Consumer preferences for different sources of vitamin A in Odisha, India and Alberta, Canada

by

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Abstract

Vitamin A deficiency is a form of malnutrition that affects 127 million people globally, leading to increased risk of infection, ocular disorders, and/or impaired growth (WHO 2004). There are multiple ways to increase vitamin A intake including supplements, whole, fortified, and biofortified foods. Given that it may be in policymakers' best interests to increase the vitamin A intake of individuals and households, understanding preferences for food or pill-based vehicles could be important. Preferences of Indian consumers (n = 120) and Canadian consumers (n = 102) were compared. Although extremely disparate population samples, data has indicated that vitamin A deficiency exists in both countries (Kirkpatrick and Tarasuk 2008; Wallace 2012). The objectives of this study were threefold: 1) to estimate the individual's preferences for different vitamin A vehicles by their willingness to exchange supplements for vitamin A rich foods, 2) to examine the impact of perceptions of naturalness, knowledge of nutrition and diet, and food technology neophobia on Vitamin A vehicle preferences, and finally, 3) to compare the subsamples within Odisha, India and Edmonton, Alberta, Canada and identify common preference indicators that may be similar, suggesting factors that might be population independent and worth further investigation in recommending programs in vitamin A deficient populations elsewhere.

A consumer choice experiment with a modified payment card was used to analyze the probability that individuals would exchange a food for supplements with which they were endowed. This allowed the calculation of willingness to pay (WTP) for different sources of vitamin A. These food-based sources included biofortified sweet potato (Meenakshi et al 2012), fortified edible oils (margarine in Canada), and carrots. Each of the food bundles satisfied seven days of recommended vitamin A intake. This way, participants could better understand what the equivalences were in terms of foods versus pills for vitamin A content. A survey was then administered to identify perceptions for naturalness, nutrition knowledge, and food technology neophobia of participants. These attitudes and perceptions were scored based on methods in the literature. Multinomial logit and random parameters logit regressions were used to estimate probabilities of exchanging each of the vitamin A rich goods within the choice set for vitamin A supplements. From the parameter estimates, the mean WTP to exchange supplements for fortified oil (or margarine in Canada), carrots, and biofortified sweet potato were calculated for the Indian and Canadian subsamples. Further, mean WTP to exchange supplements for a food was compared between participants with higher and lower scores for the three attitude measures.

Results indicated that Indian participants with high confidence in their knowledge of nutrition and diet were willing to pay significantly less for fortified oil, carrots, or biofortified sweet potato compared to participants with lower confidence. High food technology neophobia participants in India were also willing to pay less to switch from supplements to fortified oil or biofortified sweet potato. In Canada, no attitude factors except objective knowledge of nutrition and diet affected WTP estimates for different vitamin A vehicles. Overall, results suggest that Canadians and Indians were willing to pay a premium for food-based vitamin A vehicles as opposed to supplements, with the exception of margarine in Canada, which was discounted. Therefore food-based approaches may be a viable alternative to supplements for policymakers to increase vitamin A intake in these populations.

Preface

This thesis is an original work by Sandra Ngo. The research project, of which this thesis is a part, received research ethics approval from the University of Alberta Research Ethics Board, Project Name "How is vitamin A fortification/enhancement perceived in Canada and India?" No. Pro00053574, on January 7, 2015. No part of this thesis has been previously published.

Dedication

To my family, the ones who are with me and the ones I have lost.

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Chapter 1. Introduction

1.1 Background Information

Vitamin A is widely acknowledged for its role in maintaining ocular health, but is also a key component of metabolic function in all bodily tissues. Vitamin A is essential for health and growth, specifically in the visual, immune, and reproductive systems. A prolonged lack of vitamin A intake that does not satisfy physiological requirements can lead to Vitamin A Deficiency (VAD). Deficiency is characterized by liver stores of retinol <20μg/g, or serum retinol <0.7umol/L (Ramakrishnan and Darnton-Hill 2002). Symptoms of VAD include depressed immune responses, stunting in childhood, impaired iron mobilization, dryness of the eyes and blurry vision in dim light. VAD can also result in increased risk of disease and/or death due to inhibited immune system function, as well as night blindness, Bitot's spots, and xerophthamalia. Xerophthalmia is the leading cause of childhood blindness in the world by causing bilateral corneal melting and perforation. Such conditions are easily detectable with eye examinations and may serve as a proxy for measuring moderate to severe VAD (Thulasiraj et al. 2003). It is asserted by the World Health Organization (2011) that rates of >1.5% of xerophthalmia and/or >15% for VAD in a population constitutes a public health problem.

Globally, VAD affects roughly 127 million people and contributes to over 600 000 deaths per year, the majority of whom are young children and pregnant women (Adamson 2010). More than half of these deaths occur in India, where VAD is a significant public health concern, especially in rural areas or urban slums (National Institute of Nutrition 2011). Overall, 23.1% of the school-age population in India is estimated to be deficient in vitamin A intake. Children are disproportionately affected due to higher requirements for growth and concomitant smaller nutritional intakes. They are especially vulnerable as deficiencies may lead to impaired growth and development (Kapil and Sachdev 2013). Deficient mothers may also have restricted vitamin A transfer to the foetus during pregnancy and have lower levels in their breast milk after childbirth, thereby transferring VAD through generations. Children born from night blind mothers experience higher rates of stunting, morbidity, and low birth weight (Tielsch et al. 2008). Deficiency in vitamin A is a direct cause in 16% of all cases of severe diarrhoeal diseases and 16% of worldwide cases of malaria (WHO 1998). In less extreme cases, it may manifest as anemia and reduced resistance to infection. VAD can be difficult to detect, requiring specialized examinations which may be invasive or expensive (Tanumihardjo 2008). Due to this difficulty, complete data for rates of VAD is rarely available on a national or regional scale, although some studies suggest rates as high as 31 to 57% in Indian children under six (Chow et al. 2010).

In Canada, approximately 10% of children aged 9 – 18 have inadequate vitamin A intake, although data are lacking for children aged 1 to 6. Among the food insecure segment of the population, 69% of Canadian women aged 19 – 30 and 50% of women aged 31 – 50 had low vitamin A intake. Kirkpatrick and Tarasuk (2003) found that lower income Canadian households tended to purchase lower quantities of fruits, vegetables, milk, and meat products, all of which are rich sources of vitamin A. Purchases of meats and alternatives were especially lower in rent paying households versus homeowners. In their examination of the Canadian Community Health Survey (Cycle 2.2), Kirkpatrick and Tarasuk (2008) found an incidence of nutrient inadequacy of about 10% in Canadian children. However, a higher incidence of inadequate vitamin A intake was correlated with food insecurity, especially in later life. Rates of inadequate intake ranged from 34 – 69% of Canadians, with highest prevalence among food insecure women (Appendix 1.1). In developed countries which have prevented the development of VAD, prevalence of nightblindness and other symptoms are quite rare and do not exceed WHO thresholds for a public health concern. Despite this, Canadians are still experiencing inadequate intake of vitamin A, especially among food insecure populations.

There are a variety of strategies used to combat VAD including supplementation, fortified foods, and/or nutrition education to change diets and behaviour. The widest and most longstanding initiative to combat VAD in India is the Massive Dose vitamin A (MDVA) programme, in which all children from ages 0 to 56 months are given 200,000 IU of vitamin A at six month intervals, beginning with measles vaccinations (Kapil and Sachdev 2013). While it has been effective in reducing rates of xerophthamalia and VAD, coverage rates are not equal between regions and the long-term efficacy of such supplements are concerning given the high vitamin A dosage (Penniston and Tanumihardjo 2006). Other options include the food-based programs. For example, vanaspati is a commonly used cooking oil that is mandatorily fortified with vitamin A in India (Akhtar et al. 2013) and various Indian states have had milk fortified with vitamin A in the past (Dary and Mora 2002a). Non-profits, such as the Global Alliance for Improved Nutrition (GAIN), have also participated in fortification programs to boost micronutrient intake (GAIN, 2009). A recent GAIN project was a two-year program fortifying soybean oil with vitamin A. This began in 2013 within the province of Madhya Pradesh (GAIN 2013). Madhya Pradesh was identified to have a high prevalence of low vitamin A levels and the vast majority of households use soybean oil regularly. Cargill, Inc. has also been fortifying oils with vitamin A in India since 2008 as alternatives to non-fortified oils within the market.

A novel approach that has seen recent development is biofortification, which is a means of increasing micronutrients in staple food crops via selective breeding and/or transgenic means. The HarvestPlus program has developed a variety of pearl millet biofortified with iron millet in India, in addition to cassava, maize, and sweet potato varieties biofortified with Vitamin A

(HarvestPlus 2009). HarvestPlus aims to combine nutritious crops with high-yielding, productive varieties of crops, and is currently researching implementation and consumer acceptability. Whether or not a crop is transgenic will depend on the process that was used to develop that specific breed. However, the biofortified sweet potato was developed via selective breeding hasn't been used yet in India/Canada although it could be.

Canada has also participated in food fortification and nutrition education programs to help boost micronutrient intake. Fortification of skimmed or partially skimmed milk (liquid and evaporated) and margarine is mandatory (Health Canada 2010; CFIA 2014), with targets of 216.9 IU of vitamin A per 100 ml for dairy products and a minimum of 5,300 IU in margarine per 100g (Government of Canada 2014). Currently and possibly due to the long mandatory fortification programs in Canada, awareness of inadequate vitamin A intake is quite low and food characteristics that have largely concerned Canadians are weight-loss, sodium content, country of origin, sugar content, fat composition, labeling, and being organic (CCFN 2010). While vitamin A does not seem to be a public priority in Canada, the extent of VAD is unknown and its effects uncertain; although evidence exists it may be contributing to hidden hunger and micronutrient deficiency as consumption of vitamin A-rich sources declines. For example, per capita consumption of liquid dairy has decreased from 90.32 L per year in 1995 to 73.31 L in 2014 (Canadian Dairy Information Centre 2013). The availability of margarine per person, adjusted for retail, household, cooking, and plate loss may be used as a proxy for intake. In 1981, availability was 4.82kg/person and 4.21kg/person in 1996. This has further declined in recent years to 2.99kg/person in 2009 (Statistics Canada 2010). Overall then the main foods fortified with vitamin A in Canada are being consumed less among the population, which raises concerns about whether these fortification programs are effective and if the population is consuming adequate vitamin A.

From the advent of food technology and its applications in altering nutrient content, safety, and shelf life of foods, there have been consumer responses of doubt and suspicion of novel products (Urala and Lähteenmäki 2007). Some even go so far to view such foods as "unnatural". The converse of this is the trait of "naturalness" or "being natural" although the term itself is ambiguous. Despite this, natural claims on food products tend to be positively valued and may improve perceptions of how healthy a food may be (Rozin et al. 2012; Andre et al. 2014). The frequency of natural claims on food labels tends to be higher than that of organic, and American consumers have been shown to link natural with "green" more than even organic labels (Scott-Thomas 2009). Siipi (2013) posits that because the term "natural" is vague, consumers are free to attach whatever meaning to the word that best suits them. Despite heterogeneity of interpretation, naturalness in foods tends to be positively valued (Rozin et al. 2004) and it seems that the process a food undergoes is far more influential as to how natural a food is perceived rather than actual nutritive composition (Rozin 2005; Rozin 2006). Ritchey et al. (2003) suggested that people strongly correlate health with natural, and in addition, value natural in terms of morality and ideation. It is unclear if increased naturalness in a food translates to increased willingness to pay for a product in the context of improving micronutrient intake although it has been linked to increased acceptability and willingness to use in the other food studies described above.

Tied into the concept of naturalness is the role of knowledge and understanding of how processes involving food production, fortification, and biofortification occur. Resistance to a new food product or positively valuing "natural" in a food product given identical nutrient composition may be caused in part by lack of knowledge. Aertsens et al. (2011) have investigated the effects of subjective knowledge (what consumers think they know) and objective knowledge (what they actually know). Higher subjective knowledge is correlated with more positive attitudes towards a product, while objective knowledge makes one less influenced by newer information. Knowledge influences on food choice may differ between knowledge of nutrition and knowledge of the processes involved in various food products.

Preference for new food technologies is another factor that may influence consumer decision-making in increasing vitamin A intake. There are segments of the population that are adverse to or are preferential to foods produced with new technology (Cox and Evans 2008). This can be characterized by a food technology neophobia scale (FTNS), which has been shown to be stable over time and a valid measure for measuring individual neophobia. Such measures are useful in identifying early adopters of new foods, especially if that food has beneficial health characteristics. A higher FTNS rating is correlated with a greater willingness to consume. Although there are various interventions that address VAD, policymakers are unsure how participants will respond. By analyzing WTP to exchange between vitamin A rich goods and these various attitude scales concurrently, results of this study will shed light on consumer preferences for various types of vitamin A-rich goods.

1.2 Economic Problem

In 2002, VAD contributed 1.8% of global disability-adjusted life years (DALYs) (WHO 2004). In each country, there is a limited amount of resources allocated to public health in order to promote wellness and ensure sound health. Canada and India spend 11% and 4% of their GDPs respectively on public health care (World Bank 2014). It is estimated that if every child in

India received the massive dose vitamin A (MDVA) supplements, the cost of the programme would be roughly Rs. 8,000 million per year (Kapil and Sachdev 2013), or $126 million USD. Certain geographical regions may have rates as high as 11% of children developing xerophthalmia or Bitot's spots (Kapil and Sachdev 2013). In addition, illness caused by micronutrient deficiencies may exacerbate poverty and results in lost capital by impairing intellectual capacity to earn wages, contributes to more sick days and lost wages, and increases healthcare costs (Black et al. 2008). Xerophthalmia, if allowed to progress, has a 50% mortality rate for children within the first year after its development (Whitcher et al. 2001) which may lead to large economic and social losses if left unchecked. Even if childhood blindness is survived, an adult's earning potential is severely decreased as a result of disability. VAD need not progress to clinical symptoms to have deleterious effects. Subclinical VAD may also impact immune function and health, and is a concern in both India and Canada. Therefore, in order to maintain a productive and healthy population, it is within policymakers' best interests to ensure adequate intake of vitamin A.

Vitamin A intake can be boosted by increasing intake of vitamin A rich foods, changing dietary patterns, or adding supplements. A better understanding of the relationship between consumer perceptions, personal tendencies to try foods created with new technology, and existing knowledge level allows policymakers and producers to better target programmes and products. This is also linked to limited household budgets that constrain consumer behaviour and it is critical for foods and programmes to be aligned with consumer preferences to prevent wasted resources while addressing health concerns. Cost constraints within a household tend to lead to calorie-dense and nutrient poor diets (Tanumihardjo 2008) which exacerbate inadequate micronutrient intake. Therefore policymakers must ensure that affordable food options that meet nutrient needs are available to the population. It is likely that in both India and Canada, a combination of approaches is required for bettering health via reducing micronutrient deficiencies. Given that public funds are a limited resource, they must be allocated optimally between programs to minimise costs while maximizing public health. What combination of programs and how they are to be prioritized, is inextricably linked to the target populations' behaviours and preferences. Therefore by better understanding consumer preferences between vitamin A vehicles and comparing supplement and food-based approaches, results from this study will allow policy makers to better tailor programs to increase vitamin A intake in at-risk populations. The research may also identify some core or common features of vitamin A source preferences across populations, potentially reducing the necessary investigation of the best method of increasing intake in further distinct populations in India, Canada or other countries.

1.3 Research Objectives

While VAD rates have greatly declined in the past forty years, the MDVA programme has limitations and was devised as a stopgap measure. In order to better aid in the transition to food-based solutions, it would be useful to understand how consumers choose between various different sources of vitamin A, and what they would be willing to pay for these different products. In this study, fortified, biofortified, whole foods and supplements identified as providing the same level of Vitamin A, will be compared.

1. Are supplements or food-based methods more preferred by consumers, and are they willing to pay a price to exchange vitamin A supplements for food-based vitamin A sources?

2. How are these preferences affected by values and socio-demographic characteristics, food technology neophobia, objective and subjective knowledge, and perceptions of natural?
3. Do these preferences differ between Canada and India where there are different attitudes towards food products and different histories of food fortification?

Answers to these questions will allow policymakers to be better informed about which strategies to choose when tackling the problem of micronutrient deficiencies.

1.4 Study Procedure

There are a wide variety of supplements and food products available on the market. Such products may be perceived as a bundle of characteristics, and consumers make trade-offs between these characteristics. Characteristics can include nutrient content, convenience, price, taste, etc. The process of how a nutrient came to be in a product may affect how consumers view that product. When choosing between sources of vitamin A, consumers are assumed to be rational actors who maximize their utility, where utility is characterized as a function of characteristics of the goods, their prices, and individual preferences constrained by income and time. The factors that influence consumer food preferences are various, but include socio-demographic characteristics (Verbeke 2005; Kamphuis et al. 2015), knowledge (House et al. 2004; Kooijmans and Flores-Palacios 2014), and food technology neophobia (Evans et al. 2010b; Matin et al. 2012; Chen et al. 2013).

Studies in the past regarding vitamin A and consumer choices have typically looked at trade-offs between products of the same group (Low et al. 2007; Meenakshi et al. 2012; De

Groote et al. 2014). How consumers make choices between different vitamin A sources have not been examined in the context of other characteristics. Participants were sampled from India, in which VAD had been a significant public health issue in the previous 40 years, and Canada, where reports of low vitamin A intake have remained largely unaddressed by policymakers and health practitioners since the issue was dealt with by mandatory fortification in 1942. A convenience sample was developed to access tribal communities in Odisha, India and households within Edmonton, Alberta, Canada. In the province of Odisha, India, enumerators went door to door and villagers in the Koraput district were asked to participate in a two to three hour experiment (n = 120). In Edmonton, Alberta, Canada, participants were drawn from the city of Edmonton, where selection was done via email newsletters, radio advertisements, and posters in public areas (n = 102).

Given that the study objective was to assess consumer preferences between vitamin A rich goods, a choice experiment methodology was employed to examine trade-offs between supplements, fortified foods, and foods with naturally high vitamin A levels. Given the lack of biofortified goods commercially available in the target sites, a second choice experiment without food products or money was performed after the real choice experiment to explore consumer attitudes towards biofortified products. Food products were chosen that were representative of a method for increasing vitamin A intake (i.e. one for “natural” sources of vitamin A and a fortified food). A food was deemed suitable if it was widely consumed by the population in sufficient amounts to satisfy vitamin A intake, available, reasonably priced in both India and Canada. Given the high percentage of vegetarians in India, vegetable-based products were the focus in order to preserve as much similarity between experiments in India and Canada

Participants were endowed with vitamin A supplements that satisfied one week's worth of Vitamin A intake as recommended by their respective countries' health mandates (600 IU for adults in India, 700 IU for adults in Canada). They were then given the option to exchange their supplements for another good and pay a bid premium for the product. Participants in both countries received the same instructions and modified payment card for the real and hypothetical choice experiments. In addition to the economic experiment, a survey was included that ascertained preferences between food bundles, values of convenience and health, purchasing habits, perceptions of "natural", questions that measure objective and subjective knowledge, a food technology neophobia scale, and scenario rejection.

Data were analyzed with a multinomial logit model and a random parameters logit model. The multinomial logit examines the conditional effects of explanatory variables on the probability of choosing to exchange their supplements for another good. The random parameters model is used to determine whether or not there is unobserved heterogeneity while taking account of the panel nature of the data and the participants making repeated decisions

1.5 Thesis Structure

The following chapter is a literature review regarding the prevalence of Vitamin A deficiency in India, factors that predispose individuals to VAD and an exploration of the various programs that India has used to address this issue. Comparisons with attitudes and beliefs in Canada, as well as fortification programs will be discussed. In Chapter 3 the experimental design and methodology are described while preliminary analysis and descriptive statistics are performed on the data in Chapter 4. The penultimate chapter explains the econometric analysis and finally, results and key findings are then discussed in the context of policy implications and suggestions for future areas of research.

Chapter 2. Literature Review

2.1 Introduction

This literature review briefly outlines the biochemistry and role of vitamin A before exploring the prevalence of VAD in India and Canada. The methods used by these countries for increasing vitamin A intake will be described, as well as their advantages and disadvantages. Relevant determinants of preferences and behaviours in regard to consumer choices are also examined in the context of a payment card experiment. This includes the role of objective and subjective knowledge in consumers, food technology neophobia and a scale to measure it in individuals, and socio-demographic characteristics. The overall goal of this literature review is to inform our study design in order to accomplish the objectives laid out in the previous chapter.

Vitamin A, or retinol, is a fat-soluble compound found in food as pre-formed retinol or pro-vitamin A carotenoids. Retinal and pro-vitamin A compounds are converted to retinol, which is the chief bioactive form of vitamin A *in vivo*. Animal sources tend to be higher in pre-formed retinol and include liver, dairy, and eggs. Plant sources of vitamin A include green leafy vegetables, fruits and vegetables with a deep yellow or orange color, edible fats and oils, and fortified hydrogenated oil. The rate of conversion from pro-vitamin A to vitamin A is measured in units known as Retinol Activity Equivalents (RAE), or the amount of substrate required in order to produce 1μg of retinol *in vivo* (Table 1). Animal-based sources are far more efficiently converted into retinol, whereas plant-based carotenoids require 12 to 24μg to produce 1μg of retinol. It is estimated that the proportion of plant-based vitamin A consumed compared to overall vitamin A intake in developing countries is 82%, whereas vitamin A from plant-based sources in developed countries consumption is thought to be much lower (WHO 2009)

Table 2.1 Equivalencies of retinoids and carotenoids (WHO 2009)

Substance	**Common Sources**	**RAE**
Retinol	Animal-based	1
Beta-carotene (dissolved in oil)	Supplements	2
Beta-carotene	Plant-based	12
Alpha-carotene	Plant-based	24
Gamma-carotene	Plant-based	24
Beta-cryptoxanthin	Plant-based	24

Vitamin A deficiency (VAD) contributes to approximately 600 000 deaths per year and has the highest contribution to the remaining disease burden caused by micronutrient deficiencies globally (Black et al. 2008). The World Health Organization (2009) has deemed that prevalence of 15% in a population comprises a public health problem. However, women and children tend to be the focus of interventions due to children being at higher risk of deficiency due to requiring nutrient dense foods needed for development. For example, corneal xerophthalmia peaks from ages 1 to 2 (Chow et al. 2007). This is why children tend to show the greatest response to supplementation programmes. Efficacy of supplements has also been shown to wane in later years, and xerophthalmia has a high mortality rate and so prevention is more cost-effective Mothers, if they are vitamin A deficient, may confer deficiency to their children via low Vitamin A transfer into breast milk. Pregnant women have also recently been identified to be at-risk for clinical VAD, especially during pregnancy when there is a heavy draw upon nutrient stores and risk of mortality and stunting may be increased in newborns (Tielsch et al. 2008).

2.2 Prevalence of Vitamin A Deficiency in India

Vitamin A prophylaxis in India has been occurring for roughly 40 years, but VAD and its related maladies have persisted (Wallace 2012). Programs and national strategies have been plagued by logistical issues, a lack of nutrition education for increasing intake of vitamin A rich foods, and reliance on short-term strategies like high dose supplements (Ramakrishnan et al. 1995). In 1993 children aged 3 to 15 in Tamil Nadu were tested for xerophthalmia (n = 4,843) (Sampathkumar and Abel 1993). Overall prevalence was 1.1% but was more than double in males (1.5%) vs. females (0.7%). This is significantly lower than other studies performed in the same time period in different regions. In Trichy, 11% of school children had xerophthalmia while researchers in Maharashtra reported rates of 56%, with 34% of cases being mild. The Global Assessment Report compiled in 2002 by UNICEF and the Micronutrient Initiative estimated that 330,000 deaths are precipitated in India per year as a result of subclinical VAD, and 57% of children under the age of six experience subclinical VAD (Adamson 2010). The numbers of those with VAD in India has been held fairly constant over the years, despite population growth (West 2002). However, recent data shows 50 – 70% of individuals consuming less than 30% of the recommended dietary intakes for vitamin A (National Institute of Nutrition 2011), prolonged deficiency is likely a problem in India.

In India it was found that twelve percent of mothers nationwide were found to experience night blindness in 2007 with higher rates in rural areas (Chow et al. 2007). The National Family Health Survey (NHFS-3) also reported a national prevalence of 9% for night-blindness in pregnant women (Semba et al. 2010). A similar study in 2006 done by Schmid, Egeland, Salomeyesudas, Satheesh, & Kuhnlein found that 16% of mothers were found to have some symptoms of VAD, including Bitot's Spots, xerophthalmia, and or conjunctival xerosis. Increased age and higher income were found to be associated with higher VAD rates. Authors posited that higher income meant lower intake of traditional foods such as roti (made from sorghum), and green leafy vegetables rich in VA. This raises questions of whether or not targeting urban areas or rural slums is still the most effective target group for intervention.

Singh and West (2004) estimated the prevalence of VAD and xerophthalmia in children aged 5-15 years in the Southeast Asia region. Data was collected from the UNICEF Year 2001 State of the World's Report, and the 2001 World Population. Authors assumed that prevalence data with a narrower age range of six to nine years represented the entire target age range outlined in the review, and extrapolated from data in previous studies to generate an estimate of 23.1% for Vitamin A deficient children with serum retinol <0.07ug/L. Xerophthalmia rates were ascertained using data from the UNICEF Multiple Indicator Cluster Surveys as well as several other state survey reports. Overall xerophthalmia rate in India was estimated to be 2.8%. Data was arbitrarily weighed due to a lack of representativeness and certainty.

Recently in 2011, Sachdeva, Alam, Beig, Khan, & Khalique used the WHO classification of measuring xerophthalmia and VAD. Authors sampled 3,571 children less than 5 years of age from six villages in Utar Pradesh, a province in Northern India. Socio-demographic characteristics, comorbidity risk, and nutritional factors of xerophthalmia information were collected. Overall, 9.1% of the population had xerophthalmia in either mild or severe form, with prevalence increasing with age. This level far exceeds the WHO threshold of 1.5% for xerophthalmia to be characterized as a significant health problem. Significant factors affecting risk included rural dwelling, lower social class, maternal literacy and occupation outside the home. Dietary factors included lower protein consumption, higher intake of Vitamin A, and consuming a predominantly maize diet. Having measles and nutritional wasting were significant comorbidity factors.

The wide range of xerophthalmia and VAD rates reported between studies could be due to varying geographical regions with different epidemiological characteristics, and different measurement techniques (Sachdeva et al. 2011). Even 20 years ago, the cases of VAD were highly sensitive to geographic regions, and diversity of cultural and socioeconomic characteristics continues today. However, the majority of studies signify that VAD, especially clinical, remains a significant public health problem in India in certain areas and warrants further attempts at ameliorating the effects of low vitamin A intake. The disparity of rates between regions suggests that a targeted MDVA programme would be more cost-effective than the universal MDVA program that is currently in place. Encouraging consumption of vitamin A rich foods may be more suitable towards a long-term solution to combating VAD in regions where supplementation is no longer cost-effective (Kapil and Sachdev 2013).

In the Kundra block in the Koraput district of Odisha, the Meenangadi panchayat in the Wayanad district of Kerala, and in the Namakkal district of Tamil Nadu, 24-hr recalls were performed to assess nutrient intake within these three agro-biodiversity hotspots. Consumption of vitamin A-rich foods such as leafy green vegetables or dairy was almost non-existent or low and consumption of oils and fats were marginal. Vitamin A intake was on average the biggest concern, with households only consuming 13% of the recommended intake on average (Raghu et al. 2014). Across all nutrients and calories, vitamin A intake was the lowest in the sampled population within these three regions of India.

Variability of vitamin A intake has been shown to be affected by mothers' education levels (Semba et al. 2010), and is likely to be affected by, climate and rainfall that impacts the local availability of vitamin A rich foods. In addition, vitamin A rich sources such as eggs are expensive and cannot be easily purchased by low-income families. Severe symptoms of VAD seem to be restricted to socio-economically backwards, poverty-stricken areas of India with poor health infrastructure (Kapil and Sachdev 2013).What is not well understood is how consumer perceptions and attitudes come into play when individuals make decisions about what to eat, grow, or purchase. Results from this study may shed light on what consumers may prefer when deciding between vitamin A rich goods and attitude factors that affect these preferences.

2.3 Prevalence of Vitamin A Deficiency in Canada

In 2004, the Canadian government conducted the Canadian Community Health Survey, Cycle 2.2 Nutrition. Nationally representative data was collected from more than 35,000 Canadians in all age groups. A 24 hr recall was used to measure excessive or inadequate intakes of micronutrients among Canadian households. Nutrients from food and drink were included while nutrient intake from supplements was not. Inadequate intake was defined as below the Estimated Average Requirements (EARs) of a nutrient. A low prevalence of inadequate intake was defined as less than 10% of people being below the EAR. More than 35% of Canadians aged 19 and over did not consume adequate Vitamin A. Kirkpatrick and Tarasuk (2008) demonstrated a relationship between inadequate vitamin A intake and food security status using the same data. Food security status was measured with the Household Food Security Survey Module. Subpopulations classified as food insecure experienced higher rates of inadequate vitamin A intake (14 – 35% higher on average) (Appendix 1.1). This is likely due to low consumption of vitamin A-rich food sources.

Canadian data on VAD prevalence is incomplete. While the CCHS Cycle 2.2 data is nationally representative, there have been no recent updates so changes in consumption patterns of vitamin A rich goods are unclear at the national level. Consumption of dairy products has declined in the past 10 years (CDIC 2013) while the availability of margarine (adjusted for losses and used as a proxy for consumption) has also declined steadily since 1981 and has decreased by 38% in 2011 over the course of thirty years (Statistics Canada 2010). Per capita consumption of eggs has increased (AAFC 2013), while self-reported consumption of fruits and vegetables has not altered significantly (Statistics Canada 2014). Less than 50% of females aged 12 and above and 40% of males aged 12 and above reported consuming fruits or vegetables five times per day which exacerbates micronutrient deficiencies. No research has been done recently whether inadequate intake may manifest as subclinical VAD. While VAD may contribute to nonspecific maladies such as gastroenteritis, respiratory infections, bone development, and infertility, whether or not lower vitamin A intake is affecting the population remains to be seen. Therefore, research done on consumer attitudes and perceptions on vitamin A-rich vehicles will help identify if current policies and programs in Canada are aligned with consumer preferences.

2.4 Increasing Vitamin A Intake

Changing vitamin A status in a country takes many years – sometimes decades – before rates visibly improve (Arlappa 2013). A national strategy to develop food-based approaches may be difficult, as growing conditions, capacity, diet, and resources may vary by region (Underwood 2014). Major approaches to increasing vitamin A intake include supplementation and food-based approaches such as dietary diversification, fortification, and biofortification. Below each strategy is described in detail

2.4.1 Supplements

Epidemiological and economic assessments ought to play a key role in developing intervention choices. One way of measuring both of these considerations is with a costs-benefits analysis. Programs were measured in terms of cost effectiveness ratios (CERs), which factor in disability-adjusted life years (DALYs) and years of life lost (YYLs). Chow et al. (2007) modeled a vitamin A supplementation program that provided doses of 200,000 IU twice per year for children aged one to four years. Averted morbidity included impacts of contemporaneous disability due to Bitot's Spots and night blindness, and lifetime disability due to blindness. Marginal rates of vitamin A supplementation was lacking, and so rates of effectiveness for decreasing Bitot's Spots, night-blindness, and blindness were drawn from literature. High and conservative effectiveness rates were used, as well as two separate supplementation strategies. Usage of vitamin A syrup (Rs. 2.58 per child per year) is the prevailing method of vitamin A supplementation. Capsules were cheaper at Rs. 1.98 per child per year. This includes costs of two doses, shipping, storage, delivery and waste. An additional Rs. 2.96 per child per year is also used to account for training, promotional and educational materials, program monitoring, and evaluation. In rural areas in which a health center is not available, program costs jump to Rs. 23 per child per year in order to include costs of expanding sub-centers. It was assumed for this study that effectiveness rates and costs were similar throughout the nation, due to a lack of available data. Vitamin A supplementation was found to be less cost-effective in states with lower rates of VAD. This supports earlier suppositions that supplementation may not be as effective in areas where health care and immunization programs are well established (Ramakrishnan et al. 1995). Complete coverage of vitamin A supplementation could reduce disease burden by 27 – 34 lakh (1 lakh = Rs. 100 000). An estimated 700 000 deaths were avoided due to the program, but the majority of DALYs were saved by preventing blindness due to the high burden associated with it.

Vitamin A supplementation has a deep history in India, with a national program dating back to 1963 (Wallace 2012). Currently, the largest initiative is the Massive Dose Vitamin A (MDVA) programme which began in 1994 under the National Child Survival and Safe Mother programme. Children from the ages of 9 to 36 months were to be given five “mega-doses” of Vitamin A before her/his third birthday containing 200,000 IU. In 2006, the age range was revised to 5-59 months under recommendations from the WHO, UNICEF, and the Ministry of Women and Child Development. Currently, children between the ages of 0 – 60 months are to receive nine doses of vitamin A (Kapil and Sachdev 2013). The cost of this program is $1.14 USD per person, with 160 million people targeted, or $182 million USD. It is estimated that such vitamin A supplementation programs are associated with a 24% reduction in all-cause mortality, which if accounting for the 190 million children who are deficient, then estimates from a 2008 trial imply that 600 000 lives could be saved per year (Arlappa 2013). Giving a DALY a value of $1000, then benefit-costs ratios for vitamin A supplements are estimated to be 17:1 for Asia (Horton et al. 2008).

While supplementation is a cheap and cost-effective way to reduce prevalence of VAD, especially in early developing years, coverage must be substantial, targeted, and sufficiently supported in order for programs to be effective. India is a wildly variable country, with stark contrasts in child health and nutrition indicators, access to health care, and under-five mortality rates between regions (Kapil and Sachdev 2013; Arlappa 2013). While the World Bank recommended that at least 85% of children in an area received a supplement dosage once every calendar year, it was reported by the National Nutrition Monitoring Bureau that only 25% of targeted children were receiving vitamin A supplements in 2006, with variance across provinces (International Institute for Population Sciences 2009). In 2010, the World Bank only reported 34% coverage. Promotion and awareness of the VAS programme may be lacking as only 13% of mothers had received education on VAD, and most were completely unaware of the programme's existence. In a 2013 study that focused on seven Northern states in India that had the majority of the stunted children, wasted children, underweight, and infant death, only two of seven states managed to reach ≥80% full VAS coverage of children and about a third of the children not covered were from poor households (Aguayo et al. 2014). In their epidemiologic study of xerophthamalia, Dole et al. (2009) found that only 11.3 and 13.3% of preschool children in the slums of Pune, India received supplements. Therefore, instead of a universal programme, a targeted approach to improve coverage in higher risk states may be more effective.

One alternative to relying on the MDVA programme is for families to purchase supplements on their own. Chugh and Lhamo (2012) analyzed the 2010 annual Drug Compendium in India, which indicated that over-the-counter supplements were available in both mixed and single forms. However, the majority of supplements contained amounts that exceeded the recommended the recommended dietary intake. In addition, the information of the composition of the supplements was not easily obtained or unavailable. It was estimated that 23.07% of constituent vitamins did not state specific quantities. In addition, the price of such supplements was very high, which is prohibitive for use, especially for lower income families who may be at higher risk of VAD. This is exacerbated by low levels of public spending on health care per capita, as much of the burden falls onto households to make up shortfalls on health costs. This has been an important cause in persistently low standards of living, with private health costs being four times greater than that of public (Chow et al. 2007). Therefore, supplements for Indian adults may not be feasible for households to purchase on their own.

In their study on vitamin A storage in the liver, Penniston and Tanumihardjo (2006) estimated the protective effect of MDVA supplements to last roughly one month, while other studies have estimated two months (Mason et al. 2014). The authors suggest that restrictively low upper limits of vitamin A content in supplements may actually be discouraging policymakers from employing a supplementation programme that might be overall beneficial. However, another major concern of the MDVA programme is that doses given can be more than 500 times higher than the daily recommended intake. Excessive Vitamin A intake may lead to various symptoms including nausea, anorexia, vomiting, altered mental state, fatigue, weight loss, anemia, and diarhea, in addition to potentially exacerbating Vitamin D and zinc deficiencies (Rosenbloom and Gentili 2013). While multiple programs may exist within a country that addresses vitamin A status, policymakers should take care to avoid overusing preformed vitamin A as the effects of excessive intakes of vitamin A in large populations are still unknown (Tanumihardjo 2015). The case is clearer for pregnant women; excessive vitamin A may increase the risk of cancer and the WHO advises that supplements do not exceed 10 000 IU per day or 25 000 IU per week. Therefore it is difficult and inadvisable to correct Vitamin A deficient status in pregnant women with supplementation alone (Dary and Mora 2002b).

The most recent and comprehensive study done on the effects of the MDVA programme on mortality and morbidity was the five-year trial of Deworming and Enhanced Vitamin A Supplementation (DEVTA) study in 2007 (Awasthi et al. 2013). The primary aim of this study was to determine the effect on supplementation trials on mortality for children aged 1-6 years (n = 5,165). Deaths were recorded throughout the trial period, and retinol assays were used to determine VAD prevalence. Every six months, 200 000 IU of retinol were given to children in capsule form. At the end of the trial, prevalence of severe VAD was 6% in the supplement group, versus 13% in the control group. No significant effect was found on mortality reduction in the vitamin A supplement group, which contradicts earlier findings of reductions of up to 30%. For comparison, authors combined their results with eight other studies that similarly examined vitamin A efficacy, giving weights to findings that were more reliable via inverse-variance-weighted averages. The aggregate relative risk of the trials was 0.89, with the DEVTA results being significantly different from other trials. Given that the other eight existing trials yielded valid results, and that DEVTA contributes substantially more statistical information than the others, combined the results suggest that a more moderate effect of VA on mortality reduction is probable (up to 13%).

In response to the publication of the DEVTA study, Sommer et al. (2013) issued a correspondence published in the *Lancet* which raised serious concerns about its validity and generalizability. Reported coverage may have been biased, as information was taken second hand from frontline workers' logbooks, with little to no verification from supervisors. Rates of 86% of coverage contrasts starkly with subsequent coverage rates with 6.1% reported by the NHFS, which was a national household survey performed at the national and state level. Only 18 study monitors were used, each in charge of hundreds of child care staff and tens of thousands of children. Other concerns were raised including far too little spending done to feasibly undertake such a study of that magnitude adequately, and a fixed-effects model which gave excessive weight to the DEVTA findings in the meta-analyses based on large sample size.

Despite these misgivings, studies such as DEVTA are not the first to suggest that the benefits of vitamin A supplements may be overstated; while reduction of mortality due to the supplementation was estimated to be ~21% based on a pilot study in Pakistan, actual rates may be lower as initial estimates may not have been appropriately scaled for relevant serum biomarkers (Akhtar et al. 2013). Another analysis performed by Mason et al. (2014) called for a shift away from the MDVA programme as vitamin supplementation programs have shown decreasing effectiveness in reducing childhood mortality over the years. Results from the DEVTA trials have suggested that only 2% of the under-five mortality rate is addressed by the MDVA programme and that there must be higher priorities when attempting to reduce the under-five mortality rate. In light of recent shifts in the epidemiology of VAD and the inefficacy of the MDVA programme to substantially impact serum retinol levels for an extended period of time researchers are advocating for a shift away from supplementation programs. It is suggested that a cheap and quick fix for VAD prevalence allowed policymakers to ignore calls for a food-based approach to increasing Vitamin A intake. This, in tandem with calls for greater coverage and support, may have led to the lag in shifting away from supplementation programs.

Opposition to supplementation programs run deeper than simple program deficiencies. Some have argued that it is a symptoms-based approach to healthcare and is a short-term solution (Vijayaraghavan 2002; Allen 2008; Wallace 2012). In addition, the programme diverts precious resources from primary healthcare givers while failing to address the root causes of poverty and malnutrition. It has been the recommendation of numerous researchers that supplementation serve as an acute means of addressing deficiencies while long-term solutions such as education or fortification strategies are developed.

Where deficiency is not a concern, there is more attention paid to avoiding exceeding upper limits (ULs) of Vitamin A. In Canada, supplements are readily purchased from grocery and convenience stores. However, availability does not does not necessarily imply accessibility;

supplements can be costly, and vulnerable groups who need to increase their nutrient intakes tend to be unable to afford them. Vitamin supplements tend to be used by people who are already healthy. In addition, long-term supplementation of retinol and beta-carotene is not recommended in preventing or treating lung cancer or prostate cancer, as doing so may be ineffective, or at worst, exacerbate symptoms especially with sustained exposure (Fritz et. al. 2007; Beilby 2010; Mondul et. al. 2011).

2.4.2 Whole Foods

Food-based strategies are varied and can include total-food chain, from production to procurement, local or centralized markets, domestic or commercial processing, to foods away and within the home. Such approaches have been very effective in garnering buy-in from local communities, especially women. This literature review will focus primarily on dietary diversification, which is the modification of diet such that less staple crops are consumed or non-traditional foods is increased. At the 1992 International Conference on Nutrition, food-based strategies were demonstrated to be the most effective and least costly approach to reducing micronutrient deficiency in addition to offering a long term solution to micronutrient deficiencies. Currently it is recommended that "supplementation should be progressively phased out as soon as micronutrient-rich food-based strategies enable adequate consumption of micronutrients" (WHO 2011).

Dietary diversification comes with numerous benefits not necessarily provided by the other strategies. Akhtar et al. (2013) cite increased sustainability needing little external support while boosting intake of multiple nutrients at once. Chakravarty (2000) also suggests combining these initiatives with a nutrition education program, in order to increase efficacy. Combined, it may lead to a long-term solution of VAD. Dietary diversification is often overlooked as a public health intervention due to low bio-availability of retinol from plant sources. However, if consumption of plant sources is adequate or prepared in such a way to improve absorption, then low vitamin A status can be improved (Tanumihardjo 2015). Increased consumption of leafy green vegetables and nutrient dense foods would not just reduce incidence of VAD but ameliorate other kinds of micronutrient deficiencies. Eighty-one percent of school children did not meet half of the recommended intake of vitamin A, and 82 - 90% did not meet half of the recommended intake of leafy green vegetables, or dairy products (Arlappa 2013). While the conversion of carotenoids to retinol is less efficient, the rate of conversion is boosted *in vivo* when a person has depleted vitamin A stores. In addition, regulation of this conversion rate within the body almost completely removes any risk of exceeding toxicity levels of retinol, which is a risk in supplementation and fortification programs (Tanumihardjo 2015).

While there are efforts to target children in their earlier, formative years, lower caloric intake of children makes it difficult for them to satisfy their nutrient needs through diet alone, especially if there is an over-reliance on calorie-dense, nutrient-poor staple crops. About 82% of vitamin A consumed in developing countries is from carotenoids founds in plants (WHO 2009), which is converted to retinol at a lower rate than animal-based sources. Therefore, food-based approaches are not best suited to increasing intake in children (Bouis and Islam 2012). In addition, mothers with insufficient stores may confer deficiency to their child through low levels of retinol in breast milk (West 2002; Bouis et al. 2009). Therefore it is recommended that pregnant or lactating women ensure they are getting adequate VA to improve chances of child survival, and food-based approaches may be more efficacious in mothers for reasons stated above (National Institute of Nutrition 2011).

In addition to changing diets and consuming foods not regularly eaten, these initiatives must be supported by a functioning storage and transportation system of food. Timely consumption and proper preparation minimizes vitamin A loss. A concurrent nutrition education programme must also occur so that consumers demand and thus purchase new foods. In areas where home production is not an option, cost may be a significant limiting factor as many people with VAD have a lower income. Cost constraints in a household tend to cause diets higher in caloric dense foods that are rich in fat and carbohydrates (Tanumihardjo 2008). While fruits and vegetables are a rich source of micronutrients and their role in fighting disease is widely accepted, dietary diversification is not always simple, especially for the poor. Indeed, economic crises that exacerbate food prices may put lower income families at risk for higher VAD, due to inability to afford diverse food sources (West and Mehra 2010).

One alternative that overcomes issues in storage, transportation, or fluctuating prices is self-production. There are numerous varieties of leafy green vegetables that are cheap and are rich in vitamin A, including beets, cauliflower, cabbage, and several non-traditional herbs (Chakravarty 2000). Many of these plants are easily grown in kitchen gardens and do not need special tending. Home gardens are also increasingly being recognized as an easy way for families to diversify their diet, grow traditional vegetables at a low price, and as a valuable source of many micronutrients. Home cultivation of fruits and vegetables grants direct access to nutrients that people may otherwise be unable to afford (Akhtar et al. 2013).

Common sources of pro-vitamin A include orange/yellow non-citrus fruits and vegetables. Beta-carotene is better absorbed from these sources than leafy green vegetables, with large boosts in absorption when consumed with oil (Burri 2011). One widely targeted food for increased consumption is the orange-fleshed sweet potato (OFSP) due to its high carotenoid content, high-yields, and ability to be grown in a variety of conditions. In 2011, Burri calculated the minimum amount of OFSP required to satisfy vitamin A intake for various at-risk subpopulations. Values were adjusted to account for carotenoid losses due to low bioavailability, storage, and cooking. Minima and maxima were determined with varying carotenoid contents in different breeds of potato (anywhere from 4,085 to 22,900 ug/100 g). A 3 yr old child with poor vitamin A status could consume 6 to 33 g/d (0.02 to 0.13 cups/d) while lactating women with good vitamin A status could consume 68 to 381 g/d, (0.27 to 1.49 cups/d). Such amounts could be eaten daily. Overall, extent and distribution of orange-fleshed sweet potatoes suggest that they are available and accepted throughout the developing world (Burri 2011). Van Jaarsveld et al. (2005) found that children in Southern India aged 5-10 years fed 125g of orange-fleshed sweet potato had significant improvements in vitamin A status as compared to children fed the same amount of white-fleshed sweet potato. The control and intervention groups were found to have similar rates of VAD at baseline.

