Original Article

The effect of vitamin A-fortified coconut cooking oil on the serum retinol concentration of Filipino children 4-7 years old

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A 6-month intervention trial was conducted among 542 Filipino children aged 4 to 7 years to determine the effect of vitamin A-fortified coconut cooking oil intake on their vitamin A status and to identify factors that influence this. Children were randomly assigned to the Experimental group, with vitamin A-fortified cooking oil ration; to Control-1 group with unfortified cooking oil ration; and to Control-2 group without cooking oil ration. In all groups, children's serum retinol concentration improved. Relative change in serum retinol concentration was significantly higher among the Experimental group, with one-third of total vitamin A intake coming from vitamin A-fortified cooking oil intake, than in the Control groups, with more than half of intake from other vitamin A-rich foods. Determinants of post-intervention serum retinol concentration included baseline serum retinol concentration, caregiver's education, receipt of high-dose vitamin A capsule, interaction between consumption of vitamin A-fortified cooking oil and of other vitamin A-rich foods, and between households purchasing cooking oil and food expenditure. Intake of vitamin A-fortified cooking oil combined with vitamin A-rich foods was necessary to increase serum retinol concentration. It is recommended to vigorously promote the consumption of vitamin A-fortified cooking oil together with other vitamin A-rich sources to sustain the prevention and control of vitamin A deficiency.

Key Words: vitamin A fortified coconut cooking oil, vitamin A status, serum retinol concentration, weight for height, Filipino children, Philippines

Introduction

Vitamin A deficiency is a public health problem in the Philippines. Nearly four in every ten children 0 - 5 years of age (38.0%), and 2 out of every ten pregnant (22.2%) as well as lactating mothers (16.4%) had deficient to low serum retinol concentration in 1998.[1] Several efforts are being implemented to address the problem including high-dose vitamin A supplementation, food fortification and nutrition education. Fortification of different foods (such as margarine, sugar and wheat flour) with modest amounts of vitamin A has been shown to be efficacious in reducing vitamin A deficiency in several countries.[2]

In 1997, the Food and Nutrition Research Institute of the Department of Science and Technology (FNRI-DOST) developed a technology for the fortification of coconut cooking oil with vitamin A.[3] The technology aims to lead to economic impact in the coconut sector, and the improvement of the vitamin A status of the population. Furthermore, improvement of the vitamin A status will translate to increased child survival and further economic benefits

The fortification technology ensures that 15 g of vitamin A-fortified coconut cooking oil (VAFCCO) when used to cook a meal, contributes at least one-third of the Recommended Dietary Allowance (RDA) for vitamin A equivalent to 175 µg retinol for a Filipino reference man, which also provides 46.7% of the Recommended Dietary Allowance for children aged 4 to 7 years.

While the fortified product is out in the market, no efficacy or effectiveness study has as yet been carried out to document whether or not consumption of the VAFCCO will bring about improvement in vitamin A status. The direct cost of fortified cooking oil (to include cost of fortification and the manufacturer's promotion cost) was estimated at 0.50 centavos per kilo of cooking oil.[3] The direct cost borne by the households with their purchase of the fortified cooking oil was about 0.0005 centavos per gram. This was the difference in the market price of fortified cooking oil and unfortified cooking oil.

The study aimed to determine the effect of the consumption of VAFCCO on the vitamin A status of the at-risk group where vitamin A deficiency is a public health problem. Specifically, the study sought to: determine the contribution of VAFCCO to children's total vitamin A

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intake, relative to other sources of vitamin A in their current diet; identify factors that influence the children's serum retinol (SR) concentration; and evaluate the effect of VAFCCO intervention on the children's vitamin A status.

Conceptual framework

It is hypothesized that the availability of VAFCCO in households, cooking of foods in the fortified cooking oil, and consumption of these foods will increase intake of vitamin A (Fig.1). Household preferences for cooking methods and feeding and eating behaviours whether socially, economically or culturally defined, affect intake of vitamin A from all food sources and total vitamin A intake. The same influences energy, protein and vitamin C intakes, which play a role either in the synthesis of vitamin A, or in preventing infections. Nutrition education, as a component of the project, may have an effect on cooking practices as well as on nutrient intake.

Vitamin A intake determines vitamin A status, which may be reflected in serum retinol concentration. Other than vitamin A intake, current infections significantly affect serum retinol concentration.[4] Meanwhile, incidence, duration and severity of infections particularly measles, diarrhea, and acute respiratory infections may improve or worsen as a result of change in vitamin A status. Nutritional status is both an outcome and determinant of vitamin a status.

Materials and methods

Location

The study was conducted in two provinces in the Philippines, Zambales and Batangas, where vitamin A deficiency was of public health magnitude (>5% deficient with <10μg/dl serum retinol concentration and 15% deficient and low serum retinol with <20 μg/dl serum retinol concentration). Based on results of the 1998 National Nutrition Survey,[1] the provinces had a prevalence of 13.4% and 5.8% deficient serum retinol concentration and 55.8% and 42.5% deficient and low serum retinol concentration, respectively. In each province, one municipality was selected. These were Palauig in Zambales with six sample villages, and Lian in Batangas with five villages. Sample villages were those with high malnutrition prevalence, which was used as proxy indicator for vitamin A status.

