Optimising nutrition, managing insulin

Overview
The recently expanded food insulin index database suggests that the insulin response to food is more accurately predicted by net carbohydrates plus approximately half the protein compared.

This deeper understanding of the effect of carbohydrates, protein and fibre enables us to calculate the glucose load using the following formula:

\[
glucose\ load\ (g) = carbohydrates\ (g) - fibre\ (g) + 0.56 \times protein\ (g)
\]

Managing the glucose load of the diet to around one hundred grams per day will enable most people to achieve excellent blood glucose control and light nutritional ketosis. However this will vary depend on an individual’s metabolic health and activity levels.

Diabetes could use the glucose load to more accurately estimate their insulin doses accounting for the effect of protein and fibre.

Diabetics and people wanting to reduce insulin can preferentially select foods with the lowest percentage of insulinogenic calories using the formula:

\[
%\ insulinogenic\ calories = \frac{[carbohydrates - fibre + 0.56 \times protein] \times 4\ cal/g}{total\ calories}
\]

Fats and oils, butter and cream have the lowest proportion of insulinogenic calories, however consuming these foods alone is unlikely to provide adequate vitamins, minerals and protein.

Rather than simply eliminating carbohydrate and protein, an individual’s dietary insulin load should be optimised to the point where they are achieving normal blood sugar levels while still obtaining optimal levels of vitamins from some carbohydrate containing foods and amino acids from protein containing foods.

This document outlines a quantitative system for the ranking of foods that can be tailored to an individual’s goals, metabolic health and financial situation using the following metrics:

- proportion of insulinogenic calories,
- nutrient density per calorie,
- fibre per calorie,
- nutrient density per dollar,
- nutrient density per kilogram, and
- cost per calorie.
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1 Introduction

1.1 About us
I’m an engineer with an interest in nutrition who tries to optimise things numerically.

My wife is a type 1 diabetic and I have a genetic predisposition for type 2 diabetes and obesity.

We have also seen dramatic improvements in the health and happiness of our two kids with improvements in our diet.

For me this is personal, and I’m passionate. I hope that sharing our journey can help to shortcut your path to optimum health.

1.2 As simple as possible, but no simpler
There are always new things to learn in the world of health and nutrition. The range of sometimes conflicting ideas makes it difficult to craft a cohesive dietary narrative to achieve health and vitality.

The aim of this document is to consolidate a spectrum of ideas into a system that will enable an individual to tailor their food choices to their goals whether they be weight loss, blood glucose control or athletic performance. My hope is that this information will be useful and help a people short cut their journey to health and vitality.

The system document builds the LCHF, paleo and ketogenic frameworks to minimise the negative effects of high blood glucose and excess insulin while maximising nutrition through eating nutrient dense, luxurious, delicious, whole real food.

People tend to label their ‘way of eating’ and end up dividing into different camps and subcultures with militant beliefs. As outlined in this document I’ve tried to quantify the various components of nutrition to enable us to optimise our food choices to suit an individual’s particular situation. If we agree on the inputs to the system that we’re using to optimise our food choices then we can have more faith in the outputs and hopefully avoid the argument over whether paleo, LCHF, WAPF, SAD or ketogenic diets are best for everyone.

1.3 The blog
It all started with the first draft of this manifesto which I developed to try to work a few ideas through in my head. I came across the insulin index concept on my holidays in January 2015. I am someone who needs to write things down to understanding them and to craft a report style document that makes sense to me that could help progress my family’s health journey.

So I started putting together some graphs and words together to see if it would make sense as a cohesive and logical concept. I also wanted to share my ideas to get feedback from people.

I ended up with an 80 page document with graphs and numbers about nutrition and diabetes that I must admit was probably a bit daunting. My friends and family would just say, ‘wow, it’s long!’ I realised that most people don’t have the time to read long articles or books these days but rather scroll through their Facebook newsfeed and read the occasional 600 or so word blog post.

So I set up the Optimising Nutrition, Managing Insulin blog with the intention to break the manifesto document into bite sized chunks. The response since kicking off the blog in late March 2015 has been amazing.
The concept of being able to rank foods based on their insulinogenic properties seems to have really resonated with people. Thanks to the generous support and promotion of people like Professor Tim Noakes, Dr Jason Fung, Ivor Cummings (Fat Emperor) and Bob Briggs (Butter Makes Your Pants Fall Off) the blog has received nearly 100,000 hits and has nearly 1000 followers via Facebook, Twitter or WordPress.

The interaction with people via the blog has inspired me to prepare some more articles to try to address questions that were being asked. Then I heard from a few people that they were printing on the manifesto document and handing it out to their diabetes nurses and nutritionists at their hospitals and I thought it would be good to go back and polish the manifesto document to bring in the new articles to make it a more robust stand along document.

All of this information and more can be found on the blog. The blog also enables me to embed videos, have hyperlinks and interact with comment to make interactive experience. This document is a compilation of all of the blog posts into a single document that outlines the process from end to end.

1.4 Feedback

The feedback has been incredibly encouraging. It seems to have resonated with people! Here’s a sample of what various people have said to date, with a more extensive list on the feedback page on the blog.