2.4.3. Fortification

Industrial fortification of foods is the addition of a micronutrient to a processed food. It is an effective way of increasing micronutrient intake of foods without requiring any changes in dietary habit (Pambo 2014). This is due to there being little to no change in the sensory qualities of the food product. Characteristics of traits that increase success of a food fortification program can be found in Table 2.2. Appropriate food vehicles are ones that are regularly consumed by the population in adequate quantities (De Groote et al. 2011; Arlappa 2013). The extent of deficiencies and which populations to target must be known in order to fortify at an appropriate level that delivers enough micronutrients without surpassing tolerable upper limits (Klemm et al.

2010). Appropriate vehicles for vitamin A include sugar, flour or oil, although rice and bouillon cubes have also been fortified. While beneficial, food fortification may also face numerous barriers such as increased prices, illiteracy/lack of knowledge of the importance of vitamin A (especially in rural areas), and may require greater political commitment and government funding. Subsidies to keep the prices of fortified foods low may be necessary to ensure at-risk groups have access to them. In addition, a multi-sector approach is crucial for the success of food fortification programs, especially if it is done in tandem with other strategies such as supplementation, nutrition education, and social marketing. Successful food fortification also participates in the existing distribution and retail chains without disrupting normal business while offering an opportunity for industry to become involved in health initiatives. Consumers must also be willing to trust in the companies who supply a food, the third-party bodies that certify it, and governments that regulate it (Pambo et al. 2014). Without the mandating body to ensure that food safety and quality are maintained, consumption of fortified foods would be hindered. Mandatory health programs must also have monitoring and enforcement mechanisms to ensure compliance. This may be done via labeling practices or production standards.

In the developed world, food fortification is made effective and sustainable through large, centralized processors and a relatively more educated consumer base that is aware of nutritional health issue that exercises significant purchasing power (Dary and Mora 2002b). Given the relatively lower prevalence of processed foods in India, changes in the supply chain and cost controls are needed to ensure that fortified foods still reach vulnerable populations. National mandatory programs may also be susceptible to suspension based on political expediency and not national health outcomes (Ramakrishnan et al. 1995).

Table 2.2 Characteristics of fortified foods (Dary and Mora 2002b)

Desirable traits of a fortified food
• Socially acceptable, • Cheap to implement • Easy to monitor • Does not change the characteristics of the food • Does not require any behavioural change • Readily visible benefits • Must be a staple-food suitable for fortification • Be processed centrally and in large enough quantities to reach everyone • Be economically feasible

Currently the National Institute of Nutrition (2011) recommends that consumption of synthetic drinks and hydrogenated oils be minimized unless they are fortified. Vanaspati has been fortified with vitamin A since 1953 with 7.5mg retinol/kg, which, depending on consumption levels, satisfies up to 21% of the RDI (Dary and Mora 2002a). Only hydrogenated oils are mandatorily fortified at 20 IU/g (Akhtar et al. 2013; Bhagwat et al. 2014), no national program has mandated fortification for non-hydrogenated oils. Currently, the Food Standards and Safety Authority of India has deferred implementing such a program until more research can be done about the feasibility of such a program and determining whether the cooking process leads to degradation of vitamin A . Industry is ill-equipped currently to fortify oils due to the large amount of independent and decentralized producers. However, there are temporary programs that are implementing more widespread oil fortification in order to improve nutrient intake while collecting data for program assessment. GAIN is currently working with local producers to provide fortified oil and flour, although program support is set to end in December of 2015.

Canada fortifies skimmed, partially-skimmed, evaporated milk and margarine at the national level with targets of 216.9 IU per 100 ml for dairy products and a minimum of 3 300 IU in margarine per 100g (Government of Canada 2014). Formerly in India, states subsidized dairies to fortify their milk with 2,000 IU of vitamin A per litre. However, after three years, the government withdrew funding, and dairies became unwilling to pick up the costs of fortification. Consumers seemed to be largely unaware such a program had been initiated, so no outcry or demand for vitamin A fortified milk was seen.

While it is recommended that fortified foods be staples that are widely consumed by the population, oily foods are better carriers of VA due to the stabilizing effect lipids have on retinol; countries with intakes of >5g/d of fats such as oil or margarine, or >15g/d of flour or sugar may have these be reasonable carriers (Dary and Mora 2002a). Costs of adding vitamin A to foods range from $0.008 USD per person per year for oils and margarines to $0.21 for sugars, which supplies 30% of RDI per year. However, aside from only costs, coverage and extent of a food vehicle must also be considered to determine whether it would be effective to fortify a food. While sugar production is large in India (12 million metric tons/year), low income families consume very little sugar, which may make it unsuitable for fortification. Canada imports 90% of its sugar (Canadian Sugar Institute 2014), and Canadians are being encouraged to reduce its consumption, making sugar an undesirable fortification vehicle. Regardless of which vehicle is chosen, fortification will lead to increased costs. This burden of cost should not be shouldered entirely by producers, but transferred to consumers as costs of mandatory fortification are an indirect barrier to importing foods.

A food fortification approach to boosting vitamin A intake has been explored in various countries. In Cameroon, researchers performed a simulation of vitamin A fortification programs based on 24 hr recalls (Engle-Stone et al. 2014). At baseline, 53% of women and 59% of children were vitamin A deficient. A fortification program of 12mg vitamin A per kg of oil was found to lower VAD levels to 35% among both groups. Additional fortification of flour, sugar, or bouillon cubes were found to further alleviate VAD by 10 to 20% but caused concomitant increases in vitamin A intake in other regions that lead to exceeding the UL of children, or was found to be ineffective in significantly decreasing VAD incidence in other areas. Meanwhile in Indonesia, a mandatory fortified palm oil programme was put into effect and a 24hr recall among poor households was performed to estimate vitamin A intake (Sandjaja et al. 2015). On average, the fortified palm oil contributed 26% to 40% of the recommended daily intake among young children and lactating and non-lactating women. Serum retinol and retinol breast milk were shown to improve while incidence of deficiency (serum retinol <20ug/dl) decreased from 6.5 - 18% at baseline to 0.6 - 6% at end line. While causation was not linked between the palm oil fortification and improved health outcomes, researchers suggested that they were strongly associated. However, due to the inability of program software to correct for low bioavailability from plant sources, vitamin A intake was estimated only with animal and oil-based vitamin A sources, so changes in vegetable intake was unaccounted for.

Rice is another potential vehicle for vitamin A as it is the main dietary staple in various areas with higher VAD prevalence. A novel product known as Ultra Rice can be made that has the appearance, taste, and density of unfortified rice, but can provide up to 2,500 IU/g of vitamin A (Dary and Mora 2002a). It can thus be blended with regular rice to achieve optimum vitamin A levels. Despite its high vitamin A content, it still experiences many barriers for market entry. The process of inserting vitamin A into artificial kernels of rice leads to losses some would say are unacceptable and is too expensive to practically implement. Another issue is that rice is produced locally by thousands of millers, and so enforcement and monitoring would be incredibly difficult. Finally, the product has not undergone extensive market testing, and cost, acceptance, and availability are as of yet uncertain. However, regular intake of fortified race may lead to improved vitamin A status. In Thailand, extruded rice fortified with zinc, iron, and vitamin A (triple fortified) was fed to school children to determine its effects on vitamin A stores (Pinkaew et al. 2014). Vitamin A stores were measured both with serum retinol and C-retinyl acetate (C-RID), a technique which measures total body reserves. Serum retinol remained unaffected while the C-RID technique showed significant improvement in triple-fortified fed children as compared to the control. C-RID is a rather expensive and complicated method of measuring Vitamin A levels, and may not be appropriate for all study areas. Researchers also found that the vitamin A levels in the triple fortified rice was quite high (~890µg/g) due to storage in light-proof packaging, although recommended fortification amounts will change according to storage conditions.

Overall, fortification may have significant and measurable impacts on health outcomes if the appropriate food vehicle is chosen and the amount of vitamin A added is adequate to address gaps between recommended and actual intake. However, steps must be taken to ensure that the procedure is regulated and monitored to ensure compliance and food safety. Excessive costs must not be borne onto the consumer so that food insecure populations may still access the new fortified foods.

2.4.4. Biofortification

Biofortification is a novel method of increasing micronutrients in staple food crops, and is done via selective breeding, transgenic or agronomic means. HarvestPlus has developed a variety of pearl millet biofortified with iron millet in India, in addition to cassava, maize, and sweet potato varieties biofortified with Vitamin A (HarvestPlus 2009). The goal of biofortification is to combine dense micronutrients with desirable agronomic traits such as increased yield and pest resistance. It is meant to reduce overall prevalence of micronutrient deficiencies, not necessarily to eradicate it for the entire population (Bouis and Islam 2012). HarvestPlus is a leading institution in the development of biofortified crops. The process undertaken by HarvestPlus is quite extensive; the breeding and cultivation procedure is monitored from seed selection to growing to food preparation and consumption. Genes are identified within seed varieties that promote dense micro-nutrition. These seed lines are then bred with high yielding, competitive varieties during the cultivation stages. Nutritionists then test these crops for the amount of micronutrient they retain throughout harvesting, storage, preparation, and absorption into the body. The amount actually consumed is also tracked so that nutritionists set targets to ensure that crops have a significant impact on nutrition status. Plant breeders may employ both transgenic and conventional breeding techniques to meet targets.

Biofortification comes with four main advantages. It targets people who eat a large amount of staple crops, which tends to be the rural poor (Bouis and Islam 2012; Gilligan 2012). The "spread" of biofortification would then start with rural farmers and reach the cities, in contrast to supplementation strategies, which begin in urban areas (Saltzman et al. 2013). Biofortification also tends to be a one-time cost, estimated to be $400 000 per year per crop over a decade, globally (Nestel et al. 2006a), which is lower per person when compared to supplementation. While this one-time cost is large, after sufficient adoption by farmers and demand is generated for consumers, then use of biofortified crops will be self-proliferating. This "multiplier aspect" of biofortified foods as they are adopted by farmers and consumed makes them cost-effective. Supplementation, by comparison, has recurring costs and must be combined with education campaigns (Tanumihardjo et al. 2008).

While biofortified foods cannot deliver as high levels of micronutrients as supplements or industrial fortification, it is claimed that they can adequately improve intake throughout all life stages. However, biofortified crops contain far less nutrients than can be provided via fortification or supplementation (Bouis and Islam 2012). Agricultural practices also require a paradigm shift, in that breeders/farmers must take into account nutrient status when developing crops, in addition to yield and disease resistance. Each crop/nutrient combination must also be specifically tailored to target populations to maximize adoption rates, and whether the new crop will perform well at the market. Appeal to both consumers and producers is therefore critical, and new crops must be tailored to be disease resistant with comparable yields while maintaining appealing sensory attributes (Gilligan 2012; De Steur et al 2014a). This requires extensive research and development, and results from one project area may not be transferable due to cultural differences in diet, consumption patterns, and food handling.

There are two major approaches when adopting of biofortified food. This depends on whether nutrients are visible, or notably differentiated from other products, or when they are "invisible". One example of a visible trait is the color-change as a result of beta-carotene addition to a crop which will raise questions about producer and consumer acceptability (Nestel et al. 2006b). Adoption would be driven through demand creation via marketing and nutrition campaigns that highlight dietary gaps and deficiencies (Tanumihardjo et al. 2008). Other traits may be "invisible", and so efforts to target new crops to farmers and are inserted into the food supply through combination with the most productive and profitable seeds. Farmers will then buy these seeds, and distribute crops through the food chain. Regardless of whether improved nutrient profiles are visible or invisible, higher productivity or desirable end-product characteristics are important for consumer and producer acceptability.

In an attempt to assess whether biofortified orange maize commanded a premium when compared to the local yellow and white varieties, Meenakshi et al. (2012) conducted a real choice experiment that assessed the effects of information, method of information delivery, and sensory attributes on WTP measures. Overall it was found that even without nutrition information, orange maize was comparable to white maize, which was historically preferred to yellow. After information was introduced, WTP for orange maize increased and resulted in a premium. This indicates that biofortified maize may be acceptable to consumers and have significant potential to improve public health. Another biofortified crop that shows promise is the orange-fleshed sweet potato (OFSP). While containing extremely high amounts of beta-carotene, it is also calorie dense, easy to cultivate, and drought resistant. In their two-year intervention, Low et al. (2007) demonstrated that adoption of OFSP lead to significantly higher levels of serum retinol, a biomarker for Vitamin A intake. Farmers who adopted OFSP were also found to have increased their plot sizes for OFSP from $33m^2$ to $350m^2$.

In an extension of the research done with OFSP, Okello et al. (2014) examined the WTP and consumer acceptance for a biscuit made from biofortified OFSP. A value-added product is beneficial as raw vegetables are not as available in urban areas and sweet potato is not coveted by higher income consumers. Evidence suggested that certain OFSP varieties were more preferable for making biscuits; however the promotional campaign for the biscuits did not change the way consumers perceived them, especially in higher income areas. Authors concluded that evidence for greater consumer acceptance existed due to high sensory ratings and that further improvements to the marketing campaign for biscuits was likely responsible for their lower than expected WTP.

Studies in China also suggest market potential for biofortified foods. In 2014, De Steur et al performed a review of ex-ante valuation in the context of biofortification and GM technology in improving nutrient content in food. They found that acceptance was lower among women, older populations, lower income, and people with lower education. Because the biofortification process may involve transgenic methods, it is important to note that acceptance and WTP measures for biofortified goods may be similar to that of GM foods, although this depends on the crop-nutrient combination as transgenic methods may be unnecessary. Overall it was found that various studies done at the micro-level demonstrated that consumers accepted GM products and are willing to pay a premium for crops with improved micronutrient profiles. This hints at potential markets for areas at high risk of micronutrient deficiencies.

While most studies that examine willingness to pay for a crop between conventional crops and their biofortified counterparts (Table 2.3), studies in China compared willingness to pay for GM, biofortified rice and supplements with rice via a multiple product auction (De Steur et al. 2012; De Steur et al. 2014b). Rice was chosen as it is a staple crop that the majority of the population consumes regularly. Participants overall preferred the biofortified rice compared to the rice with supplements. Even when accounting for GM biofortified rice, this preference remained. While GM traits lowered preference for the product, it did not counteract the premium of biofortification overall. Results corroborate other findings that suggest that GM products in various countries (e.g. India, Brazil, and China) are acceptable to consumers if they provide some additional benefit versus their conventional counterparts.

In developing countries where the majority of produce is consumed very quickly after production, any shifts in diet must also be reflected in changed agricultural practices. As a result, the impact of increased production of OFSP in home gardens on consumption was analyzed

(Jones and de Brauw 2015). This was part of the HarvestPlus Reaching End Users program in northern Mozambique. A randomized cluster-controlled trial was used in 36 villages where seed systems were distributed to households and trained in planting and caring for OFSP. Marketing was also done in villages that included education of the benefits of consuming OFSP, methods of preparing, and health messages. Marketing in public places was also done to improve visibility. Incidence of diarrhoea decreased by 11.4% compared to non-intervention villages, and 18.9% in children under three years of age. Broad messages to the public and a significant amount of institutional support for consumer adoption of the crop seemed to be helpful in changing dietary patterns. Children with mothers with greater education had larger morbidity reductions, likely due to better understanding of potential benefits of OFSP. However given the costs of the program, implementation of such a broad program is likely undesired in areas with lower areas of VAD, where morbidity reductions would not yield the same DALYs gained in an area with greater VAD incidence.

India has also started to develop biofortified crops in partnership with various research institutes. Beginning in 2007, the Task Force for Crop Biotechnology began with the goal of developing crops with greater resilience, productivity and nutritional status. Genes in wheat were identified that lead to increased zinc and iron content. Twelve cultivars of rice are undergoing gene expression studies. Four universities within India were granted programme support and are developing more agronomically desirable crops, which is the focus going onwards. No biofortified products are available in either Canada or India that feature vitamin A, although pearl millets biofortified with iron have been implemented throughout India (HarvestPlus 2009).

2.5 Influences of Preferences

In this section the factors of interest that may influence WTP for vitamin A rich goods are described. How knowledge of diet and health influence attitudes towards products and purchase intention is explored, in addition to how consumers idealize the concept of "natural" and how that may affect consumers' relationship with what they eat or buy. Finally Food Technology Neophobia and the scale as designed by Cox and Evans (2008) that quantifies feelings of aversion to foods produced with novel technologies is examined.

2.5.1 Objective and Subjective Knowledge

A major contributing factor to consumer choices is the knowledge that they have regarding the food product, how it is produced, and what benefits it may confer. There are three major forms of knowledge: subjective, objective, and experiential (Brucks 1985). Experiential knowledge is knowledge gained from ones' own experiences. This mostly relates to characteristics such as taste, flavour, and consistency rather than nutritional content and is difficult to verify experimentally. Objective knowledge is based on factual knowledge, or what an individual actually knows. Subjective knowledge then is an individual's confidence in how much they know, or their perception of their own knowledge (Ellen 1994). Differences between subjective and objective knowledge result from inaccuracies in how people perceive their own knowledge. However, subjective knowledge and objective knowledge are not perfectly correlated; correlation coefficients range from 0.3 to 0.6 in the literature. A 2009 meta-analysis performed by Carlson et al. (2009) summarized the previous 30 years of research on the relationship between objective and subjective knowledge. In total 51 studies were included in the meta-analysis and a correlation coefficient of $r = 0.37$ was obtained that was both reliability corrected and sample weighted. This relationship tended to be stronger for products vs. nonproducts, and public vs. private goods. In studies that focused on knowledge of foods or nutrition, the correlation between SK and OK ranged from .24 to .46.

In the case of foods which are characterized by credence attributes that are unobservable to consumers, knowledge is usually the only tool that can be used to differentiate between products (Gracia and de Magistris 2007). For example, with organic labels which generally impart a positive characteristic to foods, purchase decisions may be constrained by uncertainty as to what are the characteristics of organic food. Greater knowledge generally correlates with a more positive attitude although subjective knowledge tends to have a greater effect on purchasing decisions. In an extensive survey regarding acceptance of genetically modified foods, subjective knowledge significantly affected acceptance, whereas objective knowledge did not (House et al. 2004). In 2010, Pieniak et al. found that subjective knowledge positively affected consumption of organic fruit, whereas objective knowledge indirectly affected consumption through greater subjective knowledge and improved attitude. Prior knowledge of urban agricultural activities also tended to underpin a more positive attitude toward urban agricultural practices (Shamsudin et al. 2014).

Unsurprisingly, Aertsens et al. (2011) found that objective knowledge (or factual knowledge) of GM foods increased with education, but only substantially once a college education was reached. Interestingly, higher objective knowledge may also mean that participants were less influenced by new information given (Lee and Lee 2009), which coincides with Brucks' (1985) original conceptualizing that stated that higher objective knowledge meant greater reliance on one’s memory versus new information.

How knowledge is used and applied though may vary greatly, especially in the context of applied food technology. In a study done on urban consumers in China (n = 570), the effect of objective and subjective knowledge on GM attitudes and food purchases was measured in addition to risk perception, and attitudes towards GM products (Zhang and Liu 2015). Subjective and objective knowledge was measured using techniques developed by House et al. and Pieniak et al. It was found that Chinese consumers were more affected by their objective knowledge rather than their subjective knowledge. This is in contrast to previous studies where subjective knowledge had more of an impact on attitudes and behaviours. While Chinese consumers had a fairly high level of objective knowledge of nutrition and diet, they were not necessarily confident in their knowledge. In the case of China, GM food producers and marketers may benefit from providing educational facts when attempting to sell their products. Objective knowledge was associated with improved attitudes towards GM foods and thus purchasing intent. Results were analyzed with a structural equation model and OK and SK were analyzed with confirmatory factor analysis and principal component analysis.

2.5.2 Perceptions of Naturalness

In the creation of functional foods, there is a need to modify, add, or remove ingredients. With these processes is a risk of consumers perceiving a food as less natural (Urala and Lähteenmäki 2004). "Natural" is a widely used term on labels that may have varying definitions across policies and consumers. In her 2013 exploration of the meaning of natural to consumers, Siipi examines the term from five major perspectives: natural as nutritive suitability, natural as moderate need satisfaction, natural as a lack of human influence, natural as authenticity, and natural as familiarity. Moderate need satisfaction and nutritive suitability paradigms are in-line with naturalness correlating with health. Conceptually, a natural food should satisfy our natural requirements for a healthy diet. However, familiarity, a lack of human influence, and authenticity may or may not be related to health. Familiarity of a food is relational to individuals, while authenticity is relational to other foods. Human influence on foods can be both positive and negative: processed foods may be high in sugar or fats, but at the same time, processing and treatment may improve food safety. Therefore, this conceptualization of natural may not be applicable to consumers who have complete information.

In 2004, Rozin et al. began a series of experiments characterizing how American adults perceived natural. However, in contrast to Siipi's multifaceted definition of the term, "natural" items were defined to participants as "one which has not been changed in any significant way by contact with humans. It could be picked or transported, but it is chemically essentially identical to the same item in its natural place." When presenting participants with a choice between natural or commercially processed forms of an item, there was a large preference for the natural option. People tended to prefer natural even when items within a choice set were specified to be chemically identical. Therefore how natural is perceived may be affected by the process an item undergoes and is more important to consumers than its actual content.

Perceptions of how natural an item is may be changed depending on its original nature. In a survey performed by Tenbült et al. (2005), a more natural product becoming GM was less acceptable than if the original item had been perceived as less natural. Supporting Siipi's (2008) conceptualizing as "natural as necessary", Tenbult et. al. also found greater necessity associated with being more natural. In addition to being more necessary, natural foods were associated with better taste and appearance as compared to foods with additives or artificial ingredients (Siegrist 2008).

Later in 2005, Rozin proceeded to characterize “natural” preferences in two ways: the first is instrumental, where reasons for preferring natural were based on increased health and other advantages that it may confer. The second is ideational reasons for preferring natural, due to a moral inclination, aesthetic, or because it is simply “right”. Asking American adults in college and Philadelphia to rank how natural an item is viewed on scale from 0 (not natural at all) to 6 (completely natural), Rozin attempts to quantify how certain processes or states affect an item’s naturalness. Four main findings are found: 1) naturalness of a product being reduced if it comes into contact with unnatural entities, 2) chemical transformations yield a greater change in naturalness than physical ones, 3) processing is a larger determinant of naturalness than content, and 4) mixing natural items does not markedly change naturalness. In order to further test the hypothesis that history and processing is more important to an item’s naturalness than content, Rozin performed another experiment in 2006 where he presented American participants with a hypothetical scenario in which tomato paste is changed twice. In the first stage, 1% beet sugar is added or removed and in the second stage, the change is reverted and the tomato paste is restored to its original content. Naturalness significantly decreased with further processing, despite similarities with an object’s original state.

In an extension of Rozin’s works on how consumers perceive the term “natural”, Evans et al. (2010a) developed and tested several hypotheses as to what were the most significant effectors of perceptions of naturalness. Participants in Australia were asked to rate the naturalness of certain objects which had systematically varied traits. Chemical changes were found to be more important than physical ones, while mixing natural things together minimally affected naturalness ratings, and increased processing leads to further deviations from natural perceptions. Evidence of dose-insensitivity was present, as after reaching a certain threshold, increased levels of additives did not affect naturalness, although smaller amounts of additive did. In contrast to Rozin's work, process did not have a larger impact than content, although Evans et al posited that the process undergone (i.e. use of additives versus genetic engineering) may have varying impacts. Both studies have found that trace additions of unlike natural entities lead to larger reductions in naturalness, versus mixing similar natural entities. However, it is important to note that much of Rozin's research and the works that have followed have been set in Western countries. Whether or not functional foods are perceived as natural or not widely varies with the person and the cultural context (Lähteenmäki et al. 2010).

In a more practical sense, governments have ruled what foods may be labeled as "natural". In that way, it may be easier to define natural by outlining what it is not. The Canadian Food Inspection Agency expects foods or ingredients with natural claims: 1) not to contain, or to ever have contained, an added vitamin, mineral nutrient, artificial flavouring agent or food additive, 2) not to have any constituent or fraction thereof removed or significantly changed, except the removal of water (e.g. the removal of caffeine) or 3) not to have been submitted to processes that have significantly altered their original physical, chemical or biological state (i.e. maximum processes) (CFIA, 2014). Therefore the more processed a food is, the less natural it is perceived to be. In India, "natural" food products must describe a food of traditional nature, without additives and have undergone minimal processing (FSSAI 2009). Packaging must be done in such a manner that does not use preservatives or chemicals. Compound foods may not be described as natural, but may be labeled as "made with natural ingredients" if all ingredients meet the previously mentioned criteria.

Given that natural is positively valued among consumers, either when a product is perceived or labeled as natural, it is likely that consumers are conferring additional benefits onto the product. Consumers may perceive that products are lower in calories or are better for you nutritionally if they are thought to be natural, even if the exact characteristics are unknown to them. This effect is called a “health halo” (Sundar and Kardes 2015) and occurs when consumers wish to process information or make decisions more quickly. Improved health perceptions have been linked to increased consumption of products. However, improved healthiness of a food may negatively impact consumers’ perception of how attractive a product is. If a product has been significantly changed such that it appears novel, then the perceived naturalness of a food may decrease (Lähteenmäki et al. 2010).

Recent discoveries regarding bacterial gene insertion into sweet potatoes has challenged our traditional notions of what is considered “natural”. Fragments of DNA that were identical to those found in species of Agrobacterium were discovered in 291 strains of sweet potato that are currently cultivated. These bacteria are capable of inserting functional genetic material into plants. While this practice has been adopted by geneticists and applied to agriculture, this occurrence in sweet potatoes occurred more than 8,000 years ago without human interference. This underscores that the process of transgenics is not restricted to laboratories and may alter how consumers perceive what is natural (Kyndt et al. 2015). Impacts of this new information on consumer perceptions are unknown.

2.5.3 Food Technology Neophobia

In 1992, Pliner and Hobden developed a general food neophobia scale that measured fear and reluctance to try new foods. In 2008, Cox and Evans modified this scale to apply to food technologies. The resultant Food Technology Neophobia Scale (FTNS) was a psychometric for the disgust or aversion felt towards foods produced with new technologies. In a follow-up study in 2010, Evans et al. demonstrated that the FTNS is stable over time in addition to being sensitive, reliable, and valid predictor of consumers' willingness to try food products produced with novel food technologies. These qualities have allowed the scale to be applied in various settings. Studies include foods produced with pasteurization, fortification, and proactives, as a predictor in consumer acceptance of food nanotechnology (Matin et al. 2012), examining WTP for vacuum-sealed meat products (Chen, Anders, and An 2013), and acceptance of biotechnology (Bredahl 2001). Valuing naturalness and one's perceptions of food technology are inextricably linked; people who place importance on natural foods tend to negatively evaluate new food technologies.

In order to build on efforts by Evans et al. (2010b), Verneau et al. (2014) examined whether the FTNS could predict or improve understanding of consumer preferences for various food groups. Randomly sampling 575 participants in southern Italy, the four factors of the FTNS scale as outlined by Cox and Evans were broken down into four explanatory variables in an ordered probit regression. Alternative econometric models were also computed without FTNS. However, models containing FTNS factors as explanatory variables had more significantly more predictive and explanatory power than models estimated with only demographic variables. A survey was administered in the UK, Germany, Denmark, and Italy that examined consumer attitudes and intentions to purchase genetically modified yogurt and beer. It was demonstrated that generally, perceptions of the naturalness or wholesomeness of a food affects attitudes towards a food product and thus affect intention to purchase. More favourable attitudes toward nature were strongly linked with a higher tendency to view genetically modified foods as risky. Things such as trustworthiness of a product and quality were embedded in more general attitudes about food technology and naturalness (Bredahl 2001).

2.5 Conclusion

In Canada there is a recognized national deficiency in vitamin A intake with variations according to age and gender (Health Canada 2012). However, how the deficiency is manifested between countries is quite different; India has relatively higher rates of clinical and subclinical VAD, while in Canada it is more likely that subclinical VAD is an issue. Given that the symptoms of subclinical VAD are nonspecific, it is difficult to determine how subclinical VAD contributes to poor health, and research in Canada is especially lacking. In contrast, several examinations of vitamin A status in India have been performed in the past several decades across various subpopulations and regions. Great diversity exists in prevalence of VAD between regions, and the universal MDVA programme may no longer be the most suitable approach for addressing this issue. Due to the complexity of the problem and issues regarding enforcement and regulation, a multipronged approach may be most appropriate in addressing VAD that involve programs that are acceptable, affordable, and accessible.

In order to better gauge which programmes are suitable, various determinants of attitude and thus, WTP for Vitamin A-rich products are explored. What consumers consider natural and how natural they perceive certain products to be may be linked to their general attitude towards food technology and knowledge of foods and diet. These factors in conjunction with real and hypothetical choice experiments are explored. In chapter 3 the methodology for data collection is described.

Summary of Literature for Vitamin A Studies on Valuation of Nutrition Interventions

Author(s)	**Year**	**Population**	**Objectives**	**Methods**	**Key Findings**
Banerji et al.	2012	Three major regions in Ghana were selected which produced the most maize. From this, districts with high levels of poverty were shortlisted. One district was randomly chosen from each region. From this district, ten enumeration areas, or cluster of villages, were selected.	To elicit WTP measures for biofortified maize, and to measure the effects of different WTP elicitation techniques, house money and nutrition information.	Authors employed a Becker-deGroot-Marshak auction, a kth price auction, and a choice experiment for the different elicitation mechanisms. Participants in the BDM and choice experiments were assigned participation fees ranging from 40 to 200 pesewas. Participants in the kth price auction received no participation fee. Subjects were then randomly assigned to each treatment with or without nutrition information. Maize was presented to the participants in the form of *kenkey*, a popular food based on fermented wheat available from market. For the sensory evaluation, participants were asked to rank taste, texture, aroma, and overall likeability on a five point hedonic scale. Order presentation was randomized. WTP elicitation occurred afterwards. Participants underwent training and a practice round for the BDM and kth price mechanism. The kth price auction split participants into groups of eight, with the top three highest bidders winning the auction and paying the fourth highest price. Four rounds of bidding occurred for each group, and a round was randomly selected to have the binding price. Winners from this round then paid and received their *kenkey*. For the CE, price points were discussed with key informants from the village, and a price range from 10 to 50 pesewas was chosen. Authors devised 25 scenarios and used an orthogonal choice set determined by fractional factorial design. BDM and kth price WTP estimations were determined with regression analysis, while CE	WTP measures across methods were found to be similar and aligned with theory that the three methods are incentive compatible. Without nutrition information, orange *kenkey* was found to be distinct from yellow, and sold at a 15 to 20% discount. Nutrition information had a significant impact on the WTP for orange *kenkey*, with the discount being converted to a premium. Premium size varied from 25 to 50% in the kth price and CE experiments respectively. Nutrition information decreased WTP for the white and yellow *kenkey*. Participation fee did not affect either BDM or CE WTP measures.

				WTP was determined using random utility theory and a conditional logit model.	
Chow et al.	2010	Indian states in which mustard seeds are grown and commonly consumed, and have relatively high incidence of VAD. Women of reproductive age and children were targeted.	To undergo a cost-benefits analysis between supplementation, industrially fortified mustard oil, and genetically modified mustard oil that contains higher amounts of Vitamin A.	Burden caused by VAD was calculated with disability-adjusted life years (DALYs). DALYs were calculated for each of the following scenarios: high-dose Vitamin A supplementation, industrial fortification of mustard oil, and GM-fortified mustard oil. State-specific data was used for mustard-oil consumption, and rates of effectiveness for increasing morbidity and mortality with increased VA consumption. DALYs were calculated by summing disability due to Bitot's Spots, blindness, and night blindness multiplied by their respective treatment effectiveness rates. Costs of each intervention were estimated based on previous data and health care costs. Robustness was analyzed with a Monte Carlo simulation.	Industrial fortification was found to be the least effective in diverting DALYs and deaths. Vitamin A supplementation was the least costly but was affected by coverage of health care centres. GM-fortified foods were found to have a greater reach as it targeted the entire population and not just children. Intervention effectiveness varies with estimated effectiveness rates, and prevalence of VAD.
Chowdhury et al.	2009	The sample consisted of both rural and urban participants in India. Rural participants were selected from two districts in which orange sweet potato were unavailable (n = 467). Urban participants selected randomly from markets which had low- and middle-income consumers.	To gauge WTP for biofortified sweet potato, what factors affect WTP, and whether or not nutrition information resulted in a premium. Authors also investigated if cheap talk mitigates hypothetical bias in valuation studies in developing countries	A choice experiment was used in combination with Lancaster's theory of demand and random utility theory. Nine-point hedonic scales were used to measure consumer taste and acceptance. Authors employed both discrete choice experiments and contingent valuation to compare WTP measures and estimate hypothetical bias. Four sample groups were created: 1) real, without nutrition information, 2) real, with nutrition information, 3) hypothetical, without cheap talk and 4) hypothetical with cheap talk. All hypothetical scenarios gave nutrition information. After the experiment, demographic information was collected. Random utility theory and a probabilistic choice model were employed to calculate WTP values.	WTP was significantly higher in the hypothetical scenarios than the real. The cheap talk scripts reduced hypothetical bias but did not completely eliminate it. It is this inaccuracy associated with the hypothetical cases that make contingent valuation inapplicable to developing countries. Nutrition information did lead to a significant premium for the orange maize.
De Groote and Kimenju	2008	Urban maize consumers in Nairobi, Kenya (n = 604). Respondents were chosen from three major forms of food outlets: supermarkets (n =	To assess WTP values of consumers or white maize, yellow maize, and biofortified white maize, and to analyze maize consumption patterns.	A contingent valuation study was performed. Researchers chose a dichotomous choice design with surveys performed at posho mills, kiosks, and supermarkets. WTP was estimated using randomized utility theory and a semi-double-bounded logistic model.	White maize was found to be strongly preferred in all sample areas. On average, a discount of 37% was required for yellow maize to be acceptable. Fortified white maize commanded a premium of 5.9% for those

		183), kiosks (n = 210), and posho mills (n = 211).			unaware and 7.4% for those aware.
De Groote et al.	2011	Rural and urban households were randomly selected in Eastern and Western Kenya (n = 500).	To gauge WTP for white, yellow, and fortified white maize via a revealed preference experiment.	Authors employed a BDM auction mechanism. Participants were endowed with a participant fee, and then asked to pay real money for the maize. A practice round was employed in order for participants to learn the BDM auction mechanism. A survey was developed with focus groups for factor analysis. Data was analyzed by comparing averages prices and using a regression with a random effects model.	Regional preferences exist for different varieties of maize. Consumers were willing to pay a 24% premium for nutritionally enhanced maize. Knowledge of Vitamin A and its effects were low, but knowledge was positively correlated with higher WTP.
Depositario et al.	2009	Students at the University of the Philippines Los Baños (n = 100).	"To examine WTP measures using a uniform-price auction with four units supply of golden rice" (pg 457)	A kth price auction was used in which the top four highest bidder(s) pay out of pocket for the good at the fifth highest price. Participants were split into four groups of n = 25, and each group received positive information, negative information, two-sided information, or no information. Information pertained to food safety, human impact, socioeconomic impact, and environmental impact of golden rice. Participants underwent a practice round with chocolate bars so that the mechanism was understood. Mean and median WTP were ranked and compared. To complement this, OLS was performed with WTP bids as the dependent variable. Independent variables included information type, rounds, demographics, consumption and awareness related factors.	The highest WTP was found with positive information, then no information, negative information, and the lowest WTP measure was found with two-sided information. However, the effect of negative information was more pronounced than positive information. Authors opine that findings suggest an aggressive marketing campaign for golden rice may not be beneficial until it is determined which traits lead to increased WTP is determined.
Low et al.	2007	Households in Mozambique (n = 741) which were selected from three districts that were prone to drought, had high levels of childhood malnutrition, a	To increase serum retinol concentrations and overall Vitamin A intake in young children by introducing Orange-fleshed sweet potato (OFSP) to the household, increasing farmer access to OFSP	Introduced to households in a two-year agricultural intervention by introducing social activities, information sessions for agricultural education and nutrition. Nine surveys were performed over the two year period that collected socioeconomic information, frequency of consumption of OSFP and vitamin A food sources, dietary intake overall, and blood samples for biomarker analysis. Surveys were administered at the beginning and end of the	Incidence of low serum retinol concentration dropped 30 – 68% in intervention households compared to the control. The intervention group was more likely than the control to eat OFSP three times per week (55% vs. 8%, $P < 0.001$).

		monotonous diet that relied mainly on cassava, and a poor resource base. Sample was split into intervention (n = 498) and non-intervention households (n = 243).	vines, nutrition knowledge (and generating demand), and creating sustainable market development.	two year period. Yields and market prices were annually measured.	Caregivers attended eight nutrition sessions on average. Plot sizes for farmers increased on average from $33m^2$ to $350m^2$.
Meenakshi et al.	2012	Participants were from provinces in Central and Southern Zambia, which have the highest proportion of maize production and relatively high rates of poverty. Respondents were randomly selected from districts and villages within each province (n = 478).	To estimate WTP for orange maize of rural farmers of Zambia. Authors detailed sensory perceptions and used a WTP framework for a public health issue via a revealed preference study.	Central location testing (CLT) and home-use testing (HUT) were employed. The former is cheaper and faster, while the latter allows for respondents to become used to the product, as initial premiums used in CLT may actually be declining and reflect reactions to the products' novelty. Respondents were also randomly assigned to groups in which they received 1) no nutrition information, 2) nutrition information via simulated radio, or 3) information from community leaders. WTP was measured with discrete choice experiments. Existing median prices of goods were given +/- a 30-50% premium. A linear random utility model was used, and a maximum likelihood logit model was used to compute coefficients.	Orange maize is thought to be more closely associated with the more acceptable white maize cultivars. A premium for orange maize exists when combined with nutrition information. For CLT, this premium was 23%, whereas for the HUT participants, the premium decreased to 15%. How nutrition information is disseminated does not affect consumer acceptance.
Oparinde et al.	2012	Participants were selected from Oyo (n = 343) and Imo (n = 328) states. These states were chosen due to their high rates of cassava production and consumption, as well as relatively high rates of VAD.	To investigate consumer preferences for yellow cassava biofortified with Vitamin A versus local cassava (white), the impact of nutrition campaign of health benefits of yellow cassava, and to determine whether the type of agency delivering cassava materials (international vs. federal) impacts	Sensory evaluation and WTP measures were obtained from participants, who were split into three treatments. One group received no information, another received information *and* were told that it would be delivered by Federal authorities, and the other third were given nutrition information *and* were told it would be delivered by international authorities. Sensory evaluation was performed with a survey that included a five-point Likert scale. Local women's groups were asked to choose and prepare the 'best' cassava. Bidding was performed with a Becker-deGroot-Marshak mechanism, with randomly drawn binding prices and participants	Nutrition information was shown to significantly improve WTP and sensory evaluation. The type of agency delivering the cassava was not shown to significantly change sensory evaluation. In Imo, the yellow varieties of cassava became the most preferred when paired with nutritional information. There may be a slight preference in these provinces for federal authorities. In Oyo, the

			consumer preferences.	stating their WTP. Participants were not given a participation fee, but were given a gift in kind at the end of the experiment.	yellow cassava was the most popular even without nutritional information, indicating that regional tastes may vary considerably.
Stevens and Winter-Nelson 2008	2008	Voluntary participants in a Mozambican marketplace (n =	To examine the acceptability of biofortified maize in Mozambique.	Sensory analysis and a framed field experiment were performed. Local white maize and biofortified orange maize were sold in real transactions in market stalls. A speech at the beginning of market day detailed what orange biofortified maize was. Voluntary participants who approached the stall were asked to taste the product and rate its sensory attributes. Afterwards, each participant was given a 0.6kg bag of local white maize meal. Participants could choose to trade this white maize for a bag of orange maize, which was 0.5 to 3 times the amount of white meal given. A follow-up question was given in which participants could trade their white maize away for a bag of tomatoes worth the same amount.	Orange maize was found to be comparable to yellow and white maize in terms of sensory attributes. A discount of 25% for orange maize is likely to be required for it to be acceptable. Inflated WTP estimates may have been likely due to the novel nature of the orange maize product.
Yanggen et al.	2005	Sites were selected based on prevalence of VAD and sweet potato production. Communities where OFSP had and had not been introduced earlier were also included. Two key groups were households (n = 168) and key informants (n = 38)	To analyze consumers and producer preferences for different cultivars of OFSP to determine which breeds are likeliest to be adopted by farmer.	Surveys were administered with closed ended questions about sweet potato consumption and production practices. Key informants (NGO members, government, local and regional representatives) were asked closed-ended questions on local and regional OFSP promotional efforts. In addition, 24 focus groups (4-8 farmers each) were held, and participants were asked open-ended questions about sweet potato production and consumption at the community level. Data was analyzed with Excel and SPSS, with information tallied as averages, medians, percentages, and frequencies.	High yields and disease resistant cultivars are the most desirable traits for farmers. Use of OFSP was only 20% in non-intervention areas, versus 64% in intervention areas. Spill-over effects were very limited however, which indicates that large-scale adoption may be unlikely without intervention is numerous areas.

Chapter 3. Methodology

3.1 Introduction

Consumer preferences and the probabilities of purchasing particular (WTP for) vitamin A rich goods may be captured using hypothetical and real choice experiments. This study focuses on vehicles for obtaining vitamin A that the consumer may value more or less than supplements and differences between these vehicles given the same amount of micronutrients across products. This focus is more holistic in that it examines whole products and better reflects how food choices are typically made and introduced into the diet rather than focusing on a single nutrient. Total consumption of each vehicle is determined by various factors, but includes what is technologically feasible, available in a geographic area, consumer attitudes, beliefs, knowledge, and preferences.

In order to achieve our study objectives, a consumer choice experiment with a modified payment card that captured consumer tradeoffs between vitamin A-rich food products and supplements was employed. Choice experiments provide a useful tool set for differentiating between food characteristics and determining how they affect WTP for food products (Kamphuis et al. 2015). This is done by asking participants to make repeated choices in different scenarios with different food products and prices. Typically, choice experiments are classified as “stated preference” experiments as participants reveal their preferences by stating choices in hypothetical scenarios. Conversely, “revealed preference” uses actual market demand and behaviours to infer broader assumptions about preferences. However, problems with stated preference experiments may arise, especially in the context of choice experiments. Lusk and Shogren (2007) have demonstrated that in the absence of incentives, people may over or understate their WTP for products in a phenomenon known as “hypothetical bias”. However, this is not encountered in revealed preferences and it is for this reason that a real choice experiment is preferable.

Choice experiments have typically led to higher WTP estimates in the past than those elicited by the standard Becker-DeGroot-Marshak (Alphonce and Alfnes 2015). This is likely due to greater emphasis being placed on varying attributes within choice experiments. However, the decision to use a choice experiment was based on two major reasons. The first was that compared to auctions such as the BDM mechanism, people simply are not accustomed to making absolute judgements in daily life (Champ et al. 2012), and in the case of foods, consumers typically make comparative judgements. The second is that the BDM mechanism may be difficult for consumers to understand in the field (Alphonce and Alfnes 2015). Discrete choice experiments have also been used in the past and have successfully elicited incentive compatible WTP estimates for food products in the past (refer to Table 3.3) although they tend to elicit larger WTP estimates due to its emphasis placed on comparisons between products.

Due to the unavailability of biofortified goods in the research setting, both a revealed preference and stated choice component was used. The procedures and methodologies for both components are described in the following section. In order to allow for cross-cultural comparisons, the experiments and surveys used in India and Canada were identical. Translation of the survey from English to Odia was performed by an expert fluent in both English and Odia. The survey was then cross-checked with the original questionnaire in English to ensure that the correct tones, expressions, and structure of the survey were kept intact. Due to the variability of literacy within the participants in Odisha, an enumerator read questions orally to participants. Answers were given aloud and then recorded by the enumerator.

In order to further explore linkages in consumer behavior, perceptions, and attitudes, the survey collected information pertaining to values of naturalness, food technology neophobia, objective and subjective knowledge of diet, and socio-demographic characteristics.

3.2 Experimental Design

How the food bundles were selected is explained for the choice sets in India and Canada. Afterwards the non-hypothetical and hypothetical choice experiments are described. Lastly the survey design and variables that were measured are explained.

3.2.1 Food Product Choices and Bid Prices

The bundles in the choice set contained four major groupings of vitamin A-rich products: supplements, foods, fortified foods, and bio-fortified foods. Foods were considered those in which the Vitamin A occurred in the food with no new modification or processing. Foods available in each category may be found in Figure 3.1 and products were included in the experiments based on selection criteria. In order to allow for comparisons between India and Canada, products had to be as similar as possible (Table 3.1). Many Indians are vegetarian and so only plant-based foods were considered. This ruled out animal-based foods such as liver, eggs, or dairy products. In order to avoid a novelty effect, foods also had to be consumed regularly and accessible. Therefore guava, papaya, and amaranth were excluded as they are consumed irregularly in Canada.

Next the quantity of vitamin A per kilogram of food was considered. All food bundles offered must satisfy one week's worth of recommended dietary intake. Therefore the quantity of food within each bundle must be logistically reasonable, in addition to being comparable to what would be normally purchased by a consumer. In Canada, the recommended dietary allowance (RDA) for Vitamin A for an adult male is 700µg and is the same as the % Daily Value on nutrition labels. In India, the recommended dietary intake is 600µg for males and females aged 7 and up, with greater requirements for pregnant or lactating women (National Institute of Nutrition 2011). Vitamin A content for Canadian food products was gathered from the Canadian Nutrient Files and product labels (Health Canada 2012). Nutrition information for Indian products was gathered from nutrition labels and the Indian Council for Medical Research nutrition database (Gopalan et al. 2009). Products such as cabbages, peas, and watermelon were thus excluded due to their low vitamin A content. In the case of tomatoes, 20kg would have been required in order to meet the recommended dietary intakes for one week. This amount would have been prohibitive logistically and confusing for respondents as that quantity of food is rarely purchased in one transaction.

