenced by personal and environmental factors, and nutrition education needs to extend beyond information dissemination to be effective [17]. The information-motivation-behaviour skills (IMB) model is focused on informational, motivational and behavioural constructs associated with successful practice of preventive health-related behaviours [18]. This model specifies that information provided needs to be relevant and easily enacted within the specific circumstances and serve as a guide to personal behaviour. This model was used with parents of American Indian toddlers to address low vegetable consumption [19].

Using a randomized controlled trial, this research aimed to 1) determine the effects of an IMB-based nutrition education intervention on nutrition knowledge, practices and diet quality; and, 2) determine whether intervention effects were associated with WDL membership duration or status. There is no published research that has investigated the combined effect of nutrition education using this approach and involvement in dairy development on diet quality.

METHODOLOGY

Study site

The 6,000 WDL-member households, located throughout Mukurwe-ini Division, Central Province, Kenya, represented 29% of the Division's population of 84,000. The smallholder farmer, members and non-members, lived along four rural routes and within Kiahongo village.

Study group selection and intervention allocation

Selection of the study group was detailed in a previous study [15]. Briefly, the study group included 100 women plus ten percent oversampling, from four dairy-membership duration categories (1-3, 4-6, 7-9 and 10+ years; n=4x22) and non-members (n=23). Membership-duration categories were specified by the researchers in order to examine the association of membership duration with livelihood and nutrition outcomes. There was no central list of members therefore chain-referral sampling, initiated by eight WDL members, was used to identify and recruit farmers meeting the criteria. The initiators represented the duration-groups and had various levels of involvement with WDL. These factors were important in selecting a representative sample. Directors and managers of WDL and teachers were excluded to focus the research on farming households. A list of non-members was created by referral from members; study group participants were randomly selected from this list.

For the nutrition education intervention, women from each membership-duration group and non-members were randomly assigned to either the intervention or control group. Consequently, the intervention (n=55) and control (n=56) groups had similar numbers of participants from each membership-duration and non-member group.

DOI: 10.18697/ajfand.79.15350

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 17 No. 3 July 2017 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

Prior approval to conduct the study was obtained through Farmers Helping Farmers, Wakulima Dairy Ltd., and UPEI Research Ethics Board. Written consent was obtained from all participants after the nature of the study had been fully explained to them.

Dairy development

Over the period 1999 – 2008 WDL member-farmers had the opportunity to gain additional dairy farm productivity knowledge through a series of on-farm demonstrations and educational sessions provided seasonally by Canadian volunteers and veterinary students and by FHF Kenyan staff throughout the year. Topics included cow care, feeding for milk production, silage-making, and approaches to success in reproduction [14]. Repeat sessions on each topic were held over the years to encourage member participation. Farmers were informed of the sessions by their WDL Board member and sessions were well attended.

Nutrition education intervention

The intervention was endorsed by the WDL Board of Directors and was planned and implemented by a registered Kenyan dietician, a Kenyan nutrition researcher (co-author) and the lead author of this study. As per the IMB-approach, the intervention was developed with an understanding of the limited resources of households and of culturally accepted foods. The intervention aimed to (1) increase knowledge of the importance of micronutrients in diets and health and (2) demonstrate practical strategies to increase intake of vitamin A, iron, and zinc. Specifically, food preparation methods to increase the micronutrient density of typical foods (modifying recipes and adding available vegetables and fruit) and methods to reduce intake of anti-nutrients (phytates and tannins) [21] were promoted. The focus on vitamin A, iron, and zinc was based on known deficiencies for women in Kenya and other developing countries [3] and the study group [16]. Typical foods were prepared using the strategies being promoted:

(1) Increase pro-vitamin A intake by incorporating more dark green leafy vegetables (DGLV) and orange-red flesh fruit and vegetables (OF) into foods.

(2) Increase bioavailability of iron and zinc by:
   a. pre-soaking (and draining) dried beans and maize prior to cooking;
   b. restricting the consumption of tea within 2 hours of a meal; and
   c. Consuming vitamin C-rich fruit with meals.

