THE ALLEVIATION OF VITAMIN A DEFICIENCY IN GHANA:

AN APPLICATION OF MULTIVARIATE PROBIT MODEL

by

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ABSTRACT

Ghana is a less developed country in African with excellent growing potential. However, malnutrition is severe in this country due to specific dietary style and economic status. Food fortification programs with divergent standards have been established to fight deficiencies of specific nutrients since 1996 in Ghana. As a result, vegetable oil and wheat flour are selected as food vehicles for vitamin A, folic acid, niacin, iron and zinc. This study focuses on the intake of vitamin A from fortified foods or foods that could be fortified using a survey conducted in three major cities in Ghana, i.e. Accra, Tamale, and Takoradi. The study examines factors determining the potential intake by distinguishing among consumption frequencies i.e., daily, weekly, and monthly, of five staples through the application of the multivariate probit model. The results suggest that per capita income, geographic location, employment status, education, and market access are of importance in determining the consumption frequency. The results also reveal that the existing food source of vitamin A from the program is insufficient for Ghanaian women to reach WHO daily standard. However, fortifying maize flour will largely alleviate the inadequate vitamin A intake issue.

INDEX WORDS: Africa, Ghana, Food Fortification Program, Bio-fortification, Additives Fortification, Vitamin A, Vegetable Oil, Wheat Flour, Maize Flour, Consumption Frequency, Multivariate Probit Model, Conditional Marginal Effect

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DEDICATION

Dedicated to my parents, De Wang and Hong Wang, and my beloved Xihan Liu, for their love and support.

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TABLE OF CONTENTS

Page

LIST OF TABLES

Page

CHAPTER 1

INTRODUCTION AND BACKGROUND

1.1. Introduction

Less developed countries in Africa face severe nutrition deficiency issues that are responsible for many public health problems such as premature death, disability or reduced work ability. Major deficient nutrients are vitamin A, iron, zinc, and iodine (Agble, 2009). In response to the problem, the government of Ghana has developed a food fortification program to fight against malnutrition. In Ghana, vegetable oil and wheat flour are two major food vehicles fortified with additives. Maize flour, while not fortified in Ghana, has been included in the fortification programs in other African countries such as Kenya, Malawi, Mali and Nigeria, and, thus, it is a potential food vehicle in fortification program. What then, is affecting urban consumers to purchase and consume these fortified or potentially fortified staples? Earlier studies indicate that factors including household income, prices, consumer preferences, and education are important in the consumption of fruit and vegetable in sub-Saharan Africa (Ruel et al., 2004). The socio-economic and demographic factors that impact the consumption of staples are rarely studied.

The illustration of fortified staples in the current study is based on four selected staples: palm oil, groundnut oil, all other vegetable oil, and wheat flour. The potentially fortified staple is maize flour. In order to examine the consumption frequency of the stated staples and the intake of vitamin A from staple sources, three consumption time periods are selected: daily, weekly, and monthly. And, a multivariate probit model is used to determine the probability of consuming each staple food category at each frequency level. Then, based on the consumption frequency of staples, the amount of vitamin A is calculated according to the fortification standard. Finally, by assuming daily, weekly, and monthly amount of the consumed staple, a total vitamin A intake from the fortification program is analyzed.

The thesis is organized as follows: chapter 1 provides a background and brief overview of Ghana's economy. Chapter 2 contains the literature review on nutrition deficiency and alleviation both in Africa and in Ghana; the difference between bio-fortification and fortification through additives; a history of food fortification program in Africa; the effect of food fortification program in Ghana and an explanation of the OXFORD/OECD method. Chapter 3 and Chapter 4 include the application of data and a multivariate model to examine the staple consumption in urban Ghana. Chapter 5 summarizes the results and presents calculations of the additional vitamin A intake from maize flour if it is fortified with vitamin A according to FAO recommendations. Chapter 6 concludes the thesis.

1.2. Economy, population and international trade in Ghana

Republic of Ghana, located along the Gulf of Guinea and Atlantic Ocean, is in the sub-region of West Africa. With a landmass of 238,535 squared kilometers and population of approximately 27 million in 2014 (Ghana Statistical Service, 2015), Ghana's economy is the 6th-largest on the African continent as measured by the purchasing power parity (PPP) and Nominal GDP. Ghana had the highest per capita income of $1858.2 in terms of PPP in the sub-region of western Africa in 2013 (World Bank, 2015). In this study, Accra, Tamale and Takoradi are three Ghanaian cities of interest.

Accra is the capital and largest city of Ghana, with an estimated urban population of 2.27 million in 2012. The Greater Accra Metropolitan Area (GAMA), inhabited by about 4 million people, is the eleventh-largest metropolitan area in Africa (Ghana Embassy, 2015). Tamale is the capital city of the Northern Region of Ghana, and is mostly inhabited by the Mole-Dagomba linguistic group. Home to about 350,000 people, Tamale is the commercial capital of the three northern regions and is reputed to be one of the fastest growing cities in West Africa (GhanaWeb, 2015). Takoradi, the capital of the Western Region, is an industrial and commercial center with a population of 445,205 people in 2012 (World Public Library, 2015). The urban population of Ghana was 51.9% of total population in 2011 and the annual rate of change in urbanization is 3.5% (Ghana Demographics Profile, 2014).

Table 1 shows Ghana's 2011 exports and imports of foods of particular interest in this study. Figures in the table indicate that Ghana produces most of the vegetable oil domestically, with some (50,170 tons) imported palm oil. The amount of sugar imports (453,220 tons) doubles the exports (225,400 tons). While all of the wheat flour in the market is imported (44,510 tons), maize, on the other hand, the largest staple crop in Ghana that contributes significantly to consumer diets, is an exclusively domestic product. The amount of domestically produced maize was 1,871,695 tons in 2011 according to FAO (2015). Maize dominates the area planted and accounts for 50%-60% of the total cereal production. Maize is the most important agricultural crop because different parts of the plant can be used to feed livestock or as raw material for industrial products (Armah, 2015) as well as because of the country's heavy reliance on maize in the diet.

Table 1. Domestic production, exports and imports of selected foods in Ghana

Food categories	Domestic production (tons)	Exports (tons)	Imports (tons)
Palm oil	120,000	50,170	74,431
Sugar	NA	225,400	453,220
Vegetable oil	NA	14,000	0
Wheat flour	0	0	44,510
Maize	1,871,695	0	0

Source: Food and Agriculture Organization (FAO) 2015.

1.3. Hypotheses

There are three main hypotheses in this study:

(1) the consumption between vegetable oil types and starchy food are correlated, because vegetable oils serve as cooking oil or ingredient in sauce or stew that complement starchy staples;

(2) wheat flour and maize flour, though made from different crops, may be good substitutes in that they are commonly used in various commonly consumed dishes;

(3) the palm oil is mainly used in soup due to its color, such as the popular groundnut soup, but can also be used in ways similar to groundnut oil and other vegetable oils.

Consequently, the fortification with vitamin A of all staples considered in this study has a great potential in reducing the deficiency of this essential nutrient in Ghana’s population.

CHAPTER 2

LITERATURE REVIEW

Various studies have focused on topics such as the nutrition deficiency, evaluation of government food fortification programs, efficiency and implications of such programs, and of food dietary pattern in Africa. In my study, the prevalence of health and nutrition issues in Ghana motivated the analysis of the fortified and potentially fortified foods. The focus is on vitamin A intake from staple foods.

This chapter is organized as follows: section (2.1) discusses the nutrition deficiency in Africa; section (2.2) distinguishes between bio-fortification and fortification through additives; section (2.3) reviews literature on food fortification programs in Africa; section (2.4) summarizes government nutrition fortification program in Ghana; section (2.5) shows the application of OXFORD/OECD method; and, section (2.6) reports the application of the multivariate probit model.

2.1. Nutrition Deficiency in Africa

Micronutrient deficiencies are responsible for significant public health problems in developing world, causing premature death, disability and reduced work capacity (Black et al., 2013). Regional studies in the Republic of South Africa demonstrate a risk of inadequate dietary intake of micronutrients in children. National food consumption survey among the South African children aged 1-9 years reports that one in five children is stunted, and one in ten is underweighted (Labadarios et al., 2005). Major deficient nutrients among urban population in Africa are: vitamin A, iron, zinc, and iodine according to FAO (2009).

In 2005, an estimated 42 % of children were at risk of vitamin A deficiency (VAD) in Ivory Coast (Aguayo and Baker, 2005). According to the results of a quasi-national survey that covered three rural and one urban area in West Africa, severe and moderate VAD is found to be 24 % and 7 %, respectively. Pre-school age children and non-pregnant woman of productive age have severe or moderate VAD of 56 % and 21 % in this region, respectively (Ross et al., 1993). The Vitamin A Supplementation Trials Study (VAST) conducted over the period 1988-92 in the savannah zone of Ghana shows high prevalence, approximately 65%, of vitamin A deficiency among children aged 6-59 months (Ross et al., 1993). In addition, a 2003 Ghana demographic and health survey indicates that the prevalence of vitamin A deficiency in mothers during their pregnancy is 7.7% (GSS, 2004). However, a more recent level of VAD for Ghana has yet to be documented.

Severe iodine deficiency affected one third of Ghanaian districts in1995 (Nyumuah et al., 2012). Ghana is a major salt producer and exporter to West African countries and salt was the first food vehicle chosen by the government and was fortified with potassium iodate in 1996 (Nyumuah et al., 2012). Ghana's Universal Salt Iodization program commenced in 2009 to improve iodine deficiency in neighboring countries as well as to increase domestic household coverage by iodized salt and the quality assurance of salt producers (UNICEF, 2015). In spite of years of effort, the household coverage is only 34% due to scattered domestic producers according to UNICEF (2015), and innovation in the program is highly desired.

Anemia affects 68% of pre-school age children and 48 % of non-pregnant women of reproductive age in Africa and is caused by iron deficiency in the sub-Saharan Africa according to Vanderjagt (2007). In Ghana, anemia affects more than three quarters of young children and almost half of women of childbearing age (Agble, 2009). Although many health issues deserve great attention in Ghana, this study is centered on the intake of vitamin A from either of the fortified or potentially fortified food sources.