Table 3.1 Potential vitamin A sources to be included in the choice set for hypothetical and non-hypothetical experiments

Exclusion Criteria	**Conventional Foods**	**Fortified Food (Mandated)**	**Biofortified Foods**
Unavailable in either India or Canada	N/A	Fortified sugar Fortified flour	N/A
Animal Product	Liver Eggs Goat Milk	Dairy	N/A
Consumed irregularly in either India or Canada	Guava Papaya Amaranth	N/A	Cassava Maize
Does not provide adequate vitamin A in a reasonable quantity	Cabbage Peas Pumpkin Tomato Watermelon	N/A	N/A
Acceptable option for the choice set	Carrots Kale Spinach	Fortified oils Margarine	Sweet Potato

Carrots were chosen among the conventional food products as it offered the most RAE per kg, in addition to being the least troublesome to transport and store. Margarine in Canada was chosen for the fortified product. However, due to low intake of margarine in the Odisha province, fortified sunflower oil was used for the Indian cohort. Foods that were biofortified with Vitamin A included cassava, maize, and sweet potato. However, cassava and maize are not regularly consumed in Canada and thus sweet potatoes were used in the hypothetical experiments.

Although the goods were selected with the aim of attaining a particular level of vitamin A with a week's consumption of the product, the goods are sufficiently different that there are a variety of factors unrelated to vitamin A which could influence preferences. For example, in India, a week's supply of vitamin A was provided through a bundle of carrots which were not readily available at that season to study participants. So they may like carrots and value the carrots independently of the fact that they contain vitamin A. In making a choice to exchange vitamin supplements for other foods (carrots, margarine etc.) people may have considered the logistics of transporting the product back to their home. For example, supplements may have been chosen over carrots or margarine (or oil) because they were easier to carry home. Further experimentation in the future will be necessary to unpack some of these other characteristics of the selected goods in each country.

Bids were calculated in Canada by determining market values for each food product in the quantity offered, scaling them up by increments of 1.5x, 2.0x and 3.0x the market price and then subtracting the price of the supplements bundle. This was to account for the price floor of goods available in the market while scaling up the bids so that the cut off point for WTP estimates would be captured. Market values in Canada were based off of retail flyers, online shopping sites, and retail store visits. Minimum prices in India were based off of prices in the public distribution system for the fortified sunflower oil, store prices for the vitamin A supplements, and market prices for the carrots. This reflected the primary method in which these goods were available in the province of Odisha. These minimum bids were then scaled up by a factor of 1.5x, 2.0x and 3.0x and then subtracting the price of the supplements bundle. Bid ranges and the final quantities offered in the choice experiments in both India and Canada are listed in Table 3.2 and sample bid calculations are available in Appendix 3.1. Given that the intention of biofortified products is to become adopted by market and to have similar prices as their conventional counterparts (Bouis et al. 2009), the price of conventional sweet potatoes was used in the bid calculation for the hypothetical payment card in India and Canada. Base prices were slightly lower than the market prices for the oil (margarine), carrots and biofortified sweet potato but bids were scaled up to capture this. Oil sold outside of the market place typically retailed at INR 80 per litre. The bundle used in this experiment (140mL) would cost INR 11.20, which is captured by the maximum bid price for fortified oil of INR 16.

Table 3.2 Quantities of food bundles and bid prices

	Canada			
	Supplements	*Carrots*	*Fortified Margarine*	*Biofortified sweet potato*
Bundle size	4 supplements	600g	680g	700g
Market Price ($ CAD/kg)	$8.00 per 100 pills	2.99	2.18	1.61
Initial Bid ($ CAD/kg)	N/A	0.99	2.07	0.81
Maximum Bid ($ CAD/kg)	N/A	3.60	6.86	3.06

	India			
	Supplements	*Carrots*	*Fortified Sunflower Oil*	*Biofortified sweet potato*
Bundle size	4 supplements	500g	132g	600g
Price (INR/kg)	203 per 100 pills	25	50	85
Initial Bid (INR/kg)	N/A	22	2	37
Maximum Bid (INR/kg)	N/A	82	16	127

3.2.2 Revealed and Stated Preference

Participants were asked to do two experiments, the first focusing on revealed preferences of consumers that involved a transaction between real money and real goods. The second was a hypothetical choice experiment. Combining both real and hypothetical data allows us to check consumer preferences and determine if there is any hypothetical bias with WTP estimates (Louviere and Lancsar 2009). Repeated questions also allow verification of the survey being incentive compatible; participants giving honest answers should not have large variation between responses in the real and hypothetical choice experiments (Hensher 2010). In this case the hypothetical choice data was required in order to allow for biofortified sweet potato to be included given that it is commercially unavailable in both India and Canada.

In the real choice experiment, participants were endowed with a package of supplements. Supplements were selected as the base case as they contain the micronutrient in its simplest form available to consumers. Findings from De Steur et al. (2012) suggested that supplements are actually not as convenient or as effective as initially thought and therefore are likeliest to contain the least value per to consumers mcg of Vitamin A. This would imply that people would prefer to directly receive their nutrients from food, and indeed, functionality and other food characteristics tend to be positively valued (Barreiro-Hurlé et al. 2008). Participants were then presented with the carrots or fortified oil bundles (Table 3.2) in order to better understand the quantities of food necessary to obtain an adequate amount of vitamin A from various sources. Participants were asked to behave as though goods were available from the source that they typically purchased their food from.

Laminated nutrition cards containing product information and nutrient content were given to participants to read prior to beginning the payment card. Product information included how the vitamin A came to be in the product, a brief description of how the product was presented to consumers (i.e. packaged, raw, etc.) and that each product contained 700% of the daily value for vitamin A, or enough to satisfy one's recommended dietary allowances for one week. Each bundle represents a vitamin A intervention. This is similar to bundles offered by De Steur et al. (2014a) and De Steur et al. (2014b) in their second price Vickrey auction for GM biofortified rice. Nutrient information cards detailed the amount of calories, fat, protein, carbohydrates, fibre, vitamin A, vitamin C, calcium, and iron for each bundle and may be found in Appendix 3.2. Nutrition labels as regulated by Health Canada were not used due to discrepancies in labeling policies between India and Canada.

After participants were instructed to read the nutrition cards, they were presented with a payment card in which contained two options A and B. Option A was the choice to keep their supplements and pay no bid. Option B was to exchange their supplements for another good while paying a specified bid amount with real money. A total of eight scenarios were presented with either carrots or margarine in Option B with a varying bid amount. Enumerators emphasized that each scenario was independent from the others. The scenario order was randomized across three different versions to prevent ordering effects. In order to facilitate understanding in India, a series of plates were laid out that demonstrated the different scenarios in the payment card whereas in Canada only the food bundles from the choice set were shown at the front out the room. Note that no money or goods were physically given to the participants until the end of the experiment.

After the real choice experiment was completed, participants performed an additional hypothetical experiment that included biofortified sweet potato. A hypothetical experiment was necessary due to bio-fortified products rich in vitamin A being commercially unavailable in either Canada or India. Participants were asked to behave as though real goods and money were involved. The hypothetical payment card contained all eight scenarios available in the non-hypothetical payment card, with carrots and fortified oil (or margarine) with the same bid prices. However, an additional four scenarios featured biofortified sweet potato so that in total twelve scenarios were on the hypothetical payment card. Example payment cards for the hypothetical choice experiment may be found in Appendix 3.3. Similar to the real choice experiment, scenario order was randomized across three different versions. By having the real payment card precede the hypothetical payment card, it is thought that participants would be primed to answer the hypothetical payment card similarly to the real payment card (Cherry et al. 2003). This phenomenon is known as a “rationality spillover” in which rational thinking induced by market-like conditions (i.e. the real choice experiment) may transfer into different scenarios, hypothetical situations included. Differences in WTP estimates between the two payment cards for individuals would indicate that there is hypothetical bias and thus the WTP to exchange supplements for goods is calculated for both the real and hypothetical choice experiments.

After the payment cards were completed, one of the scenarios from the real choice experiment was randomly selected to become binding. This was performed by having one participant randomly draw a scenario from an envelope. Goods and cash were given at the end of the experiment sessions to minimize endowment effects. In previous economic experiments, both gifts in kind and cash were offered (Table 3.3). For our study, a gift of $25.00 CAD was presented to Canadian participants at the end of the experiment while their Indian counterparts received Rs 500 (roughly $10.00 CAD) in order to compensate participants for their lost time that could have been spent working. Participants were given the option of having their bid payment deducted from their participant fee or paying directly out of pocket. This procedure is likely to induce real economic incentives for participants that will yield more realistic estimates of WTP for vitamin A-rich foods (Horowitz and McConnell 2002).

Table 3.3 Specific methodology of studies that used valuation techniques to elicit WTP

Study	**Auction Mechanism**	**Choice Set**	**# of Choices**	**Revealed or Stated Preference**	**Payment Vehicle**	**Practice Round**	**Significant Socioeconomic Demographics**
(Banerji et al. 2012)	BDM and kth price auctions	White (historically preferred), yellow, and biofortified orange *kenkey* (a popular food based on fermented wheat available from market).	3	Revealed	40 to 200 pesewas for BDM participants, no compensation for kth price.	Yes	None.
(Chowdhury et al. 2009)	Discrete choice experiment	White (Nakakande variety), yellow (Tanzania variety), orange (SPK004/1/1 variety); and deep orange (Ejumula variety), or none of these choices.	5	Revealed and Stated	500 Ugandan shillings	No	Gender was found to be positively associated with increasing WTP in white maize, whereas receiving prior information, and being from a different district were found to have a negative effect. Breastfeeding was found to have a negative impact on all but white maize. Preferring a different maize type was also found to have a significantly negative impact.
(De Groote and Kimenju 2008)	Discrete choice experiment	White maize, yellow maize, and fortified maize	3	Stated	None	No	Income, education, being female, shopping at a supermarket, and hailing from Central Nairobi all had a negative impact on WTP for yellow maize
(Kimenju et al. 2006)	Individual BDM auction	White, yellow, and fortified white maize	3	Revealed	15 Kenyan Shillings	Yes	None.
(De Steur et al. 2012)	Second price Vickrey auction	GM Biofortified Rice with folate, and conventional rice paired with folate supplements. Both bundles contained enough folate to satisfy 7	2	Revealed	25 Yuan ($3.80 USD) worth USB-stick for students and 45 Yuan	Yes	Students were found to be less supportive of GM technology as compared to the general group, of women.

		days of requirements or 3000ug.			($7.40 USD) for non-students		
(Depositario et al. 2009)	Uniform price auction	Golden Rice	1	Revealed	100 Phillipine pesos	Yes	WTP was found to be lower as frequency of rice purchases increased.
(Meenakshi et al. 2012)	Discrete choice experiment	White, yellow, and biofortified orange maize	3	Revealed	2000 Zambian Kwacha	No	None.
(Oparinde et al. 2012)	BDM auction	Light yellow (TMS 01/1368), and deep yellow (TMS 01/1371) cassava. A local control variety was also selected for the two sample groups (White for Oyo State and Yellow for Imo State).	3	Revealed	A gift in kind (soft drink and exercise book)	No	None.
(Stevens and Winter-Nelson 2008)	Real field experiment	White maize (initial allocation) for orange maize, and white maize or tomatoes	2	Revealed	Meat and broth to accompany their 0.6kg of white maize	No	Being male, a regular shopper, having less children, and more frequent consumer of fish and meat corresponded with lower likelihood of trading for orange maize meal.

3.3 Survey Design

According to Ajzen's theory of planned behaviour (1991), attitudes are a major determinant of consumer behaviour by acting directing or indirectly on intentions and behaviour. Attitudes may be defined as the sum of beliefs an individual has regarding a particular behaviour weighted by evaluations of one's beliefs. The attitudes were measured directly by analyzing perceptions of naturalness, knowledge, and using the food technology neophobia scale (FTNS). In some cases, these measures may be a better predictor of behaviour than socio-demographic characteristics.

3.3.1 Naturalness

Naturalness statements were developed based on various aspects of natural explored in the literature discussed in Chapter 2. Statements were created according to major aspects of what is natural, how it is conceptualized and conceived by consumers (Table 3.4). Two major facets of natural were considered: 1) natural as moral and ideational, and 2) natural as the converse of processing (Bäckström et al. 2004). Eleven statements exploring natural were presented to participants who were given the choice of rating their agreement on a scale from 1 (totally disagree) to 7 (totally agree). Statements 1, 4, 6, 8, 9, 10, and 11 were reverse scored (Table 3.4). Factors were later extracted with principal components analysis, and statements were analyzed with factor analysis. This allowed us to analyze cultural differences between the Canadian and Indian cohorts as to what impacted perceptions of naturalness.

Table 3.4 Statements exploring perceptions of naturalness and literature source

Item	Statement	Source
1	Natural foods have not been changed in any large way by humans (R)	(Urala and Lähteenmäki 2003; Urala and Lähteenmäki 2004; Urala and Lähteenmäki 2007)
2	The more familiar a food is the more natural it is	(Siipi 2013)
3	The more authentic a food is the more natural it is	(Siipi 2013)
4	Natural foods do not contain artificial flavours or additives (R)	(National Institute of Nutrition 2011; Canadian Food Inspection Agency 2014)
5	Natural foods are as good for me as other foods that might not be thought of as natural	(Bäckström et al. 2004; Rozin et al. 2004)
6	Natural foods are not necessary for my health (R)	(Bäckström et al. 2004; Tenbült et al. 2005; Siipi 2013)
7	Naturalness in foods is valuable because it is pure	(Rozin et al. 2004; Siipi 2013)
8	The more a food has been processed, the less natural it is (R)	(Tenbült et al. 2005; Rozin 2006; Evans et al. 2010a)
9	Food that has ingredients removed is less natural (R)	(Rozin 2005)
10	Food with synthetic ingredients added are less natural than foods that do not have any ingredients added (R)	(Rozin 2006; Evans et al. 2010a)
11	Foods with "natural" ingredients added are less natural than foods that do not have any ingredients added (R)	(Rozin 2006; Evans et al. 2010a)

(R) Likert scales are reverse scored

3.3.2 Knowledge

Generally, subjective and objective knowledge tend to be positively correlated (Ellen 1994; Duhan et al. 1997; Carlson et al. 2009). Men tend to have greater subjective knowledge (i.e. they are more confident about their knowledge) as compared to women. Both objective and subjective knowledge tend to increase with greater income and education, but is negatively correlated with age. Higher subjective knowledge is correlated with more positive attitudes towards a product, while objective knowledge makes one less influenced by newer information. Attitudes are influenced by both objective and subjective knowledge, whereas the amount of food product consumed tends to be more highly correlated with subjective knowledge (Figure

3.1). Aertsens et al. (2011) found that increased objective knowledge leads to higher subjective knowledge, which in turn leads to a greater positive attitude towards consumption of organic products. Therefore it may be through subjective knowledge that objective knowledge may act on consumption patterns (Pieniak et al. 2010). However, both Pieniak et al. and Aertsens et al. sampled a disproportionately large amount of organic food users in Flanders, Belgium, so generalisations to the greater population should be made with caution. Figure 3.1 demonstrates how subjective and objective knowledge may influence consumer behaviour through its effects on attitudes and perceived benefits.

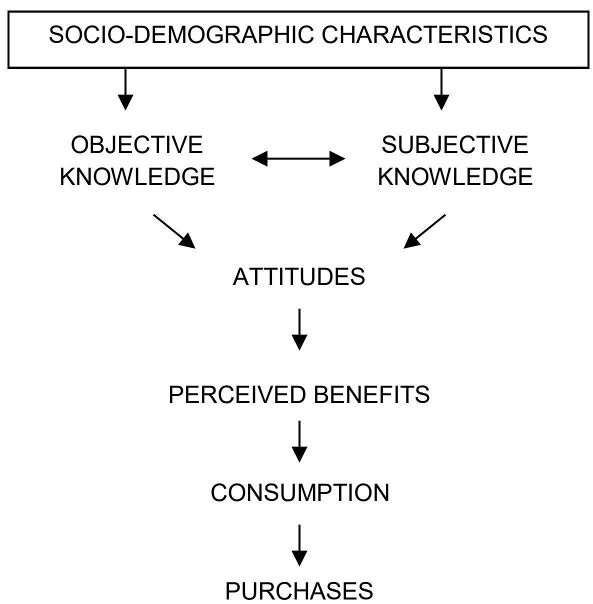


Figure 3.1 Interactions and effects of subjective and objective knowledge on attitudes and purchase behaviour. Adapted from Aertsens et al. 2011.

In the past, increased knowledge was weakly correlated with higher WTP for certain food products (Carlson et al. 2009; De Groote et al. 2011). For our survey, SK was measured by giving participants three statements on how they would rate their level of knowledge. The SK statements were developed and tested by Aertsens et al. for internal validity and reliability. These statements were then adopted in order to be used for assessing subjective knowledge of nutrition and diet (Appendix 3.1). Scores of the three statements was summed for the overall SK score. OK of nutrition and diet was measured with a five-point Likert scale asking consumers to rate how much they agreed with statements regarding the role of vitamins in diet and their impact on health. The total OK score was the sum of the five statements.

Supplemental statements of consumers' objective knowledge regarding processes of how nutrients were added to food was measured by giving a statement and asking consumers to agree or disagree with the statement and then to state how certain they were of their answer from a scale of 1 (not certain) to 5 (very certain). Statements measuring knowledge were reworded to be more relevant to the survey by including Vitamin A or vitamins. This structure is based off of questionnaires used by Aertsens et al. (2011) and Pieniak et al. (2010). The questions used in this study to measure OK and SK can be found in Appendix 3.1.

3.3.3 Food Technology Neophobia

The Food Technology Neophobia Scale (FTNS) is a development based from the Food Neophobia Scale. Cox and Evans (2008) realized that the food technology applied was conceptualized separately from the original food itself. Consumer acceptance and willingness to try a food produced with a new technology transcended the category of food product and tended to be associated with the technology itself. Therefore the FTNS was developed, a scale based off of 13 questions, which was tested and shown to be internally valid and stable over time (Evans et al. 2010b). These questions have been standardized and may be used in multiple settings. A higher score on the scale signifies greater food technology neophobia and unfactored, scores range from 13 to 91. In 2013, Chen, Anders, and An (2013) found that greater FTNS scores were associated with lower WTP for vacuum-packaged meats and whether it has a similar effect on WTP for Vitamin A-rich foods is examined.

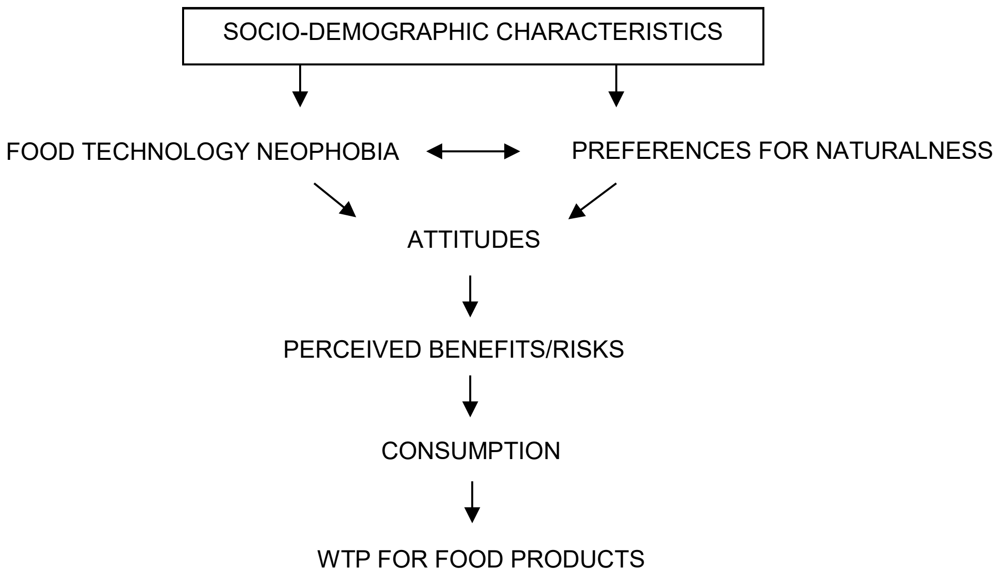


Figure 3.2 Effects of Perceptions of Naturalness and FTN on WTP for food products. Adapted from Aertsens et al. 2011

FTNS is affected by socio-demographic characteristics such as age, gender, education, and income. However, its association with WTP in the context of increasing nutrition intake has been limited and not strongly demonstrated. It is expected that as FTNS scores rise (i.e. as one becomes more neophobic towards foods produced with novel technologies), then preferences for natural foods would increase.

3.3.4 Demographics and other determinants

In order to capture socio-demographic factors, standard questions regarding income, gender, age, education, etc. were given at the end of the survey to avoid framing effects. Consumption patterns, purchasing frequency, and access to goods relevant to the survey were also collected.

Participants were also asked if they believed their own vitamin A intake and that of their children's was adequate. Finally, participants were also asked if they or their children had ever displayed or been diagnosed with common symptoms of vitamin A deficiency, such as night blindness, dry eyes or skin, or xerophthalmia.

3.4 Conclusion

Overall, the survey and experiments were written to be easily understood and administered. In Canada, participants were to take no more than an hour to complete the experiment and questionnaires. More time was given to the Indian participants as the survey had to be orally administered. Data collected with our tool will allow us to address the objectives of our study. The experiment was designed based off of best practices outlined in the literature while keeping in mind logistical constraints. The full survey instrument may be found in Appendix 3.1.

Chapter 4. Data Collection and Sample

4.1 Introduction and Sample

This chapter summarizes the descriptive statistics of the sample and preliminary analysis of the data set. Comparing the attitudes that drive consumer preferences is also an objective of this thesis and will be informed by this analysis. Below the target sample and data collection methods are explained. Socio-demographic characteristics of Canadian and Indian subsamples are compared to each other and to the population data where appropriate. Attitude scores of perceptions of naturalness, objective and subjective knowledge scores, and FTNS will be computed and examined. This will give us a baseline to examine why WTP of a consumer might vary with changes in these internal factors. Factor analysis of the FTNS and naturalness scores are performed separately for Indian and Canadian participants in order to examine key differences in attitudes between two cultures. A snapshot was created of the consumption patterns of some vitamin A sources, such as eggs, liquid milk, sweet potato, sunflower oil, and carrots. Finally, there is a summary of payment card responses for the hypothetical and real choice experiments before beginning our econometric analysis in the next chapter. Summary of responses that contained information that would be useful for extensions of this research are included in Appendix 4.1

The first target sample was disadvantaged populations within the Koraput district of Odisha, India. Compared to the rest of the country, Odisha has high levels of poverty, with the fourth lowest per capita income among all Indian provinces in 2014 – 2015. Average income of the sample is also lower than the per capita GDP of the Odisha province. Koraput is a largely rural district, with almost 90% of its population living outside of cities (Census of India 2011). In India, below poverty line (BLP) and above poverty line (APL) are economic benchmarks used by the Government of India as indicators of poverty and to better identify households that may be in need of government assistance. The definition of BPL in Odisha is based on 13 parameters that were measured in a 2002 survey. These parameters scores range from 0 – 4 and include landholding, type of house, clothing, food security, sanitation, consumer durables, literacy status, labour force, means of livelihood, status of children, type of indebtedness, reasons for migrations, etc. A total score below 17 out of 52 is indicative of being BPL. As identified in the literature review, lower socio-economic status is a risk factor for inadequate vitamin A intake and so BLP individuals were targeted. This is due to household income limiting the amount of food that may be purchased, which could impair nutrient intake. In addition, scarce public health dollars means that policies for improving nutrient intake must be aligned with consumer preferences so that vitamin A rich foods are purchased and consumed so targeting the correct populations is essential. Finally, we look to rural areas as these areas also have less access to a diverse range of foods due to their remoteness and altitude. In the Koraput district of Odisha, there are also a high proportion of tribal populations. These groups are designated by the Government of India as "scheduled tribes", which are historically disadvantaged peoples in India with an agriculture background (Government of India 2010). While 22.8% of the population of Odisha is designated as tribal, this proportion reaches as high as 50% in Koraput (Census of India 2011).These populations are some of the most at-risk populations in the world, with past projects indicating VAD rates as high as 40% (Raghu et al. 2014). Food security is a grave concern given their dependency on agriculture and its seasonal nature that affects food availability in certain times of the year (Dayal et al. 2014). Of the tribal populations in Odisha, 73.9% are considered BPL but the percentage of BPL for the whole of Odisha in rural areas is 75.6% (Government of India 2016).

The second subsample was the population of Edmonton, Alberta, Canada. This was used as a comparison point to the Indian subsample to determine if there were population independent factors that influenced consumer preferences between vitamin A vehicles. In addition, CCHS Cycle 2.2 data indicated that Canadians on average were not receiving enough vitamin A in their diet, and this risk increases for food insecure populations (Kirkpatrick and Tarasuk 2003; Kirkpatrick and Tarasuk 2008). Compared to the national population of Canada, Edmontonians are younger, many of whom are active in the work force. Because of this, Edmontonians do have higher median income than the rest of Canada ($57,000 (2013 Canadian dollars) per year in Edmonton vs. $50,700 nationally) (Edmonton Community Foundation 2013). However, one in five Edmontonians reported earning less than $15/hr. In Alberta, roughly 12.3% of the population is food insecure, which is identical to the national average. A higher median income paired with the same prevalence of food security as compared to the national average indicates that there is a greater portion of disparity in Alberta. A local survey conducted showed that 48 % of Edmontonians agreed that food security was an issue within the city and that the government should take steps to address it. While no recent data exists on micronutrient intake of people within the city of Edmonton, according to the CCHS Cycle 2.2 data, only half of Albertans (male and female) over 19 years of age consumed the estimated average requirement (EAR) of vitamin A in 2004. At the tenth percentile, males over the age of 19 were only consuming 362 RAE/d on average as compared to the EAR of 625 RAE/d, while females over the age of 19 consumed only 329 RAE/d as compared to the EAR of 500 RAE/d. These measures do not include vitamin A intake as a result of supplement usage although regular supplement use is uncommon in food insecure individuals. Fruits and vegetables, some of which are rich in vitamin A, are only being consumed in adequate amounts by a third of the population, with only 36% percent of

Edmontonians were eating the recommended five servings per day (Edmonton Community Foundation 2013). Therefore, deficiency is likely a concern in the province of Alberta and the city of Edmonton.

4.2 India/Canada Socio-demographic Summary

Given that vitamin A intake is a concern within Koraput, the following target goals of the sample were set: 1) to have ten groups of twelve participants for each session from the Koraput, Odisha region, 2) Eight groups would be BPL and two would be APL, 3) Of the eight BPL groups, three would be from standard tribes and five would be from the general population, 4) of the two APL groups, one would be from a standard tribe and one would be from the general population, and finally 5) each group would contain ten women and 2 men. This was due to the tendency of females be the primary decision makers within the household about what foods to purchase (Sachdeva et al. 2011). This composition of the sample was thought to be representative of the populations within the Koraput region while incorporating a large proportion of women, whom are believed to be the primary influencers of household diets (Sachdeva et al. 2011). A detailed breakdown of the samples may be found in Appendix 4.2. Participants were pre-selected from villages in the Koraput district in the province of Odisha in India in order to achieve target goals described above. Villages were roughly one to two hours away via motor vehicle from the city of Jeypore and thus our survey did not include tribes whose villages were not accessible by road. Sessions occurred from the dates of June 11th to June 18th, 2015.In order to be able to give written consent for participating in the experiment, all participants had to be literate. It is important to note that this is not typical for tribal communities, which typically have lower than average literacy rates compared to the provincial average literacy rate of 72.9% (81.6% for males, 64.0% for females) (Government of India 2015) and the district literacy rate of 49.21% (Census of India 2011). Females were over-represented and older than the provincial average although this was intentional (Table 4.1). In the province of Odisha, 22.8% are designated as scheduled tribes but the district of Koraput has a tribal population of 50% (Census of India 2011) whereas 40% of the study sample were designated as tribal. Some farmers may have been unavailable for surveying as it was the rainy season during which farmers must prepare their fields, but the target goals of the sample were met. Overall, participants were lower-income households in one of the poorest regions in India with a mixture of BPL, APL, tribal and general populations that is representative of the Koraput district with the exception of literate persons being over-represented.

Average reported household size was slightly smaller than the district average of 4.09 but this is likely due to the structure of the question in the survey as the maximum reported household size was four. Age is also comparable to the district average. In 2011 the per capita income of the province of Odisha The majority of participants considered themselves the partner of the head of household (65.8%), while primary income earner (18.3%), or being one of two income earners (11.7%) were the next most reported household position. Average self-rated health was reported to be low or fair with responses ranging from poor to very good. No participants rated their health as excellent. Food and non-food products were generally purchased from the local fair price shops of the Public Distribution system once a month, which coincides with the quota of PDS goods allotted to each family per month. Only one participant reported making a dietary or behavioural change within the past year. Participants were fairly physically active, with most participants smoking and consuming alcohol infrequently or never. Eighty-one percent of children and 5% of adults were reported to have received supplements as part of the

MDVA programme, which coincides with rates reported by the DEVTA trial (Awasthi et al. 2013) which indicates that the MDVA programme is meeting its program targets. The vast majority of Indian participants (91%) were not vegetarian, so it may not have been necessary to exclude meat products from the choice set as outlined in Chapter 3. A 2006 survey showed that only about 8% of the population of Odisha was vegetarian, so these results are in-line with state averages (Yadav and Kumar 2006). In addition, tribal populations also tend to enjoy non-vegetarian foods, so a low rate of vegetarianism is not unexpected (Kerketta et al. 2009).

Table 4.1 Summary of socio-demographic characteristics of Indian cohort (n = 120)

Question	**Mean (% Freq.)**	**St. Dev.**	**Min**	**Max**	**Population Data***
Age (in years)	37.2	11.61	19	72	38.70
Female	(84.17%)				(51.12%)
Pregnant	(2.00%)				
Breastfeeding	(12.87%)				
Years of Schooling Completed	10.18	2.81	0	16	
Household Income (INR)	48,412	31,031	3,750	109,999	
Household	3.84	0.47	2	4	4.09
Children in household	1.67	1.09	0	4	
Position within household					
Primary income earner	(18.33%)				
Partner of head of household	(65.83%)				
One of two income earners	(11.67%)				
Child	(0.00%)				
Other family member	(4.17%)				
Other (not family member)	(0.00%)				
Usual place of food purchases					
Supermarket	(11.67%)				
Smaller retailer	(8.33%)				
Farmer's market	(77.50%)				
Directly from neighbours or associates	(8.33%)				
Other	(2.50%)				
Frequency of public distribution system use (With 1 = never, 2 = once every few months, 3 = once or twice a month, 4 = once a week, 5 = 3-4 times a week)					
Food Products	2.57	0.546	0	3	
Non-food Products	2.57	0.546	0	3	
How often do you purchase food for your family? (With 1 = never, 2 = once every few months, 3 = once or twice a month, 4 = once a week, 5 = 3-4 times a week)	4.08	0.74	1	5	

How would you rate your personal health? (With 1 = Poor, 2 = Fair, 3 = Good, 4 = Very Good, 5 = Excellent)	2.86	0.63	1	4
In the last year, have you made any dietary or behavioural changes to improve your own health? This could include eating less fat or sugar, eating more fruits and vegetables, or exercising more often	(0.83%)			
Physical activity (with 1 = very inactive to 5 = very active)	3.36	0.67	2	5
Smoking frequency (With 1 = never, 2 = once every few months, 3 = once or twice a month, 4 = once a week, 5 = 3-4 times a week)	1.18	0.78	1	5
Alcohol Consumption (With 1 = never, 2 = once every few months, 3 = once or twice a month, 4 = once a week, 5 = 3-4 times a week)	1.34	0.77	1	4
Who in your household has received supplements as a part of the MDVA programme between the ages of 1 and 6 years?				
Yourself	(2.5%)			
Head of Household	(2.5%)			
Children	(80.5%)			
Other Adults	(0.8%)			
Other	(1.7%)			
I don't know	(9.3%)			
I do not know about the MDVA program	(2.5%)			
Please describe your diet				
I eat dairy and meat products	(91.00%)			
I eat dairy but not meat products	(5.00%)			
I eat meat products but not dairy	(2.00%)			
I am a vegetarian (no meats)	(2.00%)			
I am a vegan (no meats or animal products)	(1.00%)			

* Taken from the 2011 Census of India for the district of Koraput within Odisha, India
These data were collected from the survey instrument described in this paper

On average, participants purchased food once a week. The majority of participants (77.5%) purchased their food from a farmer's market, with the next most common option being a supermarket (11.7%), followed by a smaller retailer (8.3%) or directly from neighbours or associates (8.3%). More than half of participants typically purchased food from markers' markets once or twice a week (Table 4.2). Most people who chose to buy from supermarkets went three to four times a week, hinting that purchase sizes were likely small. Most participants who purchased from smaller retailers went once or twice a week.

Table 4.2 Breakdown of Indian consumer food purchase frequencies according to the place from which food is purchased

	Never	Once or twice every few months	Once or twice a month	Once a week	3 - 4 times a week	Total
Supermarkets	0.0%	0.0%	0.0%	3.3%	8.3%	11.7%
Smaller Retailers	0.0%	0.0%	0.8%	6.7%	0.8%	8.3%
Farmers' Markets	1.7%	0.8%	6.7%	53.3%	14.2%	76.7%
Neighbor's	0.0%	0.0%	0.0%	0.8%	0.0%	0.8%
Other	0.0%	0.0%	0.0%	2.5%	0.0%	2.5%
Grand Total	1.7%	0.8%	7.5%	66.7%	23.3%	100.0%

These data were collected from the survey instrument described in this paper

For the Canadian subsample, participants were recruited via word of mouth, radio advertisements, internet advertisements, and mailing lists around the University of Alberta within Edmonton, Alberta, Canada from March to July of 2015. Participants included undergraduate and graduate students, administrative staff, and off-campus persons but persons and students within the Department of Resource Economics and Environmental Sociology were excluded. The sample was older than the municipal average, and females were over-represented in the survey. On average, participants had more years of schooling, lower household income, and lower household size as compared to the Edmonton 2014 Census. The most common reported position within the household was head of household (40.6%), followed by one of two income earners (30.7%), then partner of head of household (13.9%). Therefore, the Canadian subsample may not be representative of the whole city and may instead be considered a convenience-based sample.

Self-rated health was either good or very good, with responses ranging from fair to excellent. No participants rated their health as poor. Participants had a higher self-rated health than the National Dairy Survey, which was believed to be a nationally representative sample (Allen 2012). A large number of participants reported making a dietary or health change within the last year (82.4%). Canadians were on average fairly physically active, with the mean smoking frequency between never or once every few months. Alcohol was consumed on average once every few weeks or once or twice a month. Roughly one-third of Canadian participants had a home or shared garden, with the majority of those eating everything that was produced, shared what was produced, or purchased less produce when the garden was in season.

Table 4.3 Summary of socio-demographic characteristics of Canadian cohort (n = 101)

Question	**Mean (% Freq)**	**St. Dev.**	**Min**	**Max**	**Population Data***
Age (years)	36.83	13.96	19	75	33.4
% Female	(68.60%)				49.5
Pregnant	0				0.01
Breastfeeding	0				0.02
Years of Schooling Completed	16.49	2.86	6	20	14.3
Household Income ($CAD)	72,627	37,322	12,499	130,000	97,390**
Household	2.20	1.09	1	4	2.9
Children in household	0.20	0.58			0.26
Position within household					
Primary income earner	(40.59%)				
Partner of head of household	(13.86%)				
One of two income earners	(30.69%)				
Child	(9.90%)				
Other family member	(2.97%)				
Other (not family member)	(4.95%)				
Usual place of food purchases					
Supermarket	(97.06%)				
Smaller retailer	(2.94%)				
Farmer's market	(10.78%)				
Directly from neighbours or associates	(0.98%)				
Other	(0.98%)				
Had a home or shared garden	(32.35%)				
Ate everything that was produced home or shared garden	(69.70%)				
Shared what was produced in home or shared gardens with others	(78.79%)				
Bought less produce when garden was in season	(90.91%)				
Food purchasing frequency (With 1 = never, 2 = once every few months, 3 = once or twice a month, 4 = once a week, 5 = 3-4 times a week)	4.09	0.68	1	5	

Self-rated Health (With 1 = Poor, 2 = Fair, 3 = Good, 4 = Very Good, 5 = Excellent)	3.61	0.80	2	5	3.36
Made a dietary change or health change within the past year	(82.35%)				
Physical Activity (with 1 = very inactive to 5 = very active)	3.52	0.90	1	5	
Smoking frequency (with 1 = never, 2 = once every few months, 3 = once or twice a month, 4 = once a week, 5 = 3-4 times a week)	1.32	0.90	1	5	
Alcohol consumption (with 1 = never, 2 = once every few months, 3 = once or twice a month, 4 = once a week, 5 = 3-4 times a week)	2.86	1.14	1	5	
Please describe your diet					
I eat dairy and meat products	(87.26%)				
I eat dairy but not meat products	(4.90%)				
I eat meat products but not dairy	(6.86%)				
I am a vegetarian (no meats)	(3.92%)				
I am a vegan (no meats or animal products)	(0.98%)				

*Taken from the 2014 Edmonton Census and the 2011 National Dairy Survey
**Median income in the province of Alberta
These data were collected from the survey instrument described in this paper

Similar to the Indian subsample, Canadian participants purchased food on average once a week. The vast majority of Canadian participants typically purchased their foods from a supermarket (97.1%), followed by farmer's markets, and smaller retailers. Of those who purchased from supermarkets, participants did so at least once a month, with almost two-thirds purchasing once a week, and 22.5% purchased 3-4 times per week (Table 4.4).

Table 4.4 Breakdown of Canadian participants' frequency of purchases according to the usual place food was purchased from

	Never	**Once or twice every few months**	**Once or twice a month**	**Once a week**	**3 - 4 times a week**	**Total**
Supermarkets	1.0%	1.0%	8.8%	63.7%	22.5%	97.1%
Smaller Retailers	0.0%	0.0%	1.0%	0.0%	0.0%	1.0%
Farmers' Markets	0.0%	0.0%	0.0%	1.0%	1.0%	2.0%
Total	1.0%	1.0%	9.8%	64.7%	23.5%	100.0%

These data were collected from the survey instrument described in this paper

The vast majority of participants consumed meat and dairy products. The Canadian population had a greater proportion of people who ate meat but not dairy, and who were vegetarian. Only one vegan from Canada was present within the entire sample.

4.3 Attitudes toward naturalness

Participants were asked to rate how natural they viewed each of the food bundles (Table 4.5; t-test comparisons of means are Appendix 4.3) Carrots were considered the most natural in both India and Canada, and were rated similarly by both sets of participants (not statistically significantly different, $p < 0.0001$). Indian participants considered Vitamin A supplements the least natural, followed by the fortified sunflower oil and the biofortified sweet potato (not significantly different from carrots, $p < 0.0001$). In Canada, margarine was viewed as the least natural product, followed by the vitamin A supplements and the biofortified sweet potato. The biofortified sweet potato was considered almost completely natural in India, while Canadian participants rated them significantly less natural. The majority of Indian participants had an agricultural background, and were likely more familiar with the process of plant breeding. This trait of familiarity is linked to the idea of naturalness, and may lead to lower levels of aversion that are evoked as a result of moral judgements (Lusk et al. 2014)

One of the interesting results is that Canadians perceived margarine to be less natural than supplements. Canadians may have perceived margarine as the least natural as hydrogenation of oils is a chemical change and considered a major modification of a food product (Rozin 2005). Extraction of a food, however, may have less of an impact or be considered more of a mechanical change.

Table 4.5 Perceptions of natural of Vitamin A rich foods of sample

Question		Mean	St. Dev.	Min	Max
How natural do you consider the following from a scale from 1 (not natural at all) to 7 (completely natural)?					
India					
	Vitamin A Supplements	1.73	0.96	1	4
	Carrots	6.73	0.66	4	7
	Fortified Sunflower Oil	3.87	0.77	2	7
	Biofortified Sweet Potato	6.60	0.73	3	7
Canada					
	Vitamin A Supplements	3.10	1.57	1	7
	Carrots	6.66	0.71	4	7
	Fortified Margarine	2.03	1.27	1	7
	Biofortified Sweet Potato	4.31	1.67	1	7

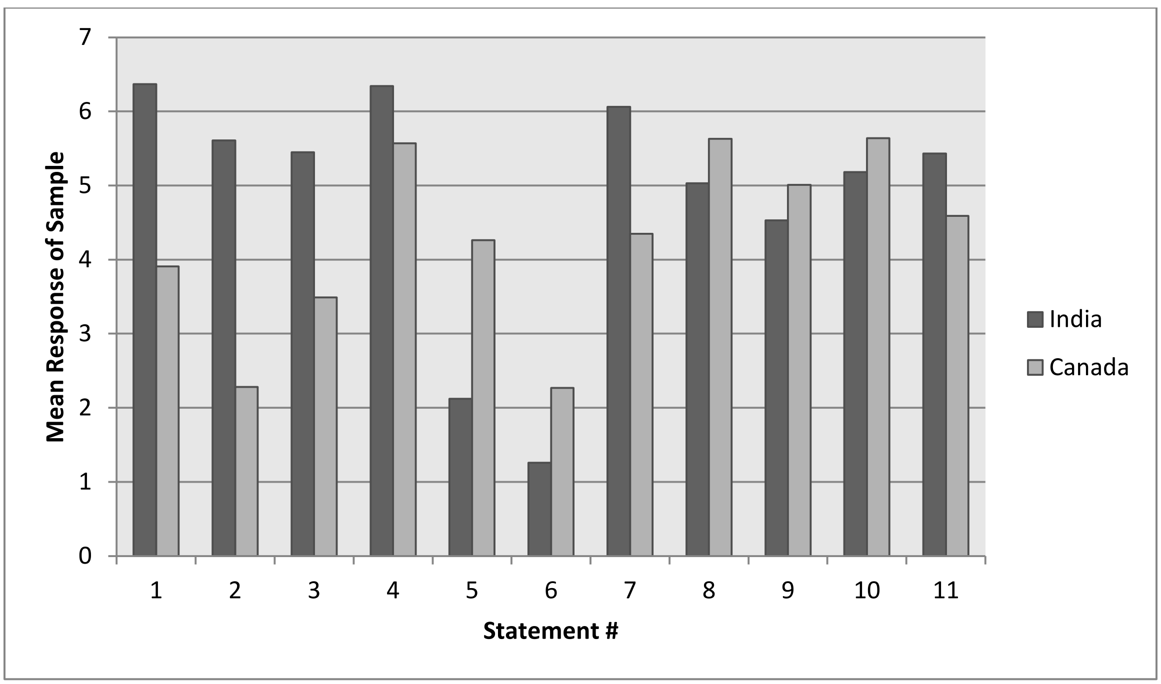
These data were collected from the survey instrument described in this paper

In order to explore attitudes towards naturalness, statements of naturalness were developed from the literature (Refer to Chapter 3, Table 3.4). Participants were asked to state whether or not they agreed or disagreed on a Likert scale from 1 to 7 with these statements. Statements may be found in Table 4.6, responses are summarized in Figure 1, and results of factor analysis are presented in Table 4.7. The Kaiser test was used to determine the number of factors the models loaded on (i.e. factors with Eigenvalues > 1). Alternatively, assessing the number of factors required to achieve 0.75 cumulative variance could have been used and yielded the same results. Both the Indian and Canadian models loaded on two factors, with variations in the items that loaded on which factor. Statements 1, 6, 8, 9, 10, and 11 were reverse scored and a varimax rotation was chosen for simplicity.

Table 4.6 Statements assessing participants' perceptions of what is natural in foods

#	Statement*
1	Natural foods have not been changed in any large way by humans (R)
2	The more familiar a food is the more natural it is
3	The more authentic a food is the more natural it is
4	Natural foods do not contain artificial flavours or additives
5	Natural foods are as good for me as other foods that might not be thought of as natural
6	Natural foods are not necessary for my health (R)
7	Naturalness in foods is valuable because it is pure
8	The more a food has been processed, the less natural it is (R)
9	Food that has ingredients removed is less natural (R)
10	Food with synthetic ingredients added are less natural than foods that do not have any ingredients added (R)
11	Foods with "natural" ingredients added are less natural than foods that do not have any ingredients added (R)

*Refer to Table 3.4 for sources statements were developed with



These data were collected from the survey instrument described in this paper

Figure 4.1 Summary of responses to natural statements of Indian and Canadian samples

The Indian cohort on average agreed or strongly agreed that natural foods have not been changed in any large way by humans nor do they contain artificial flavours or additives (Figure 4.1). Natural foods were also perceived as more valuable because they were pure. Indian participants tended to disagree or strongly disagree with the statements that natural foods were unnecessary for one's health, and that natural foods were as good for them as foods that might not be thought of as natural. Responses were relatively neutral for the statement that foods that have had ingredients removed were less natural. Generally, more Indian participants agreed that more familiar or authentic foods were more natural.

For the Canadian subsample, participants tended to disagree or strongly disagree with the statement that familiar foods were more natural, and that natural foods were not necessary for health. Participants, on average, agreed more that natural foods did not contain any artificial flavours or additives, and that it has been less processed. Participants were fairly neutral in regards to whether or not natural foods have not been changed in any large way by humans. This statement had a high variance of answers and the highest standard deviation, hinting that participants were quite polarised on the issue. Several participants made written and oral comments indicating awareness that the foods eaten today may be cultivated or altered by humans, but many participants still considered these foods to be natural. Participants also slightly disagreed with the sentiment that familiar foods were more natural, so Canadians may be more familiar with processed foods than their Indian counterparts. This is expected given the greater availability and use of processed foods in India than in Canada. Both Indian and Canadian participants disagreed or strongly disagreed that natural foods were not necessary for health, while agreeing or strongly agreeing that processing leads to decreased naturalness, and that synthetic and natural additives decreased the naturalness of a food product.