Subjects and intervention

Sample size was determined to detect a 5% difference in the proportion of the population with vitamin A deficiency, with an 80% power, using a significance level of 0.05. A 20% drop-out rate was expected based on previous studies. All 4 - <7 y old children in the selected villages whose mothers/caregivers indicated consent to participate were included as subjects, except for those children who had measles and/or infections that lasted 7 days or more within a month prior to baseline data collection, and children with certain abnormalities i.e. hydrocephalus case. Subjects were randomly allocated by assigning a number to each child and drawing at random each subject to which group he/she belongs: to the Experimental group (N = 308), who received full ration of VAFCCO for 6-months, and to Control 1 group (N = 161), who received unfortified cooking oil for the same period. Children of the same age-range and with parental consent, from 1 village each in the 2 municipalities served as the Control 2 group (N = 153), and did not receive cooking oil ration. Ethical clearance was obtained from the National Ethics Committee.

Nutrition education sessions on nutrition and vitamin A, its sources and benefits, the advantages of using cooking oil for the utilization of vitamin A, and the importance of the research undertaking were conducted in a community assembly before the start of the intervention for all three groups. In addition, the Nutritionist-Dietitians of the Project checked record-keeping, suggested and encouraged mothers/caregivers of Experimental and Control 1 during the twice-a-month household monitoring visits to: (a) provide the subject child with foods cooked in oil; (b) mix cooking oil in the child's viand/broth or rice; or (c) give cooking oil by other means, such as by adding or replacing sachets of oil found in instant noodle packs with the rationed cooking oil.

Distribution of cooking oil

The researchers who re-packed cooking oil weekly from 17–18 kg institutional containers into white opaque 200-gram calibrated color-coded plastic bottles, were not masked to the type of oil they handled. The distribution of the color-coded cooking oil ration to study households was done by Local Aides weekly. The Local Aides were not aware of the color codes and therefore masked while the Nutritionist-Dietitians were not blinded to the type of intervention subjects received. Analysis of blood samples were also blinded with only the subject codes being provided. Only in the first tabulations and data analysis were groupings unblinded. Caregivers were instructed not to exchange their ration with study participants in the household.

Samples of cooking oil were obtained from each delivery batch of institutional cans of the VAFCCO, and analyzed by an independent laboratory for vitamin A content. This analysis showed vitamin A content of 11.42 μg per gram from the first batch, to 25.22 μg per gram in the succeeding batches - these values were within minimum acceptable vitamin A level (11.6 μg/g) based on the study by Marrero *et al*.[3] Samples of the unfortified brand were also delivered in batches and tested, which showed negligible traces of vitamin A.

Data collection

Baseline assessment was conducted in September 2000, before the "Garantisadong Pambata" (GP) week when vitamin A capsules (VAC) were distributed to 1 - 5 y old children. Collection of 0.5 mL blood samples by finger prick method for measurement of serum retinol concentration and anthropometric measurements of height and weight were done for all study children. Skin punctures were performed by trained medical technologists with commercially available disposable metal lancet. Blood was collected into heparinized capillary tubes, after which one end was sealed with sealstix and one end with parafilm, placed in a brown bottle and kept inside a thermos jug that contained wet ice during the day of collection. At site station, capillary tubes were centrifuged at 5,000 rpm for 15-20 minutes to separate the plasma from the red cell portion. Plasma samples were kept in the freezer compartment fo a household refrigerator while in the field, transported to FNRI laboratory on wet ice during the same week they were collected. In FNRI, the samples were stored in an isotemp freezer (-20°C) while awaiting analyses. Serum retinol concentration was determined by high performance liquid chromatography method[5] conducted at least a month after collection by Project Chemists. Weight was measured using a cali-brated 160 kilogram Detecto weighing scale and recorded to the nearest 0.1 kilogram. Height was measured using a Microtoise attached to a flat surface and read to the nearest 0.1 centimeter. Measurement of height and weight were done on the same spot in the study villages for the four data collection periods for consistency. Mother/caregivers were interviewed on study children's food intake using 24-hour food recall and a modified 1-month food frequency for intake of vitamin A-rich food, receipt of high-dose VAC and other multivitamins, and occurrence of infection for the immediate past month. Cooking practices of the household, type of cooking method, type of oil container, frequency of use of cooking oil, extent of heating oil was also determined from the interview at baseline. Children were dewormed with Mebendazole a week before the start of the intervention.

Follow-up data collection of variables mentioned above was done on the 50th day, mid-intervention (about 3rd month), 120th day and after 6 months of intervention. The child's daily oil consumption and morbidity data including occurrence, frequency and duration of diarrhea, measles, fever and acute respiratory infections, were monitored from caregivers' daily records using calendar-type monitoring sheets. Data entry were verified weekly and retrieved monthly by the Local Aides.