2.2. Bio-fortification and Fortification through Additives

A conventional way of food fortification is through additives: the addition of specific nutrients to food (WHO and FAO, 2000). As defined by WHO and FAO, fortification refers to "the practice of deliberately increasing the content of an essential micronutrient, i.e., vitamins and minerals (including trace elements) in a food irrespective of whether the nutrients are originally in the food before processing or not, so as to improve the nutritional quality of the food supply and to provide a public health benefit with minimal risk to health" (WHO, 2015).

An alternative to fortification is bio-fortification. Bio-fortification is the process by which the nutritional quality of food crops is improved through biological means such as conventional plant breeding (WHO, 2015). Bio-fortification differs from conventional fortification in that bio-fortification aims to increase nutrient levels in crops during plant growth rather than through means of adding an ingredient during processing of the crops. Bio-fortification may, therefore, present a way to reach populations where supplementation and conventional fortification activities may be difficult to implement and/or limited (WHO, 2015). A good example of bio-fortification product is the Golden Rice (GR). GR has been genetically engineered to produce β-carotene that could cut by more than half the disease burden of VAD (Stein et al., 2008). However, Dawe et al. (2002) point out in his study on the role of GR alleviating VAD prevalence in less developed countries in Asia that although future investment in GR is more favorable in terms of cost and coverage, the amount of vitamin D delivered by this type of intervention is not sufficient, and unlikely to achieve vitamin A intake requirement (Dawe et al., 2002).

This study focuses on food fortification through additives. All considered food categories, namely, vegetable oil and wheat flour are purposely enriched by addition of micronutrients such as vitamin A, folic acid, vitamin B12, iron, zinc, thiamine, riboflavin, and niacin in Ghana.

2.3. Food Fortification Programs in Africa

Countries often fortify wheat and maize flour as well as other staples such as cooking oil, sugar, or salt as part of their approach to address vitamin and mineral deficiencies (Food Fortification Initiative, 2015). Though there are divergent standards regarding what to fortify across countries, vitamin A, vitamin B12, iron, folic acid, zinc, and niacin are among the most common micronutrients fortified in various food vehicles indicated by Sablah et al. (2013) in their study documenting food fortification in Africa.

Ghana pioneered the food fortification with iodized salt in Africa in 1996 (Agble, 2009). Zambia began its fortification program in Africa and fortified sugar with vitamin A in 1998 (Darnton-Hill and Nalubola, 2002). Nigeria followed in 2002 by mandating the fortification of wheat and maize flour, sugar, and vegetable oil (Ogunmoyela, 2013). In the same year, the Republic of South Africa launched the wheat and maize fortification program. Since 2006, Economic Community of West African States (ECOWAS) called for food fortification throughout West Africa. All members of the Professional Association of Cooking Oil Industries of the West African Economic and Monetary Union (AIFO-UEMOA) now fortify edible oil with vitamin A (Sablah et al., 2011). Since then, more and more countries join the nutrient enhancing program to fight malnutrition, including Cote d'Ivoire and Guinea in 2007, Benin in 2008, Tanzania and Cameroon in 2012, and Kenya and Liberia in 2013 (Flour Fortification Initiative (FFI), 2015).

It is estimated that the market coverage of the fortified maize meal in Kenya, Uganda and Zambia is 28%, 39%, and 23%, respectively (Fiedler et al., 2014). In Uganda, 54% of households will purchase some amount of vegetable oil (Fiedler et al., 2014). It is also estimated that 70% of the population has access to vitamin A fortified edible oil in participating 15 countries in ECOWAS and sustainable fortification of cooking oil is now a reality in all West African Economic and Monetary Union (UEMOA) countries (Sablah et al., 2011). It has been confirmed that in Ghana, 75% of the vegetable oil is adequately fortified (Nyumuah et al., 2012).

Literature on evaluation of the efficacy of fortified program on vulnerable people is rare, and the assessment of adequacy of intake of the nutrient that has been fortified is even scarcer. Papathakis and Pearson (2012) investigate the impact of food fortification with vitamin A, vitamin B6, riboflavin and zinc on breast-feeding women by comparing food records pre- and post- fortification in the Republic of South Africa. The results show that there is a significant increase in mean dietary intake post-fortification for all nutrients included in the national fortification program, but the majority of the testers still does not meet the nutrients intake standards (Papathakis and Pearson, 2012). Engle-Stone et al. (2014) employ a simulation method based on a 24-h recall data to predict the adequacy of vitamin A intake among Cameroonian women and young children. They find that current fortification program would decrease the prevalence of inadequate intakes to 35% among both women and children, but inadequate vitamin A intake would remain larger than 50% in the North of Cameroon where vitamin A deficiency is most common, and increasing fortification in oil or more food vehicle for vitamin A is needed (Engle-Stone et al., 2014).

Therefore, the current study examines the intake of vitamin A from vegetable oils and wheat flour, rather than addressing the issue of strengthening government's fortification system or judging the capacity and expansion of the program.

2.4. Government Nutrition Fortification Effects in Ghana

In 1996, according to FAO, a mandatory salt iodization law to address iodine deficiency was first initiated in Ghana. The National Food Fortification Alliance (NFFA), constituted in 2003, designed the Food Fortification Project to fortify wheat flour and commercial vegetable oil to address the high levels of anemia and vitamin A deficiency in the country (Nyumuah et al., 2012). In 2006, the standards (GS 809:2006, GS810: 2006, GS 811:2006, GS812: 2006, and GS 813:2006) are developed by Ghanaian government and have been in effect ever since. While wheat flour is fortified with several micronutrients, vegetable oil is the major carrier of vitamin A. In addition, the Ghanaian government has established a vitamin A supplementation program for children under five years old with the target being the protection of children with two annual doses of vitamin A (Agble, 2009). According to UNICEF (2007), the first round achieved 50% in 2004 and 95% in the second round of the same year. Table 2.1 provides information on the required amount of nutrients by Ghana's standards. The minimum level of vitamin A, a focus of the study, was determined by setting a target of delivering at least 20% of the Estimated Average Requirement (EAR) (Allen et al., 2006).

Table 2.1. Volume of supplemented micronutrients in wheat flour and vegetable oil according to national standards

Food category	Micronutrient	Amount (mg/kg)
Wheat flour	Vitamin A	2.00
	Folic acid	2.08
	Vitamin B12	0.01
	Thiamine	8.40
	Riboflavin	4.50
	Niacin	59.00
	Iron	58.50
	Zinc	28.30
Vegetable oil	Vitamin A	10.00

Source: Nyumuah et al., (2012).

According to USDA report “National Nutrient Database for Standard Reference”, children 1-3 and 4-8 years of age are required to take 210 and 275μg of vitamin A daily. For female teenagers, the daily intake is recommended at 420 – 485 μg, and for females in other age ranges, it is 500 μg/d.

2.5. Application of the OXFORD/OECD Method

The need for living materials, i.e. food, drink, space, energy, etc. will not increase proportionally as the number of family member increases, especially when the number of children is involved. To put it simply, a household with two members will not need twice as much resources as a single person household. To accurately account for the household resources needed, the Organization for Economic Co-operation and Development (OECD) developed multiple equivalent scales to measure household income by creating weights with each household member according to age. The OECD equivalent scale is adopted to convert household members of various ages. Accordingly, the first adult of the household member is assigned a weight of 1, each additional adult a weight of 0.7 and each child a weight of 0.5 (OECD, 1982), is adopted in this study. Although other equivalent scales exist, none is recommended by OECD for general use (OECD, 2015). The Oxford method used to calculate per capita income is applied in the current study. It is reasonable to consider the "decreasing" effect in household resource needs if the number of household members is more than one person.

2.6. Application of the Multivariate Probit Model

Discrete dependent variable model is often used to accommodate survey data of categorical nature. Empirical studies have proved that univariate probit technique is appropriate when modeling a binary choice of a respondent (Greene and Hensher, 2009). A multivariate probit model is basically an expansion of a single probit model in that a bunch of probit equations are estimated together, meaning that an observed phenomenon has multiple binary inter-dependent simultaneous outcomes. These correlated choices often occur in a consumption or decision-making survey as the case in the current study. In addition, multivariate probit is an appropriate model when the inter-relationships between equations, often induced by unknown factors, are taken into consideration and when the effects of all covariates jointly are desired (Greene and Hensher, 2009).

The use of multivariate probit model has been frequent in drug consumption studies. Preety and Zhao (2009) investigate the socio-economic and demographic factors that affect the participation in marijuana, cocaine and heroin with a trivariate probit model for the reason that under the common sense those three categories are all psychoactive substances, so the consumption of the three are likely to be correlated. As a result, the potential cross-drug correlation is well captured by a tri-variate probit model according to Preety and Zhao (2009). Another concrete example of the model adoption is its application to food purchase. Bai et al. (2007) examine individual's purchasing choice of five milk products: fluid milk, powder milk, yogurt, ice cream and cheese in urban China. By adopting the multivariate probit model, they conclude that consumer's market participation is highly interdependent across these five categories, given socio-economic and demographic factors.

In this food fortification study, I employ the same approach, i.e., multivariate probit, to estimate the consumption frequency of palm oil, groundnut oil, other vegetable oil, wheat flour and maize flour. In Ghanaian dietary culture, staple dishes are accompanied by thick sauce (Oniang et al., 2003) and edible oil is an essential part of the sauce. Therefore, it is reasonable to assume the unobserved correlation in the error term of each equation in the model. Given the strong belief that the correlation between equations exists, the choice of multivariate probit model is viewed as highly appropriate.

Despite the popularity of the use of discrete choice model in food consumption, the application of multivariate probit model in oil and flour consumption is rarely seen. Also, the estimation is expanded by incorporating three sets of regressions that further explain the determinants of consumption frequency for three different time periods, i.e., daily, weekly and monthly. Furthermore, the innovative aspect of the study is the application of the model in the African context, where dietary culture and economic status considerably differ from other regions in the world.

CHAPTER 3

DATA MEASUREMENTS

3.1. Data Collection

This study is based on data collected through a survey implemented in three major cities in Ghana (i.e., Accra, Takoradi and Tamale). The survey was carried out between February and June in 2011 and was first implemented in Tamale. Following the preparation of the survey instrument, the survey implementation started in the morning, and by the mid-afternoon, returning enumerators were debriefed because that stage was considered as a pre-test. To assure proper communication with potential respondents, Dagmoba-fluent enumerators were recruited from the workers of the Ghana National Statistical Service (GNSS) in the area, who were familiar with implementing surveys. The enumerators interviewed households selected from the sample of households used by the GNSS. The de-briefing of enumerators and scrutinized completed questionnaires did not reveal misunderstanding of posted questions. A total of 216 questionnaires were collected from Tamale households.

