PRICE COMPETITIVENESS OF FRUITS AND VEGETABLES AT LOCAL FOOD RETAIL OUTLETS IN ALL SEASONS OF THE YEAR

A dissertation submitted by:

Natalie Valpiani

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Dissertation Committee:

Dr. Parke Wilde (Chair)
Dr. Beatrice Rogers
Dr. Hayden Stewart

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Abstract

The popularity of farmers' markets has resulted in conflicting messages about the most healthful way to increase fruit and vegetable intake. Federal dietary guidance promotes all forms without distinction, whereas some supporters for locally grown food say that freshly harvested, whole produce is best. Advocates of local food outlets further state that the outlets offer fresh items that are less expensive, in season, than those sold at traditional supermarkets. If such claims are substantiated, the outlets could serve as important tools to boost Americans' sub-optimal fruit and vegetable consumption. Yet, neither has been sufficiently studied. This dissertation aims to improve future policy and educational efforts to promote fruit and vegetable intake by informing evaluation of these "fresh is best" and "local food costs less" messages.

The first article in this dissertation describes a novel method for categorizing National Health and Nutrition Examination Survey (NHANES) dietary recall data by fruit and vegetable processing form. The mean sodium, added sugar, and fiber contents of produce in each form are compared. The article also reports estimates of the contribution of fresh, processed, juice and miscellaneous forms of produce to total fruit and vegetable intake. The sodium content was highest for miscellaneous vegetables (e.g. salsa), followed by processed and juice forms, respectively. Processed fruit had the most added sugar. Fresh items made up the largest share of fruit and vegetable intake (61.2% and 48.1%, respectively), followed by fruit juice (31.2% of fruit) and processed vegetables (23.3% of vegetables). Older and higher income respondents consumed significantly more produce in fresh form, but less from fruit juice and processed vegetables.

The second article presents comparisons of prices for 29 fruits and vegetables at North Carolina farmers' markets, roadside stands, and supermarkets. It improves upon previous research by increasing representativeness of the sample, selecting fruits and vegetables based on consumption share, and including non-fresh forms of produce. Three fruits and one vegetable were cheaper at a local outlet; four vegetables were cheaper at supermarkets. The remaining items showed no difference. The significance of differences among outlets or processing forms was affected by weighting prices by consumption share.

The third article presents prices for the 29 studied fruits and vegetables in all four seasons of the year, by outlet type. Analyses examine whether the outlet types experience similar seasonal price patterns and whether the outlet types prove price competitive in all seasons. Significant price differences between supermarkets and local retail outlets in mean price and in the magnitude of price change between seasons occurred in 31% and 18% of comparisons, respectively. No outlet type demonstrated consistently lower prices or larger seasonal price fluctuations.

Taken together, the results of these studies suggest that local food retail outlets can provide, at competitive prices, the fresh fruits and vegetables that make up a large percentage of Americans' total fruit produce intake. Their ability to do so does not depend on season, though limitations in the year-round availability of produce at these outlets should be acknowledged. The results also suggest that Americans could improve their diet by either consuming a greater proportion of fresh fruits and vegetables or by selecting low-sodium and low-sugar items within processed fruit and vegetable forms.

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List of Tables and Figures

Acronyms and Abbreviations

AICR	American Institute for Cancer Research
BMI	Body mass index
CHD	Coronary heart disease
DGAC	Dietary Guidelines Advisory Committee
DHHS	United States Department of Health and Human Services
FFQ	Food frequency questionnaire
FM	Farmers’ market
FNDDS	Food and Nutrient Database for Dietary Studies
FPED	Food Patterns Equivalents Database
HR	Hazard ratio
MEC	Mobile examination center
MPED	MyPyramid Equivalents Database
NCDACS	North Carolina Department of Agriculture and Consumer Services
NHANES	National Health and Nutrition Examination Survey
PIR	Income to Poverty Ratio
PPS	Probability proportion to size
PSU	Primary sampling unit
RR	Risk ratio
RS	Roadside stand
SE	Standard error
SM	Supermarket
SNAP	Supplemental Nutrition Assistance Program
USDA	United States Department of Agriculture
WCRF	World Cancer Research Fund
WIC FMNP	Women, Infants and Children Farmers’ Market Nutrition Program

CHAPTER 1: INTRODUCTION

The burgeoning popularity of local food outlets such as farmers' markets and roadside stands has brought a new dimension to fruit and vegetable promotion. Whereas federal dietary guidelines have repeatedly advocated increased intake of fruits and vegetables in any form – fresh, canned, frozen, dried and juice – many supporters of local food systems promote fresh, locally grown produce as most nutritious. Some local food promotions also claim that fruits and vegetables, when purchased in season from a local farmer, cost less than those sold in a traditional retail setting. Whether or not future dietary guidance warrants a similar increased focus on fresh, locally grown produce should depend on a thorough evaluation of the merits of fresh, local fruits and vegetables as compared to those of any processing form or retail source.

Such a comparison requires information pertaining to four characteristics. First, the nutrient content of fresh fruits and vegetables should be compared to that of processed items. Second, the availability of commonly consumed fruits and vegetables at both local retail outlets and traditional supermarkets should be examined in all seasons of the year. Third, data are needed on how price per serving is affected by processing form as well as retail outlet type, in all seasons. Finally, the comparison should include an assessment of the form in which Americans currently consume fruits and vegetables.

This dissertation aims to improve future efforts to promote fruit and vegetable intake by presenting novel data pertaining to each of these four characteristics. The results presented below respond to two main questions that motivated the research. First, should future dietary guidance promote fresh fruits and vegetables over produce of other processing forms? And, second, to what extent should "local" be promoted in such fruit and vegetable guidance? The research effort undertaken in response to these questions consisted of two parts. While both inform the goal of improving future fruit and vegetable promotion and intake, each relied on different methods.

First, dietary intake data from the National Health and Nutrition Examination Survey (NHANES) were analyzed to estimate the proportion of total fruit and vegetable intake from each produce form as well as the mean sodium, added sugar and fiber contents of items in each form. While the nutrient analysis is not an exhaustive comparison of fruits and vegetables by form, the estimates regarding sodium and added sugar provide insight into one facet of the fresh versus processed debate. For shorthand, this part of the study is referred to below as the “Fresh versus Processed Question”.

Second, primary data collected at supermarkets, farmers’ markets and roadside stands in 34 sites across central and eastern North Carolina were used to evaluate whether local food outlets sell fruits and vegetables at prices comparable to traditional supermarkets in all four seasons of the year. Supermarket prices for different forms of fruits and vegetables were also compared in an effort to identify the lowest cost fruit and vegetable servings, locally produced or otherwise. This part of the study is referred to as the “Supermarkets versus Local Retail Question”.

Statement of Purpose

General Overview

Increasing the fruit and vegetable intake of Americans is an important public health goal. The 2010 Dietary Guidelines for Americans advocate increased intake using a simple, actionable consumer message: “Make half your plate fruits and vegetables” (USDA and DHHS 2010). Fruit and vegetable consumption has been associated with reduced risk of cardiovascular disease. Produce intake has also been associated with reduced risk of some cancers, and with the promotion of weight stability (Dauchet et al. 2006; WCRF and AICR 2007; Boeing et al. 2012). Despite these national goals and noted health benefits, Americans consume just 59% of recommended vegetable servings and 42% of recommended fruit servings (USDA and DHHS 2010).

In recent decades, health promotion campaigns have aimed to improve intakes; a well known example is the National Cancer Institute's "5 A Day for Better Health" program, more recently known under the "More Matters" slogan (Produce for Better Health, 2001). These campaigns, as well as successive rounds of the federal Dietary Guidelines for Americans, have encouraged intake of fruit and vegetables in fresh, canned, frozen, dried and juice forms (Produce for Better Health, 2001; USDA and DHHS 2005; USDA and DHHS 2010). In contrast, recent years have seen an increase in messages emphasizing the nutritional superiority of fresh, whole produce, spurred in part by the rising popularity of farmers' markets. Farmers' market promotion materials often posit that market fresh produce is most nutritious because it is harvested at peak ripeness, just prior to its sale (U.S. Department of Agriculture 2013; Lea 2005; Gibson 1994; Harvard Heart Letter 2010).

If it were the case that fresh produce was more expensive than processed items, the proliferation of "fresh is best" messages, particularly those that emphasize the superiority of locally grown foods, may discourage consumers on a budget from adding fruits and vegetables to their diets. Consumers have identified perceived high prices as a barrier to increased intake (Yeh et al. 2008). Price perceptions alone have been associated with consumption regardless of the reality of the food environment (Mushi-Brunt, Haire-Joshu, and Elliott 2007; Williams, Ball, and Crawford 2010). Furthermore, several studies have noted a belief that farmers' market prices for fresh produce exceed those of traditional supermarkets (Colasanti, Conner, and Smalley 2010; Griffin and Frongillo 2003). Low-income consumers, who consume fewer fruit and vegetable servings than their more well-off counterparts, may be most sensitive to price considerations (Dong and Lin 2009; Andreyeva, Long, and Brownell 2010).

Fresh versus Processed Question: Overview of Existing Research

Given the issues outlined above, it is worth comparing the nutritional quality and prices of produce in different forms. Are local food advocates justified in claiming that fresh produce is nutritionally best? Existing studies in the food science literature offer some insight on this question. For example, Rickman et al. review retention of vitamins A, B, C and E, and selected minerals and phytochemicals across a wide variety of fruits and vegetables of different forms (Rickman, Bruhn, and Barrett 2007; Rickman, Barrett, and Bruhn 2007). Heat involved in processing sometimes destroys volatile micronutrients; in other cases, they become more bio-available. The authors point out that fresh produce is not immune to nutrient losses from storage and conclude that micronutrient composition depends as much on cultivar as it does form (Rickman, Barrett, and Bruhn 2007). These results support the recommendations of the 2010 Dietary Guidelines for Americans, which are inclusive of all forms.

Yet the items compared in these existing studies were not selected based on their importance in current diets. The existing literature lacks study of the nutrient composition of the fruit and vegetable items in each form that are actually consumed by Americans. Processed fruits and vegetables that are comparably high in beneficial micronutrients and comparably low in additives such as sodium to fresh items are available, but may be rarely chosen. To date, this possibility has not been well studied. The present study uses national dietary recall data to address this gap in the literature, comparing the nutrient content of the produce items consumed, by form. A comparison of all nutrients is beyond the scope of this research; the analysis below focuses on sodium, added sugar, and fiber.

Comparing fresh and processed fruit and vegetables also requires an examination of prices by form. The most recent existing study found that no one form was consistently least expensive (Stewart et al. 2011). Some items, such as carrots, were least expensive per cup equivalent eaten fresh; others, such as strawberries, were least expensive in canned form (Stewart et al. 2011). The comparisons made by Stewart et al. were based on national retail price data aggregated across all package sizes, brands, seasons and retail store formats. The literature remains in need of price data reflecting direct in-store comparisons of the fruit and vegetables available in each processing form.

The education and policy actions taken as a result of the nutrient and price comparisons should depend, in part, on the amount of total fruit and vegetable intake consumed in each form. For example, if "fresh is best" messages are warranted, but the vast majority of current intake is already from fresh fruits and vegetables, further promotion of their superiority would prove unnecessary. Yet, few existing studies describe fruit and vegetable intake by form. Using loss-adjusted availability data, Buzby et al. (2010) reported that Americans consume the majority of their fruits and vegetables in fresh form (51% and 48% respectively). Fruit juice (37%) and canned vegetables (24%) followed (Buzby et al. 2010). Demydas' (2011) analysis of intake by form utilized NHANES dietary recall data, but the only vegetable form noted was fresh. Other vegetable categories were based on preparation method (Demydas 2011). The literature lacks complete estimates, based on dietary recall data, of the breakdown of total fruit and vegetable intake by form.

Fresh versus Processed Question: Novel Contributions

This part of the dissertation improves upon existing studies in several ways. First, it draws upon national dietary recall data to compare the sodium, added sugar and fiber content, by form, of fruit and vegetables actually consumed by Americans. Item selection for previous nutrient comparisons was not based on intake. Second, the study is the first to present estimates of the percent of total fruit and vegetable intake attributable to each processing form that are based on dietary recall data. The percentages are estimated for the total sample and for sub-populations defined by demographic and socioeconomic variables. Third, the mean price per serving of a number of fruit and vegetable items, by form, was estimated using primary data collected for the *Supermarkets versus Local Retail* portion of the study. Unlike previous work, the estimates are based on direct in-store comparisons of the lowest-price fruit or vegetable available in each form.

These results can be used to address the first of the two main questions that motivate this dissertation, whether future dietary guidance should promote fresh produce above other processing forms. They also enable the targeting of future messages at populations for whom they are most relevant.

Supermarkets versus Local Retail Question: Overview

If fresh fruits and vegetables provide a substantial proportion of total produce intake, local food outlets such as farmers' markets, which sell primarily fresh items, could help to boost overall intake by increasing access to them. Indeed, the Centers for

Disease Control and Prevention included the expansion of farmers' markets as one of ten recommended strategies for improving fruit and vegetable consumption (Centers for Disease Control and Prevention 2011; Powell and Chaloupka 2009). Emerging research suggests that markets may reduce produce prices and improve produce consumption (McCormack et al. 2010; Larsen and Gilliland 2009). Yet, they are sometimes seen as the territory of affluent gourmands rather than the average family cook.

The second part of this dissertation aimed to evaluate whether farmers' markets and roadside stands can promote increased fruit and vegetable intake for individuals of all income levels. The results contribute to answering the second main question motivating this dissertation, regarding the extent to which "local" items should be promoted in fruit and vegetable guidance. The few existing price comparison studies suggest that farmers' markets do compete with supermarket on price (Pirog and McCann 2009; McGuirt et al. 2011; Sommer, Wing, and Aitkens 1980). Yet these studies were based on fairly small and non-representative market samples, and included data collected about all items regardless of their dietary importance. None reported data about the availability of popular fruits and vegetables at the different outlet types.

The previous studies also fail to assess the effect of seasonality on availability and prices, despite earlier findings that suggest the likelihood of seasonal variation in market prices. For example, seasonal variation in wholesale and supermarket prices has been documented (Tronstad 1995; Parker, Zilberman, and Moulton 1991; Schotzko and Granatstein). Furthermore, the more extensive and relatively fixed intermediate costs between farmer and consumer in the supermarket retail chain (e.g. packing and shipping) suggest that supermarket prices may vary less across the year than those at local retail outlets (McLaughlin 2004; Andreatta and Wickliffe 2002). Yet, to date, this possibility has not been studied.

To address these gaps in the literature, availability and price data collected at retail outlets across central and eastern North Carolina were analyzed to determine whether local food outlets offer popular fruits and vegetables at prices comparable to supermarkets throughout the year. Comparisons of the nutritional quality of supermarket versus local retail outlet items are discussed in the literature review chapter, but were not directly assessed by this research.

Supermarkets versus Local Retail Question: Novel Contributions

This study improves on previous work in several ways. First, the sample of markets was larger and more representative of markets of all sizes than samples used in previous studies. Second, data were collected at roadside stands, an outlet type absent from previous studies despite its role in local retail sales. Third, items were chosen based in their importance to fruit and vegetable intake, and price results weighted by dietary importance. And, finally, fruit and vegetable prices were compared in all seasons rather than just the peak local harvest season as in most previous comparisons.

Outline of Dissertation

This dissertation consists of seven chapters. This introductory chapter offers an overview of the research motivation and the specific questions explored. Next, Chapter Two reviews the relevant literature. Chapter Three describes the methods used to collect fruit and vegetable price data at North Carolina retail outlets. Following this methods chapter, three independent papers answer the research questions posed here. Finally, Chapter Seven concludes the dissertation with a review of key results and discussion of their implications for nutrition policy and future research.

Specific Aims and Hypotheses

This dissertation has two aims that parallel the two questions that motivate the research. First, it aimed to characterize national fruit and vegetable intake by form and identify nutritional consequences of meeting recommendations with the items currently consumed in each form. This aim informs the question of whether future dietary guidance should promote fresh fruit and vegetables over other processing forms. Second, it aimed to evaluate whether local food outlets can provide fresh fruits and vegetables for sale at prices that compete with traditional supermarkets in all seasons. The results of this second aim inform discussion of the extent to which "local" be promoted in fruit and vegetable guidance. The aims are addressed in three articles. The research questions and hypotheses of each are described below.

<u>Article 1: Form of fruits and vegetables consumed by Americans, associated with demographic characteristics, affects sodium and added sugar content.</u>

This article addressed three research questions within the *Fresh versus Processed Question*. First, what is the sodium, added sugar, and fiber content of the fruits and vegetables consumed in each produce form by Americans? Second, what percent of total fruit and vegetable intake is attributable to fresh, processed, juice and miscellaneous items? Third, is there an association between these percentages and individual socioeconomic and demographic characteristics? The contribution of items in each form to total fruit and vegetable intake was estimated using NHANES dietary recall data. The percent consumed in each form was compared across population subgroups defined by demographic and socioeconomic characteristics. The mean amounts of sodium, added sugar, and fiber per cup equivalent in the fruits and vegetables consumed within each form were also estimated. It was expected that processed fruits and vegetables would contain more sodium and sugar, but less fiber than fresh items, all else equal.

<u>Article 2: Fruit and vegetable prices are similar at farmers' markets, roadside stands, and supermarkets in North Carolina.</u>

This article is the first of two that explore the *Supermarket versus Local Retail Question.* The aim of this article was to compare produce prices at farmers' markets and roadside stands in North Carolina to those at traditional supermarkets. Data collected in the summer in 34 sites were used to answer two research questions. First, do local food retail outlets offer fruits and vegetables at prices competitive with nearby supermarkets? It was hypothesized that local retail outlet prices would rival supermarket prices for fruits and vegetables at their peak local harvest at the time of data collection. Second, even if local outlets offer competitive prices, could consumers save further by purchasing fruits and vegetables in non-fresh forms? It was expected that the form with the lowest price per cup equivalent would vary across the fruits and vegetables observed.

<u>Article 3: North Carolina farmers' markets, roadside stands and supermarkets offer competitive fruit and vegetable prices across four seasons.</u>

The third article also answers questions pertaining to the *Supermarket versus Local Retail Question.* It assessed whether seasonality affects the price competitiveness of direct retail outlets as compared to supermarkets. Data collected in North Carolina were used to compare the availability and price of commonly consumed fruits and vegetables across three outlet types and the four seasons of the year. Several questions were explored. First, do direct retail outlets and supermarkets experience similar seasonal patterns in item availability and price volatility? Seasonal price variation was expected to be greater at local food outlets than at supermarkets. Second, are fruits and vegetables least expensive during their local harvest season? The data were expected to affirm this possibility. And, finally, are direct retail outlets and traditional supermarkets price competitive in all seasons? It was expected that local retail outlets would prove less price competitive in the winter season when local production reaches its minimum.

References

Andreatta, Susan, and William Wickliffe. 2002. Managing Farmer and Consumer Expectations: A Study of a North Carolina Farmers Market. *Human Organization* 61 (2):167-176.

Andreyeva, T., M. W. Long, and K. D. Brownell. 2010. The impact of food prices on consumption: a systematic review of research on the price elasticity of demand for food. *Am J Public Health* 100 (2):216-22.

Boeing, H., A. Bechthold, A. Bub, S. Ellinger, D. Haller, A. Kroke, E. Leschik-Bonnet, M. J. Muller, H. Oberritter, M. Schulze, P. Stehle, and B. Watzl. 2012. Critical review: vegetables and fruit in the prevention of chronic diseases. *Eur J Nutr* 51 (6):637-63.

Buzby, Jean C., Hodan Farah Wells, Aylin Kumcu, Biing-Hwan Lin, Gary Lucier, and Agnes Perez. 2010. Canned fruit and vegetable consumption in the United States. USDA Economic Research Service.

Centers for Disease Control and Prevention. 2011. Strategies to Prevent Obesity and Other Chronic Diseases: The CDC Guide to Strategies to Increase the Consumption of Fruits and Vegetables.

Colasanti, Kathryn, David Conner, and Susan Smalley. 2010. Understanding barriers to farmers' market patronage in Michigan: Perspectives from marginalized populations. *Journal of Hunger and Environmental Nutrition* 5:316-338.

Dauchet, L, P Amouyel, S Hercberg, and J Dallongeville. 2006. Fruit and vegetable consumption and coronary heart disease: a meta-analysis of cohort studies. *Journal of Nutrition* 136 (10):2588-93.

Demydas, T. 2011. Consumer segmentation based on the level and structure of fruit and vegetable intake: an empirical evidence for US adults from the National Health and Nutrition Examination Survey (NHANES) 2005-2006. *Public Health Nutr* 14 (6):1088-95.

Dong, Diansheng, and Biing-Hwan Lin. 2009. Fruit and vegetable consumption by low-income Americans: Would a price reduction make a difference? U.S. Department of Agriculture, Economic Research Service.

Gibson, Eric. 1994. *Sell what you sow! The farmer's guide to successful produce marketing*. Auburn, CA: New World Publishing.

Griffin, M.R., and E. A. Frongillo. 2003. Experience and perspectives of farmers from upstate New York farmers' markets. *Agriculture and Human Values* 20 (2):189-203.

Harvard Heart Letter. 2010. Better ways to get your produce. Boston: Harvard Health Publications.

Larsen, Kristian, and Jason Gilliland. 2009. A farmers' market in a food desert: Evaluating impacts on the price and availability of healthy food. *Health & Place* 15:1158-1162.

Lea, Emma. 2005. Food, health, the environment and consumers' dietary choices. *Nutrition & Dietetics* 62 (1):21-25.

McCormack, Lacey, Melissa Laska, Nicole Larson, and Mary Story. 2010. Review of nutritional implications of farmers' markets and community gardens: Call for evaluation and research efforts. *Journal of the American Dietetic Association* 110 (3):399-408.

McGuirt, Jared, Stephanie Jilcott, Haiyong Liu, and Alice Ammerman. 2011. Produce price savings for consumers at farmers' markets compared to supermarkets in North Carolina. *Journal of Hunger and Environmental Nutrition* 6:86-98.

McLaughlin, Edward. 2004. The dynamics of fresh fruit and vegetable pricing in the supermarket channel. *Preventive Medicine* 39:S81-S87.

Mushi-Brunt, C., D. Haire-Joshu, and M. Elliott. 2007. Food spending behaviors and perceptions are associated with fruit and vegetable intake among parents and their preadolescent children. *J Nutr Educ Behav* 39 (1):26-30.

Parker, Douglas, David Zilberman, and Kirby Moulton. 1991. How quality relates to price in California fresh peaches. *California Agriculture* 45 (2):14-16.

Pirog, Rich, and Nick McCann. 2009. Is local food more expensive?: A consumer price perspective on local and non-local foods purchased in Iowa.

Powell, L. M., and F. J. Chaloupka. 2009. Food prices and obesity: evidence and policy implications for taxes and subsidies. *Milbank Q* 87 (1):229-57.

Rickman, Joy, Diane Barrett, and Christine Bruhn. 2007. Nutritional comparison of fresh, frozen and canned fruits and vegetables. Part 1. Vitamins C and B and phenolic compounds. *Journal of the Science of Food and Agriculture* 87:930-944.

Rickman, Joy, Christine Bruhn, and Diane Barrett. 2007. Nutritional comparison of fresh, frozen and canned fruits and vegetables. Part 2. Vitamin A and carotenoids, Vitamin E, minerals and fiber. *Journal of the Science of Food and Agriculture* 87:1185-1196.

Schotzko, R. Thomas, and David Granatstein. A Brief Look at the Washington Apple Industry: Past and Present. Wenatchee: Washington State University.

Sommer, Robert, Margaret Wing, and Susan Aitkens. 1980. Price Savings to Consumers at Farmers' Markets. *The Journal of Consumer Affairs* 14 (2):452-462.

Stewart, Hayden, Jeffrey Hyman, Jean Buzby, Elizabeth Frazao, and Andrea Carlson. 2011. How Much Do Fruits and Vegetables Cost? U.S. Department of Agriculture, Economic Research Service.

Tronstad, Russell. 1995. Importance of melon type, size, grade, container, and season in determining melon prices. *Journal of Agricultural and Resource Economics* 20 (1):32-48.

U.S. Department of Agriculture. 2013. *Farmers Markets*, February 14, 2013 2013 [cited February 18 2013]. Available from http://www.nutrition.gov/shopping-cooking-meal-planning/food-shopping-and-meal-planning/farmers-markets.

U.S. Department of Agriculture, and U.S. Department of Health and Human Services. 2010. Dietary Guidelines for Americans, 2010. Washington, D.C.: U.S. Government Printing Office.

United States Department of Agriculture. 2013. *Farmers Markets*, February 14, 2013 2013 [cited February 18 2013]. Available from http://www.nutrition.gov/shopping-cooking-meal-planning/food-shopping-and-meal-planning/farmers-markets.

World Cancer Research Fund, and American Institute for Cancer Research. 2007. Food, Nutrition, Physical Activity, and the Prevention of Cancer: a Global Perspective. Washington, DC: American Institute for Cancer Research.

Williams, L, K Ball, and D Crawford. 2010. Why do some socioeconomically disadvantaged women eat better than others? An investigation of the personal, social and environmental correlates of fruit and vegetable consumption. *Appetite* 55 (3):441-6.

Yeh, Ming-chin, Scott Ickes, Lisa Lowenstein, Kerem Shuval, Alice Ammerman, Rosanne Farris, and David Katz. 2008. Understanding barriers and facilitators of fruit and vegetable consumption among a diverse multi-ethnic population in the USA. *Health Promotion International* 23 (1):42-51.

CHAPTER 2: LITERATURE REVIEW

This chapter reviews the existing literature on fruit and vegetable consumption and local food retail outlets. The chapter is divided into several sub-sections. First, to demonstrate the importance of improving fruit and vegetable intake, associations between that intake and health outcomes are briefly discussed and current dietary guidance outlined. Next, the existing studies pertaining to the healthfulness and intake of fruits and vegetables by form – fresh, canned, frozen and juice – are reviewed and their limitations discussed. The third sub-section provides a brief overview of factors that influence fruit and vegetable consumption, including access and prices. This section motivates interest in prices at local retail outlets. The final sub-section offers a discussion of the existing literature on local food outlets and their effect on produce access and prices.

Fruit, Vegetables and Health

Health practitioners emphasize the importance of fruits and vegetables based on three major contributions to health outcomes. First, fruits and vegetables contain health promoting vitamins and minerals, phytochemical antioxidants, and (Slavin and Lloyd 2012). They offer an important source of many micronutrients underconsumed by all or a sub-set of Americans, such as magnesium, potassium, vitamins A, C, and K (USDA and DHHS 2010).

Second, fruits and vegetables are high in fiber and low in calories, and as such may assist with weight control. Some evidence suggests that increased fruit and vegetable intake is associated with decreased weight gain in middle adulthood. The effect of produce intake on weight loss has not been conclusively identified (2010 Dietary Guidelines Advisory Committee 2010).

Third, fruit and vegetable intake has been associated with reduced risk of several chronic diseases. Evidence suggests that consuming at least two and a half cups per day of fruits and vegetables results in reduced risk of cardiovascular disease, including hypertension, stroke, and coronary heart disease (2010 Dietary Guidelines Advisory Committee 2010; Dauchet et al. 2006). Produce intake has also been associated with reduced risk of some cancers, particularly those of the gastrointestinal tract (Boeing et al. 2012; WCRF and AICR 2007; USDA and DHHS 2010). Finally, some research suggests an inverse association between type 2 diabetes and total fruit and vegetable intake (2010 Dietary Guidelines Advisory Committee 2010; Liu et al. 2004).

Given these health benefits, national dietary targets urge Americans to increase their fruit and vegetable intake. The key recommendations of the 2010 Dietary Guidelines for Americans include a call to consumers to increase fruit and vegetable intake as well as the variety of vegetables consumed to include more beans and dark green, red, and orange vegetables. The Dietary Guidelines also provide intake recommendations based on total calorie needs. For example, persons requiring 2,000 calories per day are advised to consume at least two servings of fruit and two and a half servings of vegetables per day (USDA and DHHS 2010). Similarly, Healthy People 2020, 10-year national objectives for improving the health of all Americans, include specific targets for improved fruit and vegetable intake. The fruit target is an increase from 0.5 cup equivalents per 1,000 calories/day to 0.9 cup equivalents, while the vegetable target is 1.1 equivalents per 1,000 calories (DHHS 2010).

Despite widespread promotion, Americans currently fall short of meeting these recommendations. The average American consumes just 42% of recommended fruit intake and 59% of recommended vegetable intake (including potatoes) (USDA and DHHS 2010). In 2007, just 14% of adults and 9.5% of adolescents consumed both two servings of fruit and three or more servings of vegetables daily (Centers for Disease Control and Prevention 2009). Low-income Americans consume even fewer servings than the population as a whole (Dong and Lin 2009; Izumi et al. 2011). Dong and Lin examined the fruit and vegetable intake of Americans with household incomes up to 130% of the federal poverty line, using data from the representative National Health and Nutrition Examination Survey (NHANES). Between 1999 and 2002, all Americans consumed 1.03 cups of fruit and 1.58 cups of vegetables per day. Low-income individuals consumed 0.96 cups of fruit and 1.43 cups of vegetables. The disparity was greater for dark green and orange vegetables.

Form of Fruit and Vegetable Intake

While widespread agreement exists about the need for Americans to consume more fruits and vegetables, some debate exists over the form this increase should take. One side of the debate, summarized in past and current dietary guidance, calls for increasing fruit and vegetable intake in any form – fresh, canned, frozen, dried or juice. The 2010 Dietary Guidelines for Americans and the American Heart Association's 2006 Diet and Lifestyle Recommendations take this inclusive stance (USDA and DHHS 2010; Lichtenstein et al. 2006). While the Dietary Guidelines specify that the majority of fruit intake should come from whole fruits, rather than fruit juice, they welcome fresh, canned, frozen and dried forms of fruits and vegetables as acceptable choices. Both sets of recommendations advise consumers to choose canned vegetables labeled "reduced-sodium" or "no salt-added" and canned fruits packed in 100% juice rather than in syrup. They give no other indication is as to which form is most healthful. Others argue that fresh produce is best. The following paragraphs look at evidence on each side of this debate.

Arguments for Including All Forms

Several food science studies comparing healthfulness of fruits and vegetables in different forms support recommendations including all produce forms. Rickman, Barrett and Bruhn reviewed studies comparing the content of vitamins A, B, C and E as well as several carotenoids and minerals in fresh, frozen and canned fruits and vegetables. The studies demonstrate that fruit and vegetable processing does lead to micronutrient and phytochemical losses via thermal processing, leaching, or the peeling of produce skins (Rickman, Bruhn, and Barrett 2007; Rickman, Barrett, and Bruhn 2007). For example, ascorbic acid (vitamin C) is particularly sensitive to thermal processing and leaching; the reviewed studies reported average losses of greater than 60% of vitamin C in the canning process, and 50% from blanching and freezing (Rickman, Barrett, and Bruhn 2007). Similarly, a study of peas, spinach, green beans and carrots found the highest antioxidant activity in fresh produce, followed by frozen and then canned items (Kalt 2005). Fruit juices leave behind antioxidants in the solids that remain after extraction of the juice (Kalt 2005).

Yet, processing can also improve the content of some compounds to levels that exceed the content of fresh produce. Thermal processing increases polyphenol levels in canned cherries and improves the bioactivity of the carotenoid antioxidant lycopene (Kalt

2005; Rickman, Bruhn, and Barrett 2007; Rickman, Barrett, and Bruhn 2007). Furthermore, cultivar choice affects comparisons by form. Fruit and vegetable cultivars grown for fresh consumption often differ from those grown for processing; the tomato cultivar used for canning tomatoes contains more α-tocopherol (vitamin E) than the fresh cultivar (Rickman, Bruhn, and Barrett 2007). Finally, the authors point out that nutrient loss may be substantial in fresh items by the time of consumption as they lose nutrients more rapidly than processed produce during handling and storage. Rickman et al. conclude that frozen and canned fruits and vegetables should not be excluded from recommendations, particularly given regional and seasonal limitations on the availability fresh products picked at peak ripeness (Rickman, Barrett, and Bruhn 2007).

Arguments that Fresh and Local is Best

Despite the inclusive position taken in federal dietary guidance and the studies discussed above, those on the other side of this debate promote consumption of whole, fresh fruits and vegetables. Renowned food writer Michael Pollan is a vocal advocate for the superiority of whole, fresh foods. In his book, In Defense of Food, he argues that "food synergy", the concept that a whole food is more than the sum of its parts, may provide unique health benefits that are lost when a food is processed (Pollan 2008). He cites a study of whole grains and their constituent micronutrients in which researchers found an unexplained health benefit to eating whole grains after adjusting for the micronutrients contained therein (Pollan 2008; Jacobs and Steffen 2003).

Supporters of the burgeoning local food movement also favor fresh fruits and vegetables, further specifying that the most nutritious produce is both fresh and locally-grown. Both the academic literature and promotional pieces pertaining to local food retail make the case that local, fresh produce is most nutritious because it is harvested at peak ripeness, just prior to its sale, and travels shorter times and distances to the table (Gibson 1994; Lea 2005; U.S. Department of Agriculture 2013; Harvard Heart Letter 2010). A Harvard Heart Letter article outlining “better” ways to get produce explains, “The fruits and vegetables on sale [at markets] have usually been picked that day or the day before. They are likely to pack more nutrients than much of the produce sitting on your supermarket’s shelves” (Harvard Heart Letter 2010). A federal government list of farmers’ market benefits echoes this view: “Freshly picked ripe food is at its peak in flavor and nutrition” (U.S. Department of Agriculture 2013).

Though data are lacking on the nutrient content of identical foods having traveled different distances, research does support the argument that fresh products experience nutrient losses in transportation and storage (Vogt and Kaiser 2008; Rickman, Barrett, and Bruhn 2007; Vallejo, Tomas-Barberan, and Garcia-Viguera 2003; Kalt 2005). One study compared the contents of several phytochemicals and vitamin C in freshly harvested broccoli, film-wrapped broccoli stored for a week at one degree Celsius to simulate a period of commercial distribution, and broccoli stored at 15 degrees Celsius for three days to simulate a period on store shelves. After cold storage and retail periods, the broccoli samples had lost 71-80% of the total cancer protective compound glucosinolate and 62-59% of total antioxidant flavonoids (Vallejo, Tomas-Barberan, and Garcia-Viguera 2003). Murcia et al., however, observed different results after observing the antioxidant activity of twenty-five vegetables on the purchase date and after seven days in a home refrigerator. All vegetables were able to scavenge free radicals after storage; the only noted losses were for cucumber and zucchini. In contrast, some canned and frozen vegetables lost antioxidant activity after 18 months and 8 months of storage, respectively, in home conditions (Murcia et al. 2009).

Storage losses are influenced not only by time of storage, but also by ripeness at harvest, storage temperature, and packaging (Kalt 2005). Vitamin C content in peaches, tomatoes, apricots, and papayas and lycopene content in tomatoes is greater in items that ripen on the plant (Lee and Kader 2000). Storage temperatures also affect nutrient content. For example, the vitamin C content of strawberries stored at one or ten degrees Celsius was greater than that retained in berries stored at 20 degrees Celsius (Lee and Kader 2000; Kalt 2005). Finally, studies have found both vitamin C and carotenoid retention to be higher in atmosphere modified packaging that traps moisture. Broccoli florets stored in a modified atmosphere package lost essentially no vitamin C over six days, whereas unpackaged florets lost 75% (Barth and Zhuang 1996).

The effects of ripening on the plant support claims that recently-picked local foods are superior. However, farmers selling directly to consumers may not protect crops from nutrient losses due to temperature or loss of moisture when bringing products to market as commercial wholesalers do. These latter studies challenge the assumption that local is always nutritionally superior.

Arguments that Fresh Avoids Excessive Sodium and Added Sugar

An additional argument for the nutritional superiority of fresh fruits and vegetables has to do with their lack of two additives found in many processed produce items, sodium and added sugar. Both are consumed in excess by the average American. Excess intake of both has been associated with deleterious health effects.

Sodium is an essential nutrient, yet Americans consume far more of it than the body requires. The Institute of Medicine set 1,500 milligrams (mg) per day as the Adequate Intake (AI) level for most Americans and the Tolerable Upper Intake Level (UL) at 2,300 mg (National Research Council 2005). Americans ages 2 years and older consume an average of more than 3,400 mg of sodium per day; usual intakes exceed the UL for more than 90% of boys older than nine years and adult men up to age 70 years, and for 50% to 75% of girls older than nine years and women of all ages (2010 Dietary Guidelines Advisory Committee 2010).

Substantial research demonstrates that excess sodium intake is positively associated with blood pressure (2010 Dietary Guidelines Advisory Committee 2010; Yang et al. 2012; Strazzullo et al. 2009; Sacks et al. 2001). A meta-analysis of 13 prospective cohort studies showed that sodium intake was associated with an increased risk of stroke and cardiovascular disease (Strazzullo et al. 2009). Among children aged eight to 18 years participating in the 2003-2008 NHANES survey, the adjusted odds ratio for risk of pre-high blood pressure or high blood pressure among subjects in the highest versus lowest sodium intake quartile was 2.0 (95% CI: 0.95–4.1, P = .062). The difference was greater among overweight or obese children (OR: 3.5 (95% CI: 1.3–9.2, P = .013) (Yang et al. 2012).

Intervention studies examining the effects of a low-sodium diet on blood pressure report similar associations. The 2010 Dietary Guidelines Advisory Committee reviewed 15 such studies. Twelve of the 15 showed a decrease in systolic blood pressure and/or diastolic blood pressure on the low sodium diet (the decrease was statistically significant in eight of the studies). Only three studies reported no change in blood pressure on a low sodium diet (2010 Dietary Guidelines Advisory Committee 2010). Given that hypertension is an established risk factor for three of the top ten leading causes of death in the United States (stroke, coronary heart disease, and kidney disease) and that one in three U.S. adults has hypertension, current efforts to reduce its intake are warranted (Dietary Guidelines Advisory Committee 2010; Centers for Disease Control and Prevention 2012).

The health impacts of added sugar consumption have not received as extensive a treatment as sodium in the nutrition literature, but a growing body of work suggests the need for similar restraint in consumption. Diets high in added sugars are more likely to have below recommended levels of essential nutrients (2010 Dietary Guidelines Advisory Committee 2010; Marriott et al. 2010). Marriott et al. found that each five percent increase in added sugar intake above the five to 10% of calories category, resulted in a decrease in intake for all micronutrients (Marriott et al. 2010). Furthermore, excessive intake of added sugars is linked to overconsumption of discretionary calories by Americans (Johnson et al. 2009). Observational data have linked intake of sugar sweetened beverages, the primary source of added sugars in the American diet, to greater energy intake and body weight (Marriott et al. 2010; Johnson et al. 2009).

For these reasons, the American Heart Association recommends that individuals limit added sugar intake to half of daily discretionary calorie intake. This is equal to 150 calories per day for most men and 100 calories per day for most women. Usual intake far exceeds this recommendation; from 2001 to 2004, Americans consumed an average 22.2 teaspoons (355 calories) per day (Johnson et al. 2009).

Form and Health Outcomes

Aside from research on the nutrient content of produce in different forms, few studies have considered differences in actual health outcomes based on form of fruit or vegetable consumption. Those that do suggest a possible advantage to consuming fresh produce. Using data from a large prospective cohort study, Griep et al. examined the association between 10-year stroke incidence and coronary heart disease (CHD) incidence and grams consumed of raw and processed fruits and vegetables. The processed category included home cooked vegetables, including from canned and frozen, tomato sauce, and fruit juices. Diet was assessed using a 178-item semi-quantitative food frequency questionnaire (FFQ) (Oude Griep et al. 2011; Oude Griep et al. 2010). Controlling for covariates, the inverse association between produce consumption and CHD incidence was of borderline significance for both raw and processed fruits and vegetables (Oude Griep et al. 2010). Total stroke incidence, however, was significantly inversely related to raw vegetable intake (Hazard ratio, highest quartile vs. lowest quartile of intake: 0.50; 95% CI: 0.34–0.73), but not processed vegetable intake (HR:1.14; 95% CI: 0.79–1.65) (Oude Griep et al. 2011).

Bazzano et al. also used a semi-quantitative FFQ to compare the effects of whole fruit and vegetable consumption versus fruit juice intake on type 2 diabetes incidence among women aged 38-63 years. Over the 18-year follow up period, total fruit and vegetable consumption was not associated with diabetes incidence (Bazzano et al. 2008). However, a three servings per day increase in whole fruit (including canned) intake was associated with reduced incidence of diabetes (HR: 0.82, 95% CI: 0.72-0.94), while a one serving/day increase in fruit juice intake was associated with an increased hazard of developing diabetes (HR: 1.18, 95% CI: 1.10-1.26). The effect of fruit juice consumption was similar to that of sweetened and unsweetened soda (Bazzano et al. 2008).

Current Consumption by Fruit and Vegetable Form

While the aforementioned studies demonstrate interest in the nutrient content and health effects of fruits and vegetable of various forms, few studies have looked at the nutrient composition of the fruits and vegetable items actually consumed by Americans in each form. Processed fruits and vegetables that are as high in beneficial micronutrients and as low in additives such as sodium and added sugars as fresh items may be readily available, but whether or not they are chosen remains an unexplored question. Studies that have approached this question report the contribution of fruits and vegetables to total dietary sodium and added sugar intake. Data from NHANES 2003-2006 show that fruits, vegetables and fruit or vegetable products contributed 2.6% of total added sugar intake (Marriott et al. 2010). Cotton et al. report that canned vegetables contribute less than one percent of total sodium intake (Cotton et al. 2004). Yet, neither study reported added sugar or sodium content in the produce items chosen, thus failing to indicate whether or not consumers could make healthier choices among fruits and vegetables in each form.

The literature also offers little insight on the composition of Americans' fruit and vegetable intake by form of processing. Only two studies using U.S. data were found. The first, a report to Congress on canned fruit and vegetable consumption, presents estimates based on three different datasets (Buzby et al. 2010). The first estimate, based on food availability data, shows Americans consuming the majority of their fruits and vegetables in fresh form (51% and 49%, respectively), followed by fruit juice (37%) and canned vegetables (24%) (Buzby et al. 2010). Next, the association between food spending and demographic variables was estimated based on 2008 Bureau of Labor Statistics' Consumer Expenditure Survey data. Estimates were reported for canned produce only; high income households, whites, and older individuals spent more on canned produce than comparison groups. Finally, because food spending does not directly equate to quantities consumed, the report includes associations between fruit and vegetable intake and demographic characteristics based on the Continuing Survey on Food Intakes by Individuals. The first two sets of estimates are not based on intake data, while the third looks at select individual items rather than fruits and vegetables as a whole (Buzby et al. 2010).

A second study by Demydas addresses this shortcoming by exploring fruit and vegetable consumption by form using 2005-2006 NHANES dietary recall data (Demydas 2011). The author found that fruit juice was consumed in greater gram quantities (236.5 g) than fresh fruits (139.3 g); both exceeded intake of canned fruits (56.9 g). The study also reports a breakdown of vegetable intake, but the designated sub-categories are not fresh, canned, frozen and juice forms but rather raw vegetables, cooked vegetables (without creams, dressings, and non-vegetable items), mixed-dish vegetables, and fried vegetables (Demydas 2011).

In summary, this section demonstrates that despite debate over the most healthful form of fruits and vegetables, the current literature lacks both a comparison of the nutrient content of produce items actually consumed by Americans within each form and a complete description of fruit and vegetable intake by form based on dietary recall data.

Factors that Affect Fruit and Vegetable Consumption

If, as food availability data suggest, Americans consume a substantial portion of their fruit and vegetable intake in fresh form, retail outlets at which local farmers sell fresh produce directly to consumers could help to boost sub-optimal intakes. Their effectiveness may depend in part on the factors that influence fruit and vegetable consumption. Research on these factors is reviewed in this section.

Individual Characteristics

Researchers have used focus groups and surveys to explore individual factors associated with fruit and vegetable intake. Several demographic characteristics affect intake. Women consume more fruits and vegetables, on average, than do men (Zhang and Fu 2011). Age also influences intake; older adults consume more produce than younger adults (Zhang and Fu 2011). Similarly, analysis of Consumer Expenditure Survey data collected between 1982 and 2003 demonstrates that Americans born recently spend less on fresh vegetables than do those of older cohorts (Stewart and Lucier 2009). Education and income have also been positively associated with produce intake (Pollard, Kirk, and Cade 2002; Dong and Lin 2009).

An individual's family may also influence fruit and vegetable intake. Married individuals, particularly those with children, consume significantly more fruits and vegetables than unmarried persons (Devine et al. 1998). More than half of variation in children's fruit and vegetable consumption has been attributed to the home environment (Zhang and Fu 2011). A study in the United Kingdom found that individuals who ate alone were less likely to take the time to prepare vegetables than those eating with others (Brug, Lechner, and De Vries 1995). Familiarity with fruits and vegetables due to childhood exposure can also affect intake (Pollard, Kirk, and Cade 2002). Finally, sensory appeal is identified as both a reason for and barrier to fruit and vegetable intake (Pollard, Kirk, and Cade 2002; Zhang and Fu 2011).

Environmental Characteristics: Availability and Price

In addition to individual characteristics, much attention has been paid to the influence of fruit and vegetable availability and price on consumption. Numerous cross-sectional studies suggest that increased neighborhood availability of fruit and vegetables boosts consumption by residents, particularly for low-income individuals who are more likely to live in neighborhoods with fewer full-service supermarkets (Evans et al. 2012). Rose et al. used data from the 1996-1997 National Food Stamp Program Survey to investigate the relationship between supermarket access and household fruit and vegetable use. Easy access to the preferred supermarket was significantly associated with increased household fruit consumption (Rose and Richards 2004). Similar results were found in two studies of 919 Detroit residents. Residents living in neighborhoods with no store carrying five or more varieties of dark-green and orange vegetables averaged 0.17 fewer daily servings of these items compared with those living in neighborhoods with two stores carrying them (P=0.047) (Izumi et al. 2011). A one supermarket increase within 0.5 miles of respondents was associated with an additional 0.67 servings of fruits and vegetables per day (Zenk et al. 2009). A survey of 102 households in New Orleans found that each additional meter of vegetable shelf space within 100 meters of a home predicted increased intake of 0.35 servings per day. The presence of a food store within 100 meters, but not shelf space, was significantly associated with fruit intake (Bodor et al. 2008).

