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**Title:** Cost effectiveness comparison related to cost per product nutrient of available meat alternative and meat products in Supermarkets and Health Food Stores of Trinidad

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COST EFFECTIVENESS COMPARISON RELATED TO COST PER PRODUCT NUTRIENT OF AVAILABLE MEAT  
ALTERNATIVES AND MEAT PRODUCTS IN SUPERMARKETS AND HEALTH FOOD STORES OF TRINIDAD

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## 1.0 ABSTRACT

**Background:** Past research have been conducted on the cost of various foods per pound and also cost in conjunction with the energy and nutritive value of the foods.

**Objectives:** The purpose of this study was to compare the average cost of meat alternatives per 100g with meat products per 100g, to compare the nutrient facts labeled on each item of meat alternatives corresponding to the actual meat and to determine the cost effectiveness using the nutrient values for both meat alternatives and actual meat.

**Design:** Popular Supermarkets and health food stores in Trinidad were used in this study. This research utilized a cross-sectional design in which 53 products and data such as cost and nutrition fact label information were identified. A comparison of the differences in average cost and nutrient values were analyzed using ANOVA. The nutrients compared in each product were calories (kcal), protein (g), Fat (g), calcium (%), iron (%), vitamin B6 (%), vitamin B12 (%) and dietary fiber (g).

**Results:** ANOVA showed that there were significant differences between both meats and meat alternatives in terms of the nutrients: Protein (g), Fat (g), Vitamin B6 (%), Vitamin B12 (%) and Dietary Fiber (g) according to the statistical analysis. Meat alternative products had higher content of protein Vitamin B6, Vitamin B12 and dietary fiber than actual meat products. Meat alternatives were more cost effective since along with having more nutrients per 100g there was no significant difference in cost per product unit between the meat alternatives and real meat; and real meats had a higher cost per protein (g), Vitamin B6 and Dietary fiber compared to alternative meats.

**Conclusion:** Meat alternatives were found to be more cost effective for Protein, Fat, Vitamin B6 and Dietary Fiber, although the average cost of meat and meat alternatives were found to have no significant differences.

## 2.0 INTRODUCTION

Comparing the cost of meat alternatives to actual meat would usually be done by prices per pound only. There are not many considerations about the amount of nutrients per item that would make cost effective. Meat alternatives are foods made from plant sources that are usually substituted for meat entrees and are typically marketed for vegetarians, vegans, persons seeking to reduce their consumption of meat, for health conscious persons, or persons who have ethical or animal rights concerns. By researching the cost of nutrients in each item this would give consumers a new approach in selecting items based on value for their money.

Very early studies were done by Wilbur Atwater (1894) where he conducted a study concerning cost of different foods and nutritive value. Atwater ignored the food weight and calculated the energy and nutrients obtained from the different foods given price. Similar studies were done by Drewnowski (2010) where his primary objective was to reestablish the relations between food cost, energy, and nutrients by using contemporary nutrient composition and food prices data from the USDA. Another study done by Matthieu Maillot et al (2007) further showed the association between diets of higher nutritional quality with higher costs per 10 MJ. They studied the relationship between energy-adjusted diet costs, dietary energy density, and nutritional quality of diets. They concluded that lower energy density and higher nutritional quality were associated with higher energy-adjusted diet costs. Higher-quality diets cost more not only because they have a low energy density but also because they are nutrient rich. Gabriel Masset et al (2014) studied the relationship between environmental impact, nutritional quality, and prices of foods representative of the French diet. They found that the correlation with price per kilocalorie was null. Carol L. Connell et al (2012) compared the differences across food groups for food cost, energy, and nutrient profiles of 100 items from a cross-sectional survey.

They found that there were significant differences existing amongst the food groups for each measure. Energy density was highest for fats, oils and sweets, whereas nutrient density was highest for vegetables. Price per serving was lowest for fats, oils and sweets and highest for meat

The following research focuses on the comparisons of meat alternatives to actual meat with respect to costs and nutrient values. The information that is gathered and analyzed is pertinent to many areas involved. Meat alternatives are widely consumed by vegan and vegetarian people. Some may contain textured vegetable protein that may replace the protein obtained from meat which is a necessary source of energy. Dietitians also need to be aware of meat alternatives, to advise vegetarian clients about their diets. There are diseases related to meat consumption such as cardiovascular diseases, associated with the over consumption of animal fats. Therefore, meat alternatives can also be a solution for persons who may want a healthier lifestyle or want to lose weight, because it doesn't contain animal fat. Another aspect is cost of meat alternatives to actual meats. In examining and comparing the cost per nutrient this can be a factor to consider based on value for money to the consumer. This study will provide new information for citizens of Trinidad since no previous research on this topic has been done before. Therefore, at the end of this project persons should be able to make healthier and more cost-effective choices and increase awareness of both meat and meat alternatives.