Food samples were provided to participants to taste and the leaders lead a discussion of the methods used to prepare the foods and why the strategies were being promoted. The need to improve iron and zinc bioavailability was based on the knowledge that absorption of these minerals from plant foods was low due to the non-heme form of iron and due to the high molar ratios of phytates and tannins to iron and zinc [22,23]. To improve bioavailability, strategies to reduce phytate and tannin intakes were employed. Fernandes [24] and Shimelis [25] found that soaking beans and discarding the soaking water prior to cooking eliminated more phytates (58-65%) and tannins (58-81%) compared to cooking beans without pre-soaking (25-28% phytate and 23-38% tannin reduction). The need to separate tea drinking from food intake is based on research that found that the average iron absorbed from soup and bread or rice was

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 17 No. 3
July 2017
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

reduced by almost 80% from the tannins in one cup of tea consumed with the food [26,27]. Finally, iron absorption is improved when foods rich in vitamin C ($\geq$50 mg) are consumed with meals [22,26].

Intervention group members responsible for household food preparation, generally women, were invited to attend one half-day workshop in August 2009. Workshops were held mid-morning and early afternoon, at four locations over two days to enable participation. Each workshop was hosted by a WDL Director. The dietician and nutrition researcher presented the messages, and participants were engaged in discussions to help ensure understanding. Participants tasted typical foods prepared using the strategies being promoted. *Githeri* (a stew) was prepared from dried maize and beans that had been soaked for 12 hours, drained, and boiled in fresh water until soft. Cooked maize and beans were mixed with fried onion and tomato. Chopped kale and indigenous DGLV (amaranthus, spider plant and *managu*) were added to the *githeri* and cooked. Vitamin A enhanced chapattis were prepared by including mashed cooked orange squash in the dough.

Participants received a pamphlet describing the strategies, recipes and nutrition information. As tokens of appreciation, and to reinforce the nutrition messages, participants were provided with vitamin A fortified cooking oil and growing instructions and seeds for DGLV and orange-flesh squash.

The intervention group was asked to not discuss the workshop topics until after the control group had attended the workshops. This message, combined with the low number of intervention-group women (55) relative to the number of dairy-group members (6,000) was deemed sufficient to prevent information-contamination of the control group.

In February 2010, immediately following the post-intervention data collection period, control-group members were invited to a workshop and provided with the same messages, samples, pamphlets and incentives as the intervention group.

Data collection

Data was collected using face-to-face interviews at the participant's home. A two-member team, a researcher with an assistant/translator, interviewed the person responsible for cooking, usually a woman. Interview questions were translated from English to Kikuyu (the local language) and back. The researcher was responsible to record the translated responses on the prepared survey document. Pre-intervention, household socio-demographic and food security data were collected using pre-tested questionnaires [15].

Pre- and post-intervention, women's food intake data were collected using a single four-pass 24-hour diet recall [16, 28]. Nutrition knowledge and practices data was collected using an adapted structured questionnaire [29]. In order to ensure interviewers were blinded to the intervention status of the women, the list of women to be interviewed was provided to the interview teams by the lead author and there were no questions regarding the intervention.

Data handling and analysis

Nutrition knowledge and practices were analyses as dichotomous (yes/no) variables. Data from the 24-hour diet recalls were used to compute diet quality indicators using the World Food Dietary Assessment System V2.0 (WFood2). Specifically, dietary diversity (DD) (a validated nine food-group indicator with a 15g minimum intake [3]), intake of targeted nutrients (iron, zinc, vitamin A), intake (grams) of food in targeted food groups (DGLV, OF and 'other fruit and vegetables'), percent energy from animal source foods (%ASF), and phytate:zinc molar ratio were computed. To compute vitamin A intake, the lower bioavailability of plant-source pro-vitamin A was accounted for by the algorithms used by Wfood2. For women who soaked beans, phytate intake was reduced by 36% to account for phytate losses from bean soaking [25]. The adjusted phytate-intake was used to estimate the phytate:zinc molar ratio (phytate-660.3g/mol).

Descriptive statistics of the dietary quality indicators were computed for the control and intervention groups, pre- and post-intervention and for the difference in these measures pre- to post-intervention. Outliers were checked for errors and accuracy and corrected where appropriate. Natural log transformations were applied to some dietary variables. The normal distribution of transformed variables was confirmed using the Shapiro-Wilks test. Dichotomous variables were computed for DGLV, OF and 'other fruit and vegetables' using median intake values as cut-points (19 g, 13 g and 36 g, respectively) as no transformation was effective to achieve normal distributions of these data. Comparability of the control- and intervention-group's socio-demographic and dietary measures was examined using Pearson Chi-square (proportions), two-sample t-test (normally distributed variables with equal variances) and Wilcoxon rank sum test (for non-parametric continuous variables).