In contrast to the above research, several studies based on longitudinal and quasi-experimental data have failed to find an association between availability and intake. A recent longitudinal study which examined food store distance and dietary consumption in a sample of 5,115 young adults over the course of seven years found that greater availability of supermarkets and grocery stores over time was unrelated to adherence to fruit and vegetable recommendations (Boone-Heinonen et al. 2011). A second study utilized a prospective, quasi-experimental design. Randomly selected households in Glasgow responded to a mail survey before and after the opening of a nearby superstore. Self-reported produce intake did not change from baseline to follow up (Cummins et al. 2005).

In addition to availability, both perceived and observed prices have been associated with intake. A cross-sectional survey of 555 parent-child pairs found that mean daily fruit and combined fruit and vegetable servings were lower for children and parents in households where the parents believed that their grocery bill would increase if they purchased fruits and vegetables as snacks (Mushi-Brunt, Haire-Joshu, and Elliott 2007). In a smaller study, focus group participants reported the high cost of fruits and vegetables as a barrier to increased intake (Yeh et al. 2008).

The effect of actual prices has also been repeatedly explored. Andreyeva, Long and Brownell review studies estimating the price elasticity of demand for fruits and vegetables. The price elasticity for fruit (0.70), vegetables (0.58) and fruit juice (0.76) were all fairly inelastic. The authors suggest that low-income populations may be more sensitive to prices than the overall population (Andreyeva, Long, and Brownell 2010). Several studies have connected self-reported fruit and vegetable intake to local price data. First, a $0.10 increase in the cost of fruit and vegetable servings decreased the odds of having a fruit or vegetable available in the homes of 1,355 children in Birmingham, Alabama (Ard et al. 2007). A second study examined the association between young adults' fruit and vegetable intake, selected food prices, and the availability of different types of restaurants and food stores, controlling for individual demographic and socioeconomic variables. A one dollar increase in the price of fruits and vegetables was associated with a 32% reduction in weekly consumption. Lower income young adults had elevated price sensitivity (Powell, Zhao, and Wang 2009).

Given the observed influence of availability and price on fruit and vegetable intake, interventions have been proposed to improve both. One such effort, the Pennsylvania Fresh Food Financing Initiative, leverages public funds to entice private investment in supermarkets in the Philadelphia area. Supermarkets have been found to offer a variety of healthy foods at lower prices than smaller stores; thus, the 32 stores funded by the initiative as of 2008 affect both availability and prices (Giang et al. 2008).

Because financing and capital can pose a barrier to supermarket development in underserved areas, local food retail outlets, such as farmers' markets, have also been promoted as a means to boost a community's fruit and vegetable supply in a short time frame (Giang et al. 2008; Nebeling et al. 2007; Blanck et al. 2011; Conner and Levine 2007; Centers for Disease Control and Prevention 2011). These outlets offer greater flexibility with less capital, start-up, and overhead expenses than "brick and mortar" stores (Briggs et al. 2010). Research suggests that consumers would utilize these outlets. A cross-sectional analysis of the National Cancer Institute's Food Attitudes and Behaviors Survey revealed that 27% of respondents used farmers' markets, roadside stands or community supported agriculture programs at least weekly in the summer. Reported usage did not vary significantly by race, education or household income

(Blanck et al. 2011). The authors conclude that, “farm-to-consumer venues have the potential to reach many Americans and can augment supermarkets and grocery stores as places to obtain fruits and vegetables” (Blanck et al. 2011). The final section of this literature review provides an overview of such venues and the research to date documenting their influence on fruit and vegetable availability and price.

Local Food Outlets: Potential to Affect Access and Price

Overview of Local Food Retail

A review of local food retail outlets should begin with a definition of local food. However, no one agreed upon definition exists (Martinez et al. 2010). Surveyed consumers and market managers often give a definition based on geographic proximity, but the distance considered “local” varies (Martinez et al. 2010; Dunne et al. 2010). For example, among nine Virginia farmers’ markets, four required that items for sale be produced within 100 miles of the market, two set the distance at 75 miles, one defined local food as that grown in the county, and two allowed the sale of non-local food (Battle 2009). Some consumers also define local using political boundaries. Zepeda and Li report that consumers asked to define local in terms of a political boundary usually give an entity smaller than “state”, such as a county or contiguous counties (Zepeda and Li 2006). In contrast, Darby et al. found that consumers are unlikely to distinguish between products grown “in-state” or “nearby” (Darby et al. 2008).

The definitions used by traditional food retailers to source local food differ from those used by customers. Interviews with representatives of food retailers in Oregon’s Willamette Valley found that six stores defined local by a distance of 100 to 200 miles from the store while another six used a geographical region encompassing several states.

The definition was often dependent on the size of the store and the produce volume required (Dunne et al. 2010). Finally, the federal government uses a definition in its marketing programs that draws on both distance and political boundaries. The 2008 Farm Bill defines an item that can be marketed as locally or regionally produced as one sold fewer than 400 miles from or in the state of its production (Martinez et al. 2010).

Retail outlets that sell locally grown foods, such as farmers' markets and roadside stands, can be defined more readily than the term local. Historically, the term farmers' market has been used to refer to a variety of agricultural sales activities directly involving producers (Pyle 1971). Currently, the term typically refers to a "common area where several farmers gather on a recurring basis to sell a variety of fresh fruits, vegetables, and other farm products directly to consumers" (Martinez et al. 2010). The federal government distinguishes roadside stands from markets, defining them as "a location at which an individual farmer sells his/her produce directly to consumers" (Food and Nutrition Service 1994).

Little has been written about roadside stands, thus the following history of local food retail outlets is based solely on farmers' market research. The first farmers' market on record in the U.S. was established in Boston, Massachusetts in 1634. Markets were widely utilized as a source of affordable produce through the late nineteenth century. The twentieth century saw a rapid decline of markets as improvements in transportation and refrigeration, as well as the growth of cities and supermarkets altered the way that people purchased food products (Pyle 1971). In 1918, just half of 240 cities (population $\geq$ 3,000) responding to a Census Bureau survey had a functioning market (Pyle 1971).

Farmers' markets have seen resurgence in popularity since the mid-1970s, in part due to two federal programs created to support their growth. The 1976 Farmer-to-

Consumer Direct Marketing Act sought to promote direct marketing of agricultural products from farmers to consumers (*Farmer-to-Consumer Direct Marketing Act of 1976* 1976). In 2002, this act was amended to create the Farmers Market Promotion Program, a federal program that offers grants to improve or expand direct marketing venues. The number of markets rebounded during this time period from 340 in 1970 to 3,000 in 2001 (Pyle 1971). By 2009 there were 5,274 farmers' markets in the United States. Sales from direct-to-consumer retail rose 49% from 2002 to 2007 (Martinez et al. 2010). Popularity of local food retail outlets is widespread: four out of five respondents to a recent national survey purchased local foods occasionally or always (Keeling Bond, Thilmany, and Bond 2009).

The results of a USDA study of farmers' markets operating in 2005 paint a picture of nationwide markets (Ragland and Tropp 2009). The median age of the surveyed markets was ten years. Seasonal markets were predominant: 88% of markets operated seasonally for an average four and a half months per year. Year-round markets reported more vendors, customers, and sales than those open fewer than six months per year. Markets were visited by an average 959 customers per week. These customers purchased products from an average of 31 vendors. Twenty-five percent of vendors used the market as their only sales outlet (Ragland and Tropp 2009).

Smaller surveys have aimed to characterize the type of customer most likely to frequent farmers' markets. Early research suggested that market shoppers were more likely to be Caucasian, middle aged, well educated, and of middle to upper income (Brown 2002). More recent studies have found little link between demographics and local food purchasing (Keeling Bond, Thilmany, and Bond 2009; Zepeda and Li 2006). Zepeda and Li argue that attitudes and behaviors related to food shopping prove better predictors of local food purchasing. For example, using data from a national survey, they demonstrate that those who enjoyed cooking, purchased organic foods and gardened had a higher probability of purchasing local foods. Food shoppers concerned about the cost of food were significantly less likely to purchase local food (Zepeda and Li 2006).

Farmers' market customers cite product characteristics among their motivations for purchasing at local food outlets. Produce quality and freshness are repeatedly cited as a top reason for frequenting farmers' markets; one review of farmers' market research found that quality and/or freshness was the primary reason that customers shopped at markets in six of eight studies (Brown 2002; Keeling Bond, Thilmany, and Bond 2009). Respondents to a national survey who preferred to always purchase directly from producers placed higher importance on product quality, vitamin and nutrient content of their foods and support for local producers than those who preferred to buy direct only occasionally or never (Keeling Bond, Thilmany, and Bond 2009; Thilmany, Bond, and Bond 2008).

Local Food Retail in North Carolina

Several studies in the farmers' market literature were conducted in North Carolina, enabling a brief description of local food retail vendors and customers in the state. More than 200 farmers' markets operate in North Carolina (Ammerman 2012). Five of these are large, permanent markets established and run by the North Carolina Department of Agriculture and Consumer Services. A North Carolina government run Web site identified 135 certified roadside farm markets in the state. These stands have received certification for selling produce grown by the stand operator and other local farmers; other non-certified roadside stands also exist (North Carolina Department of Agriculture and Consumer Services 2010).

Andreatta interviewed 33 organic growers and 74 consumers at two markets in the central Piedmont region of North Carolina. The farmers were primarily small scale, cultivating an average of two acres. Forty-one percent of them relied on the markets for more than 75% of their annual income, benefitting from the higher retail prices at the market (Andreatta 2000). A second survey of 463 shoppers at one of the five state-operated markets revealed that the most purchased items were fruits and vegetables. Eight-eight percent of the shoppers frequented the market for the freshness of products, 64% were motivated by seeking local products, and 16% came in search of inexpensive products (Andreatta and Wickliffe 2002). A more recent survey of 2,900 North Carolina families with at least one child found that 75% had purchased locally grown foods in the past year; nearly half had purchased them on 12 or more days. Blacks, those with children who ate five or more fruit and vegetable servings per day, and rural families were more likely to purchase locally grown foods (Racine et al. 2013).

Local Food Retail: Impacts on Access, Health, and Produce Prices

Local food retail offers numerous benefits, including retail prices and higher returns for local farmers, increased spending at local businesses on market days, job creation, and social interaction (Brown 2002; Andreatta and Wickliffe 2002; Zepeda 2009; Curry and Oland 1998; Otto and Varner 2005; Oberholtzer and Grow 2003; Lev, Brewer, and Stephenson 2003; Phillips and Peterson 2007). Because this dissertation is concerned with fruit and vegetable intake, this section focuses on the impacts of local retail outlets on fruit and vegetable availability and intake, health outcomes, and produce price.

One reason cited for the growing popularity of farmers' markets is their potential to increase produce availability in areas with poor access to healthful foods (McCormack et al. 2010). However, little research has directly evaluated this potential. One study conducted in a low-income neighborhood of Ontario, Canada found that the creation of a farmers' market in the neighborhood resulted in an increase in produce availability and a 12% drop in the cost of a 66-item healthy food basket (Larsen and Gilliland 2009).

A number of studies have indirectly assessed the effect of farmers' markets on availability by evaluating the impact of the federal Farmers' Market Nutrition Program for Women, Infants and Children (WIC FMNP) on fruit and vegetable intake (McCormack et al. 2010). The WIC FMNP was established by Congress in 1992 to provide fresh, locally grown fruits and vegetables to WIC participants and expand the use of farmers' markets (Oliveira and Frazao 2009). In 2011, 1.9 million women and children spent $16.4 million in vouchers at markets and roadside stands nationwide (USDA Food and Nutrition Service 2012).

Several studies found that program participation is associated with a significant increase in reported fruit and/or vegetable consumption (Kropf et al. 2007; McCormack et al. 2010). Ohio women receiving an $18 WIC FMNP voucher reported consumption of 2.2 vegetable servings per day at the end of the market season compared to 1.91 servings reported by non-participants (Kropf et al. 2007). Two demonstration projects reported similar results (Galfond, Thompson, and Wise 1991; Herman et al. 2008). For example, an evaluation of a trial that provided $10 coupons twice per month for six months found that fruit and vegetable intake increased by 1.4 servings per 1,000 calories among participants compared to 0.8 servings in the control group (Herman et al. 2008). Anliker et al., however, found no difference in change in fruit and vegetable intake from pre-intervention levels between those that received $10 farmers' market coupons and the control groups (Anliker, Winne, and Drake 1992).

A few recent studies have looked beyond produce intake, exploring associations between farmers' markets and health outcomes. Low-income farmers' market customers in Los Angeles reported not only increased fruit and vegetables intake due to the market, but also weight loss (Ruelas et al. 2012). Three studies have used county-level data to assess the effect of market access on weight; all report that an increase in access is associated with lower body mass index (BMI) (Salois 2012; Jilcott et al. 2011; Berning 2012). Salois found that with each $100 increase in per capita direct farm sales in a county the obesity rate declines by 0.80%. An additional market per 1,000 persons was associated with a 0.78% lower diabetes rate (Salois 2012). In North Carolina, a one standard deviation increase in farmers' markets per 1,000 persons is associated with 0.07% lower prevalence of obesity at the county level. The association was significant for non-metro counties (Jilcott et al. 2011).

Only one identified study assessed the impact of farm stands. Evans et al. evaluated the placement of six farm stands outside community centers in Austin, Texas during the summer of 2010. Each stand carried produce from two to three farmers and each was equipped to accept FMNP vouchers and Supplemental Nutrition Assistance Program (SNAP) benefits. Pre and post-intervention surveys were conducted door to door within a half mile radius of the stands. The number of times per week that fruits and vegetable were consumed was assessed. At baseline, average produce intake was 3.98 servings per day. At follow up, significant increases were found for reported intake of fruit, fruit juice, tomatoes, green salad and other vegetables. Total intake increased significantly to 4.41 servings per day and the proportion of residents who believed it important that their family eat fruits and vegetables increased from 76% to 92%. The study had no control group (Evans et al. 2012).

It is possible that farmers' markets encourage increased fruit and vegetable intake not only through improved availability, but also by offering lower prices than nearby supermarkets or grocery stores. Farmers' markets might be expected to offer lower prices for several reasons: there is no middle man between the producer and consumer, many producers at one site compete for customers, and markets have minimal overhead costs (Pyle 1971). A small literature has compared both the perception and reality of price differences between farmers' markets and traditional supermarkets.

Some consumers perceive local retail outlets to offer low prices, while others believe them to be prohibitively expensive. Fifty-nine percent of respondents to a survey of Missouri consumers believed that produce prices were lower when purchasing directly from producers compared to grocery stores (Brown 2003). In six studies conducted between the mid-1980s and 2000, 48% to 74% of consumers expected products to be less expensive in local retail outlets, in part due to lower transportation costs (Brown 2003).

Others perceived local retail outlet prices as greater than traditional supermarkets (Colasanti, Conner, and Smalley 2010; Grace et al. 2007; Zepeda and Li 2006; Webber and Dollahite 2008; Leone et al. 2012). Surveys of low-income consumers note a strong perception of high prices. In a sample of low-income shoppers in Oregon, 22% discussed price when asked what they disliked about farmers' markets. Respondents described markets as more expensive than grocery stores; one respondent said, "Markets are for rich people" (Grace et al. 2007). Price perceptions may impact farmers' market usage;

perceiving cost as the most important factor when making purchasing decisions reduced the probability of shopping at a market by 17% in a national sample of adults shoppers (Zepeda 2009).

In light of the contrast between perceived high prices and a recurrent claim in farmers' market promotional materials that local retail outlets can offer lower prices, particularly when an item is in season, a surprisingly small number of studies have conducted price comparisons. Five are reviewed here.

The oldest identified was conducted in 1979 in California. Researchers collected the prices charged by all vendors of every identifiable fruit and vegetable item at 15 farmers' markets and up to three nearby supermarkets (Sommer, Wing, and Aitkens 1980). The average unit cost (per pound or per item) was calculated for each outlet, and the percent savings at farmers' markets calculated by subtracting the farmers' market from the supermarket price and dividing the difference by the larger price. Vegetables cost 37% less at California markets than nearby supermarkets (n=215), while fruits were 39% less expensive at farmers' markets (n=88) (Sommer, Wing, and Aitkens 1980).

A recent study utilized these same methods to compare prices at North Carolina farmers' markets. McGuirt et al. visited the largest farmers' market in each of 12 North Carolina counties and compared prices of all items at the market to equivalent items at the closest supermarket (McGuirt et al. 2011). Seventy-nine percent of items (17 items) had a lower mean price at farmers' markets than at supermarkets for an overall savings of 17.9% for conventionally grown produce sold at farmers' markets.

A third study compared farmers' market and supermarket produce prices in four large cities in Iowa (Pirog and McCann 2009). Rather than recording prices for all available items, the researchers selected eight vegetables based on items typically found in an Iowan's food basket that are also widely available at Iowa farmers' markets. This study found few significant differences. Zucchini squash were significantly less expensive at farmers' markets, while green beans cost significantly more at markets. The mean price per pound for locally grown vegetables sold at markets was $1.25, compared to $1.39 per pound for non-locally grown supermarket items, but this difference was insignificant (Pirog and McCann 2009).

A fourth study, conducted on behalf of the Northeast Organic Farming Association of Vermont, compared prices at nine farmers' markets and ten supermarkets in Vermont (Claro 2011). Prices for twelve vegetable items likely to be found at both farmers' markets and supermarkets were collected three times per month in July and August of 2010. Prices were collected from all vendors and a market average was calculated for comparison. Farmers' market conventional produce was less expensive in 36% of cases. Of the nine items sold in organic form, all but potatoes were less expensive at farmers' markets (38.5% less) (Claro 2011).

Finally, the non-profit The Food Project conducted price comparisons in three Boston neighborhoods with a high percentage of low-income families. Data collectors visited ten famers' markets as well as seven conventional grocery stores once every two weeks for a 16-week period from July to October (Lightner 2011). Prices were collected for ten items considered staple items for the local population and available throughout the season (carrots, cucumbers, onions, tomatoes, zucchini, white potatoes, scallions, lettuce, bell peppers, and green beans). The overall mean price per pound was $1.76 at farmers' markets compared to $1.72 at supermarkets. Controlling for time period, produce quality and produce type, an insignificant price difference of $0.09 per pound was found with the higher price at farmers' markets. When the logged price was used as the outcome variable, farmers' market prices were 2.9% greater ($p<0.05$) (Lightner 2011).

In sum, these studies suggest that farmers' markets compete well with supermarkets on price. Yet, improvement of the methods employed in four key areas would further strengthen conclusions drawn from price comparisons between local food retail outlets and traditional supermarkets. These four research needs are discussed in the final section of this literature review, below.

Local Food Retail: Gaps in Current Literature

Four shortcomings were identified in the methods previously employed to compare local food retail and supermarket prices. First, the farmers' markets sampled may not be representative of all markets in the states studied. The six Iowa markets studied were located in major cities (Pirog and McCann 2009). Vermont markets were chosen by convenience, based on proximity to data collectors (Claro 2011). McGuirt et al. made sampled markets from twelve types of counties designated by various combinations of urbanicity, percent of population below poverty level, and geographic region in North Carolina. However, within each of the 12 selected counties, the largest farmers' market was sampled (McGuirt et al. 2011). Sommer, Wing and Aitkins (1980) found that vegetable savings at markets were greater in smaller cities, suggesting the relevance of striving for a sample representative of markets and cities of all sizes.

A second need in the farmers' market price literature is a comparison of prices that takes into account the relative importance of various fruits and vegetables to the overall diet and food budget. In two previous studies, prices were compared for all items regardless of how often they were consumed (McGuirt et al. 2011; Sommer, Wing, and

Aitkens 1980). The Iowa and Boston studies make an effort to select items for pricing that are consumed by the local customer base, but they do not describe specific, data-based steps used to define those items. McGuirt et al. acknowledge this limitation, calling for comparisons weighted by item importance in future research (McGuirt et al. 2011).

Third, no study included information on roadside stands. Data disaggregating direct market sales by outlet types indicate that sales at farm stands exceed those at farmers' markets (Lev and Gwin 2010). This suggests the relevance at a more thorough exploration of the effect that roadside stands have on produce availability and price.

Finally, the existing studies fail to give a thorough assessment of seasonality's impact on local retail outlet prices. Sommer, Wing and Aitkins found winter price savings to average 29.3%, but this result was based on prices at just one market (Sommer, Wing, and Aitkens 1980). Lightner also examined the effect of a time trend. Over sixteen weeks, farmers' market prices decreased ten percent, while supermarket prices maintained consistent. Yet, winter and spring prices were not examined (Lightner 2011). Pirog and McCann call for price comparisons in and out of the local production season (Pirog and McCann 2009).

A thorough exploration of seasonality is warranted for several reasons. First, the existence of seasonal variation in fresh fruit and vegetable prices has been documented in wholesale and traditional retail markets. Producer and wholesale prices may drop across an item's harvest season, as domestic supply peaks and augments imports available from year-round producers outside the United States (Riley 1961; Tronstad 1995; Parker, Zilberman, and Moulton 1991). For example, an analysis of the effects of size, grade, type, week and year on 1990-1993 Los Angeles wholesale melon prices found that week of the year had the greatest effect (Tronstad 1995). Conversely, prices sometimes climb in the post-harvest season as supply declines, as is the case for Washington apples (Schotzko and Granatstein).

Second, the magnitude and pattern of seasonal price changes may be different at direct retail outlets than at supermarkets. McLaughlin outlines several findings about supermarket pricing that support such a hypothesis. Supermarkets base prices more on local competition than prices paid to suppliers and they seek to dampen price volatility due to an industry belief that consumers dislike price change. Also, a large fraction of the retail price at supermarkets covers costs that do not fluctuate seasonally such as storage, transportation, packaging and marketing (McLaughlin 2004). These middleman costs are reduced at farmers' markets (Andreatta and Wickliffe 2002).

Third, research has demonstrated that consumers vary both the quantity and type of fruits and vegetables consumed based on the season. In one survey conducted in the northeastern United States, 78% of shoppers reported consuming certain fresh fruits only in the summer months (melons, peaches, and berries) and 67% reported certain vegetables consumed as fresh only in the summer (corn, tomatoes, green beans, and squashes) (Wilkins 2002). Similarly, the proportion of 101 surveyed Hispanic farm workers who ate apples, pears, plums, peaches, apricots, peppers, corn, and cucumbers was highest in the fall harvest season, whereas the proportion eating cherries and asparagus were highest in the summer (harvest season for both) (Locke et al. 2009). Seasonality also affects quantity consumed (Amanatidis, Mackerras, and Simpson 2001; Fjeld and Sommer 1982; Johnson, McFetridge, and Durham 2005). A 1980 survey of 120 California shoppers demonstrated that asparagus, bell peppers, broccoli, corn, green beans, strawberries and tomatoes were consumed significantly more frequently during the item's peak local growing season than during off-season months (Fjeld and Sommer 1982).

Finally, a few studies suggest that the observed decline in frequency of fruit and vegetable consumption from summer to winter may have health consequences (Ziegler et al. 1987; Cox, Whichelow, and Prevost 2000; Božena Smolková et al. 2004). In one prospective study, men who reduced consumption of salad vegetables in winter had 64% higher odds of developing cancer and women had 47% higher odds of developing cardiovascular disease than those who maintained consumption across seasons (Cox, Whichelow, and Prevost 2000). A second study examined seasonal changes in markets of oxidative damage to lipids and DNA and correlations with seasonal diet variations in a Slovakian cohort. Food frequency questionnaires and oxidative stress biomarkers were assessed in February/March and September/October, representing times of minimum and maximum local availability of fresh fruits and vegetables. Vegetable consumption in summer/autumn was twice as high as in winter/spring. Damage to DNA did not vary consistently across the seasons, but oxidative damage to lipids was significantly higher in winter/spring than summer/autumn (Božena Smolková et al. 2004).

Conclusion

In light of the association between fruit and vegetable consumption and health as well as current sub-optimal intakes, efforts to increase intake have important public health significance. Widespread agreement exists on the need to increase fruit and vegetable intake; debate continues on the form those increases should take. This chapter reviewed studies that suggest that fresh and processed forms offer similar benefits and others that support the claim that fresh, and in particular, locally harvested fresh produce is most nutrient-dense. It also reviewed the potential of local food outlets to support increased intake by boosting availability of affordable fruits and vegetables.

Several gaps in the existing literature were noted. First, little research has documented the nutrient content of the processed fruits and vegetables actually eaten by Americans or disaggregated total produce intake by form. This dissertation compares sodium and added sugar content in fresh, processed, juice and miscellaneous forms of fruits and vegetables consumed by Americans. It also examines associations between percent of total intake in each form and several demographic and socioeconomic variables. Finally, this dissertation addresses the following gaps in the limited literature comparing farmers' market to supermarket prices: first, it improves the representativeness of sampled farmers' markets; second, prices are weighted by their contribution to intake; third, roadside stands are included in comparisons; and finally, seasonality is considered.

References

2010 Dietary Guidelines Advisory Committee. 2010. Report of the Dietary Guidelines Advisory Committee on the Dietary Guidelines for Americans, 2010. Alexandria, VA. : USDA Center for Nutrition Policy and Promotion.

Amanatidis, S., D. Mackerras, and J. M. Simpson. 2001. Comparison of two frequency questionnaires for quantifying fruit and vegetable intake. *Public Health Nutr* 4 (2):233-9.

Ammerman, Alice. 2012. Accessing nutritious food in low-income neighborhoods. *North Carolina Medical Journal* 73 (5):384-385.

Andreatta, Susan. 2000. Marketing strategies and challenges of small-scale organic producers in central North Carolina. *The Journal of Culture and Agriculture* 22 (3):40-50.

Andreatta, Susan, and William Wickliffe. 2002. Managing Farmer and Consumer Expectations: A Study of a North Carolina Farmers Market. *Human Organization* 61 (2):167-176.

Andreyeva, Tatiana, Michael Long, and Kelly Brownell. 2010. The impact of food prices on consumption: A systematic review of research on the price elasticity of demand for food. *American Journal of Public Health* 100:216-222.

Anliker, J, M Winne, and L Drake. 1992. An evaluation of the Connecticut farmers' market coupon program. *Journal of Nutrition Education* 24:185-191.

Ard, Jamy, Stephanie Fitzpatrick, Renee Desmond, Bryce Sutton, Maria Pisu, David Allison, Frank Franklin, and Monica Baskin. 2007. The impact of cost on the availability of fruits and vegetables in the homes of schoolchildren in Birmingham, Alabama. *American Journal of Public Health* 97:367-372.

Barth, M. Margaret, and Hong Zhuang. 1996. Packaging design affects antioxidant vitamin retention and quality of broccoli florets during postharvest storage. *Postharvest Biology and Technology* 9 (2):141-150.

Battle, Emily. 2013. *The wait is over as area farmers markets open*. Fredericksburg.com 2009 [cited February 17 2013]. Available from http://fredericksburg.com/News/FLS/2009/042009/04222009/452725.

Bazzano, L. A., T. Y. Li, K. J. Joshipura, and F. B. Hu. 2008. Intake of fruit, vegetables, and fruit juices and risk of diabetes in women. *Diabetes Care* 31 (7):1311-7.

Berning, Joshua. 2012. Access to local agriculture and weight outcomes. *Agricultural and Resource Economics Review* 41 (1):57-71.

Blanck, H. M., O. M. Thompson, L. Nebeling, and A. L. Yaroch. 2011. Improving fruit and vegetable consumption: use of farm-to-consumer venues among US adults. *Prev Chronic Dis* 8 (2):A49.

Bodor, Nicholas, Donald Rose, Thomas Farley, Christopher Swalm, and Susanne Scott. 2008. Neighbourhood fruit and vegetable availability and consumption: the role of small food stores in an urban environment. *Public Health Nutrition* 11:413-420.

Boeing, H., A. Bechthold, A. Bub, S. Ellinger, D. Haller, A. Kroke, E. Leschik-Bonnet, M. J. Muller, H. Oberritter, M. Schulze, P. Stehle, and B. Watzl. 2012. Critical review: vegetables and fruit in the prevention of chronic diseases. *Eur J Nutr* 51 (6):637-63.

Boone-Heinonen, J., P. Gordon-Larsen, C. I. Kiefe, J. M. Shikany, C. E. Lewis, and B. M. Popkin. 2011. Fast food restaurants and food stores: longitudinal associations with diet in young to middle-aged adults: the CARDIA study. *Arch Intern Med* 171 (13):1162-70.

Božena Smolková, Mária Dušinská, Katar´ına Rašlová, Geraldine McNeill, Viera Spustová, Pavol Blaž´ı˘cek, Alexandra Horská, and Andrew Collins. 2004. Seasonal changes in markers of oxidative damage to lipids and DNA; correlations with seasonal variation in diet. *Mutation Research* 551:135-144.

Briggs, Suzanne, Andy Fisher, Megan Lott, Stacy Miller, and Nell Tessman. 2010. Real food, real choice: Connecting SNAP recipients with farmers' markets. Portland, OR: Community Food Security Coalition.

Brown, A. 2002. Farmers' market research 1940-2000: An inventory and review. *American Journal of Alternative Agriculture* 17 (4):167-176.

Brown, Cheryl. 2003. Consumers' preferences for locally produced food: A study in southeast Missouri. *American Journal of Alternative Agriculture* 18 (4):213-224.

Brug, J., L. Lechner, and H. De Vries. 1995. Psychosocial determinants of fruit and vegetable consumption. *Appetite* 25 (3):285-96.

Buzby, Jean C., Hodan Farah Wells, Aylin Kumcu, Biing-Hwan Lin, Gary Lucier, and Agnes Perez. 2010. Canned fruit and vegetable consumption in the United States. In *Administrative Publication*: USDA Economic Research Service.

Centers for Disease Control and Prevention. 2009. State indicator report on fruits and vegetables, 2009. Atlanta.

Centers for Disease Control and Prevention. 2011. Strategies to Prevent Obesity and Other Chronic Diseases: The CDC Guide to Strategies to Increase the Consumption of Fruits and Vegetables. Atlanta.

Centers for Disease Control and Prevention. 2013. *High Blood Pressure Facts.* October 17, 2012 2012 [cited March 1 2013]. Available from http://www.cdc.gov/bloodpressure/facts.htm.

Claro, Jake. 2011. Vermont farmers' markets and grocery stores: A price comparison. Richmond: Northeast Organic Farming Association of Vermont.

Colasanti, Kathryn, David Conner, and Susan Smalley. 2010. Understanding barriers to farmers' market patronage in Michigan: Perspectives from marginalized populations. *Journal of Hunger and Environmental Nutrition* 5:316-338.

Conner, David, and Ralph Levine. 2007. Circles of association: The connections of community-based food systems. *Journal of Hunger and Environmental Nutrition* 1 (3):5-25.

Cotton, Paul, Amy Subar, James Friday, and Annetta Cook. 2004. Dietary sources of nutrients amont US adults, 1994 to 1996. *Journal of the American Dietetic Association* 104:921-930.

Cox, Brian, Margaret Whichelow, and Toby Prevost. 2000. Seasonal consumption of salad vegetables and fresh fruit in relation to the development of cardiovascular disease and cancer. *Public Health Nutrition* 3:19-29.

Cummins, S., M. Petticrew, C. Higgins, A. Findlay, and L. Sparks. 2005. Large scale food retailing as an intervention for diet and health: quasi-experimental evaluation of a natural experiment. *J Epidemiol Community Health* 59 (12):1035-40.

Curry, J., and H Oland. 1998. Prince George and Region Public Market Study. Prince George, B.C. : University of Northern British Columbia, Environmental Studies Program.

Darby, K., M.T. Batte, S. Ernst, and B. Roe. 2008. Decomposing local: A conjoint analysis of locally produced foods. *American Journal of Agricultural Economics* 90 (476-496).

Dauchet, L, P Amouyel, S Hercberg, and J Dallongeville. 2006. Fruit and vegetable consumption and coronary heart disease: a meta-analysis of cohort studies. *Journal of Nutrition* 136 (10):2588-93.

Demydas, T. 2011. Consumer segmentation based on the level and structure of fruit and vegetable intake: an empirical evidence for US adults from the National Health and Nutrition Examination Survey (NHANES) 2005-2006. *Public Health Nutr* 14 (6):1088-95.

Devine, Carol, Margaret Connors, Carole Bisogni, and Jeffery Sobal. 1998. Life-course influences on fruit and vegetable trajectories: Qualitative analysis of food choices. *Journal of Nutrition Education* 30:361-370.

Dong, Diansheng, and Biing-Hwan Lin. 2009. Fruit and vegetable consumption by low-income Americans: Would a price reduction make a difference? In *Economic Research Report* U.S. Department of Agriculture, Economic Research Service.

Dunne, Jonnie, Kimberlee Chambers, Katlyn Giombolini, and Sheridan Schlegel. 2010. What does "local" mean in the grocery store? Multiplicity in food retailers' perspectives on sourcing and marketing local foods. *Renewable Agriculture and Food Systems* 26 (1):46-59.

Evans, A. E., R. Jennings, A. W. Smiley, J. L. Medina, S. V. Sharma, R. Rutledge, M. H. Stigler, and D. M. Hoelscher. 2012. Introduction of farm stands in low-income communities increases fruit and vegetable among community residents. *Health Place* 18 (5):1137-43.

Farmer-to-Consumer Direct Marketing Act of 1976. Public Law 94-462. 90 Stat. Section 3. Oct 8, 1976.

Fjeld, Carla, and Robert Sommer. 1982. Regional-seasonal patterns in produce consumption at farmers' markets and supermarkets. *Ecology of Food and Nutrition* 12:109-115.

Food and Nutrition Service. "WIC Farmers Market Nutrition Program," Title 7 Code of Federal Regularions, Pt 248.2. 1994 ed.

Galfond, G, J Thompson, and K Wise. 1991. Evaluation of the Farmers' Market Coupon Demonstration Project. Washington, DC: U.S. Department of Agriculture Food and Nutrition Service.

Giang, T., A. Karpyn, H. B. Laurison, A. Hillier, and R. D. Perry. 2008. Closing the grocery gap in underserved communities: the creation of the Pennsylvania Fresh Food Financing Initiative. *J Public Health Manag Pract* 14 (3):272-9.

Gibson, Eric. 1994. *Sell what you sow! The farmer's guide to successful produce marketing.* Auburn, CA: New World Publishing.

Grace, Christina, Thomas Grace, Nancy Becker, and Judy Lyden. 2007. Barriers to using urban farmers' markets: An investigation of food stamp clients' perceptions. *Journal of Hunger and Environmental Nutrition* 2 (1):55-75.

Harvard Heart Letter. 2010. Better ways to get your produce.

Boston: Harvard Health Publications.

Herman, D. R., G. G. Harrison, A. A. Afifi, and E. Jenks. 2008. Effect of a targeted subsidy on intake of fruits and vegetables among low-income women in the Special Supplemental Nutrition Program for Women, Infants, and Children. *Am J Public Health* 98 (1):98-105.

Izumi, B. T., S. N. Zenk, A. J. Schulz, G. B. Mentz, and C. Wilson. 2011. Associations between neighborhood availability and individual consumption of dark-green and orange vegetables among ethnically diverse adults in Detroit. *J Am Diet Assoc* 111 (2):274-9.

Jacobs, D. R., Jr., and L. M. Steffen. 2003. Nutrients, foods, and dietary patterns as exposures in research: a framework for food synergy. *Am J Clin Nutr* 78 (3 Suppl):508S-513S.

Jilcott, Stephanie, Thomas Keyserling, Thomas Crawford, Jared McGuirt, and Alice Ammerman. 2011. Examining associations among obesity and per capita farmers' markets, grocery stores/supermarkets, and supercenters in US counties. . *Journal of the American Dietetic Association* 111 (4):567-572.

Johnson, Aaron, Marc McFetridge, and Catherine Durham. 2005. Store-level retail fruit demand: Lessons from omitted variables. *Journal of Food Distribution Research* 36 (1):91-94.

Johnson, R. K., L. J. Appel, M. Brands, B. V. Howard, M. Lefevre, R. H. Lustig, F. Sacks, L. M. Steffen, and J. Wylie-Rosett. 2009. Dietary sugars intake and cardiovascular health: a scientific statement from the American Heart Association. *Circulation* 120 (11):1011-20.

Kalt, Wilhelmina. 2005. Effects of production and processing factors on major fruit and vegetable antioxidants. *Journal of Food Science* 70 (1):R11-R19.

Keeling Bond, Jennifer, Dawn Thilmany, and Craig Bond. 2009. What influences consumer choice of fresh produce purchase location? *Journal of Agricultural and Applied Economics* 41 (4):61-74.

Kropf, M. L., D. H. Holben, J. P. Holcomb, Jr., and H. Anderson. 2007. Food security status and produce intake and behaviors of Special Supplemental Nutrition Program for Women, Infants, and Children and Farmers' Market Nutrition Program participants. *J Am Diet Assoc* 107 (11):1903-8.

Larsen, Kristian, and Jason Gilliland. 2009. A farmers' market in a food desert: Evaluating impacts on the price and availability of healthy food. *Health & Place* 15:1158-1162.

Lea, Emma. 2005. Food, health, the environment and consumers' dietary choices. *Nutrition & Dietetics* 62 (1):21-25.

Lee, Seung, and Adel Kader. 2000. Preharvest and postharvest factors influencing vitamin C content of horticultural crops. *Postharvest Biology and Technology* 20:207-220.

Leone, Lucia, Diane Beth, Scott Ickes, Kathleen MacGuire, Erica Nelson, Robert Andrew Smith, Deborah Tate, and Alice Ammerman. 2012. Attitudes toward fruit and vegetable consumption and farmers' market usage among low-income North Carolinians. *Journal of Hunger and Environmental Nutrition* 7 (1):64-76.

Lev, L, L Brewer, and G Stephenson. 2003. Research Brief: How do farmers' markets affect neighboring businesses? *Oregon Small Farms Technical Report*. Corvallis: Oregon State University Extension Service.

Lev, Larry, and Lauren Gwin. 2010. Filling in the gaps: Eight things to recognize about farm-direct marketing. *Choices*.

Lichtenstein, A. H., L. J. Appel, M. Brands, M. Carnethon, S. Daniels, H. A. Franch, B. Franklin, P. Kris-Etherton, W. S. Harris, B. Howard, N. Karanja, M. Lefevre, L. Rudel, F. Sacks, L. Van Horn, M. Winston, and J. Wylie-Rosett. 2006. Diet and lifestyle recommendations revision 2006: a scientific statement from the American Heart Association Nutrition Committee. *Circulation* 114 (1):82-96.

Lightner, Robyn. 2011. Healthy food in underserved Boston neighborhoods: The affordability and viability of farmers' markets. Boston, MA: The Food Project.

Liu, S., M. Serdula, S. J. Janket, N. R. Cook, H. D. Sesso, W. C. Willett, J. E. Manson, and J. E. Buring. 2004. A prospective study of fruit and vegetable intake and the risk of type 2 diabetes in women. *Diabetes Care* 27 (12):2993-6.

Locke, E., G. D. Coronado, B. Thompson, and A. Kuniyuki. 2009. Seasonal variation in fruit and vegetable consumption in a rural agricultural community. *J Am Diet Assoc* 109 (1):45-51.

Marriott, B. P., L. Olsho, L. Hadden, and P. Connor. 2010. Intake of added sugars and selected nutrients in the United States, National Health and Nutrition Examination Survey (NHANES) 2003-2006. *Crit Rev Food Sci Nutr* 50 (3):228-58.

Martinez, Steve, Michael Hand, Michelle Da Pra, Susan Pollack, Katherine Ralston, Travis Smith, Stephen Vogel, Shellye Clark, Luanne Lohr, Sarah Low, and Constance Newman. 2010. Local Food Systems: Concepts, Impacts, and Issues. Washington, DC: U.S. Department of Agriculture.

McCormack, Lacey, Melissa Laska, Nicole Larson, and Mary Story. 2010. Review of nutritional implications of farmers' markets and community gardens: Call for evaluation and research efforts. *Journal of the American Dietetic Association* 110 (3):399-408.

McGuirt, Jared, Stephanie Jilcott, Haiyong Liu, and Alice Ammerman. 2011. Produce price savings for consumers at farmers' markets compared to supermarkets in North Carolina. *Journal of Hunger and Environmental Nutrition* 6:86-98.

McLaughlin, Edward. 2004. The dynamics of fresh fruit and vegetable pricing in the supermarket channel. *Preventive Medicine* 39:S81-S87.

Murcia, M. A., A. M. Jimenez-Monreal, L. Garcia-Diz, M. Carmona, L. Maggi, and M. Martinez-Tome. 2009. Antioxidant activity of minimally processed (in modified atmospheres), dehydrated and ready-to-eat vegetables. *Food Chem Toxicol* 47 (8):2103-10.

Mushi-Brunt, C., D. Haire-Joshu, and M. Elliott. 2007. Food spending behaviors and perceptions are associated with fruit and vegetable intake among parents and their preadolescent children. *J Nutr Educ Behav* 39 (1):26-30.

National Research Council. 2005. Dietary Reference Intakes for Water, Potassium, Sodium, Chloride and Sulfate. Washington, DC.

Nebeling, L., A. L. Yaroch, J. D. Seymour, and J. Kimmons. 2007. Still not enough: can we achieve our goals for Americans to eat more fruits and vegetables in the future? *Am J Prev Med* 32 (4):354-5.

North Carolina Department of Agriculture and Consumer Services. 2010. *NC Farm Fresh*. NCDACS 2010 [cited April 22 2010]. Available from http://www.ncfarmfresh.com/index.asp.

Oberholtzer, Lydia, and Shelly Grow. 2003. *Producer-only farmers' markets in the Mid-Atlantic region: A survey of market managers*: Henry A. Wallace Center for Agricultural & Environmental Policy at Winrock International.

Oliveira, Victor, and Elizabeth Frazao. 2009. The WIC Program: Background, Trends, and Economic Issues, 2009 Edition. Washington DC: United States Department of Agriculture.

Otto, Daniel, and Theresa Varner. 2005. Consumers, Vendors, and the Economic Importance of Iowa Farmers' Markets: An Economic Impact Survey Analysis. *Ames, IA: Leopold Center for Sustainable Agriculture, Iowa State University*.

Oude Griep, L. M., J. M. Geleijnse, D. Kromhout, M. C. Ocke, and W. M. Verschuren. 2010. Raw and processed fruit and vegetable consumption and 10-year coronary heart disease incidence in a population-based cohort study in the Netherlands. *PLoS One* 5 (10):e13609.

Oude Griep, L. M., W. M. Verschuren, D. Kromhout, M. C. Ocke, and J. M. Geleijnse. 2011. Raw and processed fruit and vegetable consumption and 10-year stroke incidence in a population-based cohort study in the Netherlands. *Eur J Clin Nutr* 65 (7):791-9.

Parker, Douglas, David Zilberman, and Kirby Moulton. 1991. How quality relates to price in California fresh peaches. *California Agriculture* 45 (2):14-16.

Phillips, Jon C, and H Christopher Peterson. 2007. Strategic marketing decisions for organic agricultural producers. *International Food and Agribusiness Management Review* 10 (1):1-16.

Pirog, Rich, and Nick McCann. 2009. Is local food more expensive?: A consumer price perspective on local and non-local foods purchased in Iowa.

Pollan, Michael. 2008. *In defense of food: An eater's manifesto*. New York: The Penguin Press.

Pollard, J, SFL Kirk, and JE Cade. 2002. Factors affecting food choice in relation to fruit and vegetable intake: a review. *Nutrition Research Reviews* 15:373-387.

Powell, LM, Z Zhao, and Y Wang. 2009. Food prices and fruit and vegetable consumption among young American adults. *Health & Place* 15 (4):1064-70.

Pyle, J. 1971. Farmers' markets in the United States: Functional anachronisms. *Geographical Review* 61 (2):167-197.

Racine, Elizabeth, Elizabeth Mumford, Sarah Laditka, and Anna Lowe. 2013. Understanding characteristics of families who buy local produce. *Journal of Nutrition Education and Behavior* 45 (1):30-38.

Ragland, Edward, and Debra Tropp. 2009. USDA National Farmers Market Manager Survey, 2006. Washington, DC: U.S. Department of Agriculture.

Rickman, Joy, Diane Barrett, and Christine Bruhn. 2007. Nutritional comparison of fresh, frozen and canned fruits and vegetables. Part 1. Vitamins C and B and phenolic compounds. *Journal of the Science of Food and Agriculture* 87:930-944.

Rickman, Joy, Christine Bruhn, and Diane Barrett. 2007. Nutritional comparison of fresh, frozen and canned fruits and vegetables. Part 2. Vitamin A and carotenoids, Vitamin E, minerals and fiber. *Journal of the Science of Food and Agriculture* 87:1185-1196.

Riley, H.E. 1961. Some aspects of seasonality in the consumer price index. *Journal of the American Statistical Association* 56:27-35.

Rose, Donald, and Rickelle Richards. 2004. Food store access and household fruit and vegetable use among participants in the US Food Stamp Program. *Public Health Nutrition* 7:1081-1088.

Ruelas, V., E. Iverson, P. Kiekel, and A. Peters. 2012. The role of farmers' markets in two low income, urban communities. *J Community Health* 37 (3):554-62.

Sacks, F. M., L. P. Svetkey, W. M. Vollmer, L. J. Appel, G. A. Bray, D. Harsha, E. Obarzanek, P. R. Conlin, E. R. Miller, 3rd, D. G. Simons-Morton, N. Karanja, and P. H. Lin. 2001. Effects on blood pressure of reduced dietary sodium and the Dietary

Approaches to Stop Hypertension (DASH) diet. DASH-Sodium Collaborative Research Group. *N Engl J Med* 344 (1):3-10.

