

The Consumption of Frozen Fruit and Vegetables in the Context of Malnutrition and Obesity: New Brunswick, Canada

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Abstract: Malnutrition, reflected in the prevalence of obesity, is increasingly affecting the developed countries. For the first time in human history the number of people in the world who are overweight approaches that of the underweight. Faced with the economic and personal cost of chronic diseases caused by obesity, public health organizations are promoting increased consumption of produce (fruit and vegetables): in most of Europe and North America (as well as many developing countries where obesity has become a challenge), people are not eating the minimum recommended by the World Health Organization. The reason for low consumption of fruit and vegetables may be affordability, but low consumption may also be due to other factors. Among these could be availability, convenience or a perception that alternatives to fresh produce (such as frozen produce) are less nutritious. This paper focuses on frozen produce by asking consumers to compare it with fresh produce. Highlighting concerns that inhibit consumption of frozen fruit and vegetables could benefit public health. A random survey is undertaken to determine preferences between fresh and frozen produce, with their attributes ranked according to Analytic Hierarchy Process. The context is a province in Canada, New Brunswick, but it is hoped lessons can be transferred to other jurisdictions.

Key words: produce; nutrition and marketing

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1. Introduction

Malnutrition, now affects almost one-third of the world's population, and is increasingly a problem of overweight, with the number of overweight people approaching that of underweight people for the first time in world history (FAO, 2014). Overweight is more prevalent than underweight in adults in China, Egypt, Mexico and the Philippines (FAO, 2014). In Colombia, 41 percent of the population are overweight, and in Brazil, 36 percent.

Good nutrition requires the consumption of fruit and vegetables (F&V). Not only are F&V a means of weight management, but produce also has many important nutrients, including potassium, vitamin C, folate, fiber, and numerous phytochemicals (USDA, 2015). Fruit and vegetables are two of the four recommended food groups (USDA, 2015). The World Health Organization (WHO) recommends a daily intake of 400 grams of F&V¹, which is more than the average consumed in North America and in most of Western Europe (WHO, 2008). A diet high in

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¹ The 400 grams does not include potatoes and other starchy tubers.

F&V is associated with reduced obesity², and consequent risk of many chronic diseases, including heart disease, stroke, high blood pressure, diabetes, and some cancers. The WHO estimated that 6.7 million deaths worldwide in 2010 were attributable to inadequate consumption of F&V (WHO, 2014).

This paper focuses on the consumption of F&V in the Canadian province of New Brunswick. The paper examines consumer choice when purchasing fresh and frozen F&V. Globally, consumers want foods that are tasty, readily available, affordable, convenient to acquire and prepare, safe and healthy (FAO & WHO, 2004). Promoting frozen produce could be one step towards enhancing consumption of F&V, and therefore mitigating obesity.

Initially the paper indicates some evidence about the nutritional value of fresh and frozen produce in the context of malnutrition. The second and third sections provide the methodology and the results, while the concluding section explores implications for marketing and public policy.

2. Malnutrition and the Nutritional Value of Fresh and Frozen Produce

Most countries in Europe and North America are in the third stage of nutritional transition. Initially, societies that are predominantly agricultural have a diet based on homegrown food whose production requires considerable physical activity. In the second stage there is urbanization when diets change and lifestyles become more sedentary. With urbanization, legumes, grains and roots are replaced by diets higher in fat and sugar. Many developing countries are in this second stage of nutritional transition. In this stage there can be the double burden of malnutrition, with under- and over-nutrition occurring simultaneously in a population. The third stage in nutritional transition occurs when populations that are urbanized become more affluent, and have more leisure time. Obligatory agricultural labor is replaced by voluntary physical activities in health spas or other outlets. In this stage there is awareness of improved nutrition and sufficient income to rectify dietary imbalances. Consumers have a preference for fish and poultry that has lower saturated fat content, and they increase their intake of whole grains and F&V.

Yet in more than half the European countries the consumption of F&V is lower than 400 g per day and in one third of the countries the average intake is less than 300 g per day (European Information Food Council, 2012). In the USA, a recent survey of fruit and vegetable consumption that used recommendations for different groups according to age, sex, and activity level, showed that more than 90 per cent of Americans did not eat enough F&V (Centers for Disease Control and Prevention, 2013).