A Pearson Chi-square test was used to examine intervention effects on the proportion of women consuming food in each DD food group. Linear and logistic regressions, using pre- and post-intervention data, were used to examine the effect of intervention status and WDL membership status, and of an interaction between these variables, on the dietary outcomes (grams of foods in the DGLV, OF and 'other fruit and vegetables' groups; intakes of iron, zinc and Vitamin A; and diet quality indicators: DD, %ASF, and phytate:zinc molar ratio). Date was included in the models to account for seasonal influence. Observations with high leverage and residuals were examined for errors and for influence. Model fit was assessed using the adjusted R^2 (linear models), and Hosmer-Lemeshow goodness-of-fit (logistic models). Statistical analyses were conducted using Stata10 (Stata Corp. College Station, TX). Significance was assessed at $p<0.05$.

RESULTS

Pre-intervention socio-demographic characteristics were not significantly different ($p<0.05$) between intervention and control groups (Table 1) which indicated that randomization was successful to evenly distribute these characteristics. All intervention-group households participated in the workshop. One household was unable

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 17 No. 3 July 2017 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

to be located for the post-intervention interview. Dietary data were not collected from two male-headed households and two lactating women because of their different dietary requirements. No evidence was found to suggest that information had been shared between the intervention and control group women.

Nutrition knowledge and practices

There were no significant differences in nutrition knowledge or practices between intervention and control groups pre-intervention (Table 2). Post-intervention, significantly more intervention-group women soaked beans, avoided tea with their meals and were familiar with the benefits of DLGV and OF compared to the control-group women (Table 2, $p<0.05$).

Diet quality indicators

The proportion of women, pre-intervention, that consumed food from each DD food group was not different for the control and intervention groups, except a higher proportion of control-group women consumed OF (Table 3). Consistent with enhanced awareness, significantly more intervention-group women consumed OF post-intervention (54%) compared with pre-intervention (24%) ($p<0.05$). Post-intervention, more intervention-group women consumed DGLV compared to control-group women, although this difference was not statistically significant ($p=0.08$).

Pre-intervention food, nutrient and anti-nutrient intakes were not significantly different between control and intervention groups, except that the intervention group had lower zinc intake ($p<0.05$) (Table 4). Post-intervention median intake (grams) of DGLV and OF was six-times higher for the intervention group compared to the control group, whereas the median intake of 'other fruit and vegetables' was 66% lower. Unadjusted phytate intake was not different between intervention and control groups at either date. However, after the post-intervention phytate intake was adjusted for bean soaking (reduced by 36% [24]) for 82% of intervention-group and 16% of control-group women, the intervention group had a significantly lower phytate intake ($p<0.05$).

The intervention group had significant improvements in DD and vitamin C intake pre- to post-intervention ($p<0.05$). Similarly, vitamin A intake was almost five times higher for the intervention group, comparing pre- and post-intervention intake ($p=0.12$).

Multivariable models of diet quality indicators

The effect of the intervention on DD and intake of vitamins A and C was dependent on WDL membership status (member vs. non-member) but not on membership duration (Table 5). The predicted DD for members in the control-group was 4.6 and was higher (4.9) for members in the intervention-group. In contrast, a DD of 4.2 was predicted for non-members in the control group and a lower DD (3.7) predicted for non-members in the intervention-group. For non-members, there was a significant positive effect of the intervention on vitamin A and C intake compared to the non-member control group. In contrast, there was no significant impact of the intervention on vitamin A and C intake for WDL members.

DOI: 10.18697/ajfand.79.15350

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 17 No. 3 July 2017 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

DISCUSSION

The intervention, an IMB approach with appropriate food-based strategies, was successful to improve women's nutrition knowledge, dietary practices and to increase intake of important micronutrients. The intervention was successful for both WDL-member and non-member women although impacts differed between these two groups.

Vitamin A Intake

Inadequate vitamin A intake is associated with morbidity, mortality and blindness, and affects a high proportion of individuals in developing countries [30, 31].