The objectives of this project are as follows:

- (1) To compare the average cost of meat alternatives per 100g with meat products per 100g
- (2) To compare the nutrient facts labeled on each item of meat alternatives corresponding to the actual meat.
- (3) To determine the cost effectiveness using the cost and nutrient values for both meat alternatives and actual meat.

Therefore the investigation is intended to determine cost effectiveness related to cost per product nutrient of available meat alternatives and meat products in Supermarkets and Health Food Stores of Trinidad.

## 3.0 LITERATURE REVIEW

### 3.1 What are meat alternatives?

Meat alternatives are also known as meat analogues, imitation meats, meat substitutes, faux and mock meats. They have very inventive qualities and chemical characteristics of real meats such as flavor, texture and appearance (Sadler, 2004). These were formulated by food researchers especially for persons who love meat, so that it can satisfy the meat consumers and would also contribute to nutrition and health as well. Most meat alternatives are soy-based. They can be characterized as a compound which is constructed similarly to another but differs slightly in composition. Meat substitutes have a striated, layered structure similar to muscle meat. In general, meat substitutes are understood to be made from non- meats. People who typically consume meat substitutes are vegans, vegetarians, persons who may be following their religious dietary laws, people who are not vegetarians but are seeking to lower their consumption of meat for ethical or health reasons. Meat substitutes are based on old recipes for legumes, tempeh, mushrooms, wheat gluten, pressed tofu, rice, which has added flavouring to make the product taste like sausage, chicken, beef, ham, turkey, lamb, and seafood. Therefore, the characteristics found in a meat product such as texture, colour, flavour, etc, must be added to the analog product developer (Egbert and Borders, 2006). They are more recent meat analogues which includes textured vegetable protein (TVP). TVP is a dried bulk produce made from soy concentrate, soy and mycoprotein-based quorn (Malav O. P, 2013).

### 3.2 Utilization and benefits of Meat Alternatives (Soy -based)

Soybeans are legume crops which were traditionally used in soy milk, tofu and fermented products. It is now seen as an economic and high-quality vegetable protein source. Soybeans typically contain 35% to 40% high-quality protein with well-balanced composition of amino acids, 15% to 20% fat, 30% carbohydrate, and 10% to 30% moisture (Golbitz and Jordan, 2006). It is also rich in fiber, iron, zinc calcium, and the B vitamins. There are three categories of soy based on the protein content which are soy flour and grits (50% protein), isolated soy protein (90% of protein) and soy protein concentrates (70 % protein). *“Texturized vegetable proteins can extend meat products while providing an economical, functional, and high-protein food ingredient or can be consumed directly as a meat analog. Meat analogs are successful because of their healthy image (cholesterol free), meat-like texture, and low cost(M.A Asgar, 2010).”*

Soy proteins are flexible food ingredients due to their meat like textures after which it has been hydrated. The amino acid composition provides complementary protein quality to that of animal proteins. With these traits this would help to increase the acceptance of meat alternatives to vegetarians and more so, non- vegetarians as well.

These proteins are used to help with fat and water retention, emulsification thereby contributing to mouth feel and texture, protein fortification, and nutrition. In analogues simulating emulsified meats, such as hotdogs/bologna, functional soy concentrates and isolated soy proteins are often used for the same reasons.

### 3.3 Product cost in relation to nutrient content

A number of studies have been done on the relationship between food cost, energy and nutrients but no studies have been done on the cost effectiveness using the nutrient facts and cost of meat alternatives compared to actual meats. Many researchers conducted research to find out which foods were more cost effective in relation to their nutrient content. The relationships between food cost, energy and nutrients were studied by Adam Drewnowski (2010), he used nutrient composition and food prices data from the USDA. Drewnowski's method of analysis for the comparisons between food groups was tested using the one-factor analysis of variance which is also used in this current study. Drewnowski found that the energy cost for vegetables was higher than for any other food group except for fruit. The serving sizes increased with water content and varied inversely with energy density of foods. The highest prices per serving were for meats, poultry, and fish, and the lowest prices per serving were for the fats category. He also found that although carbohydrates, sugar, and fat were associated with lower price per 100 g, protein, fiber, vitamins, and minerals were associated with higher price per 100 g, after adjustment for energy. Studies done by Matthieu Maillot et al (2007) further show the association between diets of higher nutritional quality with higher costs per 10 MJ. They studied the relationship between energy-adjusted diet costs, dietary energy density, and nutritional quality of diets. Their study design is a cross-sectional study of French adults and their analyses were based on food records. The monetary cost of each diet was estimated by using mean retail prices for foods. Nutritional quality was estimated by calculating the mean adequacy ratio (MAR), based on 23 nutrients. Energy density was based on solid foods only. They found that in the bivariate analysis, low-energy-density diets were of higher nutritional quality but also cost more. Therefore, they concluded that in their study of self-selected diets of French adults, lower energy density and higher nutritional quality were associated with higher energy-adjusted diet costs. Higher-quality diets cost more not only because they have a low

energy density but also because they are nutrient rich. Therefore, from these two studies it can be concluded that there is a relationship between cost of food products and their nutrient content.