The reasons for the low consumption of F&V are unclear. Lack of information does not seem a factor. In the United States there has been growing awareness of the importance of F&V. In 1991 about 8% of U.S. adults reported being aware that they should consume at least 5 servings a day of F&V. In 2004, that number had increased to 40% (American Institute for Cancer Research, 2015). Yet in spite of this, there has not been a change in behavior. Consumption of fruit has not changed since 1998 and that of vegetables has actually fallen.

One factor could be accessibility (affordability) of F&V. This appears to be a significant factor in the United States (Drewnowski & Darmon, 2005a). Income elasticity is positive with some estimates ranging from 0.64 to 0.99 (FAO & WHO, 2004). This positive relationship between income and consumption of F&V is reflected in an inverse relationship between income and obesity in the United States where the prevalence of obesity is higher among groups with low education and low incomes, and in lower-income states (Drewnowski & Darmon, 2005b).

² Obesity is defined as a body mass index (BMI) of 30.0 or higher. Overweight is defined as a BMI of 25 to 30.

Similarly in Canada aggregated data for provinces, demonstrate an inverse relationship between obesity and income. British Columbia, which is relatively wealthy nationally, has the lowest obesity rate (14%), whereas the poorer province of Newfoundland and Labrador has the highest rate at 29%, more than double that of British Columbia (Employment and Social Development Canada, 2014). The province, which is the focus of this study, New Brunswick, has the second highest obesity rate (24%) among the provinces in Canada; it is also relatively poor, with only 76% of national average income (Conference Board of Canada, 2014).

Accessibility and availability of F&V is partly determined by location. Within North America the majority of adults in North America consume fruit about 1.1 times a day and vegetables about 1.6 times a day, but this average conceals wide differences according to regions and climates (Centers for Disease Control and Prevention, 2013). The more temperate jurisdictions on the west coast have higher per capita consumption than the mid-West region with its ruder climate (Centers for Disease Control and Prevention, 2013). In Europe differences in accessibility and availability are reflected in higher consumption of vegetables, and especially fruit, in southern European countries (OECD, 2012). The percentage of adults consuming fruit daily varied from 20% in men in Finland, to about 80% in Italy. However the relationship between location and consumption of F&V is not rigid: Switzerland has among the highest daily consumption of F&V among the developed countries (OECD, 2012).

Other important factors that may influence consumption of F&V are convenience, taste or the perception that fresh produce is more nutritious than alternatives such as frozen produce. Convenience may be important for working couples with children, favoring fruit juices, which are not generally included in F&V consumption data. Taste is subjective and difficult to change, although promotion of F&V in school cafeterias is a public health policy that could familiarize children with the taste of produce.

One means of encouraging consumption of F&V would be the promotion of alternatives to fresh F&V. Frozen F&V can be equal, or superior, in terms of cost and nutrient value, which is not the same as canned produce (Cespedes, 2014). In New Brunswick on the Atlantic coast of Canada fresh produce is available, but often inaccessible because of its price. Particularly during the winter, most fresh produce is imported from the southern USA. Long distances, and a depreciated Canadian dollar, result in prices of fresh F&V that may be prohibitively high for poorer individuals. Transport costs are less onerous for frozen foods proportionately because of weight loss, and their low bulk and high value. In addition, volatility in the exchange rate is obviated if local fresh F&V are harvested in the summer and then frozen.

3. Methodology and Data

The purpose of the study was to examine whether consumers perceive frozen and fresh F&V as complementary, and whether marketing can increase total consumption of F&V.

Data was collected by a questionnaire based on a random sample. One county within the Canadian province of New Brunswick was sampled; Saint John County, which is the most populous in the province. In the last mini-census in 2006 the population of Saint John County was 74,621, constituting about one-tenth of the population of New Brunswick. The random sample was selected from the phone book with respondents asked over the phone whether they would be willing to participate in this research. Those willing to answer the questionnaire received it by mail or email. Overall 85 people were approached with 18 completing the questionnaire. The gender and age of those responding perhaps biased results; 62% were female and 78% were over the age of 45. A wider sample would have been ideal, but time and cost constraints prevented this.