Table 4.7 Factor loadings and means in analysis of attitudes towards natural in India (n=120) and Canada (n = 102)

		India		Canada	
#	**Statement**	**Pure**	**Processing**	**Processing**	**Pure**
1	Natural foods have not been changed in any large way by humans (R)	**-0.7023**	0.0337	0.1973	**-0.4447**
2	The more familiar a food is the more natural it is	0.1495	**-0.5253**	0.1062	**0.6076**
3	The more authentic a food is the more natural it is	0.0383	**-0.6702**	-0.0875	**0.7076**
4	Natural foods do not contain artificial flavours or additives	**0.7496**	-0.0874	-0.1865	**0.4193**
5	Natural foods are as good for me as other foods that might not be thought of as natural	**-0.4466**	0.1258	**0.2219**	-0.1813
6	Natural foods are not necessary for my health (R)	**0.6656**	-0.0819	-0.3011	**0.3706**
7	Naturalness in foods is valuable because it is pure	**0.5056**	0.2188	-0.2655	**0.6982**
8	The more a food has been processed, the less natural it is (R)	-0.1006	**0.4715**	**0.6758**	-0.1765
9	Food that has ingredients removed is less natural (R)	0.0399	**0.5321**	**0.6643**	-0.1633
10	Food with synthetic ingredients added are less natural than foods that do not have any ingredients added (R)	-0.1762	**0.3243**	**0.7454**	-0.0321
11	Foods with "natural" ingredients added are less natural than foods that do not have any ingredients added (R)	**-0.3838**	-0.0136	**0.5570**	-0.0734

Model 1:

Cronbach's Alpha = 0.66, Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.71

Bartlett Test of Sphericity: Chi-squared = 266.51, df = 55, $p < 0.0001$

Model 2:

Cronbach's Alpha = 0.77, Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.77

Bartlett Test of Sphericity: Chi-squared = 282.90, df = 55, $p < 0.0001$

The results of the KMO test for sampling adequacy meets the minimum requirement of 0.7 for both samples. The Bartlett Test of Sphericity also indicates that the null hypothesis that the population matrix is an identity matrix may be rejected. This indicates that factor analysis was appropriate for our sample. Cronbach's alpha was low for the first model, indicating low internal reliability, while Cronbach's alpha was greater than 0.7 for model 2 which indicated good internal reliability. This discrepancy could be due to the statements used in the survey being developed from literature that was done in a Western context. Alternatively, more data could be required to improve sampling adequacy.

For the factor analysis, items 1, 5 and 11 loaded negatively on factor 1 for the first model, while statements 4, 6, and 7 loaded positively. For factor 2, statements 2 and 3 loaded negatively while statements 8, 9, and 10 loaded positively. Generally loadings with a magnitude greater than 0.4 are considered significant (Coppola et al. 2014). Therefore a person with a higher factor 1 score tended to believe that natural foods have been changed in any large way by humans, that natural foods however did not contain artificial flavours or additives, but believed that a natural food was valuable because it was pure. This factor was named the "purity" factor, or the extent to which a participant equated naturalness with purity. Factor 2 was associated with not agreeing that natural foods were authentic or familiar, but rather had been more processed, or had synthetic ingredients or ingredients removed. This factor was named naturalness as the converse of processing. The loadings were quite low for statements 10 and 11 in model 1 however, indicating that neither item explains much of the variance in either factor.

For the Canadian sample in model 2, items 8, 9, 10, and 11 loaded positively onto factor 1 while items 2, 3, 4, and 7 loaded positively onto factor 2. Item 1 loaded negatively on factor 2. A higher score in factor 1 indicated that a participant more strongly associates naturalness with less processing while a higher score in factor 2 indicates that a natural food is more familiar, authentic, and pure while containing no flavours or additives and having not been changed in any large way by humans. Factors 1 and 2 were thus deemed "Naturalness as the converse of processing" and "Purity".

In the Canadian model, the processing factor explained much more of the variance as compared to the Indian subsample. This indicates that one attitude or perception of the meaning of naturalness may predominate in different cultures. From the factors it is apparent that there is a stronger association between natural foods and authenticity and familiarity leads to a decreased score in associating natural foods and processing. However, these traits are not necessarily associated with purity either. This implies that there may be some drivers of attitudes around naturalness in foods that is not fully captured by the survey. Further research may be warranted in exploring attitudes in non-Western cultures.

4.4 Knowledge

Objective knowledge (OK) and subjective knowledge (SK) of nutrition and health were both measured due to their differing effects on consumer behaviour. OK was assessed with a series of statements regarding of nutrition, diet, and production techniques of how vitamin A might be added to or increased in food. Participants rated how much they agreed with statements regarding nutrition, diet, and technical production processes on a scale from 1 (strongly agree) to 5 (strongly agree). Participants were then asked if they agreed or disagreed with five food technology statements, and then stated how certain they were of each of their answers. This design allowed consumers to give a measure of guessing, as questions answered correctly but had low certainty scores were given less weight when calculating OK scores. Certainty was included for the objective knowledge scores for food production and technology but these questions were considered too difficult for the Indian participants to answer. However, Indian participants gave more correct answers to the production and technology questions and were more certain of their answers compared to their Canadian counterparts. This however may have been impeded by the oral nature of the survey as participants could hear answers of others. Therefore for the analysis, only questions that assessed knowledge of nutrition and diet were used.

SK was measured with three statements based off of the questionnaire developed in Pieniak et al. (2010) and Aertsens et al. (2011) and adapted to be centered on diet and nutrition. No information was given regarding vitamin A or diet prior to the knowledge assessment, although some information was provided on fortification and biofortification on the nutrition information cards. All statements given were “correct” except for the statement “vitamin A is water soluble vitamin”. The majority of Indian and Canadian respondents agreed or strongly agreed with the nutrition and health statements as well as the food technology and processing statements. This indicates that most participants had a basic knowledge of the function of vitamins and their role in health. A lower percentage of the Indian sample agreed with whether or not foods could be bred, grown, or genetically modified to have more vitamins A. The statement that “Vitamin A was a water soluble vitamin” was incorrect, and a greater proportion of Indian participants disagreed with this statement than Canadian participants.

Table 4.8 Summary of responses to objective and subjective knowledge statements of the Indian cohort (n = 120)

Question	**Mean (% Freq.)**	**St. Dev.**	**Min**	**Max**
Objective Knowledge of Nutrition and Diet On a Scale from 1 (strongly disagree) to 5 (strongly agree)				
Vitamins are important for maintaining health	4.74	0.60	2	5
Foods with more vitamins are more nutritious	4.58	0.64	2	5
A lack of vitamins in childhood can affect growth or development	4.67	0.69	2	5
You need to eat a certain amount of each vitamin every day to meet your body's needs	4.63	0.64	2	5
Vitamins can help prevent illness and disease	4.46	0.77	2	5
Objective Knowledge (Production and Technology) % agreeing, certainty from a scale of 1 (not certain) to 5 (very certain)				
Foods can be bred, grown, or genetically modified to have more Vitamin A	(87.4%)	0.33	0	1
Certainty	4.68	1.14	3	7
Vitamin A is important in the function of the immune system	(98.3%)	0.13	0	1
Certainty	3.73	0.83	2	5
Vitamin A supplements can be made in a lab or extracted from whole foods	(96.7%)	0.18	0	1
Certainty	3.65	0.90	1	5
Vitamin A can be added to foods after it has been processed to increase its Vitamin A content	(95.0%)	0.22	0	1
Certainty	3.72	0.93	1	5
Vitamin A is a water soluble vitamin (R)	(92.5%)	0.26	0	1
Certainty	3.83	0.94	2	5
Fortification is the addition of new vitamins or minerals to a processed food	4.12	0.72	2	5
Biofortification involves breeding new plants that meet nutrient targets	4.03	0.67	1	5
Enhanced foods are animal products that have increased vitamins or minerals as a result of certain animal feeds	3.69	0.93	1	5
Foods may have vitamins and minerals as a result of their natural biology	4.18	0.71	2	5
Subjective Knowledge On a Scale from 1 (strongly disagree) to 7 (strongly agree)				
Compared with the average person, I know a lot about how to get vitamins in my diet	4.58	1.81	1	7
I know a lot about how to judge the quality of my diet	4.25	1.75	1	7
People who know me think I am an expert on what is the best way to get vitamins into my diet	3.68	1.64	1	7

These data were collected from the survey instrument described in this paper

Table 4.9 Summary of responses to objective and subjective knowledge statements of the Canadian cohort (n = 102)

Question	Mean (% Freq)	St. Dev.	Min	Max
Objective Knowledge of Nutrition and Diet On a Scale from 1 (strongly disagree) to 5 (strongly agree)				
Vitamins are important for maintaining health	4.64	0.70	1	5
Foods with more vitamins are more nutritious	3.91	1.13	1	5
A lack of vitamins in childhood can affect growth or development	4.80	0.49	2	5
You need to eat a certain amount of each vitamin every day to meet your body's needs	4.05	0.94	1	5
Vitamins can help prevent illness and disease	4.42	0.79	1	5
Objective Knowledge (Production and Technology) % agreeing, certainty from a scale of 1 (not certain) to 5 (very certain)				
Foods can be bred, grown, or genetically modified to have more Vitamin A	(93.1%)	0.29		
Certainty	3.90	1.05	1	5
Vitamin A is important in the function of the immune system	(90.2%)	0.23		
Certainty	3.25	1.19	1	5
Vitamin A supplements can be made in a lab or extracted from whole foods	(99.0%)	0.99		
Certainty	3.68	0.98	1	5
Vitamin A can be added to foods after it has been processed to increase its Vitamin A content	(92.2%)	0.52		
Certainty	3.65	1.03	1	5
Vitamin A is a water soluble vitamin (R)	(72.7%)	0.51		
Certainty	2.99	1.31	1	5
Fortification is the addition of new vitamins or minerals to a processed food	4.01	0.87	1	5
Biofortification involves breeding new plants that meet nutrient targets	4.11	0.78	2	5
Enhanced foods are animal products that have increased vitamins or minerals as a result of certain animal feeds	3.08	0.78	1	5
Foods may have vitamins and minerals as a result of their natural biology	4.73	0.51	3	5
Subjective Knowledge On a Scale from 1 (strongly disagree) to 7 (strongly agree)				
Compared with the average person, I know a lot about how to get vitamins in my diet	4.98	1.19	1	7
I know a lot about how to judge the quality of my diet	5.36	1.07	2	7
People who know me think I am an expert on what is the best way to get vitamins into my diet	3.63	1.44	1	7

These data were collected from the survey instrument described in this paper

For the SK statements, participants tended to agree with or be neutral about whether or not they knew about how to get vitamins in their diet as compared to the average person. This is similar to results for whether or not participants knew how to judge the quality of their diet. Both subsamples tended to agree less with the statement “People who know me think I am an expert on what is the best way to get vitamins into my diet”. There was greater variance for all statements in the Indian subsample as compared to the Canadian.

SK was calculated as the sum of scores for the subjective knowledge questions while OK was calculated as the sum of scores for the objective knowledge of diet and health questions only (Table 4.10). Recall that OK was calculated based on responses to the nutrition and diet related questions. Indian participants had a lower SK score than the Canadian subsample, although the variance of scores is greater. The minimum SK of the Indian sample was lower than that of the Canadian sample. The Indian subsample had a higher mean OK score and less variance than the Canadian subsample. An unpaired t-test for the comparison of the means between countries shows that the differences between subsamples in SK and OK scores are highly statistically significantly different ($p < 0.01$). This is unexpected, as typically higher SK scores positively correlates to higher OK scores (Carlson et al. 2009). However, much of the relationships examined were for Western cultures and it is unclear whether this relationship would remain. Perhaps issues of trust and self-image may have come into effect as Indian responses were given orally, in the presence of other participants. This result is also very similar to that found by Zhang and Liu (2015), where Chinese respondents had high objective knowledge but not high subjective knowledge. There is likely a cultural component then in which increased factual knowledge does not always translate to greater amounts of confidence in all countries.

Table 4.10 Summary of total subjective and objective knowledge scores for both India and Canada

SK	Mean	St. Dev	Min	Max
India	12.50	4.64	3	21
Canada	13.97	3.21	6	21

OK	Mean	St. Dev	Min	Max
India	23.08	2.37	14	25
Canada	21.82	2.60	7	25

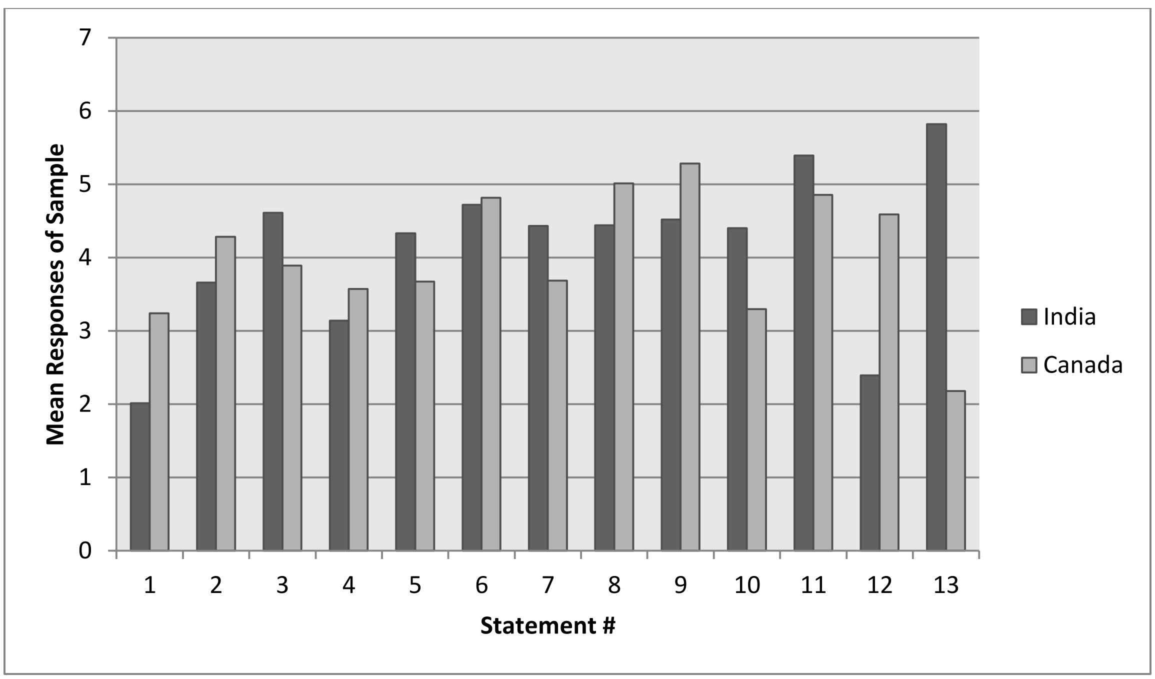
These data were collected from the survey instrument described in this paper

4.5 Food Technology Neophobia

The scale for food technology neophobia was first developed by Cox and Evans in 2008, with follow-up analysis demonstrating that it is stable over time, reliable, and internally valid (Evans et al. 2010b). Participants were asked to state whether they agreed or disagreed on a scale from 1 to 7 with thirteen statements that assessed participants' aversion or disgust felt towards foods produced with novel technologies (Table 4.11). The same scale was used for all participants and factor analysis was performed. Statements 10, 11, 12, and 13 were reverse scored. A Kaiser test was used to determine the factors that the models loaded on, and varimax rotation was used for simplicity. The responses to each statement and total FTNS scores are analyzed by summing the responses from the 13 statements after the appropriate items were reverse scored. After performing tests of appropriateness, a factor analysis was performed on both the Indian and Canadian samples.

Table 4.11 Food Technology Neophobia Scale statements (Cox and Evans 2008)

#	Description
1	There are a plenty of tasty foods around so we don't need to use food technology to produce more
2	The benefits of new technologies are often grossly overstated
3	New food technologies decrease the natural quality of food
4	There is no sense trying out high-tech food products because the ones I eat are already good enough
5	New foods are not healthier than traditional foods
6	New food technologies are something I am uncertain about
7	Society should not depend heavily on technologies to solve its food problems
8	New food technologies may have long term negative environmental effects
9	It can be risky to switch to new technologies too quickly
10	New food technologies are unlikely to have long term negative health effects (R)
11	New products produced using new food technologies can help people have a balanced diet (R)
12	New food technologies give people more control over their food choice (R)
13	The media usually provides a balanced and unbiased view of new food technologies (R)



These data were collected from the survey instrument described in this paper

Figure 4.2 Mean responses to statements in the FTNS for Indian and Canadian samples

The mean responses between the two subsamples are statistically significantly different except for statement 4 (There is no sense trying out high-tech food products because the ones I eat are already good enough) and statement 6 (new food technologies are something I am uncertain about). On average, Indian participants disagreed or strongly disagreed with the statement "There are plenty of tasty foods so we don't need food technology to produce more" whereas Canadians either disagreed or were neutral for the same statement. Participants from both countries were relatively neutral about items 2 to 7, although Canadians tended to feel more that new food technologies may have long-term negative impacts on the environment, and that it can be riskier to switch to new food technologies too quickly. Both Indian and Canadian participants agreed that food technology could lead to people having more balanced diets. However, the samples had highly differing opinions on statements 12 and 13. Canadians neither agreed nor disagreed that new food technologies could improve control over food choices, but many Indian participants either disagreed or strongly disagreed with this. In addition, Indian participants perceived their media to provide a balanced and unbiased view of new food technologies while Canadians felt the opposite which suggestions that Indian participants had higher levels of trust in the media.

Table 4.12 Mean FTNS scores for Indian and Canadian subsamples

FTNS	Mean	St. Dev	Min	Max
India	46.95	7.68	30	65
Canada	54.50	10.90	26	82

These data were collected from the survey instrument described in this paper

The total FTNS score was calculated by summing the non-factored statements. FTNS scores could theoretically range from 13 to 91. Canadians were significantly more food technology neophobic than their Indian counterparts (t-value = 6.0295, d.f. = 220, $p < 0.0001$) and there was a larger standard deviation and range of FTNS scores for Canadians.

Factor analysis of the Indian (model 1) and Canadian (model 2) subsamples were performed to collapse the statements into major drivers of food technology neophobia attitudes

(Table 4.13). Pre-tests were done to determine if factor analysis was appropriate. For model 1, there was low internal consistency within the model, in addition to mediocre sampling adequacy as determined by the Kaiser-Meyer-Olkin measure. However, a KMO > 0.50 indicates that factor analysis is still permissible, and the Bartlett Test of Sphericity supports this. The Canadian data had a Cronbach's alpha equal to 0.80, and a KMO measure > 0.70, so factor analysis was appropriate for this model. Results of factor analyses may be found in Table 4.10.

Our first model for the Indian subsample showed that items 1, 4, 6, 11, 12, and 13 loaded positively while items 3, 5, 7, 8, 9, and 10 loaded positively on the second component. Item 2 loaded negatively on factor 2. An individual with a higher score in component 1 would be associated with an aversion to foods produced with food technology, while disagreeing that food produced with new technologies help people have a balanced diet, or give more control over food choices. A higher score would also indicate less trust in how the media portrays foods produced with new technologies. Component 2 can be interpreted as the extent to which an individual may perceive using novel food technologies as risky while not increasing the quality of the food or its healthfulness. Factors 1 and 2 were thus named "necessary" and "risky" respectively.

For the second model, items 1, 2, 3, 4, 5, 6, 11, and 12 loaded positively onto component 1 while items 7, 8, 9, 10, and 13 loaded positively onto factor 13. A score in the first component indicated that consumers were less likely to see foods produced with novel technologies as necessary or provide benefits for health or increase control over food choices. Component 2 was the extent to which consumers perceived a food produced with novel technologies to be risky. However the loading for item 13 is very low, indicating that it contributes very little information in the Canadian data set.

Table 4.13 Factor loadings for FTNS Factor analysis

#	Description	India Necessary	India Risky	Canada Necessary	Canada Risky
1	There are a plenty of tasty foods around so we don't need to use food technology to produce more	**0.6574**	-0.2731	**0.7012**	0.2000
2	The benefits of new technologies are often grossly overstated	0.1452	**-0.2286**	**0.4349**	0.3818
3	New food technologies decrease the natural quality of food	-0.0275	**0.3069**	**0.7108**	0.1673
4	There is no sense trying out high-tech food products because the ones I eat are already good enough	**0.5777**	0.2543	**0.7331**	0.1036
5	New foods are not healthier than traditional foods	0.1031	**0.4783**	**0.6318**	-0.0790
6	New food technologies are something I am uncertain about	**0.2598**	0.1866	**0.4162**	0.2700
7	Society should not depend heavily on technologies to solve its food problems	-0.1079	**0.2493**	0.4574	**0.5149**
8	New food technologies may have long term negative environmental effects	0.1977	**0.5013**	0.1216	**0.7462**
9	It can be risky to switch to new technologies too quickly	0.0509	**0.6154**	0.0057	**0.6249**
10	New food technologies are unlikely to have long term negative health effects (R)	0.1168	**0.2789**	0.1199	**0.2703**
11	New products produced using new food technologies can help people have a balanced diet (R)	**0.4933**	0.0234	**0.5339**	0.0651
12	New food technologies give people more control over their food choice (R)	**0.2073**	0.1722	**0.4974**	0.0796
13	The media usually provides a balanced and unbiased view of new food technologies (R)	**0.7612**	0.1754	0.0039	**0.0637**

Model 1:

Cronbach's Alpha = 0.60, Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.56

Bartlett Test of Sphericity: Chi-squared = 281.64, df = 78, p <0.001

Model 2:

Cronbach's Alpha = 0.80, Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.77

Bartlett Test of Sphericity: Chi-squared = 385.64, df = 78, p < 0.0001

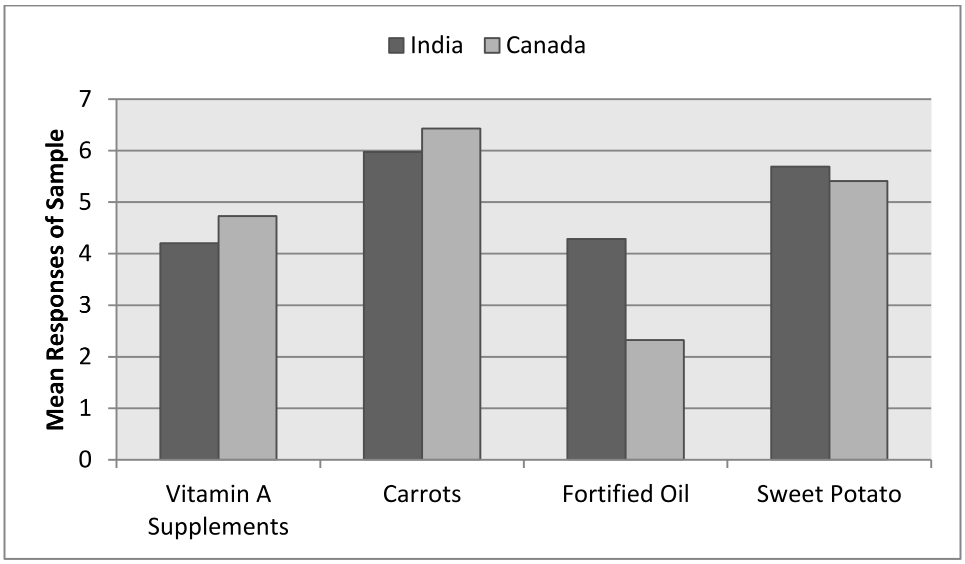
The factor analysis for both Indian and Canadian subsamples showed some similarities between Indian and Canadian cohorts. Statements 1, 4, 6, 11, and 12 loaded positively onto factor 1 while statements 7, 8, 9, and 10 loaded positively onto factor 2 in both models. Typically in the past for FTNS there are four factors that the model loads onto (Cox and Evans 2008; Evans et al. 2010b; Caracciolo et al. 2011; Verneau et al. 2014), but there have been occasions where the model only loads on two factors (Chen et al. 2013; Jezewska-Zychowicz and Królak 2015). This is likely due to a lower sample size as the papers by Chen et al. (2013) and Jezewska-Zychowicz and Królak (2015) have sample sizes of n = 108 and n=100 respectively. This may have also contributed to low Cronbach's alphas for the Indian model.

For Cox and Evans (2008) and many of the subsequent papers using FTNS, factor analysis models loaded on four factors. Items 1 through 6 loaded onto the factor named "new food technologies are unnecessary", items 7-10 loaded onto "perceptions of risks" associated with new food technologies, items 11 and 12 loaded onto the factor associated with foods produced with new technologies as "healthy choices" and item 13 loaded onto the factor associated with information/media. In models in which only two factors loaded, the results for model 2 are in-line with previous literature. However, six of the thirteen items had low loadings ($< |0.4|$), indicating that they contributed low explanatory power to the variance within a factor. This could be due to the lack of extensive food processing or novel food technologies used in India.

4.6 Characteristics of vitamin A-rich goods

This section examines consumer perceptions of the vitamin A rich sources that participants were presented with in the experiment and other common sources such as milk and dairy. Further information regarding attitudes of consumers towards these food products may be revealed by examining frequency of consumption, purchases, and usage of these foods. This may provide insight as to the drivers of WTP of Vitamin A sources in the later chapters. T-tests were done for comparisons of means for these ratings and may be found in Appendix 4.3. At the end of the section the overall relative rankings of vitamin A sources by various characteristics are summarized.

4.6.1 Healthiness



These data were collected from the survey instrument described in this paper

Figure 4.3 Mean responses of how healthy consumers considered various Vitamin A sources from a scale from 1 (not healthy at all) to 7 (extremely healthy)

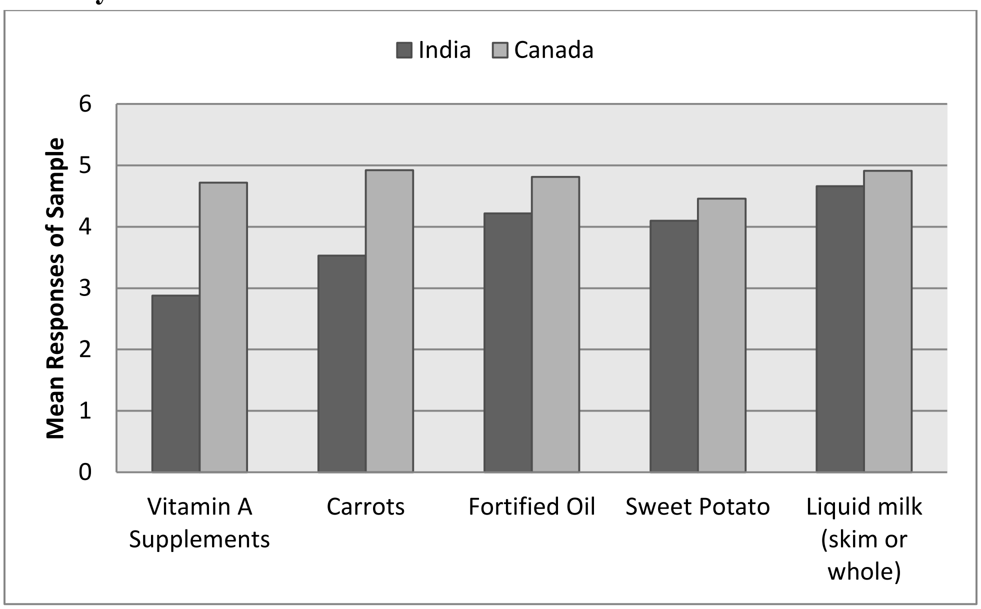
On average, Canadians rated vitamin A supplements and carrots to be healthier than their Indian counterparts. Healthiness ratings of biofortified sweet potato were not significantly different between the two subsamples. Indians rated fortified oil to be significantly healthier as compared to the Canadian rating of fortified margarine.

Indians rated carrots the healthiest, followed by sweet potato, fortified oil, and vitamin A supplements. Mean ratings of sweet potato and carrots, and fortified oil and supplements were not statistically significantly different. Canadians, on the other hand, rated carrots the healthiest, then sweet potato, vitamin A supplements, and then margarine, which was rated unhealthy or not healthy at all. All differences for the Canadian subsample were significantly different.

Table 4.14 Comparison of means with a t-test for ratings of healthiness of vitamin A sources by Indian and Canadian subsamples (d.f. 220).

	t-value	p-value
Vitamin A Supplements	3.0478	0.0026
Carrots	3.5764	0.0004
Fortified Margarine	13.3531	<0.0001
Sweet Potato	1.4967	0.1359

4.6.2 Accessibility



These data were collected from the survey instrument described in this paper

Figure 4.4 Mean ratings of the ease with which participants could acquire vitamin A sources on a scale from 1 (very hard) to 5 (very easy)

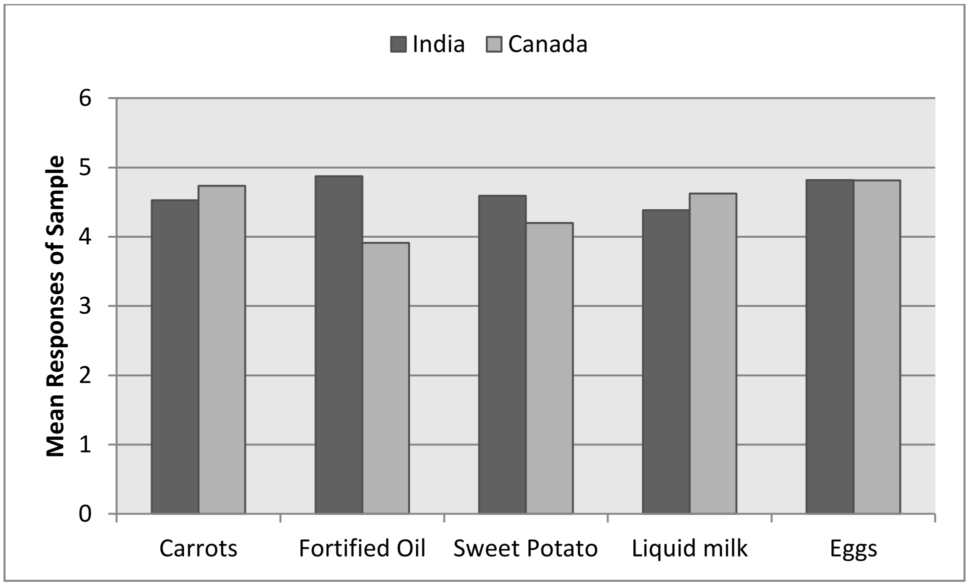
Generally Canadians found all food products very easily accessible, while their Indian counterparts found it more difficult to access all products. This could be attributed to Indian participants shopping mostly at farmers ' markets, which may not have as wide a variety of products as supermarkets nor are they as ubiquitous in India as they are in Canada. For example, many Indian respondents stated they had never seen vitamin A supplements before and supplements were only typically available from pharmacies. The availability of carrots for the Indian subsample was expected to be lower as it is a seasonal crop in India and not available year-round.

Indian participants found liquid milk the easiest to acquire, followed by fortified oil, sweet potato, carrots, and Vitamin A supplements. Oil and sweet potatoes were not statistically significantly different. For Canadians, carrots were the easiest to acquire followed by milk, margarine, vitamin A supplements, and sweet potato. There was no significant difference between carrots, milk, and margarine. Margarine and supplements were not statistically significantly different while Canadians found sweet potatoes significantly more difficult to acquire than any other product, although this difference is small.

Table 4.15 Comparison of means with a t-test for ratings of ease with which participants could acquire vitamin A-rich sources between Indian and Canadian subsamples (d.f. 220).

	t-value	**p-value**
Vitamin A Supplements	16.7814	<0.0001
Carrots	15.5323	<0.0001
Fortified Margarine	5.4067	<0.0001
Sweet Potatoes	2.7471	0.0065
Liquid milk (skim or whole)	3.8897	<0.0001

4.6.3 Ease of food preparation



These data were collected from the survey instrument described in this paper

Figure 4.5 Mean responses of the ease with which participants could prepare foods with various foods rich in vitamin A on a scale from 1 (very hard) to 5 (very easy)

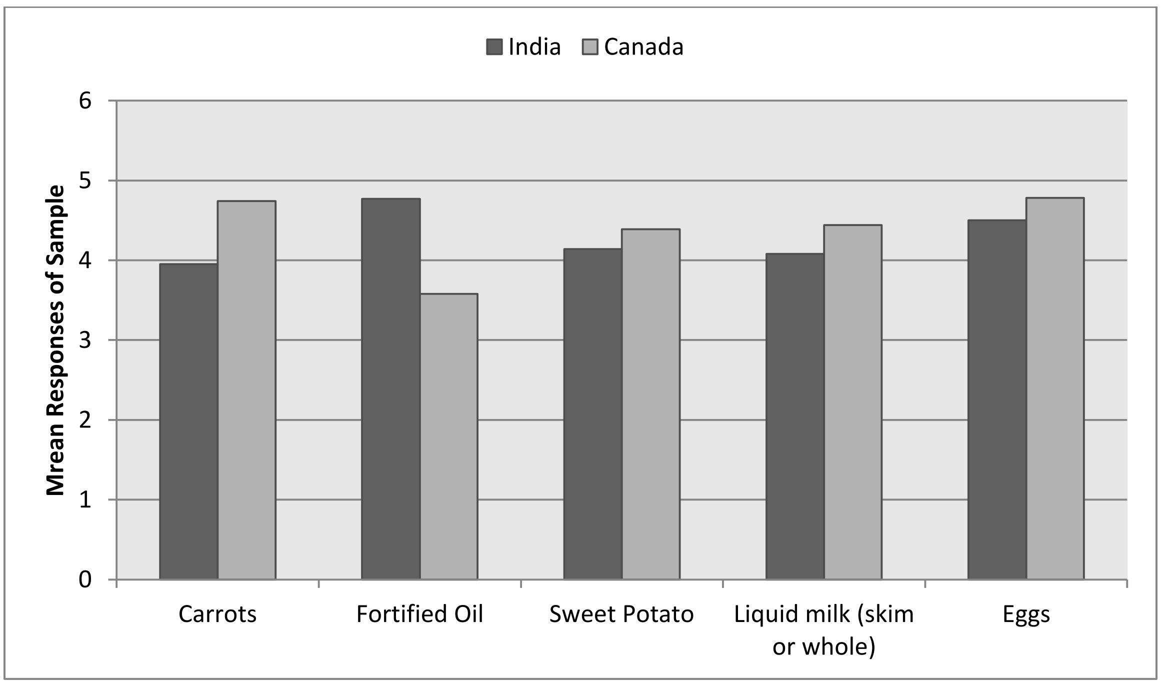
Participants form both subsamples found liquid milk and eggs easy or very easy to cook with. Canadians found cooking with carrots easier than Indians, while Indians found it easier to cook with fortified oil than Canadians did with margarine. Indians also rated cooking with sweet potato easier than Canadians, although this difference was significant but small.

Indian participants found preparing foods with fortified oil the easiest, followed by eggs, sweet potato, carrots, and liquid milk. Sweet potato, carrots, and liquid milk were not significantly different. Canadians, on the other hand, found it easiest to prepare foods with eggs, carrots, liquid milk, sweet potato, and lastly, margarine. Eggs and carrots, carrots and milk, and sweet potato and margarine were not statistically different.

Table 4.16 Comparisons of means with a t-test for ratings of ease with which participants could prepare foods with various vitamin A-rich foods between Indian and Canadian subsamples (d.f. = 220)

	t-value	p-value
Carrots	2.1605	0.0318
Fortified Margarine	7.4563	<0.0001
Sweet Potato	3.3958	0.0008
Liquid milk	1.894	0.0595
Eggs	0.1429	0.8865

4.6.4 Ease of consumption



These data were collected from the survey instrument described in this paper

Figure 4.6 Mean responses of the ease with which participants could consume vitamin A sources on a scale from 1 (very hard) to 5 (very easy)

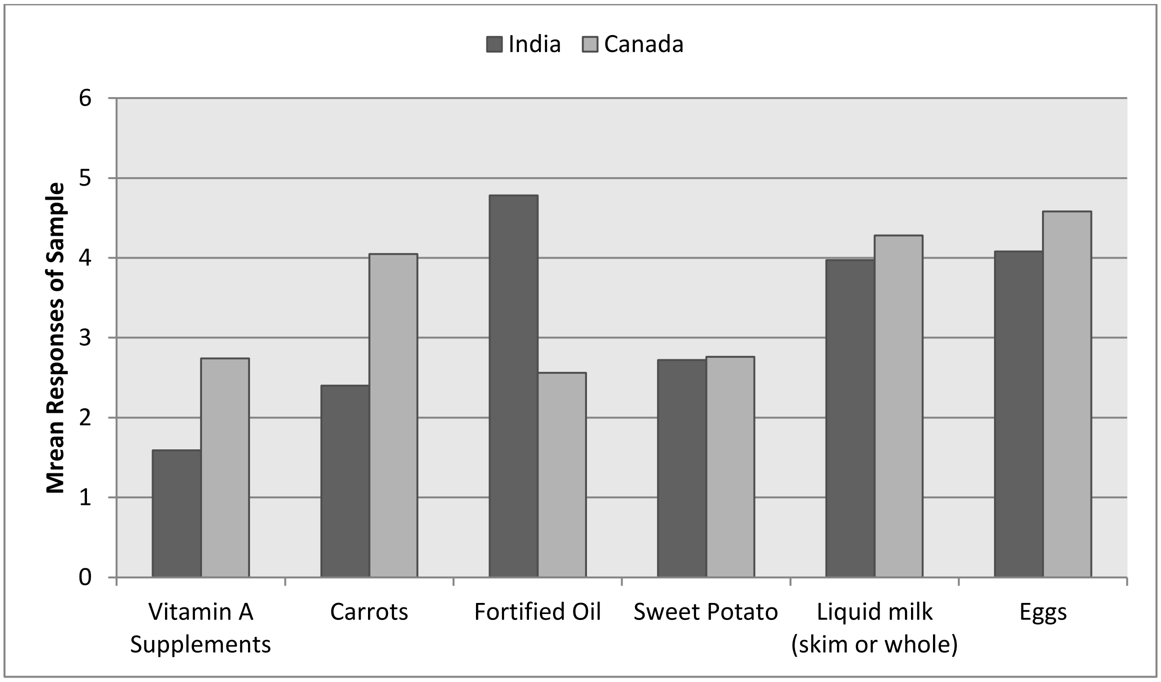
Generally Indian participants and Canadians felt that it was easy or very easy to consume all of the vitamin A sources. Canadians considered carrots, liquid milk, and eggs to be easier to consume than their Indian counterparts while Indians considered fortified oil to be easier consume than margarine. Indians and Canadians similarly found sweet potato easy to consume.

Indians considered fortified oil to be the easiest to consume, followed by eggs, sweet potato, liquid milk, and then carrots. The means for sweet potato, liquid milk, and carrots were not statistically significantly different, although eggs and fortified oil were considered significantly easier to consume. Canadians rated eggs the easiest to consume, followed by carrots, liquid milk, sweet potato, and margarine. Eggs and carrots, and sweet potatoes and liquid milk were not statistically significantly different.

Table 4.17 Comparisons of means with a t-test for ratings of ease with which participants could consume the following vitamin A sources between Indian and Canadian subsamples (d.f. 220)

	t-value	**p-value**
Carrots	6.8897	<0.0001
Fortified Margarine	7.8883	<0.0001
Sweet Potato	1.8646	0.0636
Liquid milk (skim or whole)	2.5011	0.0131
Eggs	2.5947	0.0101

4.6.5 Frequency of consumption



These data were collected from the survey instrument described in this paper

Figure 4.7 Mean responses of the frequency of consumption of different vitamin A rich sources with 1 = never, 2 = once every few months, 3 = once or twice a month, 4 = once a week, 5 = 3-4 times a week

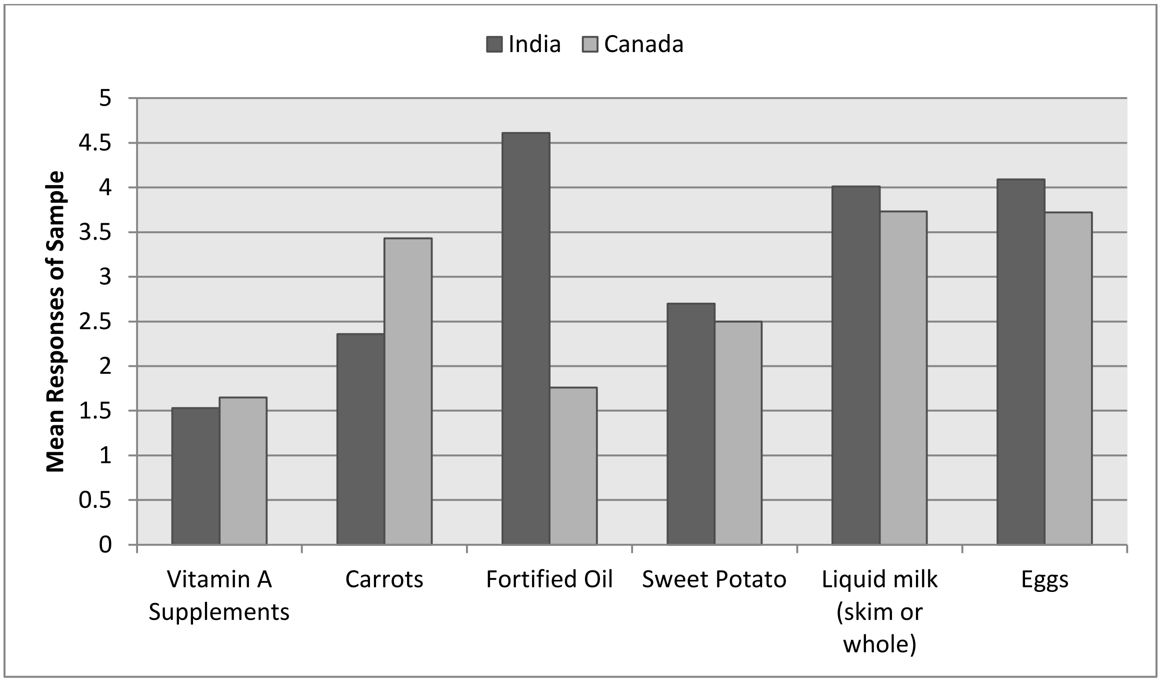
Vitamin A supplements were consumed never or once every few months for the Indian cohort, while Canadians consumed vitamin a supplements once every few months or once or twice a month. Canadians consumed carrots once a week, while Indian participants consumed carrots once every few months or once or twice a month. Indian participants consumed fortified sunflower oil 3 to 4 times a week on average, while margarine was consumed far less by Canadians, only once every few months or once or twice a month. Sweet potato was consumed in similar levels between samples, only once every few months or once or twice a month. Liquid milk and eggs were consumed once a week or more by both Indian and Canadian subsamples. Differences in mean consumption levels between the subsamples were statistically significantly different at the 5% confidence level for sweet potatoes and milk.

Indian participants ate fortified oil the most often, followed by eggs, milk, sweet potato, carrots, and vitamin A supplements. Canadians consumed eggs the most frequently on average, followed by milk, carrots, sweet potato, vitamin A supplements, and then margarine. The means for frequency of consumption were not statistically significantly different for sweet potato, vitamin A supplements, or margarine, while eggs and milk were not statistically significantly different, nor were milk and carrots.

Table 4.18 Comparisons of means with a t-test of the frequency of consumption of different vitamin A rich sources between Indian and Canadian subsamples (d.f. = 220)

	t-value	**p-value**
Vitamin A Supplements	7.004	<0.0001
Carrots	17.8997	<0.0001
Fortified Margarine	15.1075	<0.0001
Sweet Potato	0.363	0.717
Liquid milk (skim or whole)	1.895	0.0594
Eggs	4.9204	<0.0001

4.6.6. Frequency of purchasing



These data were collected from the survey instrument described in this paper

Figure 4.8 Mean responses of the frequency of purchasing Vitamin A rich sources with 1 = never, 2 = once every few months, 3 = once or twice a month, 4 = once a week, 5 = 3-4 times a week

When examining how often consumers purchased vitamin A rich goods, supplements were purchased never or once every few months by participants, and frequency of purchases were not statistically different between samples. Carrots were purchased by the Indian subsample once every few months or once or twice a month, while Canadians purchased carrots once or twice a month or once a week. Fortified oil was purchased often in India (three to four times a week), whereas margarine was purchased in Canada never or once every few months on average by the subsample. This is not unexpected as margarine has a long shelf-life and is consumed in smaller quantities. Sweet potato was purchased once or twice a month on average by both subsamples. Liquid milk and eggs was purchased once or twice a month or once a week for both samples as well but the mean for Indian participants of frequency of egg purchases was significantly higher for Indian participants.

Looking at frequency of food purchases it is clear that Indians purchased fortified oil the most often, followed by eggs, liquid milk, sweet potato, carrots, and finally, vitamin A supplements. This reflects similar results above when looking at frequency of consumption where vitamin A supplements are not purchased commonly. All differences are highly statistically significantly except milk and eggs.

For the Canadian subsample, participants purchased liquid milk and eggs the most, followed by carrots, sweet potato, margarine, and vitamin A supplements. The only two goods that are not purchased at a significantly different frequency are vitamin A supplements and fortified margarine, and milk and eggs. Vitamin A supplements and margarine being purchased the least often is unsurprising, given that both have long shelf lives and purchased in relatively larger quantities. For example, supplements are purchased in bottles that may contain 100 daily doses, so purchasing often is not necessary.

Table 4.19 Comparisons of means with a t-test of the frequency of purchasing different vitamin A rich sources between Indian and Canadian subsamples (d.f. = 220).

	t-value	**p-value**
Vitamin A Supplements	1.4001	0.1629
Carrots	11.9947	<0.0001
Fortified Margarine	29.2554	<0.0001
Sweet Potato	1.8006	0.0731
Liquid milk (skim or whole)	1.8957	0.0593
Eggs	3.7299	0.0002

4.6.7 Summary of Characteristics of Vitamin A-rich Goods

In order to assess consumer perceptions and attitudes of food products, various consumer perceptions of different vitamin A sources were analyzed, such as consumption, purchasing, and access. Among Indian participants, fortified oil was rated to be the easiest to prepare food with, the easiest to consume, and was the most frequently consumed and purchased. Carrots were considered the healthiest, but participants in India found them relatively more difficult to prepare foods with and to consume. Carrots were also consumed and purchased less frequently than any other good except for vitamin A supplements. While sweet potatoes were considered by Indian participants to be as healthy as carrots, as easy to prepare foods with and to consume, sweet potatoes were consumed and purchased more frequently. This is expected as carrots are not always in season. Eggs were considered the second easiest to consume and prepare food with. Vitamin A supplements were considered the least health and were not considered easily accessible by Indians. This is reflected in the lowest frequencies of consumption and purchasing. This is expected as vitamin supplements may be quite expensive for families to purchase on their own (Chugh and Lhamo 2012). Frequency of consumption vitamin A sources very closely reflected the frequency of purchasing.