A study on the degrees of nutrient intake for every key nutrient in the diet in relation to the diet cost and socio economic status was conducted by Anju Aggarwal et al (2012). Their method of data collection was through food frequency questionnaires. Nutrient intakes were energy-adjusted using the residual method and converted into quintiles. The retail prices from supermarkets for foods were estimated for diet cost of each respondent. Similar results from Matthieu Maillot et al (2007) were found in this study where higher intakes of dietary fiber, vitamins A, C, D, E, and B12, beta carotene, folate, iron, calcium, potassium, and magnesium were associated with higher diet costs. Higher intakes of saturated fats, trans fats and added sugars were associated with lower diet costs. Their study also made a conclusion that nutrients commonly associated with a lower risk of chronic disease were associated with higher diet costs. They also found that nutrients associated with higher disease risk were associated with lower diet costs. Therefore, these findings further support the ideas of previous research.

Gabriel Masset et al (2014) studied the relationship between environmental impact, nutritional quality, and prices of foods representative of the French diet. The nutritional quality of the foods was assessed by calculating the score for the nutritional adequacy of individual foods (SAIN) to score for disqualifying nutrients (LIM) ratio. They found that the correlation with price per kilocalorie was null.

#### 4.0 MATERIALS AND METHODS/METHODOLOGY

Stores were selected based on their popularity in Trinidad and the required meat alternatives that were available. They were also selected due to their representation of access to customers in various parts of Trinidad.

Popular Supermarkets and health food stores in Trinidad are HiLo Food Stores, Xtra Foods Supermarket, Food Basket Ltd, TruValue and Natural Delights and these were therefore used for this study. This research utilizes a cross-sectional design in which products and data such as cost and nutrition fact label information was identified. This was collected through observation in the Supermarkets and Health Food Stores. Products were chosen from each supermarket. Only products that are comparable to the actual meat were eligible for this research in various brands: For example, beef burgers vs. veggie burgers, or vege chicken vs. actual chicken sausage. From each store, all meat alternatives from all brands were listed and identified. These were used to compare to that of various meats such as chicken, beef, turkey and pork. A standardized size of both meat alternatives and actual meat was decided depending on what was available at each store. The cost and nutrient values on the labels of each item were collected. The data collected was used to determine the unit price (\$/100g) and energy cost per nutrient (\$/kcal). The main variables in this study are the costs and nutrient values.

All the analyses were performed using the Statistical Package for the Social Sciences (SPSS) version 12.0 for Windows. A comparison of the differences in average cost and nutrient values were analyzed using ANOVA. The nutrients compared in each product were calories (kcal), protein (g), Fat (g), calcium (%), iron (%), vitamin B6 (%), vitamin B12 (%) and dietary fiber (g). These were also analyzed using ANOVA. The information from SPSS is presented on tables and graphs.

## 5.0 RESULTS

Table 1 describes the product type and prevalence of the products. In this study there are 17 similar meat products (32.1%) and 36 similar meat alternatives (67.9%) available in supermarkets from Trinidad. Therefore 53 product items were used and analyzed in this study

Table 1. The Prevalence of real meat and meat alternative products available

		Real Meat	Alternative Meat	Total
Product Type	Salami	2	4	6
	Patties	5	3	8
	Turkey	3	5	8
	Bacon	2	4	6
	Burger	3	6	9
	Nuggets	2	14	16
Total		17	36	53
Percentage		32.1%	67.9%	100.0%

Figure 1 shows there is a higher prevalence of meat alternatives for each product except for turkey compared to actual meats that includes nutrition facts labels