Similar implementation procedures were followed in Takoradi and Accra. Because of coastal location, interviews were mostly held in English. In Takoradi, 230 households completed questionnaires, while 630 households were interviewed in Accra. The data were entered concurrently during the data collection by two assistants recruited from among the students at the University of Ghana at Legon.

3.2. Survey Instrument

The developed questionnaire contains a detailed list of foods developed through a discussion with scientists from University of Ghana and observations of daily diet. Respondents were asked about their consumption frequencies of certain foods or categories including vegetables, fruits, starchy staples, meats, diary products, vegetable oils, animal fats, snacks, etc. The consumption frequency were set at daily, weekly and monthly intervals. In addition, questions regarding age, gender, marital status, occupation, monthly food expenditure and household composition that comprised of number of adults and the number of children in various age ranges were included in the survey instrument. The list providing for a respondent educational attainment included nine education categories ranging from lack of formal education to university and postgraduate degree. Respondents were also presented with a list of five options indicating their possible job status. Finally, locations indicating place of residency and market access information were also included in the survey.

3.3. Data Preprocessing

The sample has 1076 observations in total. However, this study excludes incomplete observations such as a missing answer to question. Also, seven male respondents were dropped to limit the respondent gender only to females, who are the primary food shoppers and meal preparers. Five households with exceptionally high monthly income were also deleted to ensure the Gaussian distribution of the income variable. Finally, respondents below twenty years of age were excluded for the same reason. The final number of observations in the sample is 954. Per capita income is calculated by adopting OECD formula for converting household members of various ages into a more uniform household size measures. In addition, two dummies account for job status, one for those being government employees, and the second for the self-employed are included. The latter is defined as one who grows his/her own foods or trade goods with each other for a living in a Ghanaian context. Finally, respondents are grouped according to their education level, as having university degree and secondary degree, while "other educational attainment levels" serve as the benchmark.

3.4. Socio-Economic and Demographic Characteristics

Table 3.1 shows descriptive statistics of the sample. The figures include the means or the shares in case of binary variables. The following discussion is divided into three parts, where each part focuses on a specific category of respondents or household characteristics.

Demographic factors

The female respondents are on average 39.2 years old and three quarters of them are married. A typical household consists of, on average, two adults and two children.

Socio-economic factors

The average per capita income for respondents in the sample is 234.09 new cedis, while the average monthly food expenditure is 58.35 new cedis in the month preceding the survey. With regard to education, 38% of the respondents have university or higher degree and 13.4% have secondary level degree. In terms of employment status, 24.3% are government employees and 64.2% are the self-employed.

Location

Of the 954 observations selected for the empirical analysis, 18.6% are from Tamale and 20.8% are from Takoradi with the rest collected from Accra-based households. The figures also show that only 17.9% of the respondents have access to supermarket, while almost 70% of the respondents have access to grocery store and the percentage halves for ones who buy food at a street stand.

Table 3.1 Descriptive statistics of variables included in the empirical model

Variable name	Variable description / units of measurement	Mean	Std dev.
	Demographic factors		
Married	=1 if a respondent is married	0.753	0.431
Age	Actual age in years	39.222	10.656
Nump	Number of household members 19 - 60 years old	2.319	1.195
Numc	Number of household members between 4 -12 years old	2.285	1.862
	Socio-economic factors		
Per capita income	Household income in the month preceding the survey / weighted by the number of people in household, in cedis	234.086	258.831
Spend	Monthly household expenditure on food, in cedis	58.350	40.583
Employ_self	=1 if a respondent is self-employed	0.642	0.480
Employ_gov	=1 if a respondent is gov/civil employee	0.243	0.429
Education1	=1 if a respondent has a secondary education (including Senior high/GCE O-A level, Vocational school, Technical school, or Teacher training)	0.382	0.486
Education2	=1 if a respondent has a college education (including university, or postgraduate)	0.134	0.340
	Location		
Mkt1	=1 if a respondent has an access to the grocery store	0.693	0.462
Stree1	=1 if a respondent has an access to street stall	0.321	0.467
Super1	=1 if a respondent has an access to supermarket	0.179	0.383
Tamale	=1 if a household is in Tamale	0.186	0.389
Takoradi	=1 if a household is in Takoradi	0.208	0.406

3.5. Consumption Frequencies of Targeted Foods and Food Categories

Five food categories are of particular interest: palm oil, groundnut oil, all other vegetable oil, wheat flour and maize flour. The first four are already included in the government fortification program, while the maize flour is a candidate for the food fortification program.

However, maize flour has already been fortified in other countries in Africa. For instance, countries like Kenya, Nigeria, South Africa, Tanzania and Uganda, all have made the maize fortification mandatory (Sablah et al., 2013).

The Ghanaian diet largely relies on starchy roots represented by cassava and yams, fruit, such as plantain, and cereals, like maize and rice. The diversity of the diet remains low with starchy roots and cereals supplying almost three-quarters of the dietary energy (Agble, 2009). The staple foods come in many traditional forms, such as *fufu*, comprised of cassava or yam; *banku*, consisting of maize flour; *kenkey* and *tuo zafi*, both are made from ground corn. Together with corn meal and bakery products, these staples extracted from the data records establish the measure of maize flour and wheat flour consumption reflected in daily, weekly, and monthly frequencies.

Palm oil is an important ingredient in the diet of people in West Africa (Tagoe et al., 2012). In the sample, the percentages of respondents who consume palm oil daily, weekly, or monthly are 20.52%, 32.47%, and 2.99%, respectively (Table 3.2.1-3.2.3). The red-colored palm oil is processed from fruits of domestically grown palm tree (Tagoe et al., 2012). As a result, the oil has been used in specific dishes in Ghanaian cuisine although its specified use varies from place to place. The reported consumption frequencies of urban female residents, who are the focus of the current study, contrast sharply with the results from Nti (2008), who conducted his study in the Manya Krobo District in the Eastern Region of Ghana. Nti (2008) indicates the frequency of palm oil consumption is 66.5%, 31.3%, and 2.0% for daily, weekly, and monthly time periods, respectively, for mothers of child bearing age who had young children between the ages of 0 and 18 months in rural Ghana.

The percentages of respondents consuming groundnut oil are 8.56%, 15.36%, and 4.33% in the three time periods, respectively. Groundnut oil is used in homes on daily basis for the preparation of various meals (Teye et al., 2011). Together with palm oil, groundnut oil is used in in *okro stew, eto, fante fante, red red,* and *egusi stew* (Ghanaian Dishes, 2015). Based on information provided by USDA (2015), total saturated fat in peanut oil is 17% and 49.3% in palm oil. Ebong et al. (1999) report in their study that most of the palm oil is consumed in the oxidized state that is detrimental to physiological and biochemical functions of the body. Palm oil also induces reproductive toxicity to the kidney, lungs, heart and liver (Ebong et al., 1999).

Several food items in the survey are grouped into a specific category. For example, I combined corn oil, soy oil, sunflower oil and “other vegetable oil” into the category “Other oil”. Although these vegetable oils are common and tend to be less expensive in Ghana, the number of respondents, who reported eating them is rather small. Therefore, creating separate variable is unnecessary. The aggregation is accomplished by creating a dummy for each food consumed at each consumption frequency level; namely, if any of the listed vegetable oils is reported as consumed daily, then the combination is coded as 1, indicating daily consumption. For example, the variable “Other oil” is assigned a value of 1 if a respondent reported consuming any of the oil that constitute “Other oil” category, i.e. sunflower oil, corn oil, soybean oil or other vegetable oil, and a value of 0, if none of the sub-oil category is consumed. The survey results confirmed that 17.11%, 19.59%, and 6.5% of the respondents consume an oil included in the combined “Other oil” category with daily, weekly, and monthly frequency, respectively.

A similar approach has been adopted to combine the indicated corn meal, banku, kenkey, and tuozafi into a single category “maize flour” to account for corn-based products. Observed consumption shows that the corn-based product was consumed by 38.76%, 66.08% and 15.05%

of urban respondents with daily, weekly and monthly frequency, respectively. The reported consumption of loaf bread, crackers, cereal, porridge, cakes, pudding, tart, and sweet doughnut create a combined category "wheat flour". Similarly, wheat flour has even higher share of consumers than the combined maize flour category. The percentage of them consuming wheat flour with daily, weekly, and monthly frequency is 60.93%, 50.41% and 22.06%, respectively. The shares of households consuming wheat and maize flour confirm that both types of food are major staples in Ghana.

Table 3.2. Percentage of household's daily consumption of selected foods

Food category	Percentage of households consume daily	Standard error
Groundnut oil	8.56%	0.28
Palm oil	20.52%	0.40
Other oil	17.11%	0.38
Wheat flour	60.93%	0.49
Maize flour	38.76%	0.49

Table 3.3. Percentage of household's weekly consumption of selected foods

Food category	Percentage of households consume weekly	Standard error
Groundnut oil	15.36%	0.36
Palm oil	32.47%	0.47
Other oil	17.83%	0.38
Wheat flour	14.95%	0.36
Maize flour	42.47%	0.49

Table 3.4. Percentage of household's monthly consumption of selected foods

Food category	Percentage of households consume monthly	Standard error
Groundnut oil	4.33%	0.20
Palm oil	2.99%	0.17
Other oil	5.25%	0.22
Wheat flour	18.25%	0.39
Maize flour	8.66%	0.28

