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The Feasibility of a Paleolithic Diet for Low-Income Consumers

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Abbreviations

CNNP; Center for Nutrition Policy and Promotion

USDA; United States Department of Agriculture

TFP; Thrifty Food Plan

RDA; Recommended Daily Allowance

LP; Linear programming

NHANES; National Health and Nutrition Examination Survey

EPA; Eicosapentaenoic acid

DHA; Docosahexaenoic acid

Abstract

Many low-income consumers face a limited budget for food purchases. The United States Department of Agriculture developed the Thrifty Food Plan to address this problem of consuming a healthy diet given a budget constraint. This dietary optimization program uses common food choices to build a suitable diet. In this paper, USDA data sets are used to test the feasibility of consuming a Paleolithic diet given a limited budget. The Paleolithic diet is described as the diet that humans are genetically adapted to, containing only the pre-agricultural food groups of meat, seafood, fruits, vegetables, and nuts. Constraints were applied to the diet optimization model in order to restrict grains, dairy, and certain other food categories. Constraints were also applied for macronutrients, micronutrients, and long-chain polyunsaturated fatty acids. The results show that it is possible to consume a Paleolithic diet given the constraints. However, the diet does fall short of meeting the Daily Recommended Intakes for certain micronutrients. A 9.3% increase in income is needed to consume a Paleolithic diet that meets all Daily Recommended Intakes except for calcium.

Keywords: Low-income; Costs and Cost Analysis; Linear Programming; Nutrition; Nutrient Intake

1. Introduction

Achieving a healthy diet on a limited budget can be a challenge. Currently, only a small percentage of Americans meet dietary requirements for a number of vitamins and nutrients [1,2]. Cost constraints have been shown to have adverse effects on food selection as well the overall nutritional quality of diets [3]. This negative relationship between income and diet quality appears in low-income consumers, who have particularly high rates of obesity, diabetes, and heart disease [4, 5, 6].

To address the problem of eating healthy on a limited budget, the Center for Nutrition Policy and Promotion (CNNP) at the U.S. Department of Agriculture (USDA) developed the Thrifty Food Plan [7]. The Thrifty Food Plan (TFP) was developed to test diets for basic dietary standards as well as the USDA's MyPyramid diet plan. The goal of the TFP model is to provide a healthy, nutritious diet on a budget that has a minimum deviation from observed food choices.

As recently noted, the estimated cost of a nutritious diet depends on the definition of "nutritious" [8]. The USDA's MyPyramid has been criticized in the nutrition literature for various reasons [9, 10, 11]. Although MyPyramid was developed as a personalized diet plan, it recommends food groups where there may be genetic incompatibility for certain population groups. For example, MyPyramid recommends dairy products and grains for all adults, yet a percentage of Americans are either lactose-intolerant or have celiac disease and cannot consume certain grains [12-14]. Though the federal dietary guidelines were updated in 2010, high levels of grains and dairy are still recommended [15].

Along these lines of diets and compatibility, there is a growing interest among scientists on ancestral diets to which humans were genetically adapted [16]. Humans evolved during the Paleolithic era between 2.6 million and 100,000 years ago , and DNA evidence shows only small differences between modern humans and ancient hunter-gatherers [17]. Dietary changes brought on by agricultural advances in the last 10,000 years are too recent by evolutionary standards, creating a mismatch between contemporary foods and Paleolithic genome [18]. These changes include reduced fiber intake, reduced micronutrients, reduced protein, higher glycemic load, and altered n-6/n-3 ratio [18,19].

Studies of existing hunter-gatherer tribes show them to be largely free of degenerative diseases [10]. Proponents of evolutionary health models therefore argue that the diet and lifestyle of ancient hunter-gatherers provides a model of disease prevention [10, 20]. Common counterarguments to this, such as the short lifespan of ancient man, have also been addressed [21].

