

Identify the Most Suitable Sources of Protein and Their Costs for the Dr. Poon's Metabolic Diet Program

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Abstract

The objective of the Dr. Poon's Metabolic Diet Clinic is to help patients improve their obesity related medical conditions through lifestyle modifications. One of the modifications is nutrition. Patients are counseled on the importance of the essential nutrients and to avoid the foods that promote obesity and disease. Human must ingest protein to survive, but protein can be expensive. Patients who have limited food budgets may find it hard to maintain a high protein, low carbohydrate lifestyle. Furthermore, not all protein sources are equal in their biological values. This study tries to identify protein sources that have good biological values and are relatively inexpensive, so our patients can utilize their food budget wisely.

Keywords: Protein; Metabolic Diet Program; Amino acids

1. Background

In human nutrition, there are essential amino acids and fatty acids that human have to consume directly, in order to stay healthy. They are "essential" because humans cannot synthesize them from other nutrients. Cows have four stomachs and can convert grass into muscle. Humans lack the ability to build muscle from eating grass. The lean body mass determines our metabolic rate, and most of the low calorie diet plans may not provide enough good quality protein to maintain the lean body mass. Losing muscle leads to slowing in the metabolic rate and eventually slows down the rate of weight reduction and/or result in weight loss plateau. The vast majority of patients are classified as obese due to excess body fat and not over lean body mass; hence, it is important to design a diet plan

that will help patients to lose fat weight and preserve or gain lean muscle mass. The daily requirement of protein intake in the general public is about 0.6 to 0.8 g per kg body weight. This requirement will go up for patients who have low lean muscle mass to start with, or patients who do lots of exercise. While there are essential amino acids and fatty acids, there is no essential sugar or starch. There is energy starvation due to the lack of food but there is no such a thing as carbohydrate energy malnutrition. Eating a diet that is high in carbohydrate and low in protein will lead to protein energy malnutrition. Since protein is the main structure of human hair, a diet that is low in protein can lead to excessive hair loss. This is particular true for the ultra-low calorie diet plans.

What is considered as a good quality protein? Protein that can easily be digested by humans and contains the optimal qualities and ratio of the essential amino acids will be considered as a good quality protein. The building blocks of proteins are called amino acids. There are 22 common types of amino acids in the human body (Table 1), and 11 of these are classified as non-essential, because they can be synthesized by the human body from substrates such as carbohydrate, fat and other amino acids. We do not need to consume protein to synthesize these non-essential amino acids. There are 9 essential amino acids and two partial-essential amino acids. These are amino acids that cannot be synthesized by humans from other nutrients, so direct ingestion is needed. Inadequate ingestion of these essential amino acids will lead to poor muscle growth or repair, hair loss, impaired immune response to infections etc. The Amino Acid Score [1] (AAS) is a way to rank the quality and quantity of different protein sources. An AAS that is over 100 is considered a complete protein. The lower the score, the lower is the protein quality.

Food that has low AAS can be mixed with other foods that have complementary amino acids profiles to improve on the overall AAS. This is important in patients who are vegetarian, as vegetarians rely on protein sources that are incomplete and have low AAS.

Non-Essential Amino Acids	Essential Amino Acids
Alanine	Isoleucine
Arginine	Leucine
Aspartic acid	Lysine
Asparagine	Methionine
Glutamic acid	Phenylalanine
Glutamine	Threonine
Glycine	Tryptophan
Prolin	Valine
Serine	Histidine
Homocysteine	Cysteine*
Hydroxylysine	Tyrosine*

Table 1: Common Amino Acids found in human

* Partially essential amino acid

In order for a protein source to score an AAS of 100, the amino acids profile has to satisfy the minimal requirement listed in Table 2. Most protein sources contain some essential amino acids. If any one of the essential amino acids is missing in the protein source, it will have an AAS of 0.

Essential Amino Acid	Amount of Amino Acid in mg/g of protein
Isoleucine	25
Leucine	55
Lysine	51
Methionine + Cysteine	25
Phenylalanine + Tyrosine	47
Threonine	27
Tryptophan	7
Valine	32
Histidine	18

Table 2: Amino Acid profile of a complete protein

In addition to worrying about the quality of the protein source, patients also need to look at the quantity of protein in the product. Although the protein found in potato qualifies as complete, the quantity of protein in potato is very low. In order to provide all the essential amino acids needed for the whole day, an average adult needs to consume 9 large baked potatoes per day². Nine large baked potatoes contain about 500 g of sugar and starch which is equivalent to 125 teaspoons of sugar. Consuming nutritive protein is only part of the goal of Dr. Poon's diet plan. The main objective of plan is to minimize the intake of nutrients that are harmful to the patients' health and/or causes weight gain.