CHAPTER 4

MODELING CONSUMPTION OF FIVE STAPLES

4.1. Empirical Multivariate Probit Model Specification

A bivariate probit model is an extension of an ordinary probit model. It contains two equations instead of one, with interrelated error terms. A multivariate probit model is still another extension: a bivariate model enlarged by adding equations (Greene and Hensher, 2009). Theoretically the number of equations included in the system is unlimited (Cappellari and Jenkins, 2003). The model specification based on Greene and Hensher (2009) is as follows:

$$y_1^* = \gamma_1' x_1 + \varepsilon_1, \; y_1 = 1(y_1^* > 0) \tag{1}$$

$$y_2^* = \gamma_2' x_2 + \varepsilon_2, \; y_2 = 1(y_2^* > 0 \tag{2}$$

…

$$y_M^* = \gamma_M' x_M + \varepsilon_M, \; y_M = 1(y_1^* > 0) \tag{3}$$

$$E[\varepsilon_M \mid x_1, x_2, \ldots x_M] = 0, \tag{4}$$

$$Var[\varepsilon_1 \mid x_1, x_2, \ldots x_M] = 1, \tag{5}$$

$$Cov[\varepsilon_L, \varepsilon_M \mid x_1, x_2, \ldots xM] = \rho LM, \tag{6}$$

where $yi*$ is a latent variable. The sign of $yi*$ determines the binary value of yi. If $yi* > 0$, then $yi = 1$and if $yi* < 0$, then $yi = 0$. All of the error terms, $\varepsilon 1, \varepsilon 2, \varepsilon m$, have an expected value of 0 and are distributed as multivariate normal. The error term variance-covariance matrix V has values of 1 on the leading diagonal and correlations $\rho jk = \rho kj$ as off-diagonal elements (Lorenzo, 2003). The final decision on model choice is based on number of significant variables, and the log-likelihood ratio test, Wald test for overall model fit. The joint probabilities of observed events [yi1, yi2 … yiM | xi1, xi2 … xiM], i = 1,…, n are M-variate normal probabilities, denoted by:

$$Li = \Phi m(qi1\gamma 1'xi1, qi2\gamma 2'xi2, \dots, qiM\gamma M'xiM) \text{ qim} = 2\text{yim} - 1,$$

(7)

$$qim = 2yim - 1,$$

$$Rim = qijqim\rho jm.$$

This study adopts a quintuple-variate probit model, with five outcome variables referring to consumption of palm oil, groundnut oil, “other vegetable oil”, wheat flour and maize flour. A group of explanatory variables, $xi1, xi2, \dots\ xiM$, includes demographic variables: respondents' marital status, age, number of children in a household, number of adults in a household, and socio-economic variables: per capita income, monthly food expenditure per household, two employment status dummies, and two education level dummies. In addition, I also control for location differences in three major cities and use three proxies to indicate market accesses, i.e., access to grocery store, street stand and supermarket. These proxies are in fact variables indicating where the respondents purchase their food.

The choice of multivariate probit model in this study relies on the significant correlation coefficients in daily consumption model that confirms the cross equation correlation; i.e. the relation between consumption of palm oil, peanut oil, other vegetable oil, wheat flour and maize flour daily are non-negligible. Though in weekly and monthly models some $\rho mn'$s are not significant, the multivariate probit model is retained either due to reduced number of significant variables or failure to pass likelihood ratio test for separate probit models.

4.2. Conditional Marginal Effects

Unlike other non-linear models such as logit model, the parameters in multivariate probit models are not measures of the marginal effects (MEs). For continuous variables used in the specified equations like age and income, the ME is

$$\partial \mathrm{E}[\mathrm{yi}|\mathrm{xi}]\,\partial \mathrm{xi} = \Phi(\gamma'\mathrm{x1}, \gamma'\mathrm{x2}, \gamma'\mathrm{x3}, \gamma'\mathrm{x4}, \gamma'\mathrm{x5})\gamma,$$

(8)

where, for a normal distribution, Φ(t) is the standard quintuple-variate normal density. Such density function is used in the current study. The formula for the calculation of the marginal effect conditioned on binary variables is as follows (Mullahy, 2011):

$$p[y1 = 1|\mathrm{y2} = 1, \mathrm{y3} = 1, \mathrm{y4} = 1, \mathrm{y5} = 1, \mathrm{x1b1}, \mathrm{x2b2}, \mathrm{x3b3}, \mathrm{x4b4}, \mathrm{x5b5}] = -\mathrm{x1b1}\infty - \mathrm{x2b2}\infty - \mathrm{x3b3}\infty - \mathrm{x4b4}\infty - \mathrm{x5b5}\infty\Phi\mathrm{m}(\mathrm{z1}, \mathrm{z2}, \mathrm{z3}, \mathrm{z4}, \mathrm{z5})\gamma\mathrm{dz1dz2dz3dz4dz5}, \qquad (9)$$

where γ is the coefficient of variable of particular interest and $\Phi m()$ is the standard quintuple-variate normal density function.

To calculate a partial effect for a dummy variable, for example, a variable depicting the marital status, employment, or an education level of the respondent, the partial effect measures a change in probability of y equals 1 when the dummy changes from 0 to 1:

$$probyi = 1xd, di = 1 - probyi = 1xd, di = 0. \qquad (10)$$

Here, x denotes the means of all other variables in the equation. According to Greene and Hensher (2009), current practice favors averaging the individual marginal effects. Therefore in this study, we evaluate the marginal effect by calculating the ME for every observation and by taking the average ME of all observations. The ME I calculate in this study for each independent variable is conditioned on consuming all five categories at the same time. For example, the calculated marginal effect for variable "number of people in a household" is the change in the probability of consuming palm oil, peanut oil, “other vegetable oil”, wheat flour and maize flour altogether, while adding one more adult person to the household. The marginal effects are calculated using mvProbitMargEff function in “mvProbit” package written in R (Henningsen, 2015). The procedure bootstraps the data 500 times in order to obtain 500 MEs for each variable, and uses them to calculate the standard error for the ME.

CHAPTER 5

RESULTS

Estimation results of the quintuple multivariate probit model are presented in separate tables for each food or food category according to the one of the three consumption periods, i.e., daily, weekly or monthly frequencies. The discussion, divided into subsections, focuses on factors that are statistically significant in their influence on a given consumption frequency period, but, on occasion, factors that are marginally insignificant are mentioned because of the perceived importance in assuring adequate nutrient intake for the fortified foods or foods that can be fortified in Ghana. All statistically significant factors are described in groups identified in Table 3.1 that shows the descriptive statistics of variables included in the empirical specification grouped into demographic, socio-economic and location factors.

5.1. Consumption of Palm Oil

Palm oil has been traditionally produced on many farms in Ghana. The process of producing this oil with its characteristic reddish color is quite labor intensive, but still widely performed throughout the country. Palm oil, besides its color, has also a distinct flavor and is a necessary ingredient in some of traditional Ghanaian and West African dishes, especially the peanut soup.

Demographic factors

Number of adults in a household has a negative impact on the consumption of this oil daily (Table 5.1.2) while marital status influences the monthly consumption frequency and the effect is negative (Table 5.1.3). Households of married consumers are likely to have a different lifestyle and consumption patterns than non-married respondents. In married households, palm oil is likely to be used more often than once a month because the type of dishes being prepared, e.g. peanut soup.

Socio-economic factors

Interestingly, education levels have opposite effects on the palm oil consumption, respondents with university degree consume much less than the benchmark, while respondents with only secondary level consume palm oil daily more than the benchmark. Besides, households with higher per capita income tend to consume more palm oil daily (Table 5.1.1). With regard to weekly palm oil consumption, only employment status has significant negative effects (Table 5.1.2). Chen et al. (2011) indicate in their study that increased palm oil consumption is related to higher ischemic heart disease due to the excessive saturated fat. Therefore, people with more education are possibly more aware of the health issue and, thus, will reduce the intake of this kind of oil.

Location

Consumption of palm oil differs significantly from region to region (Table 5.1.1-5.1.3). Residents in Takoradi are less likely to consume palm oil daily than those from Accra, while respondents from Tamale are likely to consume it often. Takoradi, a port city of Ghana, is located in coastal climatic zone, where the whether condition is suitable for palm oil tree. However, Takoradi may have an easier access and availability of imported oil, while Accra and Tamale residents are in the major palm oil plantations triangle (Owusu-Bennoah and Visker, 2012). Easier access to palm oil facilitates the consumption in Accra and Tamale.

In terms of retail outlet type, it appears that daily consumption of palm oil is associated with shopping for food at all three types of retail outlets, i.e., accesses to grocery store, street stand, and supermarket. The results stress the popularity of palm oil among urban residents in Ghana and its relative importance as a possible food targeted for fortification (Table 5.1.1).

Table 5.1.1. Mvprobit estimation results for daily consumption of palm oil

Variable name	Coefficient	Standard error	P-value
	Demographic factors		
Numc	0.024	0.027	0.376
Nump	-0.073*	0.045	0.100
Age	0.000	0.005	0.985
Married	0.098	0.116	0.400
	Socio-economic factors		
Employ_gov	-0.180	0.180	0.316
Employ_self	-0.055	0.148	0.708
Education1	-0.314*	0.194	0.105
Education2	0.227**	0.116	0.051
Spend	0.002	0.001	0.115
Per capita income	0.001**	0.000	0.016
	Location		
Takoradi	-0.254*	0.134	0.058
Tamale	0.322**	0.140	0.022
mkt1	0.262**	0.109	0.016
stree1	0.415***	0.100	0.000
super1	0.262**	0.124	0.035

*,**,*** denote statistical significance at the 10%, 5%, 1% levels, respectively.

Table 5.1.2. Mvprobit estimation results for weekly consumption of palm oil

Variable name	Coefficient	Standard error	P-value
	Demographic factors		
Numc	-0.018	0.025	0.484
Nump	0.023	0.038	0.533
Age	-0.006	0.004	0.137
Married	0.139	0.104	0.182
	Socio-economic factors		
Employ_gov	-0.394**	0.163	0.016
Employ_self	-0.308**	0.135	0.022
Education1	-0.101	0.164	0.540
Education2	-0.129	0.106	0.223
Spend	-0.001	0.001	0.605
Per capita income	0.000	0.000	0.326
	Location		
Takoradi	-0.109	0.116	0.347
Tamale	0.115	0.127	0.365
mkt1	-0.127	0.094	0.175
stree1	0.007	0.092	0.943
super1	0.158	0.113	0.163

*,**,*** denote statistical significance at the 10%, 5%, 1% levels, respectively.

Table 5.1.3. Mvprobit estimation results for monthly consumption of palm oil

Variable name	Coefficient	Standard error	P-value
	Demographic factors		
Numc	0.041	0.046	0.373
Nump	0.041	0.065	0.532
Age	-0.006	0.008	0.494
Married	-0.332*	0.188	0.077
	Socio-economic factors		
Employ_gov	-0.088	0.287	0.758
Employ_self	-0.293	0.251	0.243
Education1	0.014	0.300	0.964
Education2	-0.088	0.220	0.688
Spend	-0.003	0.003	0.231
Per capita income	0.000	0.000	0.381
	Location		
Takoradi	0.038	0.227	0.868
Tamale	-0.113	0.253	0.657
mkt1	-0.053	0.184	0.772
stree1	-0.277	0.203	0.174
super1	0.091	0.216	0.673

*,**,*** denote statistical significance at the 10%, 5%, 1% levels, respectively.