Approximately 40% of Kenyan women experience vitamin A deficiency [30] and our previous research that found a high proportion of the study group had inadequate vitamin A intake [16]. Independent of dairy group membership, the positive effects on DGLV and OF consumption and vitamin A intake may be explained by a displacement of 'other fruit and vegetables' in response to intervention messages. The interpretation of vitamin A intake data is limited because factors that influence the absorption, bioconversion and bioavailability of pro-vitamin A such as the fat content of the meal and the food matrix [32] were not accounted for by the nutrient analysis software. As well, the wide range of vitamin A intake and high variance associated with a single 24-hour recall limited our ability to detect statistical differences in vitamin A intake. To estimate "usual" nutrient intake, multiple 24-hour recalls are recommended, although single 24-hour recalls can provide a good estimate of the mean intake of a group and enable t-test comparisons [28]. Efforts to maximize food recall and measurement accuracy were made by using a four-pass 24-hour-recall method and local measures [33].

Iron and zinc intake

Iron and zinc deficiencies can lead to fatigue, reduced work capacity, and, in pregnant women, severe anaemia may cause foetal growth retardation and contribute to maternal mortality [35]. Inadequate iron and zinc intake is common among rural women in many developing countries [3, 35]. A high proportion of Kenyan women experience deficiencies of iron (56%) and zinc (52%) [30]. A high proportion of women in this study group had inadequate intake of iron (65%-70%) and zinc (14-20%) [16]. Animal-flesh foods provide iron and zinc in abundant amounts and in highly bioavailable forms; however, low meat consumption is typical of the diet for women in Kenya and other developing countries due to limited resources [36].

Women were encouraged to separate tea drinking from meals to counter the inhibition of iron absorption due to tannins in the tea [26, 27]. The effects of ascorbic acid and tea consumption on iron intake were accounted for by an algorithm used in the WFood2 software (increased from 5% with <35mg ascorbic acid/1000kcal, to 10% with 35-105 mg ascorbic acid/1000kcal and to 15% with>105mg ascorbic acid/1000kcal; reduced by 20% for each cup of tea consumed with a meal). Soaking beans and maize was encouraged to increase the bioavailability of non-heme iron and zinc by reducing the phytate and tannin content of the cooked beans. Adams [34] found that iron and zinc absorption was 49% and 78% higher, respectively, for individuals who consumed

DOI: 10.18697/ajfand.79.15350

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 17 No. 3 July 2017 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

phytate-reduced (35 to 63%) maize in tortillas or polenta. Davies [23], using rat studies, found zinc intake was higher with lower phytate:zinc molar concentrations. Post-intervention, 80% of intervention group women soaked beans and maize, which reduced the estimated phytate:zinc molar ratio below 30 for the intervention group. This ratio is suggestive of a positive effect on iron and zinc intake. The WFood2 software estimated zinc bioavailability at 15% for diets with phytate:zinc molar ratios less than 30 and at 10% for diets with phytate:zinc molar ratios greater than 30. No adjustment any effect of lower phytates and tannins from bean and maize soaking was made on the iron or zinc intake data. Similarly, no adjustment of iron intake data was made to account for any effect of reduced tannin intake from bean and maize soaking [24, 25] because tannin content was not included in the nutrient data base. The inability to adjust iron and zinc intake data for any effect of phytate and tannin reduction from bean soaking limits the interpretation of these data. However some increase in absorption was anticipated from the altered balance between the nutrient intake modifiers (phytates, tannins and vitamin C) and these minerals. This potential under-estimate of iron and zinc intake was relevant to the intervention group as a high proportion the group adopted bean soaking. Nutritionally, this may be significant, based on the average need for menstruating women to absorb 1.5 mg of iron per day, the wide range and skewed distribution of women's iron needs [37] and the prevalence of inadequate intake of iron and zinc in this group, and Kenya more generally.

Increased DD was dependent on WDL membership which aligns with other research that reported greater success of nutrition interventions when accompanied by agricultural development [38]. This is consistent with previous research that found WDL members had higher income and greater food security [15] and with the anecdote that members obtained staple foods on credit from WDL and purchased vegetables and fruit using their casual income [13]. In contrast, the non-member intervention group women made positive dietary changes that resulted in vitamin A and C intake similar to that of WDL-members in the intervention group. This change in food selection may be attributed to knowledge gained from the intervention and may reduce the high prevalence of inadequate intake of vitamins A and C among this vulnerable group [15, 30].