The Paleolithic diet is based on the principles of evolutionary health and contains modern equivalents of ancient Paleolithic foods, primarily lean meat, seafood, fruits, vegetables, and nuts [22]. Nutrient disparities between modern American and Paleolithic diets are clearly evident with the Paleolithic diet having higher levels of protein and a lower contribution of calories from carbohydrate and fat. The Paleolithic diet is also associated with a reduction in the n-6 to n-3 fatty acid ratio and increased consumption of plant sterols and dietary fiber [23].

The Paleolithic diet contains no cereal grains or dairy products, in contrast to the MyPyramid plan. Such a diet has been shown to possess a high nutrient density [22] and also a high satiety level [24].

Recent intervention trials of a Paleolithic diet have shown impressive health effects in human volunteers. In 29 patients with heart disease, a Paleolithic diet produced greater improvement in glucose tolerance and greater decreases in waist circumference and weight than the Mediterranean diet [25]. In 14 healthy volunteers, a Paleolithic diet produced statistically significant decreases in weight, waist circumference, and blood pressure over a three week period compared with subjects consuming a normal American diet [26]. In a controlled feeding intervention in 9 sedentary adults, consumption of a Paleolithic diet for 10 days significantly improved glucose tolerance, insulin sensitivity, blood pressure, LDL cholesterol, and triglycerides compared with consumption of the subjects' normal diets [27]. In a randomized study of 13 type 2 diabetes patients, a Paleolithic diet improved markers of cardiovascular disease including glycated haemoglobin (HbA1c), diastolic blood pressure, and HDL-cholesterol compared with a standard diabetes diet [28].

Given this evolutionary and clinical evidence, it is of interest to compute the cost and affordability of a Paleolithic diet. The USDA has developed mathematical optimization models that show optimal food choices given cost and nutritional constraints. The objective of this study was to compute the cost of a Paleolithic diet for low-income consumers using data from the USDA's Thrifty Food Plan (TFP) model. The TFP plan contains prices typically paid by low-income consumers as compared to general market prices, and acknowledges constraints on time for food preparation. Further, it contains food choices typically made by consumers in this group, which are compiled into 58 food categories. In the present study, the goal was to minimize deviations from observed food choices while selecting foods that constitute a contemporary version of a Paleolithic diet. This was achieved by creating a linear programming model to predict how a representative individual would make food choices while facing a cost constraint as well as other food group and macronutrient restrictions.

2. Methods

Linear programming (LP) has been previously used to design diets where constraints influence food choices [29]. The objective function contains the quantities from the food groups $(x_1, x_2, \ldots, x_{58})$, which is to be minimized while meeting a cost constraint as well as other specific dietary constraints. Total deviation from the observed food quantities is to be minimized. This assumes that consumers with income constraints will choose diets that are as close to population averages as possible. The LP models were run using the Simplex procedure of the Premium Solver for Excel (Frontline System, Incline Village, NV).

2.1 Optimization

Linear programming is a tool to find the optimal solution of an objective function subject to a set of equality and inequality constraints. In order to be linear in relation to the decision variables, the objective function must have the following form:

$$Y(x_1, x_2, x_n) = a_0 + a_1x_1 + a_2x_2 + \ldots + a_nx_n$$

where $a_0, a_1, a_2 \ldots a_n$ are constraints

In the present model, the objective function was designed to minimize departure from the observed food choices by low-income consumers. The objective function to be minimized is the sum of these differences in food intake. The differences are calculated as the absolute value of the observed intake minus the optimal intake, divided by the observed intake to standardize the differences:

$$Y = \sum_{i=1}^{i=58} \left| \frac{(Q_i^{obs} - Q_i^{opt})}{Q_i^{obs}} \right|$$

where Y is the objective function, Q_i^{obs} is the observed food intake of food i, and Q_i^{opt} is the optimal food intake of food i.