Data processing and analysis

Data encoding, editing and processing were performed using either dBase IV or MS Excel, including the conversion of food intake to nutrients using an Food and Nutrition Research Institute in-house dBase IV program which utilized the FNRI-DOST Food Composition Tables.[6,7] Data analysis was performed using the Statistical Package for Social Sciences (SPSS for Windows Version).[11] Descriptive analysis employing frequency and percentage distribution by study group and study period was carried out. Nonparametric tests such as Wilcoxon sign rank and chi-square were employed to determine difference in categorical variables. Analysis of variance (ANOVA) was undertaken to detect significant differences between means of the 3 study groups. Post hoc multiple comparison test (for means) and z-test (for proportion/ percentages) were performed to determine pair-wise difference between Experimental and Control groups and between Control groups and by period. Cross-tabulations and General Linear Model for repeated measures were used to examine differences in serum retinol between Experimental and Control groups and across periods. Simple type of contrast was utilized, where results by intervention periods were compared with baseline data. All possible combinations of significant factors were examined for potential interaction effect. Bivariate correlations were determined to identify significant relationships between explanatory variables and output and/or outcome indicators.

Results

A. Socio-demographic description of study site, subjects, households and caregivers

There were 622 subjects at the start of the study. During the intervention, 80 dropped-out, 40 from the Experimental group, 16 from the Control 1 and 24 from the Control 2, with a total of 542 subjects who completed the study. This was within the 20% allowance for sample size. Children who dropped-out, due to refusal to be pricked for blood collection, were out-of-town/transferred residence or sick during data collection, had lower height-for-age and weight-for-age z scores and cooking oil intake, and higher baseline serum retinol concentration and fat intake than those who stayed on as subjects. Individual characteristics of the study children were not different between groups, except for age (P<0.01). Children in the Experimental group were older than in Control 1 group (Table 1).

Baseline socio-demographic characteristics of the study children's households were, to some extent, different between groups. Differences were noted particularly with regard to household size (P < 0.05), garbage disposal (P <0.05), and source of drinking water (P <0.01). A larger proportion of households in the Experimental and Control 1 groups had larger household size (35 – 36%) and used open pits for burning rubbish or threw garbage in rivers or other places (63% and 61.8%, respectively) compared to households in Control 2 group (28.9% and 58.8%, respectively). The sources of drinking water were deep well and waterworks for almost all households in Control 2 (96.1%). Whereas dug wells or surface water were more common in both the Experimental (10.1%) and Control 1 (10.3%) groups.

Mean weekly food expenditure (Php758.43) and waste disposal system (water sealed = 88.7 % of households) were not different between groups. Maternal/caregivers' characteristics were not different between study groups. The majority of mothers/caregivers of the study children were between 30-39 years of age (44.3%) and had at least a high school diploma (30.2%).

B. Examination of the research variables in the study

Cooking practices and feeding methods

At baseline, the groups were the same with regard to cooking methods and the brand of cooking oil commonly used. The frequency of use and re-use of cooking oil by households however differed between groups as shown in Table 2. A larger proportion of households in the experimental group (64.0%) vis-à-vis the Control groups (50.8% – 53.8%) tended to re-use cooking oil. According to Marero *et al.*,[3] re-use of cooking oil lead to 50% loss of vitamin A in its second use. Households in the Experimental group tend to cook vegetables, and feed the same to children, in smaller cuts or size than the Control groups.

Table 1. Baseline socio-demographic characteristics of children, households and caregivers by study group

Child/household characteristics	Study groups		
	Experimental *N* = 268	Control 1 *N* = 145	Control 2 *N* = 128
Gender			
Male	56.3	51.0	46.5
Female	43.7	49.0	53.5
Age in years (mean ± SD)	6.9* ± 13.3	4.9* ± 0.8	5.4 ± 7.4
Receipt of vac/asap (April '00)	82.7	74.1	71.4
Chews vegetables well	16.8	14.5	17.3
Sick >1 day in the last month	71.1	68.1	75.2
Age of mothers/caregivers			
% < 20	2.6	4.8	0.0
20 < 29	27.3	26.2	29.7
30 – 39	46.4	42.1	44.5
≥ 40	23.6	26.9	25.8
Educational attainment of mothers/caregivers			
none	0.04	0.0	0.0
some elementary	15.4	15.9	14.7
elementary graduate	19.9	23.4	24.0
some high school	17.6	17.9	14.7
high school graduate	31.1	32.4	27.1
some college	5.2	2.8	7.0
college graduate	5.2	2.8	4.7
some vocational	1.1	0.7	1.6
vocational graduate	4.1	4.1	6.2
Household size*			
Mean ± SD	6.08 ± 2.04	6.13 ± 2.31	5.56 ± 2.03
% < 4	5.2	5.5	10.9
4 to 6	58.6	59.3	60.2
> 6	36.2	35.2	28.9
Average food expenditure per week			
Mean ± SD	*P* 756.23 ± 472.4	*P* 779.47 ± 449.01	*P* 739.60± 458.33
% ≤ P500	17.2	18.6	17.8
P501 – P1,000	54.1	47.6	55.8
P1,001 – P2,332	28.7	33.8	26.4
Garbage disposal system*			
% Open pit then burned	49.8	52.8	54.0
Picked-up by garbage collector	17.7	21.5	25.4
Covered pit/covered pit then burned/bury	19.2	16.7	15.9
Throw in river/anywhere/others	12.8	9.0	4.0
Others	0.4	0.0	0.8
Waste disposal system			
% Water sealed	85.8	88.8	91.5
Squat and cover	4.5	4.9	2.3
Squat and run	4.5	4.9	3.1
Open pit	3.4	0.7	0.8
Pit privy	1.9	0.7	2.3
Source of drinking water**			
% Deep well	85.1	80.7	95.3
Dug well/surface water/others	10.1	10.3	1.6
Waterworks	4.5	7.6	0.8
Rain/Spring	0.4	1.4	2.3

* ANOVA, χ^2 $P < 0.05$; ** χ^2 $P < 0.01$

The practice of cooking and feeding vegetables to children in smaller cuts tends to enhance utilization of vitamin A in the body. Significant differences in cooking practices were noted across periods in all study groups. The use of frying and sautéing, and cooking oil with vitamin A, increased in all groups during the intervention ($P < 0.01$). These changes were most likely influenced by the households' interaction with the researchers, including the provision of nutrition education.