2. The Theory Behind the Dr. Poon's Diet Plan

Dr. Poon's diet can be classified as a high protein diet which also includes a good amount of omega-3, omega-6 and high fiber vegetables. The diet limits the intake of sugar, starch, bad fat and sodium. Patients are allowed to eat until full and no calorie counting is needed. Table 3 outlines the general limitations of certain micro-nutrients in the different phases of the diet. On Phase 1 of the diet, the amount of sugar and starch (net-carb) is kept to below 1 g per serving to force the body to maintain normal blood glucose levels via gluconeogenesis. During gluconeogenesis, fat and muscle are metabolized, leading to fat and muscle loss. The good news is that more fat than muscle is lost. There are no diets that can only burns fat and not muscle; hence, it is of vital importance to consume enough good quality protein to repair and replace the muscle lost. Not enough intake of the good quality protein will lead to lean muscle loss and slow down on the metabolic rate. On Phase 2 of the diet, the limitation on net-carb is reduced and allows 5 g of net-carb per serving. This will provide more food options for the patients, while continue to lose weight. On Phase 3, the maintenance phase, 10 g of net-carb per serving is allowed. As shown in Table 3, the

amount of fat and salt per serving are at the same levels, irrespective on the diet phase. There is no explicit limit on the amount of protein and fiber that one can consume; but patients are instructed to stop eating when full. There is no set hour of the day that patients should stop eating either. The theory is that even when the patients ingest protein before sleep, protein usually ends up depositing in the muscles. Exercise is encouraged as it helps to maintain or increase muscle mass.

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|---|
| <ul style="list-style-type: none"> • Net-carb less than 1 g on Phase 1 • Net-carb less than 5 g on Phase 2 • Net-carb less than 10 g on Phase 3 • Sugar alcohol less than 10 g • Total fat less than 6 g • Total saturated fat less than 2 g • 0 trans fat • Sodium less than 170 mg • No limit on protein and fiber |
|---|

Table 3: The maximum amount of macro-nutrients per serving that is allowed in Dr. Poon’s Diet Plan

The diet does not require the patient to count calories, and yet, there is no evidence that patients over-consume protein, because protein induces satiety. It is not how much our patients eat, but what they eat, that allows them to lose weight and improve health. As long as the calories are coming from the right sources, they will end up at the right places. There are no essential carbohydrates and there is no minimum daily intake of bad fats or added salt in human nutrition.

3. Objective of the Study

Some of our patients have very limited financial resources. Even though Dr. Poon’s diet program does not charge any user fees, patients with limited incomes find it difficult to afford high protein intake, since protein is more expensive than other nutrients. It is the objective of this study to identify good quality, inexpensive sources of protein, so that patients can maintain this lifestyle on any budget.

4. Method

Nutritional compositions were obtained from the USDA website and nutritiondata.self.com. Prices of the individual food items were obtained from local supermarkets and nutritional stores in the Greater Toronto Area. These prices represent the regular prices in Canadian dollars, and not the sale prices. Food items can be either fresh or frozen.

Protein from animal source	Protein from plant source

Bacon, Peameal	Beans, black
Bacon, pork	Beans, chickpeas
Bacon, turkey	Beans, fava
Beef, chuck	Beans, kidney
Beef, flank	Beans, Lima
Beef, heart	Beans, lentil
Beef, rib	Beans, mung
Beef, round steak	Beans, Navy
Beef, sirloin	Beans, soy
Beef, tenderloin	Beans, soy nut
Beef, tendon	Flour, almond
Beef, tongue	Flour, soy
Burger patty, beef	Flour, whole wheat
Cheese, light cottage	Gluten, wheat
Cheese, light feta	Milk, unsweetened almond
Cheese, low fat cream	Milk, unsweetened rice
Chicken, heart	Milk, unsweetened soy
Chicken, skinless breast	Nuts, almond
Chicken, skin-on thigh	Nuts, cashew
Chicken, whole meat	Nuts, macadamia
Chicken, wing	Nuts, peanut
Crab, imitation meat	Nuts, pecan
Crab, meat	Nuts, pine
Cuttlefish	Nuts, walnut
Egg, white	Peanut butter, regular
Egg, whole egg	Peanut butter, low fat
Extra-lean ground beef	Peanut butter, PB2 powder™
Extra-lean ground chicken	Protein shake, pea (Vega One™)
Extra-lean ground pork	Protein shake, soy protein isolate
Extra-lean ground turkey	Quinoa
Fish, cod filet (not filet)	Seeds, chia
Fish, halibut	Seeds, flax
Fish, salmon filet (smoked, +skin)	Seed, pumpkin
Fish, salmon, raw	Seed, pumpkin protein powder
Gelatin, unsweetened	Seeds, sunflower
Hot dog, all beef	Semolina
Hot dog, all chicken	Soy Curl™
Hot dog, all turkey	Tofu, firm

Jerky, beef Lamb, Chop Lamb, Shank Liver, beef Liver, chicken Liver, pork Lobster, tail Milk, homo Milk, skim Octopus Pork, chop Pork, rib Pork, Shank Pork, tenderloin Pork, tongue Protein shake, whey (BioSteel™) Sausage, turkey Sausage, pork Scallops, meat only Shrimps, headless Squid Turkey, leg (meat & skin) Turkey, skinless breast Yogurt, plain Yogurt, zero fat	Tofu, silken
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Table 4: List of Protein Sources that were included in this Study