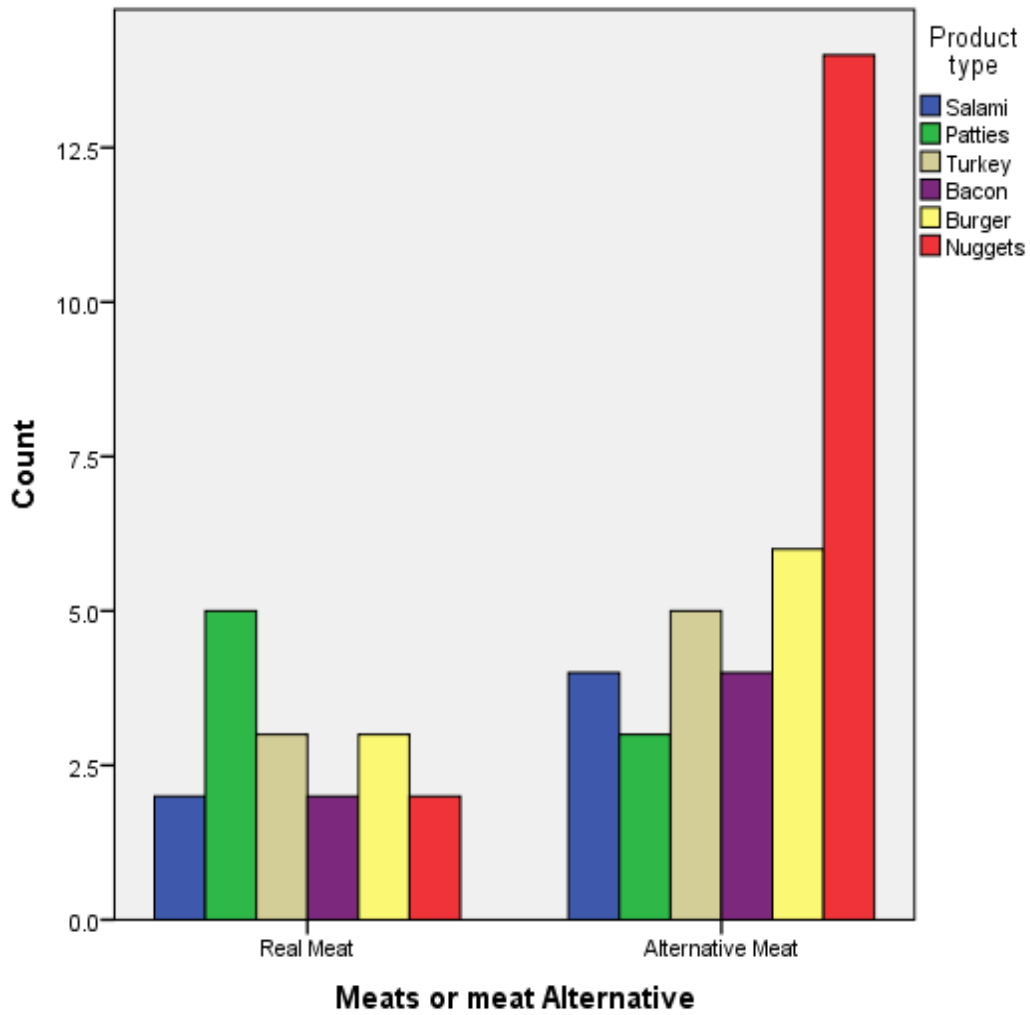


Figure 1. Prevalence of Labeled Meat and Meat Alternative Products available

Table 2 shows the individual means and standard deviation for real meats and alternatives. The results of the means test showed that meat alternatives have more protein, calories, calcium, iron Vitamin B6, Vitamin B12 and dietary fiber compared to real meats.

Table 2 Comparing means and standard deviation of nutrients for real meats and alternative meats

Meats or meat Alternative	Calories	Protein(g)	Fat(g)	Calcium(%)	Iron(%)	Vitamin B6 (%)	Vitamin B12 (%)	Dietary Fiber	
Real Meat	Mean	131.7059	11.6353	8.4824	1.1765	3.1765	.0000	.0000	.0000
	Std. Deviation	104.53753	8.42310	9.01847	1.74052	6.27729	.00000	.00000	.00000
Alternative Meat	Mean	181.5833	23.1667	4.9444	3.6111	3.7222	5.7228	4.0222	3.6944
	Std. Deviation	99.87145	19.76071	3.64648	10.31304	8.84020	11.53713	7.43302	6.49756

Table 3 shows there is no statistical significance between real meats and meat alternatives with respect to their cost/100g because it's significance is 0.586 which is greater than 0.05.

Table 3 The comparisons of cost/100g for real meats and alternative meats

Meats and meat Alternative	Sum of squares	Mean square	F	Sig.
Real Meat	5.164	5.164	.301	.586
Alternative Meat	875.703	17.171		

Table 4 shows the differences in nutrients that were analyzed. The numbers that are in bold shows a difference between both meats and meat alternatives. Therefore, Protein (g), Fat (g), Vitamin B6 (%), Vitamin B12 (%) and Dietary Fiber (g) showed a significant difference according to the statistical analysis.

Table 4 Differences in Nutrients from meat and meat alternatives showing their significance

	Between meats and meat alternatives	
	Mean Square	Sig.
Calories (kcal)	28726.589	.101
Protein (g)	1535.457	<b>.026</b>
Fat(g)	144.534	<b>.046</b>
Calcium (%)	68.446	.341
Iron (%)	3.439	.820
Vitamin B6 (%)	378.172	<b>.047</b>
Vitamin B12(%)	186.813	<b>.031</b>
Dietary Fiber(g)	157.606	<b>.024</b>

Figure 2 shows the mean protein(g) of real meats to alternative meats. Alternative meats have a greater amount of protein (g) compared to real meats.