Cooking oil intake

The mean cooking oil intake amongst the Experimental (using VAFCCO) and Control 1 (using unfortified cooking oil) study children was 3 teaspoons per day. This was not the same across periods during the intervention (P <0.01), which fluctuated between the 1st, 2nd and 3rd periods in all study groups. However, throughout the study period, unfortified cooking oil intake by children in Control 2 group was lowest, with a mean of 1.45 ± 0.64 teaspoons a day (P <0.01). At least 5 grams per day of dietary fat is recommended in a child's diet to optimize the absorption and utilization of preformed vitamin A and provitamin A,[7] whilst adequate protein intake aids vitamin A utilization.[8,9]

Nutrient intake

Baseline mean daily energy, protein and vitamin C intake and adequacy among the study children from the 24-hour food recall were not different between the study groups. Mean one-day energy intake ranged from 1058 –1132 kcal (66.1% - 70.8% adequacy). Mean one-day protein intake was 30.6g – 36.0g (95.6% - 112.5% adequacy) while intake of vitamin C was 20.5mg - 38.2mg (45.6% - 84.9% adequacy). Likewise, at all intervention periods, no differences in mean energy, protein and vitamin C intakes and percentage adequacy were noted between study groups, nor were there differences between periods from baseline for all groups.

Vitamin A intake and sources of vitamin A

Using the modified 1-month food-frequency questionnaire, baseline mean vitamin A intake of the study children was different between study groups (Table 3). Children in the Experimental group had higher intake (789.0μg ± 540.9μg) than those in the Control groups (640.7 ± 742.6μg – 646.8 ± 657.2μg) at the start of the intervention. Considering all types of cooking oil used by the study children, the proportion of vitamin A obtained from cooking oil was highest in the Experimental group (29.0%) compared with the two Control groups (4.3% – 4.6%). On the other hand, vitamin A from other fortified foods and other vitamin A rich foods, was higher in both Control groups than in the Experimental group.

During the intervention periods, the children in the Experimental group had higher vitamin A intake (815μg ± SD 854, 937μg ± SD 720) than those in the Control 1 and 2 groups (583μg ± SD 459, 953μg ± SD 161), except during the 3rd period when those in Control 1 group (952 μg ± SD 161) also had a high vitamin A intake. Across periods, the intake of vitamin A by the study children was higher (P<0.01) during the 3rd period compared to baseline in the Experimental and Control 1 groups. The contribution of other vitamin A-rich foods such as eggs, pork, squash, ripe mango, powdered filled milk, and fish was higher during the 1st and 3rd periods in the Experimental group and during the 3rd period in the Control 1 group. The percentage contribution of cooking oil to total vitamin A intake was not different between baseline and the intervention periods in the Experimental group, but had a significant decline for the two Control groups.

Nutritional status as indicated by weight-for-height z-scores

At baseline, there were no differences in mean z-scores for weight-for-height (W-H) between study groups (-0.67 ± 0.96 SD to -0.73 ± 0.74 SD) nor in the proportion of low weight-for-height between groups. The weight-for-height z-scores of the study children were not different between groups at any period during the intervention; but these were higher around the 50th and 120th day of intervention in all study groups from baseline (P <0.05). The proportion of children with low weight-for-height was higher in the Experimental group than in the Control 2 group at 120th day (2.6% vs. 0%) P < 0.05).

Morbidity

At baseline, there were no differences between groups with regard to frequency of illnesses such as acute respiratory infections, fever, diarrhea, and measles. The number of episodes per child for the past month was '1' for acute respiratory infections and fever and '2' for diarrhea. Mean duration of illnesses during the same period was 4 – 5 days for acute respiratory infections, 3 days for both fever and diarrhea. During the intervention, there were no significant differences between study groups in the prevalence, frequency and duration of illnesses at any period. Fluctuation in frequency of acute respiratory infections and a decline in the frequency of fever between intervention periods were experienced among children in the Experimental group.