5. Result and Discussion

The minimum daily requirement for protein intake is 0.6 g of protein per kg of body weight. If the patient is on a low calorie diet and goes into a catabolic state, the requirement may have to increase to 0.8 g of protein per kg of body weight. For a 100 kg patient, in order to spare muscle wasting, the patient should consume 60-80 g of protein per day. Remember, 60 g of protein does not mean 60 g of meat since only about 20% of meat is protein by weight, with the remainder being mostly water weight. Although the diet plan does not set a limit on the number of meals the patient should eat per day, most patients eat three meals per day. If the patient consumes 20 g of good quality protein per meal, the minimum daily protein requirement will be achieved, therefore, any food item that can provide 20 g of good quality protein per meal, and fulfill the requirements of net-carb, fat and salt will be considered as a protein source good for this diet (Table 5).

	Serving size (g) needed to provide 20 g of protein	Serving size (g) allowed on Phase One	Serving size (g) allowed on Phase Two	Amino Acid Score
<u>Plant Source</u>				
Protein Shake, soy protein isolate	24	20	28	108
Pumpkin Seed protein powder	32	27	35	138
<u>Animal Source</u>				
Beef, chuck steak	92	135	135	94
Beef, extra lean ground	91	102	102	94
Beef, frank steak	94	83	83	94
Beef, heart	113	127	127	94
Beef, round steak	85	182	182	94
Beef, sirloin	90	146	146	94
Beef, tenderloin	91	105	105	94
Beef, tendon	54	648	648	94
Chicken, breast	89	232	232	136
Chicken, whole	95	108	108	134
Egg white	183	102	102	145
Fish, cod filet	112	312	312	148
Fish, halibut	108	252	252	148
Fish, salmon, smoked	33	52	52	148
Fish, salmon, raw	101	97	97	148
Lamb, chop*	100	85	85	141
Lamb, shank	98	178	178	141
Liver, beef**	98	26	129	155
Liver, chicken	118	124	124	149
Liver, pork**	94	41	166	151
Pork, chop	88	230	230	150
Pork, extra lean ground	95	150	150	146
Pork, rib	92	94	94	146
Pork, shank	92	188	188	146
Pork, tenderloin	95	271	271	146
Protein shake, whey	27	34	100	100
Shrimp, headless	100	144	144	113
Squid**	128	32	160	107

Turkey leg (meat and skin)*	102	89	89	143
Turkey skinless breast	85	150	150	145

Table 5: Protein sources that contain at least 20 g of quality protein, suitable for the Dr. Poon’s Diet Program

*Lamb chop and turkey leg (meat and skin) will be a suitable protein source if the fat and skin is removed from the meat.

**The carbohydrate levels (glycogen) of beef and pork liver are too high to be consumed in Phase One but are allowed in Phase Two.

There are other good quality proteins (AAS of 100) available that are not listed above; however, they also contain excess net-carb, bad fat and/or sodium, such that patients can only consume a small quantity on Phase One or Two (Table 6). Patients cannot rely on these proteins as their main sources on Dr. Poon’s Diet. For example, the diet only allows 2 g of black bean on Phase One due to its high net-carb content (47 g per 100 per of black beans). The 2 g of black beans contains only 0.4 g of protein, which is far from the 20 g of protein that patients should be consuming per meal. Patients would need to consume 93 g of black beans in order to achieve the 20 g of protein goal. Even on Phase Two, only 11 g of black beans is allowed; hence black beans are not considered a suitable protein source, even though it is a complete protein.

The maximum serving size of soybeans is 36 g on Phase One, which is way below the 152 g needed to provide the 20 g of protein goal; however, because the net-carb limit is increased to 5 g per serving on Phase Two, 179 g of soybeans is allowed on the Phase Two diet plan. This 179 g of soybeans will provide the patient with the 20 g of protein needed to stay healthy. Egg white is a good source of protein with AAS of 145. However, because of the sodium content is slightly high, the amount of egg white allowed is limited unless the patients have no water retention or hypertension.