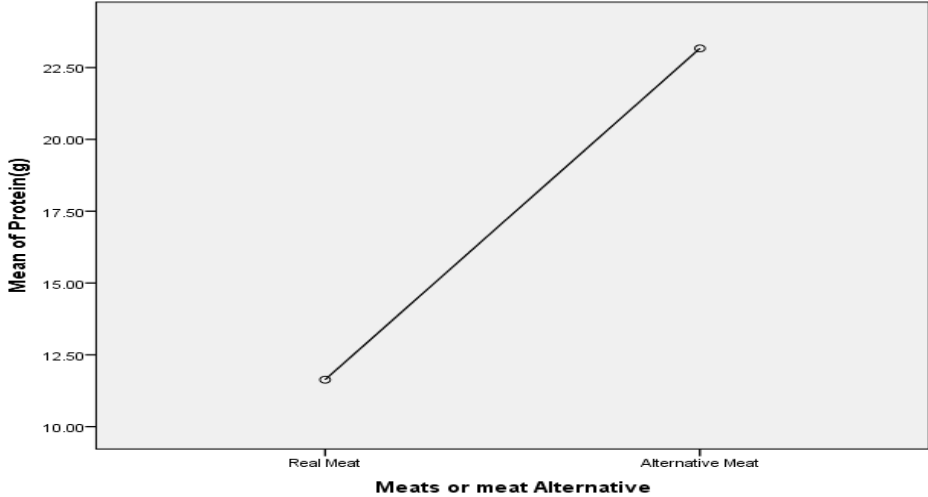


Figure 2. Mean Protein (g) of both real meats and alternative meats

Figure 3 shows the mean fat (g) of real meats to alternative meats. Real meats have a greater amount of fat (g) compared to alternative meat.

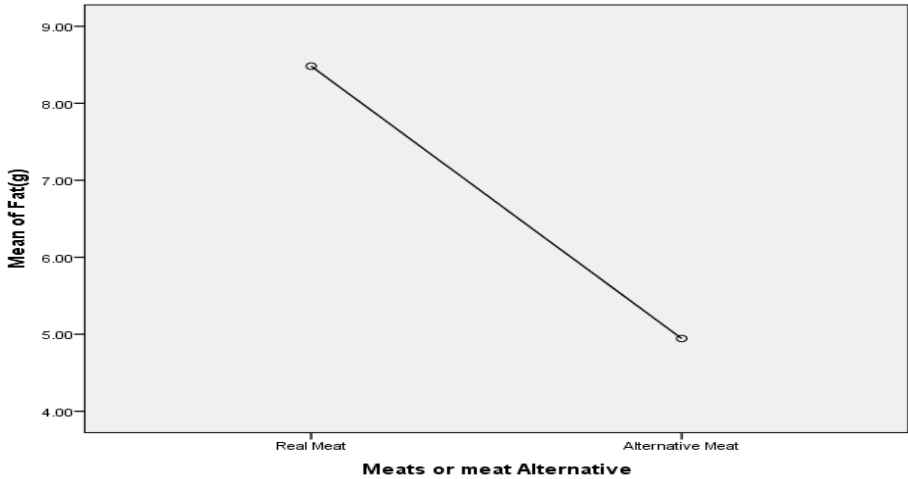


Figure 3. Mean Fat (g) of both real meats and alternative meats

Figure 4 shows the mean Vit.B6 (%) of real meats to alternative meats. Alternative meats have a greater amount of Vit.B6 (%) compared to real meats

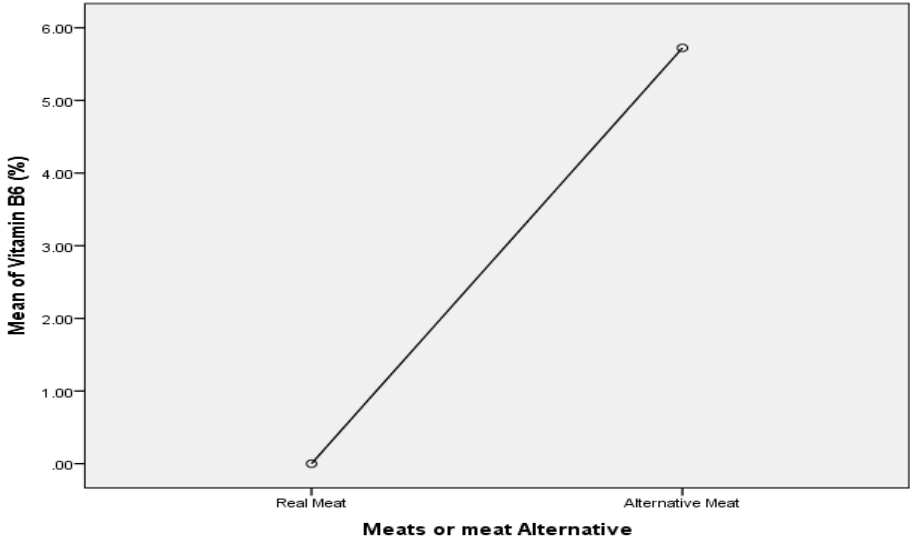


Figure 4. Mean Vitamin B6(%) of both real meats and alternative meats

Figure 5 shows the mean Vit.B12 (%) of real meats to alternative meats. Alternative meats have a greater amount of Vit.B12 (%) compared to real meats