Serum retinol concentration

Baseline serum retinol concentration among subjects were within acceptable concentration using the WHO cut-off points (Fig. 2). There were significantly less children from the Experimental group (69.4%) with acceptable serum retinol concentration compared than in the Control 1 (72.4%) and Control 2 (82.8%). All children in the Experimental group who had low serum retinol concentration at baseline registered improvements in serum retinol concentration after 6 months of intervention. Of these children, 93.5% improved to acceptable serum retinol concentration and the rest to marginal serum retinol concentration (6.5%). Among children in the Control 1 group who had low baseline serum retinol concentration, 91% improved to acceptable concentration while 9% had marginal concentration at end of the study.
All children in Control 2 who had low baseline serum retinol concentration also improved. Among study children who had marginal baseline serum retinol concentration, 98.1% in the Experimental group improved vis-à-vis 95.6% in the Control 1 group and 100% in the Control 2. Almost all children who had acceptable to high serum retinol concentration regardless of study group, maintained or improved their vitamin A status. Percentage of subjects with increased serum retinol concentration by period and group (Fig. 3) showed that the Experimental group had significantly higher increase percent-wise from 22.4%, 26.5% and 33.2%, 50th to 180th period respectively, than those in the Control 1 group where vitamin A status improved in 16.6%, 18% and 33.8% of the subjects.

The mean serum retinol concentration at baseline was significantly different only between the Experimental and Control 2 groups (Table 5). After six months, there was a significant improvement in the mean serum retinol concentration of all groups with the difference being significantly different between Control 2 with both the

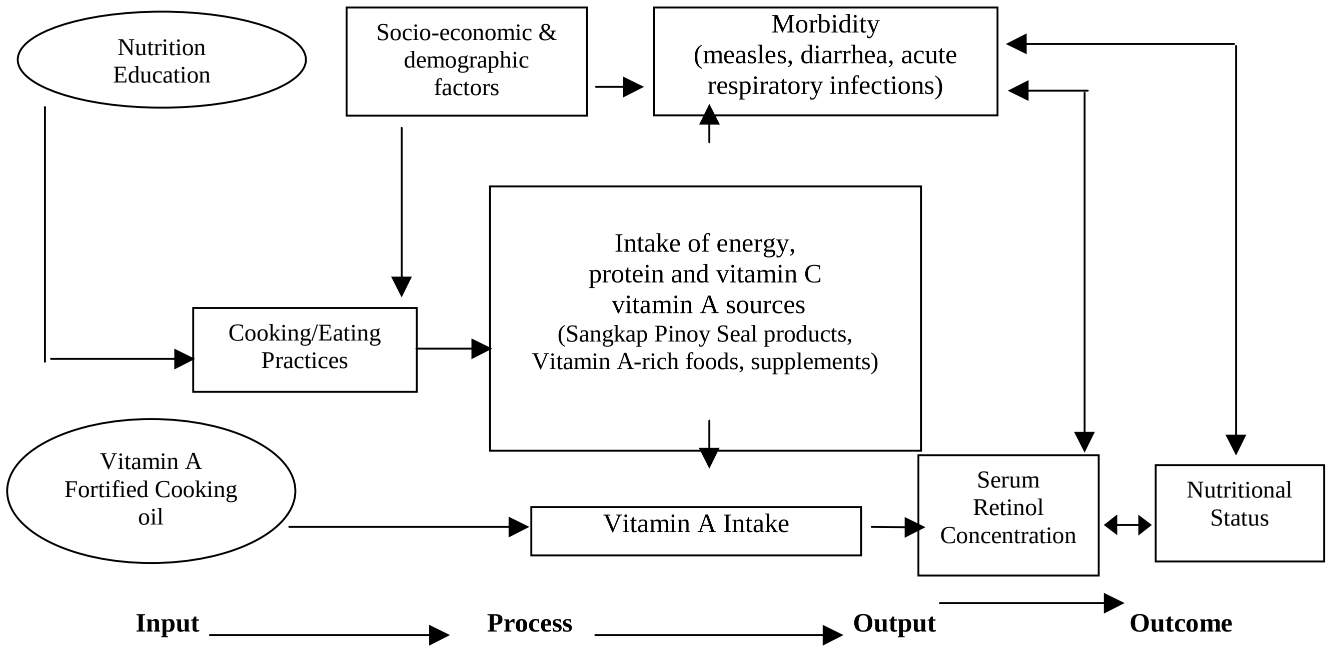

Figure 1. Conceptual framework on the effect of vitamin A-fortified cooking oil on the serum retinol concentration of children 4 to <7 years old

Table 2. Cooking practices and cooking oil use of household subjects (in %) by study group at baseline and after 6 months of intervention

Cooking Practices	Study group: Experimental N = 268		Control 1 N = 145		Control 2 N = 129	
	Baseline	After 6 mo	Baseline	After 6 mo	Baseline	After 6 mo
Common cooking method (multiple response)						
Boiled	38.1	41.7	34.5	49.0	50.0	46.9
Fried	51.5**	82.6**	51.7**	85.5**	43.0**	78.1**
Sautéed	29.9**	49.6**	28.3**	52.4**	31.3**	45.3**
Broiled	2.6	6.4	3.4	6.9	0.8	8.6
Use of cooking oil in a day[1]						
1 – 2	75.0	68.2	64.9**	67.2**	91.3**	74.7**
> 3	25.0**	31.8**	35.1	32.8	8.7**	25.3**
Save used cooking oil for re-use	64.0*	60.1	53.8*	52.4	50.8*	50.8
Portion size of vegetables fed to child						
cut in big slices	16.2		24.5		37.0	
cut in small slices	71.9**		62.3**		50.6**	
mashed	11.9		13.2		12.3	

[1]P <0.05 χ^2 test (within period between groups); ** P< 0.01 Z-test for proportion (difference between periods within groups)

Experimental and Control 1 groups. The relative change in mean serum retinol concentration from baseline to after 6 months of intervention showed a percentage change of 36.1% for the Experimental group, 33.5% for Control 2 and 31.5% for Control 1. The constant contact with the nutritionist-dietitian researchers may have motivated the mothers/caregivers to improve the subjects' food intake and to become more aware of the sources of vitamin A.