	Serving size (g) needed to provide 20 g of protein	Serving size (g) allowed on Phase One	Serving size (g) allowed on Phase Two	Amino Acid Score
<u>Plant Source</u>				
Beans, Black	93	2	11	104
Beans, chickpeas	98	3	15	106
Beans, fava	77	3	15	84
Beans, kidney	85	3	15	104
Beans, lima	187	2	11	88
Beans, lentil	81	2	9	86

Beans, mung	84	2	11	83
Beans, navy	90	2	11	82
Beans, soy	152	36	179	132
Beans, soy nuts	56	9	47	118
Flour, soy	53	4	22	118
Milk, unsweetened soy	286 ml	83 ml	417 ml	118
Nuts, cashews	110	4	14	100
Quinoa	141	2	9	106
Seeds, chia	121	13	19	115
Seeds, flax	73	14	14	92
Seeds, pumpkins	80	7	13	138
Seeds, sunflower	86	10	50	88
Soy Curls™	60	15	76	132
Tofu, firm	222	50	250	119
Tofu, silken	278	100	500	106
<u>Animal Source</u>				
Bacon, peameal	99	23	23	144
Bacon, pork	159	15	15	144
Bacon, turkey	126	16	16	143
Beef, rib	114	33	33	94
Beef, tongue	134	27	37	109
Cheese, light cottage	188	23	41	158
Cheese, light feta	86	18	18	127
Cheese, low fat cream	255	12	39	145
Chicken, heart	129	65	65	146
Chicken, wing	114	47	47	128
Crab, meat	85	45	45	113
Cuttlefish	123	46	46	107
Egg, white	183	102	170	145
Egg, whole	159	63	63	136
Extra-lean ground chicken	115	74	74	120
Hot dog, all beef	171	18	18	154
Hot dog, all chicken	129	17	17	95
Hot dog, all turkey	164	19	19	133
Jerky, beef	60	8	8	94
Lobster, tail	125	85	85	113

Milk, skim	238	8	42	90
Octopus	134	45	74	107
Pork, tongue	123	35	35	139
Sausage, turkey	106	29	29	99
Sausage, pork	130	23	23	99
Scallops, meat only	166	31	43	107
Squid	128	32	160	107

Table 6: Complete Protein that could be consumed in small quantity only

There are some foods that contain some protein, but the quality of protein is poor, so even though they can be consumed in this diet program, they cannot be considered as a good source of protein (Table 7).

	Serving size (g) needed to provide 20 g of protein	Serving size (g) allowed on Phase One	Serving size (g) allowed on Phase Two	Amino Acid Score
<u>Plant Source</u>				
Flour, almond	88	7	8	55
Flour, whole wheat	152	2	8	54
Gluten, wheat	27	8	38	54
Milk, unsweetened almond	1290	167	833	55
Milk, unsweetened rice	2985	12	60	71
Nuts, almond	94	11	12	55
Nuts, macadamia	253	8	8	4
Nuts, peanut	78	11	12	70
Nuts, pecan	200	8	8	61
Nuts, pine	146	9	9	77
Nuts, walnut	120	9	9	55
Peanut butter, regular	90	6	11	55
Peanut butter, low fat	77	3	16	55
Semolina	168	1	7	38
<u>Animal Source</u>				
Gelatin	23	100	100	0
Milk, homo	260 ml	8 ml	41 ml	85

Yogurt, plain	667	20	100	82
Yogurt, 0% fat	415	12	62	80

Table 7: Protein sources with lower Amino Acid Scores

According to Health Canada³, the Daily Value for a 2000 kcal reference diet for calcium is 1300 mg and potassium is 4700 mg; however, that is not the minimum amount of potassium that is needed to maintain health. According to National Research Council 1989⁴, the minimum daily requirement for potassium to maintain a healthy diet is between 1600 and 2000mg. When the Dr. Poon's Diet is explained to patients, and they are told that dairy products, fruits and fruit juices are not allowed on the Phase One diet, most patients voiced their concern about potassium and calcium deficiency. Table 8 showed the potassium and calcium contents of different protein sources.

Food Item from Plant Source*	K⁺, mg	Ca⁺⁺, mg	Food Item from Animal Source*	K⁺, mg	Ca⁺⁺, mg
Beans, black	1483	123	Bacon, Peameal	683	6
Beans, chickpeas	718	57	Bacon, pork	198	5
Beans, fava	1062	103	Bacon, turkey	349	80
Beans, kidney	1406	143	Beef, chuck	367	13
Beans, Lima	1724	81	Beef, flank	328	25
Beans, lentil	677	35	Beef, heart	287	7
Beans, mung	1246	132	Beef, rib	277	12
Beans, Navy	1185	147	Beef, round steak	312	13
Beans, soy	482	60	Beef, sirloin	349	25
Beans, soy nut	1200	143	Beef, tenderloin	289	13
Flour, almond	705	214	Beef, tongue	315	6
Flour, soy	2515	206	Burger patty, beef, frozen	269	7
Flour, whole wheat	363	34	Cheese, light cottage	86	71
Gluten, wheat	100	142	Cheese, light feta	62	266
Milk, unsweetened almond	176	516	Cheese, low fat cream	247	148
Milk, unsweetened rice	65	283	Chicken, heart	176	12
Milk, unsweetened soy	290	300	Chicken, skinless breast	334	5
Nuts, almond	733	269	Chicken, skin-on thigh	204	7
Nuts, cashew	660	37	Chicken, whole meat only	229	12
Nuts, macadamia	368	85	Chicken, wing	187	11
Nuts, peanut	705	92	Crab, imitation meat	294	24
Nuts, pecan	410	67	Crab, meat	354	94
Nuts, pine	596	16	Cuttlefish	354	90
Nuts, walnut	433	67	Egg, white	163	7
Peanut butter, regular	558	49	Egg, whole egg	138	56
Peanut butter, low fat	669	35	Extra-lean ground beef	357	8