Table 4.20 Ranking and statistically significant differences of vitamin A sources according to different characteristic ratings by Indian consumers (n = 120)

Ranking	Healthiness	Access	Ease of Food Preparation	Ease of consumption	Frequency of Consumption	Frequency of Purchasing
1	Carrots^{a}	Liquid milk^{a}	Fortified Sunflower Oil^{a}	Fortified Sunflower Oil^{a}	Fortified Sunflower Oil^{a}	Fortified Sunflower Oil^{a}
2	Sweet Potato^{a}	Fortified Sunflower Oil^{b}	Eggs^{a}	Eggs^{b}	Eggs^{b}	Eggs^{b}
3	Fortified Sunflower Oil^{b}	Sweet Potato^{c}	Sweet Potato^{b}	Sweet Potato^{c}	Liquid Milk^{b}	Liquid Milk^{b}
4	Vitamin A supplements^{b}	Carrots^{c}	Carrots^{bc}	Liquid Milk^{c}	Sweet Potato^{c}	Sweet potato^{c}
5		Vitamin A supplements^{d}	Liquid Milk^{c}	Carrots^{c}	Carrots^{d}	Carrots^{d}
6					Vitamin A supplements^{e}	Vitamin A supplements^{e}

For Canadian participants, the ratings of healthiness very closely resembled the perceptions of their Indian counterparts, although carrots were considered significantly healthier than sweet potatoes and vitamins were considered healthier than the fortified margarine. Carrots were rated to be the second easiest to prepare foods with and to consume, although this is not significantly different from eggs. Canadians also consumed and purchased carrots the most frequently after milk and eggs. While margarine is easy to access, it was rated the most difficult to prepare food with and to consume, and was among the most infrequently consumed and purchased. While sweet potatoes were rated the second healthiest, it was considered significantly less accessible than the other vitamin A rich goods.

Table 4.21 Ranking and statistically significant differences of vitamin A sources according to different characteristic ratings by Canadian consumers (n = 120)

Ranking	**Healthiness**	**Access**	**Ease of Food Preparation**	**Ease of consumption**	**Frequency of Consumption**	**Frequency of Purchasing**
1	Carrots^{a}	Carrots^{a}	Eggs^{a}	Eggs^{a}	Eggs^{a}	Liquid milk^{a}
2	Sweet Potato^{b}	Liquid milk^{a}	Carrots^{ab}	Carrots^{a}	Liquid milk^{b}	Eggs^{a}
3	Vitamin A supplements^{c}	Eggs^{a}	Liquid milk^{b}	Liquid milk^{b}	Carrots^{b}	Carrots^{b}
4	Fortified Margarine^{d}	Fortified Margarine^{ab}	Sweet potato^{c}	Sweet potato^{b}	Sweet potato^{c}	Sweet potato^{c}
5		Vitamin A supplements^{b}	Fortified Margarine^{c}	Fortified Margarine^{c}	Vitamin A supplements^{c}	Fortified Margarine^{d}
6		Sweet potato^{c}			Fortified Margarine^{c}	Vitamin A supplements^{d}

Note that this data about attitudes towards various products needs to be compared to the individual preferences for different vitamin A vehicles that arise from analysis of the stated preference data although this will be left for future analysis.

4.7 Payment card responses

In this section participant responses to the payment card are summarized and what factors may have influenced these decisions is discussed. Other factors that may have affected consumer decision making within the choice experiment but were not included in the survey would have been the ease of storing products or transporting them back home after the experiment or the quantity of a product an individual currently owned. Participants might have wanted products for qualities other than vitamin A (e.g. participants were already planning to buy carrots at the store in the near future, they liked the way certain products tasted, or cooked with them regularly). Additionally, participants might also have wanted to keep the cash and placed no value on the supplements (i.e. the supplements were discarded after the experiment). The timing of the survey in India may also have affected decision-making as carrots were out of season and so may have been seen as more attractive.

Participants may have also not been concerned about their vitamin A intake or had no intention of taking supplements because they don't like supplements. Concern about vitamin A intake was measured in the follow-up survey by asking if participants believed their vitamin A intake was adequate, not adequate, or if they did not know if their vitamin A intake was adequate. The vast majority of Indian participants (90.8%) believed their vitamin A intake was adequate, 5% believed vitamin A intake was not adequate and 4.2% did not know. In Canada, fewer participants believed their vitamin A intake was adequate (63.4%) while 13.9% believed it was not adequate and 22.8% did not know. Average WTP to exchange supplements for vitamin A rich goods was in calculated for participants who believed their vitamin A intake was adequate or not adequate (Table 4.22). Table 4.23 lists the p-values calculated for comparing mean WTP to exchange supplements for goods to discern if they are significantly different between those who believed their vitamin A intake was adequate, not adequate, or if they did not know if their vitamin A intake was adequate. In the majority of cases participants' perceptions of whether or not their vitamin A intake was adequate did not impact WTP estimates to exchange supplements for vitamin A-rich goods. However, Indian participants who did not know if their vitamin A intake was adequate were willing to pay significantly more for oil or carrots as compared to those who believed they were adequate. Therefore if participants are unsure about their intake, they may be willing to pay more in the case of fortified oil or carrots. However, differences of mean WTP to exchange supplements for vitamin A-rich goods were calculated based on very small sample sizes so further research is likely required to determine if concern about vitamin A-intake is a major determinant of preferences.

Table 4.22 Mean WTP to exchange supplements for vitamin A-rich goods between participants who believed their vitamin A intake was adequate, not adequate, or if they did not know their vitamin A intake was adequate.

	India Real			**Canada Real**	
	Oil	**St. Dev.**		**Margarine**	**St. Dev.**
Not Adequate	16.18	2.87	Not Adequate	-69.44	29.75
Adequate	15.41	3.25	Adequate	-54.98	40.37
Don't Know	16.35	1.74	Don't Know	-46.18	42.11
	Carrots	**St. Dev.**		**Carrots**	**St. Dev.**
Not Adequate	34.52	2.55	Not Adequate	75.08	30.45
Adequate	33.97	2.73	Adequate	83.93	39.38
Don't Know	36.87	3.72	Don't Know	90.33	45.50

	India Hypothetical			**Canada Hypothetical**	
	Oil	**St. Dev.**		**Margarine**	**St. Dev.**
Not Adequate	21.02	2.74	Not Adequate	-164.25	103.85
Adequate	20.04	4.81	Adequate	-206.88	87.36
Don't Know	22.92	1.43	Don't Know	-207.27	73.87
	Carrots	**St. Dev.**		**Carrots**	**St. Dev.**
Not Adequate	36.63	1.45	Not Adequate	119.76	34.53
Adequate	35.96	2.38	Adequate	117.95	31.05
Don't Know	38.60	1.13	Don't Know	125.19	36.53
	Sweet Potato	**St. Dev.**		**Sweet Potato**	**St. Dev.**
Not Adequate	26.17	13.15	Not Adequate	101.21	32.87
Adequate	22.61	11.05	Adequate	105.39	34.65
Don't Know	34.12	11.64	Don't Know	103.80	32.26

Table 4.23 p-values comparing mean WTP between individuals who believed their vitamin A intake was adequate or not adequate, or if they did not know if their vitamin A intake was adequate

	India Real			Canada Real		
	Oil	**Carrots**		**Oil**	**Carrots**	
Not adequate vs Adequate	0.58	0.65		0.15	0.38	
Not adequate vs Don't Know	0.92	0.32		0.06	0.24	
Adequate vs Don't Know	0.36	0.20		0.39	0.55	
	India Hypothetical			**Canada Hypothetical**		
	Oil	**Carrots**	**Sweet Potato**	**Oil**	**Carrots**	**Sweet Potato**
Not adequate vs Adequate	0.48	0.37	0.58	0.18	0.86	0.68
Not adequate vs Don't Know	0.22	0.05	0.36	0.20	0.66	0.82
Adequate vs Don't Know	**0.01**	**0.01**	0.12	0.98	0.40	0.84

At the end of the choice experiment, participants were asked to rate the accuracy of the nutrition information cards on a scale from 1 to 5, with 1 being completely inaccurate and 5 being completely accurate. Canadian participants on average reported that the nutrition information cards were accurate (3.88), while the mean rating for Indian participants was 2.84. This indicates that scenario rejection is unlikely as most participants accepted the information presented on the cards.

If participants chose to keep the supplements in all scenarios, opportunity was given for them to state why they did so. Indian participants gave a myriad of answers, from liking “free” things, to preferring supplements, or being unfamiliar with the bundles or simply not liking the bundles offered (n = 7). For the Canadian participants, nine participants preferred to get their vitamins from supplements, while another nine participants found that the other bundles did not appeal to them. Six participants stated that the bid amounts were too high, while five participants gave other reasons (e.g. sustainability of the food sources, etc.). In total, 29 participants of 102 in Canada chose to keep supplements in all scenarios

Nearly all Indian participants considered another household member when making their purchasing decisions compared to 55.4% of Canadian participants. Of those who considered other household members, 70.8% of Indian participants considered the head of household, followed by the partner of the head of household (13.3%), children (7.5%), or other (7.5%). The most commonly reported household members under the other category were mother- or daughter-in laws. Of those who reported considering other members in the Canadian sample, 36.8% of participants reported considering the partner of the head of household, followed by children (26.3%), other (23.7%), and the head of household (19.3%). The most common member of the family considered in the "other" category was spouses or partners (i.e. an equal relationship with no head of household).

Finally, participants were asked for the three most important factors that influenced their decision making. The majority of Indian participants indicated that quantity offered in the bundle (59.2%), perceived naturalness (57.5%), price (55.8%), and nutrient content (55.8%) factored into their decision-making, followed by how much each product was cooked with (35.0%) and if it was regularly available (34.2%). More than two-thirds of Canadians considered price to be one of the three most important factors that they considered, followed by nutrition content (58.0%), how much each product was liked (52.0%), and perceived naturalness (49.0%). Quantity offered within each bundle, taste, availability of the foods, and how much one cooked with each product was less considered.

Table 4.24 Determinants of choice experiment responses in the Indian and Canadian subsamples

Question	India	Canada
Primary reason for keeping supplements in all scenarios in payment card		
Preferred to get vitamins from supplements	1.7%	8.8%
Not familiar with bundles	0.8%	0.0%
The other food bundles did not appeal	0.8%	8.8%
Bids were too high	1.7%	5.9%
Other	5.0%	4.9%
Not applicable	90.0%	73.5%
Percent who made decisions while considering other household members	99.2%	55.4%
Household member considered		
Head of household	70.8%	19.3%
Partner of head of household	13.3%	36.8%
Children	7.5%	26.3%
Other	7.5%	23.7%
Top three most important factors when considering what goods to purchase		
Price	55.8%	65.0%
Nutrition Content	55.8%	58.0%
Perceived Naturalness	57.5%	49.0%
Quantity of Bundle	59.2%	20.0%
Taste	N/A	28.0%
How much product was liked	N/A	52.0%
How much you cooked with each product	35.0%	19.0%
If food was regularly available	34.2%	3.0%
Other	0.0%	9.0%

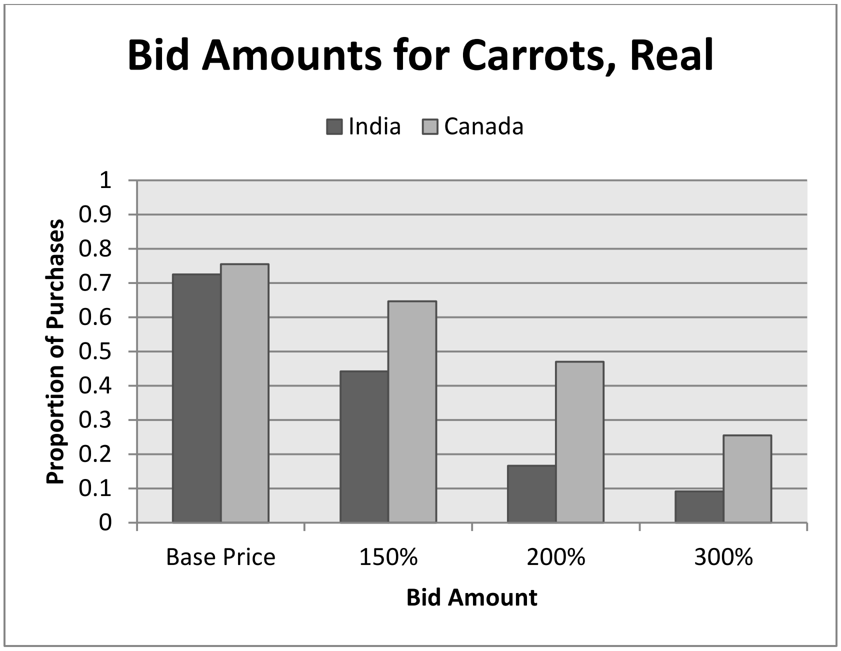
These data were collected from the survey instrument described in this paper

A crucial determinant of payment card responses was the price of the good associated with each scenario. Bid prices were determined by searching for the lowest market price available to participants, and then increasing subsequent bids by increments of 150%, 200%, and 300%. For fortified sunflower oil, the price provided in by the Public Distribution System was used (INR 45 per litre). It is important to note that 1L per month is the allotted amount per family with the PDS. Seasonal market prices for carrots and sweet potato were used for the payment cards in India. The lowest grocery store prices in the city of Edmonton, Alberta, Canada, were used to determine prices for the payment card in Canada. Table 4.25 shows bid prices broken down according to the price per 100 RAE of the various food bundles. In India, fortified oil was many times cheaper than carrots or biofortified sweet potato. Carrots were almost half the price of the biofortified sweet potato in the food bundles. In Canada, margarine was the most expensive per 100 RAE, while carrots and biofortified sweet potato were offered at the same price per 100 RAE per bundle.

Table 4.25 Prices per 100 RAE for each food bundle with varying bid prices

India	**Prices per 100 IU RAE (INR)**			
	Base	**150%**	**200%**	**300%**
Fortified Oil	0.07	0.13	0.26	0.52
Carrots	2.62	4.40	6.19	9.76
Biofortified sweet potato	4.67	7.57	10.35	16.03

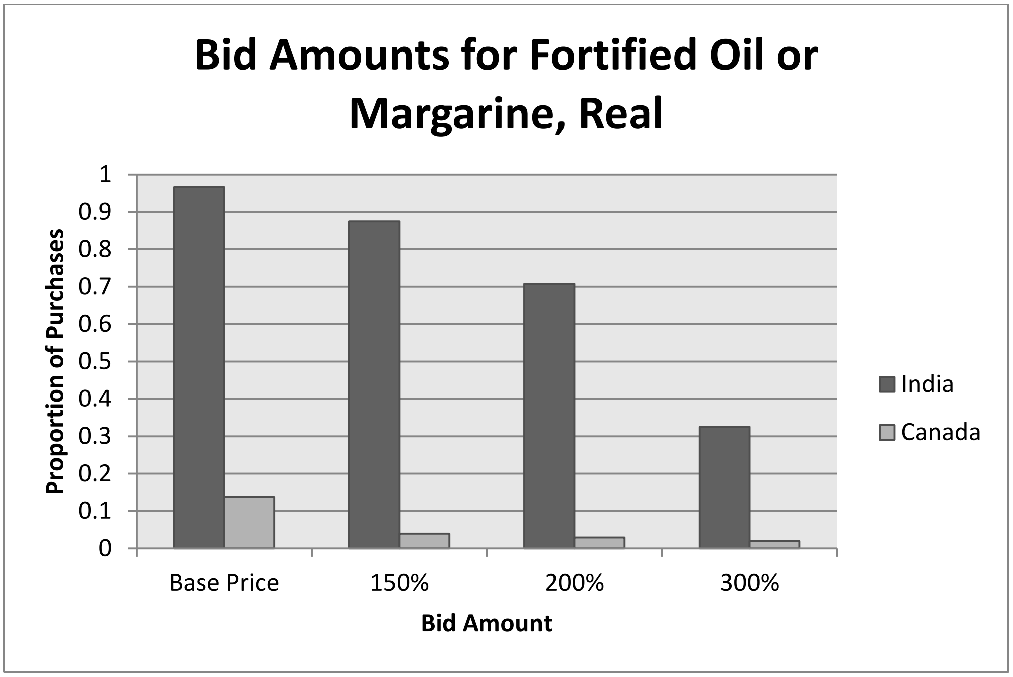
Canada	**Prices per 100 IU RAE ($ CAD)**			
Bid Amount	**Base**	**150%**	**200%**	**300%**
Margarine	0.29	0.45	0.62	0.95
Carrots	0.12	0.20	0.28	0.44
Biofortified sweet potato	0.12	0.20	0.28	0.44



These data were collected from the survey instrument described in this paper

Figure 4.9 Proportion of respondents in Indian and Canadian samples who purchased carrots in the real choice experiment

More than 70% of participants in both India and Canada purchased carrots at the lowest bid price. The proportion of participants who continued to purchase carrots after the bid price increased was much higher in Canada than in India. At the highest price in which the base price of the carrot bundle was increased by 300%, 25.5% of Canadian participants still chose to purchase carrots, as compared to 9.2% of Indian participants. The proportion of participants purchasing carrots decreased for both subsamples as bid prices increased.

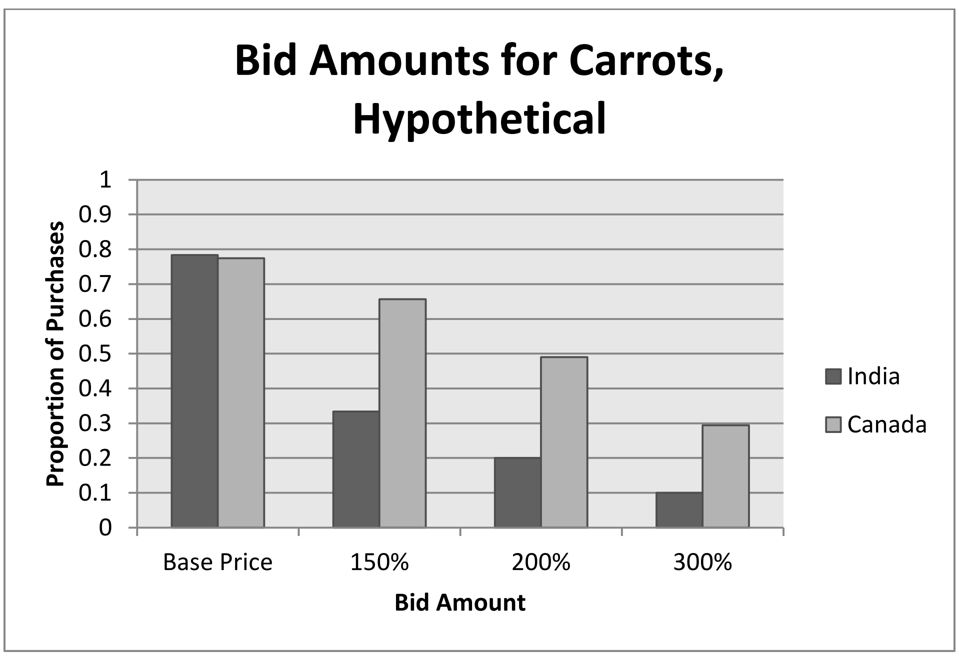


These data were collected from the survey instrument described in this paper

Figure 4.10 Proportion of respondents in Indian and Canadian samples who purchased fortified oil or margarine in the real choice experiment

Canadians were offered fortified margarine while Indian participants were offered fortified sunflower oil. Margarine was a good product choice in Canada as it is the only vitamin A fortified good that is mandatorily fortified and vegetable based. In addition, margarine is readily available in grocery stores and most Canadians are familiar with the food product. However, in India, margarine is not readily available or consumed. Instead, the popular and regularly consumed brand of sunflower oil called Sunrich was chosen, as oil is not mandatorily fortified in India and vitamin A levels vary with the exact brand of oil (although Sunrich is fortified with vitamin A and it is for this reason this particular oil was chosen for the experiments). Nearly every participant chose to purchase sunflower oil at the lowest bid price, and at the highest bid price the proportion of purchases decreased to 32.5% of the sample.

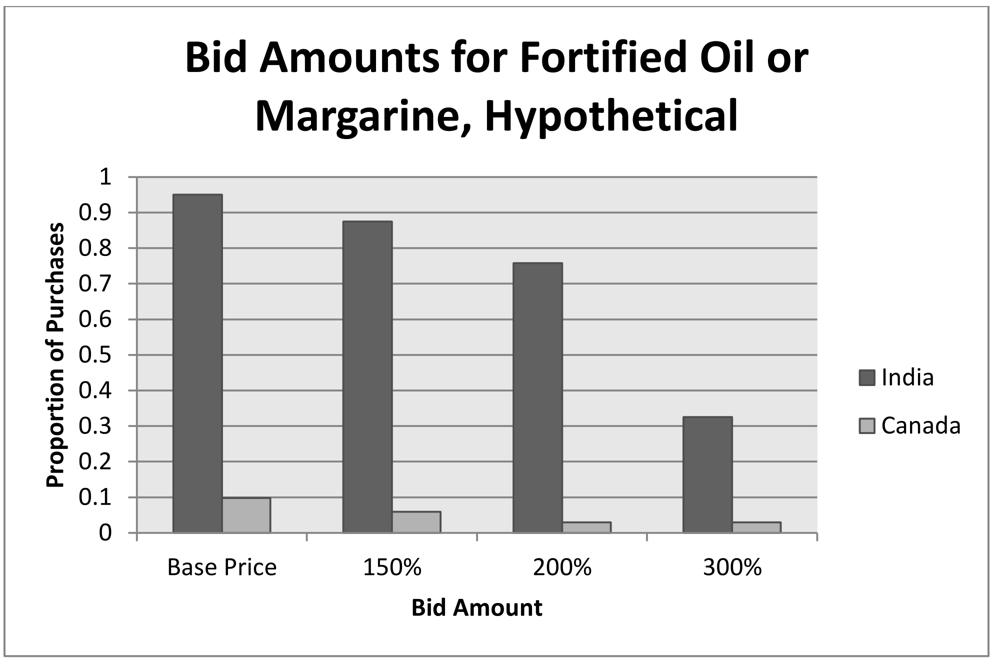
The proportion of Canadian purchases for margarine at the base price was very low at 13.8% of participants. This further decreased to 2.0% at the highest bid price. This is likely due to a variety of factors, such as being considered the least healthy, the most difficult to consume, and among the most difficult to prepare foods with. It was also the least frequently consumed and purchased by Canadians, along with the vitamin A supplements. Among the Canadian choice set, margarine was also the most expensive per 100 RAE, in contrast to fortified oil which was by far the cheapest per 100 RAE in the Indian choice set. Another key issue is that the margarine was offered in significantly higher quantities than the oil. A 680g tub of margarine for meeting one's vitamin A needs within a week may be prohibitively large. This is compared to the fortified sunflower oil, where only 140mL (about 137.2g) is needed to meet those same needs.



These data were collected from the survey instrument described in this paper

Figure 4.11 Proportion of respondents in Indian and Canadian samples who purchased carrots in the hypothetical choice experiment

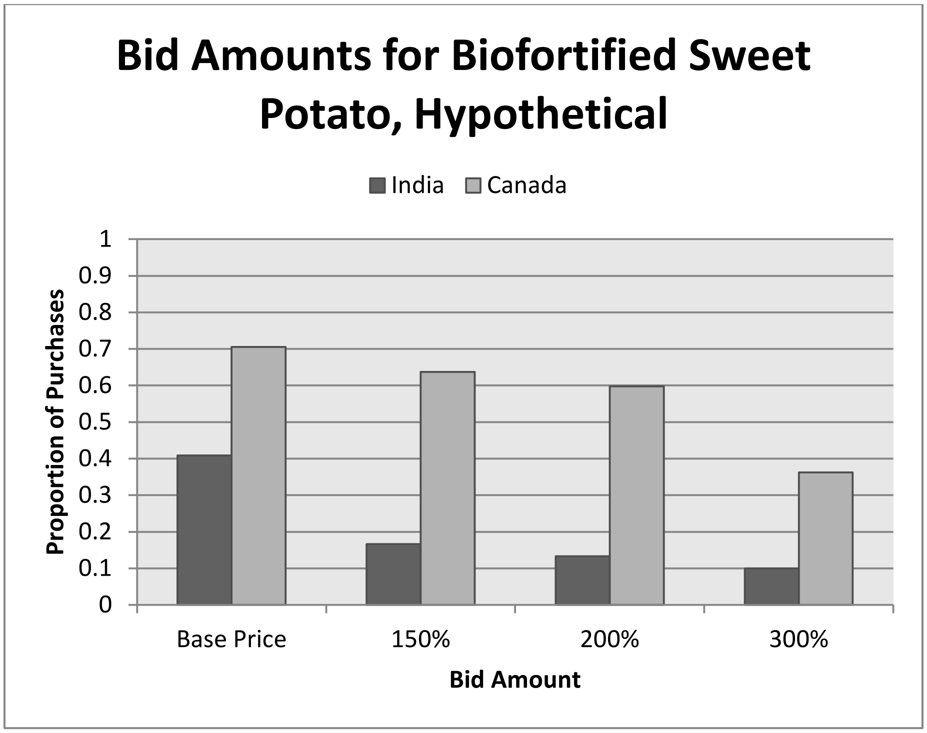
The proportion of those who purchased carrots in the real choice experiment was quite similar to the hypothetical choice experiment. The percentage of those who initially purchased carrots is similar between samples, but the Indian subsample shows a greater decrease in purchases as bid prices increased. However, the proportion of those who purchased carrots was slightly higher in the hypothetical choice experiment in both India and Canada when compared to the real choice experiment. More analysis needs to be done in order to determine if this translates to a higher WTP in the hypothetical choice experiment.



These data were collected from the survey instrument described in this paper

Figure 4.12 Proportion of respondents in Indian and Canadian samples who purchased fortified oil in the hypothetical experiment

The responses of participants when choosing to purchase fortified oil products in the hypothetical experiment were very similar to those in the real choice experiment. Almost all Indian participants chose to purchase the sunflower oil at the highest bid amount, while 32.5% of participants continued to purchase sunflower oil even at the highest bid amount. The Canadian subsample had a very low proportion of participants who were willing to exchange their supplements and purchase margarine even at the lowest bid amount. As prices increased, the proportion of participants who purchased fortified oils decreased for both India and Canada.



These data were collected from the survey instrument described in this paper

Figure 4.13 Proportion of respondents in Indian and Canadian samples who purchased biofortified sweet potato in the hypothetical experiment.

At the lowest bid amount, 70.6% of Canadian participants and 40.8% of Indian participants chose to purchase the biofortified sweet potato. For all bid amounts, a higher proportion of Canadian participants chose to purchase biofortified sweet potato as compared to the Indian sample. During the experiments it was also revealed that Indian participants were familiar with the breed of biofortified potato presented in the experiments. However, the crop failed to survive in the region and did not become commercially available. Knowing that it was difficult to grow the crop in the region could explain why a lower proportion of Indian participants exchanged their supplements for biofortified sweet potato in the hypothetical experiments. Per unit of vitamin A, biofortified sweet potato was the most expensive among the Indian choice set, which could contribute to the relatively lower amount of purchases among the Indian participants.

4.8 Conclusion

The Indian subsample was selected in order to be representative of people within the Koraput district of the province of Odisha. The Canadian subsample was a convenience-based sample in the city of Edmonton, Alberta. Overall, women were over represented within the sample although this was intentional. Participants tended to be older than the provincial average in the Indian and Canadian subsamples. Participants also tended to have higher rates of education, as all Indian participants were literate, and Canadian participants had greater years of schooling than the population average. In India, most food was purchased from farmers' markets while in Canada supermarkets were the primary way of acquiring food. Canadians had higher self-reported health and a far larger proportion indicated they had made a health or diet-related change within the past year (82.4% vs 0.83%). The Indian subsample had higher self-reported levels of physical activity and lower alcohol consumption than their Canadian counterparts.

Carrots were considered the most natural food product among Indians and Canadians, while Canadians considered margarine the least natural and Indians considered supplements the least natural. Biofortified sweet potato was rated as completely natural by the Indian cohort, while the Canadian subsample perceived them to be less natural. The major difference in what was considered natural between the Indian and Canadian subsamples was whether or not if natural foods were familiar. Both subsamples agreed that natural foods do not contain artificial flavours or additives, that processing, removal or addition of ingredients (synthetic or natural) leads to decreased naturalness in foods. Results of factor analysis in both samples revealed that perceptions of naturalness of a food were driven by qualities of purity and how much the food had been processed. However, purity explained more of the variance in the analyses in India whereas for Canadians, processing was the bigger driver.

The SK scores of Indians was significantly lower than that of the Canadian sample, but had higher objective knowledge scores. This is unexpected as literature previously showed that greater confidence in one's own knowledge usually came with greater objective knowledge. Canadians were significantly more neophobic than their Indian counterparts and showed a greater range in FTNS scores. Results of factor analysis showed similarities in behaviour between subsamples, with factor 1 being an indicator of how necessary an individual believed food technology to be for society and health, while factor 2 was a measure of how much an individual perceived adopting food technologies to be risky.

Overall, carrots and sweet potato were perceived to be healthier than vitamin A supplements and fortified oil. Vitamin A supplements and carrots were less easily accessed in India than in Canada, and this is reflected in lower frequency of consumption. Canadians more often consumed carrots, while Indians consumed fortified oils more frequently. Sweet potatoes were similarly consumed by both populations (once or twice a month on average). Purchasing frequency reflected these consumption behaviours. The majority of participants consumed both meat and dairy regularly.

In our summary of the payment card responses for the choice experiments, the proportion of participants who purchased goods at various bid prices was assessed. In all cases, increased bid amounts lead to a lower frequency of purchases although this effect was more pronounced for the Indian participants for carrots in both the real and hypothetical choice experiments. Canadians purchased margarine at a very low rate in both experiments. More Canadians purchased biofortified sweet potato in the hypothetical choice experiment than their Indian counterparts, although sweet potatoes are the most expensive per 100 RAE of all the goods. Low purchasing rates of sweet potato in the experiments is likely due to the higher unit price of sweet potatoes.

Chapter 5. Econometric Analysis

5.1 Introduction

In this chapter the econometric models are described and specified in order to finally begin addressing the objectives stated in chapter 1. The first objective was to determine what mode of vitamin A intake was most preferred by participants, holding vitamin A content constant. This will be determined by looking at WTP of participants to exchange their supplements for a good within the choice set. WTP estimates were generated with a multinomial logit and a random parameters logit. These models will be fully described in addition to providing the theory behind the random utility framework in which these discrete choice models operate. The second objective of our study was to analyze differences in preferences between Indian and Canadian participants, which will be done by comparing WTP estimates of vitamin A sources in the choice set. Finally, our last objective is to determine how preferences and WTP for vitamin-A rich goods vary according to attitude markers of interest. These were food technology neophobia, perceptions of naturalness, and objective and subjective knowledge, which were scored and described in Chapter 4.

5.2 Utility functions and Random Utility Theory (RUM)

In 1984, Hanemann constructed a framework in which dichotomous choices in contingent valuation could be analyzed. From this, parameters of a model could be readily estimated and interpreted. Let latent utility of an individual, *n*, be characterised by u_n, where u_n is a function of an individual's income, z, a vector of the characteristics the individual n and choice set j, and ε_{nj}, the preferences known by the individual but not by the researcher.

$$u_{ij} = u_j(income_i, z', \varepsilon_{nj}) \quad (1)$$

During the experiment, participants were presented with a choice to exchange or not exchange their supplements for another good and paying a bid. This choice can be characterised by the random choice variable, y:

$$y = \begin{cases} 1 & Invidual\ exchanges\ supplements\ for\ good\ j\ and\ pays\ bid \\ 0 & Individual\ does\ not\ exchange\ supplement\ for\ good \end{cases}$$

And for the choice set j, an individual may choose option, i, which may be to carrots, fortified oil or margarine, and in the case of the hypothetical experiments, biofortified sweet potato. Based on this model, the respondent would answer yes to exchanging their supplements for a good if the utility of doing so is greater than the bid price and the utility of having supplements. However, because the term ε_{nj} is a random term, only probabilistic statements can be made about participants' choices. The probability of a individual *n*, choosing to purchase good *i* is given by

$$Pr_{ni}(y = 1|z) = \Pr\big(u_{ni}(income_n - bid, z, \varepsilon_{ni}) > u_{nj}(income_n, z, \varepsilon_{nj})\big)\ \forall\ j \neq i \quad (3)$$

To further this, the utility function may be broken down into observable and unobservable parts, where v_n is observed utility of a participant is

$$u_{ni} = v_{ni}(income_n, z) + \varepsilon_{ni}\ \forall\ j \neq i \quad (4)$$

Therefore equation (3) becomes

$$Pr_{ni}(y = 1|z) = \Pr\big(v_{ni}(income_n - bid, z) + \varepsilon_{ni} > v_{nj}(income_n, z) + \varepsilon_{nj}\big)\ \forall\ j \neq i \quad (5)$$

Given that the random effects cannot be differentiated before or after decision making, let the errors in both the before and after case become

$$\varepsilon_n = \varepsilon_{ni} - \varepsilon_{nj} \quad (6).$$

If the base utility is normalized to zero, then all that matters is the difference between the utility functions. This allows (5) to become

$$Pr_{ni}(Y = 1|z) = \Pr\ (v_i(income) > 0) = \Pr(v_i(income_i - bid, z) > \varepsilon_i) \quad (7)$$

For estimation purposes, let us rewrite the utility function, v_n to be linear, additive and the sum of stochastic and deterministic components.

$$v_n = x_n'\beta + \varepsilon_n \quad (8)$$

This is substituted into the probability function to get the general probability function:

$$Pr_{ni}(Y = 1|z) = \Pr\ (v_n > 0) = \Pr(x_n'\beta > \varepsilon_n)\ (9)$$

Where x_n' is a vector of the relevant determinants of utility and β is the vector of parameters for the determinants. Before parametric estimation of the parameters may begin a probability density function and a functional form of ε_n. must be chosen. Below the three models of interest to estimate our parameters are explored while describing their advantages and disadvantages. Basic models will be done in which only the goods within the choice set are included as explanatory variables (the restricted model). These models assume no sociodemographic effects. A second, unrestricted model will be computed in order to analyze the effects of socio-demographic characteristics. A log likelihood test will allow us to discern whether socio-demographic variables add more information. Age, gender, income, and whether or not the participant had children were chosen. In addition, separate analysis must occur for the real and hypothetical choice experiments. Refer to Appendix 5.1 for the full specifications of the linear utility functions.

5.3 Multinomial Logit Models (MNL)

The first model is the standard multinomial logit (MNL) model. This model is specified by an error with a type I extreme value distribution. While this model is simple to use, there are some limitations relevant to this paper: first, it does not account for random taste variation, and secondly, it assumes that all errors are uncorrelated (Green 2012). This last property will be an issue given that panel data are being used but the subsequent random parameters logit will account for this issue.

The cumulative distribution function (cdf) of an MNL model is given by the logistic distribution:

$$F(\varepsilon_{nj}) = \frac{e^{\varepsilon_{nj}}}{1+e^{\varepsilon_{nj}}} \quad (10)$$

After this cdf is integrated and manipulated, this results in:

$$Pr_{ni} = \frac{e^{v_{ni}}}{\sum_j e^{v_{nj}}} \text{ or } Pr_{ij} = \frac{e^{x'_{ni}\beta}}{\sum_j e^{x'_{nj}\beta}} \quad (11)$$

which is the probability of an individual choosing *i* and paying a bid, given choice set *j*.

Aside from easy to interpret and perform, the logit probabilistic form exhibits several desirable properties. Pr_{ni} falls within (0,1), as required. When v_{ni} increases, Pr_{ni} similarly increases, and a decrease in vni leads to a decrease in Pr_{ni}. An improvement in an alternative leads to a decrease in Pr_{ni} as expected. The sum of the probabilities of all alternatives also sums to 1.

5.3.1 Model estimation, significances, and goodness of fit

The MNL model was estimated via maximum likelihood estimation (MLE) in NLOGIT 5. The probability of an individual, *n,* choosing to purchase a good ($y_{ni} = 1$) is given by P $\{y_{ni} = 1 \mid x_n\}$ as a function of the parameter vector β, and for an individual choosing to keep their supplements ($y_n = 0$), the probability is given by P$\{ y_i = 0 \mid x_i\}$. The log likelihood function for the whole sample is given by:

$$\log L(B) = \sum_{i=1}^{n} y_i logF(x_i'\beta) + \sum_{i=1}^{n}(1 - y_i)\log(1 - F(x_i'\beta)) \quad (11)$$

which is solved by maximizing the function with respect to β. The appropriate form of F is the logistic distribution function (equation 10). With respect to maximizing utility, β is a consistent estimator of parameters.

First the results of the restricted and unrestricted Canadian and Indian models for the real choice experiment were computed (Table 5.1). To compare the restricted and unrestricted models, likelihood ratio test was used. Log likelihood is not comparable between different samples or different alternatives being offered.

Table 5.1 Results of Multinomial Logit of Real Choice Experiment (Restricted)

	India			**Canada**	
Variable	**β**	**St. Err.**		**β**	**St. Err.**
Price	-0.083***	0.008	*Price*	-0.511***	0.083
Oil	1.606***	0.123	*Margarine*	-0.317	0.319
Carrots	2.929***	0.313	*Carrots*	1.045***	0.203
Log Likelihood = -496.49			Log Likelihood =-388.18		

***p < 0.01, **p < 0.05, *p < 0.1

For the basic multinomial logit, all variables within the models are significant at the α = 0.01 level with the exception of margarine in Canada. There is no significant effect of margarine on the probability of purchasing a good. Scenarios that presented carrots or fortified oil as the alternative had a greater likelihood of exchanging their supplements for a good. Increased price led to a decreased probability of exchanging supplements for a good and paying a bid, which is expected.

Table 5.2 Results of Multinomial Logit of Real Choice Experiment (Unrestricted)

	India			**Canada**	
Variable	**β**	**St. Err.**		**β**	**St. Err.**
Price	-0.084***	0.008	*Price*	-0.526***	0.086
Oil	1.337**	0.541	*Margarine*	0.621	0.617
Carrots	3.179***	0.682	*Carrots*	1.993**	0.397
Oil_Age	0.009	0.009	*Marg_Age*	-0.014	0.014
Oil_Fem	0.057	0.287	*Marg_Fem*	-1.041***	0.363
Oil_Y	-7.59E-03**	0.003	*Marg_Y*	3.93E-03	0.005
Oil_Child	-0.402	0.272	*Marg_Child*	-0.798	0.652
Car_Age	-0.004	0.010	*Car_Age*	0.004	0.008
Car_Fem	0.273	0.326	*Car_Fem*	-0.461**	0.229
Car_Y	-3.52E-03	0.004	*Car_Y*	-9.30E-3***	0.003
Car_Child	-0.479	0.319	*Car_Child*	-0.406	0.318
Log Likelihood = -490.60			Log Likelihood = -373.69		

***p < 0.01, **p < 0.05, *p < 0.1

When controlling for socio-demographic variables, all of the parameters that had been significant in the basic model remained significant and retained their original signs. Increased incomes significantly negatively impacted the probability of participants purchasing fortified oil in India. Meanwhile in Canada, females were significantly less likely to choose margarine and carrots compared to their male counterparts. In addition, greater income indicated a lower probability of Canadians choosing carrots.

Table 5.3 Likelihood Ratio Tests for comparing restricted and unrestricted MNL models for the real choice experiment (d.f. = 8, $\alpha = 0.05$, $\chi^2 = 15.51$)

Sample	**D**
India	12.98
Canada	28.98

The results of the log likelihood tests indicate that the restricted and unrestricted models for the Indian subsample in the real choice experiment were not significantly different. Therefore when purchasing real goods with real money, socio-demographic factors did not seem to impact decision-making. However the simplicity of the MNL model does not fully capture the same person performing multiple decisions. The restricted model is significantly different from the basic model in Canada which indicates that socio-demographic variables do add more information to our model.

Table 5.4 Results of Multinomial Logit of Hypothetical Choice Experiment (Restricted)

	India			**Canada**	
Variable	**β**	**St. Err.**	**Variable**	**β**	**St. Err.**
Price	-0.045***	0.004	*Price*	-0.622***	0.077
Oil	1.333***	0.108	*Marg*	-0.624*	0.321
Car	1.440***	0.198	*Car*	1.561***	0.197
Pot	1.525***	0.256	*Pot*	1.425***	0.174
Log Likelihood = -743.86			Log Likelihood = -604.99		

***p < 0.01, **p < 0.05, *p < 0.1

In the hypothetical choice experiments which included biofortified sweet potato in the choice set, all variables were significant at the $\alpha = 0.01$ level except for margarine in Canada, which is significant at the 0.10 level and negative. This indicated that in the hypothetical experiments, Canadians were significantly less likely to choose purchasing goods when the good in question was margarine. In scenarios where carrots or biofortified sweet potato was the alternative to supplements, participants were significantly likelier to exchange their supplements for a good and pay a bid.

Table 5.5 Results of Multinomial Logit of Hypothetical Choice Experiment (Unrestricted)

	India			Canada	
Variable	**β**	**St. Err.**		**β**	**St. Err.**
Price	-0.046***	0.004	*Price*	-0.655***	0.080
Oil	0.908*	0.537	*Margarine*	0.744	0.727
Carrots	1.465**	0.571	*Carrots*	2.707***	0.409
Pot	2.358***	0.692	*Pot*	3.093***	0.400
Oil_Age	0.018*	0.010	*Marg_Age*	0.001	0.017
Oil_Fem	-0.007	0.288	*Marg_Fem*	-0.793*	0.461
Oil_Y	-9.45E-03***	0.003	*Marg_Y*	-0.014*	0.007
Oil_Child	0.330	0.274	*Marg_Child*	-0.156	0.672
Car_Age	0.006	0.006	*Car_Age*	-0.001	0.008
Car_Fem	0.109	0.109	*Car_Fem*	-0.511**	0.238
Car_Y	4.84E-03	0.003	*Car_Y*	-0.008**	0.003
Car_Child	-0.090	0.285	*Car_Child*	-0.869***	0.325
Pot_Age	0.003	0.011	*Pot_Age*	-0.028***	0.008
Pot_Fem	-0.487	0.330	*Pot_Fem*	-0.203	0.236
Pot_Y	5.77E-03	0.004	*Pot_Y*	-0.006*	0.003
Pot_Child	-0.282	0.333	*Pot_Child*	-0.036	0.317
Log Likelihood = -733.78			Log Likelihood = -577.79		

***p < 0.01, **p < 0.05, *p < 0.1

For the unrestricted MNL models for the hypothetical choice experiment, price remains significant and negative. The attribute parameter for carrots was significant and positive in both India and Canada. Indian participants were significantly more likely to exchange their supplements for fortified oil but only at the 10% confidence level and this effect was smaller in magnitude compared to carrots. Significant socio-demographic variables for the Indian population were age (positive) and income (negative) when choosing oil. Higher income of Canadian participants significantly increased the probability of keeping supplements in all scenarios. Females were also less likely to purchase margarine and sweet potatoes although the magnitude of this effect was greater for margarine. Older participants were less likely to purchase biofortified sweet potato while people with children were less likely to purchase carrots.

Table 5.6 Likelihood Ratio Tests for comparing restricted and unrestricted models for MNL Models for the hypothetical choice experiment (d.f. = 12, α = 0.05, χ^2 = 21.03)

Sample	**D**
India	20.16
Canada	27.20

Results of the log-likelihood ratio test indicate that the restricted and unrestricted models are significantly different and that there is additional information provided by the unrestricted model for both Indian and Canadian subsamples.

5.4 Random Parameters Logit or Mixed Logit

The random parameters logit (RPL) is a highly flexible model that can be specified for a wide variety of behaviours. The key advantage of the mixed logit is that it overcomes the three limitations of the MNL model. An RPL model can account for random taste variation, allows for unrestricted substitution patterns, and considers correlation in observed factors over time (Train 2009). This is done by allowing the taste coefficients, in our case the alternative specific constants for each good, to no longer be static but have their own mean and distribution ($\beta_n \sim f(\beta|\theta)$. Instead of the standard utility model (equation 8), β is random and utility becomes

$$v_{ni} = x'_{ni}\beta_n + \varepsilon_{ni}$$

with the error term, ε_{ni} still having iid extreme value. Substituting this new utility function into equation 11 and integrating the choice probability over the density of β yields the RPL model:

$$P_{ni} = \int L_{ni}(\beta) f(\beta|\theta) d\beta$$

The flexibility of the RPL models lies in the fact that $\beta_n \sim f(\beta|\theta)$ may have a specified distribution. The slopes of β_n (i.e. the marginal utility) can vary between individuals, which is similar to a random effects model. The RPL avoids restrictions on substitution patterns as the change in the probability of choosing one option given a change in another choice is dependent on the correlation between the relative likelihood a participant would choose either alternative over various draws of β. As the parameters have their own variances, a correlation/covariance matrix can be generated that accounts for unobserved heterogeneity over observations from the same individual. For the purposes of this study, a standard normal distribution for our random parameters was chosen.

5.4.1 Model estimation, significances, and goodness of fit

A panel was specified for the RPL models, with eight observations per individual for the real choice experiment and twelve observations for the hypothetical experiment. Given that there is no functional closed form for the RPL model, P_{ni} must be simulated by taking a draw from the normal density function specified for the coefficients for our choice alternatives. Our model estimation was done in NLOGIT 5 using 50 draws using the Halton sequence, which exhibits more efficient and uniform draw pattern than the standard pseudo-random sequence (Hensher and Greene 2003). The results of each draw were then averaged to obtain β_{ni}. Results for the real and hypothetical choice experiments may be found below and the McFadden's Pseudo-R^2 values and log likelihood values describe goodness of fit. The convergence criterion was tightened in NLOGIT to improve model stability from the default 1E-2 to 1E-5 for all RPL models.