Salois, M. J. 2012. Obesity and diabetes, the built environment, and the 'local' food economy in the United States, 2007. *Econ Hum Biol* 10 (1):35-42.

Schotzko, R. Thomas, and David Granatstein. A Brief Look at the Washington Apple Industry: Past and Present. Wenatchee: Washington State University.

Slavin, J. L., and B. Lloyd. 2012. Health benefits of fruits and vegetables. *Adv Nutr* 3 (4):506-16.

Sommer, Robert, Margaret Wing, and Susan Aitkens. 1980. Price Savings to Consumers at Farmers' Markets. *The Journal of Consumer Affairs* 14 (2):452-462.

Stewart, Hayden, and Gary Lucier. 2009. Younger consumers exhibit less demand for fresh vegetables. Washington DC: U.S. Department of Agriculture, Economic Research Service.

Strazzullo, P., L. D'Elia, N. B. Kandala, and F. P. Cappuccio. 2009. Salt intake, stroke, and cardiovascular disease: meta-analysis of prospective studies. *BMJ* 339:b4567.

Thilmany, Dawn, Craig Bond, and Jennifer Bond. 2008. Going local: Exploring consumer behavior and motivations for direct food purchases. *American Journal of Agricultural Economics* 90 (5):1303-1309.

Tronstad, Russell. 1995. Importance of melon type, size, grade, container, and season in determining melon prices. *Journal of Agricultural and Resource Economics* 20 (1):32-48.

U.S. Department of Agriculture. 2013. *Farmers Markets*, February 14, 2013 2013 [cited February 18 2013]. Available from http://www.nutrition.gov/shopping-cooking-meal-planning/food-shopping-and-meal-planning/farmers-markets.

U.S. Department of Agriculture, and U.S. Department of Health and Human Services. 2010. Dietary Guidelines for Americans, 2010. Washington, D.C.: U.S. Government Printing Office.

U.S. Department of Health and Human Services. 2013. *Healthy People 2020 Topics & Objectives: Nutrition and Weight Status*, September 6, 2012 2010 [cited February 18 2013]. Available from http://www.healthypeople.gov/2020/topicsobjectives2020/overview.aspx?topicid=29.

USDA Food and Nutrition Service. 2013. *WIC Farmers' Market Nutrition Program*. U.S. Department of Agriculture, October 5, 2012 2012 [cited February 18 2013]. Available from http://www.fns.usda.gov/wic/fmnp/fmnpfaqs.htm.

Vallejo, Fernando, Francisco Tomas-Barberan, and Cristina Garcia-Viguera. 2003. Health-promoting compounds in broccoli as influenced by refrigerated transport and retail sale period. *Journal of Agricultural and Food Chemistry* 51:3029-3034.

Vogt, Rainbow, and Lucia Kaiser. 2008. Still a time to act: A review of institutional marketing of regionally-grown food. *Agriculture and Human Values* 25:241-255.

WCRF, and AICR. 2007. Food, Nutrition, Physical Activity, and the Prevention of Cancer: a Global Perspective. Washington, DC: American Institute for Cancer Research.

Webber, Caroline, and Jamie Dollahite. 2008. Attitudes and behaviors of low-income food heads of households toward sustainable food systems concepts. *Journal of Hunger and Environmental Nutrition* 3 (2):186-205.

Wilkins, Jennifer. 2002. Consumer perceptions of seasonal and local foods: A study in a U.S. community. *Ecology of Food and Nutrition* 41 (5):415-439.

Yang, Q., Z. Zhang, E. V. Kuklina, J. Fang, C. Ayala, Y. Hong, F. Loustalot, S. Dai, J. P. Gunn, N. Tian, M. E. Cogswell, and R. Merritt. 2012. Sodium intake and blood pressure among US children and adolescents. *Pediatrics* 130 (4):611-9.

Yeh, Ming-chin, Scott Ickes, Lisa Lowenstein, Kerem Shuval, Alice Ammerman, Rosanne Farris, and David Katz. 2008. Understanding barriers and facilitators of fruit and vegetable consumption among a diverse multi-ethnic population in the USA. *Health Promotion International* 23 (1):42-51.

Zenk, S. N., L. L. Lachance, A. J. Schulz, G. Mentz, S. Kannan, and W. Ridella. 2009. Neighborhood retail food environment and fruit and vegetable intake in a multiethnic urban population. *Am J Health Promot* 23 (4):255-64.

Zepeda, Lydia. 2009. Which little piggy goes to market? Characteristics of US farmers' market shoppers. *International Journal of Consumer Studies* 33 (3):250-257.

Zepeda, Lydia, and Jinghan Li. 2006. Who Buys Local Food? *Journal of Food Distribution Research* 37 (3):5-15.

Zhang, Qi, and Liuliu Fu. 2011. Review of multi-level factors contributing to fruit and vegetable consumption in the U.S.. *North American Journal of Medical Science* 4 (4):232-237.

Ziegler, Regina, Homer Wilcox, Thomas Mason, joanne Bill, and Phillip Virgo. 1987. Seasonal variation in intake of carotenoids and vegetables and fruits among white men in New Jersey. *American Journal of Clinical Nutrition* 45:107-114.

CHAPTER 3. RESEARCH METHODS

This chapter describes in detail the methods used to conduct this study. Like the research, the chapter is divided into two major parts. The first describes the methods used to study the *Fresh versus Processed Question*. The second describes methods used to collect primary data in order to study questions pertaining to the *Supermarkets versus Local Retail Question*.

Fresh versus Processed Question

The first aim of this dissertation research was to characterize national fruit and vegetable intake by form and identify nutritional consequences of meeting produce recommendations with the items currently consumed in each form. The planned analyses required a dataset with information on the demographic and socioeconomic characteristics of respondents as well as detailed data about their fruit and vegetable intake. The National Health and Nutrition Examination Survey (NHANES), a detailed and nationally representative survey with publically available data, met these criteria. The following sections describe NHANES design and data, additional datasets used, the methods used to categorize fruits and vegetables by form, and the analyses undertaken.

Sampling

This section describes sample size calculations conducted as well as the sampling procedure used to select the NHANES sample used for analysis.

Sample Size Determination

Sample size calculations for this aim were based on one of the anticipated analyses, comparing the proportions of vegetable and fruit intake in each form by socioeconomic variables. Expected differences in the proportion of fruits and vegetables consumed in each form were identified from data published the late 1990s. Pollack reported that Americans consume about 47% of their vegetables as fresh, 25% as canned, 18% as frozen and 10% as dried. The proportions for fruit were slightly different, at 44% juice, 37% fresh, 8% canned, 3% frozen, 6% dried (Pollack 2001). Based on these data, a sample size calculation for comparing two proportions was conducted using Lenth's sample size calculator. Detecting a five percentage point difference in fresh vegetable consumption between socioeconomic groups (50% and 45%), with an alpha of 0.05 and power of 0.8, would require 1,605 observations per population sub-group (Lenth 2006-9).

Data from the most recent NHANES data cycle (2009-2010) had not yet been released at the time that this calculation was made. However, in the 2007-2008 data alone contained relevant responses from 9,255 participants. Thus, it was anticipated that the final sample would have more than 17,000 respondents, more than sufficient for the planned analyses. Indeed, the final sample consisted of 19,008 respondents. The sample was limited to non-pregnant respondents aged 2 years old and older.

Sampling Procedure

NHANES participants are sampled via a multistage, complex, probability sampling design. Sampling proceeds in four stages: first, probability proportional to size (PPS) sampling is used to select primary sampling units (PSUs), which are typically single counties; next, PPS sampling is used to select segments (census blocks or a combination of blocks) from within the PSUs; third, households within each segment are randomly sampled; finally, individuals are randomly chosen from a list of all persons in selected households within age-sex-race/ethnicity subdomains. The weighted sample from each cycle is representative of the civilian, non-institutionalized U.S. population.

Data Preparation

Data preparation entailed the creation of a dataset containing information on respondent demographic characteristics, respondent 24-hour food intakes, and the nutrients composition of the consumed foods. This dataset enabled exploration of associations between individual characteristics, form of fruit and vegetable consumption, and nutrient composition. The analysis drew primarily on NHANES, but also upon several additional databases. These data sources are described below.

National Health and Nutrition Examination Survey (NHANES)

This analysis utilized variables included in three NHANES data files.

<u>Demographic Variables and Sample Weights</u>

Summary and Data Collection Methods: The Demographics data file includes family-level and individual-level information collected by trained interviewers during an in-person interview at the respondent's home.

Relevant Variables: Variables containing information on the following characteristics were used from the *Demographics* file: the respondent's age, gender, race/ethnicity, education level, the family income to poverty ratio, and an indicator of the 6-month time period during which the interview took place (November-April or May- October).

Individual Foods – First Day File

Summary and Data Collection Methods: NHANES participants provided details about the type and quantity of all foods consumed in a 24-hour period during two non-consecutive dietary recalls. Trained interviewers administered the first recall interview in person at the NHANES mobile examination center (MEC), using the U.S. Department of Agriculture's (USDA) Automated Multiple-Pass Method. Measuring guides assisted participants in reporting amounts consumed. The resulting *Individual Foods – First Day* file includes data about the type and amount of each food reported by each participant, the amounts of nutrients for each food, and information about the eating occasion for the food.

Relevant Variables: Two key variables were used. The first, the 8-digit USDA food code, uniquely identifies each reported food or beverage. Foods can be linked to a description by this food code; categorization by form was based on food descriptions (described below). The second variable is the grams of the food consumed.

Food Code Description File

Summary: This file consists of just three variables: the 8-digit USDA food code, a short description of the food item (up to 60 characters), and a long description of the food item (up to 200 characters).

Relevant Variables: Categorization of fruits and vegetables by form was based on the short description.

The MyPyramid Equivalents Database 2.0 (MPED)

The MPED database was created by USDA to translate the foods eaten by NHANES respondents into the appropriate number of MyPyramid equivalents for each of 32 MyPyramid major food groups and subgroups (following the release of the 2010 Dietary Guidelines for Americans, this database was renamed the USDA Food Pattern Equivalents Database (FPED)). Though the full MPED database consists of several data files, only the *Equivalents* file was used for this analysis.

<u>Equivalents File</u>

Summary: The *Equivalents* file presents the number of MyPyramid equivalents of 32 food groups and subgroups per 100 grams of each food. For fruits and vegetables, a MyPyramid equivalent was defined as the amount of food considered equivalent to 1 cup of cut up fruit or vegetable. One cup of fruit juice, one ½ cup of dried fruit or two cups of raw leafy greens are considered a cup equivalent.

Relevant Variables: As in the NHANES dataset, foods are identified by the 8-digit USDA food code, which proved useful for linking NHANES food intake data to the MPED database. The variables containing cup equivalents for food groups and sub-groups were also utilized (e.g. dark-green vegetables, citrus fruits, melons, and berries, etc.).

The final analytic dataset was constructed by merging the NHANES *Demographic* file, the *Individual Intake – Day 1* file, the NHANES *Food Descriptions*, and the NHANES data to MPED 2.0 *Equivalents* file. Because the analyses focus on estimating mean group intakes rather than regular individual intakes, Day 2 dietary data were not used. Finally, datasets from the 2007-2008 NHANES were appended to 2009-2010 NHANES data to ensure sufficient sample size for sub-group analysis. Data were then cleaned; respondents lacking complete dietary recall data (8.1%) were removed.

Categorization of Items by Form

Examining fruit and vegetable intake by form required categorizing each fruit or vegetable item into the appropriate form category. A first attempt to categorize the items using the 8-digit USDA food code mentioned above proved unsuccessful. The first digit of the code identifies the food as belonging to one of nine major food groups in a scheme developed by the USDA Food Surveys Research Group (e.g. "1" indicates milk products). Subsequent digits indicate food subgroups (Table 3.1). However, the food code digits do not indicate the form of a fruit or vegetable item. Thus, foods were categorized using a multi-step process that relied on food description data.

Step 1: Exclude fruits and vegetables categorized in other food groups

The detail in the NHANES database enables identification of fruit and vegetable servings in composite foods whose primary ingredient classifies them in one of the non-fruit or vegetable food groups outlined in Table 3.1 (e.g. beef stew with carrots, classified in the meat group because its primary ingredient is beef).

Table 3.1 USDA food coding scheme and Food Studies Research Group-defined food groups, with selected sub-group examples

1	Milk and milk products
14 -	*Cheeses*
142 -	*Cottage cheeses*
2	Meat, poultry, fish, and mixtures
3	Eggs
4	Legumes, nuts, and seeds
5	Grain products
6	Fruits
61 -	*Citrus fruits, juices*
611 -	*Citrus fruits*
612 -	*Citrus fruit juices*
7	Vegetables
74 -	*Tomatoes and tomato mixtures*
741 -	*Tomatoes, raw*
744 -	*Tomato sauces*
8	Fats, oils, and salad dressings
9	Sugars, sweets, and beverages

Though these servings in non-fruit and non-vegetable food groups can be quantified they were excluded for this study. Fruits and vegetables were included only if their food code began with a "6" (fruit group) or "7" (vegetable group). Limiting the items considered to these groups made the included fruits and vegetables most comparable to those selected for pricing in the primary data collection effort. Collecting primary data on the cost of a serving of the vegetables in a mixed dish (e.g. vegetables on a frozen pizza) was determined unfeasible for this research effort. Thus, the mixed items were excluded from both primary data collection and this analysis of existing NHANES data. This resulted in the exclusion of 9.7% of total fruit and 27.9% of vegetable servings reported by NHANES participants.

Step 2: Categorize foods based on NHANES Food Descriptions

Next, foods were categorized into broad groups based on words found in the NHANES short food description. In addition to words about form such as “fresh”, “canned”, “frozen” and “juice”, terms describing preparation method such as “boiled” or “baked” were used for vegetables that lacked information about form. Table 4.1, in Chapter 4, presents the full list of created categories.

Step 3: Combine some preparation-based categories under forms groups

Finally, some of the preparation-based descriptors were assigned to a form category, based on assumptions about the form of the item most amenable to the particular method of preparation. For example, the food described as “white potato, baked, peel eaten” was assumed to have been baked from a fresh potato. In the resulting categorization scheme, 3.2% of fruit and 25.6% of vegetable servings remained categorized as either “form not specified” or “miscellaneous” (Table 4.1).

Analyses

All analyses were performed using StataIC 10.0 (StataCorp, College Station, TX). To account for the complex sampling design, the *svyset* command and four-year weights were used. The sample was representative of the non-institutionalized U.S. population at the midpoint of the four-year survey interval.

The first analysis sought to determine the mean sodium, added sugar, and fiber content per cup equivalent of the fresh, processed, juice, and miscellaneous fruits and vegetables chosen by Americans. This analysis was then repeated for each MyPyramid fruit and vegetable sub-group. Wald's tests were used to compare results across forms and across fruit or vegetable sub-groups within each form ($p<0.05$).

Then, the percent of total fruit and vegetable intake attributable to fresh, processed, juice and miscellaneous items was calculated for the entire sample and for sub-groups defined by socioeconomic and demographic variables. Comparisons of the proportion of total fruit and total vegetables consumed by form were repeated across age group, race/ethnicity, and family income to poverty ratio groups. Comparisons were adjusted by Wald's tests; differences were significant if $p<0.05$.

Also of interest was whether the nutrients per cup equivalent or the percent of fruits and vegetables consumed in a particular form varied with seasonal change. The NHANES data includes a variable indicating the half-year in which the interview took place, November – April or May – October. The dataset was stratified by this variable, and the analysis repeated for each half of the year. See the description of these analyses in Chapter 4 for further detail and for a discussion of potential bias in seasonal comparisons that results from NHANES data collection methods.

Supermarkets versus Local Retail Question

To explore the effects of outlet type, seasonality, and their interaction on the prices of fruits and vegetables, primary data were collected at supermarkets, farmers' markets and roadside stands across North Carolina in each of the four seasons of 2011. A four-person research team visited outlets in 34 cities and recorded prices for 29 of the most-consumed fruits and vegetables in the American diet. The following sections describe in further detail the sampling plan, the instruments developed, and the protocol designed and implemented for this research.

Sampling

Studying the effect of outlet type on produce prices required a sample of sites, each consisting of three retail outlet types. The sampling plan aimed to select a representative sample of farmers' markets in central and eastern North Carolina, along with a supermarket and roadside stand in geographic proximity to each market. Farmers' markets were sampled using PPS sampling, with a greater probability of selection given to markets with a greater number of food vendors. Sampling frames of nearby supermarkets and roadside and/or farm stands were then created. Supermarkets and roadside stands were randomly sampled from these frames. Thus, excepting the occasional missing roadside stand, each site offers a trio of outlets that provide a snapshot of the fruit and vegetable price environment in that location.

The sampling strategy outlined below was developed after a review of the existing literature on farmers' market price comparisons revealed little detail regarding sampling strategy (see Chapter 2 for more detail). These methods improve upon past studies due to the representative nature of the farmers' market sample and the variety of city sizes represented. Furthermore, the supermarket and roadside stand corresponding to each farmers' market in this study were randomly sampled from a list of outlets included in explicitly-defined sampling frames. In previous studies, researchers visited stores located "as close as possible to the farmers' market" or "in the same town, city or general locality of the farmers' market" (Sommer, Wing, and Aitkens 1980; Claro 2011). The method used in this study aimed to eliminate errors in accounting for all nearby outlets and bias in the selection of comparison outlets. Finally, the large size of the sample (34 sites) and probability proportional to size sampling based on market size resulted in a sample of sites located in cities of diverse size (Table 3.2).

Table 3.2 Sampled study sites by size of city in which farmers' market is located, 2011

City Population Range (People)	Number of Sites
0-4,999	6
5,000-9,999	5
10,000-14,999	0
15,000-24,999	5
25,000-39,999	2
40,000-59,999	2
60,000-79,999	1
80,000-99,999	2
100,000-149,999	4
150,000-250,000	2
250,000-500,000	3
500,000-750,000	2

Sample Size Determination

Sample size calculations were motivated by planned comparisons of fruit and vegetable prices, *per serving,* by form, outlet type and season. While several studies have compared prices by outlet type, these comparisons were based on price per pound or per item. Only one study reviewed prior to sample size calculations compared produce prices by cost per serving (Reed, Frazao, and Itskowitz 2004).

Thus, sample size calculations were based on those data, which compared the cost per serving of produce in different forms (fresh, frozen, canned, juice). A series of sample size calculations was conducted using Russ Lenth's sample size calculator, for results significant with an alpha of 0.05 and a beta of 0.8. Standard deviations were not reported for the mean prices, so they were calculated as 70% of the mean, as recommended by Magnani (Magnani 1997). As can be seen in Table 3.3, the largest sample size required for detecting a $0.10 difference in price per serving between two forms of fruit or vegetable is 46. However, because such a large sample would be expensive and most analyses require many fewer sites, a sample size of 30 was

Table 3.3 Retail outlet sample size calculations based on differences in price of fruit and vegetable serving, by form.

Item	Weighted mean cost per serving ($) of first form	Mean reported difference in price between these forms	Standard deviation	Sample size to detect mean price difference	Sample size to detect $0.10 price difference
Fruit					
Fresh and canned	.18	.18	.126	10	28
Fresh and frozen	.18	.31	.126	4	28
Fresh and juice	.18	.11	.126	23	28
Canned and frozen	.24	.18	.168	15	46
Canned and juice	.24	.14	.168	24	46
Frozen and juice	.51	N/A	.357	N/A	202
Vegetables					
Fresh and canned	.12	.21	.084	4	12
Fresh and frozen	.12	.16	.084	6	12
Canned and frozen	.17	.11	.119	20	25

selected. The sample was augmented by 13% to account for sites that refuse to participate, giving a final sample size of 34 sites containing 102 total outlets.

Sampling Frames and Methods

Farmers' Markets

Sampling frames were developed separately for each outlet type, beginning with farmers' markets. A list of markets across the state was obtained from the researchers at North Carolina State University. Using this list, markets were sorted on their county into the widely recognized geographic regions in North Carolina: the Mountains region, the Piedmont region, the Inner Coastal Plain and the

Tidewater. The manager of each market in the Piedmont, Coastal Plain and Tidewater regions was contacted by phone and e-mail in October 2010 to learn if the market was still functioning and to obtain an estimate of the average number of customers who visited the market each market day in 2010.

In their replies, many managers indicated that they did not track attendance. In response, the decision was made to use the vendor count as a proxy for market size and each manager was asked this follow-up question, "In the market's busiest month last year, what is the average number of food vendors (fruits and vegetables, eggs, honey, bread, etc., but not crafts) who sold items on a market day?" This number served as the size variable that enabled PPS sampling.

From an initial list of 126 markets in the Piedmont and Coastal Plain regions, the final farmers' market sample frame contained 106 markets. Of the twenty markets excluded, fifteen had closed, three could not be reached, one was actually a roadside produce stand, and one was attempting to move to a permanent structure and did not know if it would be open in 2011. Managers reported food vendor estimates for 101 of the 106 remaining markets. If managers gave a range (e.g. eight to ten vendors), the midpoint of the range was used. Vendor counts were estimated for the five remaining markets. To arrive at an estimate, the market vendor count was regressed on the estimated 2009 population of the city in which the market was located (U.S. Census Bureau 2009). This equation was then used to estimate an average vendor count from the market's city size. From the final sampling frame, 34 farmers' markets were sampled.

Supermarkets

Next, 34 supermarket sampling frames were constructed, one for each farmers' market. First, a list of outlets was obtained from the USDA Food and Nutrition Service (FNS). This list included the names and addresses of the supermarkets and superstores in North Carolina authorized to accept Supplemental Nutrition Assistance Program (SNAP) benefits. Supermarkets, defined by USDA as stores having annual sales of at least $2 million and at least five main departments - fresh meat and poultry, produce, dairy, dry and packaged goods and frozen foods, were retained and sorted by city. Superstores, which carry groceries in addition to a variety of non-food goods, were excluded. While superstores have gained an increasing share of consumer food-at-home spending in the past decade, traditional food stores still capture the majority of food-at-home sales (67.4% in 2005) (Martinez 2007).

Because the SNAP retailer list may not capture all food retailers in an area, the "search nearby" function of Google Maps and the online Yellow Pages were used to identify other potential supermarkets near the farmers' markets. As sales data were not available from these outlets, a two-step procedure was used to determine whether or not to include them in the sampling frames. First, if the outlet was one of a retail chain represented on the FNS list, it was provisionally included in the appropriate sampling frame. If the outlet was not part of these chains, the outlet manager was called and asked to categorize the outlet as a supermarket, grocery store or convenience store. If the manager indicated that the store was a supermarket, it was provisionally included in the sample. Second, these outlets were checked against another FNS list, this one of SNAP-approved retailers categorized as outlet types other than supermarkets and superstores. Outlets not on this FNS list were then approved for inclusion in the final sampling frames (9 outlets). Google Maps was used to determine the driving distance between the market and each supermarket.

The final sampling frame for each market consisted of those supermarkets within a five-mile driving distance of the market. This distance was selected based on research on the average distance traveled by SNAP participants to their most-used food store (Ohls et al. 1999). In this study, 52% of responding households were classified as urban. These urban households were an average of 2.5 miles from their most-used food stores. When this group was broadened to include households living in “mixed” areas (between urban and rural areas), 81% of households were located an average of 4.4 miles or fewer from the most-used food store. Five miles was selected as the maximum distance between farmers’ markets and supermarkets for this study to encompass the distances that most low-income families travel to purchase food. In one case, no supermarket was located within five miles of the farmers’ market, so a sampling frame was created of those stores within seven and a half miles of the market. Each sampling frame was imported into StataIC 10.0 and the program was used to draw a random sample of three outlets. The first supermarket sampled served as the primary outlet for data collection. Others were used as back-up outlets if the first declined to participate.

Roadside Stands

The roadside stand sampling frames, one for each farmers’ market, were developed using several sources. First, the agricultural extension officers deemed the “local foods coordinator” for the county of each sampled market were asked to share a list of roadside or farm stands in the county. Few keep such a list, but several referred to a directory maintained by the NC Department of Agriculture and Consumer Services (NCDACS) at www.ncfarmfresh.com (North Carolina Department of Agriculture and Consumer Services 2010). This Web site's list of "Farms/Roadside Markets" was searched by county. Any stand that specialized in dairy, meats, ornamental plants, or just a few fruits or vegetables (e.g. strawberry patch, peach orchard, or pumpkin patch) was excluded from the results. This list was augmented for each farmers' market by searching for "farm stands" and "roadside stands" with the *Search Nearby* function on Google Maps. Each stand was then called to verify its hours of operation. Sixteen of the 60 stands had closed and were subsequently excluded, leaving 44 stands for the sampling frames.

Roadside stands were sampled from individual market-based sampling frames as described for supermarkets, though the allowed distance between the farmers' market and roadside stand was increased in some instances to account for the rural location of many stands. When possible, the sampling frames consisted of stands located within a five-mile drive of farmers' markets. If only one stand existed within a five-mile drive of the corresponding farmers' market, it was sampled with certainty. If multiple stands existed within five miles, StataIC 10.0 was used to draw a random sample of up to three outlets. If no roadside stands could be found within five miles, a sample was drawn from those within ten miles. When several roadside stands were available within a given sampling frame, back-up outlets were sampled.

Final Sample

The final farmers' market sample consisted of 34 farmers' markets, 34 supermarkets and 23 roadside stands. Of the eleven farmers' markets with missing stands, seven had no roadside stand located within ten miles. The remaining four had just one nearby stand which had already been sampled for another market.

Produce Selection

Data collection for this research required an instrument design that would capture comparable data at food retail outlets that differed by size, display type, number of items available, and extent of information available to the enumerator. The selection of fruits and vegetables to price was guided by several goals. The first of these goals was to develop a list of items consistent with consumer fruit and vegetable intake. Selecting most-consumed fruits and vegetables enabled price comparisons for items that Americans frequently purchase. Once this list was created, operational definitions for each fruit or vegetable were determined. Fruit and vegetables are often sold in several variants (e.g. loose whole carrots, packaged whole carrots, and packaged baby carrots). The operational definitions stated the variant(s) of each fruit or vegetable eligible for inclusion in data collection. The goal in creating these definitions was to make them narrow enough that comparable items were being priced at each outlet, but not so specific as to result in repeated missing data at one outlet type or another. Guided by these goals, fruits and vegetables were selected using a multi-step procedure, described below.

Step 1: Identify items consumed and sort by form

First, NHANES dietary recall data (2005-2008) was used to rank the fruits and vegetables most consumed by Americans aged two years and older, overall and by form sub-group. Next, fruits and vegetables were manually categorized by form. Based on the short description of each food included in the dataset, items were categorized as fresh (raw or cooked from fresh), juice, canned or frozen (including those cooked from canned or from frozen), dried, or form not specified. In this process, the only foods considered were those for which the USDA Food Codes begin with 6 and 7 (i.e. those categorized by the USDA Food Surveys Research Group as fruits and vegetables). Fruit or vegetable mixtures, such as vegetable beef soup, were excluded if the primary ingredient put the item in a different USDA food category.

If the form was unclear, reference was made to the Food and Nutrient Database for Dietary Studies 3.0 "FNDDS-SRLinks" file that gives the recipes used by USDA to link foods to their nutrient composition. Often this added further detail about form of fruit or vegetable ingredient. For example, food 63101110, "Applesauce, stewed apples," was categorized as canned because it is described in FNDDS-SRLinks as, "*APPLSAUC,CND,SWTND,WO/SALT*". This can be compared to food 63101310, "Apple, baked, NS as to added sweetener", which was categorized as fresh because it is described in FNDDS-SRLinks as, "*APPLES,RAW,W/SKIN*". If the description included "form NS", and the item was not further described in the FNDDS-SRLinks Recipe file, then the item was categorized as form not specified.

Finally, the FNDDS-SRLinks recipe file was not always as helpful for vegetables as it was for fruit forms. When vegetable forms were not specified in either the short food description or the FNDDS-SRLinks file, the categorization guidelines listed in Table 3.4 were followed.

Table 3.4 Vegetable form categorization rules

Item	*Coded As*
White potato	
a. Baked potato or skins, form not specified	a. Fresh
b. Boiled with or without peel, form not specified	b. Fresh
c. Potato chips, all forms	c. Dried (None noted as made from fresh in FNDDS-SRLinks file)
d. Hashed browns, form not specified	d. Fresh, based on "homemade" designation in FNDDS-SR Recipe
Greens	
a. FNDDS-SRLinks description included "garden"	a. Fresh
b. Recipe description listed "boiled" with no other details	b. Form not specified
Winter Squashes: All types described as baked in skin	Fresh
Sweet potato:	
a. If described as baked	a. Fresh
b. Boiled with or without peel, form not specified	b. Fresh
Tomato products	
a. Catsup	a. Canned
b. Salsa: if labeled RTS (ready to serve) in FNDDS	b. Canned
c. If a *mixture* where tomatoes described as canned but the other item described only as "cooked" or "boiled"	c. Form not specified
d. If mixture in which tomato is described as "ripe" but no other description included	d. Fresh
e. Soup if form not further specified, or if labeled "condensed" in FNDDS-SRLinks	e. Canned
Bittermelon (bittergourds) – baked	Fresh
Cabbage, celery, fennel bulb, eggplant, kohlrabi, red and green peppers, rutabaga, salsify	
a. Recipe listed "boiled" with no other details	a. Form not specified

Step 2: Rank most-consumed items, overall and by form

Once the items were categorized, the weighted mean consumption of each was calculated, in grams. The weights used made the sample representative of the American population aged two years and older in 2005-2008. The percent contribution of each distinct item to overall fruit and overall vegetable intake and to intake in each form sub-group was calculated and ranked. In ranking the items, different forms of a fruit or vegetable were considered distinct (e.g. raw apples vs. apple juice), while different varieties of a form were not (e.g. unsweetened, sweetened, and cinnamon applesauce). The grams consumed of all varieties of a fruit or vegetable form were consolidated. The results of these procedures are shown below in Tables 3.5 and 3.6.

Considering consumption by grams consumed has implications for the rankings. Because juice has a higher water content than whole fruit, a serving of fruit in juice form weighs more than a serving in whole or cut form. For example, one cup of peeled apple slices weighs 110 grams, whereas a cup of apple juice weighs 248 grams. However, as can be seen in Table 3.5, the most-consumed juices (orange, apple, and grape) are made from three of the most-consumed fresh fruit items. Thus, using grams consumed did not bias the final list of popular items.

Table 3.5 Fruits most consumed by Americans and the contribution of each to overall and sub-group intakes, NHANES 2005-08

Item	% contribution to overall fruit intake		% contribution to form sub-groups‡		
	Item %	Cum. %	Fresh	Frozen/ Canned	Juice
Orange juice	39.7	39.7			61.7
Apple juice	10.4	50.1			16.1
Fruit juice blend	8.3	58.4			13.0
Apple, raw	7.5	65.9	23.9		
Banana, raw	6.6	72.8	21.3		.01
Orange, raw	3.3	75.8	10.5		
Grape juice	2.5	78.3			3.8
Watermelon, raw	2.5	80.8	7.8		
Grapes, raw	2.2	82.9	6.9		
Cantaloupe, raw	1.3	84.2	4.0		
Applesauce	1.2	85.3		28.6	
Pear, raw	1.1	86.5	3.6		
Strawberries, raw	1.1	87.6	3.6		
Peach, raw	1.1	88.7	3.5		
Peach, canned	.76	89.5		19.3	
Fruit cocktail, canned	.73	90.22		20.7	
Pineapple juice	.58	90.8			.90
Grapefruit juice	.56	91.4			.87
Fruit salad	.54	91.9	1.7		
Grapefruit, raw	.51	92.4	1.6		
Mango, raw	.48	92.9	1.5		
Mango nectar	.47	93.4			.72
Avocado, raw	.43	93.8	1.4		
Tangerine, raw	.38	94.2	1.2		
Fruit smoothie, made with fruit only	.37	94.5			
Pineapple, raw	.34	94.9	1.1		
Plum, raw	.32	95.2	1.0		
Guacamole	.29	95.5	.92		
Nectarine, raw	.26	95.7	.84		
Blueberries, raw	.24	96.0	.75		
Total	**96.0**	**96.0**	**96.9**	**68.6**	**97.1**

‡ Percentages under each form represent the sum contribution of all varieties of the row fruit in the given form (e.g. canned in juice, pineapple in syrup, etc.)

Table 3.6 Vegetables most consumed by U.S. adults and the contribution of each to overall and sub-group intakes, NHANES 2005-08

Item	% contribution to overall veg intake		% contribution to form sub-groups‡		
	Item %	Cum. %	Fresh	Frozen/ Canned	Juice
White potato, fresh	11.0	11.0	21.2		
White potato, froz/canned	8.0	19.0		28.7	
Tomato, fresh	7.0	26.0	14.1		
White potato, no form spec.	7.0	33.0			
Lettuce, raw	6.5	39.5	12.9		
White potato, chips	5.1	44.6			
Tomato, canned or frozen	3.7	48.3		13.4	
Salsa, no form specified	2.7	51.0		9.9	
Carrots, fresh	2.1	53.1	4.1		
Corn, canned or frozen	2.0	55.1		7.1	
Tomato juice	1.9	57.0			80.2
Beans, string, canned or froz	1.9	58.9		6.7	
Broccoli, raw	1.7	60.6	3.5		
Onions, fresh	1.6	62.2	3.2		
Corn, from fresh	1.5	63.7	3.1		
Cucumber, fresh	1.5	65.2	3.0		
Cabbage, fresh	1.5	66.7	3.0		
Vegetable beef soup	1.4	68.1			
Mixed salad greens, raw	1.2	69.3	2.4		
Cabbage, green, raw	1.1	70.4	.23		
Cucumber pickle, dill	1.0	71.4		3.6	
Salsa, fresh	1.0	72.4	2.0		
Vegetable soup, homemade	1.0	73.4			
Carrots, form not spec	.9	74.3			
Pea, canned or frozen	.9	75.2		3.1	
Broccoli, canned or frozen	.9	76.1		3.1	
Squash, summer, fresh	.8	76.9	1.6		
String bean, fresh	.8	77.7	1.6		
Vegetable soup, canned	.7	78.4		2.4	
Spinach, fresh	.6	79.0	1.2		
Total	**79.0**	**79.0**	**76.9**	**78.0**	**88.5**

‡ Percentages under each fruit form column represent the sum contribution of all varieties of the row fruit in the given form (e.g. pineapple in juice, pineapple in syrup, etc.)

Step 3: Consolidate list, focusing on North Carolina products

The next step involved consolidating these ranked lists into a shorter list of fruits and vegetables. Four goals guided construction of the final list: first, let the chosen items (all forms) represent at least 80% of total fruit and total vegetable consumption; second, create a list that included fruits and vegetables important in North Carolina direct retail markets; third, include products important to a form sub-group to enable comparisons of per-serving price in various forms; finally, keep the list as short as possible while meeting the other goals. Mixtures, such as "fruit juice blend" and "vegetable soup", were excluded.

These goals are addressed in the final item lists. For example, based on the data in Table 3.5 (excluding "Fruit juice blend"), only the items through raw peaches were needed to cover 80% of fruits consumed. However, blueberries were added to augment the number of fruits available from North Carolina direct retail. Similarly, oranges and pineapple were included in the final list, though neither is produced in North Carolina, due to their importance to non-fresh forms. Orange juice comprises nearly 62% of all fruit juice consumed, while canned pineapple makes up 8.0% of canned fruit consumption. The banana was dropped from the final list because it is neither produced in North Carolina nor widely consumed in forms other than fresh. The goals were similarly applied to consolidate the list of vegetables to be observed. Mixtures, such as salsa, were again excluded. No other exclusions were needed, as the most-consumed vegetables are all produced in North Carolina and sold via direct retail channels. The eighteen vegetables that comprised the final list make up 80.1% of total vegetable consumption in the U.S.. Appendix tables 1 and 2, in Chapter 5, give the consolidated final lists.

Step 4: Create operational guidelines for each item to be observed

The final list of items contained eleven fruits and eighteen vegetables. Among these items, four of the five vegetable sub-groups recommended by the 2010 Dietary Guidelines for Americans were represented (dark green, red and orange, starchy, and other) (U.S. Department of Agriculture and U.S. Department of Health and Human Services 2010). The farmers' market and roadside stand instrument included rows for the fresh form of each of these 29 items. The supermarket instrument contained rows for all 29 fresh items, for fruit and vegetable juices when available, and for the more-consumed of the either canned or frozen forms as indicated by NHANES (Appendix 1). Table 3.7 summarizes the forms of each fruit and vegetable for which data were collected as well as the vegetable sub-group represented.

For each fruit and vegetable, operational guidelines were created to enable data collection. Some fresh items are available for purchase with different amounts of processing and packaging. The field manual provided details on which varieties were eligible for data collection. In general, the least-processed form of an item was observed. For example, enumerators observed whole bunch or whole bagged carrots, but not baby carrots. They observed whole watermelon. Data were collected about halved or quartered melons only if whole melons were not available. See Appendix 2 for a full list of these guidelines.

Table 3.7 Fruits and vegetables observed, North Carolina, 2011

	Forms of item for which data were collected				
Item	Fresh	Canned	Frozen	Juice	DG2010 Vegetable Sub-group
Apple	X	X		X	N/A (Fruit)
Pear	X	X		X	N/A (Fruit)
Orange	X	X		X	N/A (Fruit)
Peach	X	X	X	X	N/A (Fruit)
Plum	X	X		X	N/A (Fruit)
Strawberry	X		X	X	N/A (Fruit)
Blueberry	X		X	X	N/A (Fruit)
Grape	X	X		X	N/A (Fruit)
Pineapple	X	X		X	N/A (Fruit)
Cantaloupe	X		X	X	N/A (Fruit)
Watermelon	X				N/A (Fruit)
White Potato	X		X		Starchy
Red Tomato	X	X		X	Red/Orange
Iceberg Lettuce	X				Other
Corn	X	X			Starchy
Green beans	X	X			Other
Carrots	X		X		Red/Orange
Green Cabbage	X				Other
Broccoli	X		X		Dark Green
Cucumber	X	X			Other
Onion	X		X		Other
Peas	X	X			Starchy
Mixed Salad Greens	X				Dark Green
Spinach	X	X			Dark Green
Summer Squash	X		X		Other
Sweet Potato	X	X			Red/Orange
Collard Greens	X	X			Dark Green
Asparagus	X	X			Other
Romaine Lettuce	X				Dark Green

Instrument Development

Once the fruits and vegetables were identified, the data collection tool was developed. First, additional measures to be observed were identified. Then, the initial draft of the data collection instrument underwent field testing and revision. These steps are described in detail below.

Definitions of Key Measures

For each fruit and vegetable identified above, enumerators collected data on several characteristics. Each of these characteristics required an operational definition, defined below. These definitions facilitated accuracy and consistency in the data collection work of four enumerators working in different regions of North Carolina.

Price

Price was defined as the dollar amount charged for an item, as posted or as reported by vendors. Enumerators circled “Lb” if this dollar amount was a price per pound or “Pc” if it represented the price per piece. For each fruit or vegetable item, enumerators recorded the lowest price at which the item was sold. The lowest-price variety of an item was defined as that with the lowest unit price. For fresh items, the lowest-price variety was that with the fewest dollars per pound. For canned, frozen and juice items, the lowest-price variety was that with the fewest dollars per ounce. A few fresh items, such as oranges, are sold both by the piece (e.g. $0.50 per orange) and in standard weight packages (e.g. $4.99 per 8-pound bag). In these cases, enumerators multiplied the posted *price per piece* by three and then divided this total by the weight of three randomly selected pieces. They then compared the two prices per pound. If two varieties tied for lowest price, both were recorded.

Organic

Recent research has suggested that discrepancies in price between fruits and vegetables sold at farmers’ markets as compared to supermarkets differ in direction and magnitude for organic versus conventionally grown produce (Claro 2011). To further explore the price impact of growing practices, the *Organic* measure was used to collect data on the production methods used to grow the observed items. In supermarkets, this information was observed on product labels or signs. At farmers' markets and roadside stands, the information was available on signs or by asking vendors how the products were grown. This variable had four possible responses:

- "Certified": Enumerators considered an item if a label, sign, or vendor statement indicated "USDA Organic" or "Certified Organic". This included processed items labeled with the phrase, "Made with Organic Ingredients."
- "Non-cert, org methods": An item was considered "Non-cert, org methods" if a producer stated that the item was grown organically, but did not have certification to prove that claim.
- "No": Enumerators selected "no" if they knew from a label stating "Conventional" or from a vendor statement that an item was not organic.
- "Not sure": Enumerators selected "Not sure" if they could not determine whether the item was organic or conventionally grown.

Local

The Local measure collected data on the location of production for each item. Despite the growing body of research on local food systems, no single agreed upon definition of the term "local" exists (Martinez et al. 2010). In the absence of a conventional definition, we defined *Local* as produce grown in North Carolina. Two processed items, sweet potatoes and pickles, were sometimes labeled as processed in North Carolina. Though the growing location of these two items was unknown, we also counted these items as local. This state-based definition is consistent with that used for promotion and data collection efforts of the aforementioned “10% Campaign” (Center for Environmental Farming Systems 2010). Enumerators relied on product labels, signs and conversations with vendors to make determinations. They were instructed *not* to assume that all farmers’ market and farm stand products were grown in North Carolina. Response options included:

- “Yes”: Enumerator knew from a label, a sign, or a vendor that the item was grown in NC.
- “No”: Enumerator was certain the item was grown and processed *outside* NC.
- “Not Sure”: The enumerator was unsure of production location.

Additional Variables

Finally, enumerators recorded data on several additional variables not used for the analyses presented in this dissertation. These variables are described in Appendix 1.

Field Test

The initial draft instrument underwent field testing at three supermarkets, three farmers’ markets and two roadside stands in October 2010. This testing period led to several revisions. First, the response option “Non-cert, organic” was added to the “Organic” measure to account for claims made by direct-retail vendors that crops were grown with organic practices, though they had not sought certification. Also, the column capturing basic nutritional characteristics of processed food items was added.

Enumerator Training and Management

Three enumerators were hired to collect data during the spring, summer and fall data collection periods. All three enumerators hold a bachelor's degree; two were studying for graduate degrees at the time of their participation. Each enumerator was responsible for between seven and nine sites near her home city. Based in Charlotte, Greensboro and Apex, the three together managed the sites in the Piedmont Region. The enumerators attended a detailed, two-day training to learn about the purpose of the research, the study protocol and the data collection instrument. This training included field practice at several outlets. Ongoing management of enumerator work took place primarily by telephone and e-mail. The training and ongoing feedback shared between the candidate and the enumerators ensured that data collection was carried out consistently across the study area.

Enumerator Training

The training began with an overview of the purpose and design of the research. This presentation was followed by a detailed training on the use of the data collection instrument. First, enumerators learned to introduce the project to outlet managers. They then learned the definitions of "lowest price." Enumerators practiced calculating unit prices by observing simulated store shelves. Finally, the team conducted a line-by-line review of the data collection instrument, discussing the definition of each measure, the types of each fruit and vegetable to include in observations, and procedures for breaking price ties.

The second day of training consisted of field practice at a farmers' market and supermarket. Enumerators completed an entire survey at each outlet. Following field practice, each was provided with written feedback on her conduct and on the completeness and quality of the recorded data. By the end of this field practice, each enumerator had participated in 14 hours of training.

The enumerators also completed refresher training in early July 2011, prior to beginning their second round of data collection. This two-hour Web conference consisted of a review of the study protocol, including a discussion of the information to be recorded in the case of a tie for lowest price, how to break ties, and the level of detail expected in note-taking. Errors made by the team during the spring data collection round were reviewed.

Supervision of Enumerators

Because enumerators were dispersed geographically, supervision occurred by telephone and e-mail. Enumerators sent an e-mail following the completion of the three outlets at each site to confirm that the data were successfully collected or to report any challenges encountered. They then returned photocopies of data collection instruments by mail within a few days of completing a site. Instruments were reviewed upon receipt and enumerators contacted to clarify data items or to complete missing items where possible. Verbal and written individual feedback was provided as needed. Responses to research-related questions were sent to the entire group to facilitate improvement and consistency.

Data Collection

Enumerators completed a total of 296 outlet visits during the four seasons of 2011. The procedures used to collect data are further described in this section. The instruments and protocol were reviewed by the Tufts University Institutional Review Board (IRB) at Medford, which determined the project exempt from review because we did not gather data on human subjects (IRB Study # 1012050).

Time periods: To enable the study of seasonal price patterns, each of the data collection outlets was visited four times during 2011. These data collection periods were kept as short as possible to reduce the potential for intra-season variation in prices. The dates of the data collection periods were as follows:

- *Winter:* January 18th - February 12th
- *Spring:* April 30th - May 28th
- *Summer:* July 16th - August 7th
- *Fall:* October 1st - October 23rd

When possible, data were collected on the same day from the three outlets that comprised a site to reflect the price environment facing a consumer shopping on the given market day. Some supermarkets were visited a day before or after the farmers' market. When this occurred, enumerators contacted the supermarket to ensure that the prices would be the same on the day of the visit as on the market day.

Interacting with Outlet Staff

Upon arriving, explained the purpose of the study to the manager and asked permission to repeat the data collection conducted the previous season. When permission was granted, the enumerator also gave the manager a letter summarizing the project and providing contact information for the candidate. If the manager declined to allow observations at the outlet, the enumerator continued to the first back up outlet on her list.

Contact with staff members other than the outlet manager varied by outlet type. Enumerators often had little or no contact with supermarket employees, unless they needed to ask a question about a missing price. The team interacted much more with vendors at farmers' markets and roadside stands, to inquire about an item's origin, the weight of items, or the vendor's growing practices.

Procedures

At supermarkets, enumerators collected data about the price of the variety with the lowest unit price. Sale prices available only with a coupon were not recorded. Discount prices available to all shoppers with a store loyalty card were recorded.