Protein shake, soy protein isolate	333	150	Extra-lean ground chicken	522	6
Quinoa	563	47	Extra-lean ground pork	310	15
Seeds, chia	407	631	Extra-lean ground turkey	213	21
Seeds, flax	813	42	Fish, cod filet	413	16
Seed, pumpkin	807	43	Fish, halibut	435	7
Seed, pumpkin protein powder	1520	67	Fish, salmon filet, smoked	960	58
Seeds, Sunflower	600	133	Fish, salmon, raw	490	12
Semolina	186	30	Gelatin, unsweetened	16	55
Tofu, firm	148	201	Hot dog, all beef	364	14
Tofu, silken	120	111	Hot dog, all chicken	202	74
			Hot dog, all turkey	392	148
			Jerky, beef	597	20
			Lamb, Chop	327	18
			Lamb, Shank	327	5
			Liver, beef	313	5
			Liver, chicken	230	8
			Liver, pork	273	9
			Lobster, tail	310	47
			Milk, homo	322	276
			Milk, skim	410	504
			Octopus	350	53
			Pork, chop	354	9
			Pork, rib	358	4
			Pork, Shank	329	12
			Pork, tenderloin	399	5
			Pork, tongue	243	16
			Protein shake, whey	403	400
			Sausage, turkey	262	19
			Sausage, pork	307	8
			Scallops, meat only	205	6
			Shrimps, headless	264	64
			Squid	246	32
			Turkey, leg	273	17
			Turkey, skinless breast	242	11
			Yogurt, plain	184	120
			Yogurt, zero fat	166	110

Table 8: Potassium and calcium content of some of the protein sources

*per 100 g of food item or 250 ml of liquid

This diet plan allows patients to consume unlimited amount of green leafy vegetables and some low net-carb vegetables. As shown in Table 9, these plant foods contain good amount of potassium and also calcium. There will be no problem in meeting the minimum requirement of these two minerals. The diet program monitors the patient's

vitals and biochemistry closely. Blood tests were ordered when patient lost 10% of the original weight. There was no case of pathologically low potassium level related to the diet reported so far.

Vegetable Source*	K⁺, mg	Ca⁺⁺, mg
Broccoli	316	47
Cabbage	170	40
Cauliflower	299	22
Collard green	213	232
Cucumber	147	16
Kale	491	150
Lettuce	194	36
Mushroom, white	318	3
Okra	299	82
Spinach	559	99
Sweet pepper	175	10
Tomato	237	10

Table 9: Potassium and Calcium content of the commonly consumed vegetables

*100 g of raw vegetable

This diet program does not allow any fruits or juices on Phase One due to their high net-carb contents, and patients sometimes worry about potassium deficiency. It is a common misconception from the general population that fruits are the only good sources of potassium. One medium size banana contains 422 mg of potassium, which can easily be matched by the leafy vegetables and protein rich foods (Tables 8 and 9), while the banana contains 24 g of net-carb, which is equivalent to 6 teaspoons of sugar. Dairy products are not allowed on Phase One because they contain sugar and bad fats. One cup of homo cow's milk (244 g) provides 276 mg of calcium, but it also contains 12 g of lactose which is equivalent to 3 teaspoons of sugar, whereas unsweetened soy milk can provide 300 mg of calcium, with only 1 g of net-carb. Some milk have higher calcium contents, but those are fortified with extra calcium, which is like drinking regular milk and take a calcium pill on the side. Tables 8 and 9 show the calcium contents of different food products and dairy products do not own a monopoly on calcium. Milk protein only has an AAS of 85 and is not a complete protein.

The cost of food items per 100 g were found by visiting the local supermarkets and health food stores. Since we know the macronutrient composition of these food items, using the USDA site and the nutritiondata.self.com site,

the cost per 20 g of protein, per food item, can easily be calculated (Table 10). Using table 3 as a guideline, one can determine if the food product is appropriate for Phase One, Phase Two and/or Phase Three.