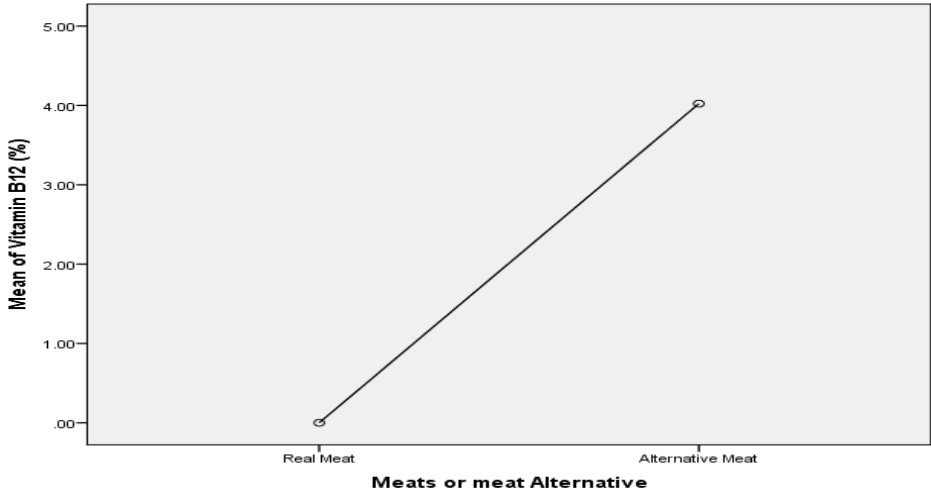


Figure 5. Mean Vitamin B12 (%) of both real meats and alternative meats

Figure 6 shows the mean dietary fiber (g) of real meats to alternative meats. Alternative meats have a greater amount of dietary fiber (g) compared to real meats.

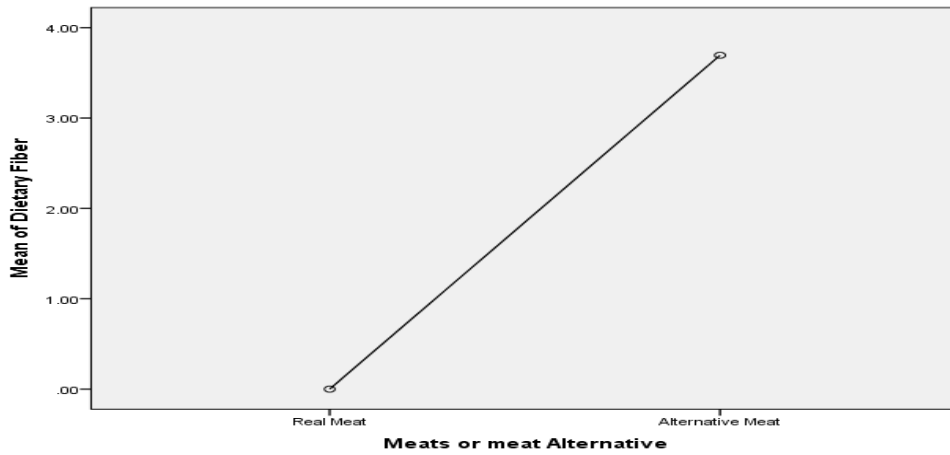


Figure 6. Mean dietary fiber (g) of both real meats and alternative meats

Table 5 show significant differences in cost/ fat(g), cost/ protein(g), cost/ Vit.B6(%) and cost/Dietary fiber(g) between meats and meat alternatives.

Table 5 Comparison of Cost per nutrient between meats and meat alternatives

		Mean	F	Sig.
Cost per kcal	Between Groups	.026	1.792	.133
Cost per gram of Protein	Between Groups	2.743	1.042	<b>.046</b>
Cost per gram of Fat	Between Groups	114.365	4.606	<b>.002</b>
Cost per gram of Calcium	Between Groups	36.996	1.304	.322
Cost per gram of Iron	Between Groups	6.169	1.903	.183
Cost per gram of Vitamin B6	Between Groups	1404.270	12.732	<b>.000</b>
Cost per gram of Dietary Fiber	Between Groups	480.044	128.303	<b>.000</b>
Cost per gram of Vitamin B12	Between Groups	12.614	.455	.720

Figure 7 shows the cost per protein (g) of real meats and alternative meats. Compared to alternative meats, real meats have a higher cost per protein (g).