The fact that many intervention effects were independent of dairy group membership supported the use of IMB approach for nutrition intervention success. In the context of this research, the intervention also addressed a belief that eating fruits and vegetables was less important than eating starchy cooked "food" [13] and increased the proportion of women who factored "health/being good for me" into their food choices [16]. The sustainability of this intervention is uncertain, given the limitations of a single intervention session and the recognition that longer duration participatory approaches have been more successful [29, 38, 39]. The pre-existing relationship may have reduced the need for extensive work to gain community participation, which appeared to be the case, given the high level of participation. Aligned with the IMB model, it is important to select strategies that can be adopted with minimal additional resources to ensure short-term impact, participation, and sustainability [11, 7, 39]. However, despite the incremental diet quality improvements from this intervention, low dietary diversity (<5)

DOI: 10.18697/ajfand.79.15350

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 17 No. 3 July 2017 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

remains a limitation to adequate intake of multiple micronutrient for women [3] and needs to be addressed.

CONCLUSION

This study provided evidence to support the use of an IMB approach for women's nutrition education to positively influence nutrition knowledge, practices and diet quality. The intervention focussed on locally relevant and appropriate food-based strategies to improve intake of vitamin A, vitamin C, iron and zinc for rural Kenyan farm women. Increased dietary diversity was dependent on dairy group membership. Independent of dairy group membership, women's knowledge and adoption of the promoted strategies provided the basis for higher intake of vitamin A, iron and zinc although this research was not able to fully quantify these effects. To fully understand the effects of dietary modifications on nutrient status, biochemical testing of zinc, iron and vitamin A is needed and may have further elucidated the combined effects resulting from the nutrition intervention and dairy-group membership. There is need to assess retention of knowledge and improved practices in a longitudinal study and to explore effective methods to disseminate culturally appropriate nutrition education and food-based strategies for rural farm families in developing countries.

ACKNOWLEDGEMENTS

The researchers would like to acknowledge the important contributions of Hilda Macharia RD Karatina Hospital, Kenya (Kenyan Nutritionist of the year, 2009), the members and Board of the Wakulima Dairy Ltd., the Canadian Home Economic Foundation and Veterinarians without Borders.

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 17 No. 3 July 2017
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Table 1: **Socio-demographic characteristics of participants pre-intervention; median (25th and 75th percentiles) or percent**

	Control group (n= 56)	Intervention group (n=55)
Woman's age (years)	40 (32,52)	39 (34,50)
Household size (number of daily inhabitants)	4 (3,5)	4 (3,6)
Number of improved home characteristics	2.5 (2,3.5)	2 (1,3)
Cattle (number)	2 (1,2.5)	2 (1,2)
Asset (number)	2 (2,3)	2 (2,3)
Household food insecurity (access) score	7 (1,12)	9 (2,13)
Woman's education level (with > primary)	25%	32%
Food Secure*	37%	31%
Floor in main house (concrete or tile)	30%	31%

**Household food security categories: secure (secure & mild food insecurity) (adapted from Coates et al., [40]*

Table 2: Percent of women, pre-and post-intervention, in control and intervention groups responding positively to nutrition knowledge and practices statements

	Pre-Intervention			Post-Intervention	
	Control group (%)	Intervention group (%)		Control group (%)	Intervention group (%)
Practice bean soaking	5	5		13 [a]	80 [b]
Practice maize soaking	7	7		22 [a]	78 [b]
Avoid tea with meals	7	2		42 [a]	67 [b]
Familiar with benefits of consuming milk	42	38		38	38
Familiar with benefits of consuming orange fruit and vegetables and dark-green leafy vegetables	55	67		51 [a]	76 [b]
Familiar with benefits of consuming meat and eggs	38	55		35	35

[a,b] values in a row with unlike superscript letters were significantly different p<0.05

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 17 No. 3
July 2017
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Table 3: Proportion of women consuming >15 grams of food within nine food groups, pre- and post-intervention

	Pre-intervention			Post-Intervention		
	Control group (n=55)	Intervention group (n=51)	p value	Control group (n=55)	Intervention group (n=51)	p value
Starch/grain	100	100	1.00	100	100	1.00
Legume	78	82	0.63	76	77	1.00
Dairy	100	98	0.48	100	96	0.23
Organ meat	2	2	1.00	0	0	1.00
Egg	7	4	0.68	6	6	0.64
Meat, fish, poultry	11	6	0.49	4	6	0.69
Dark green leafy vegetables (DGLV)	53	49	0.85	46	62	0.08
Orange-flesh fruit and vegetables (OF)	36	24[a]	0.05	46	54[b]	0.56
Other fruit and vegetables	85	82	0.79	69	69	1.00