Food Items	Cost/100g of food	Cost/20g of protein
Beans, Navy	\$0.22	\$0.20
Seeds, flax	\$0.29	\$0.21
Beans, kidney	\$0.30	\$0.25
Beans, lentil	\$0.33	\$0.27
Beans, soy	\$0.17	\$0.30
Gluten, wheat	\$1.30	\$0.35
Beans, fava	\$0.46	\$0.36
Beans, black	\$0.40	\$0.37
Chicken, whole, meat only	\$0.42	\$0.40
Beans, chickpeas	\$0.44	\$0.43
Beans, mung	\$0.52	\$0.44
Liver, pork	\$0.57	\$0.53
Soy Curl	\$0.88	\$0.53
Flour, soy	\$1.00	\$0.53
Pork, chop	\$0.65	\$0.57
Nuts, peanut	\$0.74	\$0.57
Gelatin, unsweetened	\$2.99	\$0.60
Seeds, sunflower	\$0.70	\$0.60
Hot dog, all chicken	\$0.51	\$0.66
Pork, Shank	\$0.73	\$0.67
Chicken, skin-on thigh	\$0.57	\$0.69
Pork, tenderloin	\$0.75	\$0.72
Extra-lean ground pork	\$0.77	\$0.73
Seed, pumpkin protein powder	\$2.40	\$0.76
Beef, tendon	\$1.43	\$0.77
Liver, chicken	\$0.66	\$0.78
Lamb, Shank	\$0.80	\$0.78
Chicken, heart	\$0.64	\$0.82
Flour, whole wheat	\$0.57	\$0.86
Protein shake, soy isolate	\$3.64	\$0.88
Turkey, leg	\$0.88	\$0.90

Egg, white	\$0.50	\$0.92
Egg, whole egg	\$0.58	\$0.92
Pork, rib	\$1.00	\$0.92
Semolina	\$0.55	\$0.92
Fish, salmon, smoked	\$2.86	\$0.94
Chicken, wing	\$0.86	\$0.98
Peanut butter, low fat	\$1.30	\$1.00
Peanut butter, regular	\$1.18	\$1.07
Beef, sirloin	\$1.20	\$1.09
Chicken, skinless breast	\$1.23	\$1.09
Peanut butter, PB2 powder™	\$2.42	\$1.16
Milk, skim	\$0.50	\$1.19
Tofu, silken	\$0.43	\$1.19
Burger patty, beef, frozen	\$0.88	\$1.20
Extra-lean ground beef	\$1.32	\$1.20
Cheese, light cottage	\$0.66	\$1.24
Bacon, Peameal	\$1.30	\$1.28
Milk, homo	\$0.50	\$1.30
Tofu, firm	\$0.45	\$1.30
Cheese, light feta	\$1.59	\$1.36
Beef, round steak	\$1.63	\$1.39
Beef, chuck	\$1.54	\$1.41
Sausage, turkey	\$1.33	\$1.42
Octopus	\$1.07	\$1.44
Beans, Lima	\$0.50	\$1.47
Extra-lean ground turkey	\$1.39	\$1.48
Squid	\$1.18	\$1.51
Sausage, pork	\$1.20	\$1.56
Beans, soy nut	\$2.79	\$1.56
Extra-lean ground chicken	\$1.39	\$1.59
Hot dog, all turkey	\$1.00	\$1.64
Liver, beef	\$1.70	\$1.67
Seed, pumpkin	\$2.10	\$1.68
Milk, unsweetened soy	\$0.60	\$1.71
Pork, tongue	\$1.40	\$1.72
Beef, flank	\$1.88	\$1.77
Quinoa	\$1.28	\$1.80

Beef, heart	\$1.60	\$1.81
Bacon, pork	\$1.20	\$1.90
Protein shake, pea protein	\$6.70	\$1.98
Fish, salmon, raw	\$1.98	\$2.00
Turkey, skinless breast	\$2.42	\$2.05
Cuttlefish	\$1.76	\$2.17
Bacon, turkey	\$1.73	\$2.18
Lamb, Chop	\$2.20	\$2.20
Protein shake, whey	\$8.26	\$2.20
Beef, tenderloin	\$2.47	\$2.25
Beef, rib	\$1.98	\$2.26
Flour, almond	\$2.60	\$2.29
Nuts, almond	\$2.49	\$2.35
Crab, meat	\$3.00	\$2.55
Fish, cod filet	\$2.30	\$2.58
Yogurt, plain	\$0.40	\$2.67
Hot dog, all beef	\$1.56	\$2.67
Yogurt, zero fat	\$0.66	\$2.74
Seeds, chia	\$2.36	\$2.86
Beef, tongue	\$2.45	\$3.29
Nuts, walnut	\$2.82	\$3.38
Crab, imitation meat	\$1.20	\$3.40
Lobster, tail only	\$2.86	\$3.58
Nuts, cashew	\$3.31	\$3.64
Shrimps, headless	\$3.75	\$3.73
Cheese, low fat cream	\$1.52	\$3.87
Jerky, beef	\$8.00	\$4.82
Fish, halibut	\$6.61	\$7.12
Milk, unsweetened almond	\$0.60	\$7.74
Scallops, meat only	\$4.82	\$7.99
Nuts, pecan	\$4.10	\$8.20
Nuts, pine	\$8.11	\$11.84
Nuts, macadamia	\$6.39	\$16.18
Milk, unsweetened rice	\$0.80	\$23.88

Table 10: Cost of food that will provide 20 g of protein

Not all food items that are allowed on Phase One contain the best quality protein. Taking into consideration of all the factors such as quantity allowed, the AAS and price, Table 11 provides patients with some ideal protein recommendations for Phase One when visiting the supermarket, based on cost.