Controlling for mean serum retinol concentration at baseline using regression to the mean and regardless of the type of cooking oil used, subjects whose baseline serum retinol concentration were less than the median had significantly higher mean change in serum retinol after the intervention than those whose serum retinol concentration was higher than the baseline median (59.93% vs. 10.83%, respectively).

Relationships between variables

a. Vitamin A intake by different sources

Percent contribution of vitamin A from fortified foods other than cooking oil and from other vitamin A-rich foods were positively correlated at all periods (r = 0.217 – 0.517). Total one-day vitamin A intake was also associated with vitamin A contribution from other vitamin

Table 3. Mean vitamin A intake (μg) per day and % distribution of subjects by source of vitamin A by study group by period

Vitamin A intake (period and sources)	Study group		
	Experimental *N* = 268	Control 1 *N* = 144	Control 2 *N* = 127
Baseline			
μg ± SD	789.0±540.9	646.8±657.2	640.7±742.6
% cooking oil	29.0	4.3	4.6
% other fortified foods	31.5	42.8	39.0
% other vitamin A rich food	39.2	52.3	55.8
1st Period (1st- 50th day)			
μg ± SD	848.3±697.0[1]	692.1±873.8[1]	724.0±961.0
% cooking oil	30.8	0*	1.8*
% other fortified foods	25.0*	38.5	34.7
% other vitamin A rich food	44.2*	61.5	63.4
2 Nd Period (51st - 120th day)			
μg ± SD	815.7±853.7[1]	594±777.9	582.7±459.1
% cooking oil	32.5	0*	1.8*
% other fortified foods	24.6*	43.0	42.6
% other vitamin A rich food	42.9	62	59.2
3rd Period (121st - post)			
μg ± SD	936.8±719.9*	952.5±161.2*	686.8±671.5[1]
% cooking oil	26.5	0*	1.5*
% other fortified foods	25.2	35.2	36.3
% other vitamin A rich food	48.4*	64.8*	62.3

*$P < 0.01$ GLM repeated measures (difference from base within groups); $P < 0.05$ ANOVA (difference between groups within periods)

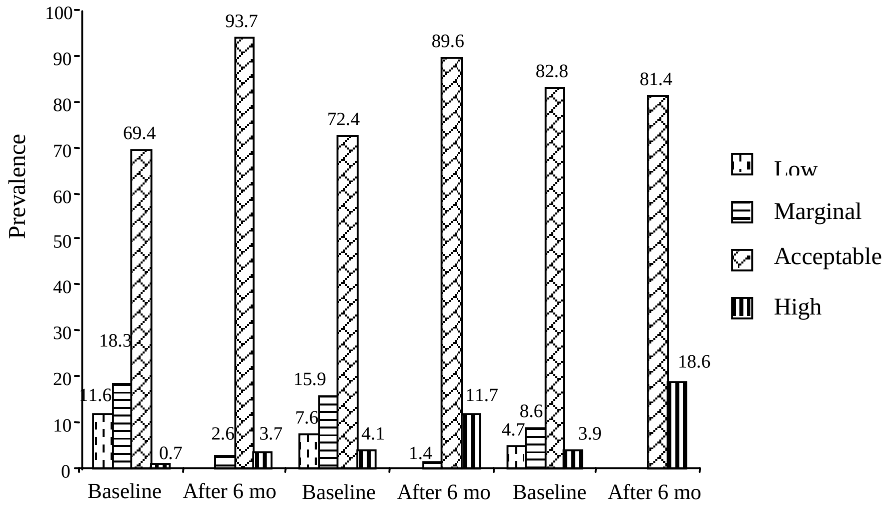

Figure 2. Percent distribution of subjects by serum retinol concentration by study group at baseline and after 6 months of intervention

A-rich foods at all periods (r= 0.280), and with percentage contribution from other vitamin A-fortified foods the first and third periods (r = -0.179 and r = -0.162, respectively). Total one-day vitamin A intake and percentage vitamin A intake from cooking oil were negatively associated (r = -0.164). The analysis showed higher percentage vitamin A and vitamin A-rich foods (r = 0.181) with increasing purchase of cooking oil. Purchase of cooking oil among households in the Control 2 group was asso-ciated with lower vitamin A intake from cooking oil (r = -0.412) and total one-day vitamin A (r =-0.110), particularly during the 3rd period.