Table 5.7 Results of RPL Estimation of the Real Choice Experiment (Restricted)

	India			Canada	
Variable	**β**	**St. Err.**		**β**	**St. Err.**
Random Parameters			Random Parameters		
Oil	2.293***	0.203	*Margarine*	-0.746	0.594
Carrots	5.037***	0.623	*Carrots*	1.612***	0.334
Non-random parameters			Non-random parameters		
Price	-0.149***	0.016	*Price*	-0.789***	0.117
Distributions of RPs St. Err.			Distributions of RPs St. Err.		
NsOil	0.770**	0.177	*NsMarg*	2.056***	0.529
NsCarrots	3.069***	0.514	*NsCarrots*	2.105***	0.315
McFadden Pseudo - R^2 = 0.32			McFadden Pseudo - R^2 = 0.40		
Log Likelihood = -452.04			Log Likelihood = -337.82		

***p < 0.01, **p < 0.05, *p < 0.1

Similar to the unrestricted MNL model, the RPL has positive and significant coefficients for all goods except for margarine in Canada. Price has a significant and negative coefficient, as expected. The random parameters specified for fortified oils and carrots in both models have significant distributions, indicating that the random parameters have a non-zero variance. Distribution of the parameter for carrots is far larger than the oil, indicating a greater variance in Indian participants for preferring carrots while the distribution of the carrots and margarine parameters is similar in magnitude in Canada. However this is likely due to the larger magnitude of the attribute parameter of carrots in both countries.

Table 5.8 Results of RPL Estimation of the Real Choice Experiment (Unrestricted)

	India			Canada	
Variable	**β**	**St. Err.**		**β**	**St. Err.**
Random Parameters			Random Parameters		
Oil	1.978**	0.718	*Margarine*	-0.304	1.080
Carrots	5.089***	1.826	*Carrots*	2.453***	0.793
Non-random parameters			Non-random parameters		
Price	-0.155***	0.016	*Price*	-0.820***	0.122
Oil_Age	0.013	0.012	*Marg_Age*	-0.003	0.027
Oil_Fem	0.058	0.368	*Marg_Fem*	-1.503***	0.689
Oil_Y	-0.012***	0.004	*Marg_Y*	-0.005	0.010
Oil_Child	0.715**	0.358	*Marg_Child*	-0.590	1.135
Car_Age	-0.016	0.029	*Car_Age*	0.020	0.018
Car_Fem	0.638	0.897	*Car_Fem*	-0.754	0.478
Car_Y	-0.009	0.010	*Car_Y*	-0.013**	0.006
Car_Child	-0.582	0.822	*Car_Child*	-1.322*	0.724
Distributions of RPs			Distributions of RPs		
NsOil	0.847***	0.184	*NsMarg*	2.216***	0.510
NsCarrots	3.217***	0.529	*NsCarrots*	2.144***	0.337
McFadden Pseudo - R^2 = 0.33			McFadden Pseudo - R^2 = 0.42		
Log Likelihood = -444.29			Log Likelihood = -328.63		

***p < 0.01, **p < 0.05, *p < 0.1

The random parameter distributions were significant in India and Canada, indicating that heterogeneity within the data is not captured fully by socio-demographic variables.. The distribution for sunflower oil was smaller compared to carrots for the Indian subsample, which reflects the ubiquity of oil in Indian cooking, whereas carrots are seasonal and less frequently consumed by participants. The distributions of carrots and margarine were similar. When controlling for socio-demographic variables, Indian participants are significantly likely to choose to exchange their supplements and pay a bid for fortified oil and carrots. Increased income lowered the probability of participants choosing oil, whereas having children increased the probability of choosing oil.

The attribute parameter for margarine was not significantly different from zero whereas carrot was significant and positive. Higher participant income led to a decrease in the probability of a participant choosing oil in India and carrots in Canada. Canadian females were significantly less likely to choose margarine. the interaction term for carrots and children was significant and negative, indicating that participants with children were less likely to purchase carrots.

Table 5.9 Likelihood Ratio Tests for comparing restricted and unrestricted RPL models for the real choice experiment (d.f. = 8, $\alpha = 0.05$, $\chi^2 = 15.51$)

Sample	**D**
India	15.51
Canada	18.38

Results of the likelihood ratio test show that the restricted and unrestricted models were significantly different for the Indian and Canadian data. This indicates that socio-demographic variables do add more information to our model for the real choice experiment although it is unlikely to be large, especially in the case of the Indian subsample.

Table 5.10 Results of RPL Estimation of the Hypothetical Choice Experiment (Restricted)

India			Canada		
Variable	**β**	**St. Err.**	**Variable**	**β**	**St. Err.**
Random Parameters			Random Parameters		
Oil	1.766***	0.149	*Margarine*	-3.774*	1.819
Car	3.165***	0.395	*Car*	4.160***	0.542
Pot	2.151***	0.600	*Pot*	5.108***	0.778
Non-RPs in utility function			Non-Random Parameters		
Price	-0.088***	-0.008	*Price*	-1.741***	0.195
Distributions of RPs St. Err.			Distributions of RPs St. Err.		
NsOil	0.658*	0.221	*NsMarg*	7.104***	1.553
NsCar	1.720***	0.313	*NsCar*	3.918***	0.581
NsPot	3.614***	0.485	*NsPot*	4.935***	0.861
McFadden Pseudo - R^2 = 0.34			McFadden Pseudo - R^2 = 0.48		
Log Likelihood Function = -657.41			Log Likelihood Function = -442.42		

***p < 0.01, **p < 0.05, *p < 0.1

The unrestricted RPL model for the hypothetical choice experiment had all significant parameters at the 1% confidence level. The distribution is smallest for oil and largest for biofortified sweet potato in the Indian subsample. For the Canadian subsample, margarine has the highest distribution and the lowest for carrots. This distribution is larger compared to the real choice experiment. With the introduction of biofortified sweet potato, participants became less likely to choose margarine and taste variation increased. Together this implies that there are individuals willing to substitute away from margarine given more options.

Table 5.11 Results of RPL Estimation of the Hypothetical Choice Experiment (Unrestricted)

	India			Canada	
Choice	**β**	**St. Err.**		**β**	**St. Err.**
Random Parameters			Random Parameters		
Oil	1.225*	0.775	*Margarine*	-2.887	2.168
Carrots	3.169***	0.780	*Carrots*	4.795***	1.218
Pot	4.960**	0.960	*Pot*	7.557***	1.683
Nonrandom parameters			Nonrandom parameters		
Price	-0.089***	0.004	*Price*	-1.842***	0.202
Oil_Age	0.021*	0.012	*Marg_Age*	-0.120**	0.048
Oil_Fem	-0.028	0.345	*Marg_Fem*	2.105*	1.208
Oil_Y	-0.010***	3.788E-6	*Marg_Y*	-0.052***	0.019
Oil_Child	-0.332	0.060	*Marg_Child*	8.037***	2.158
Car_Age	0.009	0.014	*Car_Age*	-0.060**	0.026
Car_Fem	0.015	0.468	*Car_Fem*	-1.545*	0.811
Car_Y	0.006	4.909E-6	*Car_Y*	-0.016*	0.009
Car_Child	-0.027	0.071	*Car_Child*	-2.411***	0.904
Pot_Age	-0.011	0.016	*Pot_Age*	-0.055*	0.032
Pot_Fem	-1.920	0.523	*Pot_Fem*	-0.345	0.866
Pot_Y	-0.024*	5.811E-6	*Pot_Y*	-0.009	0.012
Pot_Child	0.400	0.078	*Pot_Child*	-3.152***	1.160
Distns. Of random parameters			Distns. Of random parameters		
NsOil	0.572***	0.214	*NsMarg*	10.776***	2.219
NsCarrots	1.784***	0.325	*NsCarrots*	3.884***	0.576
NsPot	3.780***	0.517	*NsPot*	5.200***	0.929
McFadden's Pseudo $R^2 = 0.35$			McFadden's Pseudo $R^2 = 0.49$		
Log Likelihood Function = -647.89			Log Likelihood Function = -428.83		

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

The attribute parameters for oil, carrots, and biofortified sweet potato were positive for the Indian subsample. The attribute parameter for margarine was positive but not significantly different from zero. The attribute parameters for carrots and biofortified sweet potato remain positive and significantly different from zero when controlling for socio-demographic characteristics.

Greater income in India led to a decreased likelihood of choosing either fortified oil or biofortified sweet potato while increased age led to a slightly positive higher probability of choosing fortified sunflower oil. Older Canadian participants were significantly likelier to choose to keep their supplements across all scenarios. Higher income significantly lowered the probability of participants choosing margarine or carrots. Contrary to other models, being female significantly increased the likelihood of choosing margarine. Participants who had children were likelier to choose margarine but less likely to choose carrots or biofortified sweet potato.

The distribution of the random parameters was very similar to the unrestricted model in terms of significances and relative magnitudes between goods. Socio-demographic variables do not add significantly more information to the data but they do for Canada. However there was unobserved heterogeneity that affects choices for both subsamples as evidenced by the positive and significant size of the distributions on the random parameters.

Table 5.12 Likelihood Ratio Tests for comparing restricted and unrestricted models for RPL Models for the hypothetical choice experiment (d.f. = 12, $\alpha = 0.05$, $\chi^2 = 21.03$)

Sample	**D**
India	19.04
Canada	27.18

5.5 Estimating WTP for Vitamin A-rich goods in the choice set

WTP values for vitamin A-rich goods were calculated using the parameter estimations from the RPL model. The formula for calculating WTP for good *i* for the basic model (no socio-demographic effects) is

$$WTP = \frac{ASC_i}{\lambda}$$

where λ is the marginal utility of money, or the negative of the parameter associated with the price variable in each model. Variance and significance of WTP was calculated directly in NLOGIT 5 with the Wald command using 10000 draws and the Krinsky & Robb method of draws. For WTP calculations for unrestricted models that account for socio-demographic effects, individual WTP for good *i* was calculated by multiplying the coefficient of each parameter with the individual's socio-demographic characteristic. This is given by the formula

$$WTP_i = \frac{(ASC_i + \beta_{i1}age + \beta_{i2}fem + \beta_{i3}y + \beta_{i4}child)}{\lambda}$$

The WTP for each individual was calculated, and the average and standard error for the subsamples are reported in Table 4.19. WTP for goods in India and Canada was calculated for 4,200 RAE and converted to INR with the average exchange rate from CDN to INR during which the data was collected.

Table 5.13 Estimated WTP for items in choice set in India and Canada for 4,200 RAE (INR)

	India		Canada	
	MNL	**RPL**	**MNL**	**RPL**
Good	**WTP (St. Err.)**	**WTP (St. Err.)**	**WTP (St. Err.)**	**WTP (St. Err.)**
Real, restricted				
Fortified Oil (Margarine)	19.24***	15.42***	-26.78	-40.85
	(1.71)	(1.05)	(33.76)	(35.66)
Carrots	35.10***	33.86***	88.28***	88.30***
	(1.40)	(2.06)	(8.84)	(12.99)
Real, unrestricted				
Fortified Oil (Margarine)	19.33***	15.49***	-33.83	-54.91
	(1.54)	(1.11)	(32.77)	(38.43)
Carrots	35.11***	34.12***	88.25***	84.22***
	(1.39)	(2.14)	(9.84)	(11.88)
Hypothetical, restricted				
Fortified Oil (Margarine)	29.39***	20.15***	-43.38	-93.64**
	(3.25)	(2.03)	(27.56)	(46.61)
Carrots	31.75***	36.11***	108.49***	103.23***
	(2.53)	(2.48)	(8.25)	(8.75)
Biofortified Sweet Potato	33.62***	24.54***	99.10***	126.73***
	(3.60)	(5.68)	(8.02)	(13.45)
Hypothetical, unrestricted				
Fortified Oil (Margarine)	29.85***	20.18***	-48.61	-201.12**
	(3.46)	(1.77)	(29.92)	(62.29)
Carrots	31.80***	36.09***	108.37***	105.47***
	(2.61)	(2.40)	(6.95)	(7.62)
Biofortified Sweet Potato	33.52***	23.15***	98.96***	104.43***
	(3.22)	(5.63)	(7.40)	(12.49)

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

All WTP calculations for the Indian choice set are positive and statistically significantly different from zero at the 1% confidence level. Controlling for socio-demographic variables did not significantly alter WTP estimates in either real or hypothetical choice experiments and the log likelihood tests showed that controlling for socio-demographic variables better described the data, except for the case for the MNL model with real choice data and RPL model with hypothetical choice data in India

WTP to exchange supplements for carrots is higher than the WTP to exchange supplements for fortified sunflower oil in the real choice set. This is likely due to the small amount of fortified oil offered (only 138g) as compared to the carrots (500g) and biofortified sweet potato (600g). This may indicates that other attributes of the food come into play such as the quantity obtained. For the Indian subsample, 59.2% of participants stated that quantity was the most important consideration for purchasing food bundles, which is the highest among all factors listed (Table 4.26) which coincides with lower WTP to exchange supplements for fortified oil among participants who had high WTP to exchange supplements for carrots. The RPL model yielded the lower WTP estimates to exchange supplements for goods than estimates from the MNL model. The WTP estimates for the hypothetical data set do not show similar ordering of WTP estimates between models. Results of t-tests indicated that the WTP estimates to exchange supplements for fortified oil, carrots, and biofortified sweet potato were not statistically significantly different for the MNL. For the RPL, WTP to exchange supplements for biofortified sweet potato and fortified sunflower oil were the same, but carrot was statistically significantly higher (INR 36.09 for carrots vs. INR 20.18 and INR 23.15 for oil and biofortified sweet potato respectively).

The WTP of Canadians to exchange their supplements for fortified margarine in the real choice experiments was negative and not significantly different from zero for the MNL and RPL models. This indicates that fortified margarine is either less preferred than supplements or as preferred as supplements by Canadian participants. There may also be an endowment effect as participants were given the supplements at the beginning of the experiment and may have automatically assigned those supplements greater value. The WTP for carrots is higher than fortified margarine for every model, and this persists even when socio-demographic characteristics are controlled for. In the hypothetical choice experiments the WTP for fortified margarine remains negative and becomes significantly different from zero for the RPL model. This indicates that when individual differences are controlled for, it becomes apparent there is a discount on margarine in the hypothetical choice experiment. This could be due to the addition of biofortified sweet potato into the choice set. Because the RPL allows for different substitution patterns then it is possible that the introduction of more food alternatives makes margarine even less attractive to consumers. Similar to the Indian models, the premia for the different goods in the MNL model was very similar between the restricted and unrestricted models. The WTP to exchange supplements for carrots was higher than the WTP to exchange for the biofortified sweet potatoes except for the restricted RPL model. However, this reverses for the unrestricted RPL model, which better explains the data than the restricted RPL model. However, a t-test indicates that the WTP estimates for to exchange supplements for carrots or sweet potatoes are not statistically significantly different in any of the models. Thus it can be concluded that overall, Canadians preferred carrots the same as biofortified sweet potato but both are more preferred than supplements. Margarine was less preferred than supplements as WTP estimates for margarine were zero or negative.

Given that the price ranges of the bids were quite variable for each good (refer to Table 3.2), additional models were run separately for fortified oils (or margarine), carrots, and biofortified sweet potato to account for potential price effects. Results of these estimations are found in Appendix 5.2. Overall, results of coefficients and WTP estimates to exchange supplements for other goods were minimally impacted and so the models that took into account all goods within the choice set were chosen.

5.6 Variations in individual WTP with changing FTN, OK, SK, and Perceptions of Naturalness Scores

In this section WTP of individuals' is connected to their scores on the various attitude scales. Recall that for perceptions of naturalness, the "purity" score is the extent to which one associates naturalness with purity and familiarity. The "processing" score is a measure of increased association between what is natural and what has undergone less processing. Subjective knowledge scores are measures of one's confidence in one's own knowledge of diet and health, whereas objective knowledge scores is a measure of factual knowledge of an individual. From the food technology neophobia scale (FTNS) there is the measure of "necessary", or the extent to which foods produced with novel technologies are associated with increased benefits to society. A higher score in the "risky" factor is associated with a consumer having a greater perception of foods produced with novel technologies as posing health and environmental risks. Also included are the unfactored total FTNS scores, in which a higher FTNS score is associated with greater food technology neophobia.

Additional conditional logit and random parameters logit models were estimated containing the attitude variables. However, given the high amount of endogeneity within the models, they were only used to analyze significant effects of the attitude variables. Results of these estimations may be found in Appendix 5.3. Perceptions of naturalness and food technology neophobia were a significant parameter in both the Indian and Canadian models, while objective knowledge in India and subjective knowledge in Canada was also a significant model parameter.

Therefore, attitude variables may have an effect on WTP to exchange supplements for vitamin A-rich foods but the magnitude and effects are unclear from model estimations.

In order to analyze the effects of attitude factors while taking into account endogenity, WTP estimates for each good was estimated for each individual and compared to the seven attitude variables described above. Data from the four choice experiments are included to allow cross-cultural comparisons and between real and hypothetical. WTP to exchange supplements for each good within the choice-set is for 4,200 RAE in Indian rupees, which will allow for better comparison between Canadian and Indian subsamples. Parameters used to calculate individual WTP are from the RPL unrestricted model for the respective data-set. Average WTP between high and low scoring participants was compared and a two-tailed t-test was performed to determine differences of the mean.

5.6.1 Fortified Oil (India) or Margarine (Canada)

Indian participants with a higher confidence in their nutrition and diet knowledge, or a high SK score, greater food technology neophobia, greater perceptions that foods produced with novel technologies were not necessary or risky, were willing to pay less for fortified oil compared to their lower scoring counterparts. This was true and highly significant for both the real and hypothetical choice experiments. Greater subjective knowledge was correlated with higher income or age in our Indian participants, and it has been shown that this subgroup is likelier to use supplements (Datta and Vitolins 2014). However it is likelier that being more confident in one's nutrition knowledge makes one more confident in accepting other means of meeting dietary intakes, possibly through improved perception of benefits (Aertsens et al. 2011).

More food technology neophobic participants having lower average WTP for fortified oil suggests that participants are more unfamiliar with fortified oil than they are with supplements.

In Canada, only objective knowledge had an impact on WTP for fortified margarine in the real choice experiment. This effect was not significant in the hypothetical choice set. Participants with high OK of nutrition and diet had a significantly larger discount for fortified margarine compared to those with low OK. This suggests that knowledge increases, participants preferred to keep their supplements rather than exchange them for margarine.

Table 5.14 Average WTP for 4,200 RAE of Fortified Oil of Indian participants and Fortified Margarine of Canadian participants (INR) with high and low attitude scores

India

	Real			Hypothetical		
	High	**Low**	**p-value**	**High**	**Low**	**p-value**
Natural						
Purity	15.93	15.06	0.16	20.73	19.63	0.22
St. Err.	0.45	0.36		0.69	0.50	
Processing	15.82	15.16	0.24	20.56	19.80	0.33
St. Err.	0.40	0.42		0.59	0.61	
Knowledge						
Objective	15.79	15.20	0.30	20.42	19.93	0.56
St. Err.	0.43	0.39		0.64	0.56	
Subjective	14.21	16.78	**0.00**	18.40	21.95	**0.00**
St. Err.	0.41	0.34		0.57	0.55	
Food Technology Neophobia	14.28	16.71	**0.00**	18.80	21.55	**0.00**
St. Err.	0.41	0.35		0.59	0.56	
Necessity	14.66	16.33	**0.00**	19.12	21.23	**0.01**
St. Err.	0.32	0.30		0.60	0.58	
Riskiness	14.48	16.51	**0.00**	19.10	21.25	**0.01**
St. Err.	0.41	0.37		0.58	0.60	

Canada

	Real			Hypothetical		
	High	**Low**	**p-value**	**High**	**Low**	**p-value**
Natural						
Purity	-60.12	-49.68	0.18	-192.85	-209.40	0.34
St. Err.	5.39	5.74		12.16	12.41	
Processing	-52.14	-57.65	0.52	-200.28	-201.96	0.93
St. Err.	5.84	5.36		13.29	11.32	
Knowledge						
Objective	-65.29	-44.50	**0.01**	-207.68	-194.56	0.42
St. Err.	5.02	5.80		11.37	13.18	
Subjective	-56.20	-53.59	0.76	-201.12	-201.13	1.00
St. Err.	5.77	5.45		12.91	11.75	
Food Technology Neophobia	-57.53	-52.26	0.54	-192.95	-209.30	0.34
St. Err.	5.42	5.78		14.01	10.28	
Necessity	-61.71	-48.08	0.12	-199.83	-202.41	0.89
St. Err.	4.89	6.11		13.60	10.94	
Riskiness	-53.26	-56.53	0.66	-207.98	-194.27	0.40
St. Err.	5.79	5.42		12.84	11.75	

5.6.2 Carrots

Carrots are commonly consumed in both India and Canada. The discrepancy between WTP estimates for carrots between the real and hypothetical choice experiments is very low for both the Indian and Canadian subsamples. Canadians were willing to pay a higher amount but this is most likely due to differences in purchasing power and standards of living. This indicates that there is little hypothetical bias when comparing WTP estimates between real and hypothetical choice experiments.

Indian participants with low SK scores had slightly higher but significant WTP for carrots. Other attitude factors did not seem to impact individual WTP for carrots for the Indian subsample. Therefore SK does seem to have an effect but it is not likely to be large. Participants with high food technology neophobia also had a slightly lower WTP for carrots but this effect is also small. Perceptions of riskiness of new food technologies did not affect WTO for carrots. For Canadian participants, knowledge also seemed related to WTP, as high OK scoring participants were willing to pay slightly more to switch away from supplements. High or low scores in food technology neophobia and or perceptions of naturalness did not seem to affect WTP for carrots by Canadians.

Table 5.15 Average WTP for 4,200 RAE of carrots of Indian and Canadian participants (INR) with high and low attitude scores

India

	Real			Hypothetical		
	High	**Low**	**p-value**	**High**	**Low**	**p-value**
Natural						
Purity	34.10	34.14	0.93	36.32	35.88	0.32
St. Err.	0.35	0.38		0.32	0.28	
Processing	34.46	33.78	0.16	36.30	35.89	0.28
St. Err.	0.33	0.39		0.29	0.32	
Knowledge						
Objective	33.93	34.31	0.45	36.12	36.07	0.90
St. Err.	0.32	0.41		0.31	0.30	
Subjective	33.57	34.67	**0.04**	35.23	36.97	**0.00**
St. Err.	0.37	0.35		0.29	0.28	
Food Technology Neophobia	33.96	34.28	0.51	35.53	36.67	**0.00**
St. Err.	0.41	0.31		0.31	0.28	
Necessity	34.02	34.22	0.73	35.57	36.62	**0.01**
St. Err.	0.41	0.32		0.32	0.28	
Riskiness	34.03	34.20	0.76	35.69	36.50	0.06
St. Err.	0.40	0.33		0.31	0.29	

Canada

	Real			Hypothetical		
	High	**Low**	**p-value**	**High**	**Low**	**p-value**
Natural						
Purity	79.62	88.81	0.24	116.36	123.44	0.33
St. Err.	5.78	5.36		5.03	4.12	
Processing	86.23	82.21	0.62	125.62	114.18	0.11
St. Err.	5.89	5.31		4.65	4.46	
Knowledge						
Objective	72.40	96.03	**0.00**	77.09	94.53	**0.00**
St. Err.	5.11	5.61		3.96	3.98	
Subjective	81.82	86.62	0.59	87.16	84.46	0.61
St. Err.	6.09	5.08		4.36	3.93	
Food Technology Neophobia	81.95	86.48	0.59	88.81	82.81	0.33
St. Err.	5.47	5.74		4.33	3.93	
Necessity	83.58	84.86	0.88	82.98	88.64	0.40
St. Err.	4.83	6.30		3.79	4.46	
Riskiness	85.64	82.80	0.70	85.85	85.77	0.99
St. Err.	5.70	5.53		4.25	4.06	

5.6.3 Biofortified Sweet Potato

Overall perceptions of naturalness did not affect WTP to exchange goods for supplements between high or low scoring participants in the purity or processing scale (elements of naturalness) in our sample for any of the items within the choice set. In India, high SK participants had a lower WTP for biofortified sweet potato. Like with fortified oil and carrots, Indians with high FTN had a lower WTP biofortified sweet potato. None of the attitude scores seemed to impact average WTP for high or low scoring Canadians.

Table 5.16 Average WTP for 4,200 RAE of biofortified sweet potato of Indian and Canadian participants (INR) with high and low attitude scores

	India				Canada		
	High	**Low**	**p-value**		**High**	**Low**	**p-value**
Natural				**Natural**			
Purity	24.59	21.70	0.16	Purity	105.44	103.44	0.78
St. Err.	1.51	1.43		St. Err.	4.59	4.89	
Processing	23.26	23.03	0.92	Processing	100.54	108.35	0.31
St. Err.	1.27	1.67		St. Err.	5.22	4.14	
Knowledge				**Knowledge**			
Objective	23.86	22.43	0.51	Objective	104.47	104.42	0.99
St. Err.	1.44	1.52		St. Err.	4.78	4.71	
Subjective	19.49	26.80	**0.00**	Subjective	100.45	108.44	0.28
St. Err.	11.47	10.28		St. Err.	4.85	4.57	
Food Technology Neophobia	19.97	26.32	**0.00**	**Food Technology Neophobia**	99.55	109.34	0.15
St. Err.	1.46	1.39		St. Err.	4.84	4.54	
Necessity	19.50	26.79	**0.00**	Necessity	103.87	105.02	0.86
St. Err.	1.43	1.38		St. Err.	4.53	4.95	
Riskiness	20.90	25.39	**0.05**	Riskiness	103.77	105.12	0.85
St. Err.	1.53	1.37		St. Err.	4.45	5.02	

5.7 Conclusion

The prevalence of VAD makes it important to examine consumer preferences for the various methods of increasing the amount of vitamin A in one's diet. Some possible ways of increasing vitamin A are associated with products of technology development while others are associated with fortification. Regardless of community or demographic characteristics, it is possible that the methods of increasing vitamin A may raise concerns in the minds of the public. The route to obtaining increased levels of vitamin A could be through mandatory (margarine in Canada) or voluntary fortification (oils in India), through increased consumption of fresh vegetables (carrots in both places) or through a biofortified vegetable (sweet potato in both places). While there are clear differences between countries, communities, contexts, and individuals there is an interest in examining whether reactions to different vitamin A vehicles are in any sense common and perhaps related to similar concerns about technology or lack of naturalness. If certain vehicles are more preferred by consumers, use of those vehicles could result in higher vitamin A intake. Given that this study found commonality in concerns and preferences from widely disparate groups in two different countries, then research results could provide the basis for further research on the consumer concerns in more communities and the subsequent development of vehicles likely to achieve the highest uptake in the widest distribution globally. However, more work needs to be done to fully understand consumer preferences and attitudes towards foods in developing nations. Additional behavioural research and impact assessments of interventions on health are also needed before governments or policymakers develop new products or mandate fortification policies.

When comparing major trends between our three models, higher income Indian participants were less likely to purchase oil in exchange for supplements. This result is robust as it was significant and negative across the hypothetical and real data sets and across models. In the hypothetical choice experiment, increased age was positively correlated with the probability of purchasing oil. In the MNL models, income was thought to contribute to the probability of exchanging supplements for carrots or biofortified sweet potato, but this effect did not remain significant once time invariant characteristics within our sample was controlled for. Higher income Canadian participants were likelier to prefer carrots less than supplements. This effect was significant and negative across models and data sets. Females were significantly less likely to purchase margarine and carrots in Canada in both the real and hypothetical choice experiment. Participants with children were likelier to not purchase vitamin A rich goods and keep the supplements.

Overall, WTP estimates for the vitamin-A rich goods across the three models of interest showed that Indians preferred carrots more than fortified sunflower oil when purchasing real goods, and that the WTP estimates for biofortified sweet potato likely falls between carrots and fortified oil, but is likely very similar to the WTP for oil. Given that the attribute parameters for the choice set, in addition to their WTP estimates were significantly greater than zero it can be asserted that Indian participants prefer supplements the least. The WTP for margarine was either negative or not statistically significantly different from zero, indicating that Canadians preferred it less than or as much as the supplements. Average WTP to exchange supplements for carrots was higher than the WTP to exchange for biofortified sweet potatoes but these means were not significantly different. Canadians had a greater WTP for carrots and biofortified sweet potato than their Indian counterparts but this is likely due to income effects as biofortified sweet potatoes are more expensive.

Individual WTP for goods was calculated with estimates from the RPL model. The average WTP for goods of individuals with the high or low attitude scores was compiled to analyze average individual WTP for vitamin A-rich goods. Scores on the perceptions of naturalness scales did not yield any significant differences between high or low scoring participants. Indian participants with high SK scores had lower average WTP to exchange their supplements for fortified oil, carrots, or biofortified sweet potato while Canadians with highOK scores had a lower WTP for margarine and carrots. A higher FTNS score was also associated with lower WTP to exchange supplements for fortified oil or biofortified sweet potato in the Indian subsample. High food technology neophobic Indians were willing to pay less for carrots but only in the hypothetical experiment. No difference was found in the Canadian subsample between high or low scoring FTNS participants in both hypothetical and real choice experiments. In the next chapter the policy implications of the econometric and attitude analysis will be described.

Chapter 6. Conclusions, Policy Implications, and Study Limitations

6.1 Introduction

Attitudes of consumers toward vitamin A rich vehicles were examined with a survey that measured perceptions of naturalness, subjective and objective knowledge, and food technology neophobia. These attitudes were explained in the literature review (Chapter 2), while how they were measured was outlined in Chapter 3. The probability of individuals in two national groups exchanging supplements for vitamin A-rich food was examined through the use of a choice experiment. In the experiment a payment card approach was used (also explained in Chapter 3). The differences in individual preferences for different vitamin A sources is illustrated by estimating WTP to exchange vitamin A supplements for carrots, fortified oil or margarine, and biofortified sweet potato. WTP was estimated using econometric analysis of the choice experiment data as outlined in chapter 5. Due to the commercial unavailability of the biofortified sweet potato in our study areas, it was included in a hypothetical choice experiment while the other goods in the choice set were included in both real and hypothetical choice experiments. The combined use of the choice experiment and a survey allowed the examination of trade-offs consumers make between vitamin A-rich goods while looking at the underlying attitudes that may drive these preferences.

The above was done with the goal of informing the most effective public policies that may increase vitamin A intake in at-risk populations. The first subsample was persons within the Koraput district of Odisha, India which has a high proportion of tribal and BLP persons. These populations are at high risk of being vitamin A deficient due to low access to vitamin A sources. The second subsample was persons within Edmonton, Alberta, Canada. Health Canada has identified that the Canadian population as a whole is vitamin A deficient, and within Edmonton there exists significant income disparity and food insecurity. Research done by Kirkpatrick and Tarasuk (2008) indicate that food insecure populations are at high risk of being vitamin A deficient. Consumers and policymakers are constrained by budgets, with consumers having limited income with which to purchase foods and governments such that there is only so much funding they may put towards each program. Therefore results of this paper will allow policymakers to better tailor programs (e.g. mandatory food fortification, supplement programs, etc.) such that they align with what consumers intend to eat and purchase in order to effectively maximize health benefits as a result of adequate vitamin A intake.

Below the study objectives are addressed.

1) Are supplements or food-based methods more preferred by consumers, and are they willing to pay a price to exchange vitamin A supplements for food-based vitamin A sources?

The first objective was to quantify consumer preferences and premiums/discounts for different vitamin A rich goods. Participants were endowed with one week's worth of vitamin A supplements and asked to make decisions, across multiple scenarios, whether to trade in their supplements or pay for another good within the choice set. All goods within the choice set contained the quantities required to meet one week's worth of recommended vitamin A intake. The probability of selecting a certain good was then modeled from the choice data a multinomial logit and random parameters logit regression model. WTP for each good was calculated from the model parameters (Table 5.19). All WTP estimates are for exchanging supplements for a good within the choice set. However it is recognized that the goods (carrots out of season in India) may have had other intrinsic value to participants aside from vitamin A and further research is necessary to control for that. For example, the data collected in this study indicated that many participants valued the quantity of food provided, or the convenience of cooking with or eating a certain food product.

In the Indian subsample, WTP estimates to exchange supplements for carrots, followed by biofortified sweet potato, sunflower oil, and then vitamin A supplements. This ordering mimics how healthy each good was considered to be and the naturalness ratings given by participants. Carrots were considered to be as healthy as sweet potato but they were consumed and purchased more frequently than sweet potato. It was expected that the WTP premium to exchange supplements for carrots and biofortified sweet potato were higher than the WTP calculated for fortified sunflower oil. This may be due to cheaper market prices and the higher concentration of vitamin A in fortified sunflower oil, leading to smaller food bundles in the choice set, another example of other characteristics of the food bundles which could affect outcomes

Similar to the Indian subsample, Canadians preferred carrots the most, followed by biofortified sweet potato, and vitamin A supplements. This was evidenced by significantly positive WTP estimates to exchange supplements for carrots and biofortified sweet potato. However, a significant discount on margarine demonstrated that Canadians were very unlikely to substitute margarine for supplements in an attempt to increase their vitamin A intake. Deterrents may have included the perceived low healthfulness of the product and the large quantity required to meet weekly requirements. Margarine was also the most difficult to consume and prepare foods with as well as being the most infrequently purchased and consumed for the respondents in our sample Margarine has also received a lot of negative attention in the media in Canada over the past few years (Parti 2015).

2) How are these preferences affected by values and socio-demographic characteristics, food technology neophobia, objective and subjective knowledge, and perceptions of natural?

The impact of socio-demographic variables was analyzed by looking at significant parameters within the models. Canadians with higher income were likelier to prefer supplements over carrots, biofortified sweet potato, and margarine (hypothetical choice experiment only) compared to their lower income counterparts. Participants with children were less likely to choose carrots or biofortified sweet potato over supplements but likelier to choose margarine over supplements. Canadian females were less likely to choose margarine as well. In India, participants with higher income were significantly less likely to choose fortified oil over supplements. This result was robust across models and remained in both the real and hypothetical choice experiments. Participants with higher income were also significantly less likely to choose biofortified sweet potato over supplements in the random parameters logit.

In order to examine the impact of different attitudes, average WTP of individuals was calculated for participants with the low and high attitude scores (Section 5.6). Indian participants that were less confident in their own knowledge had a lower average WTP to exchange supplements for fortified sunflower oil and biofortified sweet potato while participants that were less likely to view foods produced with novel technologies as risky had a lower average WTP for fortified oil and carrots. Greater food technology neophobia was associated with a lower average

WTP to exchange supplements for fortified oils and biofortified sweet potato in India. Canadian participants with greater confidence in their own knowledge had a lower WTP for fortified oil and carrots, similar to India. Greater association between naturalness and lack of processing led to a higher willingness to exchange supplements for margarine in Canada but only for the hypothetical choice experiment.

3) Do these preferences differ between Canada and India where there are different attitudes towards food products and different histories of food fortification?

Recall that in India, the sample selected was among the most poor and disadvantaged people within India and have low access to vitamin A sources. They are representative of rural tribal populations in Odisha. In Canada, women were overrepresented within the sample but they are still the primary grocery shoppers. The Canadian subsample also had income lower than the municipal average. In studies done with the CCHS 2.2 data, authors demonstrated that lower income – and thus more food insecure – populations were far likelier to have low vitamin A intakes (Kirkpatrick and Tarasuk 2003; Kirkpatrick and Tarasuk 2008). Therefore both of our samples represent populations in which vitamin A interventions would be beneficial.

In the choice experiments, Indians and Canadians preferred carrots and biofortified sweet potato more than vitamin A supplements. Evidence also suggested that in both India and Canada, higher income participants have a greater preference for supplements than the food-based vitamin A vehicles within the choice set. The major difference in preferences was that Canadians preferred supplements over margarine while Indians preferred fortified sunflower oil over supplements. High SK scoring Indians were willing to pay less to trade away their supplements for any of the goods within the choice set. In Canada, OK played more of role as high OK scoring Canadians were willing to pay less to exchange supplements for fortified oil or carrots, but no effect between low or high SK participants. Food technology neophobia had a negative effect on WTP estimates for the Indian subsample but no effect was found in Canadians.

Altogether, this implies that despite profound differences between our two subsamples, Indians and Canadians similarly preferred carrots and biofortified sweet potato over supplements while sharing some similarities in regards to food preferences and attitudes. Perceptions of naturalness were not associated with changes in average WTP in either subsample. Foods perceived as more natural were preferred in both Canadian and Indian subsamples which suggest that naturalness in foods is valued positively by both subsamples. However, how participants define natural is not the same; in general Canadians viewed naturalness as the converse of processing, while Indian participants consider naturalness to be something pure and without additives. In both subsamples, there was no effect between high or low scoring participants in the perceptions of naturalness. It may be that it is not what naturalness is defined as by participants but simply how natural a product is perceived to be.

6.2 Policy implications and areas of further research

Here it is discussed how the results of this paper might inform policy of various vitamin A programs. The most longstanding vitamin A program, the MDVA supplementation program, has been ongoing in India for 40 years. While supplementation is still effective in areas with severe deficiency, it is recommended that moves be made toward food-based approaches over time (Sachdeva et al. 2011; WHO 2011; Wallace 2012; Kapil and Sachdev 2013). Positive and significant WTP estimates to exchange supplements for any of the three food products (carrots, fortified oil, and biofortified sweet potato) indicates that there is consumer intention to pay more for foods versus supplements. Since foods offer many other benefits than just vitamin A content (e.g. calories, fibre, antioxidants, other micronutrients, etc.) then it may be beneficial for food-based programs to be considered for development.

In India, supplementation program is mandatory but the fortification of oils is voluntary. Oil fortification could be a viable alternative to the MDVA supplementation program in India Fortified oils were also the most frequently consumed, purchased, and easiest to consume and prepare. These qualities align with traits that make a food choice attractive for mandatory fortification (Table 2.2). One company that has led industry fortification is Cargill, Inc., who has been providing oils fortified with vitamin A to India since 2008. Competing brands have begun fortifying oil with vitamin A as well to maintain market share (Cargill, Inc. 2015). Due to the success of this initiative and potential gains in health, the Indian government has suggested implementing a mandatory oil fortification program. However, there is pushback from the industry due to the lack of vertical integration in the edible oil supply chain as Indian production is done with thousands of small producers. A mandatory program would lead to higher costs of production that smaller producers are not equipped to comply with (ET Bureau 2015). In addition, monitoring to ensure compliance would be expensive given such a large number of producers. Opponents of mandatory fortification have also argued that the deep frying process degrades the vitamin A so that no nutritional benefit is imparted to the consumer. Therefore, more research is needed to determine if a fortification is cost-effective in addition to researching what level of vitamin A fortification is required to have tangible impacts on heath. It would seem from the results of this study that certain consumers would be willing to absorb increased costs of fortified oil if necessary. These consumers would have lower income, lower subjective knowledge scores, be less likely to see foods produced with novel technologies as risky and/or have lower aversion to foods produced with novel technologies.

WTP estimates for carrots were greater than the WTP for biofortified sweet potato in the Indian subsample. These two vitamin A sources contain similar amounts of vitamin A per gram, but given the high costs required to develop a biofortified crop, introduction of biofortified crops may not be as cost effective in India. Even if a biofortified sweet potato crop was successfully introduced and established, sweet potatoes are still seasonal in India and are not widely available year round. Therefore, increasing the intake of carrots and biofortified sweet potatoes would depend on improving year round availability either with proved regional trade or storage infrastructure.

The negative WTP estimates to exchange supplements for margarine indicate that this product was highly undesirable to participants. Recall that margarine is mandatorily fortified within Canada in recognition of low vitamin A levels as people switched from butter to margarine. If Canadians are not consuming margarine anymore and still have low levels of butter/dairy products then there may be a problem with vitamin A intake in Canada and other mechanisms of increasing intake need to be considered although butter intake may be on the rise (CDIC 2013). Results from the 2002 CCHS Cycle 2.2 study showed that across Canada, Canadians were not consuming adequate vitamin A, especially those among the food insecure population. The other program of fortifying skim or partially skimmed milk products in Canada is also unlikely to fully address VAD as consumption of dairy products – particularly milk – is declining (Canadian Dairy Information Centre 2013). Therefore a repeat of the CCHS Cycle 2.2 study should be done in order to update what is known about Canadian diets on a national level in order to identify if deficiencies still exist and potential vehicles to improve intake. Food-based alternatives such as carrots or biofortified sweet potato would likely be a more sustainable solution with the right nutrition education programs.

Possible approaches used by policymakers to increase vitamin A intake could be done by addressing potential gaps in consumer knowledge. These interventions include labeling, education programs, and advertising campaigns. For example, to increase Indian intake of fortified oils or carrots, education programs and advertising should focus on lowering the perceptions of food technologies as risky. If Indian policymakers wanted to increase the intake of supplements, nutrition education campaigns should be performed that boosts consumer confidence in their own knowledge or companies could provide additional information on labels. However, education and advertising campaigns are outside the scope of this thesis.

In some cases, education is not enough to counteract values or cultural ideals within a society (Kahan and Braman 2006). In order to change behaviour, further work must be done to address concerns about risks, values, and concerns. In Canada, to increase the intake of margarine, emphasis would be placed on decoupling the concept of naturalness as the inverse of processing. In both India and Canada, promoting intake of biofortified sweet potato could be done by lowering food technology neophobia. This could be done through numerous channels such as demonstrating health benefits that could be conferred by foods produced with novel technologies, allowing taste testing or free samples in grocery stores to improve familiarity, showing that foods produced with novel technologies are safe for the environment or that they do not expose consumers to higher health risks, etc. Another way to increase biofortified sweet potato in both countries would be to promote their natural qualities of purity or authenticity, rather than naturalness being the opposite of processed. This could be done by promoting sweet potatoes as already being “naturally” transgenically modified, as found by Kyndt et al. (2015) and further elaborated on in the literature review.

6.3 Study Limitations

The major limitation is that this research focuses primarily on consumer intentions. Before policymakers or governments invest in large product development costs or mandate fortification, further behavioural research is necessary. This research should test constructs in other communities to see how stable they are. Also, household monitoring with dietary survey administered over a year should be done in order to provide critical information on whether a single vehicle or combination of vehicles is the best way of stabilizing vitamin A intake during the year. If certain vehicles are currently not preferred then governments or communities must do more to work with individuals to better understand the benefits and lower apprehension of using technology in food product development. Also as individual intentions were assessed in this study, community or group level factors such as geography, access to vitamin A-rich goods, and climate were not taken into consideration. Related to this issue is that a very limited number of vitamin A rich goods are included in this study. Cultural foods such as amaranth, vanaspati, etc. are not included in the Indian choice set which may be relevant to decision-making. Meat products such as eggs and butter were also excluded which are commonly consumed in India and Canada. Therefore it is difficult to extrapolate consumer behaviour when only a limited number of products were considered in the experiments. The use of whole products also meant that consumer preference for vitamin A was confounded by the other attributes of a product, and so it was not possible to disentangle the value of vitamin A from the vehicle.

Direct comparisons of WTP estimates for vitamin A rich goods were not possible between the Indian and Canadian subsample. This was due to different choice sets offered between countries (i.e. margarine in Canada and sunflower oil in India). The survey and experiment were also administered orally in India in a room, in which it was possible to hear other persons' responses. This may have led to participants giving different responses than if they were performing the survey and experiment in private. There were also slight adjustments made in order to aid Indian participants in understanding the experiment. Plates were laid out detailing different scenarios in the payment card whereas in Canada only the food bundles from the choice set were shown at the front out the room. The fortified sunflower oil was also offered in glass jars for sessions 1 through 5. However, given that participants found the jar appealing, possibly rather than the oil, the jars were switched for food-grade pouches for sessions 6 to 10.Limitations related to the use of a choice experiment include having larger WTP estimates for goods compared to different elicitation methods, such as auctions. This is due to emphasis placed on differences between products (Alphonce and Alfnes 2015). However participants may find it difficult to understand different auction mechanisms and due to constrictions in time it was not possible to perform a practice round as is sometimes necessary with a Becker-DeGroot-Marshak auction.

Another limitation is that with a payment card, it is possible that price-signalling occurs, in which giving listed prices signals to participants that certain goods are inherently more valuable than others. The initial endowment of one week's worth of vitamin A supplements also assumed that the supplements were positively valued. Some people may have kept the supplements in order to avoid carrying other food products around but had no intention of taking the supplements. Additional survey questions should have captured what participants planned to do with the supplements after the conclusion of the experiment. To estimate the value of vitamin A to consumers, it would have been possible to use a Becker-deGroot-Marshak referendum in which participants formulated their own bid. This is an incentive compatible auction mechanism that has found success in developing countries in the past (Banerji et al. 2012; De Groote et al. 2014). Additionally, not endowing participants with the supplements but rather including supplements as its own alternative within the payment card would have allowed estimation of WTP for carrots, biofortified sweet potato, oil, and supplements directly. A missed opportunity with the experimental design became apparent, as randomizing the order of the hypothetical and real payment cards would have shed light on ordering effects. However, having the real payment card precede the hypothetical is thought to prime participants to give responses that are incentive compatible via the rationality spillover effect (Cherry et al. 2003).

WTP estimates in the experiments were higher than the lowest market prices available that were used to estimate the bid prices (refer back to Table 3.2). Carrots, while seasonable and less available, could still be found in city markets. This raises the question of why participants would be willing to pay higher prices for goods in the experiment than what could have been available at market. This may have been due to the house money effect, in which knowledge of receiving the participation fee may have affected decision-making during the choice experiment. Past research has shown that initial gains or losses may affect choices later on (Thaler and Johnson 1990; Nalley et al. 2005), with larger initial endowments leading to significantly higher bids on average, likely leading to overbidding (Loureiro et al. 2003). Nalley et al (2015) demonstrated that when participants felt as though they had earned their initial endowment, the house money effect disappeared. In order to minimize the house money effect in our experiment, participants were given payments at the end of the experiment although this is likely insufficient to have mitigated the effect completely. Another possible explanation is transaction costs; many of the villages were remote so availability of products was low. For example, carrots were out of season and thus only available in the larger city markets almost one hour away. So the market price we use to compare to willingness to pay may in fact be artificially low. Another possibility is that there may have been social desirability bias, in which participants wished to be helpful and chose to respond in a manner that they believed would be wanted by researchers (Lusk and Norwood 2009).