Foods that patient can eat until full	Cost per 20 g protein	comment
Chicken, whole	\$0.40	
Pork chop	\$0.65	
Gelatin, unsweetened	\$0.60	AAS is 0
Pork shank	\$0.67	
Chicken thigh	\$0.69	
Pork tenderloin	\$0.72	
Extra-lean ground pork	\$0.73	
Pumpkin protein powder	\$0.76	
Beef tendon	\$0.77	Very low fat
Chicken liver	\$0.78	Low glycogen
Lamb shank	\$0.78	
Soy isolate protein shake	\$0.88	AAS 108
Turkey leg	\$0.90	
Egg white	\$0.92	
Whole egg	\$0.92	
Pork rib	\$0.92	
Chicken wings	\$0.98	
Beef sirloin	\$1.09	
Chicken breast, skinless	\$1.09	
Ground beef, extra-lean	\$1.09	
Beef round steak	\$1.39	
Beef chuck steak	\$1.41	
Beef flank steak	\$1.77	
Beef heart	\$1.80	
Pea protein shake	\$1.98	AAS 60
Salmon	\$2.00	
Turkey breast, skinless	\$2.05	
Lamb chop	\$2.20	
Whey protein shake	\$2.20	AAS 100
Beef tenderloin	\$2.20	
Cod filet	\$2.58	

Halibut filet	\$7.12	
Foods that patient can eat some everyday	Cost per 20 g protein	Reason for limitation
Flaxseed	\$0.21	High fat, AAS 92
Pork liver	\$0.53	Have glycogen
Chicken heart	\$0.82	Higher fat
Smoked salmon	\$0.94	High sodium
Peanut butter powder, PB2	\$1.16	Some net-carb, AAS 55
Tofu, silken	\$1.19	Some net-carb, low protein
Tofu, firm	\$1.30	Some net-carb, low protein
Octopus	\$1.44	Some net-carb, higher salt
Ground turkey, extra-lean	\$1.48	Higher in fat
Squid	\$1.51	Some net-carb
Ground chicken, extra-lean	\$1.59	Higher in fat
Beef liver	\$1.67	Have glycogen
Pumpkin seed	\$1.68	High fat
Soy milk, unsweetened	\$1.71	Some net-carb, low protein
Pork Tongue	\$1.40	High fat
Cuttlefish	\$2.05	Higher in sodium
Beef rib	\$2.25	High fat
Crab meat	\$2.55	Higher in sodium
Chia seed	\$2.86	High fat and high carb
Beef Tongue	\$3.29	High fat
Lobster tail	\$3.58	Higher in sodium
Shrimp tail	\$3.73	Higher in sodium
Beef jerky	\$4.82	Higher in sodium
Almond milk, unsweetened	\$7.74	Low protein
Scallop	\$7.99	Higher in sodium

Table 11: Recommended Phase One protein sources

The best protein source for the Phase One diet should be one that has AAS of over 100, relatively inexpensive, more than 20 g of protein, less than 1 g of net-carb, less than 6 g of fat, and less than 170 mg of sodium per serving. The daily minimal requirement for good quality protein is about 60 g. If the patient consumes 100 g of chicken meat three times a day will be an equivalent to 60 g of protein per day. The AAS of chicken is 134 (Table 5). One

hundred grams of chicken meat contains minimal net-carb, 2.9 g of fat and 77 mg of sodium. Three servings of 100 g of chicken meat cost a total of \$1.20. Using pork chop as another example, the patient needs to consume 88 g of pork chop to yield 20 g of protein. The AAS of Pork Chop is 150 (Table 5). Eighty eight grams of pork chop contains minimal net-carb, 2.3 g of fat and 55 mg of sodium. The cost of pork chop equivalent to 60 g of protein is \$1.95. Patient was told to remove the visible fat before consumption which will lower the fat content even more. Gelatin is an animal product derived from collagen. Although it is mainly protein and inexpensive, the AAS is 0 meaning that it lacks many essential amino acids in its composition. Gelatin is allowed on Phase One but cannot be counted as a protein source due to poor nutritive value. Another product that is allowed on the Phase One diet which contains good amount of protein but low AAS is pea protein shake. Soy protein shake and whey protein shake have better quality protein than the pea protein shake. Soy protein shake is much cheaper than the whey protein shake. There are many kinds of soy and whey protein shakes on the market. Patients are reminded to look for the one that is low in net-carb, fat and salt. If the shake comes in a powder form, patient should make the shake with water, unsweetened soy milk or almond milk only. Fruit smoothie is not allowed on the diet because fruits will increase the net-carb count of the protein shake.

Peanut butter was invented by a doctor long time ago to provide a source of protein to the elderly who had dental problem and cannot chew meat. Peanut butter was considered as a meat substitute. Peanut butter contains protein but is too high in fat for Phase One consumption. A product called PB2 took the peanut butter and removed most of the fat content and resulted in a peanut butter powder with higher protein content and less fat. However, the AAS is only 55 which limit its nutritional value.