At farmers' markets with multiple produce vendors, enumerators randomly selected a vendor by numbering all fruit and vegetable vendors present and then using a random number table. They then collected data for as many items as were available from that vendor. If the first vendor sampled was missing some fruits or vegetables, the enumerator repeated the random selection procedure to choose a second vendor. This procedure was repeated until data were collected for as many items as possible.

For items sold in standard weight packages, such as supermarket strawberries and canned or frozen goods, enumerators recorded the weight of the package. For fresh items sold "loose", such as oranges or bunch spinach, which did not have a standard weight (random weight items) enumerators recorded the weight of three items. This enabled the use of an average weight during data analysis to account for the variation in size observed among fresh produce items. Watermelons were measured, not weighed, due to their large size. Enumerators used a flexible measuring tape to take the length from pole to pole and the circumference at the middle of three randomly selected watermelons. If only round watermelons were sold, they measured the circumference at the middle to the nearest 1/8th of an inch.

Data Management

Data were entered by hand into a StataIC 10.0 dataset upon the receipt of raw data from enumerators. Several steps were also taken to clean the data. Following each season, the data were re-entered into a new dataset. StataIC 10.0 then listed discrepancies between the databases. Along with double entry, frequencies were run to verify that data values fell within appropriate ranges for each variable. Discrepancies and outliers were checked against the paper instruments and errors corrected in the original dataset.

Analysis

Analyses were again conducted in StataIC 10.0 (StataCorp, College Station, TX). Analysis began with descriptive statistics that provide a picture of the sampled outlets and the cities in which they are located. In comparing prices, observed supermarket prices were multiplied by the two percent local food tax.

Fruit and vegetable prices are compared as dollars per cup equivalent. The weight of the observed item was converted to cup equivalents. Then, the mean price per cup equivalent for individual fruits and vegetables at supermarkets was compared to mean prices at farmers' markets and roadside stands using one-way analysis of variance models with the Bonferroni correction for multiple comparisons. Weighted and un-weighted means were also compared by outlets for a subset of most-consumed fruits and vegetables. To determine whether differences in mean prices were due to additional variables associated with outlet type, multivariate linear regression models were employed. Price per cup equivalent for several of the most-consumed fresh items was regressed on indicator variables for outlet type and for other observed characteristics (e.g. whether or not the item was organic or produced in North Carolina.

To examine the effect of seasonality, the comparisons of mean price by outlet type were repeated in each season. Additionally, the magnitude of price change observed from one season to the next, for each item, was estimated for each outlet type. A series of individual F-tests were then conducted to test the null hypotheses that the difference in season to season change at one outlet equaled the change at another outlet type.

A few final analyses were conducted to explore the impact of smaller methods decisions. The t-test was used to assess whether or not mean prices differed by the size of the farmers' market. The price per cup of produce items in different forms was also compared using Bonferroni-corrected ANOVA models. To evaluate the importance of weighing fruits and vegetables sold by the item, ANOVA models compared the weight, in pounds, of these items by outlet type. See Chapter 5 and Chapter 6 for further description of these analyses.

References

Center for Environmental Farming Systems. 2010. *The 10% Campaign: Building North Carolina's Local Food Economy*. North Carolina State University 2010 [cited June 15 2010]. Available from http://www.ncsu.edu/project/nc10percent/index.php.

Claro, Jake. 2011. Vermont farmers' markets and grocery stores: A price comparison. Richmond: Northeast Organic Farming Association of Vermont.

Lenth, R.V. 2010. *Java Applets for Power and Sample Size [Computer software]* 2006-9 [cited January 11 2010]. Available from http://www.cs.uiowa.edu/~rlenth/Power/.

Magnani, R. 1997. Sampling Guide. Washington DC: USAID Food and Nutrition Technical Assistance Project.

Martinez, Steve. 2007. The U.S. Food Marketing System: Recent Developments, 1997-2006. Washington D.C.: U.S. Department of Agriculture.

Martinez, Steve, Michael Hand, Michelle Da Pra, Susan Pollack, Katherine Ralston, Travis Smith, Stephen Vogel, Shellye Clark, Luanne Lohr, Sarah Low, and Constance Newman. 2010. Local Food Systems: Concepts, Impacts, and Issues. Washington, DC: U.S. Department of Agriculture.

North Carolina Department of Agriculture and Consumer Services. 2010. *NC Farm Fresh*. NCDACS 2010 [cited April 22 2010]. Available from http://www.ncfarmfresh.com/index.asp.

Ohls, James, Michael Ponza, Lorenzo Moreno, Amy Zambrowski, and Rhoda Cohen. 1999. Food Stamp Participants' Access to Food Retailers. Princeton: Mathematica Policy Research, Inc.

Pollack, Susan. 2001. Consumer Demand for Fruit and Vegetables: The U.S. Example. In *Changing Structure of Global Food Consumption and Trade*, edited by A. Regmi: U.S. Department of Agriculture, Economic Research Service.

Reed, Jane, Elizabeth Frazao, and Rachel Itskowitz. 2004. How much do Americans pay for fruits and vegetables? *Agriculture Information Bulletin*: U.S. Department of Agriculture, Economic Research Service.

Sommer, Robert, Margaret Wing, and Susan Aitkens. 1980. Price Savings to Consumers at Farmers' Markets. *The Journal of Consumer Affairs* 14 (2):452-462.

U.S. Census Bureau. 2010. *Vintage 2009: City and Town Tables*. U.S. Department of Commerce, June 27, 2012 2009 [cited September 1 2010]. Available from http://www.census.gov/popest/data/historical/2000s/vintage_2009/city.html.

U.S. Department of Agriculture, and U.S. Department of Health and Human Services. 2010. Dietary Guidelines for Americans, 2010. Washington, D.C.: U.S. Government Printing Office.

CHAPTER 4: FORM OF FRUITS AND VEGETABLES CONSUMED BY AMERICANS, ASSOCIATED WITH DEMOGRAPHIC CHARACTERISTICS, AFFECTS SODIUM AND ADDED SUGAR CONTENT

Natalie Valpiani

Corresponding Author:

Natalie A. Valpiani

Food Policy and Applied Nutrition Program

Gerald J. and Dorothy G. Friedman School of Nutrition Science and Policy

Tufts University

150 Harrison Avenue, Boston MA, 02111

Phone: 763-213-4604

E-mail: Natalie.valpiani@tufts.edu

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ABSTRACT

The popularity of farmers' markets has resulted in conflicting messages about the most healthful way to increase fruit and vegetable intake. Federal dietary guidance promotes all forms without distinction, whereas supporters for local food systems suggest that freshly harvested, whole produce is best. Studies have compared the antioxidant content of produce in different forms. However, the literature lacks data on the nutrient content and the breakdown of total intake, by form, of the fruits and vegetables actually consumed by Americans. This study uses National Health and Nutrition Examination Survey (NHANES) dietary recall data to estimate the contribution of fresh, processed, juice and miscellaneous forms of produce to total fruit and vegetable intake for the entire sample and for sub-groups defined by age, race/ethnicity, and household income. The study compares the mean sodium, added sugar, and fiber content of produce in each form. Fresh items made up the largest share of fruit and vegetable intake (61.2% and 48.1%, respectively), followed by fruit juice (31.2% of fruit) and processed vegetables (23.3% of vegetables). Older and higher income respondents consumed significantly more produce in fresh form and significantly less from fruit juice and processed vegetables. The sodium content was highest for miscellaneous vegetables (818.7 mg/cup), followed by processed and juice forms (437.6 mg and 457.3 mg/cup, respectively). Processed fruit had the most added sugar (4.9 tsp/cup). The results suggest that Americans should either be urged to consume an even greater portion of produce in fresh form or make better choices within processed forms so as to select items low in sodium and added sugars.

INTRODUCTION

Numerous studies have documented fruit and vegetable intake and its association with individual and environmental characteristics, but few have considered the form in which produce is consumed. This study utilizes National Health and Nutrition Examination Survey (NHANES) dietary recall data to estimate the contribution of fresh, processed, juice and miscellaneous forms to the total fruit and vegetable intake of Americans. It compares the amount of several nutrients – sodium, added sugar, and fiber – present in the produce items consumed, by form. This study informs a debate about the most healthful way to increase Americans' fruit and vegetable intake. The results below suggest that future guidance should either advise consumers to prioritize consumption of fresh produce or offer stronger advice on making healthful choices within the form groups.

Background

Seven of the ten leading causes of death in the United States are chronic diseases; poor nutrition is one behavioral cause of these diseases (1). A nationwide increase in fruit and vegetable intake could help reduce the burden of these diseases. Fruits and vegetables contain health promoting vitamins and minerals, phytochemical antioxidants, and fiber (2). Evidence demonstrates that increased fruit and vegetable consumption results in reduced risk of cardiovascular disease, including hypertension, coronary heart disease, and stroke (3-5). Produce intake has also been associated with reduced risk of some cancers (4, 6). Furthermore, limited evidence suggests that fruits and vegetables, low in energy-density yet satiety promoting, may help to promote weight stability, thus indirectly affecting the risk of weight-related chronic diseases (4, 7). Yet, less than one-third of U.S. adults consume at least two servings of fruit or three servings of vegetables each day (8).

Given the benefits of fruit and vegetable consumption and low current intakes, consumers are peppered with messages encouraging them to increase their intake. While these “eat more” messages garner support from producers, public health practitioners, and government, debate exists over what form this increase should take. Some eschew industrial processing, instead advocating for consumption of whole, fresh fruits and vegetables (9-10). Messages emanating from the burgeoning local food movement also favor fresh fruits and vegetables, arguing that locally-grown fresh produce is most nutritious because it is harvested when ripe, just prior to its sale (11-14). Proponents of local foods can support their position with research that demonstrates antioxidant losses in fresh fruits and vegetable as they move through the commercial retail chain (15-18).

Manufacturers of processed fruits and vegetables push back against the “fresh is best” message. Comments submitted during the development of the 2010 Dietary Guidelines for Americans portray their position (see comments submitted by the following groups: the Juice Products Association, 2009; National Council of Farmer Cooperatives 2010; Canned Food Alliance, 2010). The Canned Food Alliance states, “fresh does not always mean more nutritious,” citing several studies, including one that found recipes prepared with fresh or canned items to be nutritionally comparable. Furthermore, the American Fruit and Vegetable Processors and Growers Coalition argue that canned and frozen items often offer better value due to their lower cost per serving, longer shelf life, and easy portioning. Value and cost are important attributes for those looking to meet fruit and vegetable recommendations on a tight budget. Fresh produce, particularly farmers' market fresh, is sometimes perceived as being cost-prohibitive (19-23).

The 2010 Dietary Guidelines for Americans and the American Heart Association's 2006 Diet and Lifestyle Recommendations align with those who argue for inclusiveness (24-25). While the Dietary Guidelines specify that the majority of fruit intake should come from whole fruits, rather than fruit juice, they welcome fresh, canned, frozen and dried forms of fruits and vegetables as acceptable choices. Both recommendations advise consumers of canned items to choose low-sodium vegetables and fruits packed in 100% juice rather than syrup. They give no other indication as to which of the forms is most healthful.

Some food science studies comparing healthfulness of fruits and vegetables in different forms support this inclusiveness. Rickman et al review the retention of vitamins A, B, C and E, and selected minerals and phytochemicals across fruit and vegetable forms (17, 26). As fruits and vegetables travel from plant to plate, their nutrients are vulnerable to oxidation, leaching, and degradation due to light or heat exposure. For example, thermal processing results in the loss of 25 to 30% of heat-sensitive ascorbic acid (vitamin C) in tomatoes, peeling peaches leads to a loss of up to 48% of their phenolic compounds (17). Yet, in other cases, the bioavailability of antioxidants, such as lycopene, improves in processing (26). As noted, fresh fruits and vegetables stored for long periods are not immune to nutrient loss. The authors conclude that nutrient composition depends as much on cultivar and on harvest, processing and storage conditions as it does on processing form (17-18, 26).

Fresh, frozen and canned fruits and vegetables may be comparable in their micronutrient and antioxidant content, but the plethora of processed fruit and vegetable products available to consumers contain differing amounts of added sodium and sugars. These nutrients are consumed in excess by Americans, with deleterious consequences. A strong body of evidence finds an association between sodium intake and blood pressure (5, 27-29). A nascent body of evidence suggests that intake of added sugars might also raise blood pressure (30-32). Additionally, excessive sugar intake has been associated with dyslipidemia, excess intake of discretionary calories, weight gain, and reduced intake of important micronutrients (31, 33).

Processed fruits and vegetables that are as low in sodium and added sugar as their fresh counterparts may be readily available; they may also be rarely consumed. If that were the case, it would suggest the need for increased emphasis in nutrition guidance on making smart choices within a fruit or vegetable form. However, few studies have estimated the content of these nutrients in the processed fruits and vegetables actually chosen by consumers. Just two were identified that estimated processed produce as a percent of total intake.

Using United States Department of Agriculture (USDA) loss-adjusted availability data, Buzby et al report that Americans consume the majority of their fruit in fresh form (51%), followed by juice (37%) (34) . Fresh vegetables were also the most consumed form (49%); canned vegetables were a more substantial proportion of intake (24%) than were canned fruits (6%) (34). In an analysis of grams consumed, Demydas found that fruit juice was consumed in greater quantities (236.5 g) than fresh fruit (139.3 g); both exceeded consumption of canned fruits (56.9 g) (35). The study also reports vegetable intake, but the designated sub-categories are not fresh, canned, frozen and juice, but rather raw vegetables, cooked vegetables, mixed-dish vegetables, and fried vegetables.

Both studies explore the association of demographic characteristics with form of intake, but with limitations. Buzby et al make comparisons based on Bureau of Labor Statistics Consumer Expenditure data. Differences in consumption among race/ethnic, income and age-based groups were noted; for example, whites spent more on canned produce than any other race in 2008. However, quality differences among products limit use of expenditure data as a reliable indicator of intake (34). Demydas' comparisons are based on intake data, but the associations studied are across three produce intake patterns of varying healthfulness rather than across produce forms (35).

Knowledge of the association between intake by fruit and vegetable form demographic or socioeconomic characteristics would complement demonstrated associations between demographics and nutrient intake. Sodium intake has been associated with sex, age, race/ethnicity, and socioeconomic indices (36-38). Similarly, Thompson et al report that added sugar intake was higher among American males than females, and that it was inversely related to age, educational status, race/ethnicity and family income (39). Consumption of sugar-sweetened beverages, the primary source of added sugar in the American diet, has also been related to race, income and education among adults and children (40-41). Observed differences in nutrient intake may be due in small part to differences in the form of produce intake most consumed by various demographic groups; this is yet unexplored.

This research seeks answer three research questions. First, what are the mean amounts of sodium, added sugar, and fiber present per cup of the items actually chosen and consumed in each produce form by Americans? Second, what percent of total fruit and vegetable intake is attributable to fresh, processed and juice items? Third, is there an association between these percentages and individual socioeconomic and demographic characteristics? Dietary recall data from NHANES 2007-2010 were used to explore these questions.

MATERIALS AND METHODS

Study Sample and Survey Design

This study used data from the United States National Health and Nutrition Examination Survey (NHANES). The National Center for Health Statistics collects NHANES data continually, using a multistage probability sampling design, to assess the nutritional status and health of adults and children in the United States. The data are released in two-year cycles; each dataset includes sample weights that adjust for unequal probability of selection, non-response and post-stratification. Weighted estimates are representative of the non-institutionalized U.S. population.

The demographic and dietary data used for this study were collected through a series of interviews. Survey participants responded to demographic and socioeconomic questions during a home interview. Following the interview, participants provided details about the type and quantity of all foods consumed in a 24-hour period during two non-consecutive dietary recalls. The first of these recalls, “Day 1”, was administered in person by trained interviewers at the NHANES mobile examination center (MEC), using the U.S. Department of Agriculture’s (USDA) Automated Multiple-Pass Method. The second, or “Day 2” recall, was conducted by telephone. Because this study focused on estimating mean group intakes, only Day 1 dietary data were used.

Dataset Preparation

The analytic dataset was constructed by merging several NHANES datasets. Each respondent's demographic and socioeconomic data were linked to his Day-1 dietary recall data. Next, these data were merged with the NHANES food description file using the unique 8-digit food code that identifies each food. Finally, using the 8-digit food code, the NHANES data were merged with the USDA MyPyramid Equivalents Database 2.0 (MPED) *Equivalents* file (this database was renamed the Food Pattern Equivalents Database when MyPlate superceded MyPyramid; MPED 2.0 was the most current database at the time the research was conducted). This file presents the number of MyPyramid cup equivalents of 32 food groups and subgroups (e.g. dark green vegetables) per 100 grams of each food. To ensure a sample size sufficient for population sub-group estimates, merged datasets from the 2007-2008 and the 2009-2010 survey cycles were combined. The final sample consisted of all non-pregnant respondents over the age of 2 years with complete Day-1 dietary recall data.

Fruit and Vegetable Categorization

Examining fruit and vegetable intake by form required identifying the form of each item. This was completed using a multi-step process. The first step was to determine which fruits and vegetables to include for analysis. The NHANES dietary recall data provide information about fruits and vegetables consumed individually and those consumed as part of composite foods such as pizza or pie. Each food's unique food code can be used to link the item to a description and nutrient composition information. The USDA Food Surveys Research Group developed a scheme to organize the foods into nine major food groups. The first digit of the code identifies the group in which the food belongs (e.g. “1” for milk products, “6” for fruits, etc.). The detail in the combined NHANES-MPED database enables calculation of fruit and vegetable servings in composite foods whose primary ingredient classifies them in one of the non-fruit or vegetable food groups (e.g. beef stew). No conclusion about the processing form of these fruits or vegetables could be made. Thus, for this study, a food was included only if its code began with a “6” (fruit group) or “7” (vegetable group). This resulted in the exclusion of 9.7% of total fruit and 27.9% of vegetable servings that were incorporated into mixed dishes whose primary ingredient was not a fruit or vegetable.

The next step consisted of categorizing the remaining fruits and vegetables. Because the 8-digit USDA food codes do not indicate form, categorization relied on the text food descriptions. Foods were categorized into groups based on specific words noted in the food description. In addition to words about form such as “fresh” and “canned”, terms describing preparation method such as “boiled” were used for vegetables that lacked information about form (Table 1). Next, some of the preparation-based descriptors were assigned to a form category based on assumptions about the form most amenable to the method of preparation. For example, the food described as “white potato, baked, peel eaten” was assumed to have been baked from a fresh potato.

In the resulting categorization scheme, 3.2% of fruit and 25.6% of vegetable servings remained as either “form not specified” or “miscellaneous”. Miscellaneous fruits were a small percent of total fruit intake (2.9%); they were mostly guacamole, fruit smoothies and frozen juice bars. Vegetable miscellaneous items make up a larger percent of total intake (18.9%). Major contributors to this form include salsa, tomato catsup, white potatoes in a few unspecified forms (home fries, scalloped, boiled), and vegetable beef soup.

Statistical Analyses

All analyses were performed using StataIC 10.0 (StataCorp, College Station, TX). To account for the complex sampling design, the *svyset* command and four-year weights were used. Descriptive statistics were calculated to characterize the 2007-2010 NHANES sample. The mean age of respondents is reported, as are the percent of respondents in a variety of race/ethnicity, education, and family income to poverty ratio categories.

The first analysis sought to determine the mean sodium, added sugar, and fiber content per cup equivalent of the fresh, processed, juice, and miscellaneous fruits and vegetables chosen by Americans. Each estimate is a ratio of means; that is, one aggregate ratio exists for the population. The milligrams (mg) of sodium, teaspoons (tsp) of added sugar, and grams (g) of fiber from each fruit and vegetable form were summed for each respondent. The cup equivalents consumed from each form were also summed for each respondent. Then, the weighted totals were calculated for the entire sample and a ratio created from these totals. This analysis was then repeated for each MyPyramid fruit and vegetable sub-group. Wald's tests were used to compare ratios across forms and across fruit or vegetable sub-groups within each form ($p<0.05$).

The next analyses addressed the second major research question, regarding the percent of total fruit and vegetable intake attributable to fresh, processed, juice and miscellaneous items. Ratios were again calculated. To arrive at these ratios, variables were created, each equaling the sum of the fruit or vegetable cup equivalents consumed in a particular form by the respondent. Next, the weighted sum of cup equivalents, by form, was calculated across the sample. Finally, percents were derived by dividing these sums by weighted total fruit or total vegetable cups. Comparisons were adjusted by Wald's tests; differences were significant if $p<0.05$.

Also of interest was whether the nutrients per cup equivalent or the percent of fruits and vegetables consumed in a particular form varied with seasonal change. The NHANES data include a variable indicating the half-year in which the interview took place, November – April or May – October. Due to the design of data collection, the time at which data are collected is associated with the location of the respondent. Physical examinations are performed in mobile vans, thus data are collected in northern latitudes during warmer months and southern latitudes during colder months. This data collection practice biases seasonal comparisons if the combination of geography and season has a substantial impact on the fruits and vegetables available to consumers in each form. Because the grocery retail supply chain draws upon domestic and international producers with long growing seasons to make a variety of produce items available at supermarkets nationwide outside of their local harvest season, this potential for bias was not deemed significant enough to forgo examination of seasonality. The dataset was stratified by the half-year of interview variable, and the analysis repeated for each.

Finally, the association between demographic and socioeconomic characteristics and the percent of total fruit and vegetable intake in each form was explored. Comparisons of the proportion of total fruits and total vegetables consumed by form were repeated across age group, race/ethnicity, and family income to poverty ratio groups. Four age categories were created: children aged 6-11 years; teenagers aged 12-18 years; adults aged 19-59 years; and, older adults aged 60 years and older. Five race/ethnicity categories reported in the NHANES dataset were used for this analysis: Mexican American, other Hispanic, non-Hispanic White, non-Hispanic Black and other race.

Individuals with a low family income-to-poverty (PIR) ratio of less than 1.3 (the ratio at which families become eligible for the federal Supplemental Nutrition Assistance Program) were compared to individuals in middle-income households (1.3<PIR<3.5) and upper income households (PIR>3.5).

RESULTS

Sample Characteristics

The combined sample consisted of 19,008 respondents. The mean age of the sample was 38.3 years (Table 2). Just over half of the respondents were female (51.3%). The majority of the sample was non-Hispanic White (67.0 %); the next largest race/ethnic groups were non-Hispanic Black (12.0%) and Mexican American (9.6%). One-fifth of the sample had a household poverty-to-income ratio (PIR) of less than 1.3, while for nearly half the sample, the PIR exceeded 3.5. Compared to 2008 Census bureau data, women were overrepresented by one percentage point and non-Hispanic Whites by three percentage points, while non-Hispanic Blacks respondents were underrepresented by about two percentage points (42).

Nutrient Content by Form of Produce

Figure 1 highlights the main nutrient results. It presents the mean grams per cup equivalent of added sugar from fruits, the milligrams of sodium from vegetables, and grams of fiber from both fruits and vegetables, by form. More complete results for the nutrient analysis follow in Table 3.

The mean mg of sodium per cup equivalent in the items consumed by NHANES respondents varied significantly by form for both fruit and vegetables. Of the fruits, fresh items had the least sodium per cup equivalent (2.3 mg) while miscellaneous fruits had the most (60.8 mg) (Table 3). Among the vegetables, fresh items had the least sodium per cup (169.2 mg/cup), while miscellaneous items had the most (818.7 mg/cup; differences significant $p<0.05$; Figure 1 and Table 3). The processed and juice forms fell between these extremes, with no significant difference between these two forms. Items in the processed tomato sub-group have more sodium per cup than the other processed MyPyramid sub-groups.

Teaspoons of added sugar were greater in processed and juice forms of fruits chosen by NHANES respondents than in the vegetables of the same form (Table 3). The mean teaspoons of added sugar per cup equivalent of fruit varied significantly among fruit forms (Figure 1 and Table 3). A cup equivalent of processed fruit had three and a half times the amount of added sugar, on average, than miscellaneous fruit items (4.9 tsp vs. 1.4 tsp). The fresh and juice fruits chosen by respondents contained very little added sugar, on average (< 0.05 tsp). Items with the most added sugar were from the citrus, melon and berries sub-group (processed and juice forms).

Finally, the mean fiber content, in grams per cup equivalent, of the fruit and vegetable items consumed also varied significantly across produce form, but the magnitude of the differences was less remarkable than for sodium or added sugars (Figure 1 and Table 3). As expected, fiber content was lowest in fruit juice (0.6 g/cup equivalent). Fiber content was highest in miscellaneous fruit items (4.3 g/cup) and, somewhat surprisingly, higher in processed than fresh fruits by about a half-gram per cup equivalent. Similarly, the mean grams of fiber per cup was highest for processed vegetable items (3.9 g/cup equivalent), and lowest for juice (1.6 g/cup equivalent).

Percent of Intake by Form of Produce

Table 4 highlights the amounts of fruit and vegetables consumed by individuals. The percent of total cup equivalents contributed by fresh, processed, juice and miscellaneous items differed significantly across both fruits and vegetables. Fresh items amounted to 61.2% of total fruit cup equivalents. Fruit juice followed, making up nearly one-third of total fruit cups consumed. Processed fruits accounted for only 4.6% of fruit cup equivalents consumed. The percent contributions differed significantly ($p<0.05$).

The most consumed vegetable form was also fresh (48.1% of cup equivalents) (Table 4). Vegetable juice, however, made up a small fraction of vegetable intake (2.0%), while processed vegetables were more important (23.3%). Vegetable items categorized as miscellaneous remained important contributors, making up nearly one-fifth of total intake. These proportions differed significantly ($p<0.05$). The potato sub-group was an important contributor to each form and was by far the largest contributor to processed vegetable cup equivalents.

Form of Intake and Demographic/Socioeconomic Characteristics

The results in Tables 5a and 5b (key results highlighted in Appendix Figure 1) demonstrate an association between socioeconomic and demographic characteristics and form of consumption (the significance of individual paired comparisons are noted in Appendix Table 1 and Appendix Table 2). The percent of fruit intake from fresh fruits rose significantly with age (Table 5a). The inverse was true of fruit juice intake. Similarly, the percent of total fruit cups from fresh items increased with household PIR, while respondents from higher income households consumed significantly less juice than middle and lower income respondents (26.6% versus 32.1% and 40.6% respectively).

Interestingly, the percent intake from processed fruits varied less. Income had no effect on percent of intake from processed fruits; significant differences across race/ethnicity or age groups were observed, but were of smaller magnitude for processed than for fresh or juice forms (Table 5a).

Vegetable intake also varied by socioeconomic and demographic characteristics. As with fruit, the percent of vegetable cups consumed in fresh form increased as age increased, while the percentage of processed vegetables was inversely related to age (Table 5b). Non-Hispanic Whites consumed the largest percent of vegetables from fresh (50.4%), followed by Mexican Americans and Other Hispanic respondents, then non-Hispanic Blacks and respondents of other race groups. By contrast, the consumers of the largest percent of processed vegetables were non-Hispanic Blacks (36.8%). The percent of total vegetables from processed items varied significantly across race/ethnicity categories. Finally, fresh vegetable consumption increased markedly with PIR, while processed vegetable consumption decreased significantly.

Seasonality Effects

Seasonal differences in the proportion of total fruits or vegetables consumed in each form were most evident for fresh items (Table 4; significance of differences by season not shown). Considering total fruit and total vegetables, the percent from fresh was higher among May-October respondents than November-April respondents, but neither difference (fruit or vegetables) was significant. By contrast, the percent of the citrus, melon and berry fruit subgroup was significantly greater among respondents interviewed in May-October (18.6%) as compared to those interviewed between November and April (12.6%). The percent of dark green vegetables in fresh form was greater in the winter. No seasonal change was noted for processed fruits and vegetables; only one difference was seen among juices.

Seasonality in consumption broken out by respondent characteristics displays a similar pattern, with significant differences between winter and summer occurring in fresh form. The proportion of both fruit and vegetable intake from fresh was greater among summer respondents of all ages, but the difference was only significant for those aged 19-59 years (results not shown). A seasonal effect on fresh produce consumption was significant among high income individuals but not low income individuals. In regards to nutrient content, the sodium, fiber and added sugars per serving of fruit or vegetable varied little between the two halves of the year (results not shown).

DISCUSSION

This study set out to compare the nutritional merit of the fruit and vegetables currently consumed by Americans across processing form, based on the items' sodium, added sugar, and fiber content. The results suggest that the fresh fruit and vegetable items currently consumed by Americans, lower in sodium and added sugars than those of other processing forms, are most healthful. Though fresh items did not have the most fiber per cup, the amount by which the forms differed was smaller than for sodium and added sugar. Furthermore, fresh items offered four times more fiber, on average, than juice items. Though juices were found to be low in added sugars (Table 3), have been associated with improved dietary nutrient adequacy, and can be incorporated into a healthy diet, they also offer more calories per serving than fresh items (45). Furthermore, though the association between fruit juice consumption and diabetes incidence is not yet conclusive, Bazzano et al found the effect to be similar to that of sweetened and unsweetened soda (46-47).

Assuming Americans' within form choices remain fairly static, these nutrient results indicate that the healthfulness of their diets would be well served by a shift in fruit and vegetable intake toward a greater percentage from fresh. The following example illustrates this point. Consider a hypothetical moderately-active 55-year old female. According to the 2010 Dietary Guidelines, this woman should consume a minimum of 22 g of fiber and a maximum of 1,500 mg of sodium each day while staying within a 1,800 kcal/day energy limit (24). While the Dietary Guidelines do not make specific recommendations about added sugars, the American Heart Association recommends added sugar limits for optimal weight control and cardiovascular health, to the tune of 5 tsp/day for our hypothetical woman (31). While meeting these nutrient goals, this woman should consume 1.5 cup equivalents of fruit and 2.5 cup equivalents of vegetables each day (24).

If this woman were to meet the fruit and vegetable recommendations eating only fresh items chosen from the basket currently consumed by Americans, she would consume, on average, about 426 mg of sodium, less than one-tenth of a tsp of added sugar, and nearly 11 g of fiber. If she were to replace all fresh items with the processed items consumed by Americans, the nutrient values change to 1108 mg of sodium, 7.9 tsp of added sugar, and 15 g of fiber. Using exclusively juice items to meet recommendations offers 1156 mg of sodium, 0.05 tsp of added sugar, and just 4.5 g of fiber.

On average, individuals consume a mix of products, so the contribution of fruits and vegetables to sodium and added sugar intake is unlikely to be as low as the all-fresh case or as high as the all-processed case. Nonetheless, this example demonstrates that while nutritionally similar fruits and vegetables may be available in both fresh and processed forms, the items currently chosen by Americans do not have equivalent dietary implications. Though previous studies found that canned fruits and fruit juices contribute just 1.3% of total added sugars and canned vegetables account for less than one percent of sodium intake, shifts in produce intake toward fresh items could still play a role in reducing Americans' excess intake of sodium (50% more than the tolerable upper level intake) and of added sugars (16% of daily calories) (43)(44).

The results of the second major analysis described above, the contribution of each form to total fruit and vegetable intake, demonstrate that promoting such a shift toward increased fresh intake may indeed be feasible. For both fruits and vegetables, fresh items contribute the greatest percent to total cup equivalents consumed. Nearly two-thirds of fruit and half of vegetable servings are consumed as fresh, suggesting an existing preference for the processing form.

While fresh items make up a substantial proportion of total intake for all individuals, the results presented in Table 5a and Table 5b suggest that some people consume more processed items than others, on average. Across the entire sample, the percentage of total fruit intake from fresh items is nearly twice that of juice items. However, individuals living in households with income below 1.3 times the poverty level consume fewer fresh and more juice servings; the difference between the two forms falls from 30 percentage points to 12 percentage points. Non-Hispanic Black individuals, on average, consume slightly more juice cup equivalents than fresh cup equivalents. Individuals in the low-income, non-Hispanic Black, and Other Hispanic groups also consume a greater percentage of vegetables in processed form than other groups. The difference between fresh intake and processed is just nine percentage points for low-income individuals. The contribution of fresh and processed vegetables is nearly equal in the diet of the average non-Hispanic Black respondent.

Sub-group differences in intake by processing form demonstrate that fruit and vegetable promotion designed to reach all Americans should not emphasize the healthfulness of fresh items to the exclusion of processed forms. Two strategies might be employed to make sure that such promotion prioritizes health while meeting the needs of all groups. One option is to emphasize the healthfulness of fresh items, while identifying and addressing barriers to increased fresh intake among groups with current low fresh intakes. One of these barriers may be higher prices for fresh items. Research by Stewart et al. (2011) suggests that some fruit and vegetables are most expensive per serving in fresh form, while others cost more in canned, frozen or dried form. Nonetheless, policy efforts to reduce the objective or perceived prices of fresh fruit and vegetables could facilitate a shift toward these items.

A second option is to focus on promoting healthful choices within each processing form, rather than emphasizing one form over another. As discussed above, current U.S. dietary guidance urges consumers to increase their fruit and vegetable intake using all forms of produce. Encouragement to choose canned items low in sodium or added sugars is buried in the details of the current Dietary Guidelines policy document, but not mentioned in the key consumer recommendations. Given the items that Americans currently consume, future guidance should place greater emphasis on making healthful choices within each fruit and vegetable form group, and in particular among processed and miscellaneous items.

The associations between form of fruit and vegetable intake and demographic and socioeconomic characteristics presented in Tables 5a and 5b, can help target such messages. For example, consumption of processed vegetables was greatest among 12-18 year olds (30.6%), Non-Hispanic Blacks (36.8%) and low-income families (30.5%) (Table 5b). Promotion of low-sodium processed and miscellaneous products, while important for the population as a whole, might have the greatest impact among people who consume the greatest amount of these products. Reductions in sodium intake are particularly relevant to non-Hispanic Black individuals, for whom the recommended Adequate Intake level is 1,500 mg rather than 2,300 mg/day, due to a greater risk of hypertension and increased responsiveness of blood pressure to dietary sodium (24).

Each of the reported analyses was repeated and compared across the two broad seasonal strata. Previous research has shown that the fruits and vegetable types and quantities consumed can vary with season; thus it was thought plausible that the percent of total intake due to each form might similarly vary across the year (48-50). Yet, season had little effect on the results of this study. Mean nutrient levels were similar in the foods chosen by both winter and summer respondents. And, while fruit and vegetable intake from fresh produce was slightly higher in the summer, the variation was by fewer than ten percentage points. Patterns of intake by form are similar across seasons, thus messages about choosing processed products low in sodium and added sugars prove relevant year-round.

This study raises several questions for future research. First, do the mean sodium, added sugar, and fiber content per form vary by individual characteristics of the respondent? Just as an association was seen between socioeconomic and demographic variables and the percent of produce items consumed in each form (Tables 5a and 5b), it is possible that some population groups make more healthful choices within the processed and miscellaneous form categories than others. Interactions might also be identified that explain the percent of total intake due to each form. For example, the high percentage of fruit intake from juice for the Other Hispanic or Non-Hispanic Black groups may be skewed by the heavy consumption by individuals of a particular age or income group within the race/ethnicity group. Such work would enable even more precise targeting of nutrition programming.

Second, future research should ask whether there is a link between the form of fruit or vegetable consumed and diet-related health outcomes. Existing research in this vein is limited. Two cohort studies conducted in the Netherlands used data from semi-quantitative food frequency questionnaires to assess the association between grams of raw, cooked, juice or sauce forms of produce and both ten-year stroke and coronary heart disease (CHD) incidence (51-52). Controlling for a variety of covariates, raw vegetable consumption was inversely related to total stroke incidences, while consumption of processed vegetables was not. The inverse association between produce consumption and CHD incidence was of borderline significance for both raw and processed fruits and vegetables. No similar studies were identified using a U.S. sample, though several have focused on the health consequences of juice consumption (47). These studies suggest the relevance of future inquiry into the relationship between form of produce intake and health outcomes.

Third, the strong associations found between demographic characteristics and percent of intake by form suggest the need for additional research to identify the factors that drive those differences. Are they related to culinary skills or cultural heritage? Or, are there environmental factors that strongly influence the forms purchased, such as the availability and price of different forms of fruit and vegetables? For example, individuals with limited access to food retail outlets or private transportation may make fewer shopping trips, and thus rely more heavily on processed, shelf-stable fruits and vegetables (53). In cases where the environment shapes intake more than preferences, efforts to increase access to affordable fruits and vegetables through outlets such as supermarkets, farmers' markets, corners stores, or mobile markets could enhance consumers' ability to make healthful choices both within and among produce forms.

This research is subject to several limitations. First, assumptions were made in the categorization of vegetable items whose descriptions did not include detail about the form of processing which could have led to misclassification (see Table 1). It is possible, for example, that roasted vegetables were roasted from frozen rather than fresh items or that fruit items described as "stewed" were stewed from fresh fruits rather than canned. The contributions to total intake from the categories for which these assumptions were made, however, were quite small. A second limitation is the large proportion of total vegetable intake (25%) categorized in the *form not specified* and *miscellaneous* categories. Proper categorization of these items into fresh, processed or juice forms may have affected the percent contribution of each of these forms to total intake, overall or by the population subgroups investigated. Also, it should be noted that the nutrient content results, particularly for sodium per cup, would likely have been different had processed vegetables been disaggregated into canned and frozen forms.

In conclusion, this study makes novel comparisons of Americans' fruit and vegetable intake across fresh, processed, juice and miscellaneous produce forms. The percent of total intake due to each form varied significantly across the nationally-representative NHANES sample for both fruits and vegetables. Estimates of the sodium, added sugar and fiber content per cup equivalent of items consumed by Americans within each form were also presented. The significantly greater levels of sodium and added sugars in processed and miscellaneous forms as compared to fresh and juice forms suggests the need for either increased consumption of fresh produce or stronger guidance and education on the most healthful choices within each produce form.

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Table 1 Composition of U.S. fruit and vegetable intake, by processing form, NHANES 2007-2010

NHANES Description	Percent of total cup equivalents (SE)	Form for analysis	Percent of total cup equivalents (SE)	Examples of most-consumed foods
Fruit				
Fresh	61.2 (.9)	Fresh	61.2 (.9)	Banana, raw
Canned	2.4 (.2)			Applesauce, not specified as to sweet or unsweetened; Peach, cooked or canned
Frozen	.6 (.1)			
Canned or frozen				
Dried	.8 (.1)	Processed	4.6 (.3)	
Stewed	1.1 (.2)			
Cooked or canned	2.2 (.2)			
Juice	31.2 (.8)	Juice	31.2 (.8)	Orange juice
Form not specified	.05 (.02)	Form not spec.	.01 (<.01)	Cranberry, form NS
Fruit bar	.4 (.1)			Guacamole; Fruit smoothie
Smoothie	.6 (.2)	Miscellaneous	2.9 (.2)	
Miscellaneous	2.0 (.1)			
Total:	**102.6** [1]		**100.0**	
Vegetables				
Fresh	39.9 (.9)			Lettuce, raw; Tomatoes, raw
Salad	6.2 (.3)	Fresh	48.1 (.9)	
Baked	3.8 (.2)			
Roasted	.7 (.2)			
Canned	3.8 (.3)			White potatoes, French fries, from frozen; White potato chips
Frozen	8.1 (.3)			
Dried	1.2 (.1)	Processed	23.3 (.6)	
Chips	8.3 (.3)			
Tomato sauces	1.9 (.2)			
Juice	2.0 (.2)	Juice	2.0 (.2)	Tomato and vegetable juice
Form not specified	7.7 (.3)	Form not spec.	7.6 (.3)	White potato, mashed, form NS
Boiled	1.2 (.2)			Salsa, red; Tomato catsup; White potato, home fries; Vegetable beef soup, home recipe
Homemade	.2 (.03)			
Not homemade	2.4 (.2)	Miscellaneous	18.9 (.8)	
Pickle	1.4 (.1)			
Miscellaneous	13.7 (.8)			
Total:	**102.6** [1]		**100.0**	

1 Totals exceed 100% because some fruits and vegetables were included in several categories based on their description. For example, "Mandarin oranges, canned or frozen", was categorized in both canned and frozen fruits. Double counting disappeared in aggregation.

Table 2 Characteristics of NHANES respondents,[1] 2007-10

Characteristic	Estimate (SE)
Age (yr), *mean*	38.3 (0.4)
Gender, *percent*	
Female	51.3 (.005)
Male	48.7 (.005)
Race/Ethnicity, *percent*	
Mexican American	9.6 (.01)
Other Hispanic	5.5 (.01)
Non-Hispanic White	67.0 (.02)
Non-Hispanic Black	12.0 (.01)
Other race	5.9 (.01)
Education, *percent*	
High school or less	32.9 (.01)
Some college or AA degree	22.9 (.01)
College grad or above	19.7 (.01)
Missing	24.4 (.01)
Ratio family income to poverty, *percent*	
PIR < 1.3	22.7 (.01)
PIR ≥ 1.3 & PIR <3.5	32.2 (.01)
PIR ≥ 3.5	45.1 (.02)
Cup equivalents/day[2], *mean*	
Fruit	.97 (.03)
Vegetable	1.02 (.02)
N	19,008

1 Non-pregnant participants over 2 yrs of age
2 Of fruit and vegetables included in this study (See Table 1)

Table 3 Mean quantity of sodium, added sugars and fiber per cup equivalent of fruits and vegetables consumed by NHANES respondents, by form and MyPyramid sub-group [1]

	Sodium (mg)				Added Sugars (teaspoons)				Fiber (g)			
	Fresh	Proc.	Juice	Misc.	Fresh	Proc.	Juice	Misc.	Fresh	Proc.	Juice	Misc
Fruit												
Citrus, melon, berries	4.6 ^{a} (.3)	9.5 ^{b} (1.1)	5.6 ^{c} (.1)	69.9 ^{d} (23.7)	<.01 ^{a} (<.01)	17.2 ^{b} (1.4)	<.01 ^{a} (<.01)	19.3 ^{b} (6.9)	2.5 ^{a} (.1)	3.5 ^{b} (.3)	.7 ^{c} (< .01)	7.0 ^{d} (1.1)
Other fruit	1.5 ^{a} (.04)	8.9 ^{b} (.3)	13.5 ^{c} (.3)	67.9 ^{d} (9.0)	-	2.2 ^{a} (.1)	.1 ^{b} (.02)	1.3 ^{c} (.2)	3.0 ^{a} (.03)	3.5 ^{b} (.1)	.6 ^{c} (.01)	4.7 ^{d} (.2)
Total	2.3 ^{a} (.1)	9.0 ^{b} (.3)	8.1 ^{c} (.1)	60.8 ^{d} (8.5)	< .01 ^{a} (< .01)	4.9 ^{b} (.4)	.03 ^{c} (.01)	1.4 ^{d} (.2)	2.9 ^{a} (.04)	3.5 ^{b} (.1)	.6 ^{c} (< .01)	4.3 ^{d} (.3)
Vegetables												
Potato	501.3 ^{a} (17.1)	375.1 ^{b} (4.4)	-	547.3 ^{a} (24.4)	.04 ^{a} (<.01)	<.01 ^{b} (<.01)	-	< .01 ^{c} (< .01)	3.1 ^{a} (.03)	3.4 ^{b} (.04)	-	3.2 $^{a b}$ (.1)
Other Starchy	319.8 ^{a} (17.1)	424.6 ^{b} (16.1)	-	623.0 ^{c} (75.5)	<.01 ^{a} (<.01)	.02 ^{b} (.01)	-	.7 $^{a b}$ (.4)	4.5 ^{a} (.2)	6.1 ^{b} (.3)	-	4.6 ^{a} (.4)
Orange	189.5 ^{a} (9.4)	353.0 ^{b} (42.4)	121.3 ^{c} (12.2)	47.9 ^{d} (21.0)	.02 ^{a} (.01)	.5 ^{b} (.2)	-	1.5 ^{c} (.3)	4.1 ^{a} (.1)	6.4 ^{b} (.6)	-	6.1 ^{b} (.2)
Tomato	13.8 ^{a} (1.8)	1661.5 ^{b} (154.0)	583.0 ^{c} (11.3)	1645.3 ^{b} (26.6)	< .01 ^{a} (< .01)	4.2 ^{b} (.5)	-	20.2 ^{c} (1.2)	2.1 ^{a} (>.01)	5.0 ^{b} (.4)	1.7 ^{c} (.1)	2.2 ^{a} (.1)
Dark green	145.0 ^{a} (7.9)	472.9 ^{b} (29.5)	-	1740.2 ^{c} (124.6)	<.01 ^{a} (<.01)	-	-	.5 ^{a} (.3)	3.2 ^{a} (.1)	5.5 ^{b} (.1)	-	5.1 ^{b} (.3)
Other vegetable	100.2 ^{a} (5.7)	420.3 ^{b} (25.9)	115.4 ^{a} (25.3)	782.5 ^{d} (45.5)	.1 ^{a} (.01)	.03 ^{b} (.01)	-	.9 ^{d} (.1)	2.0 ^{a} (.04)	3.9 ^{b} (.1)	1.4 ^{a} (.6)	2.9 ^{c} (.1)
Total	169.2 ^{a} (5.8)	437.6 ^{b} (9.5)	457.3 ^{b} (21.8)	818.7 ^{c} (21.5)	.03 ^{a} (<.01)	.2 ^{b} (.02)	-	4.3 ^{c} (.3)	2.5 ^{a} (.02)	3.9 ^{b} (.04)	1.6 ^{c} (.1)	2.8 ^{d} (.04)

1 Superscript letters indicate significant differences in the mean quantity of the given nutrient between the fresh, processed, juice and miscellaneous forms, within a given fruit or vegetable sub-group.