5.2. Consumption of Groundnut Oil

Groundnut oil has been widely used by households in Ghana. Indeed, some of the peanut varieties introduced by the government a few decades ago were varieties with high oil content. It is expected that by producing such variety households would also increase their consumption of oil that is pressed from their own harvested peanuts. Peanut oil is highly valued, but it tends to be relatively expensive. It is available in peanut growing areas, especially near Tamale, but it is distributed around the country.

Demographic factors

The number of children has a significant positive effect on daily consumption (Table 5.2.1), and chances are, as one gets older, he is less likely to consume groundnut oil monthly (Table 5.2.3). This contradicts Jolly et al.'s (2008) findings that people older than 35 years of age are 1.94 times more likely to consume groundnut products than younger ones, but Jolly et al. also point out that the age effect of consumption frequency depend on the vocations of respondents.

Socio-economic factors

Respondents with university or secondary degree are more likely to consume groundnut oil with daily frequency (5.2.1) while only those with university degree more likely to consume groundnut oil weekly (Table 5.2.2). Respondents who are self-employee will also more likely to consume groundnut oil daily, but these effects vanish in weekly and monthly scenarios (Table 5.2.1). Government employees are less likely to consume groundnut oil weekly. Also, weekly consumption is negatively influenced by per capita income, the higher per capita income, the less likely one will consume groundnut oil weekly (Table 5.2.2).

Location

Tamele residents has a higher consumption tendency of groundnut oil weekly as compared to those in Accra (Table 5.2.2), it is a major town in northern area as well as a leading groundnut producer (Jolly et al., 2008). Therefore, residents in that town have possibly easy access to groundnut oil. Takoradi residents have a higher likelihood of monthly groundnut consumption than Accra residents (Table 5.2.3). The reason behind the different consumption frequency maybe attributed to the type of dishes consumed in the Takoradi.

Market access has an important influence on groundnut oil consumption. Easy access encourages daily consumption as indicated by the statistically significant effect of shopping for food at street stands (Table 5.2.1). Besides, weekly consumption of groundnut oil is positively influenced by the present of grocery store.

Table 5.2.1. Mvprobit estimation results for daily consumption of groundnut oil

Variable name	Coefficient	Standard error	P-value
	Demographic factors		
Numc	0.110***	0.034	0.001
Nump	0.055	0.042	0.196
Age	-0.001	0.005	0.895
Married	0.062	0.055	0.906
	Socio-economic factors		
Employ_gov	0.160	0.204	0.432
Employ_self	0.408**	0.183	0.025
Education1	0.428**	0.182	0.019
Education2	0.224*	0.122	0.066
Spend	0.000	0.001	0.777
Per capita income	-0.00009	0.0003	0.784
	Location		
Takoradi	-0.115	0.135	0.392
Tamale	-0.230	0.164	0.161
mkt1	0.111	0.110	0.312
stree1	0.342***	0.106	0.001
super1	0.060	0.130	0.644

*,**,*** denote statistical significance at the 10%, 5%, 1% levels, respectively.

Table 5.2.2. Mvprobit estimation results for weekly consumption of groundnut oil

Variable name	Coefficient	Standard error	P-value
	Demographic factors		
Numc	-0.034	0.030	0.263
Nump	-0.012	0.046	0.799
Age	0.004	0.005	0.405
Married	-0.129	0.124	0.298
	Socio-economic factors		
Employ_gov	0.354*	0.206	0.087
Employ_self	0.145	0.175	0.406
Education1	0.387*	0.198	0.051
Education2	-0.119	0.134	0.375
Spend	0.001	0.002	0.526
Per capita income	-0.0008**	0.0003	0.019
	Location		
Takoradi	0.124	0.142	0.383
Tamale	0.764***	0.145	0.000
mkt1	0.237**	0.119	0.046
stree1	0.077	0.112	0.494
super1	-0.195	0.143	0.172

*,**,*** denote statistical significance at the 10%, 5%, 1% levels, respectively.

Table 5.2.3. Mvprobit estimation results for monthly consumption of groundnut oil

Variable name	Coefficient	Standard error	P-value
	Demographic factors		
Numc	-0.042	0.052	0.419
Nump	-0.032	0.078	0.679
Age	-0.014*	0.008	0.092
Married	0.024	0.200	0.906
	Socio-economic factors		
Employ_gov	-0.449	0.311	0.149
Employ_self	-0.015	0.264	0.953
Education1	0.444	0.301	0.140
Education2	0.287	0.184	0.118
Spend	0.003	0.002	0.229
Per capita income	0.000	0.001	0.552
	Location		
Takoradi	1.067***	0.199	0.000
Tamale	0.350	0.274	0.201
mkt1	0.113	0.180	0.528
stree1	-0.031	0.172	0.858
super1	0.265	0.188	0.158

*,**,*** denote statistical significance at the 10%, 5%, 1% levels, respectively.

5.3. Consumption of Miscellaneous Vegetable Oil

Vegetable oil has been traditionally used in Ghanaian households because it is made from indigenous crops or crops that have been long established in the region. However, the growing demand for vegetable oil leads also to the introduction of other oil crops and imports. Today, sunflower and soybean oils are commonly eaten beside the traditional palm and peanut oil. The consumption frequency estimation results of the "other vegetable oil" are discussed in this section.

Demographic factors

Daily consumption frequency of this oil category is negatively influenced by the marital status of a respondent (Table 5.3.1), suggesting that the married respondents are less likely to report daily consumption as compared to those with different marital status. The dishes eaten in a married respondent household require different types of oil. It appears that a large number of adults encourages consumption at least some of other vegetable oils within a month (Table 5.3.3) possibly because of larger food requirements or preferences for wider food variety of food preferences. This study supports earlier findings that the size of family would significantly increase the diversity of foods consumption daily, weekly and monthly (Moon et al., 2002).

Socio-economic factors

Per capita income positively influences the likelihood of daily consumption of "other vegetable oils", reflecting the importance of income in determining the consumption of fortified staples (Table 5.3.1). Diet that includes various sources of fat tends to be priced relatively high and easing the household budget constraint allows additional purchase and consumption. The self-employed have a higher likelihood to consume this type of vegetable oil daily than those in the omitted employment category (Table 5.3.1). “Other vegetable oils” are more easily accessible and being self-employed often means a job that requires mobility in Ghana, so such individuals can more easily come across places offering that type of oil than those from omitted category, which includes potentially individuals less likely to travel daily such as the elderly.

Both types of educational attainment level increase the likelihood of daily consumption of “other vegetable oils” as compared to those with the lowest educational attainment level (Table 5.3.1). Education and the acquired knowledge permit adoption of cooking recipes to non-traditional oil types. The category includes sunflower oil, soybean oil and corn oil that have a healthier fatty aid profile than palm oil that is high in saturated fatty acid. University level education also is associated with the consumption of this kind of oil weekly (Table5.3.2).

Location

Monthly consumption of “other vegetable oils” is positively associated with the household location in Takoradi as compared to households from the Greater Accra (Table 5.3.3). Takoradi is a major industrial city in Ghana, but also a major port of imported goods. It is plausible that imported vegetable oil is, therefore, more commonly available in Takoradi than in the capital city. Similarly, Tamale residents are more likely to consume miscellaneous oils monthly (Table 5.3.1).

Consumers shopping at street stalls are more likely to consume “other vegetable oils” daily (Table 5.3.1). Street stalls are easily accessible and fairly common in major urban areas of Ghana. They may offer vegetable oil in smaller containers than those found in stores or supermarkets and thus providing some convenience and, therefore, encourage a purchase and consumption. Weekly consumption frequency of this vegetable oil type is less likely to be reported by respondents shopping for food at grocery stores but more likely by respondents shopping at supermarkets (Table 5.3.2). The influence of the place of purchase is not a surprise because “other vegetable oils” such as sunflower or soybean oil are imported in retail size plastic bottles or sold in such containers by domestic distributors. Standard sized plastic bottles contrast with packages from multiple sources of domestic palm or peanut oils. In addition, monthly consumption of “other vegetable oils” is positively influenced by the accessibility of supermarkets (Table 5.3.3).

Table 5.3.1. Mvprobit estimation results for daily consumption of other vegetable oils

Variable name	Coefficient	Standard error	P-value
	Demographic factors		
Numc	-0.028	0.031	0.364
Nump	0.055	0.042	0.196
Age	-0.001	0.005	0.895
Married	-0.198*	0.117	0.091
	Socio-economic factors		
Employ_gov	0.160	0.204	0.432
Employ_self	0.408**	0.183	0.025
Education1	0.428**	0.182	0.019
Education2	0.224*	0.122	0.066
Spend	0.000	0.001	0.777
Per capita income	0.0007***	0.0002	0.001
	Location		
Takoradi	-0.115	0.135	0.392
Tamale	-0.230	0.164	0.161
mkt1	0.111	0.110	0.312
stree1	0.342***	0.106	0.001
super1	0.060	0.130	0.644

*,**,*** denote statistical significance at the 10%, 5%, 1% levels, respectively.

Table 5.3.2 Mvprobit estimation results for weekly consumption of other oils

Variable name	Coefficient	Standard error	P-value
	Demographic factors		
Numc	0.035	0.028	0.212
Nump	0.049	0.040	0.220
Age	0.002	0.005	0.629
Married	0.086	0.117	0.462
	Socio-economic factors		
Employ_gov	-0.062	0.188	0.742
Employ_self	0.099	0.159	0.534
Education1	0.421**	0.177	0.017
Education2	0.140	0.118	0.236
Spend	-0.001	0.001	0.595
Per capita income	0.000	0.000	0.841
	Location		
Takoradi	-0.154	0.130	0.236
Tamale	0.111	0.141	0.433
mkt1	-0.309***	0.102	0.002
stree1	-0.072	0.105	0.495
super1	0.252**	0.122	0.038

*,**,*** denote statistical significance at the 10%, 5%, 1% levels, respectively.