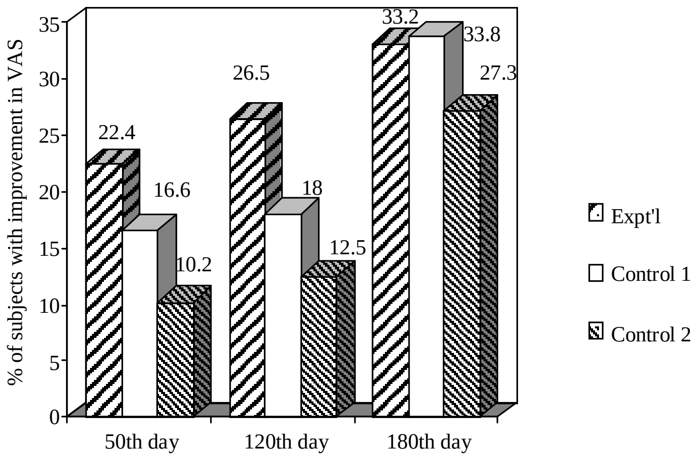

Fig 3. Percent of subjects with increased serum retinol concentration by study group by study period

Table 4. Weight-for-height z-scores and % with low weight-for-height among subjects by study group and study period

Study group/period	Weight-for-height z-score Mean ± SD	% Low weight-for-height <20 µg/dl
Experimental (*N* = 263)		
Baseline	-0.69 ± 0.76	2.6
50th	-0.56 ± 0.75*	2.2
Mid	-0.68 ± 0.79	4.5
120th	-0.57 ± 0.77*	2.6[1]
Endline	-0.69 ± 0.85	4.1
Control 1 (*N* = 145)		
Baseline	-0.67 ± 0.96	3.4
50th	-0.52 ± 0.95*	2.1
Mid	-0.47 ± 1.32	1.4
120th	-0.54 ± 0.93*	1.4
Endline	-0.67 ± 0.95	4.1
Control 2 (*N* = 128)		
Baseline	-0.73 ± 0.74	1.6
50th	-0.59 ± 0.83*	1.6
Mid	-0.68 ± 0.8	3.1
120th	-0.57 ± 0.77**	0.0[1]
Endline	-0.7 ± 0.78	1.6

* *P* <0.05 between periods from baseline within groups; ** *P* <0.01 between periods from baseline within groups; [1] P *<0.05 between groups within periods*

b. *VAFCCO intake and nutritional status as indicated by weight-for-height z-scores*

It can be noted that in the Experimental group, no subjects consumed <5 g of cooking oil per day. Subjects who consumed high amounts of VAFCCO (>15g per day) improved in weight-for-height z-scores by 80%. The weight-for-height z-scores decreased by >80% for those who consumed average amount of VAFCCO (5 to 15g per day) from base to after 6 months of cooking oil intervention.

The findings show that there was no significant effect of VAFCCO intake on nutritional status of subjects. Hadi *et al.,*[10] also showed that while vitamin A deficiency is associated with stunting and wasting in preschoolers, vitamin A supplementation had not shown a consistent effect on growth. The protective effect of vitamin A was shown by Rahmathullah *et al.,*[11] to be unremarkable in children with wasting and in those with normal anthropometric measures. A significant effect on child growth, being a product of multiple factors, including both nutritional and environmental, should not be expected from a single nutrient intervention such as the cooking oil intervention, except possibly in a population where vitamin A deficiency is the strongest growth-limiting factor. Weight-for-height z-score was included as an outcome variable in the study to determine if VAFCCO can effect a change in this very important indicator of nutritional status. There was no significant association between nutritional status and percent vitamin A contribution from cooking oil, even as children with lower height-for-age (r = -0.132) or weight-for age z scores (r = -0.114) tend to have higher vitamin A intake from cooking oil. Serum retinol concentration was significantly associated with lower cooking oil intake (r = -0.121), but not with the intake of VAFCCO except at the end of the intervention period (r = -0.122).

c. Vitamin A intake, vitamin A status and morbidity

Occurrence of infection during the intervention period did not exhibit any relationship with vitamin A intake either from VAFCCO or other vitamin A-rich sources, or with serum retinol concentration. Most of the households in the Experimental group had larger household size, practiced open-pit-then-burned type of garbage disposal system and had drinking water obtained from deep well,

Table 5. Relative change of mean serum retinol concentration of subjects from baseline to after 6 months of vitamin A fortified coconut cooking oil usage by study group

Study group	Mean serum retinol		Relative change (%)
	Baseline (µg/dL±SD)	After 6 months (µg/dL±SD)	
Experimental (*N*=268)	28.81±8[1]	36.88±7[2]	36.1*
Control (*N* =145)	30.77±9	37.94±8[3]	31.5*
Control (*N* = 128)	33.06±8[1]	41.82±8[2,3]	33.5*

[1,2,3] Post hoc test (difference bet. groups) significant at $P = 0.05$; * ANOVA significant at $P = 0.05$

dug wells and surface water, but did not differ with regard to morbidity vis-à-vis the Control groups. Adair et al.,[11] have found that environmental sanitation, food processing and water quality affect diarrhea, while factors that increase person-to-person contact (such as crowded households) affect febrile respiratory infection. Despite the presence of high risk factors to infection among subjects consuming fortified cooking oil, the use of VAFCCO may have had a protective effect.

Determinants of vitamin A status

The significant determinants of serum retinol concentration post-intervention, after considering variables on household and socio-demographic characteristics, nutritional status and morbidity, and cooking oil (both VAFCCO and unfortified cooking oil) and vitamin A intake were as follows (step-wise): serum retinol concentration at baseline (β = 0.282), interaction of buying cooking oil and food expenditure (β = 0.004), education of caregiver (β = 0.109), receipt of high-dose vitamin A capsule (β = 1.214), and interaction of vitamin A from vitamin A-rich foods and cooking oil (β = 0.000005).