Due to the absolute value, the objective function was nonlinear. Following the approach of Masset et al [30], new decision variables were created to transform this into a linear function. The decision variables represent the positive (P_i) and negative differences (N_i) from the observed food quantities:

$$\text{If } Q_i^{opt} < Q_i^{obs}, \text{then } N_i = \frac{Q_i^{obs} - Q_i^{opt}}{Q_i^{obs}} \text{ and } P_i = 0$$

$$\text{If } Q_i^{opt} > Q_i^{obs}, \text{then } N_i = 0, \text{and } P_i = \frac{Q_i^{obs} - Q_i^{opt}}{Q_i^{obs}}$$

$$\text{If } Q_i^{opt} = Q_i^{obs}, \text{then } N_i = 0, \text{and } P_i = 0$$

$$\text{Subject to: } P_i - N_i = \frac{Q_i^{opt} - Q_i^{obs}}{Q_i^{obs}}$$

The new function containing the sum of the deviational variables was labeled Y* and was to be minimized:

$$Y^* = \sum_{i=1}^{i=58} P_i + N_i$$

The various food categories were linked with cost, micronutrient, and macronutrient information. The model started with the observed food choices of low-income consumers. Quantities of one or more food groups were changed while minimizing the deviation from the population averages. Cost and nutrient information were calculated at all times. Total deviation was minimized by adjusting quantities across the 58 food categories.

2.2 Introduction of Constraints

2.2a Energy and Cost

The energy content of the diet was fixed for a sample individual, a female age 20 to 50. The USDA's energy requirement (derived from the Institute of Medicine) was selected for a female in this age group with low levels of physical activity [7]. This energy constraint was fixed at 9.2 MJ (2200 kcal). The selection of this isoenergetic diet allowed for the analysis of different combinations of quantities from the 58 food categories.

The cost constraint comes from the TFP estimate for a female age 20 to 50. This constraint is a budget of $3.89 in 2001 dollars for daily spending on food made at home. This is the equivalent of $4.91 in 2010 dollars. The cost constraint requires that the plan's total cost cannot exceed the cost target for the representative individual. Costs were not updated to current dollars due to changes in the relative prices of fruits and vegetables over the last ten years [31].

2.2b Constraint on Food Categories

The Paleolithic diet excludes grains, dairy products, and legumes. It also excludes all modern processed foods, including sugars, soft drinks, and coffees. In this LP model, all these food categories are constrained to maximum of zero. In addition, the three categories of eggs, meat mixtures, and low fat meat mixtures were also constrained to zero, as these mixtures may contain grains or other non-Paleolithic food items. Exclusion of these categories left the model with 31 remaining food categories representing general food choices of meat, seafood, nuts, fruits, and vegetables.

2.2c Nutritional Content

To ensure a similarity to historical Paleolithic diets, constraints were placed on the macronutrient content of the diet. The latest macronutrient estimates of a Paleolithic diet [32] show protein content was 25 – 29% of total calories, carbohydrate was 39 – 40% of total calories, and fat was 30 – 39% of total calories. These constraints were imposed as minimums and maximums for each macronutrient group.

In terms of micronutrients, the Daily Recommended Intakes from the Institute of Medicine were used for a number of nutrients [7]. Following the approach of Wilde [8], constraints were implemented for calcium, fiber, folate, Vitamin A, Vitamin C, Vitamin B6, Vitamin B12, potassium, and iron. A summary of all constraints are presented in Table 1.

An important element of Paleolithic diets is the fatty acid profile. The latest reconstruction of an East African Paleolithic diet shows a high intake of long-chain polyunsaturated fatty acids [32]. Specifically, these ancient diets were high in the fatty acids eicosapentaenoic acid (EPA) and Docosahexaenoic acid (DHA) [32]. A constraint was added to the model with a minimum level of 450 mg EPA+DHA. This value was used in the most recent Paleolithic diet reconstruction, and is also in line with recommendations from various health organizations [32].