The questionnaire was constituted in three parts, along with an introduction in the first page by telling the participants the purpose of the survey, and requesting personal information from respondents, such as gender and age range. Initially there was a descriptive section in which respondents were asked their actual share of purchases between fresh and frozen F&V. They were then asked to rank the attributes that decide their choice. Another question asked them to indicate how important are nutritional and health benefits when deciding whether to buy fresh or frozen F&V. A second section focused on the criteria they use when comparing fresh and frozen F&V. In a pre-survey that was undertaken of consumer preferences, four were dominant. Another attribute that was mentioned by only one respondent (smell) was discarded. As a result only four criteria were retained: convenience, perceived nutritional and health value, taste and price.

A third part ranked these four criteria with frozen F&V using the Analytical Hierarchal Process (AHP). This is an approach for dealing with complex decisions. AHP is an approach to decision-making that enables a multi-dimensional scaling problem to be converted into a un-dimensional one. By organizing and assessing alternatives against a hierarchy of multifaceted objectives, the advantage of AHP is that compared with other multi-criterion techniques, AHP imposes less burden on respondents because the question breaks down into a series of simple comparisons between two objectives. It was developed by Thomas L. Saaty in the 1970s and has been extensively studied and applied to a wide range of decision problems (Saaty & Vargas, 1982; Saaty & Vargas, 2001). Although conceived originally as a decision tool for use by an individual, AHP is now also used in evaluating preferences and choices at group and community level (Ridler & Ridler, 2014).

The purpose of AHP is to get numerical score by asking participants to compare different criteria ranking their preferences. Pair-wise comparisons are made between the four criteria; convenience, perceived nutritional value, price and taste. The number 1 means that criteria A and B are *equally* important. The number 3 means that A is thought to be *moderately* more important than B, and 5 that criteria A is thought to *strongly* more important than B. The number 7 means that A is *thought to be or has been demonstrated to be much more important* than B and 9 that A has been *demonstrated to have much more importance* than B. In between those there are even numbers. These numerical responses constitute a comparison matrix, showing the weight of one attribute of F&V relative to another. After deriving the pair wise comparison matrix, Excel is used to calculate the geometric mean of each row in the matrix and normalize it so the weights sum to 1.0 (or 100%). The higher the weight, the more important is the corresponding criterion.

To obtain the relative weight of each of the four criteria the priority vector, which is the normalized Eigen vector of the matrix, must be computed. Columns of the original elements of the matrix are totaled. Each element of the matrix is divided by the sum of the column, giving normalized relative weights. The sum of each column is 1. The normalized Eigen vector is obtained by averaging across the rows; this is the Priority Vector. It shows the relative weights among the criteria that are compared.

With the four principal criteria: convenience, perceived nutritional and health value, taste and price, there were six possible combinations with AHP: where n is the number of criteria the combinations equal $\{n(n-1)/2\}$. The purpose is to get a numerical score by asking participants which preferences are most important; for example, the price of frozen F&V compared with its perceived nutritional benefits. Similarly, preferences can be ranked between fresh F&V and frozen F&V.

While the AHP provides information on participants' preferences, it generates no information on the reason for those choices. The AHP has a temporal and spatial component. The instrument can be designed to evaluate participants' preferences during a given period but the preferences are likely to change over time.

4. Results

The initial questions focused on the consumption of fresh F&V. All respondents answered that they primarily purchased fresh produce rather than frozen produce. The share of fresh produce purchased as a proportion of total produce averaged 79%. This average hid some variation; almost one-fifth of respondents purchased half of their produce frozen; the same proportion who purchased almost no (less than 10%) frozen produce. The median respondent purchased between 20 to 30 % of their total produce in frozen form.

4.1 Reasons for Choosing Fresh versus Frozen Produce

Respondents were asked their criteria when buying produce, and to rank the criteria by importance. The aim is to ascertain what attributes are most important to consumers in choosing between fresh and frozen F&V. The four criteria were; convenience, perceived nutritional value, price, and taste. Convenience and taste were ranked first by most respondents; perceived nutritional value was ranked first by 30% of respondents. Price was not ranked first by any respondent. When the first and second ranks are aggregated, perceived nutritional value becomes the most important; 80% of respondents had this as their first or second criteria. Convenience was second with 70%. This is indicated in Table 1.