Some information was not included in the survey that would have been valuable. For example, information on Indian home gardening practices was not collected within our sample. Given that numerous NGOs have performed research in India on home gardening to improve vitamin A deficiency, this practice merits further exploration (Ruel 2001; Vijayaraghavan 2002; Berti et al. 2004). Anecdotal evidence provided suggested that participants did produce food at home, such as garden vegetables, eggs, and milk. This likely factored in to decision making during the choice experiment and is a key component that was not included in the survey. In addition, the perceptions of naturalness statements were derived from literature from a Western context, and including more perceptions of natural from India may have allowed us to better capture attitudes and improve the accuracy of the purity and processing factors derived from factor analysis. Multiple definitions of natural used in previous research were also excluded in order to keep the survey a reasonable length.

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Appendix 1.1. Summary of average vitamin A intake and prevalence of inadequate intake from Cycle 2.2 of the Canadian Community Health Survey (Kirkpatrick and Tarusak 2008).

	Mean Vitamin A Intake from first 24-h recall (RAE)		*Prevalence of inadequate intake (%)*	
	Food Secure	**Food Insecure**	**Food Secure**	**Food Insecure**
Male 19-30y	695.0	597.3	46.0	60.0
	(25.0)	(60.0)	(41-50)	(38-82)
Females 19-30y	603.4	478.3	24.0	43.0
	(26.0)	(47.7)	(22-27)	(37-48)
Male 31-50y	713.4	703.3	14.0	32.0
	(28.2)	(84.3)	(13-17)	(26-38)
Female 31-50y	641.3	575.3	22.0	37.0
	(19.7)	(57.6)	(20-24)	(32-42)
Male 51-70y	762.8	579.5	25.0	41.0
	(24.9)	(77.7)	(23-27)	(34-48)
Female 51-70y	652.5	558.8	21.0	57.0
	(18.3)	(56.2)	(21-23)	(51-63)

Appendix 3.1 Calculations for bid prices in the choice experiments

$$Bid\ Price = \left[\left(\frac{RAE\ per\ 100g}{\%DV\ of\ RAE\ per\ 100g}\right) * 7\ days * Price/100g\right] * Bid\ Multiplier - Cost\ of\ Supplements$$

Where:

- RAE per 100g = Amount of retinol activity equivalents contained in 100g of food (carrots, margarine/oil, or biofortified sweet potato
- %DV of RAE per 100g = Percentage of recommended daily value satisfied (700 RAE in Canada, 600 RAE in India)
- Price/100g = Lowest local market price of food
- Bid multiplier = Used to scale bids up. Multipliers used were 100%, 150%, 200%, and 300%
- Cost of supplements = Cost of supplements that satisfied one week's worth of recommended dietary intake (Rs. 8 in India, $0.32 in Canada)

Appendix 3.2 Example Nutrition Information Cards

Vitamin A Supplements

These supplements contain retinol in the form of oil. This form improves absorption into the body. These supplements are derived from fish liver oil. These supplements are valued to be about Rs 8 in the store.

These supplements have enough Vitamin A to satisfy your recommended dietary intake for one week (600 RAE x 7 Days = 4,200 RAE). A summary of nutrition information is provided below. The pills are quite small and will last roughly one year in a cool, dry place.

Nutrition Information

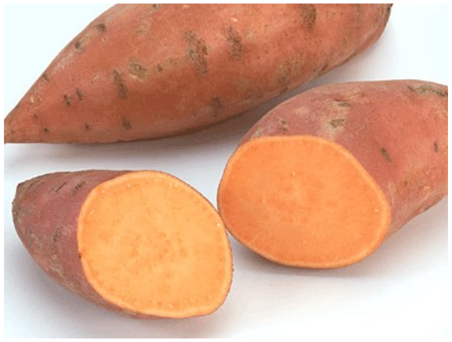
	Total Amount	Units	% Daily Value
Calories	0	Kcal	0%
Fat	0	g	0%
Protein	0	g	N/A
Carbohydrates	0	g	0%
Fibre	0	g	0%
Vitamin A	4,800	RAE	800.0%
Vitamin C	0	mg	0%
Calcium	0	mg	0%
Iron	0	mg	0%

*The Daily Values for nutrients are based on the highest recommended intakes. They apply to most people ages 2 and over, but do not include extra nutrient needs for women who are pregnant or breastfeeding.

Vitamin A Biofortified Sweet Potato (530g)

This orange-fleshed sweet potato has been bred to increase its nutritional value through a process called **biofortification**. Biofortification is when selective breeding or genetic engineering is used to reach a target level of micronutrients. This target level must have a measurable positive impact on human health, and researchers must track the extent to which storage, processing, and cooking affects nutrient levels. Currently there are no biofortified sweet potatoes commercially available in India.

These biofortified sweet potatoes have enough Vitamin A to satisfy your recommended dietary intake for one week (600 RAE x 7 Days = 4,200 RAE). A summary of nutrition information is provided below. The nutrition information below is for biofortified sweet potatoes boiled without skin or salt.



Conventional sweet potato

Biofortified sweet potato

Nutrition Information

	Total Amount	Units	% Daily Value
Calories	410.9	kcal	20.5%
Fat	0.7	g	1.1%
Protein	7.3	g	N/A
Carbohydrates	94.6	g	31.5%
Fibre	13.3	g	53.4%
Vitamin A	4,200	RAE	700.0%
Vitamin C	68.3	mg	113.8%
Calcium	144.1	mg	13.1%
Iron	3.8	mg	27.4%

*The Daily Values for nutrients are based on the highest recommended intakes. They apply to most people ages 2 and over, but do not include extra nutrient needs for women who are pregnant or breastfeeding.

Vitamin A Fortified Sunflower Oil (140 ml)

This sunflower oil has been fortified with Vitamin A. **Fortification** is when a food has had micronutrients added after harvest in amounts that are greater than the levels found before harvest. There are times where a person is lacking adequate micronutrients in their food or simply not eating enough. Therefore, fortification may be needed to boost intake of the limiting nutrient in order to prevent illness. All edible oils in India must be fortified with Vitamin A as mandated by the Government of India since the 1950s.

This fortified sunflower oil has enough Vitamin A to satisfy your recommended dietary intake for one week (600 RAE x 7 Days = 4,200 RAE). A summary of nutrition information is provided below. This fortified sunflower oil comes in a plastic container.

Nutrition Information

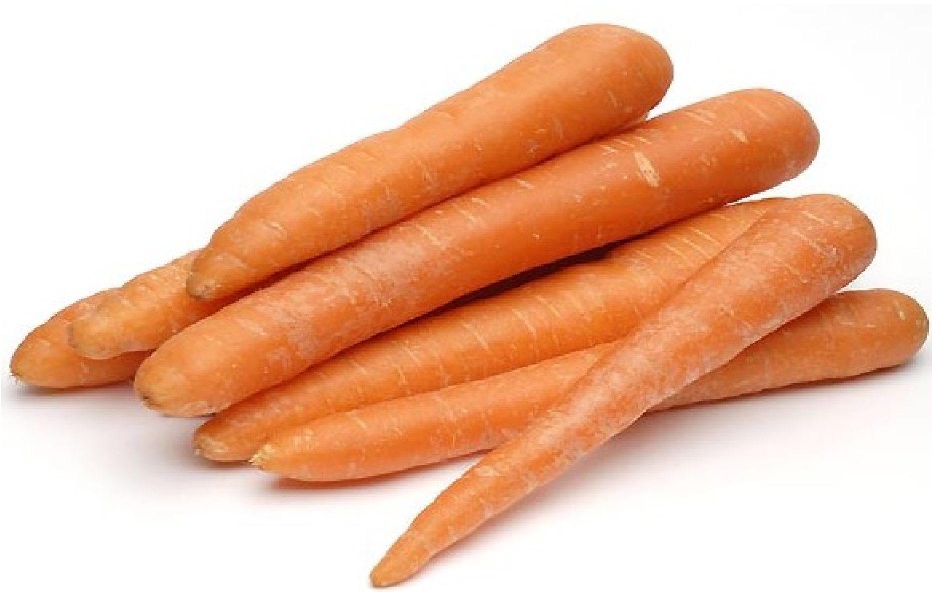
	Total Amount	Units	% Daily Value
Calories	839.7	kcal	42.0%
Fat	93.3	g	143.5%
Protein	0	g	N/A
Carbohydrates	0	g	0%
Fibre	0	g	0%
Vitamin A	4,200	RAE	700%
Vitamin C	0	mg	0.%
Calcium	0	mg	0%
Iron	0	mg	0%

*The Daily Values for nutrients are based on the highest recommended intakes. They apply to most people ages 2 and over, but do not include extra nutrient needs for women who are pregnant or breastfeeding.

Carrots (500g)

This is a **whole, unprocessed food** in which the vitamin A is developed as a part of the normal biology of the food source.

These carrots have enough Vitamin A to satisfy your recommended dietary intake for one week (600 RAE x 7 Days = 4,200 RAE). A summary of nutrition information is provided below. The nutrition information below is for carrots that are whole and uncooked.



Nutrition Information

	Total Amount	Units	% Daily Value
Calories	205	kcal	10.3%
Fat	1.2	g	1.9%
Protein	4.5	g	N/A
Carbohydrates	47.9	g	16.0%
Fibre	12	g	48.0%
Vitamin A	4,175	RAE	695.8%
Vitamin C	29.5	mg	49.1%
Calcium	165	mg	15.0%
Iron	1.5	35	10.7%

*The Daily Values for nutrients are based on the highest recommended intakes. They apply to most people ages 2 and over, but do not include extra nutrient needs for women who are pregnant or breastfeeding.

Appendix 3.3 Choice Experiment and Survey

Introduction

Four products have been placed at the front of the room. Please observe these food items. Each food item has a nutrition information card that tells you what nutrients are available in each food, as well as a description of that item. Each of the four bundles contains the same amount of Vitamin A, and is enough to meet one week's required intake (about 4,200 RAE total). After you have reviewed the information, please answer the following questions below. **Remember that this survey is voluntary and you do not need to answer any question you do not feel comfortable answering.**

1) How healthy do you consider the food products described? Please rate this on a scale of 1 (not healthy at all) to 7 (extremely healthy).

	Not healthy at all	**Very slightly healthy**	**Slightly healthy**	**Moderately healthy**	**Quite healthy**	**Very healthy**	**Extremely healthy**
	1	2	3	4	5	6	7
Vitamin A supplements	☐	☐	☐	☐	☐	☐	☐
Carrots	☐	☐	☐	☐	☐	☐	☐
Fortified Sunflower Oil	☐	☐	☐	☐	☐	☐	☐
Biofortified Sweet potato	☐	☐	☐	☐	☐	☐	☐

2) How natural would you consider the food products listed above? Please rate this on a scale from 1 (not natural at all) to 7 (completely natural).

	Not natural at all 1	**Very slightly natural** 2	**Slightly natural** 3	**Moderately natural** 4	**Very natural** 5	**Extremely natural** 6	**Completely natural** 7
Vitamin A supplements	☐	☐	☐	☐	☐	☐	☐
Carrots	☐	☐	☐	☐	☐	☐	☐
Fortified Sunflower Oil	☐	☐	☐	☐	☐	☐	☐
Biofortified Sweet potato	☐	☐	☐	☐	☐	☐	☐

Experiment I

Now we move on to the experiment portion. **The following situation is real and you will receive real goods in exchange for a payment.**

You will be given a small package of Vitamin A supplements. You have the option to keep these Vitamin A supplements (Option A) or to exchange your supplements for either sunflower oil or carrots by paying a bid (Option B). There are eight scenarios, each with a different product and price. Please consider each scenario individually and select the option that you prefer on the payment card provided on the next page. Remember that there are information sheets with nutrition information for each product.

After you have completed your payment card and related questions, one of the scenarios listed on the payment card will be randomly selected. You will receive the food you have chosen and depending on whether or not you chose to exchange your supplements for another package, **you will pay the bid amount**. This bid amount will be deducted from your participation fee. Only one transaction will occur.

Please note that it is in your best interest if you are honest about which scenario you prefer. Your choices for this experiment do not affect anyone else.

If you have any questions, please ask the investigator at the front of the room. Remember that this is a voluntary experiment and you may skip any question you do not feel comfortable answering.

Payment Card: ID #R (India) _________

Please choose to either keep your Vitamin A supplements or to exchange your supplements for carrots or fortified sunflower oil and pay the bid amount in each scenario. Remember that the supplements and food all contain enough Vitamin A to satisfy one week's requirement. There are information sheets with nutrition information for each product. Please think of each scenario as being separate from the others. Select your choice by circling either A or B below.

After you have completed this card, one scenario will be randomly selected to be binding. You will receive the package you have chosen at the end of the experiment and depending on whether or not you chose to exchange your supplements for another package, you will pay the bid amount.

Scenario	Option A	Option B	Choose A or B
1	I will keep the **Vitamin A supplements**	I will exchange the vitamin supplements for **140mL of fortified sunflower oil and pay Rs 16**	A B
2	I will keep the **Vitamin A supplements**	I will exchange the vitamin supplements for **500g of carrots and pay Rs 37**	A B
3	I will keep the **Vitamin A supplements**	I will exchange the vitamin supplements for **140mL of fortified sunflower oil and pay Rs 4**	A B
4	I will keep the **Vitamin A supplements**	I will exchange the vitamin supplements for **140mL of fortified sunflower oil and pay Rs 2**	A B
5	I will keep the **Vitamin A supplements**	I will exchange the vitamin supplements for **500g of carrots and pay Rs 22**	A B
6	I will keep the **Vitamin A supplements**	I will exchange the vitamin supplements for **140mL of fortified sunflower oil and pay Rs 8**	A B
7	I will keep the **Vitamin A supplements**	I will exchange the vitamin supplements for **500g of carrots and pay Rs 82**	A B
8	I will keep the **Vitamin A supplements**	I will exchange the vitamin supplements for **500g of carrots and pay Rs 52**	A B

Payment Card: ID #R (Canada) _________

Please choose to either keep your Vitamin A supplements or to exchange your supplements for carrots or fortified margarine and pay the bid amount in each scenario. Remember that the supplements and food all contain enough Vitamin A to satisfy one week's requirement. There are information sheets with nutrition information for each product. Please think of each scenario as being separate from the others. Select your choice by circling either A or B below.

After you have completed this card, one scenario will be randomly selected to be binding. You will receive the package you have chosen at the end of the experiment and depending on whether or not you chose to exchange your supplements for another package, you will pay the bid amount.

Scenario	Option A	Option B	Choose A or B	
1	I will keep the **Vitamin A supplements**	I will exchange the vitamin supplements for **680g of margarine and pay $6.86**	A	B
2	I will keep the **Vitamin A supplements**	I will exchange the vitamin supplements for **600g of carrots and pay $1.64**	A	B
3	I will keep the **Vitamin A supplements**	I will exchange the vitamin supplements for **680g fortified margarine and pay $3.27**	A	B
4	I will keep the **Vitamin A supplements**	I will exchange the vitamin supplements for **680g fortified margarine and pay $2.07**	A	B
5	I will keep the **Vitamin A supplements**	I will exchange the vitamin supplements for **600g of carrots and pay $0.99**	A	B
6	I will keep the **Vitamin A supplements**	I will exchange the vitamin supplements for **680g fortified margarine and pay $4.46**	A	B
7	I will keep the **Vitamin A supplements**	I will exchange the vitamin supplements for **600g of carrots and pay $3.60**	A	B
8	I will keep the **Vitamin A supplements**	I will exchange the vitamin supplements for **600g of carrots and pay $2.30**	A	B

<u>Experiment II</u>

The following situation is hypothetical and you will not receive any products or give a payment. However, please behave as though the situation is real.

You will be given a small package of Vitamin A supplements. You have the option to keep these Vitamin A supplements (Option A) or to exchange your supplements for Sunflower Oil, carrots, or biofortified sweet potato by paying a bid (Option B). There are nine scenarios with differing products and prices. Please consider each scenario individually and select the option that you prefer on the payment card provided on the next page. Remember that there are information sheets with nutrition information for each product.

Please note that it is best if you are honest about which scenario you prefer. Your choices for this experiment do not affect anyone else.

If you have any questions, please ask the investigator at the front of the room. Remember that this is a voluntary experiment and you may skip any question you feel uncomfortable answering or may stop at any time.

Payment Card: ID #H (India)_________

Please choose to either keep your Vitamin A supplements or to exchange your supplements for carrots, fortified sunflower oil, or biofortified sweet potato and pay the bid amount in each scenario. Remember that the supplements and food all contain enough Vitamin A to satisfy one week's requirement. Remember that there are information sheets with nutrition information for each product. Please think of each scenario as being separate from the others. Select your choice by circling either A or B below.

Scenario	Option A	Option B	Choose A or B
1	I will keep the **Vitamin A supplements**	I will exchange the vitamin supplements for **140mL of fortified sunflower oil and pay Rs 2**	A B
2	I will keep the **Vitamin A supplements**	I will exchange the vitamin supplements for **500g of carrots and pay Rs 82**	A B
3	I will keep the **Vitamin A supplements**	I will exchange the vitamin supplements for **530g of biofortified sweet potato and pay Rs 82**	A B
4	I will keep the **Vitamin A supplements**	I will exchange the vitamin supplements for **140mL of fortified sunflower oil and pay Rs 8**	A B
5	I will keep the **Vitamin A supplements**	I will exchange the vitamin supplements for **500g of carrots and pay Rs 22**	A B
6	I will keep the **Vitamin A supplements**	I will exchange the vitamin supplements for **140mL of fortified sunflower oil and pay Rs 16**	A B
7	I will keep the **Vitamin A supplements**	I will exchange the vitamin supplements for **500g of carrots and pay Rs 52**	A B
8	I will keep the **Vitamin A supplements**	I will exchange the vitamin supplements for **140mL of fortified sunflower oil and pay Rs 4**	A B
9	I will keep the **Vitamin A supplements**	I will exchange the vitamin supplements for **500g of carrots and pay Rs 37**	A B
10	I will keep the **Vitamin A supplements**	I will exchange the vitamin supplements for **530g of biofortified sweet potato and pay Rs 127**	A B
11	I will keep the **Vitamin A supplements**	I will exchange the vitamin supplements for **530g of biofortified sweet potato and pay Rs 60**	A B
12	I will keep the **Vitamin A supplements**	I will exchange the vitamin supplements for **530g of biofortified sweet potato and pay Rs 37**	A B

Payment Card: ID #H (Canada)_________

Please choose to either keep your Vitamin A supplements or to exchange your supplements for carrots, fortified margarine, or biofortified sweet potato and pay the bid amount in each scenario. Remember that the supplements and food all contain enough Vitamin A to satisfy one week's requirement. Remember that there are information sheets with nutrition information for each product. Please think of each scenario as being separate from the others. Select your choice by circling either A or B below.

Scenario	Option A	Option B	Choose A or B
1	I will keep the **Vitamin A supplements**	I will exchange the vitamin supplements for **680g fortified margarine and pay $2.07**	A B
2	I will keep the **Vitamin A supplements**	I will exchange the vitamin supplements for **600g of carrots and pay $3.60**	A B
3	I will keep the **Vitamin A supplements**	I will exchange the vitamin supplements for **700g of biofortified sweet potato and pay $1.93**	A B
4	I will keep the **Vitamin A supplements**	I will exchange the vitamin supplements for **680g fortified margarine and pay $4.46**	A B
5	I will keep the **Vitamin A supplements**	I will exchange the vitamin supplements for **600g of carrots and pay $0.99**	A B
6	I will keep the **Vitamin A supplements**	I will exchange the vitamin supplements for **680g of margarine and pay $6.86**	A B
7	I will keep the **Vitamin A supplements**	I will exchange the vitamin supplements for **600g of carrots and pay $2.30**	A B
8	I will keep the **Vitamin A supplements**	I will exchange the vitamin supplements for **680g fortified margarine and pay $3.27**	A B
9	I will keep the **Vitamin A supplements**	I will exchange the vitamin supplements for **600g of carrots and pay $1.64**	A B
10	I will keep the **Vitamin A supplements**	I will exchange the vitamin supplements for **700g of biofortified sweet potato and pay $3.06**	A B

11	I will keep the **Vitamin A supplements**	I will exchange the vitamin supplements for **700g of biofortified sweet potato and pay $1.37**	A B
12	I will keep the **Vitamin A supplements**	I will exchange the vitamin supplements for **700g of biofortified sweet potato and pay $0.81**	A B

Please answer the following questions about the experiment.

1) If you chose to keep your supplements for ALL scenarios in Experiments 1 and 2, please indicate the primary reason why you did so:

☐ I prefer to get my vitamins from supplements
☐ I am not familiar with eating the foods provided in the food bundles
☐ None of the other food bundles appealed to me
☐ The bids were too high
☐ Other: __________ (please specify)
☐ Not applicable

2) How accurate do you think the information sheets are? Please rate this on a scale of 1 (completely inaccurate) to 5 (completely accurate).

Not Accurate		Mostly Accurate		Very Accurate
1	2	3	4	5
☐	☐	☐	☐	☐

3) When making your decisions about which bundles to purchase, did you consider other people in your household?

☐ Yes
☐ No

If yes, who in your household were you primarily concerned about?

☐ Head of household
☐ Partner of head of household
☐ Children
☐ Other: ___________ (please specify)

4) What were the three most important factors you considered when deciding what goods to purchase? (Check THREE (3)).

☐ Price
☐ Nutrient content
☐ How natural the product was
☐ Amount of each product given
☐ Taste
☐ How much you liked each product
☐ How much you cooked with each product
☐ Food is not regularly available
☐ Other: ________________

The first portion of the experiment is now complete. Please wait for others to finish and then we will proceed to draw the binding scenario as a group.

<u>**Survey - Part I**</u>

Please state how much you agree with the following statements. Your participation is voluntary and you are not required to answer any questions you feel uncomfortable answering.

1) Please state whether or not you agree with the following statements from a scale of 1 (strongly disagree) to 7 (strongly agree)

	Strongly Disagree 1	**2**	**Neither agree nor disagree 3**	**4**	**Strongly Agree 5**
Vitamins are important for maintaining health	☐	☐	☐	☐	☐
Foods with more vitamins are more nutritious	☐	☐	☐	☐	☐
A lack of vitamins in childhood can affect growth or development	☐	☐	☐	☐	☐
You need to eat a certain amount of each vitamin every day to meet your body's needs	☐	☐	☐	☐	☐
Vitamins can help prevent illness and disease	☐	☐	☐	☐	☐

2) Compared with the average person, I know a lot about how to get vitamins in my diet

Strongly Disagree 1	2	3	Neutral 4	5	6	Strongly Agree 7
☐	☐	☐	☐	☐	☐	☐

3) I know a lot about how to judge the quality of my diet

Strongly Disagree			Neutral			Strongly Agree
1	2	3	4	5	6	7
☐	☐	☐	☐	☐	☐	☐

4) People who know me think I am an expert on what is the best way to get vitamins into my diet

Strongly Disagree			Neutral			Strongly Agree
1	2	3	4	5	6	7
☐	☐	☐	☐	☐	☐	☐

5) Foods can be bred, grown, or genetically modified to have more Vitamin A
   - ☐ Agree
   - ☐ Disagree

How certain are you of this answer on a scale of 1 from 5?

Not Certain		Somewhat Certain		Very Certain
1	2	3	4	5
☐	☐	☐	☐	☐

6) Vitamin A is important in the function of the immune system
   - ☐ Agree
   - ☐ Disagree

How certain are you of this answer on a scale of 1 from 5?

Not Certain		Somewhat Certain		Very Certain
1	2	3	4	5
☐	☐	☐	☐	☐

7) Vitamin A supplements can be made in a lab or extracted from whole foods.
   - ☐ Agree
   - ☐ Disagree

How certain are you of this answer on a scale of 1 from 5?

Not Certain		Somewhat Certain		Very Certain
1	2	3	4	5
☐	☐	☐	☐	☐

8) Vitamin A can be added to foods after it has been processed to increase its Vitamin A content.
   - ☐ Agree
   - ☐ Disagree

How certain are you of this answer on a scale of 1 to 5?

Not Certain		Somewhat Certain		Very Certain
1	2	3	4	5
☐	☐	☐	☐	☐

9) Vitamin A is a water soluble vitamin.
   - ☐ Agree
   - ☐ Disagree

How certain are you of this answer on a scale of 1 to 5?

Not Certain		Somewhat Certain		Very Certain
1	2	3	4	5
☐	☐	☐	☐	☐

10) The following four statements ask about your opinions on food and nutrients. Please state on a scale from 1 to 5 how much you agree or disagree with these statements:

	Strongly Disagree 1	**Disagree 2**	**Neither Agree nor Disagree 3**	**Agree 4**	**Strongly Agree 5**
Fortification is the addition of new vitamins or minerals to a processed food	☐	☐	☐	☐	☐
Biofortification involves breeding new plants that meet nutrient targets	☐	☐	☐	☐	☐
Enhanced foods are animal products that have increased vitamins or minerals as a result of certain animal feeds	☐	☐	☐	☐	☐
Foods may have vitamins and minerals as a result of their natural biology	☐	☐	☐	☐	☐

11) The following statements are ideas about what is natural. Please state if you agree or disagree with the following statements:

	Totally Disagree 1	2	3	Neither agree nor disagree 4	5	6	Totally Agree 7
Natural foods have not been changed in any large way by humans	☐	☐	☐	☐	☐	☐	☐
The more familiar a food is the more natural it is	☐	☐	☐	☐	☐	☐	☐
The more authentic a food is the more natural it is	☐	☐	☐	☐	☐	☐	☐
Natural foods do not contain artificial flavours or additives	☐	☐	☐	☐	☐	☐	☐
Natural foods are as good for me as other foods that might not be thought of as natural	☐	☐	☐	☐	☐	☐	☐
Natural foods are not necessary for my health	☐	☐	☐	☐	☐	☐	☐
Naturalness in foods is valuable because it is pure	☐	☐	☐	☐	☐	☐	☐
The more a food has been processed, the less natural it is	☐	☐	☐	☐	☐	☐	☐
Food that has ingredients removed is less natural	☐	☐	☐	☐	☐	☐	☐
Food with synthetic ingredients added are less natural than foods that do not have any ingredients added	☐	☐	☐	☐	☐	☐	☐
Foods with “natural” ingredients added are less natural than foods that do not have any ingredients added	☐	☐	☐	☐	☐	☐	☐

Do you have anything else to add about what you consider to be natural?

____
____
____
____

12) The following questions detail how you feel about using food technologies and what you think of them. Please state if you disagree or disagree with the following statements on a scale from 1 (totally disagree) to 7 (strongly agree). When responding we ask you to think about new food technologies in general rather than one specific technology.

	Totally Disagree 1	**2**	**3**	**Neither agree nor disagree 4**	**5**	**6**	**Totally Agree 7**
There are a plenty of tasty foods around so we don't need to use food technology to produce more	☐	☐	☐	☐	☐	☐	☐
The benefits of new technologies are often grossly overstated	☐	☐	☐	☐	☐	☐	☐
New food technologies decrease the natural quality of food	☐	☐	☐	☐	☐	☐	☐
There is no sense trying out high-tech food products because the ones I eat are already good enough	☐	☐	☐	☐	☐	☐	☐
New foods are not healthier than traditional foods	☐	☐	☐	☐	☐	☐	☐
New food technologies are something I am uncertain about	☐	☐	☐	☐	☐	☐	☐
Society should not depend heavily on technologies to solve its food problems	☐	☐	☐	☐	☐	☐	☐
New food technologies may have long term negative environmental effects	☐	☐	☐	☐	☐	☐	☐
It can be risky to switch to new technologies too quickly	☐	☐	☐	☐	☐	☐	☐
New food technologies are unlikely to have long term negative health effects	☐	☐	☐	☐	☐	☐	☐
New products produced using new food technologies can help people have a balanced diet	☐	☐	☐	☐	☐	☐	☐
New food technologies give people more control over their food choice	☐	☐	☐	☐	☐	☐	☐
The media usually provides a balanced and unbiased view of new food technologies	☐	☐	☐	☐	☐	☐	☐

Part II. Vitamin A

Vitamin A is an essential nutrient for health and well-being. Its active form in the body is called retinol which plays a key role in maintaining eye health. Vitamin A is also involved in metabolism and cell growth. The recommended dietary intake by the National Institute of Nutrition is 600 mcg of retinol daily for every adult.* It is estimated that 50 to 70% of individuals consume less than 30% of this recommended amount. While mild Vitamin A Deficiency (VAD) may not display any symptoms, there may still be a higher risk of infection, and/or delayed growth and bone development. Moderate cases of VAD may include dry skin, fatigue, or lead to the development of anemia. In extreme cases, night blindness and/or a higher risk of disease or death may occur. The cornea may also become weaker and lead to lesions or tears. If left unchecked, extreme VAD may lead to irreversible blindness in adults and children.

VAD can occur when you don't get enough Vitamin A over a long period of time. Therefore, people need to have foods that are rich in vitamin A. Vitamin A may come from both plant and animal sources. Animal sources include liver, fish liver oils, dairy, and eggs. Plants such as leafy green vegetables, yellow vegetables (pumpkin, squash, sweet potato, carrots), and non-citrus yellow and orange fruits (mangos, papayas, and apricots) are also rich sources of vitamin A.

Please answer the following questions regarding your attitudes to vitamin A and diet to the best of your ability. Your participation is voluntary and you are not required to answer any questions you feel uncomfortable answering.

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*National Institute of Nutrition. 2010. Dietary Guidelines for Indians. A Manual. Second Edition.

Please answer the following questions about foods rich in Vitamin A to the best of your ability.

1) How easy is it for you to acquire the following food products from a location near you? Please rate this on a scale from 1 (very hard) to 5 (very easy).

	Very hard 1	**Somewhat hard** 2	**Neither easy or hard** 3	**Somewhat easy** 4	**Very easy** 5
Vitamin supplement capsule	☐	☐	☐	☐	☐
Carrots	☐	☐	☐	☐	☐
Sunflower oil	☐	☐	☐	☐	☐
Sweet potato (conventional)	☐	☐	☐	☐	☐
Liquid milk (skim or whole)	☐	☐	☐	☐	☐
Eggs	☐	☐	☐	☐	☐

2) How easy is it for you to prepare foods with the following items?

	Very hard 1	**Somewhat hard** 2	**Neither easy or hard** 3	**Somewhat easy** 4	**Very easy** 5
Carrots	☐	☐	☐	☐	☐
Sunflower oil	☐	☐	☐	☐	☐
Sweet potato (conventional)	☐	☐	☐	☐	☐
Liquid milk (skim or whole)	☐	☐	☐	☐	☐
Eggs	☐	☐	☐	☐	☐

3) How easy is it for you is it to consume foods with the following ingredients?

	Very hard	**Somewhat hard**	**Neither easy nor hard**	**Somewhat easy**	**Very easy**
	1	2	3	4	5
Carrots	☐	☐	☐	☐	☐
Sunflower oil	☐	☐	☐	☐	☐
Sweet potato (conventional)	☐	☐	☐	☐	☐
Liquid milk (skim or whole)	☐	☐	☐	☐	☐
Eggs	☐	☐	☐	☐	☐

4) How often do you consume the following food products?

	Never	**Once every few months**	**Once or twice a month**	**Once a week**	**3 – 4 times a week or more**
	1	2	3	4	5
Vitamin supplement capsule	☐	☐	☐	☐	☐
Carrots	☐	☐	☐	☐	☐
Sunflower oil	☐	☐	☐	☐	☐
Sweet potato (conventional)	☐	☐	☐	☐	☐
Liquid milk (skim or whole)	☐	☐	☐	☐	☐
Eggs	☐	☐	☐	☐	☐

5) How often do you buy these food products?

	Never	Once every few months	Once or twice a month	Once a week	3 – 4 times a week or more
	1	2	3	4	5
Vitamin supplement capsule	☐	☐	☐	☐	☐
Carrots	☐	☐	☐	☐	☐
Sunflower oil	☐	☐	☐	☐	☐
Sweet potato (conventional)	☐	☐	☐	☐	☐
Liquid milk (skim or whole)	☐	☐	☐	☐	☐
Eggs	☐	☐	☐	☐	☐

6) How often do you eat carrots?

☐ Never
☐ Regularly during the growing season
☐ occasionally during the growing season

7) How nutritious would you rate the foods below? Please rate this on a scale of 1 (not nutritious at all) to 7 (extremely nutritious).

	Not nutritious at all	Very nutritious healthy	Slightly nutritious	Moderately nutritious	Quite nutritious	Very nutritious	Extremely nutritious
	1	2	3	4	5	6	7
Vitamin supplement capsule	☐	☐	☐	☐	☐	☐	☐
Carrots	☐	☐	☐	☐	☐	☐	☐
Sunflower oil	☐	☐	☐	☐	☐	☐	☐
Sweet potato (conventional)	☐	☐	☐	☐	☐	☐	☐
Liquid Milk (skim or	☐	☐	☐	☐	☐	☐	☐

whole)							
Eggs	☐	☐	☐	☐	☐	☐	☐

8) If you wanted to get Vitamin A into your diet, how likely are you to consume more of the following?

	Very unlikely	**Unlikely**	**Neither likely nor unlikely**	**Likely**	**Very likely**
	1	2	3	4	5
Vitamin supplement capsules	☐	☐	☐	☐	☐
Carrots	☐	☐	☐	☐	☐
Sunflower oil	☐	☐	☐	☐	☐
Sweet potato (conventional)	☐	☐	☐	☐	☐
Liquid milk (skim or whole)	☐	☐	☐	☐	☐
Eggs	☐	☐	☐	☐	☐

9) Do you consider your Vitamin A intake adequate?

☐ Yes, my intake is adequate
☐ No, my intake is inadequate
☐ I don't know

10) Do you consider the Vitamin A intake of <u>your child(ren)</u> adequate?

☐ Yes, it is adequate
☐ No, it is inadequate
☐ I don't know
☐ Not applicable (no children)

11) Who in your household has received Vitamin A supplements as a part of the Massive Dose Vitamin A program between the ages of 1 and 6 yrs? Please check all that apply.

☐ Yourself
☐ Head of household
☐ Children
☐ Other adults
☐ Other: _______
☐ I don't know
☐ I am not aware of that program

12) The following questions ask about your usage of the Public Distribution System. Please select how often you

	Never	**Once every few months**	**Once or twice a month**	**Once a week**	**3 – 4 times a week or more**
	1	2	3	4	5
Acquire food items from the Public Distribution System	☐	☐	☐	☐	☐
Acquire NON-food items from the public distribution system	☐	☐	☐	☐	☐

13) Which of these options best describe your dietary preferences?

☐ I eat dairy and meat products
☐ I eat dairy but not meat products
☐ I eat meat products but not dairy
☐ I am a vegetarian (no meats)
☐ I am a vegan (no meats or animal products of any kind)

14)Have you ever had the following symptoms or been diagnosed with the following from a doctor?

	Yes	No	Don't know
Difficulty seeing at night or in dim light	☐	☐	☐
Chronic fatigue	☐	☐	☐
Dry skin	☐	☐	☐
Dry eyes	☐	☐	☐
White plaques on the eyes	☐	☐	☐
Corneal thinning or ulceration	☐	☐	☐

15)Has your child(ren) ever had the following symptoms or been diagnosed with the following from a doctor?

	Yes	No	Don't know
Difficulty seeing at night or in dim light	☐	☐	☐
Chronic fatigue	☐	☐	☐
Dry skin	☐	☐	☐
Dry eyes	☐	☐	☐
White patches on the eyes	☐	☐	☐
Corneal thinning or ulceration	☐	☐	☐

Follow-Up Questions

Please answer the following questions about yourself

1) What is your age? ______

2) Which is your gender?
   ☐ Female
   ☐ Male

   a. If you are female, please answer the following two questions:
      i. Are you currently pregnant?
         ☐ Yes (Please
         ☐ No

      ii. Are you currently breastfeeding?
         ☐ Yes
         ☐ No

3) What is the highest level of schooling you have completed? Choose only one.
   ☐ Elementary school
   ☐ Secondary (high) school
   ☐ Technical/business school/college certification
   ☐ Undergraduate studies
   ☐ Graduate studies/post-doctoral studies

4) What is the approximate range of your total household income? Check ONE (1)
   ☐ Rs 7,999 or under
   ☐ Between Rs 8,000 and Rs 14,999
   ☐ Between Rs 15,000 and Rs 29,999
   ☐ Between Rs 30,000 and RS 54,999
   ☐ Between Rs 55,000 and Rs 99,999
   ☐ Between Rs 100,000 and Rs 119,999
   ☐ Rs 120,000 or more

5) How many members are there in your household?
   ☐ 1
   ☐ 2
   ☐ 3
   ☐ 4+

6) How many children are in your household between the ages of one (1) to six (6)?

☐ 1
☐ 2
☐ 3
☐ 4+

7) What is your position within the household? Choose only one.

☐ Primary income source/head of household
☐ Partner of head of household
☐ One of two income earners
☐ Child
☐ Other family member
☐ Other (not family)

8) What is the primary way you acquire your food? Choose only one.

☐ Grocery store/market
☐ Home garden
☐ Farm or home garden
☐ Share home gardens among neighbours
☐ Other: ________

9) Do you have a home or shared garden for growing food?

☐ Yes
☐ No

10) How often do you purchase food for your family?

Never	Once every few months	Once or twice a month	Once a week	3 – 4 times a week or more
1	2	3	4	5
☐	☐	☐	☐	☐

11) Generally, how would you rate your personal health?

☐ Excellent
☐ Very Good
☐ Good
☐ Fair
☐ Poor

12) In the last year, have you made any dietary or behavioural changes to improve your own health? This could include eating less fat or sugar, eating more fruits and vegetables, or exercising more often.

☐ Yes
☐ No

13) How physically active are you? Please rate this on a scale from 1 (very inactive) to 5 (very active).

Very inactive	Not often active	Moderately Active	Often Active	Very Active
1	2	3	4	5
☐	☐	☐	☐	☐

14) How often do you smoke? Please rate this on a scale from 1 (once a month or less) to 5 (daily).

Never	Several times a year	One to two times per month	2 – 4 times per week	Daily
1	2	3	4	5
☐	☐	☐	☐	☐

15) How often do you consume alcohol? Please rate this on a scale from 1 (once a month or less) to 5 (daily).

Never	Several times a year	One to two times per month	2 – 4 times per week	Daily
1	2	3	4	5
☐	☐	☐	☐	☐

16) Lastly, do you have any questions, comments or concerns?

____
____
____
____
____
____

Thank you very much! The experiment is now complete. Please receive your gift from the experiment moderators and the good you selected in the first part of the survey.

Appendix 4.1 Summary of participant responses for supplemental questions

Perceptions of Vitamin A intake of Indian participants (n = 120)

Question	Answer	Mean
Do you consider your Vitamin A intake adequate?		
	Yes	90.8%
	No	5.0%
	Don't Know	4.2%
Do you consider the Vitamin A intake of your child(ren) adequate?		
	Yes	84.2%
	No	1.7%
	Don't Know	7.5%
	Not Applicable	5.8%
Have you ever had or been diagnosed with the following by a doctor?		
	Difficulty seeing at night or in dim light	14.2%
	Chronic fatigue	7.6%
	Dry Skin	4.2%
	Dry Eyes	4.2%
	White plaques on the eyes	1.7%
	Corneal thinning	0.8%
Have your children ever had or been diagnosed with the following by a doctor?		
	Difficulty seeing at night or in dim light	1.7%
	Chronic fatigue	2.5%
	Dry Skin	8.3%
	Dry Eyes	1.7%
	White plaques on the eyes	1.7%
	Corneal thinning	0.0%

Perceptions of Vitamin A intake in Canadian Consumers (n = 101)

Question		Mean	St. Dev.	Min	Max
Do you consider your Vitamin A intake adequate?					
	Yes	63.4%			
	No	13.9%			
	Don't Know	22.8%			
Do you consider the Vitamin A intake of your child(ren) adequate?					
	Yes	14.9%			
	No	5.0%			
	Don't Know	5.0%			
	Not Applicable	76.2%			
If you wanted to get Vitamin A into your diet, how likely are you to consume the following on a scale from 1 (very unlikely) to 5 (very likely)?					
	Vitamin A supplements	3.32	1.469	1	5
	Carrots	4.53	0.76	2	5
	Margarine	1.79	1.04	1	4
	Conventional sweet potato	3.85	1.18	1	5
	Liquid milk (skim or whole)	4.05	1.35	1	5
	Eggs	4.5	0.83	1	5
Percentage who have had or been diagnosed with the following VAD symptoms					
	Difficulty seeing at night or in dim light	15.8%			
	Chronic fatigue	20.8%			
	Dry Skin	41.6%			
	Dry Eyes	25.7%			
	White plaques on the eyes	1.0%			
	Corneal thinning	1.0%			
Percentage of households with children where the children have had or been diagnosed with the following VAD symptoms					
	Difficulty seeing at night or in dim light	0.00%			
	Chronic fatigue	4.2%			
	Dry Skin	29.2%			
	Dry Eyes	4.2%			
	White plaques on the eyes	0.0%			
	Corneal thinning	0.0%			

Attitudes, consumption, and purchasing behaviour of Indian consumers (n = 120) of Vitamin A rich foods

Question	Mean (% Freq)	St. Dev.	Min	Max
How healthy do you consider the following from a scale from 1 (not healthy at all) to 7 (extremely healthy)?				
Vitamin A Supplements	4.20	1.261	1	7
Carrots	5.98	1.080	3	7
Fortified Sunflower Oil	4.29	0.991	2	7
Sweet Potato	5.69	1.208	3	7
How easy is it for you to acquire the following on a scale from 1 (very hard) to 5 (very easy)?				
Vitamin A Supplements	2.88	0.975	1	5
Carrots	3.53	0.859	1	5
Fortified Sunflower Oil	4.22	0.972	2	5
Sweet Potato	4.10	0.974	1	5
Liquid milk (skim or whole)	4.66	0.579	3	5
Eggs				
How easy is it for you to prepare foods with the following on a scale from 1 (very hard) to 5 (very easy)?				
Carrots	4.53	0.744	2	5
Fortified Sunflower Oil	4.88	0.379	3	5
Sweet Potato	4.59	0.628	2	5
Liquid milk (skim or whole)	4.38	1.047	1	5
Eggs	4.82	0.534	1	5
How easy is it for you to consume foods with the following on a scale from 1 (very hard) to 5 (very easy)?				
Carrots	3.95	0.924	1	5
Fortified Sunflower Oil	4.77	0.512	2	5
Sweet Potato	4.14	0.969	2	5
Liquid milk (skim or whole)	4.08	1.046	1	5
Eggs	4.50	0.860	1	5
How often do you consume the following? With 1 = never, 2 = once every few months, 3 = once or twice a month, 4 = once a week, 5 = 3-4 times a week				
Vitamin A Supplements	1.59	0.527	1	3
Carrots	2.40	0.510	2	4
Fortified Sunflower Oil	4.78	0.490	2	5
Sweet Potato	2.72	0.724	2	5
Liquid milk (skim or whole)	3.97	1.161	1	5
Eggs	4.08	0.724	1	5
How often do you buy the following? With 1 = never, 2 = once every few months, 3 = once or twice a month, 4 = once a week, 5 = 3-4 times a week				
Vitamin A Supplements	1.53	0.549	1	3
Carrots	2.36	0.515	2	4
Fortified Sunflower Oil	4.61	0.539	3	5
Sweet Potato	2.70	0.754	2	5
Liquid milk (skim or whole)	4.01	1.131	1	5

Eggs	4.09	0.725	1	5
How nutritious would you rate the following from a scale of 1 (not nutritious at all) to 7 (extremely nutritious)?				
Vitamin A Supplements	3.99	0.939	2	6
Carrots	5.13	0.913	2	7
Fortified Sunflower Oil	4.59	2.818	2	33
Sweet Potato	5.70	0.894	2	7
Liquid milk (skim or whole)	5.57	0.968	1	7
Eggs				
How often do you acquire the following from the public distribution system? With 1 = never, 2 = once every few months, 3 = once or twice a month, 4 = once a week, 5 = 3-4 times a week				
Food Products	2.57	0.546	0	3
Non-food Products	2.57	0.546	0	3

Attitudes, consumption, and purchasing behaviour of Canadian consumers (n = 120) of Vitamin A rich foods

Question	**Mean**	**St. Dev.**	**Min**	**Max**
How healthy do you consider the following from a scale from 1 (not healthy at all) to 7 (extremely healthy)?				
Vitamin A Supplements	4.73	1.326	1	7
Carrots	6.43	0.726	3	7
Fortified Margarine	2.32	1.207	1	6
Sweet Potato	5.41	1.576	1	7
How easy is it for you to acquire the following on a scale from 1 (very hard) to 5 (very easy)?				
Vitamin A Supplements	4.72	0.569	3	5
Carrots	4.92	0.304	3	5
Fortified Margarine	4.81	0.563	2	5
Sweet Potato	4.46	0.972	1	5
Liquid milk (skim or whole)	4.91	0.318	3	5
Eggs	4.88	0.380	3	5
How easy is it for you to prepare foods with the following on a scale from 1 (very hard) to 5 (very easy)?				
Carrots	4.73	0.614	2	5
Fortified Margarine	3.91	1.365	1	5
Sweet Potato	4.20	1.058	2	5
Liquid milk (skim or whole)	4.62	0.798	1	5
Eggs	4.81	0.502	2	5
How easy is it for you to consume foods with the following on a scale from 1 (very hard) to 5 (very easy)?				
Carrots	4.74	0.757	1	5