3. Data

The data sets for this paper come from the USDA data sets for the 2006 TFP revision [7]. The USDA calculated average consumption from daily food intake derived from the 2001-2002 National Health and Nutrition Examination Survey (NHANES). Survey weights were applied to produce estimates of population averages. This was done for 15 age-sex combinations and across 58 food groups. The USDA selected a sample of households with income at or below 130% of the poverty level to comprise its thrifty consumer sub-group.

Food prices come from the USDA's 2001-2002 Food Price Database. The USDA attached food prices to the NHANES data using the ACNielsen Homescan Panel, which is a commercial representative survey panel. Prices for individual foods were compiled into a quantity-weighted index of prices for each of the 58 food groups. Since the consumption of specific foods can be different for each age-sex groups, the resulting prices for the food categories can vary across the different groups.

Data for energy and micronutrients were provided by the USDA per 100 g for each food category. Data for energy and micronutrient targets come from the *Dietary Guidelines for Americans* and the Institute of Medicine at the National Academies. The recommended daily allowances were obtained for specific micronutrients analyzed in the model. Data for macronutrient ranges come from the latest research estimates of the Paleolithic diet [32].

Data for the EPA and DHA content of the fish food categories were not directly available from the USDA. A proxy measure was developed in its place. Previously, the USDA has listed the 20 most commonly consumed seafood items [33]. The EPA and DHA content of these items per 100 gram serving is listed in Table 2. It was assumed that these seafood items were cooked in dry or moist heat. There are other types of preparation available, and though this can sometimes affect EPA and DHA content, the EPA and DHA content generally stays the same across different cooking and packaging methods [34].

Research has shown that low-income residents consume a fairly wide variety of seafood [35]. A recent survey of low-income residents in Newport News, Virginia, showed that they consumed many of the top 20 seafood items listed by the USDA [36]. Therefore, this proxy measure of EPA and DHA content in the fish food categories seems to be appropriate given the data limitations.

4. Results

4.1 Characteristics of Observed Food Intake

The observed intake from the various food categories in Table 3 shows a high consumption of liquid calories. Soft drinks and coffee represent the two categories with the highest quantity of food intake. All of the 58 food categories show some positive average intake. Grains and dairy make a significant contribution in terms of total food intake by weight. Grains represent 14.7% and dairy represents 7.9% in terms of the total in terms of food intake in weight, respectively. Consumption across the vegetable food categories was low, with the exception of potatoes. In terms of costs, the three most costly food categories were low fat meat mixtures, regular cost fish, and regular cost lean fish. These higher prices lead to relatively low consumption in these three food categories.

4.2 Impact of Constraints

With the inclusion of all constraints, no feasible solution could be found. It was determined that certain micronutrient constraints prevented the LP model from reaching a feasible solution. The calcium, fiber, and iron micronutrient constraints were removed to allow the objective function to be minimized. With all other constraints in place, a feasible solution was found. Table 3 shows the changes in quantities across the 58 food categories.

Overall, the model produces a drastic change in food consumption patterns. The amount of fish in the diet sharply increases, with low cost lean fish rising from 0.3 to 74.8 grams. The meat consumption shifted to two, cheaper food categories: low cost poultry and low cost lean poultry. The change in low cost lean poultry consumption is quite dramatic, rising by 11,845% from 2.2 grams to 262.8 grams. Consumption of eggs rises by 73.7% from 26.2 grams to 45.5 grams.

Consumption in the citrus, melon, and berries category and the other fruits category both become zero. The consumption of potatoes and low cost potatoes both increase to a large degree. Consumption of low fat potatoes rises by 5,075%, from 15.6 grams to 807.3 grams as potatoes become the most important category of the diet in terms of weight. Consumption of many other vegetables categories increase, notably the dark green vegetables with no fat added category and the other vegetables category.