Table 1 Question: Rank Your Criteria When You Purchase Fresh and Frozen F&V

	First	Second	Third	Fourth	Total
Convenience	50%	20%	30%	-	100%
Perceived Nutritional Value	30%	50%	-	20%	100%
Price	-	30%	50%	20%	100%
Taste	50%	15%	20%	15%	100%

The remaining questions followed the AHP format with respondents given a pair-wise choice among criteria with 1 being equally important between the two, and 9 indicating very strong preference for one attribute compared to the other. As above, there were four criteria (n): convenience, perceived nutritional value, price and taste, and therefore six possible pair-wise comparisons

The initial AHP questions focused on the choice between fresh and frozen F&V. This was to verify the subjective answers indicated in Table 1. For example, if consumers preferred fresh to frozen produce, a pair-wise comparison of criteria enables quantification. Results in part confirmed the earlier conclusions with the average respondent strongly favoring fresh produce. This is indicated by the strong positive for all criteria. However, the ranking using pair-wise comparisons, partly contradicts the subjective reasons given in Table 1, in which respondents ranked convenience and taste the primary criterion. With AHP the highest weights were given to perceived nutritional value, and taste. Convenience was ranked last.

In Table 2 illustrating the AHP preferences, the priority weight of 4.7 given to perceived nutritional value suggests that respondents considered it *very* important. Taste and price were considered *moderately* more important while convenience was least important.

4.2 Reasons for Choosing Frozen Produce

Later questions gave pair-wise choices exclusively for frozen produce. Respondents were asked to focus just on frozen produce and rank the four attributes they valued most. Table 3 indicates the weight given to the attribute. For example respondents ranked convenience versus price higher than convenience versus taste. The highest weight was given to taste versus price. The last row indicates that respondents valued the perceived nutritional

content of frozen produce slightly more than its taste; a weight of unity indicates indifference between the two attributes.

Table 4 is determined from the elements underlying Table 3 and is used to compute the Priority Vector. This normalized Eigen vector is obtained by averaging across the rows of the matrix.

Table 2 AHP Ranking of the Criteria between Fresh and Frozen F&V

Criteria	AHP pair-wise comparison	
	Rank	Priority Vector (>1 favors fresh)
Convenience	3.2	4
Perceived Nutritional Value	4.7	1
Price	3.9	3
Taste	4.4	2

Table 3 Comparing the Attributes of Frozen F&V

AHP pair-wise comparison	Average Weight
Convenience versus Taste	2.5
Convenience versus Price	4.0
Convenience versus Nutrition	3.4
Taste versus Price	5.0
Taste versus Nutrition	3.6
Price versus Nutrition	0.9

Table 4 Normalized Ranking of Preferred Attributes of Frozen F&V

	Convenience	Nutrition	Price	Taste	Priority Vector
Convenience	0.5190	0.6162	0.3582	0.3477	0.4603
Nutrition	0.1516	0.1801	0.1055	0.4881	0.2313
Price	0.1303	0.1532	0.0898	0.0275	0.1002
Taste	0.1991	0.0505	0.4465	0.1367	0.2082
Total	1	1	1	1	1

Table 4 indicates that respondents most valued the convenience of frozen F&V. Convenience accounted for almost half (46%) of the total weight. Nutrition with 23% was only half as important for respondents in deciding about purchases of frozen produce. Taste was important with 21% but price was a relatively unimportant factor with only 10%.

As required in AHP, the preferences indicated in Table 4 were examined for consistency. Using the geometric mean of the original matrix, a priority vector and a priority row were estimated to determine the consistency index and the consistency ratio. A consistency ratio is estimated in order to ensure that stated preferences are internally consistent. A ratio < 0.10 shows high consistency. The ratio from Table 2 had a ratio of 0.19, which is not ideal but is just acceptable

5. Discussion

Results from the survey indicate that respondents in New Brunswick clearly prefer fresh produce to frozen produce. This was evident from the unanimous response to preferences. It is also indicated by the weight of fresh produce purchased as a proportion of the total (79%). Reasons for this preference are more ambiguous. The AHP analysis illustrated in Table 1 ranked convenience and taste first among criteria. However, when first and second

choices are aggregated, perceived nutritional value becomes paramount for 80% of respondents. Nutrition, therefore, is a major (if not dominant) criterion when choosing between fresh and frozen produce.

In the choice among frozen produce, convenience is the dominant criterion, as shown in Table 4. There appears to be a two-stage process in consumer decision-making. In the choice as to which produce to purchase, fresh produce is preferred to frozen produce, in part because of its perceived greater nutritional benefits. Once the decision to buy frozen produce is made, the principal criterion then becomes convenience.