Table 5.3.3. Mvprobit estimation results for monthly consumption of other oil

Variable name	Coefficient	Standard error	P-value
	Demographic factors		
Numc	0.054	0.034	0.114
Nump	0.172***	0.045	0.000
Age	-0.003	0.006	0.604
Married	-0.076	0.164	0.643
	Socio-economic factors		
Employ_gov	-0.156	0.256	0.542
Employ_self	-0.076	0.216	0.723
Education1	-0.258	0.269	0.338
Education2	-0.021	0.163	0.896
Spend	0.002	0.002	0.255
Per capita income	0.000	0.000	0.534
	Location		
Takoradi	0.288*	0.170	0.091
Tamale	0.374*	0.223	0.093
mkt1	-0.101	0.147	0.492
stree1	0.214	0.137	0.120
super1	0.376**	0.158	0.017

*,**,*** denote statistical significance at the 10%, 5%, 1% levels, respectively.

5.4. Consumption of Maize Flour

Maize flour is an important component of Ghanaian cuisine, it is a critical ingredient of banku, which is made of a proportional amount of fermented corn and cassava dough; kenkey, made with fermented corn dough and wrapped in plantain leaves; and, tuo zaafi, a maize flour dish made with jute leaves (GhanaWeb, 2015). Maize flour is the only category included in the study that has not been included in the fortification program in Ghana, but has been fortified in Ethiopia, Madagascar, Malawi, Mozambique, South Africa and Tanzania (Jorgensen, 2014). Indeed, the percentage of households that purchase fortified maize flour in those countries, is quite high, reaching 97% in Malawi and 71% in Tanzania, respectively, and 22% of households purchase it in Ethiopia (Jorgensen, 2014The daily amount of maize flour consumption differs across countries in Africa. In Tanzania, the average consumption of maize flour is 240.7g of maize flour per day per person.

Demographic factors

The number of household members increases the likelihood of weekly maize flour consumption (Table 5.4.2). In West Africa, maize flour is a major ingredient of porridge (IITA, 2015) and it is likely that larger households eat more foods with this kind of flour.

Socio-economics factors

Both levels of education categories have negative effects on the likelihood of daily maize flour consumption as compared to the least educated (Table 5.4.1). It appears that fortifying maize flour would benefit primarily the most vulnerable consumers. Moreover, the larger monthly food expenditures, the lower the likelihood of eating maize flour everyday (Table 5.4.1). As much maize flour as wheat flour is consumed in Ghana (Table 3.5.1- Table 3.5.3). This leads to an interesting insight: though dominant in

Ghanaian cuisine, maize flour is not preferred by people. Respondents do not actively seek maize flour products when they are more knowledgeable or have more flexible food budget. That could be one reason why maize flour has not been fortified in this country. Similarly, higher education and secondary level education reduces the likelihood of consuming maize flour weekly and monthly, respectively (Table 5.4.2-5.4.3).

Location

The results confirm that the likelihood of maize flour consumption differs from place to place. Residents of Takoradi have lower likelihood of maize flour consumption with daily, weekly, or monthly consumption frequency as compared to Accra residents. On the contrary, residents of Tamale are more likely to consume maize flour daily and monthly (Table 5.4.1-5.4.3). Such differences across locations reflect, to some extant, different eating habits.

The type of retail outlet where respondents shop for food has a limited affect on frequency of maize flour consumption. Respondents shopping for food in grocery stores have a lower likelihood to consume maize flour weekly (Table 5.4.2) while respondents with access to street stalls have a higher likelihood to consume it monthly (Table 5.4.3).

Table 5.4.1 Mvprobit estimation results for daily consumption of maize flour

Variable name	Coefficient	Standard error	P-value
	Demographic factors		
Numc	0.038	0.027	0.161
Nump	-0.068	0.043	0.117
Age	-0.002	0.004	0.560
Married	0.047	0.106	0.660
	Socio-economic factors		
Employ_gov	-0.271	0.172	0.116
Employ_self	-0.033	0.142	0.815
Education1	-0.547***	0.174	0.002
Education2	-0.272***	0.109	0.012
Spend	-0.002*	0.001	0.064
Per capita income	0.000	0.000	0.262
	Location		
Takoradi	-0.400***	0.121	0.001
Tamale	0.996***	0.132	0.000
mkt1	0.150	0.097	0.123
stree1	-0.002	0.095	0.987
super1	-0.161	0.122	0.186

*,**,*** denote statistical significance at the 10%, 5%, 1% levels, respectively.

Table 5.4.2 Mvprobit estimation results for weekly consumption of maize flour

Variable name	Coefficient	Standard error	P-value
	Demographic factors		
Numc	0.011	0.027	0.681
Nump	0.090**	0.042	0.032
Age	0.001	0.004	0.839
Married	-0.078	0.105	0.460
	Socio-economic factors		
Employ_gov	0.129	0.170	0.448
Employ_self	-0.076	0.141	0.589
Education1	-0.300*	0.167	0.073
Education2	0.067	0.108	0.537
Spend	0.000	0.001	0.731
Per capita income	0.000	0.000	0.689
	Location		
Takoradi	-0.784***	0.114	0.000
Tamale	0.270**	0.129	0.036
mkt1	-0.213**	0.093	0.022
stree1	0.027	0.095	0.776
super1	0.162	0.116	0.161

*,**,*** denote statistical significance at the 10%, 5%, 1% levels, respectively.

Table 5.4.3. Mvprobit estimation results for monthly consumption of maize flour

Variable name	Coefficient	Standard error	P-value
	Demographic factors		
Numc	-0.041	0.032	0.199
Nump	-0.021	0.049	0.666
Age	0.006	0.005	0.178
Married	-0.031	0.120	0.794
	Socio-economic factors		
Employ_gov	-0.084	0.202	0.679
Employ_self	0.033	0.165	0.844
Education1	0.154	0.190	0.416
Education2	-0.318**	0.158	0.044
Spend	-0.001	0.001	0.695
Per capita income	0.000	0.000	0.281
	Location		
Takoradi	-0.510***	0.190	0.008
Tamale	-0.373**	0.161	0.020
mkt1	0.014	0.112	0.902
stree1	0.275**	0.127	0.030
super1	0.171	0.133	0.198

*,**,*** denote statistical significance at the 10%, 5%, 1% levels, respectively.

5.5. Consumption of Wheat Flour

Wheat flour is a popular and common dietary staple of population living in the sub-continent. As a result, it is the key food vehicle for micronutrient fortification (Akhtar et al., 2010). The wheat consumption was approximately 325,000 MT in Ghana in 2014/2015 and the per capita consumption is estimated to be 13kg (Ashitey, 2014). About 80 percent of produced wheat flour is used for bread making in Ghana, and the remainder is for making cakes and pastries. Fortifying wheat flour with vitamin A, folic acid, vitamin B12, thiamine, riboflavin, niacin, iron and zinc has been made mandatory by Ghanaian government (Nyumuah et al., 2012).

Demographic factors

The number of household members positively influences the likelihood of weekly wheat flour consumption (Table 5.5.2). The result is similar to the effect of the number of household members in maize flour consumption frequency equation. Although the consumption frequency of food is likely to increase with the number of household members (Moon et al., 2002), the reason for consuming wheat flour maybe preference for its taste. The monthly consumption frequency of wheat flour is positively associated with respondents' ages, older consumers consume wheat flour, but at a lower frequency (Table 5.5.3).

Socio-economic factors

The Ghanaian consumers prefer high quality hard wheat flour that produces desirable high-topped loaf and fluffy bread (Ashitey, 2014). Not surprisingly, consumers with high monthly food expenditure have high likelihood of consuming wheat flour daily (Table 5.5.1) and weekly (Table 5.5.2). Employment status significantly influences the likelihood of weekly and monthly wheat flour consumption. Specifically, government employees and self-employees have a lower likelihood of consuming wheat flour weekly and monthly, respectively (Tables 5.4.2 and 5.4.3) as compared to the benchmark employment category. However, per capita income reduces the monthly consumption of wheat flour (Table 5.5.2).

Location

The results show that residents of Takoradi are less likely to consume wheat flour with daily, weekly, and monthly consumption frequency as compared with residents of Accra (Tables 5.5.1-5.5.3). On the contrary, Tamale residents are more likely to consume wheat flour daily in comparison to residents of Accra (Table 5.5.1).

Access to some retail outlets makes a significant difference in daily and weekly wheat flour consumption. Consumers shopping at grocery stores and street stalls are more likely to consume wheat flour with the daily and weekly frequency (Tables 5.5.1-5.5.2) while consumers shopping for food at supermarkets have a lower likelihood of monthly wheat flour consumption (Table 5.5.3).

Table 5.5.1. Mvprobit estimation results for daily consumption of wheat flour

Variable name	Coefficient	Standard error	P-value
	Demographic factors		
Numc	0.008	0.027	0.778
Nump	0.011	0.040	0.792
Age	-0.001	0.001	0.444
Married	0.104	0.104	0.317
	Socio-economic factors		
Employ_gov	0.002	0.166	0.990
Employ_self	0.153	0.138	0.269
Education1	-0.074	0.165	0.651
Education2	0.107	0.106	0.315
Spend	0.001***	0.091	0.011
Per capita income	0.018	0.094	0.852
	Location		
Takoradi	-0.903***	0.114	0.000
Tamale	0.430***	0.133	0.001
mkt1	0.196**	0.094	0.037
stree1	0.252**	0.118	0.033
super1	-0.030	0.202	0.883

*,**,*** denote statistical significance at the 10%, 5%, 1% levels, respectively.

Table 5.5.2. Mvprobit estimation results for weekly consumption of wheat flour

Variable name	Coefficient	Standard error	P-value
	Demographic factors		
Numc	0.014	0.025	0.566
Nump	0.084**	0.039	0.029
Age	0.002	0.001	0.131
Married	0.007	0.099	0.948
	Socio-economic factors		
Employ_gov	-0.290*	0.160	0.069
Employ_self	-0.164	0.133	0.216
Education1	0.254	0.157	0.107
Education2	0.097	0.103	0.347
Spend	0.002*	0.020	0.101
Per capita income	-0.210**	0.092	0.023
	Location		
Takoradi	-0.435***	0.112	0.000
Tamale	0.022	0.124	0.860
mkt1	0.147*	0.090	0.103
stree1	0.226**	0.111	0.043
super1	-0.179	0.193	0.352

*,**,*** denote statistical significance at the 10%, 5%, 1% levels, respectively.