4.3 Overall Diet Composition

A general summary of the observed diet and the proposed diet is presented in Table 4. In general, the diet shifts towards more calorie-dense whole foods, with the calories per 100 grams of food rising 38.3% from 93.7 to 129.6 calories per 100 g of food. The total food weight being consumed falls by 27.8%, from an observed total of 2,348 grams to 1,696 grams. The cost per gram increases with the shift to more expensive food, rising 35.3% from $0.17 per 100 g of food to $0.23 per 100 g of food. The macronutrient constraints are met with protein, carbohydrate, and fat providing 25%, 39%, and 36% of the total energy intake respectively. This reflects an increase in protein, a decrease in carbohydrate, and an increase in fat relative to the observed diet.

4.4 Nutritional Adequacy

Except for calcium, fiber, and iron, all other micronutrient constraints were satisfied. Table 5 below shows the outcomes for nine micronutrients and their recommended amounts.

Levels for Vitamins A, C, B6, and B12 are well above the minimum amounts in the proposed model. This shows a Paleolithic diet provides a high level of vitamins. The Paleolithic diet also contains sufficient folate and potassium.

Additional analysis was performed to determine how much more income would be needed to consume a Paleolithic diet that meets all RDAs except for calcium (see discussion below related to calcium). If the cost constraint was lifted from $3.89 per day to $4.25 per day, this would provide enough income for a Paleolithic diet that meets all micronutrient standards except for calcium. This would represent a 9.3% necessary increase in income.

5. Discussion

The present model shows that constraining food categories to only Paleolithic food groups is not cost-prohibitive for a low-income consumer. This result shows that consumers have an alternative diet choice if they do not prefer to consume foods such as grains and dairy. However, such a diet is a radical departure from the observed food choices of the average consumer. Roughly half of all the 58 food categories are eliminated under a simulated Paleolithic diet. Food choices end up heavily weighted into a few categories like lean poultry and potatoes.

Behavioral research suggests that many consumers have trouble making large departures from their current food intake [37]. However, behavior change intervention studies have reported success in increasing fruit and vegetable consumption among population subgroups [38]. The clinical trial database may provide some insight into potential adherence to a modern Paleolithic diet. In a twelve-week study comparing the Paleolithic and Mediterranean diets, 3 of the 17 participants following the Paleolithic diet dropped out while none in the Mediterranean group did [25]. In a three-week test of the Paleolithic diet, one subject out of 20 was unable to fulfill the diet [26]. In a three-month study of the Paleolithic diet in Type 2 diabetes patients, one subject out of 17 was unwilling to follow the diet [28]. Overall, these studies that it is feasible to follow a modern Paleolithic diet, at least in the short-term. However, it may be difficult to translate these results to a population level as the interventions included only a small number of subjects. Therefore, longer-term studies of adherence to a Paleolithic diet may be warranted.

The result for a lack of calcium is to be expected given the constraint on dairy consumption. In previous research, it was shown that a modern Paleolithic diet would likely fall short in calcium [22]. However, net calcium balance in the body depends on the systematic acid-base balance [39]. The high level of fruits and vegetables in a Paleolithic diet is proposed to result in a positive calcium balance despite a lower calcium intake [22, 40]. A higher protein intake combined with high fruit and vegetable intake, both present in the Paleolithic diet, may also improve dietary calcium absorption and whole-body calcium retention [41]. Therefore, meeting the RDA for calcium is not a goal within a Paleolithic diet per se; the focus is on calcium retention given a lower dietary calcium intake.

The lack of fiber and iron in the Paleolithic diet model would be a concern. Whole grains are often a good source of fiber, yet they are excluded in this model. Vegetables are another good source of fiber, and even though they are increased in the model Paleolithic diet compared to the observed food choices, the target for fiber was not achieved. Iron-fortified grain products are excluded from the model, leaving red meat and poultry food categories as the main choices for high-iron foods. Given the other constraints of the model, increasing quantities in these food categories prevents a feasible solution from being found.