The first significant interaction term implies that, among children in households that purchased cooking oil (i.e the Control 2 group), higher food expenditure tends to increase serum retinol concentration. Higher food expenditure may have enabled households that did not receive VAFCCO to purchase and consume other vitamin A-rich food sources. The second interaction term indicates that among children with intake of vitamin A from cooking oil, intake of vitamin A-rich foods was necessary to contribute to increasing serum retinol concentration. Consumption of VAFCCO alone was not a determinant of serum retinol concentration.

Even with the availability of cooking oil in the household, daily usage attributable to the fortified brand was not shown to improve serum retinol concentration. The same result was observed in the study of Solon *et al.,*[13] wherein no definite result due to the vitamin A in the oil itself could be ascertained, but it can be stated that the oil preparation contributed to the total vitamin A intake of the subjects. Also, in the same study, there was a significantly higher difference in weight gain between the Control and Experimental groups which took the oil with other foods, but not with the group which consumed oil without intake of other vitamin A foods.

In a study on the efficacy of a dietary intervention done in India,[14] serum retinol concentration values of Experimental subjects who consumed small amounts of inexpensive and readily available vegetable sources of provitamin A were significantly higher than those of the Controls. Significant improvements in serum retinol concentration were seen among study children who were classified as having low to marginal serum retinol concentration at baseline. Improvement in serum retinol concentration was also observed among school age children fed with vitamin A-fortified bread in a study by Solon *et al*.[15]

More than half of the household subjects in this study saved used cooking oil for re-use, even though they received fresh and sufficient supply of cooking oil weekly. This practice somehow shows that culturally, there is a tendency to save and re-use cooking oil, even with enough available supply. Some of our findings (i.e intake of VAFCCO alone was not shown to improve serum retinol concentration among study children) might be explained by the loss of vitamin A from VAFCCO during re-use. This suggests that vitamin A from cooking oil could otherwise be more available if fresh cooking oil was used.

The results of this study revealed that usage of VAFCCO alone is not sufficient to increase vitamin A status of 4 to <7 y old children. However, together with vitamin A-rich foods, intake of VAFCCO showed significant change in the serum retinol level concentration considering the results of multivariate regression. Increased availability and consumption of vitamin A-rich foods to adequate amounts through continued efforts in backyard and community gardening, is an important component of the solution to the problem of vitamin A deficiency. Although it is a long-term approach, it is more sustainable and economically sound and should be pursued simultaneously with massive dosing programs.[16] Green leafy and yellow vegetables, rich sources of provitamin A, are not only cheaper, but can easily be grown in backyard and community gardens. Hence, food production programs at the local or household level should also be pursued and intensified in combination with nutrition education.

The low bioefficacy of provitamin A carotenoids from green-leafy and yellow vegetables can be enhanced with the inclusion of at least one teaspoon of fat in the meal. In a study of children in Central Africa,[17] the addition of small amounts of fat to the vegetarian diet improved absorption of provitamin A carotenoids, increased serum retinol concentration and reduced vitamin A deficiency symptoms, in agreement with the result of this study.

Promotion of the Nutritional Guidelines, specifically to eat foods cooked in cooking oil daily, for the absorption and utilization of vitamin A is also needed to improve calorie adequacy of Filipinos. An information-education-communication strategy on nutrition and health education is an intervention that should universally accompany all other interventions in order to effect a behavioural change in the role of cooking oil in food selection, food production, and or purchase, food preparation, and food consumption. Awareness, however, needs to extend beyond the health establishment and include all levels from national and local political leaders to household caregivers of children.

Conclusions and Recommendations

The study, conducted in a community-setting for a period of six-months, has the following conclusions:

- VAFCCO intake, which contributed to about 30% of vitamin A intake, was significantly higher among the Experimental group than in the two Control groups, but taken alone was not shown to improve the serum retinol concentration of children 4 to <7 y old ;
- the use and consumption of VAFCCO together with intake of vitamin A from other sources such as green leafy and yellow vegetables, liver, fish, meat and eggs, improves serum retinol concentration;
- as the intake of fat, whether fortified or not, enhances absorption of vitamin A, the use of coconut oil improves vitamin A status and nutritional status, in general.

Looking at implications of the results on a macro scale, fortification of coconut oil with vitamin A is value-adding that would translate to:

- improved vitamin A status at a minimal cost;
- increased product demand, production and employment opportunities among coconut farmers and hence contribute to poverty reduction;
- improved economic as well as nutritional conditions of small-scale coconut farmers and their households.

It is therefore recommended that the following actions be undertaken:

- Program implementers should promote the consumption of VAFCCO hand in hand with vitamin A-rich foods such as green leafy and yellow vegetables, liver, meat, fish, milk and eggs to sustain the prevention and control of vitamin A deficiency, and to pursue vitamin A supplementation in areas at high-risk of vitamin A deficiency; a food production program at the local or household level should be pursued and intensified in combination with nutrition education;
- Barangay Health Workers should vigorously engage in health and nutrition education to promote behavioural change, especially the role of VAFCCO in food selection and eating pattern, and the promotion of the Nutritional Guidelines for Filipinos.

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