[a,b] *values in a row with unlike superscript letters were significantly different p<0.05*

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 17 No. 3
July 2017
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Table 4: Women's dietary diversity, micronutrient and food group intakes, and change in intake pre- and post-intervention for control and intervention groups; median (25th and 75th percentiles)

	Pre-Intervention (August)		p value	Post-Intervention (February)		p value	Difference (post-pre)		p value
	Control (n=55)	Intervention (n=51)		Control (n=55)	Intervention (n=51)		Control (n=55)	Intervention (n=51)	
Dietary diversity	5 (4,5)	4 (4,5)	0.08	5 (4,5)	5 (4,6)	0.25	0 (-1,0)	0 (0,1)	<0.05
Percent energy from ASF	11 (7,15)	10 (6,17)	0.62	9 (6,16)	8 (4,14)	0.65	-0.93 (-6.1,4.1)	-1.8 (-7.4,3.8)	0.53
Phytate:zinc molar ratio	22 (17,28)	27 (18,33)	0.12	28 (23,34)	26§ (21,31)	0.25	6.1 (-1.2, 11.8)	0.8 (-7.4,8.1)	<0.05
Dark green leafy vegetables (g)	15 (0,81)	14 (0,99)	0.83	5.7 (0,82)	39 (0,100)	0.20	0 (-45,23)	0 (-21,61)	0.42
Orange-flesh fruits and vegetables (g)	0 (0,35)	0 (0, 9.9)	0.26	0 (0,163)	41 (0,207)	0.10	0 (-2.2,82)	29 (0,167)	<0.05
Other fruit and vegetables (g)	103 (36,342)	102 (6,228)	0.83	43 (10,126)	28 (2,83)	0.07	-37 (-231,19)	-38 (-146,0.3)	0.74
Vitamin A (Retinol Equivalents)	820 (374,1168)	531 (245,1254)	0.20	798 (266,1290)	900 (452,1568)	0.19	62 (-422,633)	340 (-188,1128)	0.12
Vitamin C (mg)	89 (59,151)	80 (50,114)	0.24	106 (56,139)	117 (67,153)	0.76	-11 (-49,39)	20 (-20,92)	<0.05
Calcium (mg)	739 (440,1114)	616 (430,932)	0.31	618 (418,808)	511 (332,721)	0.09	-110 (-347,102)	-89 (-386,96)	0.88
Iron (available)(mg) †	1.1 (0.7,1.6)	0.8 (0.6, 1.4)	0.17	1.1 (0.7, 1.5)	0.9‡ (0.5,1.5)	0.21	-0.08 (-0.63,0.34)	-0.11 (-0.37,0.40)	0.74
Zinc (available) (mg)†	1.7 (1.2,2.7)	1.3 (0.9, 2.2)	<0.05	1.2 (1.0,1.8)	1.1‡ (0.7,1.4)	<0.05	-0.51 (-1.18,0.45)	-0.24 (1.14,0.12)	0.06
Phytate (mg)	1947 (1117, 3481)	1860 (1149,2527)	0.60	2417 (1472,3567)	1718§ (1109,2734)	<0.05	2.7 (-730,1267)	-47 (-887,654)	0.53

† *basal status used for iron and zinc bioavailability estimates*
‡ *iron and zinc intakes excludes effects of bean soaking (phytate and tannin reduction) on zinc and iron bioavailability*
§*phytate:zinc molar ratio and phytate intake adjusted for bean soaking*

DOI: 10.18697/ajfand.79.15350

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 17 No. 3
July 2017
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Table 5: Women's predicted dietary diversity, vitamin A and vitamin C intake; mean (95% confidence interval)

	Control group	Intervention group	
	Dietary Diversity	(R^2adjusted=0.08)	
Non-members	4.2 (3.6-4.8)	3.7(2.7-4.6)	
WDL members	4.6(3.9-5.2)	4.9(3.5-6.3)	
	Vitamin A (RE) intake	(R^2adjusted=0.07)	
Non-members	323(225,464)	1315(592,2920)	
WDL members	649(539,783)	766 (557, 1053)	
	Vitamin C (mg) intake	(R^2adjusted=0.02)	
Non-members	73(53, 95)	128 (79, 187)	9
WDL members	103(91, 116)	98(78, 121)	44

REFERENCES

1. Black RE, Allen LH, Bhutta ZA, Caulfield LE, de Onis M, Ezzati M, Mathers C and J Rivera Maternal and child undernutrition: global and regional exposures and health consequences. Lancet 2008; 371(9608):243-260.