The shift to a modern Paleolithic diet showed a shift towards more expensive foods on a cost per calorie basis. The higher protein content of the Paleolithic diet is a factor, as protein is generally more expensive per calorie than other macronutrients [42]. The model output shows that making such a shift is possible, but not without a failure to meet RDAs for calcium, fiber, and iron. While the target for calcium may not be as much of concern, the importance of fiber and iron in terms of health is clear. High-fiber diets are associated with positive health outcomes [43]. A lack of dietary iron has detrimental health effects, especially in children and pregnant women [44, 45]. Such research should give caution to the results presented here. Nutritional supplements could be used to address the lack of iron, though multivitamin supplements are currently only used by 26% of low-income adults [46].

There are several limitations to this study. First, it is unknown how well the Paleolithic diet would be received specifically by low-income groups. As mentioned above, it is also unknown how well subjects would adhere to the Paleolithic diet over the long run. The existing Paleolithic diet studies are short-term, and no long-term studies have been performed to date. There may be additional social challenges in adhering to the Paleolithic diet. Social support is one of the key factors in the effectiveness of any diet intervention [47]. Adhering to a diet that excludes common foods such as grains and dairy may require additional social support for long-run adherence.

The results presented here show that a Paleolithic diet is feasible for low-income consumers though not without nutritional shortcomings. If the Paleolithic diet does represent the diet that humans are genetically adapted to, then it is of significant public health interest as to the cost of such a diet. The cost constraint of the TFP model does not allow the RDAs for fiber and iron to be reached within a Paleolithic diet framework. Cost is the primary issue, as an unconstrained Paleolithic diet is nutritionally dense and has performed well in clinical trials. An additional 9.3% increase in income would be needed to achieve all micronutrient standards (except for calcium). Given the potential health-promoting effects of the Paleolithic diet, these findings are of value given the need to improve nutrition and lower rates of chronic disease among the poor.

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TABLE 1 Summary of Constraints

Constraints	Value	Units
Energy	2200	Calories
Cost	3.89	Dollars per day
Food Categories		
All grain categories	0	grams
All dairy categories	0	
Legumes	0	
Categories with grain in mixes	0	
Liquids other than water	0	
Macronutrients		
Protein	≥ 25 and ≤ 29	Percentage of Energy Intakes
Carbohydrate	≥ 39 and ≤ 40	
Fat	≥ 30 and ≤ 39	
Micronutrients (≥)		
Calcium	1000	mg
Fiber	30.8	g
Folate	400	mcg
Vitamin A	700	mcg
Vitamin C	75	mg
Vitamin B6	1.3	mg
Vitamin B12	2.4	mcg
Potassium	4700	mg
Iron	18	mg
Long-Chain Polyunsaturated Fatty Acids		
EPA + DHA	≥ 450	mg

TABLE 2 EPA and DHA Content of 20 Most Frequently Consumed Seafood Items[1]

Item (per 100 grams)	EPA(g)	DHA(g)	EPA+DHA(g)
Blue crab	0.101	0.067	0.168
Catfish	0.020	0.069	0.089
Clams/Mollusk	0.138	0.146	0.284
Cod	0.004	0.154	0.158
Flounder/Sole	0.168	0.132	0.300
Haddock	0.051	0.109	0.160
Halibut	0.080	0.155	0.235
Lobster	0.117	0.078	0.195
Ocean Perch	0.075	0.186	0.261
Orange Roughy	0.006	0.025	0.031
Oysters	0.229	0.211	0.440
Pollock	0.091	0.451	0.542
Rainbow Trout	0.259	0.616	0.875
Rockfish	0.107	0.238	0.345
Salmon (atlantic)	0.690	1.457	2.147
Salmon (chum/pink)	0.218	0.399	0.617
Scallops	0.072	0.104	0.176
Shrimp	0.050	0.052	0.102
Swordfish	0.127	0.772	0.899
Tilapia	0.005	0.130	0.135
Tuna	0.363	1.141	1.504
Average	0.141	0.319	0.460

[1] USDA National Nutrient Database for Standard Reference. http://www.nal.usda.gov/fnic/foodcomp/search. Accessed May 1, 2011.