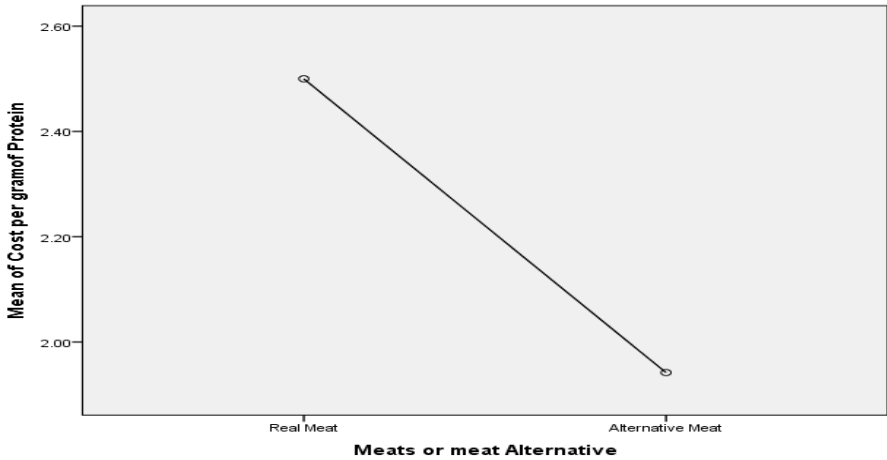


Figure 7 Mean cost per protein (g) of meats and alternative meats

Figure 8 shows the cost per fat (g) of real meats and alternative meats. Compared to alternative meats, real meats have a lower cost per fat (g).

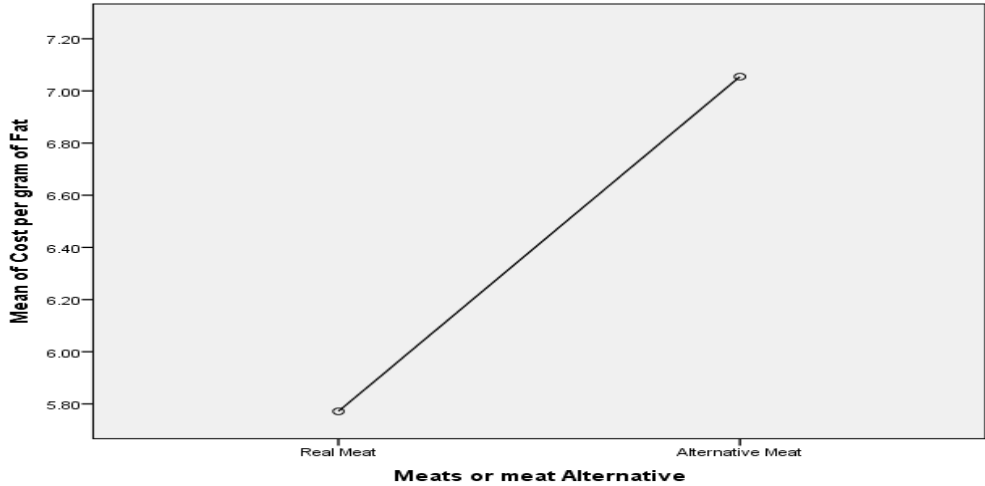


Figure 8 Mean cost per fat (g) of meats and alternative meats

Table 6 shows the cost per calorie between real meats and alternative meats. There is no statistical difference between both groups since the significant figure is .338 which is greater than 0.05

Table 6 Cost per calorie between real meats and meat alternatives

Cost/Calorie	Mean Square	F	Sig.
Between Groups	.015	.937	.338

## 6.0 DISCUSSION & LIMITATIONS

In this present research, based on the nutrient facts and product cost provided in popular supermarkets and health food stores, it was shown that actual meats and meat alternatives have different nutrient values and cost per nutrient. In this study it was found to have more meat alternatives than actual meats. This may be due to the fact that only some actual meat items contained nutrient fact labels. Using a cross tabulation analysis from SPSS it was found that there is a higher prevalence of meat alternatives for each product except for turkey compared to actual meats that includes nutrition facts labels.

Cost effectiveness in terms of cost per nutrient might be a very important aspect in food economy; but more so in health. However, Frazao (2009) does not support this view. Frazao did a study on less-energy-dense diets of low-income women in California, associated with higher energy-adjusted costs but not with higher daily diet costs. Frazao (2009) stated that it is not useful to know that tortilla chips were cheaper per calorie than were fresh strawberries, as long as the 2 packages cost the same, \$3.99. The fact that the tortilla chips provided 16 times more energy than did strawberries (4480 compared with 280 kcal) was not viewed as relevant.