2. IFAD. International Fund for Agricultural Development. Rural Poverty Report. Rome, 2011; Available from: http://www.ifad.org/rpr2011/index.html. Accessed February 2017.

3. Arimond M, Wiesmann D, Becquey E, Carriquiry A, Daniels MC, Deitchler M, Fanou-Fogny N, Joseph ML, Kennedy G, Martin-Prevel Y and LE Torheim Simple food group diversity indicators predict micronutrient adequacy of women's diets in 5 diverse, resource-poor settings. J Nutr 2010;140(11):2059S-2069S.

4. Grantham-McGregor S, Cheung YB, Cueto S, Glewwe P, Richter L and B Strupp Child development in developing countries 1: Developmental potential in the first 5 years for children in developing countries Lancet 2007;369(9555):60-70.

5. Hyder AA, Maman S, Nyoni JE, Khasiani SA, Teoh N, Premji Z and S Salim The pervasive triad of food security, gender inequity and women's health: Exploratory research from sub-saharan Africa. Afr Health Sci 2005 ;(4):328-334.

6. FAO. United Nations Food and Agriculture Organization. The State of Food Insecurity in the World. 2006; Available from: http://www.fao.org/docrep/009/a0750e/a0750e00.html. . Accessed February 2017.

7. Moron C Food-based nutrition interventions at community level. Br. J Nutr 2006; Aug: 96 Suppl 1:S20-22.

8. Ayele Z and C Peacock Improving access to and consumption of animal source foods in rural households: The experiences of a women-focused goat development program in the highlands of Ethiopia. J Nut 2003; 133(11):3981S-3986S.

9. Berti PR, Krasevec J and S FitzGerald A review of the effectiveness of agriculture interventions in improving nutrition outcomes. Public Health Nutr 2004; 7(5):599-609.

10. Leroy JL and EA Frongillo Can interventions to promote animal production ameliorate under-nutrition? J Nutr 2007; 137(10):2311-2316.

11. Low JW, Arimond M, Osman N, Cunguara B, Zano F and D Tschirley A food-based approach introducing orange-fleshed sweet potatoes increased vitamin A intake and serum retinol concentrations in young children in rural Mozambique. J Nutr 2007; May;137(5):1320-1327.

12. Allen LH Interventions for micronutrient deficiency control in developing countries: Past, present and future. J Nutr 2003; 133(11 Suppl 2):3875S-3878S.

13. Walton CG Sustainable livelihoods and food and nutrition security of Kenyan smallholder farm women [dissertation] Charlottetown, Canada, University of Prince Edward Island; 2012.

14. VanLeeuwen JA, Mellish T, Walton C, Kaniaru A, Gitau R, Mellish K, Maina B and J Witchtel Management, productivity and livelihood effects on Kenyan smallholder dairy farms from interventions addressing animal health and nutrition and milk quality. Trop Anim Health Prod 2012; 44:231-238.

15. Walton C, VanLeeuwen J, Yeudall F and J Taylor Associations between duration of community based group membership and sustainable livelihoods for Kenyan women dairy farmers. J Ag Food Systems, and Com Dev 2012; October: 1-18.

16. Walton C, Taylor J, VanLeeuwen J, Yeudall F and S Mbugua Associations of diet quality with dairy group membership, membership duration, and non-membership for Kenyan farm women and children: A comparative study. Public Health Nutr 2014; 17(2):307-316.

17. Contento IR Nutrition Education: linking research, theory and practice. Asia Pac J Clin Nutr 2008; 17(1):176-179.

18. Fisher JD and WA Fisher Changing AIDS risk behavior. Psych Bull 1992; 111:455-474.

19. Sinley RC and JA Albrecht Fruit and vegetable perceptions among caregivers of American Indian toddlers and community stakeholders: a qualitative study. J Racial and Ethnic Health Disparities 2015; 2:341-350.