The perception that fresh produce is more nutritional than frozen produce appears to be widespread although often misguided. If intended for freezing and if freezing occurs immediately after harvesting, frozen produce may actually contain as much of their original nutritional content as fresh produce when bought in supermarkets (Rickman et al., 2007; Duglos, 2014). In fact some frozen F&V have more nutrition than fresh F&V unless the fresh produce comes from one's own garden or is purchased at a farmers' market. The reason for frozen F&V retaining nutrition is that when intended for freezing, they are harvested at their ripest, which allows them to retain their nutrients during the freezing process. Vegetables are washed and peeled if necessary, and then blanched by exposing them briefly to scalding water or steam before freezing. Not only does blanching remove dirt but also destroys enzymes that break down nutrients, preserving freshness.

The blanching process does negatively affect certain vitamins such as water-soluble nutrients, vitamins C and B, but it halts enzymatic activity and thus in the long run actually preserves more of the vegetables' nutritional value (Tourney, 2014). 'Fresh' produce that is stored too long on the other hand, degrades. Fresh F&V are often picked unripe, days or even weeks earlier, in order to be transported, but nutrient content begins to decline after picking. Vegetables lose moisture after harvesting, and their starches and sugars begin to degrade. This decline continues during inter-country transport, warehouse storage and shipment to grocery stores. While fresh green beans have more beta-carotene -a pigment that turns into vitamin A during digestion, than frozen; the opposite is true for peas; frozen peas have as much, if not more, nutrition than fresh varieties (Duglos, 2014). Similarly with spinach, frozen spinach is denser than raw spinach, and provides higher levels of vitamins and minerals per serving than fresh spinach (American Council on Exercise, 2014).

Fruits are not typically blanched before being frozen; so fresh and frozen varieties are usually equally healthy. Both fresh and frozen blueberries, for example, have nearly equal health benefits (Ipatenco, 2014). Frozen unsweetened blueberries have less Vitamin A, C and K than fresh blueberries, but they have 17% more fiber.

If, as this paper suggests, nutrition is a significant factor in the choice between fresh and frozen produce, there are marketing and policy implications. Firms producing frozen produce could publicize the nutritional value of their products. Such marketing would not only benefit the firms, but also enhance health indicators if there is a net increase in the consumption of F&V. Reducing malnutrition and obesity would conform to corporate and social responsibility.

In addition, public health authorities could increase consumption of F&V by countering the widespread impression that frozen produce is less nutritious than fresh produce. Most consumers do not purchase produce at farmers' markets, either because of convenience or because they do not exist in certain seasons. Fresh produce in supermarkets is typically subject to lengthy transport and storage delays, with detrimental impacts on nutritional value. Publicizing the deterioration of fresh produce would be counter-productive to consumption of F&V, but if the nutritional benefits of frozen produce were more commonly known, substitution to frozen produce could increase. This should occur particularly in regions where seasonal factors inhibit local cultivation. The result could be a net increase in the consumption of F&V.

6. Conclusion

The paper has used survey data to examine the consumption of fresh and frozen fruit and vegetables. This is in the context of growing malnutrition and obesity, and the inadequate consumption of produce. The survey was undertaken in the province of New Brunswick, Canada, but could have ramifications elsewhere. Results suggest that consumers primarily choose to buy fresh rather than frozen fruit and vegetables, in large part, because they perceive fresh produce more nutritious than frozen produce. If they do choose frozen produce the primary criterion is convenience.

Scientific studies indicate that frozen produce is at least as fresh produce, particularly if fresh produce is not cultivated locally. When purchased in supermarkets fresh produce has lost many nutrients because of transport distances or because of storage delays. An additional factor is that frozen produce is harvested at peak ripeness, unless most “fresh” produce that has a longer shelf life if picked unripe.

To improve malnutrition and encourage more consumption of fruit and vegetables, the misperception of consumers about the relative nutritious value of fresh and frozen produce should be rectified. One means would be for companies producing frozen foods to market their products for their nutrition, as well as convenience and taste. This marketing would benefit the companies but also society as a whole. A complementary approach is for public health bodies to publicize the scientific evidence about the nutritious value of frozen produce. The purpose would be to increase the net consumption of fruit and vegetables.

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