Table 4 Percent of total fruit and vegetable cup equivalents in each processing form and MyPyramid sub-group, by season, NHANES 2007-2010[1]

	Full Year					May-October				November-April			
	Fresh	Proc.	Juice	Misc.	Row Totals	Fresh	Proc.	Juice	Misc.	Fresh	Proc.	Juice	Misc
Fruit													
Citrus,	16.2 [a]	.9 [b]	19.6 [c]	.3 [d]	**37.0**	18.6 [a]	.8 [b]	18.3 [a]	.3 [c]	12.6 [a]	.9 [b]	21.6 [c]	.4 [d]
melon, berry	(1.0)	(.1)	(.6)	(.05)		(1.5)	(.1)	(.7)	(.1)	(1.0)	(.2)	(1.0)	(.1)
Other fruit	45.0 [a]	3.7 [b]	11.6 [c]	2.6 [d]	**62.9**	44.4 [a]	3.8 [b]	11.3 [c]	2.8 [d]	46.0 [a]	3.7 [b]	12.1 [c]	2.8 [b]
	(.8)	(.3)	(.4)	(.2)		(1.2)	(.3)	(.5)	(.3)	(1.1)	(.5)	(.6)	(.3)
All Fruit	**61.2 [a]**	**4.6 [b]**	**31.2 [c]**	**2.9 [d]**	**99.9**	**63.0 [a]**	**4.6 [b]**	**29.7 [c]**	**2.8 [d]**	**58.5 [a]**	**5.0 [b]**	**33.7 [c]**	**3.2 [d]**
	(.9)	(.3)	(.8)	(.2)		(1.2)	(.3)	(1.0)	(.3)	(1.2)	(.5)	(1.2)	(.4)
Vegetable													
Potato	7.7 [a]	14.7 [b]	-	6.5 [a]	**28.9**	7.8 [a]	14.8 [b]	-	6.2 [c]	7.6 [a]	14.5 [b]	-	7.0 [a]
	(.9)	(.4)		(.5)		(.6)	(.7)		(.5)	(.5)	(.8)		(.9)
Other	1.5 [a]	2.6 [b]	-	.5 [c]	**4.8**	2.4 [a]	2.5 [a]	-	.4 [b]	.5 [a]	2.9 [b]	-	.1 [a]
Starchy	(.3)	(.2)		(.1)		(.4)	(.3)		(.1)	(.1)	(.3)		(.1)
Orange	3.0 [a]	.5 [b]	.2 [c]	.7 [b]	**4.4**	3.1 [a]	.4 [b]	.2 [c]	.6 [b]	2.7 [a]	.7 [b]	.4 [b]	.9 [b]
	(.2)	(.1)	(.1)	(.1)		(.2)	(.1)	(.04)	(.1)	(.2)	(.1)	(.2)	(.1)
Tomato	6.8 [a]	1.1 [b]	1.5 [b]	4.2 [c]	**13.6**	7.5 [a]	1.1 [b]	1.7 [b]	3.7 [c]	5.6 [a]	1.0 [b]	1.3 [b]	5.1 [a]
	(.4)	(.1)	(.2)	(.2)		(.6)	(.2)	(.2)	(.3)	(.3)	(.1)	(.2)	(.3)
Dark green	7.0 [a]	1.1 [b]	.01 [c]	.3 [d]	**8.4**	6.2 [a]	1.0 [b]	.1 [c]	.3 [d]	8.4 [a]	1.2 [b]	.1 [c]	.2 [d]
	(.4)	(.1)	(.01)	(.04)		(.5)	(.1)	(.02)	(.1)	(.4)	(.1)	(.03)	(.1)
Other	21.8 [a]	3.3 [b]	.2 [c]	6.7 [d]	**32.0**	23.4 [a]	3.0 [b]	.2 [c]	6.2 [d]	19.2 [a]	3.9 [b]	.2 [c]	7.8 [d]
vegetable	(.7)	(.1)	(.04)	(.5)		(.9)	(.2)	(.05)	(.6)	(.8)	(.4)	(.1)	(.9)
All	**48.1 [a]**	**23.3 [b]**	**2.0 [c]**	**18.9 [d]**	**92.3** [2]	**50.4 [a]**	**22.8 [b]**	**2.1 [c]**	**17.4 [d]**	**44.0 [a]**	**24.2 [b]**	**1.9 [c]**	**21.6 [b]**
Vegetables	(.9)	(.6)	(.2)	(.8)		(1.3)	(.9)	(.3)	(.9)	(1.2)	(1.2)	(.3)	(1.3)

[1] Superscript letters indicate significant differences in the percent of total equivalents, within a given fruit or vegetable sub-group and season, ($p<0.05$).

[2] Does not sum to 100.0% due to vegetables in the form not specified group, not shown.

Table 5a. Percent of total fruit equivalents in each processing form, by socioeconomic/demographic characteristics

	Full Year				
	Percent (SE)				
	Fresh	Proc.	Juice	Misc.	**Row Totals**
Age					
6-11	57.9 (1.8)	5.8 (.5)	34.1 (.2)	2.2 (.5)	**100.0**
12-18	58.1 (2.6)	3.1 (.5)	37.1 (.3)	1.7 (.4)	**100.0**
19-59	60.9 (1.3)	3.8 (.4)	31.7 (1.0)	3.5 (.3)	**99.9**
60+	67.7 (1.2)	5.9 (.5)	23.8 (1.2)	2.6 (.3)	**100.0**
P-value for F-test of difference by age category	<.01	<.01	<.01	<.01	
Race/Ethnicity					
Mexican American	60.6 (1.7)	2.2 (.2)	34.1 (1.7)	3.1 (.6)	**100.0**
Other Hispanic	50.5 (3.0)	3.4 (.5)	43.2 (3.3)	2.9 (.7)	**100.0**
Non-Hispanic White	64.7 (1.2)	5.3 (.4)	26.8 (.9)	3.2 (.3)	**100.0**
Non-Hispanic Black	44.6 (1.7)	4.9 (.6)	48.5 (1.7)	2.0 (.3)	**100.0**
Other race	68.6 (2.2)	2.3 (.4)	26.8 (2.2)	2.3 (.8)	**100.0**
P-value for F-test of difference by race category	<.01	<.01	<.01	.14	
Family Income to Poverty Ratio					
PIR < 1.3	52.7 (1.3)	4.3 (.5)	40.6 (1.2)	2.3 (.3)	**99.9**
1.3 < PIR <= 3.5	60.3 (1.7)	4.6 (.6)	32.1 (1.3)	3.0 (.4)	**100.0**
PIR >3.5	65.6 (1.1)	4.7 (.4)	26.6 (1.0)	3.2 (.3)	**100.1**
P-value for F-test of difference by PIR category	<.01	.88	<.01	.15	
Full Sample	**61.2** (.9)	**4.6** (.3)	**31.2** (.8)	**2.9** (.2)	**99.9**

Table 5b. Percent of total vegetable equivalents in each processing form, by socioeconomic/demographic characteristics [1]

	Full Year				
	Fresh	Proc.	Juice	Misc.	**Row Totals**
Age					
6-11	30.0 (2.0)	42.5 (2.6)	1.5 (.9)	16.1 (1.5)	**90.1**
12-18	40.3 (2.6)	30.6 (2.2)	.7 (.3)	18.8 (1.5)	**90.4**
19-59	48.5 (1.1)	22.7 (.9)	2.1 (.3)	19.0 (1.0)	**92.3**
60+	55.4 (1.6)	16.3 (.8)	2.5 (.3)	19.8 (1.5)	**94.0**
P-value for F-test of difference by age	<.01	<.01	<.01	.31	
Race					
Mexican American	44.6 (2.0)	24.7 (1.0)	2.2 (.6)	19.2 (.9)	**90.7**
Other Hispanic	47.6 (1.6)	18.8 (1.8)	3.9 (1.0)	22.1 (1.8)	**92.4**
Non-Hispanic White	50.4 (1.2)	21.8 (.8)	2.1 (.3)	18.2 (1.0)	**92.5**
Non-Hispanic Black	38.8 (1.6)	36.8 (1.5)	1.1 (.4)	16.3 (1.2)	**93.0**
Other race	38.6 (2.4)	19.2 (2.6)	1.3 (.9)	30.6 (3.5)	**89.7**
P-value for F-test of difference by race/ethnicity	<.01	<.01	<.01	<.01	
Family Income to Poverty Ratio					
PIR < 1.3	39.2 (1.3)	30.5 (1.2)	1.4 (.3)	21.5 (1.8)	**92.6**
1.3 < PIR <= 3.5	45.2 (1.4)	25.5 (.9)	2.4 (.4)	19.0 (1.1)	**100.5**
PIR >3.5	53.1 (1.1)	19.2 (.7)	2.1 (.3)	18.0 (.8)	**92.4**
P-value for F-test of difference by PIR	<.01	<.01	.10	.08	
Full Sample	**48.1** (.9)	**23.3** (.6)	**2.0** (.2)	**18.9** (.8)	92.3

1 Some rows do not sum to 100 due to vegetables in the form not specified group, not shown.

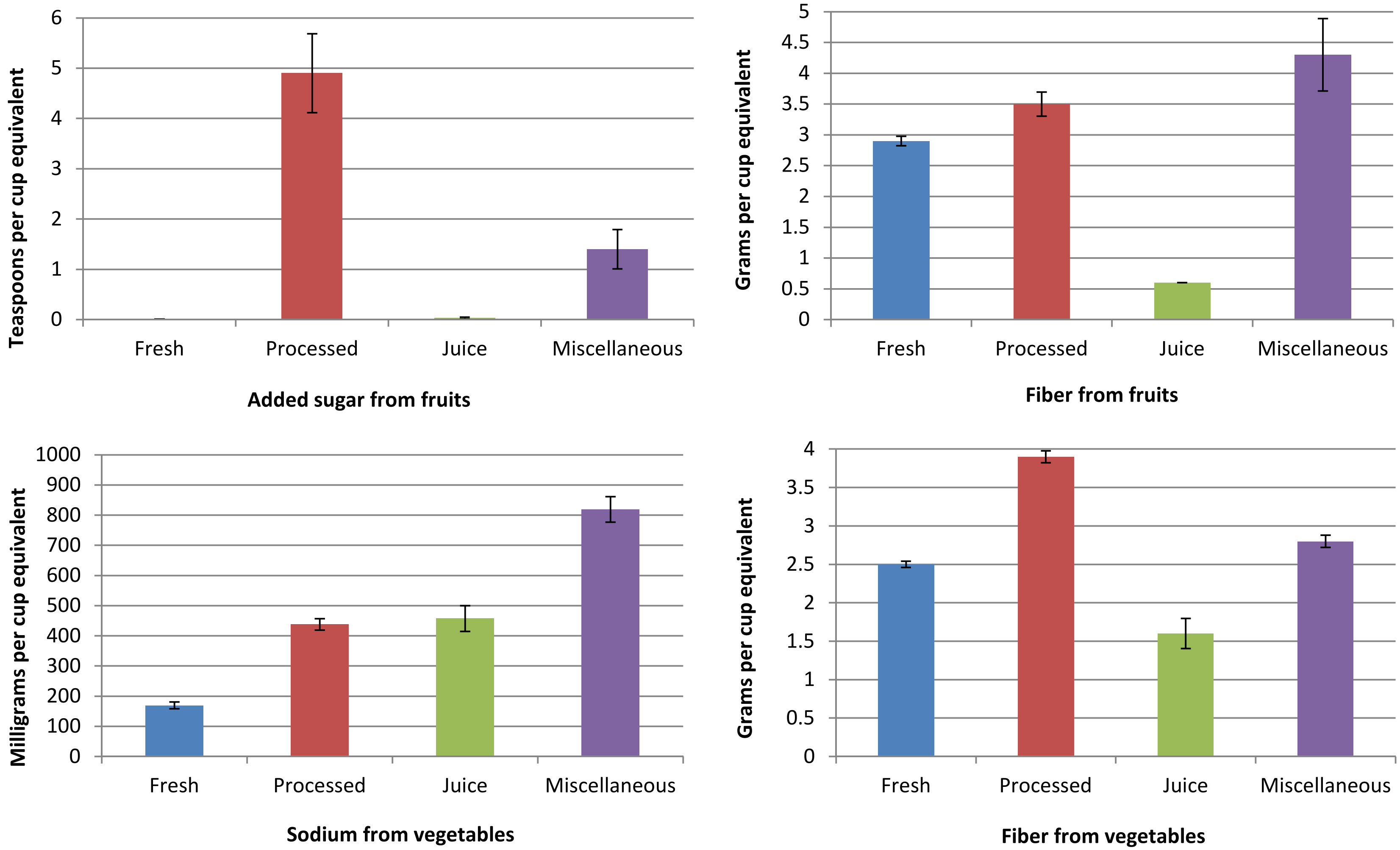


Figure 1. Significance of differences in mean sodium, added sugar, and fiber content in one cup equivalent of fruit and vegetables consumed by Americans, by form, NHANES 2007-2010

Error bars represent 1.96 * SE

Appendix Tables

Appendix Table 1. Significant differences among socioeconomic and demographic groups in the percent of total fruit from each form, full year [1]

Age	6-11	12-18	19-59	60+
6-11		P	P M	F J
12-18			M	F P J
19-59				F P J M
60+				

Race	Mexican American	Other Hispanic	Non-Hispanic White	Non-Hispanic Black	Other Race
Mexican American		F J	P J	F P J	F J
Other Hispanic			F P J		F J
Non-Hispanic White				F J M	P
Non-Hispanic Black					F P J
Other race					

Family Income to Poverty Ratio	PIR < 1.3	1.3 < PIR <= 3.5	PIR >3.5
PIR < 1.3		F J	F J
1.3 < PIR <= 3.5			F J
PIR >3.5			

[1] F = fresh; P = processed; J = juice; M = Miscellaneous; The presence of a letter indicates a significant difference between row group and column group in the percentage of total intake from that form, (p<0.05). The absence of a letter denotes no significant difference between the row and column group. For example, the percent of total intake from processed fruit was significantly different for respondents aged 6-11 yrs as compared to 12-18 yrs, but not significantly different for those 6-11 yrs versus those 60+ yrs old.

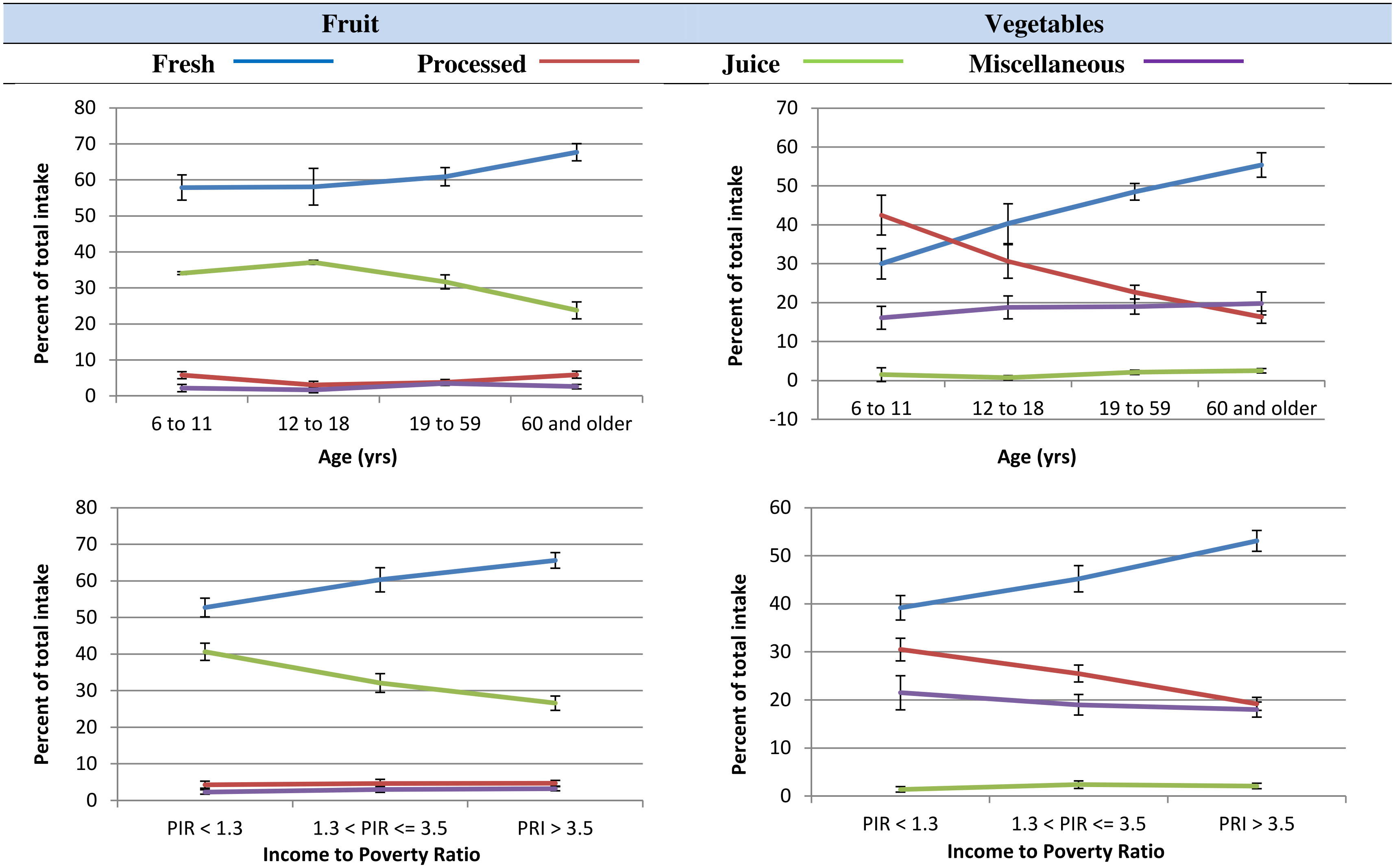
Appendix Table 2. Significant differences among socioeconomic and demographic groups in the percent of total vegetables from each form, full year [1]

Age	6-11	12-18	19-59	60+
6-11		F P	F P	F P
12-18			F P J	F P J
19-59				F P
60+				

Race	Mexican American	Other Hispanic	Non-Hispanic White	Non-Hispanic Black	Other Race
Mexican American			F P	F P	M
Other Hispanic				F P J M	F M
Non-Hispanic White				F P J	F M
Non-Hispanic Black					P M
Other race					

Family Income to Poverty Ratio	PIR < 1.3	1.3 < PIR <= 3.5	PIR >3.5
PIR < 1.3		F P	F P
1.3 < PIR <= 3.5			F P
PIR >3.5			

[1] F = fresh; P = processed; J = juice; M = Miscellaneous; The presence of a letter indicates a significant difference between row group and column group in the percentage of total intake from that form, (p<0.05). The absence of a letter denotes no significant difference between the row and column group. For example, the percent of total intake from processed vegetables was significantly different for Mexican American respondents versus Non-Hispanic Whites, but not significantly different between Mexican Americans as compared to those of Other Hispanics.



Appendix Figure 1. Associations between respondent age and household income and the percent of total fruit or vegetable intake in each processing form, NHANES 2007-2010

Error bars represent 1.96 * SE

REFERENCES

1. Heron M. Deaths: leading causes for 2009. Natl Vital Stat Rep. 2012;61:1-96.
2. Slavin JL, Lloyd B. Health benefits of fruits and vegetables. Adv Nutr. 2012 Jul;3:506-16.
3. Dauchet L, Amouyel P, Hercberg S, Dallongeville J. Fruit and vegetable consumption and coronary heart disease: a meta-analysis of cohort studies. Journal of Nutrition. 2006;136:2588-93.
4. Boeing H, Bechthold A, Bub A, Ellinger S, Haller D, Kroke A, Leschik-Bonnet E, Muller MJ, Oberritter H, et al. Critical review: vegetables and fruit in the prevention of chronic diseases. Eur J Nutr. 2012 Sep;51:637-63.
5. 2010 Dietary Guidelines Advisory Committee. Report of the Dietary Guidelines Advisory Committee on the Dietary Guidelines for Americans, 2010. Alexandria, VA. : USDA Center for Nutrition Policy and Promotion; 2010.
6. WCRF, AICR. Food, Nutrition, Physical Activity, and the Prevention of Cancer: a Global Perspective. Washington, DC: American Institute for Cancer Research; 2007.
7. Tohill BC, Seymour J, Serdula M, Kettel-Khan L, Rolls BJ. What epidemiologic studies tell us about the relationship between fruit and vegetable consumption and body weight. Nutr Rev. 2004 Oct;62:365-74.
8. Centers for Disease Control and Prevention. State Indicator Report on Fruits and Vegetables, 2009: Centers for Disease Control and Prevention; 2009.
9. Pollan M. In defense of food: An eater's manifesto. New York: The Penguin Press; 2008.

10. Jacobs DR, Jr., Steffen LM. Nutrients, foods, and dietary patterns as exposures in research: a framework for food synergy. Am J Clin Nutr. 2003 Sep;78:508S-13S.
11. Gibson E. Sell what you sow! The farmer's guide to successful produce marketing. Auburn, CA: New World Publishing; 1994.
12. Lea E. Food, health, the environment and consumers' dietary choices. Nutrition & Dietetics 2005;62:21-5.
13. United States Department of Agriculture. Farmers Markets. 2013 February 14, 2013 [cited 2013 February 18]; Available from: http://www.nutrition.gov/shopping-cooking-meal-planning/food-shopping-and-meal-planning/farmers-markets.
14. Harvard Heart Letter. Better ways to get your produce. Boston: Harvard Health Publications; 2010.
15. Vallejo F, Tomas-Barberan F, Garcia-Viguera C. Health-promoting compounds in broccoli as influenced by refrigerated transport and retail sale period. Journal of Agricultural and Food Chemistry. 2003;51:3029-34.
16. Vogt R, Kaiser L. Still a time to act: A review of institutional marketing of regionally-grown food. Agriculture and Human Values. 2008;25:241-55.
17. Rickman J, Barrett D, Bruhn C. Nutritional comparison of fresh, frozen and canned fruits and vegetables. Part 1. Vitamins C and B and phenolic compounds. Journal of the Science of Food and Agriculture. 2007;87:930-44.
18. Kalt W. Effects of production and processing factors on major fruit and vegetable antioxidants. Journal of Food Science. 2005;70:R11-R9.
19. Leone L, Beth D, Ickes S, MacGuire K, Nelson E, Smith RA, Tate D, Ammerman A. Attitudes toward fruit and vegetable consumption and farmers' market usage among

low-income North Carolinians. Journal of Hunger and Environmental Nutrition. 2012;7:64-76.

20. Colasanti K, Conner D, Smalley S. Understanding barriers to farmers' market patronage in Michigan: Perspectives from marginalized populations. Journal of Hunger and Environmental Nutrition. 2010;5:316-38.
21. Grace C, Grace T, Becker N, Lyden J. Barriers to using urban farmers' markets: An investigation of food stamp clients' perceptions. Journal of Hunger and Environmental Nutrition. 2007;2:55-75.
22. Zepeda L, Li J. Who Buys Local Food? Journal of Food Distribution Research. 2006;37:5-15.
23. Webber C, Dollahite J. Attitudes and behaviors of low-income food heads of households toward sustainable food systems concepts. Journal of Hunger and Environmental Nutrition. 2008;3:186-205.
24. U.S. Department of Agriculture, U.S. Department of Health and Human Services. Dietary Guidelines for Americans, 2010. 7th Edition ed. Washington, D.C.: U.S. Government Printing Office; 2010.
25. Lichtenstein AH, Appel LJ, Brands M, Carnethon M, Daniels S, Franch HA, Franklin B, Kris-Etherton P, Harris WS, et al. Diet and lifestyle recommendations revision 2006: a scientific statement from the American Heart Association Nutrition Committee. Circulation. 2006 Jul 4;114:82-96.
26. Rickman J, Bruhn C, Barrett D. Nutritional comparison of fresh, frozen and canned fruits and vegetables. Part 2. Vitamin A and carotenoids, Vitamin E, minerals and fiber. Journal of the Science of Food and Agriculture. 2007;87:1185-96.

27. Sacks FM, Svetkey LP, Vollmer WM, Appel LJ, Bray GA, Harsha D, Obarzanek E, Conlin PR, Miller ER, 3rd, et al. Effects on blood pressure of reduced dietary sodium and the Dietary Approaches to Stop Hypertension (DASH) diet. DASH-Sodium Collaborative Research Group. N Engl J Med. 2001 Jan 4;344:3-10.
28. Yang Q, Cogswell ME, Flanders WD, Hong Y, Zhang Z, Loustalot F, Gillespie C, Merritt R, Hu FB. Trends in cardiovascular health metrics and associations with all-cause and CVD mortality among US adults. JAMA. 2012 Mar 28;307:1273-83.
29. Strazzullo P, D'Elia L, Kandala NB, Cappuccio FP. Salt intake, stroke, and cardiovascular disease: meta-analysis of prospective studies. BMJ. 2009;339:b4567.
30. Nguyen S, Choi HK, Lustig RH, Hsu CY. Sugar-sweetened beverages, serum uric acid, and blood pressure in adolescents. J Pediatr. 2009 Jun;154:807-13.
31. Johnson RK, Appel LJ, Brands M, Howard BV, Lefevre M, Lustig RH, Sacks F, Steffen LM, Wylie-Rosett J. Dietary sugars intake and cardiovascular health: a scientific statement from the American Heart Association. Circulation. 2009 Sep 15;120:1011-20.
32. Dhingra R, Sullivan L, Jacques PF, Wang TJ, Fox CS, Meigs JB, D'Agostino RB, Gaziano JM, Vasan RS. Soft drink consumption and risk of developing cardiometabolic risk factors and the metabolic syndrome in middle-aged adults in the community. Circulation. 2007 Jul 31;116:480-8.
33. Marriott BP, Olsho L, Hadden L, Connor P. Intake of added sugars and selected nutrients in the United States, National Health and Nutrition Examination Survey (NHANES) 2003-2006. Crit Rev Food Sci Nutr. 2010 Mar;50:228-58.

34. Buzby JC, Wells HF, Kumcu A, Lin B-H, Lucier G, Perez A. Canned fruit and vegetable consumption in the United States: USDA Economic Research Service; 2010.

35. Demydas T. Consumer segmentation based on the level and structure of fruit and vegetable intake: an empirical evidence for US adults from the National Health and Nutrition Examination Survey (NHANES) 2005-2006. Public Health Nutr. 2011 Jun;14:1088-95.

36. Beydoun MA, Wang Y. How do socio-economic status, perceived economic barriers and nutritional benefits affect quality of dietary intake among US adults? Eur J Clin Nutr. 2008 Mar;62:303-13.

37. Redmond N, Baer HJ, Hicks LS. Health behaviors and racial disparity in blood pressure control in the national health and nutrition examination survey. Hypertension. 2011 Mar;57:383-9.

38. Ayala C, Gillespie C, Cogswell M, Keenan NL, Merritt R. Sodium consumption among hypertensive adults advised to reduce their intake: national health and nutrition examination survey, 1999-2004. J Clin Hypertens (Greenwich). 2012 Jul;14:447-54.

39. Thompson FE, McNeel TS, Dowling EC, Midthune D, Morrissette M, Zeruto CA. Interrelationships of added sugars intake, socioeconomic status, and race/ethnicity in adults in the United States: National Health Interview Survey, 2005. J Am Diet Assoc. 2009 Aug;109:1376-83.

40. Garnett BR, Rosenberg KD, Morris DS. Consumption of soda and other sugar-sweetened beverages by 2-year-olds: findings from a population-based survey. Public Health Nutr. 2012 Oct 4:1-8.

41. Han E, Powell LM. Consumption patterns of sugar-sweetened beverages in the United States. J Acad Nutr Diet. 2013 Jan;113:43-53.

42. U.S. Census Bureau. State and County QuickFacts: USA. 2013 January 10 2013 [cited 2013 February 18]; Available from: http://quickfacts.census.gov/qfd/states/00000.html

43. Guthrie J, Morton J. Food sources of added sweeteners in the diets of Americans. Journal of the American Dietetic Association. 2000;2000:43-8, 51.

44. Cotton P, Subar A, Friday J, Cook A. Dietary sources of nutrients amont US adults, 1994 to 1996. Journal of the American Dietetic Association. 2004;104:921-30.

45. O'Neil CE, Nicklas TA, Zanovec M, Kleinman RE, Fulgoni VL. Fruit juice consumption is associated with improved nutrient adequacy in children and adolescents: the National Health and Nutrition Examination Survey (NHANES) 2003-2006. Public Health Nutr. 2012 Oct;15:1871-8.

46. Pereira MA, Fulgoni VL, 3rd. Consumption of 100% fruit juice and risk of obesity and metabolic syndrome: findings from the national health and nutrition examination survey 1999-2004. J Am Coll Nutr. 2010 Dec;29:625-9.

47. Bazzano LA, Li TY, Joshipura KJ, Hu FB. Intake of fruit, vegetables, and fruit juices and risk of diabetes in women. Diabetes Care. 2008 Jul;31:1311-7.

48. Wilkins J. Consumer perceptions of seasonal and local foods: A study in a U.S. community. Ecology of Food and Nutrition. 2002;41:415-39.

49. Fjeld C, Sommer R. Regional-seasonal patterns in produce consumption at farmers' markets and supermarkets. Ecology of Food and Nutrition. 1982;12:109-15.

50. Macdonald HM, Hardcastle AC, Duthie GG, Duthie SJ, Aucott L, Sandison R, Shearer MJ, Reid DM. Changes in vitamin biomarkers during a 2-year intervention trial involving increased fruit and vegetable consumption by free-living volunteers. Br J Nutr. 2009 Nov;102:1477-86.

51. Oude Griep LM, Verschuren WM, Kromhout D, Ocke MC, Geleijnse JM. Raw and processed fruit and vegetable consumption and 10-year stroke incidence in a population-based cohort study in the Netherlands. Eur J Clin Nutr. 2011 Jul;65:791-9.

52. Oude Griep LM, Geleijnse JM, Kromhout D, Ocke MC, Verschuren WM. Raw and processed fruit and vegetable consumption and 10-year coronary heart disease incidence in a population-based cohort study in the Netherlands. PLoS One. 2010;5:e13609.

53. Wiig K, Smith C. The art of grocery shopping on a food stamp budget: factors influencing the food choices of low-income women as they try to make ends meet. Public Health Nutr. 2009 Oct;12:1726-34.

CHAPTER 5: FRUIT AND VEGETABLE PRICES ARE SIMILAR AT FARMERS' MARKETS, ROADSIDE STANDS AND SUPERMARKETS IN NORTH CAROLINA

Natalie Valpiani

Corresponding Author:

Natalie Valpiani

Food Policy and Applied Nutrition Program

Gerald J. and Dorothy G. Friedman School of Nutrition Science and Policy

Tufts University

150 Harrison Avenue, Boston MA, 02111

Phone: 763-213-4604

E-mail: Natalie.valpiani@tufts.edu

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Abstract

This study compares prices of 29 fruits and vegetables at North Carolina farmers' markets, roadside stands, and supermarkets. It improves upon previous research by increasing representativeness of the sample, selecting fruits and vegetables based on consumption share, and including non-fresh produce forms. Three types of fruit and one type of vegetable were cheaper at a local outlet; four vegetables were cheaper at supermarkets. The remaining items showed no difference. Weighting prices by each item's importance to overall intake caused some comparisons to lose significance. Local food outlets are price competitive and should be considered among tools to boost produce intake.

INTRODUCTION

Encouraging the proliferation of "local food" outlets, characterized by direct retail sales from farmers to consumers, has been proposed as a way to boost Americans' sub-optimal fruit and vegetable consumption. The effectiveness of these outlets as a means to improved intake depends in part on their price competitiveness with more traditional food retail channels. This study adds to the sparse literature comparing produce prices at local food retail outlets to those at supermarkets and improves upon previous methods in three ways: increased representativeness of the sampled outlets, fruit and vegetable selection more consistent with the intake of an average American, and inclusion of non-fresh forms of produce that may prove cheaper than their fresh counterparts.

Background

Americans' fruit and vegetable consumption, influenced by diverse environmental and personal factors, falls far short of recommendations. Consumption of fruits and vegetables is associated with reduced risk of weight gain in middle adulthood, coronary heart disease, stroke, and cancers of the alimentary tract (Committee 2010; Dauchet et al. 2006; WCRF and AICR 2007). Yet, fewer than one-third of U.S. adults consume at least two servings of fruit or three servings of vegetables each day (Centers for Disease Control and Prevention 2009). Factors affecting intake range from age and ethnicity to the neighborhood accessibility of produce (Devine et al. 1998; Stewart and Lucier 2009; Pollard, Kirk, and Cade 2002; Gary et al. 2004; Rose and Richards 2004; Zenk et al. 2009). Studies also suggest that the real or perceived high cost of fruits and vegetables pose a barrier to increased consumption, particularly for low-income Americans who consume fewer fruits and vegetables than average and who may be more price-sensitive than the general population (Dong and Lin 2009; Andreyeva, Long, and Brownell 2010; Mushi-Brunt, Haire-Joshu, and Elliott 2007). Improving the availability and affordability of fruits and vegetables could boost intake and population health.

Some proponents of the burgeoning local food movement believe that local food outlets improve produce affordability. Farmers' markets and consumer protection units promote the potential cost savings of buying locally produced, seasonal foods (CT Department of Consumer Protection 2010; Neighborhood Farmers Market Alliance 2012). Others see direct retail as a niche market in which consumers are willing to pay higher prices for product quality or shopping experience attributes (Lev and Gwin 2010; Carpio and Isengildina-Massa 2009; Thilmany, Bond, and Bond 2008). Many surveyed consumers also perceive local retail outlet prices as greater than traditional supermarkets (Leone et al. 212; Zepeda and Li 2006; Colasanti, Conner, and Smalley 2010; Webber and Dollahite 2008; Grace et al. 2007).

In light of this debate, the literature documenting price comparisons between direct farmer-to-consumer retail and traditional supermarkets is surprisingly thin. Just two studies were published in peer-reviewed journals. The first, conducted 30 years ago in California, found that farmers' market fruits and vegetables cost nearly 40% less than comparable items at nearby supermarkets (Sommer, Wing, and Aitkens 1980). A recent study replicating this work in North Carolina found that 79% items had a lower mean price at farmers' markets than at supermarkets for an overall savings of 17.9% (McGuirt et al. 2011). Two additional studies, published by non-profit organizations, note significantly lower prices at farmers' markets for some, but not a majority of items studied (Claro 2011; Pirog and McCann 2009). The present study augments this limited information and improves upon the methods used to compare prices by outlet type.

This study makes three primary improvements to methods employed in previous price-comparison studies. First, the sampling strategy enhances the representativeness of the results in several ways. Study sites were chosen based on a sampling frame that included all farmers' markets in central and eastern North Carolina. In previous research, markets were selected for their location in metropolitan areas, or convenience to data collectors (Pirog and McCann 2009; McGuirt et al. 2011; Claro 2011). In one study, counties were purposively selected to represent a variety of income, geographic and urbanization categories, but the market sampled in each county was chosen on the basis of being the largest in that county (McGuirt et al. 2011). The present study also included observations at roadside farm stands in the vicinity of each farmers' market – supermarket pair. These methods aimed to increase the extent to which observed local food prices are representative of those available from direct farmer-to-consumer retail.

Second, the fruits and vegetables priced in this study were selected primarily based on their importance in the diet of the average American. Availability at direct-retail outlets was also of interest, but was not the predominant selection criterion as in one prior study (Claro 2011). Selecting items based on dietary importance enables comparison of overall mean prices to prices for a subset of most-consumed fruits and vegetables as well as the weighting of prices by consumption shares. Consumption-weighted prices of the most-consumed items facilitate an assessment of the practical significance of observed differences. Differences by outlet for rarely purchased items would be of less practical interest than those for the handful of fruits and vegetables that make up the majority of Americans' produce intake.

Finally, this study strengthens the evaluation of how direct-retail outlets improve fruit and vegetable affordability by including data on non-fresh forms of fruits and vegetables. Fresh produce is often, but not always, the least expensive way to consume a serving of fruit or vegetable (Reed, Frazao, and Itskowitz 2004). While visiting sampled supermarkets, enumerators collected data on canned, frozen and juice forms of produce. Data on multiple forms enable exploration of whether or not fresh fruits and vegetables sold via local direct-retail prove not only price-competitive with fresh supermarket items, but also the most economical way to meet fruit and vegetable recommendations.

METHODS

Outlet Selection

Studying the effect of outlet type on prices required a sample of sites, each consisting of three outlet types. The sample was designed to represent all farmers' markets operating in central and eastern North Carolina, along with a comparison supermarket and roadside stand in geographic proximity to each market. Sampling proceeded as follows:

Step 1: Sample farmers' markets

Probability-proportional-to-size (PPS) sampling was used to select 34 farmers' markets from a sampling frame of all markets in central and eastern North Carolina. The average number of food vendors selling at the market during the market's busiest month in 2010 was used as a proxy for market size. If market managers reported a range of vendors, the midpoint was used.

Step 2: Sample a supermarket within 5 miles of each farmers' market

Next, a supermarket sampling frame was constructed for each farmers' market, consisting of supermarkets located within a five-mile drive of the market. Supermarkets were identified from the list of retailers authorized by the United States Department of Agriculture (USDA) to accept Supplemental Nutrition Assistance Program (SNAP) benefits. Nine additional supermarkets were identified using Google Maps and the Yellow Pages. These were added to the frames if they were categorized as a supermarket by a manager, but not found on the USDA list of non-supermarket SNAP retailers. Small grocery stores and superstores were excluded.

Step 3: Sample a roadside stand within 10 miles of each farmers' market

Finally, a roadside stand sampling frame was constructed for each market by searching the NC Farm Fresh web site for "Farms/Roadside Markets" within a five-mile drive of the market. When no stand existed within five miles, a sample was drawn from those within ten miles. Twenty-three roadside stands were randomly sampled. Seven farmers' markets had no stand within ten miles while four had one already sampled stand.

Produce Selection

Fruits and vegetables were selected to represent Americans' fruit and vegetable intake. Selection used the following multi-step procedure:

Step 1: Identify consumed fruits and vegetables and sort by form

Fruits and vegetables consumed by Americans two years and older were identified using 24-hour dietary recall data from the nationally representative National Health and Nutrition Examination Survey (NHANES). Each fruit and vegetable item was categorized as fresh, canned, frozen, or juice based on the description in the dataset.

Step 2: Rank most-consumed items, overall and by form

Next, the mean grams consumed of each item were calculated using weights that made the sample representative of Americans aged two years and older in 2005-2008. The contribution of each item to total fruit or total vegetable intake and to each form was calculated and ranked. Different forms of a fruit or vegetable were considered distinct (e.g. raw apples vs. apple juice), while varieties of a form were not (e.g. unsweetened vs. cinnamon applesauce). Mixtures like "juice blend" were excluded.

Step 3: Consolidate list, focusing on North Carolina products

The lists were then consolidated for study. Four goals guided consolidation: first, choose a bundle of items (all forms) that represent about 80% of total fruit and total vegetable consumption; second, include fruits and vegetables important in North Carolina direct retail; third, include items important to a form sub-group; finally, keep the list as short as possible. These goals can be seen at work in the final list (all 29 items are presented in tables 3a and 3b; see appendix tables 1 and 2 for detail on the contribution of each item to fruit and vegetable intake). For example, though blueberries were not among the top 80% of fruit consumed, they were included to augment the fruit available from North Carolina direct retail. Oranges, though not produced in North Carolina, were included due to their importance to non-fresh forms.

Step 4: Create an operational definition for each item

Operational definitions were then developed for each fruit and vegetable. Each was designed to be narrow enough that comparable items were priced at each outlet, but not so specific as to result in excessive missing data. For example, enumerators observed only red slicing tomatoes, but within the category could select the lowest priced item among options such as "slicing", "hot house", or "vine-ripened". In general, the least-processed form of an item was observed.

Data Collection

Enumerators visited the sampled sites between mid-July and mid-August, 2011. The data collection period lasted just four weeks to reduce the potential for intra-season price variation. When possible, data were collected on the same day from a site's three outlets to reflect the price environment facing a consumer shopping that day. Some supermarkets were visited a day before or after the farmers' market, but only after ensuring that the supermarket prices would be the same on that day as on market day.

At farmers' markets with multiple produce vendors, enumerators sampled a vendor using a random number table. They then collected data for as many items as were available from that vendor. If the first vendor sampled was missing items, the enumerator selected a second vendor. This procedure was repeated until data were collected for as many produce items as possible. For each fruit or vegetable, data were collected about variety with the lowest unit price (some items, such as apples, may be sold in several varieties with varying prices). Sales available to all shoppers with a store loyalty card were recorded. Prices available only with a coupon were not.

At all outlets, prices were recorded as posted, either per pound or per item. For fresh items sold in standard packages and for canned or frozen goods, enumerators recorded the weight listed. For fresh items sold per item (e.g. bunch spinach) enumerators recorded the weight of three items. This enabled the use of an average weight during data analysis to account for the variation in size among fresh produce items. Watermelons were measured, not weighed, due to their large size.

The instruments and protocol for this study were determined exempt from review by the Tufts University Institutional Review Board (IRB) at Medford.

ANALYSIS

Data cleaning and analysis were conducted in StataIC 10.0 (StataCorp, College Station, TX). The data were entered twice; inconsistencies were corrected by referencing the original survey forms. Analysis began with descriptive statistics that provide a picture of the sampled outlets and the cities in which they are located.

In comparing prices, observed supermarket prices were multiplied by 1.02 to account for the local food tax. Fruit and vegetable prices were compared as dollars per cup equivalent. The equivalents used were those of the USDA MyPyramid Food Guidance System (Bowman, Friday, and Moshfegh 2008). To calculate the price per cup equivalent, the amount of each item observed in “as purchased” form was translated into edible cup equivalents as follows:

1. The weight of the observed item was converted from pounds to grams.
2. For fresh items, a percentage of the weight was subtracted to account for the portion of each item not typically consumed (e.g. peel, seeds, etc.). This percentage was determined from the USDA National Nutrient Database for Standard Reference, Release 18.
3. The number of cup equivalents per 100 edible grams of each item was then calculated using the USDA MyPyramid Equivalents Database, 2.0.

Once the cup equivalents had been calculated, the effect of outlet type on mean price per cup equivalent of each fruit or vegetable was assessed. First, the mean price per cup equivalent for individual fruits and vegetables at supermarkets was compared to mean prices at farmers' markets and roadside stands using one-way analysis of variance models with the Bonferroni correction for multiple group comparisons. Weighted and un-weighted means were also compared by outlets for a subset of most-consumed fruits and vegetables observed. The price of each item was weighted by its contribution to total fresh fruit and vegetable intake, as reported in NHANES.

To determine whether differences in mean prices were due to additional variables associated with outlet type, multivariate linear regression models were employed. Price per cup equivalent for several of the most-consumed fresh items was regressed on indicator variables for outlet type and for other observed characteristics (e.g. whether or not the item was organic or produced in North Carolina).

Analyses further assessed the effect of several decisions about study methods. The t-test was used to compare mean cup equivalent prices between markets of different sizes to identify a potential size effect. Bonferroni-corrected ANOVA models enabled comparison of item prices by form. When only two forms were observed, a *t*-test was used to detect significant differences. To evaluate the importance of weighing fruits and vegetables sold by the item, ANOVA models compared the weight, in pounds, of these items by outlet type. Results were considered significant at $p<0.05$.

RESULTS

Descriptive statistics demonstrate wide variation in the size of the sampled farmers' markets and the cities in which they are located. Farmers' markets ranged in size from 4 to 102 vendors. More than half of the markets were small, having fewer than 20 vendors (table 1). Markets were located in cities that ranged in population and income, though there was no evident association between these characteristics and market size (table 1).

Farmers' market size may have an effect, however, on the mean price per cup equivalent of produce as evidenced by prices for a subset of fruits and vegetables widely available at markets during the summer season (table 2). For all four fruits and eight vegetables reported, prices were lower at markets with 20 or fewer vendors than at larger markets. Smaller markets were less expensive per cup equivalent for weighted and unweighted averages prices across all 29 items as well as for the subset of most-consumed fruits and vegetables. The differences were not significant for fruit, but were significant for three vegetables and for the weighted and unweighted mean for all vegetables ($p<0.05$, table 2).

Roadside stands offered nearly as many types of fruit and vegetables as farmers' markets, though neither local outlet carried as many items as supermarkets. On average, roadside stands sold 3.7 of the 11 fresh fruits priced, compared to 4.5 at farmers' markets and 10.4 at supermarkets. Similarly, roadside stands sold 6.6 of the 18 vegetables observed, compared to 8.4 at farmers' markets and 16.7 at supermarkets (appendix table 3).

Roadside stands offered not only similar numbers of items as farmers' markets, but also similarly competitive prices. Results of one-way ANOVA models show that fresh fruit cost less per cup, on average, at farmers' markets ($0.64) and significantly less at roadside stands ($0.48/cup, $p<0.05$) than at supermarkets ($0.71/cup) (table 3a). The mean cup equivalent of all vegetables was least expensive at roadside stands and most expensive at farmers' markets, but these differences were not significant (table 3b). Considering individual items, prices for eight of the 11 fruits and 13 of the 18 vegetables did not differ significantly between the outlet types (tables 3a and 3b).

Additional descriptive and analytic results demonstrate the value of considering the intake of each item when selecting fruits and vegetables for study. Five of the six most-consumed fruits (apples, oranges, watermelon, grapes and cantaloupe; bananas excluded) make up more than 50% of Americans' fresh fruit intake (appendix table 1). Just four vegetables (white potatoes, tomatoes, iceberg lettuce and carrots) account for more than 52% of fresh vegetable intake (appendix table 2). The contribution of a single item to a sub-group total is as high as 80%.

Farmers' markets appeared to be a better bargain for the fruits Americans actually consume most frequently. The simple average price for fresh fruits was only $0.07 lower in farmers' markets than in supermarkets. By contrast, the simple average price for the five most-consumed fresh fruits was \$0.17 lower in farmers' markets than in supermarkets (table 3a). Roadside stands had the lowest average fruit price in either case, however, the price advantage shrunk when considering only the most-consumed fruits (table 3a). For all vegetables, there was no significant difference in the simple average price by outlet type. However, supermarkets and roadside stands proved much cheaper sources of the six most-consumed vegetables than farmers' markets (table 3b).

