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The Feasibility of a Paleolithic Diet for Low-Income Consumers

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31

32 **Abbreviations**

33 CNNP; Center for Nutrition Policy and Promotion

34 USDA; United States Department of Agriculture

35 TFP; Thrifty Food Plan

36 RDA; Recommended Daily Allowance

37 LP; Linear programming

38 NHANES; National Health and Nutrition Examination Survey

39 EPA; Eicosapentaenoic acid

40 DHA; Docosahexaenoic acid

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58 **Abstract**

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

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

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86 **1. Introduction**

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

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

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

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

114 Studies of existing hunter-gatherer tribes show them to be largely free of degenerative
115 diseases [10]. Proponents of evolutionary health models therefore argue that the diet and
116 lifestyle of ancient hunter-gatherers provides a model of disease prevention [10, 20]. Common
117 counterarguments to this, such as the short lifespan of ancient man, have also been addressed
118 [21].

119 The Paleolithic diet is based on the principles of evolutionary health and contains modern
120 equivalents of ancient Paleolithic foods, primarily lean meat, seafood, fruits, vegetables, and nuts
121 [22]. Nutrient disparities between modern American and Paleolithic diets are clearly evident
122 with the Paleolithic diet having higher levels of protein and a lower contribution of calories from

123 carbohydrate and fat. The Paleolithic diet is also associated with a reduction in the n-6 to n-3
124 fatty acid ratio and increased consumption of plant sterols and dietary fiber [23].

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

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

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

152 **2. Methods**

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

160

161 2.1 Optimization

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

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

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

165

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

171

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

172

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

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

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

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

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

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

179

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

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

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

187 2.2 Introduction of Constraints

188 2.2a Energy and Cost

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

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

199 *2.2b Constraint on Food Categories*

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

207 *2.2c Nutritional Content*

208 To ensure a similarity to historical Paleolithic diets, constraints were placed on the macronutrient
209 content of the diet. The latest macronutrient estimates of a Paleolithic diet [32] show protein

210 content was 25 – 29% of total calories, carbohydrate was 39 – 40% of total calories, and fat was
211 30 – 39% of total calories. These constraints were imposed as minimums and maximums for
212 each macronutrient group.

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

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

223 **3. Data**

224 The data sets for this paper come from the USDA data sets for the 2006 TFP revision [7]. The
225 USDA calculated average consumption from daily food intake derived from the 2001-2002
226 National Health and Nutrition Examination Survey (NHANES). Survey weights were applied to
227 produce estimates of population averages. This was done for 15 age-sex combinations and
228 across 58 food groups. The USDA selected a sample of households with income at or below
229 130% of the poverty level to comprise its thrifty consumer sub-group.

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

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

241 Data for the EPA and DHA content of the fish food categories were not directly available from
242 the USDA. A proxy measure was developed in its place. Previously, the USDA has listed the
243 20 most commonly consumed seafood items [33]. The EPA and DHA content of these items per
244 100 gram serving is listed in Table 2. It was assumed that these seafood items were cooked in
245 dry or moist heat. There are other types of preparation available, and though this can sometimes

246 affect EPA and DHA content, the EPA and DHA content generally stays the same across
247 different cooking and packaging methods [34].

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

253 **4. Results**

254 *4.1 Characteristics of Observed Food Intake*

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

264 *4.2 Impact of Constraints*

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

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

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

281 *4.3 Overall Diet Composition*

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

291 *4.4 Nutritional Adequacy*

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

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

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

302 **5. Discussion**

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

309 Behavioral research suggests that many consumers have trouble making large departures from
310 their current food intake [37]. However, behavior change intervention studies have reported
311 success in increasing fruit and vegetable consumption among population subgroups [38]. The
312 clinical trial database may provide some insight into potential adherence to a modern Paleolithic
313 diet. In a twelve-week study comparing the Paleolithic and Mediterranean diets, 3 of the 17
314 participants following the Paleolithic diet dropped out while none in the Mediterranean group did
315 [25]. In a three-week test of the Paleolithic diet, one subject out of 20 was unable to fulfill the

316 diet [26]. In a three-month study of the Paleolithic diet in Type 2 diabetes patients, one subject
317 out of 17 was unwilling to follow the diet [28]. Overall, these studies that it is feasible to follow
318 a modern Paleolithic diet, at least in the short-term. However, it may be difficult to translate
319 these results to a population level as the interventions included only a small number of subjects.
320 Therefore, longer-term studies of adherence to a Paleolithic diet may be warranted.

321 The result for a lack of calcium is to be expected given the constraint on dairy consumption. In
322 previous research, it was shown that a modern Paleolithic diet would likely fall short in calcium
323 [22]. However, net calcium balance in the body depends on the systematic acid-base balance
324 [39]. The high level of fruits and vegetables in a Paleolithic diet is proposed to result in a
325 positive calcium balance despite a lower calcium intake [22, 40]. A higher protein intake
326 combined with high fruit and vegetable intake, both present in the Paleolithic diet, may also
327 improve dietary calcium absorption and whole-body calcium retention [41]. Therefore, meeting
328 the RDA for calcium is not a goal within a Paleolithic diet per se; the focus is on calcium
329 retention given a lower dietary calcium intake.

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

337 The shift to a modern Paleolithic diet showed a shift towards more expensive foods on a cost per
338 calorie basis. The higher protein content of the Paleolithic diet is a factor, as protein is generally
339 more expensive per calorie than other macronutrients [42]. The model output shows that making
340 such a shift is possible, but not without a failure to meet RDAs for calcium, fiber, and iron.
341 While the target for calcium may not be as much of concern, the importance of fiber and iron in
342 terms of health is clear. High-fiber diets are associated with positive health outcomes [43]. A
343 lack of dietary iron has detrimental health effects, especially in children and pregnant women
344 [44, 45]. Such research should give caution to the results presented here. Nutritional
345 supplements could be used to address the lack of iron, though multivitamin supplements are
346 currently only used by 26% of low-income adults [46].

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

353 common foods such as grains and dairy may require additional social support for long-run
354 adherence.

355 The results presented here show that a Paleolithic diet is feasible for low-income consumers
356 though not without nutritional shortcomings. If the Paleolithic diet does represent the diet that
357 humans are genetically adapted to, then it is of significant public health interest as to the cost of
358 such a diet. The cost constraint of the TFP model does not allow the RDAs for fiber and iron to
359 be reached within a Paleolithic diet framework. Cost is the primary issue, as an unconstrained
360 Paleolithic diet is nutritionally dense and has performed well in clinical trials. An additional
361 9.3% increase in income would be needed to achieve all micronutrient standards (except for
362 calcium). Given the potential health-promoting effects of the Paleolithic diet, these findings are
363 of value given the need to improve nutrition and lower rates of chronic disease among the poor.

364

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370

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509 **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

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515 **TABLE 2 EPA and DHA Content of 20 Most Frequently Consumed Seafood Items¹**

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

516 ¹ USDA National Nutrient Database for Standard Reference.

517 <http://www.nal.usda.gov/fnic/foodcomp/search>. Accessed May 1, 2011.

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528 **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
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Total	2348.9	1696.6

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544 **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
			Percentage of energy intake
Protein	14.2	25.0	
Carbohydrate	53.9	39.0	
Fat	31.9	36.0	

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561 **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

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