Fortified Margarine	3.58	1.557	1	5
Sweet Potato	4.39	1.026	1	5
Liquid milk (skim or whole)	4.44	1.095	1	5
Eggs	4.78	0.726	1	5
How often do you consume the following? With 1 = never, 2 = once every few months, 3 = once or twice a month, 4 = once a week, 5 = 3-4 times a week				
Vitamin A Supplements	2.74	1.706	1	5
Carrots	4.05	0.845	2	5
Fortified Margarine	2.56	1.520	1	5
Sweet Potato	2.76	0.917	1	5
Liquid milk (skim or whole)	4.28	1.275	1	5
Eggs	4.58	0.789	1	5
How often do you buy the following? With 1 = never, 2 = once every few months, 3 = once or twice a month, 4 = once a week, 5 = 3-4 times a week				
Vitamin A Supplements	1.65	0.726	1	5
Carrots	3.43	0.802	2	5
Fortified Margarine	1.76	0.893	1	5
Sweet Potato	2.50	0.901	1	5
Liquid milk (skim or whole)	3.73	1.055	1	5
Eggs	3.72	0.750	1	5
How nutritious would you rate the following from a scale of 1 (not nutritious at all) to 7 (extremely nutritious)?				
Vitamin A Supplements	4.63	1.383	1	7
Carrots	6.31	0.809	3	7
Fortified Margarine	2.52	1.205	1	6
Sweet Potato	6.11	0.969	3	7
Liquid milk (skim or whole)	5.62	1.272	1	7
Eggs	6.12	1.002	1	7

Appendix 4.2 Session details of Indian Data Collection Process

#	Date	Version	Village	General or Standard Tribe	BPL or APL	Binding Scenario
1	11-06-2015	1	Nuaguda	ST	BPL	Carrots INR 52
2	12-06-2015	2	Nuaguda	ST	BPL	Carrots INR 82
3	13-06-2015	3	Nuaguda	General	BPL	Sunflower Oil INR 2
4	13-06-2015	1	Lima	General	BPL	Carrots INR 52
5	14-06-2015	2	Lima	General	BPL	Sunflower Oil INR 8
6	15-06-2015	3	Tentulipar	ST	APL	Carrots INR 22
7	16-06-2015	1	Aasna	General	APL	Carrots INR 22
8	16-06-2015	2	Linkaguda	General	BPL	Sunflower Oil INR 8
9	17-06-2015	3	Aasna	General	BPL	Carrots INR 22
10	18-06-2015	2	Chiariaguda	ST	BPL	Sunflower Oil INR 4

Appendix 4.3 Comparison of means of consumer ratings for vitamin A-rich products with a t-test

Table A1. Comparison of mean ratings of naturalness between Indian and Canadian subsamples for different vitamin A-rich goods via t-test (df = 220)

	t-value	p-value
Vitamin A Supplements	7.9679	<0.0001
Carrots	0.7606	0.44
Fortified Oil and Margarine	13.2629	<0.0001
Biofortified Sweet Potato	13.5766	<0.0001

Table A2. Comparison of mean ratings of naturalness between different vitamin A-rich goods for the Indian subsample via t-test (df = 238).

	t-value	p-value
Vitamin A Supplements vs Carrots	47.0152	<0.0001
Vitamin A Supplements vs Fortified Oil	19.0489	<0.0001
Vitamin A Supplements vs Biofortified Sweet Potato	44.2347	<0.0001
Carrots vs Fortified Sunflower Oil	30.8926	<0.0001
Carrots vs Biofortified Sweet Potato	1.4471	0.1492
Fortified Sunflower Oil vs Sweet Potato	28.1853	<0.0001

Table A3. Comparison of mean ratings of naturalness between different vitamin A-rich goods for the Canadian subsample via t-test (df = 202)

	t-value	p-value
Vitamin A Supplements vs Carrots	20.8663	<0.0001
Vitamin A Supplements vs Margarine	5.3515	<0.0001
Vitamin A Supplements vs Biofortified Sweet Potato	5.3315	<0.0001
Carrots vs Margarine	32.1381	<0.0001
Carrots vs Biofortified Sweet Potato	13.0789	<0.0001

Margarine vs Biofortified Sweet Potato	10.9754	<0.0001

Table A4. t-test comparing means between Indian and Canadian subsamples for naturalness statements (df = 220)

Statement #	**t-value**	**p-value**
1	10.6259	<0.0001
2	19.3822	<0.0001
3	8.9284	<0.0001
4	4.3657	<0.0001
5	8.6076	<0.0001
6	6.4052	<0.0001
7	7.9314	<0.0001
8	2.9312	0.0037
9	2.2749	0.0239
10	2.4377	0.0156
11	3.9235	0.0001

Table A5. t-test comparing means between Indian and Canadian subsamples for food technology neophobia statements (df = 220)

#	**t-value**	**p-value**
1	5.582	<0.0001
2	3.2771	0.0012
3	3.6267	0.0004
4	1.7465	0.0821
5	3.2875	0.0012
6	0.4316	0.6664
7	3.3147	0.0011
8	3.0754	0.0024
9	4.4121	<0.0001
10	5.5153	<0.0001
11	3.3181	0.0011
12	12.1119	<0.0001
13	19.6587	<0.0001

Table A6. Comparison of means with a t-test for ratings of healthiness of Vitamin A sources by the Indian subsample (d.f. = 238)

	t-value	p-value
Vitamin A Supplements vs Carrots	11.7444	<0.0001
Vitamin A Supplements vs Fortified Oil	0.6147	0.5393
Vitamin A Supplements vs Sweet Potatoes	9.3470	<0.0001
Carrots vs Fortified Oil	12.6302	<0.0001
Carrots vs Sweet Potato	1.9605	0.0511
Fortified Oil vs Sweet Potato	9.8153	<0.0001

Table A7. Comparison of means with a t-test for ratings of healthiness of Vitamin A sources for the Canadian subsample (d.f. = 238)

	t-value	p-value
Vitamin A Supplements vs Carrots	11.3572	<0.0001
Vitamin A Supplements vs Fortified margarine	13.5743	<0.0001
Vitamin A Supplements vs Sweet Potatoes	3.3344	0.001
Carrots vs Fortified Margarine	29.4699	<0.0001
Carrots vs Sweet Potato	5.9368	<0.0001
Fortified margarine vs Sweet Potato	15.7208	<0.0001

Table A8. Comparison of means with a t-test for ratings of the ease with which participants could acquire vitamin A sources (d.f. = 238)

	t-value	p-value
Vitamin A Supplements vs Carrots	5.4796	<0.0001
Vitamin A Supplements vs Fortified Oil	10.6621	<0.0001
Vitamin A Supplements vs Sweet Potatoes	9.6974	<0.0001
Vitamin A supplements vs. Liquid Milk	17.1954	<0.0001
Carrots vs Fortified Oil	5.8269	<0.0001
Carrots vs Sweet Potato	4.808	<0.0001
Carrots vs Milk	11.9494	<0.0001
Fortified Oil vs Sweet Potato	0.9553	0.3404
Fortified Oil vs Milk	4.2602	<0.0001
Sweet Potatoes vs Milk	5.4139	<0.0001

Table A9. Comparison of means with a t-test for ratings of the ease with which Canadian participants could acquire vitamin A sources (d.f. = 202)

	t-value	p-value
Vitamin A Supplements vs Carrots	3.1311	0.0020
Vitamin A Supplements vs Fortified margarine	1.1355	0.2575
Vitamin A Supplements vs Sweet Potatoes	2.3314	0.0207
Vitamin A supplements vs. Liquid Milk	2.9439	0.0036
Carrots vs Fortified Margarine	1.7363	0.084
Carrots vs Sweet Potato	4.5617	<0.0001
Carrots vs Milk	0.2296	0.8187
Fortified Margarine vs Sweet Potato	3.1469	0.0019
Fortified Margarine vs Milk	1.5619	0.1199
Sweet potatoes vs Milk	4.4439	<0.0001

Table A10. Comparisons of means with a t-test for ratings of ease with which Indian participants could prepare foods with various vitamin A-rich foods (d.f. = 238)

	t-value	p-value
Carrots vs Fortified Oil	4.5918	<0.0001
Carrots vs Sweet Potato	0.6751	0.5003
Carrots vs Liquid Milk	1.2793	0.202
Carrots vs Eggs	3.4689	0.0006
Fortified Oil vs Sweet Potato	4.331	<0.0001
Fortified oil vs milk	4.919	<0.0001
Fortified oil vs eggs	1.0037	0.0001
Sweet potato vs milk	1.8842	0.0608
sweet potato vs eggs	3.0564	<0.0001
liquid milk vs eggs	4.101	<0.0001

Table A11. Comparisons of means with a t-test for ratings of ease with which Canadian participants could prepare foods with various vitamin A-rich foods (d.f. = 238)

	t-value	p-value
Carrots vs Fortified margarine	5.5331	<0.0001
Carrots vs Sweet Potato	4.3758	<0.0001
Carrots vs Liquid Milk	1.1034	0.2712
Carrots vs Eggs	1.0187	0.3095
Fortified margarine vs Sweet Potato	1.6959	0.0914
Fortified margarine vs milk	4.5351	<0.0001

Fortified margarine vs eggs	6.2498	<0.0001
Sweet potato vs milk	3.2009	0.0016
Sweet potato vs eggs	5.2608	<0.0001
liquid milk vs eggs	2.0354	0.0431

Table A12. Comparisons of means with a t-test for ratings of ease with which Indian participants could consume the following vitamin A sources (d.f. 238).

	t-value	**p-value**
Carrots vs Fortified Oil	8.5033	<0.0001
Carrots vs Sweet Potato	1.5545	0.1214
Carrots vs Liquid Milk	1.0204	0.3086
Carrots vs Eggs	4.773	<0.0001
Fortified Oil vs Sweet Potato	6.2971	<0.0001
Fortified oil vs milk	6.4904	<0.0001
Fortified oil vs eggs	2.9551	0.0034
Sweet potato vs milk	0.461	0.6452
sweet potato vs eggs	3.0439	0.0026
liquid milk vs eggs	3.3976	0.0008

Table A13. Comparisons of means with a t-test for ratings of ease with which Canadian participants could consume the following vitamin A sources (d.f. 202).

	t-value	**p-value**
Carrots vs Fortified margarine	6.767	<0.0001
Carrots vs Sweet Potato	2.7723	0.0061
Carrots vs Liquid Milk	2.276	0.0239
Carrots vs Eggs	0.3852	0.7005
Fortified margarine vs Sweet Potato	4.3872	<0.0001
Fortified margarine vs milk	4.563	<0.0001
Fortified margarine vs eggs	7.0546	<0.0001
Sweet potato vs milk	0.3365	0.7368
sweet potato vs eggs	3.1338	0.002
liquid milk vs eggs	2.6136	0.0096

Table A14. Comparisons of means with a t-test of the frequency of consumption of different vitamin A rich sources for the Indian subsample (d.f. = 238).

	t-value	p-value
Vitamin A Supplements vs Carrots	12.0991	<0.0001
Vitamin A Supplements vs Fortified Oil	48.5611	<0.0001
Vitamin A Supplements vs Biofortified Sweet Potatoes	13.8232	<0.0001
Vitamin A supplements vs. Liquid Milk	20.4482	<0.0001
Vitamin A supplements vs eggs	30.4599	<0.0001
Carrots vs Fortified Oil	36.8634	<0.0001
Carrots vs Biofortified Sweet Potato	3.9583	<0.0001
Carrots vs Milk	13.5626	<0.0001
Carrots vs Eggs	20.781	<0.0001
Fortified Oil vs Biofortified Sweet Potato	25.8127	<0.0001
Fortified Oil vs Milk	7.0412	<0.0001
Fortified oil vs eggs	8.7713	<0.0001
Biofortified Potatoes vs Milk	10.0078	<0.0001
Biofortified Potatoes vs eggs	14.5504	<0.0001
liquid milk vs eggs	0.8807	0.3794

Table A15. Comparisons of means with a t-test of frequency of consumption of vitamin A rich sources for the Canadian subsample (d.f. = 202).

	t-value	p-value
Vitamin A Supplements vs Carrots	6.9494	<0.0001
Vitamin A Supplements vs Fortified margarine	0.7956	0.4272
Vitamin A Supplements vs Biofortified Sweet Potatoes	0.1043	0.9170
Vitamin A supplements vs. Liquid Milk	7.3027	<0.0001
Vitamin A supplements vs eggs	9.8866	<0.0001
Carrots vs Fortified margarine	8.653	<0.0001
Carrots vs Biofortified Sweet Potato	10.4481	<0.0001
Carrots vs Milk	1.5186	0.1304
Carrots vs Eggs	4.63	<0.0001
Fortified margarine vs Biofortified Sweet Potato	1.1379	0.2565
Fortified margarine vs Milk	8.7559	<0.0001
Fortified margarine vs eggs	11.9125	<0.0001
Biofortified Potatoes vs Milk	9.7747	<0.0001
Biofortified Potatoes vs eggs	15.1946	<0.0001
liquid milk vs eggs	2.0207	0.0446

Table A16. Comparisons of means with a t-test of the frequency of purchasing different vitamin A rich sources by Indian participants (d.f. = 238).

	t-value	**p-value**
Vitamin A Supplements vs Carrots	12.0787	<0.0001
Vitamin A Supplements vs Fortified Oil	43.854	<0.0001
Vitamin A Supplements vs Biofortified Sweet Potatoes	13.7416	<0.0001
Vitamin A supplements vs. Liquid Milk	21.6091	<0.0001
Vitamin A supplements vs eggs	30.8369	<0.0001
Carrots vs Fortified Oil	33.0624	<0.0001
Carrots vs Biofortified Sweet Potato	4.079	<0.0001
Carrots vs Milk	14.5444	<0.0001
Carrots vs Eggs	21.3103	<0.0001
Fortified Oil vs Biofortified Sweet Potato	22.5745	<0.0001
Fortified Oil vs Milk	5.2461	<0.0001
Fortified oil vs eggs	6.3054	<0.0001
Biofortified Potatoes vs Milk	11.0407	<0.0001
Biofortified Potatoes vs eggs	14.5569	<0.0001
liquid milk vs eggs	0.6523	0.5148

Table A17. Comparisons of means with a t-test of the frequency of purchasing different vitamin A rich sources by Canadian participants (d.f. = 202)

	t-value	**p-value**
Vitamin A Supplements vs Carrots	16.6065	<0.0001
Vitamin A Supplements vs Fortified margarine	0.9653	0.3355
Vitamin A Supplements vs Biofortified Sweet Potatoes	7.4191	<0.0001
Vitamin A supplements vs. Liquid Milk	16.4032	<0.0001
Vitamin A supplements vs eggs	20.0282	<0.0001
Carrots vs Fortified margarine	14.052	<0.0001
Carrots vs Biofortified Sweet Potato	7.7867	<0.0001
Carrots vs Milk	2.2863	0.0233
Carrots vs Eggs	2.6673	0.0083
Fortified margarine vs Biofortified Sweet Potato	5.8914	<0.0001
Fortified margarine vs Milk	14.3945	<0.0001
Fortified margarine vs eggs	16.9744	<0.0001
Biofortified Potatoes vs Milk	8.9538	<0.0001
Biofortified Potatoes vs eggs	10.5104	<0.0001
liquid milk vs eggs	0.078	0.9379

Appendix 5.1 Linear utility function specifications

Below we define the utility functions that will be used:

The simple form of v_j has the linear utility function for the real choice experiment:

$$v_j(x_j) = \lambda * price + ASC_1 * oil + ASC_2 * car + \varepsilon_{ij}$$

and the hypothetical choice experiment which contained the biofortified sweet potato scenarios is denoted by:

$$v_j(x_j) = \lambda * price + ASC_1 * oil + ASC_2 * car + ASC_3 * pot + \varepsilon_{ij}$$

In order to estimate individual WTP for vitamin A-rich goods in addition to controlling for various socio-demographic factors, an unrestricted utility function is also specified. They are, for the real and hypothetical choice experiments respectively:

$$\begin{aligned} v_j(x_j) = \lambda * price + ASC_1 * oil + ASC_2 * car + \beta_{11} * oil\_age + \beta_{12} * oil\_fem \\ + \beta_{13} * oil\_y + \beta_{14} * oil\_child + \beta_{21} * car\_age + \beta_{22} * car\_fem + \beta_{23} \\ * car\_y + \beta_{24} * car\_child + \varepsilon_{ij} \end{aligned}$$

and

$$\begin{aligned} v_j(x_j) = \lambda * price + ASC_1 * oil + ASC_2 * car + ASC_3 * pot + \beta_{11} * oil\_age + \beta_{12} * oil\_fem \\ + \beta_{13} * oil\_y + \beta_{14} * oil\_child + \beta_{21} * car\_age + \beta_{22} * car\_fem + \beta_{23} \\ * car\_y + \beta_{24} * car\_child + \beta_{31} * pot\_age + \beta_{32} * pot\_fem + \beta_{33} * pot\_y \\ + \beta_{34} * pot\_child + \varepsilon_{ij} \end{aligned}$$

Appendix 5.2 Estimation of models with only one good

Table A18. WTP Estimates for vitamin A-rich goods in models with data from only one good (2015 INR for 4,300 RAE)

Real						
India				Canada		
Oil	MNL	RPL		Margarine	MNL	RPL
Restricted	12.66***	12.58***		Restricted	-275.79	-360.11
Unrestricted	12.65***	12.55***		Unrestricted	-337.09	-387.73
Carrots				Carrots		
Restricted	33.94***	33.98***		Restricted	88.95***	89.43***
Unrestricted	33.95***	33.92***		Unrestricted	89.02***	89.36***
Hypothetical						
Oil	MNL	RPL		Margarine	MNL	RPL
Restricted	12.87***	12.92***		Restricted	-397.15	-457.99
Unrestricted	12.86***	12.87***		Unrestricted	-487.74	-492.40
Carrots	MNL	RPL		Carrots	MNL	RPL
Restricted	34.04***	34.48***		Restricted	104.40***	85.29***
Unrestricted	34.05***	34.36***		Unrestricted	104.34***	84.69***
Sweet Potato	MNL	RPL		Sweet Potato	MNL	RPL
Restricted	6.81	7.59		Restricted	97.95***	94.44***
Unrestricted	6.66	6.00		Unrestricted	97.46***	95.85***

*** $p < 0.01$, **$p < 0.05$, *$p < 0.10$

Table A19. Results of the multinomial logit in the real choice experiment

India

Oil, Restricted			Carrots, Restricted		
Variable	**β**	**St. Err**	**Variable**	**β**	**St. Err**
Price	-0.237***	0.023	Price	-0.062***	0.007
Oil	2.997***	0.247	Carrots	2.097***	0.288
Loglikelihood function		-216.184	Loglikelihood function		-248.629

Oil, Unrestricted			Carrots, Unrestricted		
Variable	**β**	**St. Err**	**Variable**	**β**	**St. Err**
Price	-0.244***	0.023	Price	-0.062***	0.007
Oil	2.693***	0.660	Carrots	2.301***	0.635
Oil_Age	0.012	0.011	Car_Age	0.003	0.010
Oil_Fem	0.008	0.336	Car_Fem	0.239	0.306
Oil_Income	-0.010***	0.004	Car_Income	-0.003	0.004
Oil_Child	0.552*	0.321	Car_Child	-0.418	0.296
Loglikelihood function		-210.623	Loglikelihood function		-247.044

Canada

Marg, Restricted			Carrots, Restricted		
Variable	**β**	**St. Err**	**Variable**	**β**	**St. Err**
Price	-0.213**	0.094	Price	-0.840***	0.120
Marg	-1.359***	0.397	Carrots, Restricted	1.729***	0.269
Loglikelihood function		-125.593	Loglikelihood function		-254.454

Marg, Unrestricted			Carrots, Unrestricted		
Variable	**β**	**St. Err**	**Variable**	**β**	**St. Err**
Price	-0.199**	0.097	Price	-0.883***	0.124
Marg	-0.534	0.649	Carrots	2.827***	0.466
Marg_Age	-0.013	0.013	Car_Age	0.004	0.008
Marg_Fem	-1.040***	0.354	Car_Fem	-0.506**	0.241
Marg_Income	0.004	0.005	Car_Income	-0.010***	0.003
Marg_Child	-0.773	0.640	Car_Child	-0.443	0.332
Loglikelihood function		-120.175	Loglikelihood function		-244.382

Table A20. Results of the random parameters logit in the real choice experiment

India

Oil, Restricted	β	St. Err.	Carrots, Restricted	β	St. Err.
Random parameters			**Random parameters**		
Oil	3.990***	0.444	Carrots	3.186***	0.491
Nonrandom parameters			**Nonrandom parameters**		
Price	-0.317***	0.036	Price	-0.094***	0.012
Distribution of random parameters			**Distribution of random parameters**		
NsOil	1.449***	0.286	NsCar	1.835***	0.318
Loglikelihood Function		-253.103	Loglikelihood Function		-229.068
McFadden Pseudo R-squared		0.38	McFadden Pseudo R-squared		0.312

Oil, Unrestricted	β	St. Err.	Carrots, Unrestricted	β	St. Err.
Random parameters			**Random parameters**		
Oil	3.48241***	1.028	Oil	3.42180***	1.193
Nonrandom parameters			**Nonrandom parameters**		
Price	-0.315***	0.036	Price	-0.094***	0.012
Oil_Age	0.015	0.017	Car_Age	0.007	0.019
Oil_Fem	-0.072	0.512	Car_Fem	0.301	0.594
Oil_Income	-0.012*	0.006	Car_Income	-0.006	0.007
Oil_Child	0.684	0.499	Car_Child	-0.552	0.588
Distribution of random parameters			**Distribution of random parameters**		
NsOil	1.339***	0.286	NsCar	1.819***	0.318
Loglikelihood Function		-259.739	Loglikelihood Function		-228.175
McFadden Pseudo R-squared		0.39	McFadden Pseudo R-squared		0.314

Canada

Marg, Restricted	β	St. Err.	Carrots, Restricted	β	St. Err.
Random parameters			**Random parameters**		
Marg	1.979***	0.557	Carrots	4.345***	0.772
Nonrandom parameters			**Nonrandom parameters**		
Price	-0.237**	0.107	Price	-2.099***	**0.313**
Distribution of random parameters			**Distribution of random parameters**		
NsMarg	1.53221***	0.348	NsCar	3.68485***	0.628
Loglikelihood Function		-282.804	Loglikelihood Function		-196.399
McFadden Pseudo R-squared		0.591	McFadden Pseudo R-squared		0.306

Marg, Unrestricted		
	β	**St. Err.**
Random parameters		
Marg	-1.043	0.871
Nonrandom parameters		
Price	-.22891**	0.108
Marg_Age	-0.012	0.018
Marg_Fem	-.89973**	0.459
Marg_Income	0.003	0.006
Marg_Child	-1.074	0.818
Distribution of random parameters		
NsMarg	1.30540***	0.313
Loglikelihood Function		-112.613
McFadden Pseudo R-squared		0.602

Carrots, Unrestricted		
	β	**St. Err.**
Random parameters		
Carrots	6.73348***	1.608
Nonrandom parameters		
Price	-2.10283***	0.313
Car_Age	0.004	0.029
Car_Fem	-1.164	0.875
Car_Income	-.02162*	0.011
Car_Child	-1.242	1.206
Distribution of random parameters		
NsCar	3.50699***	0.603
Loglikelihood Function		-192.413
McFadden Pseudo R-squared		0.32

Table A21. Results of the multinomial logit in the hypothetical choice experiment

India

Oil, Restricted

Variable	B	St. Err
Price	-0.240***	0.023
Oil	3.089***	0.254
Loglikelihood function		-211.641

Carrots, Restricted

Variable	B	St. Err
Price	-0.062***	0.007
Carrots	2.115***	0.289
Loglikelihood function		-246.423

Sweet Potato, Restricted

Variable	B	St. Err
Price	-0.022***	0.004
Potato	0.149	0.294
Loglikelihood function		-225.639

Oil, Unrestricted

Variable	B	St. Err
Price	-.25292***	0.024
Oil	2.603***	0.674
Oil_Age	.02554**	0.012
Oil_Fem	-0.009	0.345
Oil_Income	-0.014***	0.004
Oil_Child	0.472	0.330
Loglikelihood function		-202.767

Carrots, Unrestricted

Variable	B	St. Err
Price	-0.063***	0.007
Carrots	2.137***	0.633
Car_Age	0.007	0.010
Car_Fem	0.121	0.304
Car_Income	-0.005	0.004
Car_Child	-0.101	0.301
Loglikelihood function		-244.972

Sweet Potato, Unrestricted

Variable	B	St. Err
Price	-0.022***	0.004
Potato	0.864	0.667
Pot_Age	0.003	0.010
Pot_Fem	-0.421	0.305
Pot_Income	-0.005	0.004
Pot_Child	-0.246	0.309
Loglikelihood function		-223.443

Canada

Marg, Restricted

Variable	B	St. Err
Price	-0.215*	0.124
Marg	-1.973***	0.516
Loglikelihood function		-83.797

Carrots, Restricted

Variable	B	St. Err
Price	-0.829***	0.118
Carrots	2.003**	0.276
Loglikelihood function		-252.428

Sweet Potato, Restricted

Variable	B	St. Err
Price	-0.022***	0.004
Potato	0.149	0.294
Loglikelihood function		-225.639

Marg, Unrestricted

Variable	B	St. Err
Price	-0.199	0.128
Marg	-0.780	0.820
Marg_Age	0.001	0.017
Marg_Fem	-0.802*	0.452
Marg_Income	-0.013*	0.007
Marg_Child	0.164	0.656
Loglikelihood function		-79.412

Carrots, Unrestricted

Variable	B	St. Err
Price	-0.881***	0.123
Carrots	3.271***	0.483
Car_Age	-0.001	0.008
Car_Fem	-0.554**	0.247
Car_Income	-0.008***	0.003
Car_Child	-0.917***	0.335
Loglikelihood function		-240.702

Sweet Potato, Unrestricted

Variable	B	St. Err
Price	-0.022***	0.004
Potato	0.864	0.667
Pot_Age	0.003	0.010
Pot_Fem	-0.421	0.305
Pot_Income	-0.005	0.004
Pot_Child	-0.246	0.309
Loglikelihood function		-223.443

Table A22. Results of the random parameters logit in the hypothetical choice experiment

India

Oil, Restricted	β	St. Err.	Carrots, Restricted	β	St. Err.	Sweet Potato, Restricted	β	St. Err.
Random parameters			**Random parameters**			**Random parameters**		
Oil	4.688***	0.557	Carrots	3.340***	0.525	Potato	0.324	0.505
Nonrandom parameters			**Nonrandom parameters**			**Nonrandom parameters**		
Price	-0.363***	0.043	Price	-0.097***	0.013	Price	-0.043***	0.008
Distribution of random parameters			**Distribution of random parameters**			**Distribution of random parameters**		
NsOil	1.820***	0.337	NsCar	1.867***	0.325	NsPot	2.654***	0.467
Loglikelihood Function		-195.422	Loglikelihood Function		-225.986	Loglikelihood Function		-186.264
McFadden Pseudo R-squared		0.413	McFadden Pseudo R-squared		0.317	McFadden Pseudo R-squared		0.440

Oil, Unrestricted	β	St. Err.	Carrots, Unrestricted	β	St. Err.	Sweet Potato, Unrestricted	β	St. Err.
Random parameters			**Random parameters**			**Random parameters**		
Oil	3.909***	1.230	Carrots	3.312***	1.217	Potato	2.356	1.663
Nonrandom parameters			**Nonrandom parameters**			**Nonrandom parameters**		
Price	-0.363***	0.044	Price	-0.097***	0.013	Price	-0.043***	0.008
Oil_Age	0.036*	0.020	Car_Age	0.011	0.019	Pot_Age	-0.007	0.028
Oil_Fem	-0.141	0.607	Car_Fem	0.151	0.609	Pot_Fem	-0.855	0.843
Oil_Income	-0.018**	0.007	Car_Income	-0.009	0.007	Pot_Income	-0.017	0.011
Oil_Child	0.579	0.591	Car_Child	-0.102	0.600	Pot_Child	-0.308	0.877
Distribution of random parameters			**Distribution of random parameters**			**Distribution of random parameters**		
NsOil	1.697***	0.338	NsCar	1.851***	0.324	NsPot	2.661***	0.456
Loglikelihood Function		-190.101	Loglikelihood Function		-225.051	Loglikelihood Function		-332.711
McFadden Pseudo R-squared		0.429	McFadden Pseudo R-squared		0.319	McFadden Pseudo R-squared		0.446

Canada

Marg, Restricted

	β	St. Err.
Random parameters		
Marg	-4.280***	1.330
Nonrandom parameters		
Price	-0.404**	0.176
Distribution of random parameters		
NsMarg	3.633***	1.100
Loglikelihood Function		-70.487
McFadden Pseudo R-squared		0.750

Carrots, Restricted

	β	St. Err.
Random parameters		
Carrots	2.546***	0.378
Nonrandom parameters		
Price	1.047***	0.143
Distribution of random parameters		
NsCar	1.202***	0.224
Loglikelihood Function		-236.444
McFadden Pseudo R-squared		0.164

Sweet Potato, Restricted

	β	St. Err.
Random parameters		
Potato	0.324	0.505
Nonrandom parameters		
Price	-0.043***	0.008
Distribution of random parameters		
NsPot	2.654***	0.467
Loglikelihood Function		-186.264
McFadden Pseudo R-squared		0.440

Marg, Unrestricted

	β	St. Err.
Random parameters		
Marg	-1.431	1.880
Nonrandom parameters		
Price	-0.391**	0.174
Marg_Age	-0.009	0.040
Marg_Fem	-1.273	1.084
Marg_Income	-0.027	0.018
Marg_Child	0.672	1.557
Distribution of random parameters		
NsMarg	3.466***	1.023
Loglikelihood Function		-67.923
McFadden Pseudo R-squared		0.759

Carrots, Unrestricted

	β	St. Err.
Random parameters		
Carrots	4.364***	0.735
Nonrandom parameters		
Price	-1.138***	0.154
Car_Age	-0.005	0.012
Car_Fem	-0.780**	0.348
Car_Income	-.00947**	0.004
Car_Child	-1.736***	0.517
Distribution of random parameters		
NsCar	1.282***	0.235
Loglikelihood Function		-223.733
McFadden Pseudo R-squared		0.209

Sweet Potato, Unrestricted

	β	St. Err.
Random parameters		
Potato	2.356	1.663
Nonrandom parameters		
Price	-0.043***	0.008
Pot_Age	-0.007	0.028
Pot_Fem	-0.855	0.843
Pot_Income	-0.017	0.011
Pot_Child	-0.308	0.877
Distribution of random parameters		
NsPot	2.661***	0.456
Loglikelihood Function		-184.281
McFadden Pseudo R-squared		0.446

Appendix 5.3 Attitudes as explanatory variables

Below we have computed the multinomial logit and the random parameters logit taking into account attitude scores of participants while controlling for socio-demographic variables. Differences between the Indian and Canadian subsamples are described in more detail below, but overall, greater association between carrots and processing seemed to increase the probability of participants exchanging supplements for other goods. In India, objective knowledge appeared to have more significant effects while in Canada, subjective knowledge played the bigger role in affecting decision making in the choice experiments. Food technology neophobia had opposite effects in India and Canada in the hypothetical choice experiment in the RPL. However, in RPL (real) model, no significant effects were found except for increased association between naturalness and no processing. However this was only significant at the 10% level. Finally, the attribute parameters have either ceased to become significant in many of the models, or have even reversed signs and become significant in the case of the MNL model for India (real) as compared to results when we split participants into high or low scoring on the various attitude scales.

Table A23. 1 Results of Multinomial Logit Estimation of Real Choice Experiment

	India			**Canada**	
Variable	**β**	**St. Err.**	**Variable**	**β**	**St. Err.**
Oil	0.195	2.401	*Margarine*	-3.336	6.245
Carrots	-5.141*	2.730	*Carrots*	-4.527	3.401
Price	-0.087***	0.008	*Price*	-0.545***	0.088
Oil_Age	0.012	0.010	*Marg_Age*	-0.007	0.015
Oil_Fem	0.106	0.298	*Marg_Fem*	-1.113**	0.396
Oil_Income	-0.007**	0.004	*Marg_Income*	0.002	0.005
Oil_Child	0.303	0.292	*Marg_Child*	-0.851	0.691
Carrots_Age	0.009	0.011	*Car_Age*	-0.002	0.009
Carrots_Fem	0.236	0.339	*Car_Fem*	-0.585**	0.243
Carrots_Income	-0.007	0.004	*Car_Income*	-0.012***	0.003
Carrots_Child	-0.505	0.345	*Car_Child*	-0.391	0.344
Oil_Proc	0.204	0.172	*Marg_Proc*	0.100	0.238
Oil_Pure	-0.065	0.178	*Marg_Pure*	0.185	0.244
Oil_SK	0.014	0.031	*Marg_SK*	0.021	0.063
Oil_OK	0.091	0.070	*Marg_OK*	0.171*	0.099
Oil_FTNS	-0.026	0.039	*Marg_FTNS*	-0.003	0.097
Oil_Risk	0.110	0.279	*Marg_Risk*	-0.032	0.671
Oil_Nec	0.010	0.300	*Marg_Nec*	-0.279	0.998
Car_Proc	0.462**	0.195	*Car_Proc*	-0.107	0.143

Car_Pure	-0.216	0.210	*Car_Pure*	-0.2714*	0.143
Car_SK	0.042	0.035	*Car_SK*	0.060*	0.035
Car_OK	0.221***	0.084	*Car_OK*	0.027	0.045
Car_FTNS	0.060	0.044	*Car_FTNS*	0.103*	0.057
Car_Risk	-0.236	0.316	*Car_Risk*	-0.558	0.388
Car_Nec	-0.178	0.346	*Car_Nec*	-0.683	0.565
Log Likelihood	-479.54		Log likelihood	-361.83	

***p < 0.01, **p < 0.05, *p < 0.10

Indian participants with increased association between naturalness and processing and greater nutrition knowledge were more likely to exchange their supplements for carrots. The effect of associating processing with natural was greater than that of knowledge. When controlling for attitude factors, the attribute parameter for oil was no longer significant and became negative and significant at the 10% level for carrots.

In the Canadian sample, objective knowledge was positively correlated with the probability of exchanging supplements for margarine. As association between naturalness and purity increased, the probability of exchanging supplements for carrots decreased. However, Canadians with greater food technology neophobia were likelier to trade away their supplements for carrots. However all effects of attitudes on the probability of exchanging supplements for other goods were only significant at the 10% confidence level. The attribute parameters are no longer significant when controlling for attitude variables.

Table A24. Results of Multinomial Logit Estimation of Hypothetical Choice Experiment

	India			**Canada**	
Variable	**β**	**St. Err.**	**Variable**	**β**	**St. Err.**
Oil	-2.144	2.435	*Margarine*	3.743	7.517
Carrots	-2.851	2.407	*Carrots*	-4.988	3.483
Potato	-6.931**	2.949	*Potato*	5.231	3.607
Price	-0.047***	0.004	*Price*	-0.693***	0.083
Oil_Age	0.022**	0.010	*Marg_Age*	0.004	0.018
Oil_Fem	0.034	0.297	*Marg_Fem*	-0.719	0.502
Oil_Income	-0.009**	0.004	*Marg_Income*	-0.014*	0.007
Oil_Child	0.265	0.293	*Marg_Child*	0.394	0.711
Carrots_Age	0.011	0.010	*Car_Age*	-0.005	0.009
Carrots_Fem	0.097	0.300	*Car_Fem*	-0.666***	0.254
Carrots_Income	-0.006	0.004	*Car_Income*	-0.010***	0.003
Carrots_Child	-0.158	0.306	*Car_Child*	-0.993***	0.351

Pot_Age	0.009	0.012	*Pot_Age*	-0.028***	0.009
Pot_Fem	-0.665*	0.349	*Pot_Fem*	-0.203	0.261
Pot_Income	-0.006	0.005	*Pot_Income*	-0.008**	0.003
Pot_Child	-0.311	0.365	*Pot_Child*	-0.138	0.352
Oil_Proc	0.311*	0.172	*Marg_Proc*	-0.141	0.299
Oil_Pure	-0.004	0.178	*Marg_Pure*	-0.141	0.313
Oil_SK	0.014	0.032	*Marg_SK*	0.125	0.083
Oil_OK	0.089	0.071	*Marg_OK*	-0.006	0.110
Oil_FTNS	0.014	0.039	*Marg_FTNS*	-0.087	0.110
Oil_Risk	-0.127	0.279	*Marg_Risk*	0.576	0.110
Oil_Nec	-0.092	0.298	*Marg_Nec*	0.456	1.210
Car_Proc	0.454***	0.174	*Car_Proc*	-0.009	0.149
Car_Pure	-0.218	0.188	*Car_Pure*	-0.174	0.146
Car_SK	0.007	0.030	*Car_SK*	0.075**	0.036
Car_OK	0.182**	0.075	*Car_OK*	0.031	0.045
Car_FTNS	0.000	0.039	*Car_FTNS*	0.120**	0.059
Car_Risk	0.045	0.279	*Car_Risk*	-0.838**	0.399
Car_Nec	0.077	0.308	*Car_Nec*	-0.896	0.579
Pot_Proc	0.652***	0.215	*Pot_Proc*	0.159	0.154
Pot_Pure	-0.284	0.230	*Pot_Pure*	-0.194	0.151
Pot_SK	-0.026	0.036	*Pot_SK*	-0.017	0.037
Pot_OK	0.209**	0.093	*Pot_OK*	0.122***	0.047
Pot_FTNS	0.102**	0.050	*Pot_FTNS*	0.078	0.060
Pot_Risk	-0.441	0.345	*Pot_Risk*	0.070	0.407
Pot_Nec	-0.441	0.384	*Pot_Nec*	0.453	0.593
Log Likelihood = -714.90			Log Likelihood		

***p < 0.01, **p < 0.05, *p < 0.10

Similar to the real choice experiments, Indian participants with increased association between naturalness and processing and greater nutrition knowledge were more likely to exchange their supplements for fortified oil, carrots, or biofortified sweet potato. This effect was greatest in magnitude when participants were presented with biofortified sweet potato. Increased knowledge of nutrition and diet led to a greater likelihood of exchanging supplements for carrots and biofortified sweet potato. Participants with greater food technology neophobia were less likely to choose biofortified sweet potato.

In Canada, the probability of participants choosing margarine in the hypothetical experiment was not affected by attitude variables. There was a small but positive effect of confidence in knowledge on exchanging supplements for carrots and while greater knowledge of nutrition and health had a positive effect on exchanging supplements for biofortified sweet potato. Participants with greater food technology neophobia were also likelier to choose carrots over supplements. However, participants who viewed foods produced with novel technologies as risky were far less likely to purchase carrots.

The attribute parameters were not significant in either Indian or Canadian subsamples in the hypothetical choice experiment.

Table A25. Results of random parameters logit with the real choice experiment

	India			Canada	
Variable	**B**	**St. Err.**	**Variable**	**B**	**St. Err.**
Random parameters			Random parameters		
Oil	1.690	3.058	*Margarine*	-8.890	12.450
Carrots	-7.523	6.817	*Carrots*	-5.011	6.912
Non-random Parameters			Non-random Parameters		
Price	-0.155***	0.016	*Price*	-0.858***	0.128
Oil_Age	0.012	0.012	*Marg_Age*	0.032	0.037
Oil_Fem	0.081	0.374	*Marg_Fem*	-1.674**	0.817
Oil_Income	-0.012**	0.005	*Marg_Income*	-0.010	0.011
Oil_Child	0.564	0.381	*Marg_Child*	0.165	1.035
Carrots_Age	0.017	0.029	*Carrots_Age*	0.026	0.022
Carrots_Fem	0.341	0.889	*Carrots_Fem*	-0.782	0.511
Carrots_Income	-0.016	0.011	*Carrots_Income*	-0.019***	0.007
Carrots_Child	-0.744	0.867	*Carrots_Child*	-1.161*	0.684
Oil_Proc	0.197	0.226	*Marg_Proc*	-0.001	0.487
Oil_Pure	-0.062	0.233	*Marg_Pure*	0.320	0.464
Oil_SK	0.020	0.038	*Marg_SK*	0.077	0.143
Oil_OK	0.087	0.093	*Marg_OK*	0.130	0.192
Oil_FTNS	-0.041	0.050	*Marg_FTNS*	0.079	0.197
Oil_Risk	0.187	0.364	*Marg_Risk*	-0.546	1.390
Oil_Nec	0.103	0.376	*Marg_Nec*	-1.651	1.946
Car_Proc	0.919*	0.484	*Car_Proc*	-0.346	0.313
Car_Pure	-0.156	0.590	*Car_Pure*	-0.402	0.320
Car_SK	0.054	0.087	*Car_SK*	0.055	0.079
Car_OK	0.382	0.237	*Car_OK*	0.053	0.101
Car_FTNS	0.081	0.111	*Car_FTNS*	0.109	0.116
Car_Risk	-0.284	0.782	*Car_Risk*	-0.477	0.815
Car_Nec	0.378	0.857	*Car_Nec*	-0.736	1.107
Distributions of random parameters			Distributions of random parameters		
NsOil	0.814***	0.188	*NsMargarine*	2.624***	0.742
NsCarrots	3.094***	0.188	*NsCarrot*	2.136***	0.358
McFadden Pseudo R-squared = 0.34			McFadden Pseudo R-squared = 0.43		

Log Likelihood = -438.53	Log Likelihood = -322.02
***p < 0.01, **p < 0.05, *p < 0.10	

In the real choice experiment when controlling for random distributions of the choice attributes, Indian participants with higher association between naturalness and processing had a higher likelihood of exchanging supplements for carrots. However, this effect was only significant at the 10% level. None of the attribute parameters were significant in the Indian or Canadian subsample.

Table A26. Results of random parameters logit with the real hypothetical experiment

	India			**Canada**	
Variable	**B**	**St. Err.**	**Variable**	**B**	**St. Err.**
Random parameters			Random parameters		
Oil	-2.130	2.732	*Margarine*	-12.576	27.056
Carrots	-6.470	4.789	*Carrots*	-3.309	10.532
Potato	-27.543***	10.199	*Potato*	26.424**	10.664
Non-random Parameters			Non-random Parameters		
Price	-0.094***	0.009	*Price*	-1.958***	0.213
Oil_Age	0.027**	0.012	*Marg_Age*	0.008	0.074
Oil_Fem	0.042	0.338	*Marg_Fem*	0.008	1.899
Oil_Income	-0.009**	0.004	*Marg_Income*	-0.103***	0.034
Oil_Child	0.269	0.332	*Marg_Child*	6.839***	2.501
Carrots_Age	0.021	0.019	*Carrots_Age*	-0.003	0.030
Carrots_Fem	-0.037	0.598	*Carrots_Fem*	-0.855	0.935
Carrots_Income	-0.007	0.008	*Carrots_Income*	-0.012	0.011
Carrots_Child	-0.302	0.592	*Carrots_Child*	-1.961**	0.995
Pot_Age	0.027	0.041	*Pot_Age*	-0.114***	0.040
Pot_Fem	-2.466*	1.467	*Pot_Fem*	0.599	1.005
Pot_Income	-0.027	0.018	*Pot_Income*	-0.012	0.013
Pot_Child	0.472	1.262	*Pot_Child*	-2.553**	1.098
Oil_Proc	0.339*	0.193	*Marg_Proc*	2.281*	1.286
Oil_Pure	-0.002	0.201	*Marg_Pure*	1.483	1.243
Oil_SK	0.017	0.035	*Marg_SK*	0.806**	0.343
Oil_OK	0.091	0.080	*Marg_OK*	0.053	0.303
Oil_FTNS	0.019	0.043	*Marg_FTNS*	-0.096	0.462
Oil_Risk	-0.169	0.312	*Marg_Risk*	3.298	3.578
Oil_Nec	-0.114	0.331	*Marg_Nec*	-0.075	4.032
Car_Proc	0.771**	0.347	*Car_Proc*	0.103	0.447
Car_Pure	-0.435	0.347	*Car_Pure*	-0.794	0.497
Car_SK	0.010	0.058	*Car_SK*	0.091	0.139

Car_OK	0.327**	0.152	*Car_OK*	0.063	0.155
Car_FTNS	0.043	0.075	*Car_FTNS*	0.136	0.191
Car_Risk	-0.231	0.529	*Car_Risk*	-1.160	1.236
Car_Nec	-0.160	0.615	*Car_Nec*	-0.542	1.826
Pot_Proc	2.316***	0.774	*Pot_Proc*	0.826	0.548
Pot_Pure	-0.748	0.835	*Pot_Pure*	-0.332	0.538
Pot_SK	0.010	0.122	*Pot_SK*	-0.132	0.124
Pot_OK	0.487	0.320	*Pot_OK*	0.312**	0.138
Pot_FTNS	0.434**	0.171	*Pot_FTNS*	-0.397**	0.184
Pot_Risk	-2.047*	1.064	*Pot_Risk*	0.988	1.323
Pot_Nec	-1.916	1.314	*Pot_Nec*	3.270*	1.721
Distributions of random parameters			Distributions of random parameters		
NsOil	0.513**	0.214	*NsMargarine*	13.283***	2.834
NsCarrot	1.853***	0.331	*NsCarrot*	4.004***	0.620
NsPotato	4.222***	0.639	*NsPotato*	4.731***	0.755
Log likelihood function = -632.411			Log Likelihood = -410.880		
McFadden Pseudo R-squared = 0.37			McFadden R-squared = 0.51		

***p < 0.01, **p < 0.05, *p < 0.10

Participants in the Indian subsample that more strongly associated naturalness and processing were likelier to exchange supplements for oil, carrots, and biofortified sweet potato. This effect was most pronounced with biofortified sweet potato and least pronounced with fortified oil. Greater food technology neophobia was associated with higher likelihood of participants exchanging supplements for biofortified sweet potato but participants who were likelier to see foods produced with novel food technologies as risky were less likely to exchange supplements for biofortified sweet potato. This effect was only significant at the 10% level. The attribute parameters for biofortified sweet potato were negative in India and significant while carrots and oil had no effect.

Canadian participants with greater confidence in their knowledge were likelier to choose margarine over supplements. Greater knowledge of nutrition and diet led to a greater likelihood of choosing biofortified sweet potato. Greater food technology neophobia led to a lower probability of participants choosing biofortified sweet potato. However, a participant who believed that foods produced with technology were necessary to society was likelier to choose biofortified sweet potato. Canadian participants who were presented with biofortified sweet potato in the scenario of the payment card were far likelier to exchange their supplements. No effect was found for carrots or margarine.