Table 5.5.3. Mvprobit estimation results for monthly consumption of wheat flour

Variable name	Coefficient	Standard error	P-value
	Demographic factors		
Numc	0.028	0.027	0.304
Nump	0.006	0.041	0.889
Age	0.002*	0.001	0.051
Married	-0.049	0.111	0.658
	Socio-economic factors		
Employ_gov	-0.243	0.171	0.155
Employ_self	-0.358**	0.142	0.012
Education1	0.012	0.171	0.942
Education2	0.007	0.115	0.950
Spend	0.000	0.000	0.404
Per capita income	-0.100	0.102	0.325
	Location		
Takoradi	-0.505***	0.135	0.000
Tamale	-0.143	0.141	0.314
mkt1	-0.102	0.102	0.320
stree1	0.059	0.122	0.632
super1	-0.522**	0.207	0.012

*,**,*** denote statistical significance at the 10%, 5%, 1% levels, respectively.

5.6. Correlation Coefficient between Equations

Tables 5.6.1-5.6.3 contain the correlation coefficients indicating the potential dependency between selected food categories given three time periods. All correlation coefficients across five equations in the daily consumption frequency model are statistically significant. This confirms that the consumption of each food category is strongly dependent on consumption of other selected staples. The significance justifies the use of multivariate probit technique for daily consumption frequency estimation (Table 5.6.1).

In case of weekly consumption frequency model, all correlation coefficients are significant except for one. It appears that the weekly consumption frequency of groundnut oil and other vegetable oil is not correlated (Table 5.6.2). However, the number of statistically significant correlation coefficients in the monthly consumption frequency model (Table 5.6.3) is seven out of ten. The consumption of maize flour and palm oil, palm oil and groundnut oil, maize flour and other vegetable oil are independent of each other. Since other correlation coefficients are confirmed to be significant in monthly consumption frequency model, the multivariate probit approach is retained for the purpose of consistency.

Table 5.6.1 Correlation coefficients between three types of vegetable oil and two flours in daily consumption frequency model

Food item	Palm oil	Groundnut oil	Other oil	Wheat flour	Maize flour
Palm oil	1	0.613*** (0.062)	0.327*** (0.065)	0.446*** (0.055)	0.587*** (0.048)
Groundnut oil		1	0.201** (0.091)	0.246*** (0.088)	0.268*** (0.082)
Other oil			1	0.479*** (0.057)	0.332*** (0.059)
Wheat flour				1	0.360*** (0.053)
Maize flour					1

*,**,*** denote statistical significance at the 10%, 5%, 1% levels, respectively.

Table 5.6.2. Correlation coefficients between three types of vegetable oil and two flours in weekly consumption frequency model

Food item	Palm oil	Groundnut oil	Other oil	Wheat flour	Maize flour
Palm oil	1	0.266*** (0.063)	0.298*** (0.056)	0.476*** (0.046)	0.481*** (0.049)
Groundnut oil		1	0.108 (0.072)	0.116* (0.066)	0.132** (0.066)
Other oil			1	0.349*** (0.055)	0.062*** (0.059)
Wheat flour				1	0.109** (0.054)
Maize flour					1

*,**,*** denote statistical significance at the 10%, 5%, 1% levels, respectively

Table 5.6.3. Correlation coefficients between three types of vegetable oil and two flours in monthly consumption frequency model

Food item	Palm oil	Groundnut oil	Other oil	Wheat flour	Maize flour
Palm oil	1	0.186 (0.158)	0.258* (0.140)	0.242** (0.105)	-0.007 (0.128)
Groundnut oil		1	0.289** (0.122)	0.419*** (0.090)	0.177* (0.109)
Other oil			1	0.493*** (0.072)	0.059 (0.102)
Wheat flour				1	0.138** (0.068)
Maize flour					1

*,**,*** denote statistical significance at the 10%, 5%, 1% levels, respectively.

5.7. Conditional Marginal Effects

Variable coefficients estimated using the multivariate probit are not directly interpretable as measures of changes induced in the dependent variable resulting from a change in explanatory variables. For the practical purpose of understanding the effectiveness of fortification of selected staples and development of recommendations for decision-makers, the estimated coefficients require an additional step of converting them into two types of effects, namely, marginal effects associated with a change in the continuous variable, and the effect of a change from 0 to 1 in case of binary variables. This section describes the magnitude and the change in probability of consumption frequency conditioned on five staples being consumed together within each of the three time periods by urban households in Ghana.

Demographic factors

Married consumers are 19.8% less likely to consume daily all staple food categories considered in the current study as compared to the non-married people (Table 5.7.1). These consumers are more likely to enjoy a wider variety of foods reflecting different food preferences and consequently, are less dependent on consumption of five staples considered in the model. Such differences between households of different marital status have to be considered when anticipating the effects of food fortification. It is possible that those married enjoy a wider variety of foods in general and the wide variety may be sufficient to assure adequate intake of nutrients.

Adding a person to a household increases the probability of eating all five staples within a month by 17.2% (Table 5.7.3). With that being said, policy makers may focus on large families to promote fortified staple consumption. However, small households, elderly consumers should not be neglected because they maybe at risk of inadequate nutrients intake and would benefit from fortified foods.

Socio-economic factors

Consistent with expectations, rising per capita income significantly increases the probability of consuming all the considered food categories with daily frequency (Table 5.7.1). Providing targeted subsidies to low income families will be more helpful because income rather than food expenditure significantly influences consumption frequency and the frequency matters in eating the fortified food. In the latter circumstance, providing food coupons or vouchers would be more appropriate than cash supplement.

Having university or secondary level degree increases the probability of consuming all five staples by 42.8% and 22.4%, respectively, on a daily basis as compared to households of members with less or no formal education (Table 5.7.1). Similarly in the weekly consumption frequency model, having a university degree increases the probability of consumption of all staples by 42.1% (Table 5.7.2) as compared to the benchmark education category. These results further support the provision of information through training programs to the community to enhance the effectiveness of food fortification programs. Also, being a self-employed increases the consumption of five staples by 40.8% (Table 5.7.1.).

Location

Consumers, who shop at a street stand have a 34.2% higher probability of consuming all five staples within a day (Table 5.7.1). It appears that street stall is potentially a very important distribution channel of fortified foods if consumption of desired nutrients is to rise among urban households.

Similarly, a positive effect on weekly consumption frequency of five staples is observed for consumers who shop for food at supermarkets. With access to supermarket, consumers are 25% more likely to consume the listed staples altogether weekly (Table 5.7.2). On the other hand, reporting to shop at grocery stores decreases the probability of consuming the five foods weekly by 30.9% (Table 5.7.2). Moreover, consumers who report to shop for food at supermarkets have a 37.6% higher probability of eating all five staples within a month than those, who do not shop at this type of retail outlet (Table 5.7.3).

With regard to the location of household and its effect on monthly consumption frequency, residents in Takoradi are 28.8% more likely to consume all considered foods as compared to residents of Accra (Table 5.7.3). Residents in a large city and a capital such as Accra likely have a wider variety of foods available and are less dependent on the five selected foods. The relevant practical question is whether such decline in the probability of consuming fortified or potentially fortified foods threatens the adequate intake of nutrients in question. Additional research may be necessary to provide the needed insights.

Table 5.7.1 Conditional Marginal Effect of Daily Consumption Model

Variable names	Conditional marginal effect	Standard error
	Demographic factors	
Numc	-0.028	0.031
Nump	0.055	0.042
Married	-0.198*	0.117
Age	-0.001	0.005
	Socio-economic factors	
Employ_gov	0.160	0.204
Employ_self	0.408**	0.183
Education1	0.428**	0.182
Education2	0.224*	0.122
Per capita income	0.001***	0.0002
Spend	-0.0004	0.001
	Location	
Tamale	0.230	0.135
Takoradi	-0.115	0.135
mkt1	0.111	0.110
stree1	0.342***	0.106
super1	0.600	0.130

*,**,*** denote statistical significance at the 10%, 5%, 1% levels, respectively.

Table 5.7.2 Conditional Marginal Effect of Weekly Consumption Model

Variable ames	Conditional arginal ffect	Standard error
	Demographic factors	
Numc	0.034	0.029
Nump	0.049	0.040
Married	0.086	0.117
Age	0.002	0.005
	Socio-economic factors	
Employ_self	0.086	0.117
Employ_gov	-0.062	0.188
Education1	0.421**	0.177
Education2	0.140	0.118
Per capita income	0.0004	0.0002
Spend	-0.001	0.001
	Location	
Tamale	-0.111	0.141
Takoradi	-0.154	0.130
mkt1	-0.309***	0.102
stree1	-0.072	0.105
super1	0.252**	0.122

*,**,*** denote statistical significance at the 10%, 5%, 1% levels, respectively.

Table 5.7.3. Conditional Marginal Effect of Monthly Consumption Model

Variable ames	Conditional arginal ffect	Standard error
	Demographic factors	
Numc	0.054	0.034
Nump	0.172***	0.045
Married	-0.076	0.164
Age	-0.003	0.006
	Socio-economic factors	
Employ_gov	-0.156	0.256
Employ_self	-0.076	0.216
Education1	-0.258	0.269
Education2	-0.021	0.163
Per capita income	0.002	0.002
Spend	0.0002	0.003
	Location	
Tamale	0.230	0.135
Takoradi	0.288*	0.170
mkt1	0.101	0.147
stree1	0.214	0.137
super1	0.376**	0.158

*,**,*** denote statistical significance at the 10%, 5%, 1% levels, respectively.

5.8. Unconditional Marginal Effects

This section describes the magnitude and the change in probability of consumption frequency for five staples being consumed separately within each of the three time periods by urban households in Ghana.

Demographic factors

Married consumers are 19.6% less likely to consume other vegetable oil daily in the current study as compared to the non-married people (Table 5.8.1), and being married also reduces the palm oil monthly consumption by 31.8% (Table 5.8.3). But the married respondents are 10.5% more likely to consume wheat flour weekly as compared to the unmarried respondents. Every addition child in the household increases groundnut oil daily consumption by 11%, while each additional adult decreases the palm oil consumption by 7% and increases other vegetable oil weekly consumption by 14.5% (Table 5.8.3). The number of adults in a household also increases the weekly wheat flour consumption by 10.7%.

Socio-economic factors

Being a government employee is likely to facilitate the weekly consumption of groundnut oil by 33.9%, while decreases palm oil and other vegetable oil weekly consumption both by 38.1% (Table 5.8.2). On the contrary, being a self-employed increases other vegetable oil consumption daily by 41.3% (Table 5.8.1), while decreases the weekly consumption of palm oil, other vegetable oil and wheat flour each by about 30% (Table 5.8.2). This form of employment also decreases the monthly wheat flour consumption by 32.1% (Table 5.8.3).