Roadside stands remained the best bargain for all fruits when prices were weighted by consumption share, but their price advantage over supermarkets shrunk by \$0.09/cup as compared to the simple average (table 3a). Roadside stands remained the least expensive source of all vegetables when prices were weighted by item importance, and the difference between roadside stand and farmers' market prices gained significance ($p<0.05$; table 3b).

All three outlet types compete well on price when comparing the consumption-weighted averages of only the most popular fruit and vegetable items. The weighted average of the most-consumed fruit remains lowest at local outlets and farmers' markets retain the highest vegetable price. Yet, for both fruits and vegetables, the previously noted significance of price differences across outlet types disappears (tables 3a and 3b).

Multivariate models, controlling for growing method and location, corroborate the above results, finding price differences for some items. Cantaloupe and tomatoes were significantly less expensive at farmers' markets ($\beta = -0.13$, and -0.25, respectively) and roadside stands ($\beta = -0.20$ and -0.37, respectively) than supermarkets ($p<0.05$, appendix table 4). Broccoli and watermelon also cost less per cup at farmers' markets than supermarkets. Carrots, on the other hand, cost \$0.30 per cup more at farmers' markets than at supermarkets. For 5 of the 11 most-consumed fruits and vegetables, outlets charged a higher price if an item was organically grown ($p<0.05$, appendix table 4).

Finally, as hypothesized, the least expensive form of a fruit or vegetable was not always fresh. When observed, juice proved the least expensive form of a cup equivalent of the item (table 4). Excluding juices, three fresh fruits and eight fresh vegetables had a significantly lower price per cup than their frozen or canned counterparts, whereas one fruit and five vegetables cost less per cup in frozen or canned form than fresh (table 4). Considering all the fresh fruits and vegetables available in both forms, fresh servings cost less on average than frozen or canned (fruit: \$0.76 vs. \$0.96; vegetable: \$0.63 vs. \$0.77). However, the difference in price lost significance when only the three most-consumed fruits were considered and reversed direction for all vegetables weighted by consumption and when considering only the most-consumed vegetables (table 4).

DISCUSSION

The results of this study suggest that local food outlets are price-competitive with traditional supermarkets. Three fruits and one vegetable had a significantly lower price per cup equivalent at a local food outlet than at supermarkets, while the opposite was true for four vegetables (tables 3a and 3b). The remaining 20 items had no significant differences. The significance of mean differences between outlets depended on the set of items considered as well as whether prices were weighted by consumption share.

The results of previous studies suggest that increasing the number of farmer-to-consumer retail outlets may improve fruit and vegetable consumption. Participation in farmers' market coupon programs has been associated with increased fruit and vegetable intake and a positive perception about fruits and vegetables (McCormack et al. 2010). Local food outlets have also been found to augment fruit and vegetable availability while reducing prices. For example, the creation of a farmers' market in a low-income Ontario neighborhood resulted in an increase in produce availability and a 12% drop in the cost of a 66-item healthy food basket (Larsen and Gilliland 2009; Sommer, Wing, and Aitkens 1980; McGuirt et al. 2011). This study provides partial support to this optimistic body of work. The farmers' markets and roadside stands studied provide consumers an additional source of popular produce items at prices similar, and sometimes below, those already available at supermarkets.

While the present results corroborate prior work, this study found price savings at local outlets for a much smaller percentage of fruit and vegetable items than previous studies (McGuirt et al. 2011; Sommer, Wing, and Aitkens 1980). These differences may be the result of differences in the methods employed, underscoring the importance of giving careful consideration to study design in future price comparisons.

Researchers designing future studies might consider several findings from this research when planning their methods. First, differences between these and previous findings could be due to this study's larger sample size or sampling methods. We conducted surveys at twice the number of sites as previous studies. Our sampling method resulted in a sample including markets of a variety of sizes, located in cities ranging in population from 843 inhabitants to 704,422 inhabitants. This sample may be more representative of all markets than past samples. Representativeness is an important aim, as these results suggest a possible relationship between market size and item prices.

Second, comparing the cost of items in different forms adds an important dimension to local food versus supermarket comparisons. Current dietary guidance asserts that all forms of fruits and vegetables can be used to meet recommendations (USDA and DHHS 2010). As demonstrated here, canned or frozen items may sometimes be less expensive than fresh items. This was especially the case for the most commonly consumed vegetables. Nutrition educators helping consumers to meet fruit and vegetable targets on a budget should be aware of and highlight potential savings by both outlet type and form.

Additionally, this research may have uncovered less frequent savings at local outlets because it focused on 29 fruits and vegetables commonly consumed by Americans. We may have missed less common items for which local food outlets prove highly price competitive or items that carry a high local price premium. Yet, selecting and weighting items based on their dietary importance helps to clarify the practical significance of observed price differences. For example, in the case of fresh vegetables, no overall price difference was found among outlet types, whereas supermarkets had the most competitive mean price for the six most-consumed vegetables. The supermarket price advantage shrinks in size and loses significance, however, when the mean for the subset is weighted (table 3b). Similarly, considering all items at supermarkets, fresh fruits and vegetables are significantly less expensive than their canned or frozen counterparts. However, this difference disappears for popular fruits and reverses direction for popular vegetables (weighted or unweighted; table 4). Thus, the least expensive outlet or form for a consumer depends on whether or not his or her fruit and vegetable intake, in type and quantity, resembles that of an average American.

Finally, this study demonstrated that weighing items sold by the piece results in more accurate price comparisons. Fresh items sold by the unit (e.g. melon) were weighed or measured to enable price comparison per cup equivalent. Previous studies compared prices per item when a fruit or vegetable was sold by the item. This can cause problems if items vary in size by outlet type, as was found for several items in this study. The mean weight of cantaloupes differed significantly by outlet type, weighing most at roadside stands and least at supermarkets ($p<0.01$, appendix table 5). Watermelons were largest at farmers' markets and smallest at supermarkets ($p=0.02$). The mean weight of collard bunches differed by outlet type, ranging from 1.63 lbs/bunch at supermarkets to 3.63 lbs/bunch at roadside stands. Failing to account for these differences could result in incorrect comparisons and conclusions.

This research has several limitations. Vendors were randomly sampled at farmers' markets, rather than canvassed to identify the lowest price for each item at the market. Thus, the results denote the mean price per fruit or vegetable across all markets. While this enabled a larger sample size, it is possible that lower prices were available at some markets. Furthermore, organic items were not excluded from data collection. Price premiums at local food outlets, when noted, may be due in part to a greater availability of organic items for sale at farmers' markets and roadside stands than at supermarkets. However, multivariate results controlling for organic production did not find an outlet with lower prices across all items. Finally, price differences between outlet types may reflect real differences in produce quality, not measured in these observations.

CONCLUSION

The majority of fruits and vegetables studied did not show significant price differences between traditional supermarkets and direct farmer-to-consumer retail outlets, suggesting that the outlets compete quite well with one another on fresh produce prices. Additional work would further enhance understanding of the price dynamics in the local food system. Given the potential of roadside stands to provide commonly consumed fruits and vegetables at competitive prices, future research should assess their accessibility and convenience. Subsequent research should also explore the impact of seasonality on the relationship between outlet type, item availability, and produce prices. Findings in these areas could enhance nutrition education and policy efforts to improve food environments, and in turn help consumers to optimize their produce spending and consumption.

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LITERATURE CITED

Andreyeva, Tatiana, Michael Long, and Kelly Brownell. 2010. The impact of food prices on consumption: A systematic review of research on the price elasticity of demand for food. *American Journal of Public Health* 100:216-222.

Bowman, SA, JE Friday, and A Moshfegh. 2008. MyPyramid Equivalents Database, 2.0 for USDA Survey Foods, 2003-2004. Food Surveys Research Group. Beltsville, MD: Agricultural Research Service, U.S. Department of Agriculture.

Carpio, Carlos, and Olga Isengildina-Massa. 2009. Consumer willingness to pay for locally grown products: the case of South Carolina. *Agribusiness* 25 (3):412-426.

Centers for Disease Control and Prevention. 2009. State Indicator Report on Fruits and Vegetables, 2009.

Claro, Jake. 2011. Vermont farmers' markets and grocery stores: A price comparison. Richmond: Northeast Organic Farming Association of Vermont.

Colasanti, Kathryn, David Conner, and Susan Smalley. 2010. Understanding barriers to farmers' market patronage in Michigan: Perspectives from marginalized populations. *Journal of Hunger and Environmental Nutrition* 5:316-338.

2010 Dietary Guidelines Advisory Committee. 2010. Report of the Dietary Guidelines Advisory Committee on the Dietary Guidelines for Americans, 2010. Alexandria, VA. : USDA Center for Nutrition Policy and Promotion.

CT Department of Consumer Protection. 2010. *Saving Money at the Grocery Store*, Jan 26, 2010 2010 [cited July 19 2010]. Available from http://www.ct.gov/dcp/cwp/view.asp?a=1629&q=421268.

Dauchet, L, P Amouyel, S Hercberg, and J Dallongeville. 2006. Fruit and vegetable consumption and coronary heart disease: a meta-analysis of cohort studies. *Journal of Nutrition* 136 (10):2588-93.

Devine, Carol, Margaret Connors, Carole Bisogni, and Jeffery Sobal. 1998. Life-course influences on fruit and vegetable trajectories: Qualitative analysis of food choices. *Journal of Nutrition Education* 30:361-370.

Dong, Diansheng, and Biing-Hwan Lin. 2009. Fruit and vegetable consumption by low-income Americans: Would a price reduction make a difference? Washington D.C.: U.S. Department of Agriculture, Economic Research Service.

Gary, Tiffany, Kesha Baptiste-Roberts, Edward Gregg, Desmond Williams, Gloria Beckles, Edgar Miller, and Michael Engelgau. 2004. Fruit, vegetable and fat intake in a population-based sample of African Americans. *Journal of the National Medical Association* 96 (12):1599-1605.

Grace, Christina, Thomas Grace, Nancy Becker, and Judy Lyden. 2007. Barriers to using urban farmers' markets: An investigation of food stamp client' perceptions. *Journal of Hunger and Environmental Nutrition* 2 (1):55-75.

Larsen, Kristian, and Jason Gilliland. 2009. A farmers' market in a food desert: Evaluating impacts on the price and availability of healthy food. *Health & Place* 15:1158-1162.

Leone, Lucia, Diane Beth, Scott Ickes, Kathleen MacGuire, Erica Nelson, Robert Andrew Smith, Deborah Tate, and Alice Ammerman. 212. Attitudes toward fruit and vegetable consumption and farmers' market usage among low-income North Carolinians. *Journal of Hunger and Environmental Nutrition* 7 (1):64-76.

Lev, Larry, and Lauren Gwin. 2010. Filling in the gaps: Eight things to recognize about farm-direct marketing. *Choices*.

McCormack, Lacey, Melissa Laska, Nicole Larson, and Mary Story. 2010. Review of nutritional implications of farmers' markets and community gardens: Call for evaluation and research efforts. *Journal of the American Dietetic Association* 110 (3):399-408.

McGuirt, Jared, Stephanie Jilcott, Haiyong Liu, and Alice Ammerman. 2011. Produce price savings for consumers at farmers' markets compared to supermarkets in North Carolina. *Journal of Hunger and Environmental Nutrition* 6:86-98.

Mushi-Brunt, C., D. Haire-Joshu, and M. Elliott. 2007. Food spending behaviors and perceptions are associated with fruit and vegetable intake among parents and their preadolescent children. *J Nutr Educ Behav* 39 (1):26-30.

Neighborhood Farmers Market Alliance. *Are the farmers' markets really more expensive?* 2012. Available from http://www.seattlefarmersmarkets.org/ripe-n-ready/are-the-farmers-markets-really-more-expensive.

Pirog, Rich, and Nick McCann. 2009. Is local food more expensive?: A consumer price perspective on local and non-local foods purchased in Iowa. Ames.

Pollard, J, SFL Kirk, and JE Cade. 2002. Factors affecting food choice in relation to fruit and vegetable intake: a review. *Nutrition Research Reviews* 15:373-387.

Reed, Jane, Elizabeth Frazao, and Rachel Itskowitz. 2004. How much do Americans pay for fruits and vegetables? *Agriculture Information Bulletin*: U.S. Department of Agriculture, Economic Research Service.

Rose, Donald, and Rickelle Richards. 2004. Food store access and household fruit and vegetable use among participants in the US Food Stamp Program. *Public Health Nutrition* 7:1081-1088.

Sommer, Robert, Margaret Wing, and Susan Aitkens. 1980. Price Savings to Consumers at Farmers' Markets. *The Journal of Consumer Affairs* 14 (2):452-462.

Stewart, Hayden, and Gary Lucier. 2009. Younger consumers exhibit less demand for fresh vegetables. Washington D.C.: U.S. Department of Agriculture, Economic Research Service.

Thilmany, Dawn, Craig Bond, and Jennifer Bond. 2008. Going Local: Exploring Consumer Behavior and Motivations for Direct Food Purchases. *American Journal of Agricultural Economics* 90 (5):1303-1309

U.S. Department of Agriculture, and U.S. Department of Health and Human Services. 2010. Dietary Guidelines for Americans, 2010. Washington, D.C.: U.S. Government Printing Office.

WCRF, and AICR. 2007. Food, Nutrition, Physical Activity, and the Prevention of Cancer: a Global Perspective. Washington, DC: American Institute for Cancer Research.

Webber, Caroline, and Jamie Dollahite. 2008. Attitudes and behaviors of low-income food heads of households toward sustainable food systems concepts. *Journal of Hunger and Environmental Nutrition* 3 (2):186-205.

Zenk, S. N., A. J. Schulz, L. L. Lachance, G. Mentz, S. Kannan, W. Ridella, and S. Galea. 2009. Multilevel correlates of satisfaction with neighborhood availability of fresh fruits and vegetables. *Ann Behav Med* 38 (1):48-59.

Zepeda, Lydia, and Jinghan Li. 2006. Who Buys Local Food? *Journal of Food Distribution Research* 37 (3):5-15.

Table 1. Characteristics of study sites by size of farmers' market, North Carolina, 2011

Number of vendors at farmers' market	Number of sites	Mean city size[1] (SE)	Mean distance (miles) to supermarket[2] (SE)	Mean distance (miles) to roadside stand[2] (SE)	Median income ($) of market census tract [3] (SE)	Median income ($) of market city [3] (SE)
1-10	11	20,637 (7,893)	1.9 (.5)	5.5 (1.4)	40,035 (5,003)	35,857 (5,452)
11-20	9	197,438 (99,481)	2.0 (.4)	5.9 (1.4)	55,882 (8,190)	50,100 (5,611)
21-30	6	126,363 (58,894)	2.0 (.4)	9.3 (2.4)	55,256 (13,793)	48,848 (8,545)
31-40	4	43,961 (21,024)	4.2 (1.2)	5.6 (1.0)	51,978 (14,007)	37,141 (1,541)
41+	4	220,937 (78,605)	3.2 (0.3)	7.8 (1.9)	36,217 (7,281)	54,684 (12,460)
Full Sample	34	112,392 (31,703)	2.4 (0.3)	6.30 (0.7)	47,872 (4,057)	44,286 (3,197)

1 U.S. Census Bureau estimated population, 2009.
2 Mean of distances between each farmers' market in the given size range and the corresponding supermarket or roadside stand, in miles.
3 Income data source: 2006-2010 American Community Survey 5-year estimates.

Table 2. Mean farmers' market price per cup equivalent of fresh fruits and vegetables, by market size, North Carolina, 2011

	Dollars per 1-Cup Equivalent (SE)		
Produce Item	1-20 vendors	>20 vendors	p-value
Fruits			
Blueberries	1.20 (.11)	1.53 (.18)	.16
Cantaloupe	.40 (.04)	.43 (.03)	.55
Peach	.74 (.26)	1.07 (.49)	.54
Watermelon	.23 (.02)	.25 (.02)	.58
Vegetables			
Cabbage (green)	.14 (.02)	.20 (.04)	.28
Corn	.55 (.05)	.86 (.10)	.01
Cucumber	.36 (.03)	.51 (.04)	.01
Green Beans	.55 (.05)	.64 (.07)	.26
Onions	.47 (.04)	.57 (.09)	.30
White Potato	.45 (.05)	.65 (.08)	.03
Summer Squash	.37 (.03)	.45 (.04)	.08
Tomato (red)	.77 (.09)	.86 (.07)	.45

Continued

Table 2 *Continued*

	Dollars per 1-Cup Equivalent *(SE)*		
	1-20 vendors	>20 vendors	p-value
All fruits, unweighted	.55 (.07)	.72 (.10)	.14
All fruits, weighted[1]	.43 (.05)	.56 (.05)	.09
Most-consumed fruits, unweighted[2]	.35 (.03)	.43 (.05)	.16
Most-consumed fruits, weighted	.37 (.04)	.47 (.05)	.18
All vegetables, unweighted	.51 (.03)	.69 (.05)	< .01
All vegetables, weighted[1]	.49 (.04)	.70 (.05)	.02
Most-consumed veg, unweighted[2]	.53 (.05)	.63 (.06)	.17
Most-consumed veg, weighted	.47 (.05)	.56 (.06)	.32

1 Prices weighted by each item's proportion of fresh fruit and vegetable intake.

2 Most-consumed indices made of the 5 most-consumed fruits (apple, orange, grape, cantaloupe, watermelon) and 6 most-consumed vegetables (potato, tomato, iceberg lettuce, cabbage, carrots and broccoli).

Table 3a. Mean price per cup equivalent of fresh fruits, by outlet type, North Carolina, 2011[1]

Produce Item	% contribution to fresh fruit intake	Dollars per 1-Cup Equivalent[2] (SE)		
		Super-market	Farmers Market	Roadside Stand
Fruits				
Apple	23.9	.34 [a] (.01)	.33 [a] (.04)	.32 [a] (.03)
Blueberries	0.8	1.34 [a] (.05)	1.37 [a] (.12)	1.09 [a] (.14)
Cantaloupe	4.0	.50 [a] (.02)	.42 [b] (.03)	.32 [b] (.02)
Grape	6.9	.79 [a] (.05)	.90 [a] (.11)	.71 [a] (.18)
Orange	10.5	.71 [a] (.06)	.47 [a] (.07)	.48 [a] (.03)
Peach	3.5	.57 [a] (.03)	.89 [a] (.26)	.45 [a] (.05)
Pear	2.6	.82 [a] (.06)	.52 [a] (.08)	
Pineapple	1.1	.73 [a] (.05)	.83 [a] (.19)	
Plum	1.0	.77[a] (.03)	.58 [b] (.06)	.71 [a,b] (.03)
Strawberries	3.6	.97 [a] (.05)	.95 [a] (.08)	
Watermelon	7.8	.42 [a] (.03)	.24 [b] (.01)	.30 [b] (.02)
All fruits, unweighted		.71 [a] (.02)	.64 [a, b] (.06)	.48 [b] (.03)
All fruits, weighted[3]		.56 [a] (.02)	.50 [a, b] (.04)	.42 [b] (.03)
Most-consumed fruits, unweighted[4]		.56 [a] (.02)	.39 [b] (.03)	.37 [b] (.03)
Most-consumed fruits, weighted		.50 [a] (.02)	.43 [a] (.04)	.40 [a] (.04)

1 A missing observation indicates that the item was available at two or fewer outlets of the given type.
2 Differences superscripts indicate a significant difference at $p<0.05$.
3 Prices weighted by each item's proportion of fresh fruit intake.
4 Indices made of the 5 most-consumed fresh fruits (apple, orange, grape, cantaloupe and watermelon).

Table 3b. Mean price per cup equivalent of fresh vegetables, by outlet type, North Carolina, 2011[1]

Produce Item	% contribution to fresh veg. intake	Dollars per 1-Cup Equivalent[2] (SE)		
		Super-market	Farmers Market	Roadside Stand
Vegetables				
Asparagus	0.8	1.86 [a] (.05)		
Broccoli	3.5	.66 [a] (.04)	.45 [a] (.06)	.47 [a] (.04)
Cabbage (green)	3.2	.17 [a] (.01)	.17 [a] (.03)	.14 [a] (.01)
Carrots	4.1	.29 [a] (.01)	.69 [b] (.14)	.51 [a,b] (.22)
Collards	1.0	.29 [a] (.02)	.38 [a] (.05)	
Corn	3.1	1.02 [a] (.20)	.69 [a] (.06)	.68 [a] (.12)
Cucumber	3.0	.42 [a] (.03)	.41 [a] (.03)	.40 [a] (.03)
Green Beans	1.6	.56 [a] (.02)	.60 [a] (.04)	.51 [a] (.07)
Iceberg Lettuce	12.9	.30 [a] (.02)	.22 [a] (.03)	.31 [a] (.03)
Mixed Greens[3]	2.4			
Onions	3.2	.37 [a] (.02)	.51 [b] (.05)	.37 [a,b] (.03)
Peas	0.4		2.35 [a] (.60)	1.40 [a] (.07)
White Potato	21.2	.27 [a] (.01)	.54 [b] (.05)	.42 [b] (.03)
Romaine Lettuce	0.8	.31 [a] (.02)	.36 [a] (.07)	
Spinach	1.2	.44 [a] (.03)	.80 [b] (.19)	
Summer Squash	1.6	.43 [a] (.01)	.40 [a] (.02)	.36 [a] (.03)
Sweet Potato	1.1	.62 [a] (.03)	.58 [a] (.05)	.55 [a] (.05)
Tomato (red)	14.1	.90 [a] (.06)	.81 [a, b] (.06)	.66 [b] (.06)

Continued

Table 3b. *Continued*

	% contribution to fresh veg. intake	Dollars per 1-Cup Equivalent[2] (SE)		
		Super-market	Farmers Market	Roadside Stand
All vegetables, unweighted		.55 [a] (.02)	.60 [a] (.03)	.52 [a] (.03)
All vegetables, weighted[4]		.52 [a, b] (.04)	.59 [a] (.04)	.46 [b] (.03)
Most-consumed veg, unweighted[5]		.42 [a] (.02)	.58 [b] (.04)	.48 [a,b] (.04)
Most-consumed veg, weighted		.45 [a] (.02)	.52 [a] (.04)	.44 [a] (.03)

1 A missing observation indicates that the item was available at two or fewer outlets of the given type.
2 Different superscripts indicate a significant difference at $p<0.05$.
3 Loose mixed greens (packed excluded).
4 Prices weighted by each item's proportion of fresh vegetable intake.
5 Indices made of the 6 most-consumed fresh vegetables (potato, tomato, lettuce, carrots, broccoli and cabbage).

Table 4. Mean price per cup equivalent of fruits and vegetables by form, North Carolina supermarkets, 2011

	Dollars per 1-Cup Equivalent[1] *(SE)*		
Produce Item	Fresh	Frozen or Canned	Juice
Fruits			
Apple	.34[a]	.49[b]	.26[c]
	(.01)	(.03)	(.01)
Blueberries	1.34[a]	1.47[a]	
	(.05)	(.04)	
Grape	.79[a]		.41[b]
	(.05)		(.01)
Orange	.71[a]	.78[a]	.27[b]
	(.06)	(.03)	(.01)
Peach	.57[a]	.64[a]	.37[b]
	(.03)	(.03)	(.03)
Pear	.82[a]	.72[a]	.46[b]
	(.06)	(.03)	(.08)
Pineapple	.73[a]	.59[b]	.39[c]
	(.05)	(.02)	(.02)
Plum	.77[a]	2.55[b]	.55[a]
	(.03)	(.88)	(.02)
Strawberries	.97[a]	1.17[b]	.36[c]
	(.05)	(.04)	(.01)
All fruits, unweighted	.76[a]	.96[b]	.37[c]
	(.02)	(.04)	(.01)
All fruits, weighted[2]	.53[a]	1.14[b]	.28[c]
	(.02)	(.26)	(.01)
Most-consumed fruits, unweighted[3]	.61[a]	.64[a]	.31[b]
	(.03)	(.03)	(.01)
Most-consumed fruits, weighted	.47[a]	.53[a]	.28[b]
	(.02)	(.03)	(.01)
Vegetables			
Asparagus	1.86[a]	2.86[b]	
	(.05)	(.11)	
Broccoli	.66[a]	.50[b]	
	(.04)	(.02)	
Carrots	.29[a]	.57[b]	
	(.01)	(.01)	

Continued

Table 4. *Continued*

Produce Item	*Dollars per 1-Cup Equivalent[1] (SE)* Fresh	Frozen or Canned	Juice
Collards	.29 [a] (.02)	.52 [b] (.03)	
Corn	1.02 [a] (.20)	.40 [b] (.01)	
Green Beans	.56 [a] (.02)	.42 [b] (.03)	
Onions	.37 [a] (.02)	.85 [b] (.05)	
Potato	.27 [a] (.01)	.34 [b] (.03)	
Spinach	.44 [a] (.03)	.80 [b] (.03)	
Summer Squash	.43 [a] (.01)	.63 [b] (.04)	
Sweet Potato	.62 [a] (.03)	.77 [b] (.05)	
Tomato (red)	.90 [a] (.06)	.41 [b] (.01)	.33 [b] (.02)
All vegetables, unweighted	.63 [a] (.03)	.77 [b] (.04)	
All vegetables, weighted[2]	.53 [a] (.02)	.41 [b] (.01)	
Most-consumed veg., unweighted[3]	.62 [a] (.05)	.44 [b] (.01)	
Most-consumed veg., weighted	.55 [a] (.02)	.38 [b] (.02)	

1 Differences determined by t-tests; different superscripts indicate a significant difference at $p<0.05$.
2 Each item has different weight by column, based on its contribution to fruit or vegetable intake in that form.
3 This index is made of the 3 most-consumed fruits with (apple, orange, grapes) and 4 most-consumed vegetables (potato, tomato, carrots and broccoli) with multiple forms available.

Appendix Tables

Appendix Table 1. Fruits selected for data collection and the contribution of each to overall and form sub-group intakes, NHANES 2005-08[1]

Fruit	% contribution of all forms to overall fruit intake [2]		% contribution to form sub-groups [3]		
	Item %	Cumulative %	Fresh	Frozen/ Canned	Juice
Observed fruit					
Apple	19.10	19.10	23.9	28.6	16.1
Grapes	4.70	23.80	6.9	0.0	3.8
Watermelon	2.62	26.42	7.8	n/a	.2
Peach	1.98	28.40	3.5	19.3	.2
Pear	1.41	29.81	3.6	8.0	.1
Cantaloupe	1.34	31.15	4.0	0.0	.1
Strawberries	1.22	32.37	3.6	1.9	.2
Plum	.33	32.70	1.0	.2	.2
Blueberries	.30	33.00	0.8	1.4	n/a
Orange	43.35	76.35	10.5	4.1	61.7
Pineapple	1.24	77.59	1.1	8.0	.9
All other fruit	22.41	22.41	33.3	28.5	16.8
Total	**100.00**	**100.00**	**100.0**	**100.0**	**100.0**

[1] Italicized fruits are those potentially produced in North Carolina.
[2] All forms of the fruit are included in the cumulative percent (e.g. applesauce, apple juice, raw apple).
[3] Percentages under each form column represent the contribution of all varieties of the row fruit to the given form (e.g. canned pineapple *in juice*, canned pineapple *in heavy syrup*, etc.).

Appendix Table 2. Vegetables selected for data collection and the contribution of each to overall and form sub-group intakes, NHANES 2005-08[1]

Vegetable	% contribution of all forms to overall vegetable intake[3]		% contribution to form sub-groups[2]		
	Item %	Cumulative %	Fresh	Frozen/ Canned	Juice
Observed vegetables					
White potato	31.2	31.2	21.2	28.7	
Tomato	13.3	44.5	14.1	13.4	80.2
Iceberg lettuce	6.5	51.0	12.9	n/a	
Corn	4.1	55.1	3.1	7.1	
String beans (Green)	3.6	58.7	1.6	6.7	
Carrot	3.3	62.0	4.1	.7	5.8
Cabbage	3.3	65.3	3.2	.1	
Broccoli	3.2	68.5	3.5	3.1	
Cucumber	2.5	71.0	3.0	3.6	
Onion	2.0	73.0	3.2	.1	
Pea, green	1.3	74.3	.4	3.1	
Mixed salad greens	1.2	75.5	2.4	n/a	
Spinach	1.1	76.6	1.2	1.2	
Squash, summer	1.0	77.6	1.6	.04	
Sweet potato	.9	78.5	1.1	1.3	
Collards	.7	79.2	1.0	.5	
Asparagus	.52	79.72	.8	.2	
Romaine	.42	80.14	.8	n/a	
All other vegetables	**19.9**	**19.9**	**21.0**	**30.2**	**14.0**
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

1 All of these vegetables are produced in North Carolina.

2 Percentages under each form column represent the sum contribution of all varieties of the row vegetable to the given form (e.g. whole tomatoes, crushed tomatoes, etc.).

3 All forms of the row vegetable are included (i.e. fresh carrots, frozen carrots, etc.).

Appendix Table 3. Characteristics of sampled outlets, North Carolina, 2011[1]

	Mean (SE)		
Characteristic	Supermarket	Farmers Market	Roadside Stand
Cash Registers	6.8 (0.4)		
Total vendors[2]		22.6 (3.6)	
Produce vendors[3]		9.6 (1.5)	
Yrs in Operation	15.6 (1.3)	16.7 (2.9)	8.3 (2.1)
Unique fresh fruits sold[4]	10.4 (0.2)	4.5 (0.4)	3.7 (0.6)
Unique fresh vegetables sold[5]	16.7 (0.3)	8.4 (0.6)	6.6 (1.0)
N	32	34	20

1 Data collected in the summer season. Results regarding fruits and vegetables sold vary slightly if data from a different season are used.
2 Total number of vendors observed, including crafts, garden plants, bread, cheese, etc.
3 Number of vendors observed selling fruits and vegetables.
4 Number of fruits available of the 11 included in survey.
5 Number of vegetables available of the 18 included in survey.

Appendix Table 4. Estimated effect of outlet type and quality characteristics on mean price per cup equivalent of most-consumed fresh fruits and vegetables, North Carolina, 2011

	Parameter Estimate[1] (SE)										
Variables	Apple	Orange	Watermelon	Grapes	Cantaloupe	White Potato	Tomato	Lettuce	Carrot	Broccoli	Cabbage
Farmers' Market[2]	-.05 (.03)	-.23 (.14)	-.19* (.06)	.02 (.12)	-.13* (.06)	.14 (.07)	-.25* (.11)	-.06 (.04)	.30* (.14)	-.17* (.08)	-.07 (.03)
Roadside Stand[2]	-.01 (.04)	-.23 (.14)	-.12 (06)	-.20 (.14)	-.20* (.06)	.09 (.06)	-.37* (.12)	.05 (.06)	.19 (.19)	-.11 (.09)	-.06 (.04)
Local[3]	.01 (.02)	-.08 (.10)	-.01 (.03)	.21* (.08)	.02 (.03)	.05 (.03)	.05 (.07)	-.05 (.05)	.04 (.09)	-.03 (.09)	.02 (.02)
Organic[4]	.11* (.15)	-.05 (.33)	.02 (.05)	.03 (.19)	.06 (.04)	.11* (.05)	.23* (.09)	.23* (.08)	.15 (.12)	.68* (.13)	.11* (.03)
Median City Inc[5]	<.01 (.00)	-.02 (.03)	.03* (.01)	.06* (.02)	.01 (.01)	.02* (.01)	.02 (.02)	<.01 (.01)	<.01 (.02)	.01 (.01)	-.01 (.01)
Constant	.35 (.03)	.78 (.14)	.31 (.04)	.63 (.12)	.46 (.05)	.21 (.06)	.82 (.10)	.24 (.06)	.29 (.12)	.53 (.12)	.21 (.03)
N	49	42	67	44	61	73	84	36	48	28	49

1 A * Indicates significance at $p<0.05$.
2 Compared to the reference category, supermarkets.
3 Local is defined as produced in the state of North Carolina.
4 Organic includes USDA certified organic items and those reported by vendors to be non-certified organic.
5 Median income of city in which market located, in thousands of dollars

Appendix Table 5. Mean weight or volume of fruits and vegetables sold by the item, by outlet type, North Carolina, 2011[1]

Produce Item	Form of Sale	Weight (lbs.) or Volume (cubic in.)[3] (SE) Super-market	Farmers Market	Roadside Stand	P-value
Fruits					
Blueberries	Pint	.75 (.02)	.82 (.04)	.79 (.06)	.24
Cantaloupe	Melon	3.12 (.14)	4.11 (.25)	4.33 (.26)	<.01
Pineapple	Fruit	3.53 (.08)	3.24 (.28)		.28
Watermelon[2]	Melon	405.09 (21.42)	515.30 (29.29)	464.69 (44.06)	.02
Vegetables					
Collards	Bunch	1.63 (.15)	2.22 (.62)	3.63 (1.01)	.02
Corn	Ear	.64 (.03)	.61 (.03)	.66 (.03)	.59
Romaine Lettuce	Head	1.27 (.10)	1.16 (.24)		.61
Spinach	Bunch	.68 (.03)	.83 (.08)		.17

1 Weights based on peak season for the particular fruit or vegetable: Blueberries, cantaloupe, pineapple, watermelon and corn from summer data; collards from fall data; romaine and spinach from spring data.
2 Watermelon comparisons based on volume of the fruit.

CHAPTER 6: NORTH CAROLINA FARMERS' MARKETS, ROADSIDE STANDS AND SUPERMARKETS OFFER COMPETITIVE FRUIT AND VEGETABLE PRICES ACROSS FOUR SEASONS

Natalie Valpiani

Corresponding Author:

Natalie Valpiani

Food Policy and Applied Nutrition Program

Gerald J. and Dorothy G. Friedman School of Nutrition Science and Policy

Tufts University

150 Harrison Avenue, Boston MA, 02111

Phone: 763-213-4604

E-mail: Natalie.valpiani@tufts.edu

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ABSTRACT

Objectives. This study compares produce prices observed at farmers' markets, roadside stands, and supermarkets in each season. Analyses examine whether the outlet types experience similar seasonal price patterns and whether the outlet types prove price competitive in all seasons.

Methods. Enumerators visited 34 sites in central and eastern North Carolina, each consisting of a supermarket, farmers' market and roadside stand, in each season of 2011. They recorded the lowest unit price available for each of 29 popular fruits and vegetables.

Results. Significant price differences between outlet types occurred in 31% of supermarket to direct retail outlet item comparisons ($p<0.05$). Differences were distributed across the seasons. Significant differences among outlet types in the magnitude of price change between seasons occurred in 18% of comparisons. No one outlet type consistently demonstrated larger seasonal price fluctuations.

Conclusions. North Carolina farmers' markets and roadside stands are price competitive with supermarkets year-round, though supermarkets offer more items for sale in the winter. All three outlet types could help consumers minimize the cost of meeting fruit and vegetable recommendations.

INTRODUCTION

Despite the documented health benefits of consuming sufficient fruits and vegetables, such as reduced risk of stroke, coronary heart disease and some cancers, most Americans fall short of meeting the daily intake recommendations outlined in the 2010 Dietary Guidelines for Americans [1-4]. Less than one-third of U.S. adults consume at least two servings of fruit or three servings of vegetables each day [5].

Both produce availability and price have received attention in research exploring the factors that influence fruit and vegetable consumption. Increased intake of fruits and vegetables has been associated with the presence of an additional supermarket per census tract, shorter distances to the nearest supermarket, or increased shelf space devoted to fruits and vegetables [6-8]. Additionally, researchers debate the extent to which price affects intake [9-12]. Recent work identified associations between lower fruit and vegetable prices and greater consumption, controlling for food outlet availability and other food prices [13]. Consumer perceptions alone regarding availability and price may also influence fruit and vegetable intake [14-15].

Motivated by this research documenting the importance of the food environment to produce intake, some have recommended the use of "local food" outlets, with direct farmer-to-consumer sales, to improve produce availability and affordability. For example, the addition of a farmers' market to an Ontario neighborhood increased produce availability and reduced the cost of a healthy food basket by 12% [16]. Several studies suggest that farmers' markets compete with supermarkets on price. Sommer et al. found fruits and vegetables at California farmers' markets to be nearly 40% less expensive than comparable supermarket items [17]. In North Carolina, McGuirt et al. found lower mean prices for nearly 80% of items [18]. Others found fewer significant differences, suggesting that prices are similar across outlets [19-20]. Concluding from these few studies that the outlet types are price competitive, however, may prove premature. Only one examined prices in the non-peak season. A 29% savings at the market was noted in the winter, but this figure was based on data from just one market [17].

The effect of seasonality on comparisons of direct retail to supermarkets merits further exploration for several reasons. First, the existence of seasonal variation in fresh fruit and vegetable prices has been documented in wholesale and traditional retail markets. Producer and wholesale prices may drop across an item's harvest season, as domestic supply peaks and augments imports available from year-round producers outside the United States [21-23]. Conversely, prices sometimes climb in the post-harvest season as supply declines [24]. Consumers also experience seasonal price swings. The Quarterly Food-at-Home Price Database, which provides market-level prices actually paid by U.S. households, reveals seasonal patterns in the relative price of dark green vegetables to starchy vegetables and the price of whole fruit compared to snacks [25].

Second, the magnitude and pattern of seasonal price changes may be different at direct retail outlets than at supermarkets. We hypothesize that seasonal price volatility at direct retail outlets exceeds that at supermarkets. McLaughlin outlines several findings about supermarket pricing that support such a hypothesis. He argues that retailers base prices more on local competition than prices paid to suppliers and that they seek to dampen price volatility due to a belief that consumers dislike price change. Furthermore, a large fraction of the retail price at supermarkets covers costs that do not fluctuate seasonally such as storage, transportation, packaging and marketing [26].

Greater seasonal price change at direct retail outlets, if it exists, may also be due to characteristics of these outlets. Farm-to-consumer direct marketing has fewer of the intermediate, relatively fixed costs described above in the chain between farm and fork [27]. Farmers lacking cold storage facilities may be willing to offer discounts to move supply at the peak of the local harvest season. Furthermore, rather than downplaying price volatility, the possibility of seasonal discounts has been used to promote local food [28-29]

Given this potential for different patterns of seasonal price variation by outlet type, this study explores whether seasonality affects conclusions about the price competitiveness of direct retail outlets as compared to supermarkets. Data collected in North Carolina are used to compare the availability and price of commonly consumed fruits and vegetables across three outlet types and the four seasons of the year. Several questions are explored. First, do direct retail outlets and supermarkets experience similar seasonal patterns in item availability and price volatility? Second, are fruits and vegetables least expensive during their local harvest season? And, finally, are direct retail outlets and traditional supermarkets price competitive in all seasons?

METHODS

Study Design

Studying the effect of outlet type on fruit and vegetable prices across seasons required a sample of sites, visited repeatedly throughout the calendar year. Thirty-four sites, each consisting of three retail outlet types, were selected and visited by enumerators in each of the four seasons. The study methods are summarized below.

Outlet Selection

The sampling plan was designed to select a sample representative of all farmers' markets operating in central and eastern North Carolina, along with a comparison supermarket and roadside stand in geographic proximity to each market. First, probability-proportional-to-size sampling, based on the number of food vendors at a market, was used to select 34 farmers' markets from a sampling frame of all markets in central and eastern North Carolina. Next, a supermarket was randomly sampled from those located within a five-mile drive of the farmers' market. Finally, a roadside stand was randomly sampled from a frame of all stands within a five-mile drive of the farmers' market. When no stand existed within five miles, a stand was drawn from those within ten miles. Roadside stands were available for 23 of the sites.

Produce Selection

Fruits and vegetables to be priced were selected to be representative of Americans' fruit and vegetable intake. Twenty-four hour dietary recall data collected by the nationally representative National Health and Nutrition Examination Survey (NHANES) were used to calculate the grams consumed of fruits and vegetables by Americans aged two years and older. The contribution of each item to total fruit or total vegetable intake, as well as to the intake of different produce forms (fresh, canned, frozen, and juice) was calculated and the items ranked accordingly.

This ranked list of fruits and vegetables was then consolidated to be as short as possible, while still representing close to 80% of total fruit and total vegetable consumption when considering all forms. Some items that contributed smaller amounts to total intake, such as blueberries, were included due to their importance in North Carolina direct retail. Others, like pineapple, were included because they proved important to a non-fresh form. Eleven fruits and eighteen vegetables were selected. Data were collected about fresh forms at all three outlet types, while data about canned, frozen and juice forms were collected only at supermarkets. The present analysis is based on fresh fruit and vegetable data only.

Seasonality

Enumerators visited each site once during each of the four seasons of 2011. The data collection periods were designed to be approximately evenly distributed over the year while capturing seasonal changes in North Carolina food production and availability. Each period was kept as short as possible to reduce the potential for intra-season price variation. Enumerators collected data according to the following schedule:

- *Winter:* January 18 - February 12, 2011
- *Spring:* April 30 - May 28, 2011
- *Summer:* July 16 - August 7, 2011
- *Fall:* October 1 – October 23, 2011

Data Collection Procedures

At each outlet, enumerators collected data about the availability, price, location of production and the methods of production (organic or conventional) for each fruit or vegetable. Data were collected about the variety with the lowest unit price. Prices were recorded as posted, either per pound or per item. For fresh items sold in standard packages, enumerators recorded the weight on the package. For those sold per item (e.g. cantaloupe) enumerators recorded the weight of three items. These weights were averaged during analysis to account for the variation in size among fresh produce items. Sales available by store loyalty card were recorded, while those available only with a coupon were not.

If multiple vendors sold produce at a farmers' market, enumerators sampled one vendor using a random number table. They then collected data for all the items available for sale by that vendor before repeating this procedure until they had completed as many items as possible. The instruments and protocol for this study were determined exempt from review by the Tufts University Institutional Review Board (IRB) at Medford.

ANALYSIS

Data cleaning and analysis was conducted in StataIC 10.0 (StataCorp, College Station, TX). The data were entered twice following each round. Discrepancies were corrected by referencing the paper forms. Supermarket prices were multiplied by 1.02 to account for the local food tax. Prices were converted from dollars per pound to dollars per cup equivalent as defined by the USDA MyPyramid Food Guidance System [30]. The number of edible cup equivalents in each item in its "as purchased" form was calculated as follows:

1. The weight of the observed item was converted from pounds to grams.
2. For fresh items, a percentage of the weight was subtracted to account for the portion not typically consumed (e.g. peel, seeds, etc.). This percentage was determined from the USDA National Nutrient Database for Standard Reference, Release 18.

3. The number of cup equivalents per 100 edible grams of each item was then calculated using the USDA MyPyramid Equivalents Database, 2.0.

Descriptive statistics were calculated to characterize the sample of outlets visited in each season and to describe the pattern of availability of each fruit and vegetable item across the four seasons, by outlet type.

The effect of outlet type on price per cup equivalent was examined for each produce item, in each season. Within a single season, the mean price per cup equivalent for an item at farmers' markets was compared to the price at supermarkets and roadside stands by employing one-way analysis of variance models (ANOVA) with Bonferroni corrections for multiple group comparisons. Additionally, weighted means were calculated across all fruits and vegetables. The price of each item was weighted by its contribution to total fresh fruit and vegetable intake, as reported in NHANES. Differences significant at $p<0.05$ and $p<0.01$ are reported.

Also of interest was whether the magnitude of price change observed from one season to the next, for each item, was consistently larger for one of the three outlet types. To compare seasonal price changes, ANOVA was used to model the price per cup equivalent of an item on season, outlet type and their interaction. A series of individual F-tests were then conducted to test the null hypotheses that the season to season change at one outlet type equaled the change at another outlet type. For example:

$$H_0: (P_{apple}\text{ winter, SM} - P_{apple}\text{ spring, SM}) - (P_{apple}\text{ winter, FM} - P_{apple}\text{ spring, FM}) = 0$$

These tests were conducted for changes from winter to spring, spring to summer, summer to fall, and fall to winter, and repeated for each fruit and vegetable.

RESULTS

Descriptive statistics suggest the relevance of seasonality to comparisons of supermarkets to direct food outlets. Descriptive findings are summarized here; see Appendix Table 1 for details. The number of each outlet type in operation varied by season. All supermarkets were open year-round. More than 29 or more farmers' markets were open from spring through fall, but only 12 of 34 remained open in winter. Most of the roadside stands were open in spring and summer, but only 14 were open in the fall and two in the winter. The number of fruits and vegetables sold also varied by season. The number of fruits available for sale peaked in the summer season, but remained fairly constant across seasons within each outlet type. Direct retail outlets displayed more seasonal variation than supermarkets in the number of vegetables available over the year (Appendix Table 1).

Examining the availability of each fruit and vegetable across the year revealed three patterns. First, a number of items were available at most supermarkets in all four seasons, but only seasonally at direct-retail outlets. For example, apples were available at all supermarkets in each season, but their availability at local outlets varied (Figure 1). Similarly, white potato and tomato availability peaked at direct retail outlets in the summer, while remaining constant at supermarkets year round (Figure 2). Three additional fruits and nine additional vegetables followed this pattern.

Second, availability proved seasonal at all outlet types for three vegetables and four fruits. The peach chart offers an example of this pattern (Figure 1). Availability peaks for all three outlet types in the summer when the percent of farmers' markets carrying peaches nearly equals that of supermarkets, but falls in other seasons, even at supermarkets. Similarly, corn was rarely observed at any outlet type in winter (Figure 2). Third, a few items were difficult to find in NC direct retail outlets throughout the year. At their peak, just seven farmers' markets and five roadside stands sold oranges (Figure 1). A similar pattern existed for pears, plums, iceberg lettuce and asparagus.

In addition to availability, the mean item prices were examined across outlet type and season. The graphed prices again reveal several patterns. First, some items were least expensive at one outlet type in all four seasons. White potatoes (Figure 2) and carrots (results not shown) were consistently least expensive at supermarkets. Others, such as cantaloupe (Figure 1) and tomatoes (Figure 2), were less expensive at local retail outlets in the item's peak local harvest season ($p< 0.05$). Still others were more expensive in the local harvest season (peaches, Figure 1) or showed very little difference between local direct retail and supermarket prices despite abundant local production (sweet potatoes, Figure 2). Overall, no outlet proved least expensive for a majority of items in any season.