In the current study, the one way ANOVA was used for analysis to show if there were any significant differences in relation to the nutrients from actual meats and meat alternatives. ANOVA shows that there are significant differences between meats and meat alternatives in terms of Protein (g), Fat (g), Vitamin B6 (%), Vitamin B12 (%) and Dietary Fiber (g) according to the statistical analysis

From the mean plots this implies that the meat alternatives have greater kcal, protein, calcium, iron, Vitamin B6, Vitamin B12 and dietary fiber than the actual meats from the products. The actual meats have more fat (g) than the meat alternatives.

Using ANOVA to analyze the cost per 100 grams of the products for actual meats and meat alternatives, the significance level was found to be .586 which is greater than 0.05. Therefore, contrary to expectations, this study did not find a significant difference between cost per 100 grams of meats and meat alternatives. The null,  $H_0$  is accepted because there are no significant differences in average cost of meat alternatives per 100g compared to actual meats per 100g. Although using ANOVA analysis to compare the cost per nutrient between meats and meat alternatives it was found to be significant for some nutrients Protein, Fat, Vitamin B6 and Dietary Fiber. Real meats had a higher cost per kcal, protein (g), calcium (%) and iron (%) compared to alternative meats. Real meats are found to have a lower cost per fat (g) compared to alternative meats. Therefore, in terms of cost per product nutrient, meat alternatives were found to be more cost effective than actual meats.

Adam Drewnowski (2010) did a study on the relationships between food cost, energy and nutrients where he used nutrient composition and food prices data from the USDA. For the foods Drewnowski studied he found that the energy cost for vegetables was higher than for any other food group except for fruit. The serving sizes increased with water content and varied inversely with energy density of foods. The highest prices per serving were for meats, poultry, and fish, and the lowest prices per serving were for the fats category. He also found that although carbohydrates, sugar, and fat were associated with lower price per 100 g, protein, fiber, vitamins, and minerals were associated with higher price per 100 g, after adjustment for energy. The findings of Drewnowski (2010) are consistent with this current study since based on results from the cost per nutrient of meats and meat alternatives it was found that

there is a lower cost per grams fat of real meats and higher cost per grams of protein and fiber in real meats.

Another study by Maillot et al (2007) examined if there is an association between diets of higher nutritional quality and higher costs per 10 MJ. They studied the relationship between energy-adjusted diet costs, dietary energy density, and nutritional quality of diets. Nutritional quality was estimated by calculating the mean adequacy ratio (MAR), based on 23 nutrients. Energy density was based on solid foods only. They found that in the bivariate analysis, low-energy-density diets were of higher nutritional quality but also cost more. Therefore, they concluded that higher-quality diets cost more not only because they have a low energy density but also because they are nutrient rich. This finding corroborates the ideas of Adam Drewnowski (2012) and other researchers (Anju Aggarwal et al 2012; Matthieu Maillot et al 2007; Connell et al 2012). The current study was different in that two different types of nutrient-dense foods were analyzed and compared (meat alternatives vs. real meats); and there was no difference observed in cost per 100g food with the comparison; but meat alternatives were found to have higher content of some nutrients like protein, fiber, and B vitamins (more nutrient dense) than meats. Therefore, it can be surmised that the commodity with more nutrient content (meat alternatives) in our study cost less (more cost effective), since there was no significant price difference between the 2 types of products compared.

A possible explanation for these current results pertaining to the nutrient content comparisons of actual meats and meat alternatives, may be due to the fact that soybean made products are economic and have high-quality vegetable protein as a source for humans (Malav ,2013). Soybeans vary widely in nutrient content typically containing 35% to 40% high-quality protein with well-balanced composition of amino acids, 15% to 20% fat, 30% carbohydrate, and 10% to 30% moisture also rich in calcium, zinc, fiber, iron and B vitamins (Golbitz and Jordan, 2006). Therefore, these research authors support the fact

that meat alternatives can be a healthy alternative to real meat in regards to certain nutrients (protein, calcium, iron, Vitamin B6, Vitamin B12 and dietary fiber) that were found to have greater amounts per product. The findings from this study have important implications for the development of a Trinidadian's perception of meat alternatives. The study was successful as it was able to show significant differences of the comparison of meats to meats alternatives in terms of nutrient content and cost effectiveness. However future studies on the current topic are recommended. Studies were only conducted with product items that had nutrient fact labels, this is a limitation in that many meats could not have been analyzed for that reason. There is also a lot of room for further progress in determining these results for a bigger sample size.

## 7.0 CONCLUSION & RECOMMENDATION

This study concludes that cost effectiveness can be determined by examining cost per product nutrient of available meat alternatives and meat products in Supermarkets and Health Food Stores of Trinidad.

The fact that meat alternatives have a less cost per nutrient/g than actual meats is an indicator that it is more cost effective. Therefore, this study confirms that meat alternatives are more cost effective than actual meats with respect to the nutrients protein, calcium, iron, Vitamin B6, Vitamin B12 and dietary fiber, which were found to have greater amounts than real meats.

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APPENDICES

Sample of Product Meat:



Sample of a Meat alternative