Having a university or higher education level results in a lower probability of daily groundnut oil consumption by 67.1% as well as a less of the daily maize consumption by 54.2%, while increases other vegetable oil daily consumption by 43.4% (Table 5.8.1). The highest category of education also increases the weekly consumption of groundnut oil and maize flour by

39.4% and 27.5% respectively. Interestingly, those reporting the secondary education are prone to consume palm oil and other vegetable oil daily with about 23% higher probability than those in the benchmark education category (Table 5.8.1). Respondents falling into the secondary education category reduce the probability of maize flour daily consumption by 27%, but are more likely to consume maize flour weekly by 25.1% (Table 5.8.1). Also, respondents having the secondary education are 31.8% less likely to consume maize flour monthly (Table 5.8.3). The marginal effects of per capita income and monthly food expenditure, though significant in the daily and weekly consumption models (Tables 5.8.1-5.8.2), are too small to be informative. However, their signs suggest generally, positive effect except in case of daily maize flour consumption.

Location

Takoradi residents are 25.4% less likely to consume palm oil daily as compared to Accra residents. In case of flour consumption, Takoradi residents are about 40% less likely to consume maize flour and 90% less likely to consume wheat flour daily than Accra residents (Table 5.8.1). In the weekly consumption frequency model, Takoradi residents are 55.1% less likely to consume maize flour, but 42% more likely to consume wheat flour (Table 5.8.2). In the monthly consumption model, Takoradi residents are 83% more likely to consume groundnut oil, 53% more likely to consume other veg oil, and 80.7% more likely to consume wheat flour, but 51% less likely to eat maize flour (Table 5.8.3). Quite the opposite, Tamale residents are about 32% more likely to consume palm oil daily, 21% more likely to consume groundnut oil, nearly twice as likely to consume maize flour daily, and 43.1% more likely to eat wheat flour daily as in comparison to respondents from Accra (Table 5.8.1).

In terms of retail outlet type, having access to a regular market increases palm oil daily consumption by 26.3% and groundnut oil consumption by 37%, respectively. This kind of outlet type also increases the weekly groundnut oil consumption by about 23%, but decreases the weekly maize flour consumption by 26.5% (Table 5.8.2). Similarly, shopping at street stands is likely to increase daily palm oil and groundnut oil by more than 40%, other vegetable oil by 34.4% and wheat flour by 20.2%, respectively (Table 5.8.1). This kind of outlet also increases the probability of monthly maize flour consumption by 27.6% (Table 5.8.3). Finally, having access to a supermarket only increases by 26.2% palm oil consumption and wheat flour consumption by 25.1% on a daily basis (Table 5.8.1). Also, having access to a supermarket increases the maize flour weekly consumption by 20% (Table 5.8.2).

Table 5.8.1. Unconditional Marginal Effect of Daily Consumption Model

	Palm Oil	Groundnut Oil	Other Veg Oil	Maize Flour	Wheat Flour
			Demographic factors		
Numc	---	0.110***	---	---	---
Nump	-0.073*	---	---	---	---
Married	---	---	-0.196*	---	---
Age	---	---	---	---	---
			Socio – conomic actors		
Employ_gov	---	---	---	---	---
Employ_self	---	---	0.413**	---	---
Education1	---	-0.671**	0.434**	-0.542***	---
Education2	0.230**	---	0.228*	-0.270**	---
Per capita ıcome	0.0005**	---	0.0007***	---	0.0006**
Spend	---	0.004**	---	-0.003**	---
			Location		
Takoradi	-0.254*	---	---	-0.401***	-0.907***
Tamale	0.321*	0.21***	---	0.996***	0.431***
mkt1	0.263**	0.370**	---	---	---
stree1	0.417***	0.416***	0.344***	---	0.202**
super1	0.262**	---	---	---	0.251**

*,**,*** denote statistical significance at the 10%, 5%, 1% levels, respectively.

Table 5.8.2. Unconditional Marginal Effect of Weekly Consumption Mode

	Palm Oil	Groundnut Oil	Other Veg Oil	Maize Flour	Wheat Flour
			Demographic factors		
Numc	---	---	---	---	---
Nump	---	---	---	---	0.107**
Married	---	---	---	---	0.105***
Age	---	---	---	---	---
			Socio – conomic actors		
Employ_gov	-0.381**	0.339*	-0.381**	---	---
Employ_self	-0.297**	---	-0.297**	---	-0.281*
Education1	---	0.394**	---	0.275*	---
Education2	---	---	---	0.251**	---
Per capita income	---	-0.0007**	---	---	---
Spend	---	---	---	---	0.002*
			Location		
Takoradi	---	---	---	-0.551***	0.420***
Tamale	0.775***	---	---	-0.726***	-0.378**
mkt1	---	0.233**	---	-0.265***	---
stree1	---	---	---	---	---
super1	---	---	---	0.200*	---

*,**,*** denote statistical significance at the 10%, 5%, 1% levels, respectively.

Table 5.8.3. Unconditional Marginal Effect of Monthly Consumption Mode

	Palm Oil	Groundnut Oil	Other Veg Oil	Maize Flour	Wheat Flour
			Demographic factors		
Numc	---	---	---	---	---
Nump	---	---	0.145***	---	---
Married	-0.318*	---	---	---	---
Age	---	---	---	---	0.008*
			Socio – conomic actors		
Employ_gov	---	---	---	---	---
Employ_self	---	---	---	---	-0.321**
Education1	---	---	---	---	---
Education2	---	---	---	-0.318**	---
Per capita income	---	---	---	---	---
Spend	---	---	---	---	---
			Location		
Takoradi	---	0.830***	0.530***	-0.510***	0.807***
Tamale	---	---	0.375*	---	---
mkt1	---	---	---	---	---
stree1	---	---	---	0.276**	---
super1	---	---	---	---	---

*,**,*** denote statistical significance at the 10%, 5%, 1% levels, respectively.

5.9. Additional Vitamin A Intake

In this section, I calculate the amount of vitamin A intake from maize flour by assuming the quantity of daily consumption according to the estimated daily intake in Africa (Ranum et al., 2014). In Table 5.9, the first column on the left lists the estimated quantity consumed by a Ghanaian at three levels, namely 50g, 100g and 200g. The third column presents levels of vitamin A in the fortified vegetable oil according to Nyumuah et al. (2012). The listed fortification amount in maize flour is based on WHO recommendations (WHO, 2009). The product of figures in two columns is the estimated intake of vitamin A per person per day. To generalize the results to population as a whole, I take a weighted average daily vitamin A intake with the weights being the share of households that consume maize flour daily, weekly and monthly as presented in Tables 3.2-3.4 To be specific, the daily maize flour consumption by those respondents, who report to be weekly consumers is the estimated daily quantity divided by 7, while for the monthly consumers, I divide the regular daily amount by 30. Finally, column five in Table 5.9 shows the percent of recommended daily intake for adult women represented by figures in column four. As , the percent of vitamin A intake is 6.78%, 13.55% and 27.1% if the average daily maize flour consumption per person is 50g, 100g and 200g, respectively. Therefore, if the government program results in fortification of the maize flour according to the WHO standard, and the population consumes on average of 200g maize flour each day, maize flour will account for a substantial amount of the recommended vitamin A intake and, thus, mitigate vitamin A deficiency in Ghana.

Table 5.9. Vitamin A intake from Maize Flour

Daily Consumption Level (g)	Vitamin A fortified (ppm)	Intake of Vitamin A (mg/d)	Weighted Average Daily Intake (g)	Percentage of Recommendation (%)
50	1.5	75E-03	33.86E-03	6.78
100	1.5	150E-03	67.74E-03	13.55
200	1.5	300E-03	135.48E-03	27.10

CHAPTER 6

CONCLUSIONS

This chapter summarizes the results from regression and their policy implications on food fortification program implementation in Ghana. The discussion includes conclusions, limitations of the study, and suggestions for future research.

The multivariate probit model results reveal that while many social economic and demographic factors can explain the daily consumption of foods, their power vanishes as the consumption become more infrequent. As the time lapse gets longer, many more factors are bound to effect one's eating behavior. For daily consumption, the direction of the effects of marital status, number of children, and number of adults depends on the food category of interest. Generally, education, specifically a university level education, reduces the likelihood of consuming vegetable oil of any kind and flour on the daily basis, while monthly food expenditure and access to various markets increases the probability of consumption. However, those with large monthly food budget are bound to consume less maize flour. Also, the regional location plays a big role in the amount of staple daily consumption. For weekly and monthly consumption, though the number of significant explanatory variables substantially decreases, the education level retains its potent effect although the directional effect is unpredictable across food categories. In case of maize flour, a higher level of education tends to reduce its consumption and if one has grocery store access, they are less likely to consider maize flour.

The consumer profile is essential for policy makers in efforts to fortify the maize flour in addition to the existing fortification of wheat flour in Ghana. According to the results, the number of people in the household facilitates the consumption, so a policy maker or manufacturer may target large-sized household and educate people about the link between health and nutrients in the products. In addition, food distribution can also increase the consumption of maize flour by improving access to the product, especially in supermarkets and at street stands.

The study has several limitations. First, a larger number of observations could enhance results. Although, the final sample has 954 data points, one reported consumption frequency for a specific food item within a certain time period is very low: there are only 8.56% of households that report consuming groundnut oil daily, this small proportion of sample causes problems when using the maximum likelihood estimation in the multivariate probit model such as an invertible correlation coefficient matrix. Also, the number of regions is limited to only three cities. Future studies may include additional cities, including those located in other areas of the country to compare the consumption across regions of different economic development. Further, since the current focus is on health issue, some proxies for health concerns could also be considered. The available data permits the use of smoking information to indicate health concerns, but due to the infrequent incidence of tobacco smoking, that proxy is omitted. However, caution should be exercised because the proxy should be representative of the underlying phenomenon. Lastly, we are developing consumer profile to learn about the consumer behavior, existence of a niche market and to make suggestions about policy. It will also be more helpful if the exact consumed amount of foods is recorded because the intake of vitamin is directly related to the consumed amount. Researchers may conduct interviews or include open questions in the survey, and then apply the text mining technique and sentiment analysis to gain insights from the text. That approach offers additional information about consumers and broadens program evaluation.

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79