Price comparisons and their significance are summarized in Table 1 (see Appendix Tables 2 & 3 for means). Reported across the row for each fruit or vegetable is the percent by which the farmers' market and roadside stand mean prices exceed the supermarket price for the given season. Several results prove noteworthy. Estimated mean prices for eight of the nine fruits were lowest at one of the direct retail outlets in the spring and/or summer, and these differences were significant for apples, cantaloupe, pears and plums (Table 1). For vegetables, however, farmers' markets were more expensive than supermarkets or roadside stands. Supermarkets had the lowest price for 16 of 21 significant vegetable price differences (Table 1). Overall, significant price differences among outlets occurred in 30.5% of the possible supermarket – direct retail outlet comparisons ($p<0.05$). Significant differences were distributed across the seasons.

Finally, Table 2 reports the magnitude of seasonal price changes by outlet type. In the case of a number of vegetables, supermarket prices varied little over the year and less than farmers' market prices for the item. This was true of carrots, iceberg and romaine lettuce, white and sweet potatoes, and tomatoes. For other items, however, such as blueberries, strawberries, watermelon and corn, prices fluctuated greatly between seasons at supermarkets as well as at direct retail outlets when available. Significant differences among outlet types in the magnitude of price change from one season to the next occurred in just 17.9% of supermarket versus direct retail comparisons. Of the significant differences observed, direct retail outlets often had the larger price change. Yet, across all results, no one outlet type consistently demonstrated larger price fluctuations.

DISCUSSION

Previous studies comparing fruit and vegetable prices at direct farmer-to-consumer retail outlets and supermarkets used data collected primarily in the peak harvest season. Questioning whether seasonality affects these comparisons, this study examined seasonal produce availability and price patterns at farmers' markets, roadside stands and supermarkets. Data collected in each season at 34 sites across North Carolina were analyzed in order to assess whether the outlets are price-competitive year-round.

It was hypothesized that price volatility from one season to the next would be greater at direct retail outlets than at supermarkets. While this proved true for some vegetables, there were few significant differences among outlet types in the magnitude of seasonal price shifts. Both supermarkets and direct retail outlets experienced large swings in prices. It was also expected that each fruit and vegetable would be cheapest during its local harvest season, especially at direct retail outlets, as supply peaked. This was not consistently the case; a few items were more expensive in their local harvest season.

Thus, one possible explanation for the local price competitiveness observed in previous studies, that local outlet prices reflect harvest season peaks in supply and seasonal price fluctuation better than do supermarkets, was not supported by these data. Instead, the price comparisons suggest that local retail outlets in central and eastern North Carolina are price competitive with traditional supermarkets not just in the local harvest season, but year-round. Price differences between outlet types were insignificant for the majority of item-season combinations; significantly lower prices that were noted were shared between local retail outlets and traditional supermarkets. In general, local food outlets fared better on fruit prices, whereas supermarkets offered lower vegetable prices.

To the extent that price affects fruit and vegetable intake, this ability of burgeoning local food outlets to offer competitive prices in all seasons may help to boost the consistency of produce intake across the year. Previous studies have documented seasonal fluctuation in both the type and quantity of fruit and vegetable intake. In one study in the northeastern United States, 78% of surveyed shoppers reported consuming particular certain fresh fruits only in the summer months (melons, peaches, and berries) and 67% reported consuming certain fresh vegetables only in the summer (corn, tomatoes, green beans, and squashes)[31]. Similarly, the proportion of 101 surveyed Hispanic farm workers who ate apples, pears, plums, peaches, apricots, peppers, corn, and cucumbers was highest in the fall harvest season, whereas the proportion eating cherries and asparagus were highest in the summer (harvest season for both) [32].

Research also notes changes in quantity of fruits and vegetables over the course of the year. The results of a 1980 survey of California shoppers, demonstrated that asparagus, bell peppers, broccoli, corn, green beans, strawberries and tomatoes were consumed significantly more frequently during the item's peak local growing season than during off-season months [33]. Though the marketing season for many fresh fruits and vegetables has lengthened since the early 1980s, recent studies still show seasonal fluctuations in consumption [25, 32, 34-35].

The importance of maintaining fruit and vegetable consumption across the year is supported by research which suggests that seasonal fluctuation in consumption may have negative health effects. The observed decline in frequency of fruit and vegetable consumption from summer to winter has been associated with altered serum carotenoid levels and chronic disease risk [36-38]. In one prospective study, men who reduced consumption of salad vegetables in winter had a 64% higher odds of developing cancer and women had a 47% higher odds of developing cardiovascular disease than those who maintained consumption across seasons [38].

For consumers with access to local food retail outlets, minimizing seasonal fluctuation in produce consumption at lowest cost may require legwork to understand price patterns in the particular locality. Just as no one outlet type consistently provided lower prices in a season, no outlet type offered larger seasonal swings in price across all items. The data presented here suggest that generalizations such as “local produce is cheaper in the harvest season” paint an inaccurate picture of the food price environment.

Though this study demonstrated the potential of farmers’ markets and roadside stands to provide competitively priced produce year-round, many were not open in all seasons. Of the 34 farmers’ markets and 23 roadside stands in our sample, just 35.3% and 8.7%, respectively, were open during the winter season. Less than two-thirds of the roadside stands were open in the fall. Furthermore, across seasons, direct retail outlets sold about half the observed vegetables and one-third of the observed fruits offered by supermarkets. These conditions are by design, as direct retail outlets often purposefully market only that which can be grown nearby. These conditions do, however, highlight the continued importance of traditional supermarkets in promoting year-round produce intake.

These results are subject to several limitations. First, prices may reflect real, unmeasured differences in produce quality. Such differences may explain some of the counterintuitive results, such as the higher price for farmers’ market peaches during the harvest season. Second, premiums at local food outlets may result in part from a greater availability of organic items for sale at these outlets than at supermarkets. However, controlling for organic production did not result in consistently lower prices at local outlets (results not shown). Third, these results remain specific to central and eastern North Carolina. This local specificity may be desirable, however, as seasonal price patterns have been shown to vary by region [25].

CONCLUSION

Farmers' markets and roadside stands were price competitive with traditional supermarkets year-round in central and eastern North Carolina. Consumers could utilize direct retail outlets, when in operation, as well as supermarkets to meet fruit and vegetable recommendations at minimal cost.

ACKNOWLEDGEMENTS

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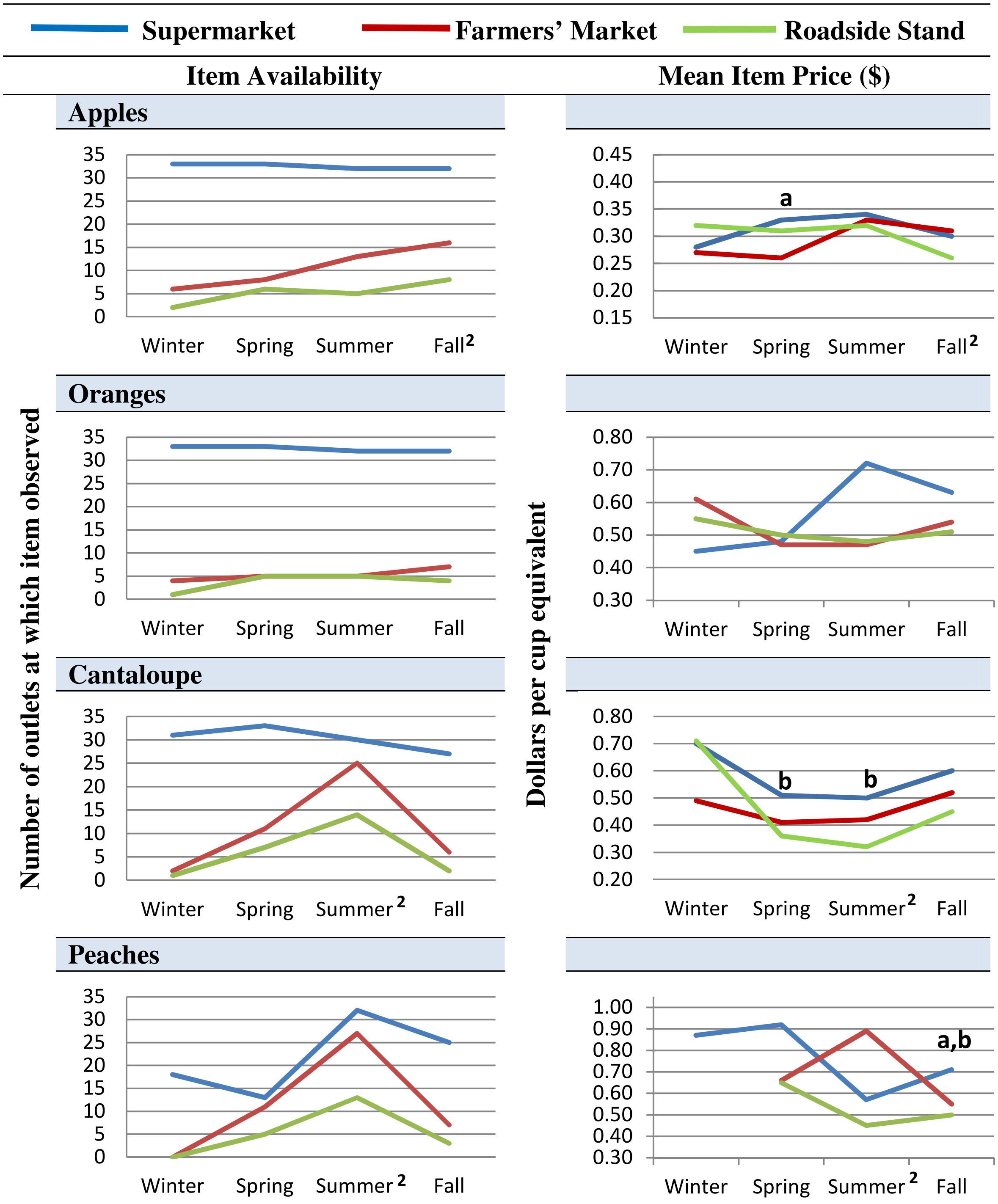
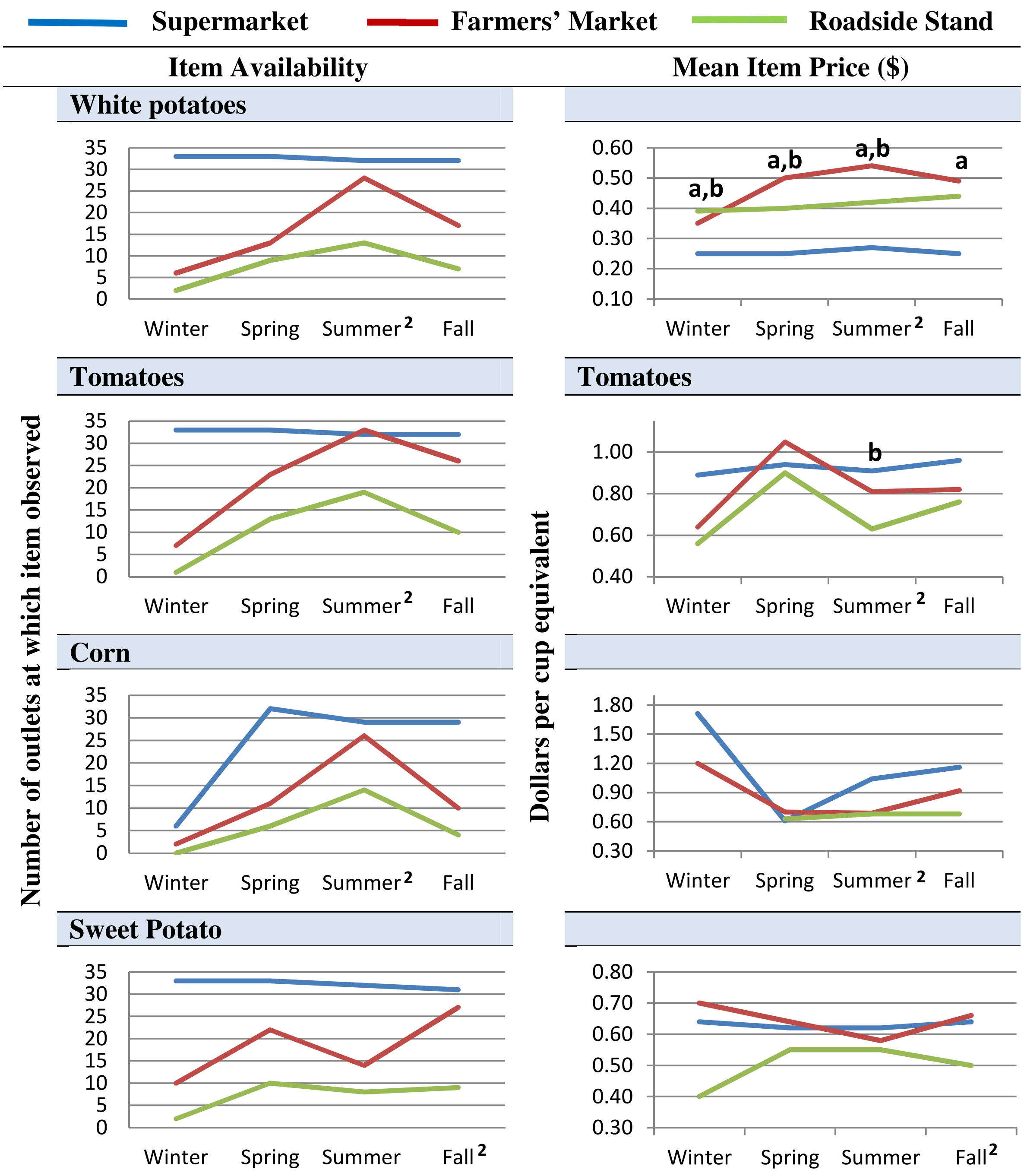
Figure 1. Availability and Mean Price of Selected Fruits, by Outlet and Season[1]



1 Differences significant at p<0.05; a = supermarket vs farmers' market, b = supermarket vs roadside stand, c = farmers' market vs roadside stand.
2 Peak harvest season of item in North Carolina.

Figure 2. Availability and Mean Price of Selected Vegetables, by Outlet Type and Season[1]



1 Differences significant at $p<0.05$; a = supermarket vs farmers' market, b = supermarket vs roadside stand, c = farmers' market vs roadside stand.
2 Peak harvest season of item in North Carolina.

Table 1. Percent by Which Mean Fruit and Vegetable Prices at Direct Retail Outlets Exceed Price at Comparison Supermarkets, by Season, North Carolina, 2011 [1, 2]

	Percent by which outlet mean price exceeds supermarket mean							
	Winter		Spring		Summer		Fall	
	Farmers Market	Roadside Stand	Farmers Market	Roadside Stand	Farmers Market	Roadside Stand	Farmers Market	Roadside Stand
Fruit								
Apples	- 3.6		-21.2 *	-6.1	-2.9	-5.9	3.3	-13.3
Blueberries					2.2	-18.7		
Cantaloupe			-19.6	-29.4 *	-16.0	-36.0 **	-13.3	
Grapes			-14.1	-25.9	12.5	-11.3	7.9	1.3
Oranges	35.6		-2.1	4.2	-34.7	-33.3	-14.3	-19.0
Peaches			-28.3	-29.3	56.1	-21.1	-22.5 **	-29.6 **
Pears			-52.1 **		-36.6		-25.0 *	
Pineapple			0.0		12.2		-20.6	
Plums				-14.7	-24.7*	-7.8	4.2	-5.6
Strawberry			13.2	-23.1	-2.1			-5.6
Watermelon			-40.7	-31.5	-48.1	-15.4	-54.2 **	
Means								
All fruit			-33.7 **	-37.2 **	-11.1	-29.2 **	-38.2 **	-42.7 **
All fruit, weighted			-19.3 *	-19.3 *	-10.5	-21.1 **	-19.0 *	-23.8 *

Continued

Table 1. *Continued*

	Winter		Spring		Summer		Fall	
	Farmers Market	Roadside Stand	Farmers Market	Roadside Stand	Farmers Market	Roadside Stand	Farmers Market	Roadside Stand
Vegetables								
Asparagus			43.8 **	19.5				
Broccoli			21.9	-4.7	-32.8	-29.9	9.7	6.5
Cabbage (green)	-30.0		5.9	-5.9	0.0	-23.5	-5.6	-27.8
Carrots	100.0 **		121.4 **	67.9	137.9 **	75.9	-3.6	
Collards	13.5		0.0		31.0		43.2	-27.0
Corn			14.8	3.3	-33.7	-34.6	-20.7	-41.4
Cucumber	-10.9		37.8	-11.1	-2.4	-4.8	-7.1	-11.9
Green Beans	-31.6 **		-13.5	-28.8 *	7.1	-8.9	-14.5	-23.2
Iceberg			20.7	6.9	-26.7	3.3	-16.7	
Mixed Greens			0.6				-33.8	
Onions	-16.7		72.4 **	51.7	37.8 **	0.0	37.5 **	12.5
Peas	-74.4		-31.3					
Potato (white)	40.0 *		100.0 **	60.0 **	100.0 **	55.6 *	96.0 **	76.0
Romaine	188.9 **		39.4	121.2 *	16.1		32.4 *	
Spinach	12.3		91.2 **	17.5	77.8 **		60.8	
Summer Squash	-30.8 *		0.0	0.0	-7.0	-16.3	-30.0 **	-26.7 **
Sweet Potato	9.4		3.2	-11.3	-6.5	-11.3	3.1	-21.9
Tomato (red)	-28.1		11.7	-4.3	-11.0	-30.8 *	-14.6	-20.8
Means								
All vegetables	-8.5		49.1 **	9.4	9.1	-5.5	-1.7	-15.3
All veg, weighted	-17.5		29.4 *	7.8	13.5	-9.6	3.8	-7.5

1 * $p < 0.05$, ** $p < 0.01$; A missing observation indicates that the item was available at two or fewer outlets of the given type.
2 See Appendix Table 4 for a comparison of farmers' market versus roadside stand prices

Table 2. Percent Change in Mean Fruit and Vegetable Prices from One Season to the Next, by Outlet; North Carolina, 2011 [1, 2, 3]

	Winter to Spring			Spring to Summer			Summer to Fall			Fall to Winter		
	SM	FM	RS	SM	FM	RS	SM	FM	RS	SM	FM	RS
Fruit												
Apples	17.9	-3.7		3.0	26.9	3.2	-11.8	-6.1	-18.8	6.7	12.9	
Blueberries	11.9			-54.0			139.6			19.0		
Cantaloupe	-27.1			-2.0	2.4	-11.1	20.0	23.8		-16.7		
Grapes	-10.5			-5.9	23.3	12.7	-5.0	-8.9	8.5	-25.0		
Oranges	6.7	-23.0		50.0	0.0	-4.0	-12.5	14.9	6.3	28.6	-13.0	
Peaches	5.7			-38.0	34.8	-30.8	24.6	-38.2	11.1	-22.5		
Pears	5.8			12.3	48.6		-12.2	3.8		4.2		
Pineapple	-5.9			15.6	29.7		-8.1	-34.9		0.0		
Plums	-2.9			-24.5		-18.4	-6.5	29.3 *	-4.2	-45.8		
Strawberry	-31.1			6.6	-7.8		48.5			8.3		
Watermelon	-53.8			-3.7	-15.6	18.9	59.6	40.7	-15.9	-41.0		
Vegetables												
Asparagus	-11.1			11.2			6.4			-5.0		
Broccoli	-3.0			4.7	-42.3 *	-23.0	-7.5	51.1	40.4	6.5		
Cabbage (green)	-15.0	28.6		0.0	-5.6	-18.8	5.9	0.0	0.0	11.1	-17.6	
Carrots	12.0	24.0		3.6	11.3	8.5	-3.4	-60.9 **		-10.7	85.2 *	
Collards	-8.1	-19.0		-14.7	11.8		27.6	39.5		0.0	-20.8	
Corn	-64.5			70.5	-1.4	7.9	11.5	33.3	0.0	48.3		
Cucumber	-2.2	51.2		-6.7	-33.9 *	0.0	0.0	-4.9	-7.5	9.5	5.1	
Green Beans	-34.2	-16.7		7.7	33.3	37.8	23.2	-1.7	3.9	14.5	-8.5	

Continued

Table 2. *Continued*

	Winter to Spring			Spring to Summer			Summer to Fall			Fall to Winter		
	SM	FM	RS	SM	FM	RS	SM	FM	RS	SM	FM	RS
Iceberg	0.0			3.4	-37.1	0.0	0.0	13.6	-41.9	-3.3		
Mixed Greens	5.4			10.9			-7.5			-7.5		
Onions	-19.4	66.7**		27.6	2.0	-15.9	-13.5	-13.7	-2.7	12.5	-31.8 *	
Peas	-46.2	44.2 *										
Potato (white)	0.0	42.9		8.0	8.0	5.0	-7.4	-9.3	4.8	0.0	-28.6	
Romaine	-8.3	-55.8 **		-6.1	-21.7		9.7	25.0		5.9	131.1 **	
Spinach	0.0	70.3 *		-21.1	-26.6		13.3	2.5		11.8	-22.0	
Summer Squash	-13.5	25.0 *		-4.4	-11.1	-20.0	39.5	5.0 **	22.2	-13.3	-14.3	
Sweet Potato	-3.1	-8.6		0.0	-9.4	0.0	3.2	13.8	-9.1	0.0	6.1	
Tomato (red)	5.6	64.1 *		-3.2	-22.9	-30.0	5.5	1.2	20.6	-7.3	-22.0	

1 Starred results indicate that the percent change in mean price for the outlet differed significantly from the change in supermarket mean price; * $p < 0.05$, ** $p < 0.01$. See Appendix Table 5 for significant differences in seasonal change between farmers' markets and roadside stands.
2 SM = Supermarket; FM = Farmers' Market; RS = Roadside Stand.
3 Missing data indicates that the item was available only at two or fewer outlets in one of the comparison seasons.

Appendix Table 1. Characteristics of Sampled Outlets, by Season North Carolina, 2011

	Mean (SE)											
	Winter			Spring			Summer			Fall		
	SM[1]	FM	RS	SM	FM	RS	SM	FM	RS	SM	FM	RS
Cash Registers	6.8 (0.4)	-	-	6.8 (0.4)	-	-	6.8 (0.4)	-	-	6.8 (0.4)	-	-
Total vendors[2]	-	9.7 (2.7)	-	-	23.7 (4.7)	-	-	22.6 (3.6)	-	-	20.7 (3.7)	-
Produce vendors[3]	-	2.5 (0.5)	-	-	7.4 (1.2)	-	-	9.6 (1.5)	-	-	7.3 (1.3)	-
Years in Operation	15.6 (1.3)	18.8 (3.8)	3.5 (.5)	15.6 (1.3)	16.9 (3.0)	8.3 (2.1)	15.5 (1.3)	16.7 (2.9)	8.3 (2.1)	15.7 (1.3)	17.6 (3.3)	7.2 (2.4)
Unique fresh fruits sold[4]	8.9 (.2)	2.6 (0.9)	3 2.0	9.3 (0.1)	2.7 (0.6)	2.9 (0.7)	10.4 (0.2)	4.5 (0.4)	3.6 (0.6)	9.6 (0.3)	2.4 (0.6)	2.6 (0.9)
Unique fresh veg. sold[5]	15.8 (0.5)	6.4 (1.6)	8.5 2.5	16.7 (0.3)	8.9 (0.8)	5.8 (1.1)	16.7 (0.3)	8.4 (0.6)	6.4 (1.0)	16.4 (0.4)	8.7 (0.7)	5.9 (1.4)
N	33	12	2	33	33	22	32	34	20	32	29	14

1 SM = supermarket; FM = farmers' market; RS = roadside stand
2 Total number of vendors observed, including crafts, garden plants, bread, cheese, etc.
3 Number of vendors observed selling fruits and vegetables.
4 Number of fruits available of the 11 included in survey.
5 Number of vegetables available of the 18 included in survey.

Appendix Table 2. Mean Fresh Fruit Prices ($/Cup Equivalent) by Outlet Type and Season, North Carolina, 2011[1]

	Mean (se)											
	Winter			Spring			Summer			Fall		
Fruit	SM	FM	RS	SM	FM	RS	SM	FM	RS	SM	FM	RS
Apples	.28	.27		.33	.26	.31	.34	.33	.32	.30	.31	.26
	(.01)	(.04)		(.01)	(.02)	(.03)	(.01)	(.04)	(.03)	(.01)	(.03)	(.03)
Blueberries	2.6			2.91			1.34	1.37	1.09	3.21		
	(.16)			(.11)			(.05)	(.12)	(.14)	(.17)		
Cantaloupe	.70			.51	.41	.36	.50	.42	.32	.60	.52	
	(.02)			(.03)	(.04)	(.05)	(.02)	(.03)	(.02)	(.04)	(.06)	
Grapes	.95			.85	.73	.63	.80	.90	.71	.76	.82	.77
	(.07)			(.06)	(.11)	(.14)	(.05)	(.11)	(.18)	(.04)	(.06)	(.10)
Oranges	.45	.61		.48	.47	.50	.72	.47	.48	.63	.54	.51
	(.02)	(.15)		(.02)	(.07)	(.03)	(.06)	(.07)	(.03)	(.03)	(.08)	(.02)
Peaches	.87			.92	.66	.65	.57	.89	.45	.71	.55	.50
	(.03)			(.12)	(.04)	(.09)	(.03)	(.26)	(.05)	(.02)	(.06)	(.11)
Pears	.69			.73	.35		.82	.52		.72	.54	
	(.03)			(.03)	(.10)		(.07)	(.08)		(.02)	(.07)	
Pineapple	.68			.64	.64		.74	.83		.68	.54	
	(.03)			(.03)	(.16)		(.06)	(.19)		(.07)	(.02)	
Plums	1.05			1.02		.87	.77	.58	.71	.72	.75	.68
	(.08)			(.10)		(.15)	(.03)	(.06)	(.03)	(.02)	(.16)	(.04)
Strawberry	1.32			.91	1.03	.70	.97	.95		1.44		1.36
	(.09)			(.04)	(.13)	(.08)	(.06)	(.08)		(.05)		(-)
Watermelon	1.17			.54	.32	.37	.52	.27	.44	.83	.38	
	(.06)			(.09)	(.03)	(.02)	(.11)	(.02)	(.14)	(.08)	(.05)	
Fruit Average	.90			.86	.57	.54	.72	.64	.51	.89	.55	.51
(Unweighted)	(.04)			(.04)	(.05)	(.04)	(.02)	(.06)	(.04)	(.04)	(.03)	(.05)
Fruit Average	.66			.57	.46	.46	.57	.51	.45	.63	.51	.48
(Weighted)	(.02)			(.02)	(.04)	(.03)	(.02)	(.04)	(.04)	(.02)	(.04)	(.06)

1 Missing data indicates that the item was available only at two or fewer outlets in one of the comparison seasons.

Appendix Table 3. Mean Fresh Vegetable Prices ($/Cup equivalent) by Outlet Type and Season , North Carolina, 2011 [1]

	Mean (se)											
	Winter			Spring			Summer			Fall		
Vegetable	SM	FM	RS	SM	FM	RS	SM	FM	RS	SM	FM	RS
Asparagus	1.90			1.69	2.43	2.02	1.88			2.00		
	(.08)			(.08)	(.26)	(.13)	(.05)			(.07)		
Broccoli	.66			.64	.78	.61	.67	.45	.47	.62	.68	.66
	(.04)			(.04)	(.07)	(.04)	(.05)	(.06)	(.04)	(.06)	(.12)	(.15)
Cabbage	.20	.14		.17	.18	.16	.17	.17	.13	.18	.17	.13
(green)	(.01)	(.02)		(.02)	(.02)	(.01)	(.01)	(.03)	(.01)	(.01)	(.02)	(.01)
Carrots	.25	.50		.28	.62	.47	.29	.69	.51	.28	.27	
	(.004)	(.12)		(.01)	(.16)	(.17)	(.01)	(.14)	(.22)	(.01)	(.03)	
Collards	.37	.42		.34	.34		.29	.38		.37	.53	.27
	(.03)	(.08)		(.03)	(.05)		(.03)	(.05)		(.03)	(.09)	(.05)
Corn	1.72			.61	.70	.63	1.04	.69	.68	1.16	.92	.68
	(.19)			(.04)	(.04)	(.06)	(.21)	(.06)	(.12)	(.08)	(.07)	(.07)
Cucumber	.46	.41		.45	.62	.40	.42	.41	.40	.42	.39	.37
	(.04)	(.07)		(.04)	(.10)	(.05)	(.03)	(.03)	(.03)	(.02)	(.03)	(.05)
Green Beans	.79	.54		.52	.45	.37	.56	.60	.51	.69	.59	.53
	(.03)	(.15)		(.03)	(.04)	(.04)	(.02)	(.04)	(.07)	(.02)	(.04)	(.02)
Iceberg	.29			.29	.35	.31	.30	.22	.31	.30	.25	
	(.02)			(.02)	(.18)	(.02)	(.02)	(.03)	(.03)	(.02)	(.05)	
Mixed Greens	1.48			1.56	1.57			2.13		1.60	1.06	
	(.25)			(.16)	(.16)			(.19)		(.12)	(.23)	
Onions	.36	.30		.29	.50	.44	.37	.51	.37	.32	.44	.36
	(.01)	(.04)		(.02)	(.08)	(.06)	(.02)	(.05)	(.03)	(.02)	(.04)	(.04)
Peas	6.36	1.63		3.42	2.35			2.35				
	(2.08)	(.88)		(.00)	(.29)			(.60)				

Continued

Appendix Table 3. *Continued*

	Winter			Spring			Summer			Fall		
	SM	FM	RS	SM	FM	RS	SM	FM	RS	SM	FM	RS
White Potato	.25	.35		.25	.50	.40	.27	.54	.42	.25	.49	.44
	(.01)	(.07)		(.01)	(.06)	(.03)	(.01)	(.05)	(.03)	(.02)	(.06)	(.09)
Romaine	.36			.33	.46	.73	.31	.36		.34	.45	
	(.02)			(.02)	(.06)	(.40)	(.02)	(.07)		(.02)	(.06)	
Spinach	.57	.64		.57	1.09	.67	.45	.80		.51	.82	
	(.03)	(.09)		(.03)	(.14)	(.27)	(.03)	(.19)		(.05)	(.16)	
Summer	.52	.36		.45	.45	.45	.43	.40	.36	.60	.42	.44
Squash	(.02)	(.03)		(.02)	(.04)	(.02)	(.01)	(.02)	(.03)	(.02)	(.03)	(.03)
Sweet Potato	.64	.70		.62	.64	.55	.62	.58	.55	.64	.66	.50
	(.03)	(.11)		(.03)	(.05)	(.04)	(.03)	(.05)	(.05)	(.04)	(.07)	(.05)
Tomato (red)	.89	.64		.94	1.05	.90	.91	.81	.63	.96	.82	.76
	(.05)	(.11)		(.06)	(.07)	(.09)	(.06)	(.06)	(.05)	(.05)	(.08)	(.05)
Veg. Average	.59	.54		.53	.79	.58	.55	.60	.52	.59	.58	.50
(Unweighted)	(.03)	(.05)		(.02)	(.04)	(.04)	(.02)	(.03)	(.03)	(.02)	(.03)	(.03)
Veg. Average	.57	.47		.51	.66	.55	.52	.59	.47	.53	.55	.49
(Weighted)	(.03)	(.05)		(.03)	(.05)	(.05)	(.04)	(.04)	(.03)	(.03)	(.04)	(.07)

1 Missing data indicates that the item was available only at two or fewer outlets in one of the comparison seasons.

Appendix Table 4. Percent by Which Roadside Stand Mean Price ($/Cup Equivalent) Exceeds Price at Comparison Farmers' Market, by Season; North Carolina, 2011 [1]

	Winter	Spring	Summer	Fall
Fruit				
Apples		19.2	-3.0	-16.1
Blueberries			-20.4	
Cantaloupe		-12.2	-23.8*	
Grapes		-13.7	-21.1	-6.1
Oranges		6.4	2.1	-5.6
Peaches		-1.5	-49.4	-9.1
Pears				
Pineapple				
Plums			22.4	-9.3
Strawberry		-32.0		
Watermelon		15.6*	63.0	-2.6
Vegetables				
Asparagus		-16.9		
Broccoli		-21.8	4.4	-2.9
Cabbage (green)		-11.1	-23.5	-23.5
Carrots		-24.2	-26.1	
Collards				-49.1
Corn		-10.0	-1.4	-26.1
Cucumber		-35.5	-2.4	-5.1
Green Beans		-17.8	-15.0	-10.2
Iceberg		-11.4	40.9	
Mixed Greens				
Onions		-12.0	-27.5	-18.2
Peas			-40.4	
Potato (white)		-20.0	-22.2	-10.2
Romaine Lettuce		58.7		
Spinach		-38.5*		
Summer Squash		0.0	-10.0	4.8
Sweet Potato		-14.1	-5.2	-24.2
Tomato (red)		-14.3	-22.2	-7.3
All fruit		-5.3	-20.3	-7.3
All fruit, weighted		0.0	-11.8	-5.9
All vegetables		-26.6***	-13.3	--13.8
All veg, weighted		-16.7	-20.3**	-10.9

1 * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; Missing data indicates that an item was available at two or fewer of an outlet in the given season.

Appendix Table 5. Significance of Differences Between Farmers' Markets and Roadside Stands in Magnitude of Change in Mean Price ($/Cup Equivalent) from One Season to the Next; North Carolina, 2011 [1, 2]

	Winter to spring	Spring to summer	Summer to fall	Fall to winter
Fruit				
Apples				
Blueberries				
Cantaloupe				
Grapes				
Oranges				
Peaches				
Pears				
Pineapple				
Plums				
Strawberry			RS *	
Watermelon				
Vegetables				
Asparagus				
Broccoli				
Cabbage (grn)				
Carrots				
Collards				
Corn				
Cucumber		FM **		
Green Beans				
Iceberg				
Mixed Greens				
Onions				
Peas				
Potato (white)				
Romaine Lettuce		RS **		
Spinach				
Summer Squash				
Sweet Potato				
Tomato (red)				
Means				
All fruit				
All fruit, weighted				
All vegetables		FM *		
All veg, weighted				

1 An outlet listed in the results column has the larger seasonal price change of the two outlets compared. * $p < 0.1$ ** $p < 0.05$ *** $p < 0.01$

2 FM = Farmers' market; RS = roadside stand

References

1. WCRF, AICR. Food, Nutrition, Physical Activity, and the Prevention of Cancer: a Global Perspective. In. Washington, DC: American Institute for Cancer Research; 2007.
2. U.S. Department of Agriculture, U.S. Department of Health and Human Services. Dietary Guidelines for Americans, 2010. Washington, D.C.: U.S. Government Printing Office; 2010.
3. Dauchet L, Amouyel P, Hercberg S, Dallongeville J. Fruit and vegetable consumption and coronary heart disease: a meta-analysis of cohort studies. *Journal of Nutrition* 2006;136(10):2588-93.
4. Report of the Dietary Guidelines Advisory Committee on the Dietary Guidelines for Americans, 2010. In. Alexandria, VA. : USDA Center for Nutrition Policy and Promotion; 2010.
5. Centers for Disease Control and Prevention. State Indicator Report on Fruits and Vegetables, 2009.
6. Larson NI, Story MT, Nelson MC. Neighborhood environments: disparities in access to healthy foods in the U.S. *Am J Prev Med* 2009;36(1):74-81.
7. Michimi A, Wimberly M. Associations of supermarket accessibility with obesity and fruit and vegetable consumption in the coterminous United States. *International Journal of Health Geography* 2010;8(9).
8. Bodor N, Rose D, Farley T, Swalm C, Scott S. Neighbourhood fruit and vegetable availability and consumption: the role of small food stores in an urban environment. *Public Health Nutrition* 2008;11:413-420.

9. Cassady D, Jetter K, Culp J. Is price a barrier to eating more fruits and vegetables for low-income families? *Journal of the American Dietetic Association* 2007;107:1909-1915.

10. Drewnowski A, Darmon N, Briend A. Replacing Fats and Sweets with Vegetables and Fruits - A Question of Cost. *American Journal of Public Health* 2004;94(9):1555-1559.

11. Dong D, Lin B-H. Fruit and vegetable consumption by low-income Americans: Would a price reduction make a difference? Washington D.C.: U.S. Department of Agriculture, Economic Research Service; 2009.

12. Pollard J, Kirk S, Cade J. Factors affecting food choice in relation to fruit and vegetable intake: a review. *Nutrition Research Reviews* 2002;15:373-387.

13. Powell L, Zhao Z, Wang Y. Food prices and fruit and vegetable consumption among young American adults. *Health & Place* 2009;15(4):1064-70.

14. Yeh M-c, Ickes S, Lowenstein L, et al. Understanding barriers and facilitators of fruit and vegetable consumption among a diverse multi-ethnic population in the USA. *Health Promotion International* 2008;23(1):42-51.

15. Caldwell E, Kobayashi MM, DuBow W, Wytinck S. Perceived access to fruits and vegetables associated with increased consumption. *Public Health Nutr* 2009;12(10):1743-50.

16. Larsen K, Gilliland J. A farmers' market in a food desert: Evaluating impacts on the price and availability of healthy food. *Health & Place* 2009;15:1158-1162.

17. Sommer R, Wing M, Aitkens S. Price Savings to Consumers at Farmers' Markets. *The Journal of Consumer Affairs* 1980;14(2):452-462.

18. McGuirt J, Jilcott S, Liu H, Ammerman A. Produce price savings for consumers at farmers' markets compared to supermarkets in North Carolina. *Journal of Hunger and Environmental Nutrition* 2011;6:86-98.

19. Pirog R, McCann N. Is local food more expensive?: A consumer price perspective on local and non-local foods purchased in Iowa. Ames; 2009.

20. Claro J. Vermont farmers' markets and grocery stores: A price comparison. Richmond: Northeast Organic Farming Association of Vermont; 2011:31.

21. Tronstad R. Importance of melon type, size, grade, container, and season in determining melon prices. *Journal of Agricultural and Resource Economics* 1995;20(1):32-48.

22. Parker D, Zilberman D, Moulton K. How quality relates to price in California fresh peaches. *California Agriculture* 1991;45(2):14-16.

23. Riley HE. Some aspects of seasonality in the consumer price index. *Journal of the American Statistical Association* 1961;56:27-35.

24. Schotzko RT, Granatstein D. A Brief Look at the Washington Apple Industry: Past and Present. Wenatchee: Washington State University.

25. Todd J, Leibtag E, Penberthy C. Geographic Differences in the Relative Price of Healthy Foods. Washington D.C.: U.S. Department of Agriculture; 2011.

26. McLaughlin E. The dynamics of fresh fruit and vegetable pricing in the supermarket channel. *Preventive Medicine* 2004;39:S81-S87.

27. Andreatta S, Wickliffe W. Managing Farmer and Consumer Expectations: A Study of a North Carolina Farmers Market. *Human Organization* 2002;61(2):167-176.

28. NY State Consumer Protection Board. Stretch your dollar effort: Grocery shopping tips. Available at: http://www.nysconsumer.gov/pdf/educating/shopping/on_your_syde_grocery_shopping_tips.pdf. Accessed July 19 2010.

29. CT Department of Consumer Protection. Saving Money at the Grocery Store. Available at: http://www.ct.gov/dcp/cwp/view.asp?a=1629&q=421268. Accessed July 19 2010.

30. Bowman S, Friday J, Moshfegh A. MyPyramid Equivalents Database, 2.0 for USDA Survey Foods, 2003-2004. Food Surveys Research Group. Beltsville, MD: Agricultural Research Service, U.S. Department of Agriculture; 2008.

31. Wilkins J. Consumer perceptions of seasonal and local foods: A study in a U.S. community. *Ecology of Food and Nutrition* 2002;41(5):415-439.

32. Locke E, Coronado GD, Thompson B, Kuniyuki A. Seasonal variation in fruit and vegetable consumption in a rural agricultural community. *J Am Diet Assoc* 2009;109(1):45-51.

33. Fjeld C, Sommer R. Regional-seasonal patterns in produce consumption at farmers' markets and supermarkets. *Ecology of Food and Nutrition* 1982;12:109-115.

34. Johnson A, McFetridge M, Durham C. Store-level retail fruit demand: Lessons from omitted variables. *Journal of Food Distribution Research* 2005;36(1):91-94.

35. Amanatidis S, Mackerras D, Simpson JM. Comparison of two frequency questionnaires for quantifying fruit and vegetable intake. *Public Health Nutr* 2001;4(2):233-9.

36. Božena Smolková, Mária Dušinská, Katar´ına Rašlová, et al. Seasonal changes in markers of oxidative damage to lipids and DNA; correlations with seasonal variation in diet. *Mutation Research* 2004;551:135-144.

37. Ziegler R, Wilcox H, Mason T, Bill j, Virgo P. Seasonal variation in intake of carotenoids and vegetables and fruits among white men in New Jersey. *American Journal of Clinical Nutrition* 1987;45:107-114.

38. Cox B, Whichelow M, Prevost T. Seasonal consumption of salad vegetables and fresh fruit in relation to the development of cardiovascular disease and cancer. *Public Health Nutrition* 2000;3:19-29.

CHAPTER 7: DISCUSSION AND CONCLUSION

This dissertation had two major aims. The first was to characterize national fruit and vegetable intake by form and identify the mean levels of nutrients of concern contained in items currently consumed in each form. The second aim was to evaluate whether local food retail outlets provide fresh fruits and vegetables for sale at prices that compete with traditional supermarkets in all seasons.

Taken together, the results of both aims suggest that local food retail outlets can provide, at competitive prices, the fresh fruits and vegetables that make up a large percentage of Americans' total produce intake. Their ability to do so does not depend on season; prices were found to be competitive in all four seasons. The results also suggest that the quality of Americans' fruit and vegetable intake could be improved either by increasing the percentage of total intake in fresh form or by choosing more low-sodium and low-sugar items within processed forms.

This chapter begins with a review of the key findings and contributions to the literature from each of the articles presented in this dissertation. It then comments on the implications of the findings. It concludes by making recommendations for future research and by discussing study limitations.

Review of Findings and Contributions to the Literature

Fresh versus Processed Question: Review of Findings

The first article presented in this dissertation utilized recent National Health and Nutrition Examination Survey (NHANES) dietary recall data to estimate the contribution of fresh, processed, juice and miscellaneous forms to the total fruit and vegetable intake of Americans. Associations between the estimated percentages and respondent age, race/ethnicity, and household income were assessed. The article also presented comparisons of the mean quantities of sodium, added sugar, and fiber present in cup equivalents of the produce items consumed by Americans in each form.

Estimates of the percent of total produce intake attributable to each form showed that fresh items make up the largest share of intake for both fruits and vegetables (61.2% and 48.1%, respectively). Fruit juice made up nearly one-third of fruit cup equivalents (31.2%); the contribution of vegetable juice was negligible (2.0%). Processed items made up nearly a quarter of vegetable intake, but less than five percent of fruit intake. The percentages differed significantly by form for both fruit and vegetables ($p<0.05$).

Several significant associations were identified between individual characteristics and form of fruit and vegetable intake. Older respondents consumed a larger percentage of both fruit and vegetables from fresh, while the percent of total intake from fruit juice and processed vegetables declined with age. The contribution of fresh fruit and vegetable items also increased significantly across household income category. Fruit juice and processed vegetable consumption showed the inverse, falling significantly as income rose. Some associations existed across race/ethnicity categories as well. For example, non-Hispanic Blacks consumed a significantly greater percent of fruit in juice form than in fresh form. White non-Hispanic Americans consumed significantly more fresh vegetables and fewer processed vegetables than Mexican Americans.

The mean quantity of sodium was greater in non-fresh forms of vegetables than non-fresh fruits; the reverse was true of added sugars. The mean milligrams of sodium per cup were highest for miscellaneous vegetables (818.7 mg/cup). Processed and juice forms followed, with no significant difference between these two forms (437.6 mg and 457.3 mg/cup, respectively). The mean teaspoons of added sugar per cup equivalent also varied significantly among fruit forms. A cup equivalent of processed fruit had the most added sugar per cup (4.9 tsp), whereas the fresh and juice fruits chosen by respondents contained very little added sugar (<.05 tsp).

The effect of seasonality was also examined. For example, the percent of fresh citrus, melon and berry fruit intake was significantly greater among May-October respondents (18.6%) than November and April respondents (12.6%). No seasonal change was noted for processed fruits and vegetables. A seasonal effect on fresh produce consumption was significant among high-income individuals, but not low-income individuals. Average nutrient content varied little between the two halves of the year.

Fresh versus Processed Question: Novel Contributions

This study contributes to the literature by offering a new method for breaking out NHANES dietary recall data on fruit and vegetable intake by processing form. Previous studies of fruit and vegetable consumption by form relied on availability data, or vegetable groups defined by food preparation type rather than processing form. Using this method, the article presents new estimates of associations between form of produce intake and demographic and socioeconomic variables. It also contributes estimates of the nutrient content by form, not of items available as could be assessed using food composition data, but of the items actually selected and consumed by Americans.

Supermarkets versus Local Retail Question: Review of Findings

The second and third articles presented in this dissertation explored the *Supermarket versus Local Retail Question.* The second article reports estimates of the mean prices of 29 fruits and vegetables at farmers' markets, roadside stands, and supermarkets at 34 sites in North Carolina. The study sought to determine whether local retail outlets are price competitive with traditional supermarkets using methods that improve upon previous price comparison studies. The effect of form on mean price was also assessed.

The results suggest that local food outlets are price-competitive with traditional supermarkets in the summer season. Considering simple item-specific mean prices, three fruits and one vegetable had a significantly lower price per cup equivalent at a local food outlet, while four vegetables were cheaper at supermarkets. The remaining 21 items had no significant differences.