Foods that patient can eat some everyday	Cost per 20 g protein	Reason for limitation
Navy bean	\$0.20	High net-carb
Kidney bean	\$0.25	High net-carb
Lentil bean	\$0.27	High net-carb
Soybean	\$0.30	Some net-carb, AAS 132
Fava bean	\$0.36	High net-carb
Black bean	\$0.37	High net-carb
Chickpea	\$0.43	High net carb
Mung bean	\$0.44	High net-carb
Soy flour	\$0.53	High net-carb and high potassium
Peanut	\$0.57	High fat and some net-carb
Sunflower seed	\$0.60	High fat and some net-carb
Peanut butter, low fat	\$1.00	High net carb and fat, AAS 55
Skim milk	\$1.19	Lactose
Light cottage cheese	\$1.24	Higher in sodium and net-carb

Light feta cheese	\$1.36	Higher in sodium and net-carb
Lima bean	\$1.47	High net-carb
Soy nut	\$1.56	Some fat and net-carb
Almond flour	\$2.29	High fat and some net-carb
Almond	\$2.35	High fat and some net-carb
Yogurt, zero fat	\$2.74	Some net-carb
Walnut	\$3.38	High fat and some net-carb
Cashew	\$3.64	High fat and some net-carb
Cream Cheese, low fat	\$3.87	Some fat and net-carb
Pecan	\$8.20	High fat and some net-carb
Pine nut	\$11.84	High fat
Macadamia	\$16.18	High fat and some net-carb

Table 12: Recommended Phase Two protein sources

After patients lose 10 pounds of fat and water on average, they will be given the Phase Two diet plan, which increases the net-carb per serving to 5 g. However, the amount of fat and sodium remains the same. Patients should continue to lose weight on Phase Two. The Phase Two diet does not provide more nutrients than Phase One, but it provides more choices for the patients. It is mainly designed to help patients to satisfy their cravings. On Phase Two, legumes are allowed in small amounts. Legumes can be classified as carbohydrate with some protein and fat, they are not pure proteins. Soybeans have the highest protein content of all the legumes and also has the highest AAS of 132. Black beans, chickpeas and kidney beans are also complete proteins (AAS over 100). All other legumes mentioned in Table 12 are incomplete proteins with AAS around 85. While consuming a combination of the incomplete proteins can complement each other and result in a complete protein dish, the net-carb content, however, is still too high (except the soybeans) for this program. Therefore, only 2 tablespoons of legumes are allowed per serving on Phase Two.

Nuts have high fat and net-carb contents. They also have a good amount of potassium and calcium. Other than cashew which has an AAS of 100, all other nuts are classified as incomplete protein. The worse one is macadamia nut which has an AAS of 4. Macadamia nut is the most expensive per gram of protein of all nuts.

Small amount of dairy products is allowed on Phase Two. The amount of dairy product allowed is determined by the amount of net-carb and fat in the product.

On the Phase Three diet, small amount of starch (10 g of net-carb per serving) is allowed. Table 13 shows food items that are allowed on Phase Three. These food items contain some protein, but the quantity of protein in these products is too low to make an impact on the daily protein requirement. Proteins from whole wheat flour, semolina, peanut butter and rice milk have low AAS. Even the food items that have high AAS, such as Quinoa and imitation

crab have too many net-carb, which limits the serving size. Phase Three items are included mainly for enjoyment, and cannot be considered as good sources of protein in this diet plan.

Food that patient can eat some everyday	Cost per 20 g protein	Reason for limitation
Whole wheat flour	\$0.86	High net-carb, AAS 55
Semolina	\$0.92	High net-carb, AAS 38
Peanut butter, regular	\$1.07	High fat and high net-carb, AAS 55
Homo milk	\$1.30	Lactose and high fat, AAS 85
Quinoa	\$1.80	High net-carb, AAS 106
Yogurt, regular	\$2.67	High net-carb, AAS 82
Imitation crab	\$3.40	High net-carb and sodium, AAS 114
Rice milk	\$23.88	Low protein and net-carb, AAS 71

Table 13: Recommended Phase Three protein sources

6. Conclusion

A good protein source for this program should be low in net-carb, salt and fat. It should have a high AAS and be relatively inexpensive. This study demonstrates that if the patients are shown how to identify these good protein sources, a high protein diet does not have to be expensive. The minimum 60 g of good quality protein from whole chicken, pork chop and extra-lean ground beef cost \$2.40 per day for Phase One patients. On Phase Two, patients can substitute the animal protein with some legumes, to lower the overall cost. For example, 60 g of protein from whole chicken, pork tenderloin and soybeans can drop the cost to \$1.40 per day. Patient should try to eat fish at least twice a week for its omega-3 and omega-6 content. Similar study will be done in the future to identify inexpensive food products with good omega-3 and omega-6 contents.

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