TABLE 3 Food Quantity in Observed Versus Model Diet

Food Categories	Observed Intake (grams)	Model Intake (grams)
Milk	62.9	0.0
Low fat milk	70.6	0.0
Cheese	13.9	0.0
Milk-based desserts	30.1	0.0
Low fat milk-based desserts	8.7	0.0
Low cost red meat	8.5	0.0
Regular cost red meat	9.8	0.0
Low cost lean red meat	1.4	0.0
Regular cost lean red meat	11.0	0.0
Low cost fish	2.5	23.0
Regular cost fish	7.3	0.0
Low cost lean fish	0.3	74.8
Regular cost lean fish	6.1	0.0
Low cost poultry	4.9	136.1
Regular cost poultry	13.6	0.0
Low cost lean poultry	2.2	262.8
Regular cost lean poultry	14.6	0.0
Lunch meat	10.4	0.0
Low fat lunch meat	13.9	0.0
Eggs	26.2	45.5
Meat mixtures	48.3	0.0
Low fat meat mixtures	50.1	0.0
Legumes	26.5	0.0
Nuts and seeds	4.8	0.1
Whole grain breads	0.7	0.0
Non-whole grain breads	75.4	0.0
Non-whole grain cereals	9.7	0.0
Whole grain low calorie cereals	1.8	0.0
Whole grain cereals	14.4	0.0
Whole grain rice and pasta	5.6	0.0
Non-whole grain rice and pasta	33.9	0.0
Whole grain cakes and pies	0.5	0.0
Non-whole grain cakes and pies	37.9	0.0
Whole grain snacks	5.4	0.0
Non-whole grain snacks	11.5	0.0
Grain mixtures	98.3	0.0
Low fat grain mixtures	52.1	0.0
Citrus, melon and berry juice	54.3	0.0
Citrus, melon and berries	15.3	0.0
Other fruit juice	41.4	0.0
Other fruits	46.8	0.0

Potatoes	35.7	102.5
Low fat potatoes	15.6	807.3
Dark green vegetables	4.0	0.0
Orange vegetables	0.9	0.0
Dark green vegetables, no fat	3.4	110.5
Orange vegetables, no fat	6.0	0.0
Other vegetables	16.4	93.0
Tomatoes	2.5	0.0
Other vegetables, no fat	26.9	40.9
Tomatoes, no fat	13.5	0.0
Mixed vegetables	4.0	0.0
Mixed vegetables, no fat	8.7	0.0
Fats and oils	26.5	0.0
Coffee	417.0	0.0
Soft drinks	669.4	0.0
Low calorie soft drinks	120.1	0.0
Sugars	24.7	0.0
Total	2348.9	1696.6

TABLE 4 General Diet Characteristics

Item	Observed Diet	Paleolithic Diet	Unit
Food Weight	2348.9	1696.5	grams(g)
Energy	2200	2200	calories
Calories per 100 grams	93.7	129.6	calories/100 g
Cost	3.89	3.89	$
Cost per 100 grams	0.17	0.23	$/100 g
Protein	14.2	25.0	Percentage of energy intake
Carbohydrate	53.9	39.0	
Fat	31.9	36.0	

TABLE 5 Micronutrient Outcomes

Micronutrient	Recommended amount	Model Output	Unit
Calcium	1000	462.9	mg
Fiber	30.8	23.1	g
Folate	400	400	mcg
Vitamin A	700	1117.3	mcg
Vitamin C	75	159.6	mg
Vitamin B6	1.3	3.9	mg
Vitamin B12	2.4	3.9	mcg
Potassium	4700	5035.6	mg
Iron	18	15.4	mg