Differences in the mean price for all fruits and all vegetables depended on whether or not the prices were weighted by consumption share. For example, mean fruit prices were significantly less expensive at local food outlets, but their price advantages shrunk when fruits were weighted by dietary importance. When prices were averaged and weighted for the five most-consumed fruits and six most-consumed vegetables, no significant difference remained in the mean prices across the outlet types. The results indicate that, especially for the most-popular fruits and vegetables, the three outlet types offer consumers similar prices.

Finally, the data collected on canned, frozen and juice items at supermarkets revealed that the least expensive form of a fruit or vegetable was not always fresh. Juice forms proved least expensive. Considering all the fresh fruits and vegetables available in both forms, fresh servings cost less than frozen/canned (fruit: $0.76 vs. $0.96; vegetable: $0.63 vs. $0.77). However, the difference in price lost significance when only the three most-consumed fruits were considered and reversed direction when considering the weighted mean of the most-consumed vegetables. Thus, in some cases, popular produce items cost less in processed form than fresh form.

The third dissertation article, also addressing questions related to the *Supermarket versus Local Retail Question,* focused on seasonality. The study used prices observed at North Carolina farmers' markets, roadside stands, and supermarkets in each season of the year. These prices were analyzed to determine whether fruit and vegetable prices fluctuate more at local retail outlets than at supermarkets. The question of whether the outlet types prove price competitive in all seasons was also answered.

Season had an impact on both the number of outlets open for business and the number of fruits and vegetables available for sale. All supermarkets were open year-round. More than 85% of the farmers' markets and most roadside stands were open from spring through fall, but only 12 farmers markets (35%) and 2 roadside stands (9%) were open in winter. The number of fruits and vegetables available also varied by season. Fifteen fruits and vegetables were available at supermarkets year round, but only seasonally at local food retail outlets. Availability of seven items was seasonal at all three outlet types.

Seasonality had a less consistent impact on prices. Some items, such as carrots and white potatoes, were least expensive at supermarkets in all seasons. Other items, such as tomatoes, were least expensive at local retail outlets in the peak local harvest season. Still others showed little difference between local direct retail and supermarket prices, even in the local harvest season. Overall, price differences among outlets occurred in just 27.2% of the supermarket versus local retail comparisons and no outlet proved least expensive for a majority of items in any season. Furthermore, the magnitude of seasonal price changes depended more on item than on outlet type. For some items, such as carrots, supermarket prices varied little and less than at local retail outlets. For other items, like melon and berries, prices fluctuated at all outlets. Few differences in the magnitude of change at one outlet type versus another were significant.

Supermarkets versus Local Retail Question: Novel Contributions

The research conducted to compare supermarkets versus local retail outlets improves upon previously employed methods in numerous ways. First, the research improves the representativeness of the sampled local retail outlets by employing PPS sampling. Markets of a variety of sizes were included; several previous studies had included only larger markets. Also, previously unstudied roadside stands were included. Second, the fruits and vegetables studied were selected primarily based on their importance in the American diet. The study reports the first weighted price comparisons; the interpretation of price differences is strengthened by results that prove more relevant to current fruit and vegetable purchasing and consumption habits. Finally, the research included non-fresh form prices, to enable exploration of whether fresh fruits and vegetables sold via local direct-retail prove not only price-competitive with fresh supermarket items, but also the most economical way to eat produce overall.

This study also advances local food retail literature by reporting price comparisons for all seasons. Of the existing price comparison studies, only one looks at farmers' market prices in the winter (Sommer, Wing, and Aitkens 1980). Two others observed prices over a series of weeks, but all observations took place in the spring and summer (Claro 2011; Lightner 2011). This is the first study to report year-round prices and to compare price change by outlet type. The results affirm the potential of local food outlets to offer competitive prices in all season, contingent on fruit and vegetable availability.

Implications of Findings

Americans currently consume just 59% of recommended vegetable servings and 42% of recommended fruit servings (USDA and DHHS 2010). Burgeoning local food retail outlets have been promoted as a means to increase fruit and vegetable intake. Indeed, local outlets may improve both access and intake. Yet, messages communicating that local fresh produce is the best form of produce may also have the effect of discouraging increased fruit and vegetable intake among low-income consumers, who may perceive the prices of fresh produce and farmers' market produce in particular as prohibitive. The results of this study's evaluation of "fresh is best" and "local food costs less" messages, reviewed above, have implications for future nutrition promotion messages and for the future use of local food outlets as a tool to boost fruit and vegetable intake.

Fresh versus Processed Question

This study evaluated the claim of advocates for locally grown produce that fresh is best. Existing literature compares the healthfulness of fresh versus processed fruits and vegetables, focusing on the effects on vitamin and antioxidant content of each form due to processing, harvesting conditions, transportation, retail conditions and typical consumer home storage (Rickman, Bruhn, and Barrett 2007; Rickman, Barrett, and Bruhn 2007; Kalt 2005; Vallejo, Tomas-Barberan, and Garcia-Viguera 2003). In this study, the focus was not on beneficial vitamins and phytochemicals, but rather on the content nutrients over-consumed by Americans, with detrimental health consequences.

The nationally representative results indicate that Americans choose to consume processed and miscellaneous items that are higher in sodium and added sugars than their fresh counterparts. The results suggest that diets could be improved if consumers shifted their fruit and vegetable intake away from processed items toward fresh items. Alternatively, they could be urged to make better choices within processed and miscellaneous forms. There exist a plethora of sodium and added-sugar free processed items on supermarket shelves that compare more favorably with fresh items on these nutrients than the items currently consumed by Americans. Some of these, processed immediately after harvesting, may even guard more micronutrients than fresh counterparts stored at warm temperatures or over long time periods. Consumers who continue to select processed items should be more strongly advised to select these low-sodium and low-sugar options.

The current, 2010 Dietary Guidelines for Americans offer such guidance, but it is buried in the details of the policy document rather than emphasized in key consumer recommendations. Previous research has indicated that fruits and vegetables, regardless of form, contribute a small percentage of total dietary sodium and sugar intake (Guthrie and Morton 2000; Cotton et al. 2004). Nonetheless, given the excessive consumption of both sodium and added sugars, even small reductions in intake from any food group should be sought.

The results of this part of the study also support the relevance of using local food retail outlets as a tool to boost overall fruit and vegetable intake. Farmers' markets and roadside stands primarily sell fresh fruits and vegetables. If this study had demonstrated that Americans prefer processed produce, local food retail outlets would fail to meet the needs of most consumers. Across the sample, however, nearly two-thirds of fruit and nearly half of vegetable cups consumed by Americans were in fresh form.

The reported associations between individual characteristics and percent of produce intake by form suggest that local food retail outlets may need to make a special effort to attract customers in particular demographic groups. On average, younger adults, non-Hispanic Blacks, and those with lower household incomes consume a smaller percent of their total produce from fresh fruits and vegetables. Local food outlet advocates and managers who believe in promoting fresh, locally grown foods to individuals from all walks of life should not discount these groups, as they do consume a substantial proportion of their produce in fresh form. Rather, they should seek to understand what motivates fruit and vegetable consumption patterns among these individuals. They can then use this information, be it related to ease of preparation, taste, familiarity, or price, to more effectively promote their fresh products to all.

Supermarkets versus Local Retail Question

Previous research suggests that low-income households perceive fresh fruits and vegetables, and especially locally grown produce, to be cost prohibitive. This study compared prices of fruits and vegetables across retail outlet type to assess whether local food outlets offer prices that are attractive not only to affluent customers, but also to shoppers seeking to meet recommendations with limited means. The results suggest that local retail outlets do offer prices as attractive as those at supermarkets, and that they do so even outside the peak local harvest season if they continue to operate in the off season.

These results thus lend support to the use of local food retail outlets as tools to boost fruit and vegetable access and intake in low-income and low-access neighborhoods (Nebeling et al. 2007; Blanck et al. 2011; Centers for Disease Control and Prevention 2011; Giang et al. 2008; Conner and Levine 2007). Several public and private programs are already operating on the assumption that local food outlets improve accessibility to affordable foods. For example, funding priority for 2012 federal Farmers' Market Promotion Program grants was given to projects seeking to develop producer to consumer retail in food deserts and low-income communities, "In an effort to reduce the number of urban, rural, and tribal areas with limited access to affordable and nutritious food in the United States" (U.S. Department of Agriculture Agricultural Marketing Service 2011). Public-private partnerships to promote produce consumption via farmers' markets also exist. The Boston Bounty Bucks program, for example, provides farmers' markets with terminals to accept SNAP benefits as well as dollar-for-dollar matching for all SNAP purchases up to ten dollars at markets in Boston, Massachusetts. In 2011 alone, $120,000 of combined SNAP benefits and BBB matching dollars were spent at markets in Boston (The Food Project 2012). The results of this study suggest that investing in such local retail initiatives can help consumers maximize their fruit and vegetable budget as effectively as investments in expanding access to traditional supermarkets.

However, the disconnect between the results presented here, which demonstrated the competitiveness of local retail outlets, and the perception of many consumers that farmers' markets are more expensive than supermarkets, suggests a need for more effective consumer education on the issue of prices. Local retail outlets may wish to consider strategies such as special promotions for first-time customers or coupons for certain, abundant seasonal items to attract hesitant shoppers who could then discover that the prices are in line with those they would pay at the supermarket. Local food supporters who are most concerned with bolstering farmer incomes may balk at promotions that emphasize low market prices. Yet, by ensuring that local food systems are accessible to people of all backgrounds, price competitiveness could serve to boost local food system use, sales and sustainability.

Furthermore, while these results demonstrated that local retail outlets offer competitive prices in all seasons, numerous fruits and vegetables were not available at local retail outlets year round as they were at supermarkets. This is an unfortunate limitation of their ability to address food access issues, especially given that the start up and operating costs of local retail outlets are much lower than those of traditional supermarkets (Briggs et al. 2010). Though the aim of many farmers' markets and roadside stands is to sell only products grown by local producers, those outlets seeking to meet produce needs in food deserts should perhaps consider a type of hybrid structure whereby only those products that are locally grown are sold in the local growing season and items grown elsewhere are sold in the off-season. This would enable the market to offer a consistent selection year round at comparable prices to a traditional supermarket. There is a precedent at some markets for the sale of items grown outside the local area: nationally, nearly 29% of farmers' market vendors sell some items that they did not produce (Ragland and Tropp 2009). Further research would be needed to assess the impact of such a market structure on consumers' interest in shopping at it.

Study Limitations

Fresh versus Processed Question

There are several limitations related to the *Fresh versus Processed Question.* First, relying on the NHANES food description to categorize fruits and vegetables by processing form resulted in substantial percentage of vegetable items being classified as "form not specified" (the description included this phrase; 7.6% of total cups), or "miscellaneous" (18.9% of total cups). Properly classifying these vegetables as fresh or processed, were such an effort possible, might have altered the observed nutrient content results or the results describing percent of total intake by form.

Second, it is possible that the results for mean sodium, added sugar, and fiber content per cup equivalent were skewed by a few heavily consumed items in a particular processing form. For example, perhaps the greatest *number* of processed vegetables chosen by Americans is of the low-sodium canned variety, but the greatest *quantity* of processed vegetables consumed is frozen, French fried potatoes that are high in sodium. The overall processed vegetable mean would disguise the fact that consumers make smart decisions when purchasing processed vegetable items. A related caveat is that the nutrient content results, particularly for sodium per cup, would likely have been affected by disaggregating the processed category into canned and frozen forms.

Supermarkets versus Local Retail Question

There are also limitations related to the *Supermarket versus Local Retail Question.* First, data collection did not include an assessment of produce quality, aside from the observation of fruit and vegetables' organic status. Other means of visually assessing product quality were deemed too subjective. Thus, prices may reflect real, unmeasured differences in produce quality. Farmers' market customers have reported a belief that locally grown items are fresher, more nutritious and better tasting (Brown 2003; Thilmany, Bond, and Bond 2008; Keeling Bond, Thilmany, and Bond 2009). If this holds true, local food retail prices may have been at a disadvantage by a failure to control for superior quality.

Similarly, the mean prices for each outlet type may include prices for both organic and conventional items. Previous studies have examined price results separately for the two types of produce (Claro 2011; McGuirt et al. 2011). Because organic items often command a price premium, there may have been a greater number of significantly lower mean prices at local retail outlets had this study also included observation and comparison of two separate sets of data.

Finally, the results of this portion of the study may only be generalized to farmers' markets in central and eastern North Carolina. Due to resource limitations, the study did not include sites in the western mountain region of the state. Furthermore, because growing seasons, harvest seasons, and produce items grown locally vary widely across states and regions, a similar study conducted elsewhere may reveal quite different results. Nonetheless, this dissertation provides a detailed account of study methods; these methods could be utilized to replicate the research in other locations.

Recommendations for Future Research

Fresh versus Processed Question

The first article presented in this dissertation suggests several areas ripe for future research. The results presented above give the mean sodium, added sugar, and fiber content by processing form across the entire sample of respondents. Future studies should identify associations between demographic and socioeconomic characteristics and the nutrient content of produce items in each processing form. For example, it is possible that the majority of processed fruits high in added sugar are consumed by children and teenagers. In a related vein, research should seek to identify products within each processing form that contribute a substantial proportion of the mean quantity of each nutrient. Knowledge on both issues would enable even more effective creation and targeting of future fruit and vegetable education and promotion.

Future research should also delve further into potential links between form of fruit or vegetable consumed and health outcomes. Studies have looked at the relationship between juice intake and health outcomes, but few have also considered other processing forms like canned, frozen and dried items (Bazzano et al. 2008; Oude Griep et al. 2011; Oude Griep et al. 2010). Finally, studies could examine whether changes in nutrition guidance to more strongly emphasize the importance of selecting products low in sodium and added sugars would in fact impact purchasing decisions. It could be the case that strong taste preferences would negate any benefits from improved education on this matter.

Supermarkets versus Local Retail Question

This study provides the first data identified on prices at roadside stands as compared to traditional supermarkets. The current local food retail literature has a dearth of information on roadside stands (Lev and Gwin 2010). Future research should explore this retail outlet type further. Useful research topics include the availability of roadside stands, the profile of customers who frequent them, the average volume of fruit and vegetable sales, and factors that promote or limit their successful operation.

Future research could also examine the effects of local food retail outlets on prices at traditional supermarkets. Natural experiments made possible by the opening of new farmers' markets or roadside stands would enable comparison of fruit and vegetable prices at nearby supermarkets before and after the addition of the market. The effects of a new local food retail outlet on supermarket produce sales could also be studied. It is possible that sales fall as customers shift their produce purchasing to the farmers' market or roadside stand. Alternatively, produce sales at the supermarket may increase if consumers gain new knowledge of and appreciation of fruits and vegetables that they then purchase at the supermarket when shopping for non-produce items or when visiting the store on non-market days.

Conclusion

This dissertation contributes novel data to an ongoing national debate about the most healthful way to increase fruit and vegetable intake. The results point to two overarching conclusions. First, while Americans consume more fruits and vegetables in fresh form than any other form, the processed produce items they choose contribute sodium and added sugars to their diets. Dietary guidance should place stronger emphasis on the need to select processed items low in these nutrients. Second, local food retail outlets offer fruits and vegetables at prices comparable to those of supermarkets. This price competitiveness held regardless of season. With efforts to boost the number of items offered outside the growing season, local retail outlets could play key roles in improving access to affordable fruits and vegetables.

References

Bazzano, L. A., T. Y. Li, K. J. Joshipura, and F. B. Hu. 2008. Intake of fruit, vegetables, and fruit juices and risk of diabetes in women. *Diabetes Care* 31 (7):1311-7.

Blanck, H. M., O. M. Thompson, L. Nebeling, and A. L. Yaroch. 2011. Improving fruit and vegetable consumption: use of farm-to-consumer venues among US adults. *Prev Chronic Dis* 8 (2):A49.

Briggs, Suzanne, Andy Fisher, Megan Lott, Stacy Miller, and Nell Tessman. 2010. Real food, real choice: Connecting SNAP recipients with farmers' markets. Portland, OR: Community Food Security Coalition.

Brown, Cheryl. 2003. Consumers' preferences for locally produced food: A study in southeast Missouri. *American Journal of Alternative Agriculture* 18 (4):213-224.

Centers for Disease Control and Prevention. 2011. Strategies to Prevent Obesity and Other Chronic Diseases: The CDC Guide to Strategies to Increase the Consumption of Fruits and Vegetables. Atlanta.

Claro, Jake. 2011. Vermont farmers' markets and grocery stores: A price comparison. Richmond: Northeast Organic Farming Association of Vermont.

Conner, David, and Ralph Levine. 2007. Circles of association: The connections of community-based food systems. *Journal of Hunger and Environmental Nutrition* 1 (3):5-25.

Cotton, Paul, Amy Subar, James Friday, and Annetta Cook. 2004. Dietary sources of nutrients amont US adults, 1994 to 1996. *Journal of the American Dietetic Association* 104:921-930.

Giang, T., A. Karpyn, H. B. Laurison, A. Hillier, and R. D. Perry. 2008. Closing the grocery gap in underserved communities: the creation of the Pennsylvania Fresh Food Financing Initiative. *J Public Health Manag Pract* 14 (3):272-9.

Guthrie, Joanne, and Joan Morton. 2000. Food sources of added sweeteners in the diets of Americans. *Journal of the American Dietetic Association* 2000 (100):43-48, 51.

Kalt, Wilhelmina. 2005. Effects of production and processing factors on major fruit and vegetable antioxidants. *Journal of Food Science* 70 (1):R11-R19.

Keeling Bond, Jennifer, Dawn Thilmany, and Craig Bond. 2009. What influences consumer choice of fresh produce purchase location? *Journal of Agricultural and Applied Economics* 41 (4):61-74.

Lev, Larry, and Lauren Gwin. 2010. Filling in the gaps: Eight things to recognize about farm-direct marketing. *Choices*.

Lightner, Robyn. 2011. Healthy food in underserved Boston neighborhoods: The affordability and viability of farmers' markets. Boston, MA: The Food Project.

McGuirt, Jared, Stephanie Jilcott, Haiyong Liu, and Alice Ammerman. 2011. Produce price savings for consumers at farmers' markets compared to supermarkets in North Carolina. *Journal of Hunger and Environmental Nutrition* 6:86-98.

Nebeling, L., A. L. Yaroch, J. D. Seymour, and J. Kimmons. 2007. Still not enough: can we achieve our goals for Americans to eat more fruits and vegetables in the future? *Am J Prev Med* 32 (4):354-5.

Oude Griep, L. M., J. M. Geleijnse, D. Kromhout, M. C. Ocke, and W. M. Verschuren. 2010. Raw and processed fruit and vegetable consumption and 10-year coronary heart disease incidence in a population-based cohort study in the Netherlands. *PLoS One* 5 (10):e13609.

Oude Griep, L. M., W. M. Verschuren, D. Kromhout, M. C. Ocke, and J. M. Geleijnse. 2011. Raw and processed fruit and vegetable consumption and 10-year stroke incidence in a population-based cohort study in the Netherlands. *Eur J Clin Nutr* 65 (7):791-9.

Ragland, Edward, and Debra Tropp. 2009. USDA National Farmers Market Manager Survey, 2006. Washington, DC: U.S. Department of Agriculture.

Rickman, Joy, Diane Barrett, and Christine Bruhn. 2007. Nutritional comparison of fresh, frozen and canned fruits and vegetables. Part 1. Vitamins C and B and phenolic compounds. *Journal of the Science of Food and Agriculture* 87:930-944.

Rickman, Joy, Christine Bruhn, and Diane Barrett. 2007. Nutritional comparison of fresh, frozen and canned fruits and vegetables. Part 2. Vitamin A and carotenoids, Vitamin E, minerals and fiber. *Journal of the Science of Food and Agriculture* 87:1185-1196.

Sommer, Robert, Margaret Wing, and Susan Aitkens. 1980. Price Savings to Consumers at Farmers' Markets. *The Journal of Consumer Affairs* 14 (2):452-462.

The Food Project. 2013. *Boston Bounty Bucks*. The Food Project 2012 [cited February 26 2013]. Available from http://thefoodproject.org/bountybucks.

Thilmany, Dawn, Craig Bond, and Jennifer Bond. 2008. Going local: Exploring consumer behavior and motivations for direct food purchases. *American Journal of Agricultural Economics* 90 (5):1303-1309.

U.S. Department of Agriculture, and U.S. Department of Health and Human Services. 2010. Dietary Guidelines for Americans, 2010. Washington, D.C.: U.S. Government Printing Office.

U.S. Department of Agriculture Agricultural Marketing Service. *FMPP: Guidelines, Grants and Final Reports, FY 2012*. U.S. Department of Agriculture, February 19, 2013 2011. Available from http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELPRDC5097653.

Vallejo, Fernando, Francisco Tomas-Barberan, and Cristina Garcia-Viguera. 2003. Health-promoting compounds in broccoli as influenced by refrigerated transport and retail sale period. *Journal of Agricultural and Food Chemistry* 51:3029-3034.

APPENDIX 1: DATA COLLECTION INSTRUMENTS

This appendix contains the instrument used to collect fruit and vegetable data at North Carolina retail outlets. It also defines five variables observed in data collection, but not described above. These variables were not utilized in the analyses presented in this dissertation.

Additional Variables

For each fruit or vegetable item, enumerators recorded not only the lowest price at which the item was sold, but also the price for the variety of the item with the most shelf space. The price of the variety with the most shelf space was also recorded, based on the possibility that the least-expensive variety of an item may not always be the most purchased variety. Many items, such as fresh apples or frozen potatoes, were sold in more than one variety and/or size. When this was the case, enumerators compared varieties and sizes to determine that with the most space. Rules were set for distinguishing between "different" varieties of an item, and defined shelf space:

- *Fresh:* Varieties of fresh fruits and vegetables were considered different if their names differed (e.g., Red Delicious vs. Fuji apples) or if their packaging differed (e.g., loose potatoes vs. a 10-pound bag of potatoes).
- *Processed:* Distinct processed items were distinguished in three ways:
  - *Size:* We considered Mott's 16-ounce applesauce a different product than Mott's 32-ounce applesauce, because the size of the jars differed.

- *Brand:* Mott's 16-ounce applesauce was distinct from White House 16-ounce applesauce because the brand differed.
- *Nutrition Characteristics:* Mott's 16-ounce original applesauce was considered a different product than Mott's 16-ounce *unsweetened* applesauce, because their nutrition characteristics differed.

Sugar Content

For each canned or frozen fruit or fruit juice, enumerators recorded phrases from the product labels describing how the item was sweetened (e.g., "in syrup") in the Comments box. They also indicated whether items were "Sweetened" or "Reduced Sugar" as follows:

- "Sweetened": Sweetened items included applesauce labeled as "Original", "Cinnamon", or "Chunky"; fruit and sweet potatoes canned in heavy syrup; and fruit frozen "with sugar" or in syrup.
- "Reduced Sugar": Reduced sugar items included applesauce labeled as "Natural" or "Unsweetened"; fruit canned in light syrup, juice or water; unsweetened or "fresh frozen" frozen fruit; and all 100% juices and nectars.

Sodium content

Enumerators recorded the labeled phrase describing sodium content of processed items. They also indicated whether items were "Regular" or "Reduced Sodium" based on this classification:

- “Reduced Sodium”: All canned or frozen vegetables labeled as “Low sodium”, “Reduced sodium”, “No salt added”, “No sodium” or with another phrase indicating reduced sodium content such as “Fresh Frozen”.
- “Regular”: All other items were considered “Regular” sodium items.

Processing Type

This string variable refers to the variety of fresh or processed fruit or vegetable observed. For example, the enumerator might record “Granny Smith” in an apple row, or “Crushed” in an entry for canned pineapple. Enumerators recorded the type, when applicable, in the Type box of each row. If several varieties tied for lowest price, both were noted in the Type box.

Brand

Finally, enumerators also recorded the brand of each item, if applicable, in the comments box. To preserve the confidentiality of participating stores, private-label store-brand items were described as “Store”. Other brands were recorded by the name observed.

Data Collection Instrument

The supermarket data collection instrument is below. The farmers’ market and roadside stand instruments were identical for the fresh items sections only.

Supermarket Data Collection Instrument

North Carolina Fruit and Vegetable Purchasing Survey

Retail Outlet General Information

Enumerator name:

____

Outlet Number: ☐☐☐ — ☐

Observation Date:
/ /
month day year

Record time at which observation
Begins: *Ends*:

☐☐ ☐☐ ☐☐ ☐☐

A.M. A.M.
P.M. P.M.P.M.
P.M.

In the boxes below: Record the number of cash registers

☐☐

Operating hours of this outlet
Days Open:

Hours Open:

Does this outlet accept SNAP benefits?
- ☐ Yes
- ☐ No

Does this outlet accept WIC benefits?
- ☐ Yes
- ☐ No

For how many years has this outlet been in operation?

☐☐

Comments

To ask questions or return a found survey, please contact Natalie Valpiani
Ph: 763-213-4604 | 110 N Marion Drive, Goldsboro NC 27534

North Carolina Fruit and Vegetable Purchasing Survey

Supermarket Section 1: Fresh Fruit

PROCEED TO THE PRODUCE DEPARTMENT and RECORD DATA FOR FRESH FRUIT ONLY. PLEASE CHECK TO SEE THAT YOU HAVE COMPLETED ALL BOXES BEFORE MOVING TO THE NEXT SECTION.]

Item	Type	Drawn	Price ($)	Unit	Weight of 3 pcs (lbs)	Local	Organic	Comments
Apple [ ] Available [ ] Unavailable								
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org [ ] No	
Pear [ ] Available [ ] Unavailable								
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org [ ] No	
Orange [ ] Available [ ] Unavailable								
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org [ ] No	
Peach [ ] Available [ ] Unavailable								
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org [ ] No	
Plum [ ] Available [ ] Unavailable								
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	

Item	Type	Drawn	Price ($)	Unit	Weight of 3 pcs (lbs)	Local	Organic	Comments
Blueberries [ ] Available [ ] Unavailable								
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	
Strawberries [ ] Available [ ] Unavailable								
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	
Grapes [ ] Available [ ] Unavailable								
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cer, org methods [ ] No	
Cantaloupe [ ] Available [ ] Unavailable								
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	
Watermelon [ ] Available [ ] Unavailable								
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	
Pineapple [ ] Available [ ] Unavailable								
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	

Supermarket Section 2: Fresh Vegetables

[PROCEED TO THE PRODUCE DEPARTMENT and RECORD DATA FOR FRESH VEGETABLES ONLY. PLEASE CHECK TO SEE THAT YOU HAVE COMPLETED ALL BOXES BEFORE MOVING TO THE NEXT SECTION.]

Item	Type	Drawn	Price ($)	Unit	Weight of 3 pcs (lbs)	Local	Organic	Comments
White potato [ ] Available [ ] Unavailable								
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	
Tomato, Red [ ] Available [ ] Unavailable								
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	
Lettuce, Iceberg [ ] Available [ ] Unavailable								
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	
Corn, Ear [ ] Available [ ] Unavailable								
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	
String Beans, Green [ ] Available [ ] Unavailable								
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	

Item	Type	Drawn	Price ($)	Unit	Weight of 3 pcs (lbs)	Local	Organic	Comments
Carrots, Whole [ ] Available [ ] Unavailable								
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	
Cabbage, Green [ ] Available [ ] Unavailable								
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	
Broccoli, Bunch [ ] Available [ ] Unavailable								
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	
Cucumber [ ] Available [ ] Unavailable								
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	
Onion, Any Color [ ] Available [ ] Unavailable								
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	
Peas, Green [ ] Available [ ] Unavailable								
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	

Item	Type	Drawn	Price ($)	Unit	Weight of 3 pcs (lbs)	Local	Organic	Comments
Mixed Salad Greens			[ ] Available		[ ] Unavailable			
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	
Spinach, Bunch			[ ] Available		[ ] Unavailable			
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	
Summer Squash, Green or Yellow			[ ] Available		[ ] Unavailable			
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	
Sweet Potato			[ ] Available		[ ] Unavailable			
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	
Collard Greens, Bunch			[ ] Available		[ ] Unavailable			
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	
Asparagus			[ ] Available		[ ] Unavailable			
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	
Romaine Lettuce			[ ] Available		[ ] Unavailable			
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	

Supermarket Section 3: Canned Fruit

[PROCEED TO THE CANNED FRUITS. PLEASE CHECK TO SEE THAT YOU HAVE COMPLETED ALL BOXES BEFORE MOVING TO THE NEXT SECTION.]

Item	Type	Drawn	Price ($)	Unit	Weight of 1 pc (oz)	Local	Organic	Nutrition Charact.	Comment
Applesauce [ ] Available [ ] Unavailable									
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	☐ Sweetened ☐ Reduced sugar	
Canned Pear [ ] Available [ ] Unavailable									
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	☐ Heavy syrup ☐ Reduced sugar	
Canned Orange [ ] Available [ ] Unavailable									
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	☐ Heavy syrup ☐ Reduced sugar	
Canned Peach [ ] Available [ ] Unavailable									
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	☐ Heavy syrup ☐ Reduced sugar	
Canned Plum [ ] Available [ ] Unavailable									
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	☐ Heavy syrup ☐ Reduced sugar	
Canned Grapes [ ] Available [ ] Unavailable									
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	☐ Heavy syrup ☐ Reduced sugar	

Canned Pineapple [ ] Available [ ] Unavailable									
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	☐ Heavy syrup ☐ Reduced sugar	

Supermarket Section 4: Canned Vegetables

[PROCEED TO THE CANNED VEGETABLES. PLEASE CHECK TO SEE THAT YOU HAVE COMPLETED ALL BOXES BEFORE MOVING TO THE NEXT SECTION.]

Item	Type	Drawn	Price ($)	Unit	Weight of 1 pc (oz)	Local	Organic	Nutrition Charact.	Comm-ent
Canned Tomatoes, Whole [ ] Available [ ] Unavailable									
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org [ ] No	☐ Regular ☐ Reduced sodium	
Canned Corn [ ] Available [ ] Unavailable									
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org [ ] No	☐ Regular ☐ Reduced sodium	
Canned String Beans, Green [ ] Available [ ] Unavailable									
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org [ ] No	☐ Regular ☐ Reduced sodium	
Canned Cucumber Pickle, Dill [ ] Available [ ] Unavailable									
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org [ ] No	☐ Regular ☐ Reduced sodium	

Canned Green Peas			[ ] Available		[ ] Unavailable				
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	☐ Regular ☐ Reduced sodium	
Canned Spinach			[ ] Available		[ ] Unavailable				
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	☐ Regular ☐ Reduced sodium	
Canned Sweet Potato			[ ] Available		[ ] Unavailable				
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	☐ Regular ☐ Reduced sodium	
Canned Collard Greens			[ ] Available		[ ] Unavailable				
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	☐ Regular ☐ Reduced sodium	
Canned Asparagus			[ ] Available		[ ] Unavailable				
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	☐ Regular ☐ Reduced sodium	

Supermarket Section 5: Frozen Fruit

[PROCEED TO THE FROZEN FOODS DEPARTMENT and RECORD DATA FOR FROZEN FRUIT ONLY. PLEASE CHECK TO SEE THAT YOU HAVE COMPLETED ALL BOXES BEFORE MOVING TO THE NEXT SECTION.]

Item	Type	Drawn	Price ($)	Unit	Weight of 1 pc (oz)	Local	Organic	Nutrition Charact.	Comments
Peaches			[ ] Available		[ ] Unavailable				
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	☐ Sweetened ☐ Unsweetened	

Blueberries			[ ] Available		[ ] Unavailable				
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	☐ Sweetened ☐ Unsweetened	
Strawberries			[ ] Available		[ ] Unavailable				
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	☐ Sweetened ☐ Unsweetened	
Cantaloupe			[ ] Available		[ ] Unavailable				
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	☐ Sweetened ☐ Unsweetened	

Supermarket Section 6: Frozen Vegetables

[RECORD DATA FOR FROZEN VEGETABLES ONLY. PLEASE CHECK TO SEE THAT YOU HAVE COMPLETED ALL BOXES BEFORE MOVING TO THE NEXT SECTION.]

Item	Type	Drawn	Price ($)	Unit	Weight of 1 pc (oz)	Local	Organic	Nutrition Charact.	Comments
White Potato				[ ] Available		[ ] Unavailable			
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	☐ Regular ☐ Reduced sodium	
Carrots				[ ] Available		[ ] Unavailable			
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	☐ Regular ☐ Reduced sodium	

Onion, Any Color [ ] Available [ ] Unavailable									
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	☐ Regular ☐ Reduced sodium	
Summer Squash, Green or Yellow [ ] Available [ ] Unavailable									
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	☐ Regular ☐ Reduced sodium	
Broccoli [ ] Available [ ] Unavailable									
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	☐ Regular ☐ Reduced sodium	

Supermarket Section 7: Fruit and Vegetable Juice

[THESE ITEMS MAY BE FOUND IN DIFFERENT SECTIONS OF THE STORE. ONCE YOU HAVE COMPLETED THIS FINAL SECTION, PLEASE CHECK BACK THROUGH THE ENTIRE QUESTIONNAIRE AND COMPLETE ALL FIELDS BEFORE LEAVING THE STORE.]

Item	Type	Drawn	Price ($)	Unit	Volum (oz)	Local	Organic	Nutrition Charact.	Comments
100% Orange Juice, Refrigerated [ ] Available [ ] Unavailable									
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	☐ Regular ☐ Reduced sugar	
100% Apple Juice, Bottled [ ] Available [ ] Unavailable									
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	☐ Regular ☐ Reduced sugar	

100% Grape Juice, Bottled				[ ] Available		[ ] Unavailable			
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	☐ Regular ☐ Reduced sugar	
100% Peach Nectar				[ ] Available		[ ] Unavailable			
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	☐ Regular ☐ Reduced sugar	
100% Pear Nectar				[ ] Available		[ ] Unavailable			
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	☐ Regular ☐ Reduced sugar	
100% Cantaloupe Nectar				[ ] Available		[ ] Unavailable			
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	☐ Regular ☐ Reduced sugar	
100% Strawberry Juice				[ ] Available		[ ] Unavailable			
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	☐ Regular ☐ Reduced sugar	
100% Pineapple Juice				[ ] Available		[ ] Unavailable			
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	☐ Regular ☐ Reduced sugar	
100% Tomato Juice				[ ] Available		[ ] Unavailable			
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	☐ Regular ☐ Reduced sodium	
100% Prune Juice				[ ] Available		[ ] Unavailable			
Lowest price				Lb Pc		☐ Yes [ ] No ☐ Not sure	☐ Certified [ ] Not sure ☐ Non-cert, org methods [ ] No	☐ Regular ☐ Reduced sugar	

APPENDIX 2: OPERATIONAL FRUIT AND VEGETABLE DEFINITIONS

The following instructions are taken from the enumerator field manual. They describe the fruits and vegetables that were to be included in observations.

Fresh Fruit

Apple: Observe and compare both loose and bagged apples. Record type observed in the **Type** column.

Pear: Do not include Asian pears. Record the type observed under the **Type** column.

Orange: Observe both loose and bagged oranges. Do not include tangerines or tangelos. Record the type observed under the **Type** column.

Peach: Observe and compare both white and yellow peaches.

Plum: Include red and black plums in your observation. Record type observed under the **Type** column.

Blueberries: Blueberries are likely to be packaged. Determine which package provides the cheapest unit price; record the package weight (e.g. "pint, 8 oz").

Strawberries: Strawberries are also likely to be packaged. Determine which package provides the cheapest unit price; record the package weight.

Grapes: Include red and green grapes. Record the type observed under the **Type** column.

Cantaloupe: You may need to weigh the three cantaloupes individually, depending on their size. *If whole cantaloupes are not available*, mark "unavailable". Observe one of the following substitutes, in order: Wrapped cantaloupe halves, wrapped quarters, then packaged chunks.

Watermelon: Include both seeded and seedless varieties. Record the variety observed under the **Type** column. Do not weigh watermelon. Measure the length and the circumference at the center of oval melons. Measure just the circumference of small, round melons. Observe oval melons first, and if these are unavailable, then round. *If whole watermelons are not available*, mark "unavailable". Observe one of the following substitutes, in order: Wrapped watermelon halves, wrapped quarters, then packaged chunks.

Pineapple: You may need to weigh the three pineapples individually, depending on their size. *If whole pineapples are not available*, mark "unavailable". Observe the following substitute: packaged pineapple chunks. Record "packaged chunks" in the Type column.

Fresh Vegetables

White potato: Observe both loose and bagged potatoes. White potatoes include Russet, White, Yukon Gold. Do not include red or purple potatoes. Record type observed in the **Type** column.

Tomato, red: Do not include grape, cherry, or Roma tomatoes. Do include tomatoes on the vine. If red tomatoes are not available at a farmers' market or road side stand, record "unavailable". Then, look for a substitute heirloom variety that may be a different color and record data for that variety. Record the type observed under the **Type** column.

Lettuce, Iceberg: Observe heads of iceberg, and record whether wrapped or unwrapped. *If whole Iceberg heads are not available*, mark "unavailable". Then, look for the least-processed substitute, such as chopped, but not pre-washed lettuce. Record information about the packaging and item form. **Do not** observe salad kits.

Corn, ear: Include both white and yellow corn. Observe corn with the husk. *If corn with the husk is not available*, mark "unavailable". Then, look for the least-processed substitute, such as whole, but already shucked and wrapped. Often, these packages contain three ears of corn. Record "3-ear package" and weigh 3 packages.

String Beans, green: Observe loose string beans. *If loose string beans are unavailable*, mark "unavailable". Then, look for the least-processed substitute, such as packaged, but not cut or pre-washed beans. Record information about the packaging and form, as well as package weight.

Carrots, whole: Include both loose and packaged whole carrots. **Do not** include baby carrots. Consider packages of different weight (1-Lb, 2-Lb, 5-Lb) different items.

Cabbage, green: Observe heads of cabbage. Note on data form if wrapped. *If whole heads of cabbage are not available*, mark "unavailable". Then, look for the least-processed substitute. Record information about the packaging and cabbage form. **Do not** include prepared cabbage salads, such as packaged coleslaw. Record the form and packaging observed.

Broccoli, bunch: Look for loose, bunch broccoli. *If loose bunch broccoli is not available,* mark “unavailable”. Then, look for the least-processed substitute, beginning with loose broccoli heads or wrapped bunches, and then loose or packed florets. Record the type and packaging observed.

Cucumber: Record data for whole, loose cucumbers. Do not include English cucumbers. *If loose cucumbers are not available*, mark “unavailable”. Then, observe the least-processed substitute. Record the type and packaging observed.

Onion, any color: Observe whole, loose and bagged root onions. Do not include green onions. Record the type observed under the **Type** column. Do not include shallots or pearl onions.

Peas, green: Observe loose, whole green peas (round pod, garden peas). *If loose green garden peas are not available*, mark “unavailable”. Then, look for the least-processed substitute, such as loose snap peas or packaged snap peas. Record information about packaging, form and package weight.

Mixed salad greens: Observe loose mixed greens. *If loose mixed greens are not available*, observe the least-processed substitute, such as packaged mixed greens. Include Spring Mix or Garden Mix varieties. Record whether loose or packaged.

Spinach, bunch: Observe loose, bunch spinach. *If loose bunch spinach is not available*, mark “unavailable”. Observe the least-processed substitute, such as unwashed, bagged whole leaf spinach. **Do not** observe baby spinach. Record information about packaging and form.

Summer squash, green or yellow: Observe both green and yellow squash. *If loose squash are unavailable,* observe the least-processed substitute, such as wrapped whole squash.

Sweet potato: Observe loose and bagged sweet potatoes and yams. Record whether loose or bagged.

Collard Greens, bunch: Observe loose bunch collard greens. *If loose bunch greens are not available*, mark “unavailable”. Then, observe the least-processed substitute. Record data about whether the item was loose or packaged.

Asparagus: Observe bunch asparagus. *If bunch asparagus is not available*, mark “unavailable”. Observe the least-processed substitute, such as packaged whole asparagus. Record information about the observed packaging and form.

Lettuce, Romaine: Observe loose heads of romaine. *If loose heads are not available*, mark “unavailable”. Observe the least-processed substitute. Observe packaged romaine hearts before chopped romaine. **Do not** include salad kits. Record information about the packaging and form.

Canned Fruit

Applesauce: **Do not** include applesauce blended with other fruits. Record any labeled information describing the sugar content/sweetening of the applesauce in the Comments box.

Pear: **Do not** include mixtures such as fruit cocktail, or a mixture of pears and peaches. Record if “sliced”, “irregular pieces” or “halves” in the “Type” box. Record the type of canning liquid (e.g. water, juice, light syrup, etc) in the Comments box.

Orange: Canned oranges will be labeled as mandarin oranges. For each item observed, record the type of canning liquid.

Peach: **Do not** include fruit mixtures or a combination of pears and peaches. Record if “sliced”, “irregular pieces” or “halves” in the “Type” box. Record the type of canning liquid in the Comments box.

Plum: **Do not** include fruit mixtures. For each item observed, record the type of canning liquid.

Grapes: Observe any color of grape. For each item observed, record the type of canning liquid.

Pineapple: **Do not** include fruit mixtures. Consider crushed pineapple, pineapple rings, and pineapple chunks. Record this “cut” type in the comments box. Record the type of canning liquid in Comments.

Canned Vegetables

Tomatoes, whole: Record any labeled information describing the sodium content. If the label on the can actually includes the word “Roma” do not include that item. If the label does not include “Roma,” then include the item even if you suspect it might be Roma tomatoes.

Corn: Include white and yellow corn. Indicate white or yellow in the “Type” box. **Do not** include corn mixed with other vegetables or creamed corn. Record information describing the sodium content.

String beans, Green: Record the type of cut in the “Type” box. Record any labeled information describing the sodium content.

Cucumber Pickles, Dill: Include any type of *dill* pickle (whole, spears, sandwich rounds, etc.). Do not include sweet pickles or relishes. Record any labeled information describing the sodium content.

Green Peas: **Do not** include peas mixed with any other vegetable. Record any labeled information describing the sodium content in the Comments box.

Spinach: Include whole and cut leaf spinach. Record any labeled information describing the sodium content.

Sweet potatoes: Include sweet potatoes and yams. Record any labeled information describing the sodium or sugar content. Record if labeled as "candied" or "in syrup".

Collard Greens: Record any labeled information describing the sodium content or seasoning in the Comments box.

Asparagus: Observe whole spears if available. *If whole spears not available,* observe asparagus tips. Record any labeled information describing the sodium content.

Frozen Fruit

Peaches: **Do not** include peaches mixed with other fruits. Record any labeled information describing the sugar content/sweetening of the peaches. Include pie filling if plain peaches are unavailable.

Blueberries: **Do not** include blueberries mixed with other fruits. Record any labeled information describing the sugar content/sweetening of the blueberries.

Strawberries: **Do not** include strawberries mixed with other fruits. Record any labeled information describing the sugar content/sweetening of the strawberries.

Cantaloupe: **Do not** include cantaloupe mixed with other fruits. Record any labeled information describing the sugar content/sweetening of the cantaloupe.

Frozen Vegetables

White potato: Include any form of potato (tater tots, French fries, oven fries, hash browns, mashed). Record the form selected in the "Type" box. Record any labeled information describing the sodium content.

Carrots: **Do not** include carrots mixed with any other vegetable. If the item has a sauce, describe it in the **Comments** column. Describe whether whole or cut in the

"Type" box. Record any labeled information describing the sodium content or if fresh frozen.

Onion, any color: Include whole and chopped onions. Record information on the form of the onion, and any labeled information describing the sodium content or if fresh frozen.

Summer Squash, Green or Yellow: First look for squash not mixed with any other vegetables. If this is unavailable, check "unavailable". Only then should you note the price of squash mixed with any other vegetable. If the item has a sauce, describe it in the **Comments** column. Record any labeled information describing the sodium content or if the item is fresh frozen.

Broccoli: **Do not** include broccoli mixed with any other vegetable. Describe the form (Cut, florets, spears) in the "Type" column. If the item has a sauce, describe it in the **Comments** column. Record any labeled information describing the sodium content or if the item is fresh frozen.

Fruit and Vegetable Juice

100% Orange Juice: Observe refrigerated orange juice. **Do not** include mixed-fruit juice. Note if the juice is made from concentrate in the "Type" box. Record any labeled information describing the sugar content of the juice. Record if fortified in the Comments box and include the vitamins.

100% Apple Juice: Observe shelf-stable apple juice. Include cider labeled "100% Cider". **Do not** include mixed-fruit juice, like cran-apple. Note if the juice is made from concentrate in the "Type" box. Record any labeled information describing the sugar content of the juice. Record if fortified.

100% Grape Juice: Observe shelf-stable grape juice, both white grape juice and purple/red grape juice. **Do not** include mixed-fruit juice, like cran-grape. Note if the juice is made from concentrate in the "Type" box. Record any labeled information describing the sugar content of the juice. Record if fortified.

Peach Nectar: **Do not** include mixed-fruit juice nectars. The container should say "100% Nectar". Note if the juice is made from concentrate in the "Type" box. Record any labeled information describing the sugar content of the juice. Record if fortified.

Pear Nectar: **Do not** include mixed-fruit nectars. The container should say "100% Nectar". Note if the juice is made from concentrate in the "Type" box. Record any labeled information describing the sugar content of the juice. Record if fortified.

Cantaloupe Nectar: **Do not** include mixed-fruit nectars. Note if the juice is made from concentrate in the "Type" box. The container should say "100% Nectar". Record any labeled information describing the sugar content of the juice. Record if fortified.

100% Strawberry Juice: **Do not** include mixed-fruit juice. The container should say "100% Juice" or "100% Nectar". Note if the juice is made from concentrate in the "Type" box. Record any labeled information describing the sugar content of the juice. Record if fortified.

100% Tomato Juice: Observe bottled and canned tomato juice. **Do not** include mixed vegetable juice. Note if the juice is made from concentrate in the "Type" box. Record any labeled information describing the sodium content of the juice.

100% Prune Juice: **Do not** include mixed-fruit juice.. Note if the juice is made from concentrate in the "Type" box. Record any labeled information describing the sugar content of the juice. Record if fortified.