20. Gibson RS and EL Ferguson Nutrition intervention strategies to combat zinc deficiency in developing countries. Nutr Res Rev 1998; Jun; 11(1):115-131.

21. Siegenberg D, Baynes RD, Bothwell TH, Macfarlane BJ, Lamparelli RD, Car NG, MacPhail P, Schmidt U, Tal A and F Mayet Ascorbic acid prevents the dose-dependent inhibitory effects of polyphenols and phytates on nonheme-iron absorption. Am J Clin Nutr1991; 02/00; 53(2):537-541.

22. Davies NT and SE Olpin Studies on the phytate:zinc molar contents in diets as a determinant of Zn availability to young rats. Br J Nutr 1979; 41(3):591-603.

23. Fernandes AC, Waleska N and RD Da Costa Proença Influence of soaking on the nutritional quality of common beans (Phaseolus vulgaris L.) cooked with or without the soaking water: a review. Int J Food Sci Tech 2010;45(11):2209-2218.

24. Shimelis EA and SK Rakshit Effect of processing on antinutrients and in vitro protein digestibility of kidney bean (Phaseolus vulgaris L.) varieties grown in East Africa. Food Chem 2007; 103(1):161-172.

25. Zijp IM, Korver O and LB Tijburg Effect of tea and other dietary factors on iron absorption. Crit Rev Food Sci Nutr 2000; Sep; 40(5):371-398.

26. Disler PB, Lynch SR, Charlton RW, Torrance JD, Bothwell TH, Walker B and F Mayet The effect of tea on iron absorption. Gut 1975; Mar; 16(3):193-200.

27. Gibson RS Principles of nutritional assessment. Second edition. New York Oxford University Press, 2005.

28. Yeudall F, Gibson RS, Cullinan TR and B Mtimuni Efficacy of a community-based dietary intervention to enhance micronutrient adequacy of high-phytate maize-based diets of rural Malawian children. Public Health Nutr 2005; Oct;8(7):826-836.

29. Kenya Situation Analysis. Republic of Kenya 2011 Available from: www.transformnutrition.org/wpcontent/uploads/sites/3/2011/11/Kenya_situation_analysis.pdf. Accessed February 2017.

30. Ruel MT Can food based strategies help alleviate vitamin A and iron deficiencies? A review of recent evidence. 2001;IFPRI Washington DC.

31. Weber D and T Grune The contribution of beta-carotene to vitamin A supply of humans. Mol Nutr Food Res 2012; Feb;56(2):251-258.

32. Kigutha HN Assessment of dietary intake in rural communities in Africa: experiences in Kenya. Am J Clin Nutr 1997;65(4):1168S-1172S.

33. Adams CL, Hambidge M, Raboy V, Dorsch JA, Sian L, Westcott JL and NF Krebs Zinc absorption from a low-phytic acid maize. Am J Clin Nutr 2002; Sep;76(3):556-559.

34. Expert Consultation on Anemia Determinants and Interventions: proceedings of a conference. Ottawa, Canada: © Micronutrient Initiative 1998.

35. Bwibo NO and CB Neumann The need for animal source foods by Kenyan children. J Nutr 2003; Nov;133(11 Suppl 2):3936S-3940S.

36. Otten JJ, Hellwig JP and DL Meyers, editors. Dietary Reference Intakes The essential guide to nutrient requirements. Washington DC: National Academies Press, 2006. 541p.

37. Trowbridge FL, Harris SS, Cook J, Dunn JT, Florentino RF, Kodyat BA, Mannar MG, Reddy V, Tontisirin K and BA Underwood Coordinated strategies for controlling micronutrient malnutrition: a technical workshop. J Nutr 1993; Apr;123(4):775-787.

38. Creed-Kanashiro HM, Bartolini RM, Fukumoto MN, Uribe TG, Robert RC and ME Bentley Formative research to develop a nutrition education intervention to improve dietary iron intake among women and adolescent girls through community kitchens in Lima, Peru. J Nutr 2003; Nov; 133(11 Suppl 2):3987S-3991S.

39. Coates J, Swindale A and P Bilinsky Household food insecurity access scale (HFIAS) for measurement of household food access: Indicator guide (v. 3) 2007. Washington, D.C.: FHI 360/FANTA Available from www.fantaproject.org. Accessed February 2017.