One of the best online resources I’ve ever seen was written by Marty Kendall who details specific foods and their insulin effect. He has written an absolutely fantastic series of post on insulinogenic effect of foods, and well worth a look. It’s absolutely terrific stuff. Like Dr Bernstein, Marty is also an engineer, who developed an interest in foods for type 1 diabetes because his wife suffers from this disease.

Dr Jason Fung, Intensive Dietary Management

This is the best explanation I’ve read on the topic of the insulin effect of food anywhere. Marty is an engineer who takes the numbers and makes sense of them instead of relying of the opinions of others with an agenda.

“Butter” Bob Briggs

The more insulin resistant one is, the more one needs to eat these foods. And excellent resource.

Professor Tim Noakes

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1 http://www.thenoakesfoundation.org/
2 https://intensivedietarymanagement.com/
3 http://www.thefatemperor.com/
4 http://www.buttermakesyourpantsfalloff.com/
5 https://www.facebook.com/buttermakesyourpantsfalloff/posts/867089750017436
6 https://twitter.com/ProfTimNoakes/status/602497913470767104
All doctors, dieticians and diabetes educators need to read this!

Lisa Scherger, The Diabetic Alien\(^7\) and My Healthy Type 1 Son\(^8\)

From Marty Kendall comes a stunning document that will help all to manage their insulin levels. Carb is the major provoker, but keep an eye on yer protein too. As always, fat is the king of energy sources, the cleanest burning fuel for humankind – once you keep the demon carb under control that is.

I will be using this as my go-to reference on the subject, and you should too! How has Marty managed to produce such an excellent document we wonder?

Ivor Cummings, The Fat Emperor\(^9\)

Awesome, thanks Marty, nice work! I am making all of my diabetes care management nurses here at work read ALL OF YOUR STUFF–this is now mandatory!

Dr Ted Naiman, Burn Fat Not Sugar\(^{10}\)

This is one of the most impressive works that I’ve read since finding Dr. Richard K. Bernstein’s Diabetes Solution. I really appreciate the time and effort you put into analysing real data to draw clear-cut and defendable conclusions. This is a pleasant change to drawing conclusions from population studies that allow you to reach whatever conclusion the author is promoting. Once again, well done!!!

Steve Cook

This insulin index concept seems like it really could be a game changer!!!\(^{11}\)

Kikor, forum.lowcarber.org

This is amazing. We know that GI and GL are unreliable and inconsistent and don’t always predict what a food will do to our blood glucose. We know there’s more to dose calculation than just carbs or even just carbs and protein. This data looks directly at the insulin response of foods. It’s not too much to imagine this replacing carb counting one day for diabetics.\(^{12}\)

Spiker, Diabetes.co.uk

I’ve been using your algorithm and for the first time I am really getting great results on a low carb diet.

Joseph O’Brien


\(^8\) [https://www.youtube.com/watch?v=RtiduHZdbUg](https://www.youtube.com/watch?v=RtiduHZdbUg)


\(^12\) [http://www.diabetes.co.uk/forum/threads/insulin-load-index-most-ketogenic-foods.75704/](http://www.diabetes.co.uk/forum/threads/insulin-load-index-most-ketogenic-foods.75704/)
I've only been on LCHF for two weeks and have dropped 8 lbs. Already my skirts (and even my underwear!) are falling off of me... I want to thank you for compiling that list of optimal foods that diabetics can eat. I found your website a while back and your list really helped me to understand what I should and shouldn’t eat.

Marie

13 https://intensivedietarymanagement.com/lchf-for-type-1-diabetes/
2  Paleo, obesity and insulin resistance

2.1  The impact of diet on insulin resistance

You’ve probably heard it said that our ancestors didn’t eat a particular macronutrient ratio that kept them healthy, but rather they avoided obesity and the diseases of modern civilisation by consuming sugar and carbohydrates the natural packaging that it came in. Our ancestral diet included a diverse range of plant and regularly provided more than 100g of dietary fibre per day.14

The first time I heard of the insulin index was in a series of enlightening videos by Doctor Jason Fung15 in which he highlighted research on the “food insulin index” (FII) which that carbohydrate alone is not a fantastic predictor of insulin requirement.

While pure fats such as butter and olive oil are the lowest on the insulin index, it was intriguing to see that some carbohydrate-containing foods are lower on the insulin index than you’d expect from their carbohydrate content alone while lean protein foods such as steak and white fish cause high levels of insulin to be secreted even though they contain minimal carbohydrates. The insulin index data just didn’t seem to align with conventional low carb diabetes wisdom.

Doctor Fung also highlighted that the typical modern practice of having three meals plus snacks doesn’t give the body any time that there is not insulin circulating in our blood. In earlier times this wasn’t always the way. Before we could access whatever we wanted from the supermarket there would have been periods of feasting in summer when carbohydrates eaten were stored via insulin as fat along with corresponding periods of famine and winter where insulin levels were low and fat stores could be used.

Constant elevated insulin levels can contribute to insulin resistance. The pancreas then produces more insulin to remove sugar from the blood. This compounds the insulin resistance which then leads to diabetes and obesity.

As well as high blood sugar, we have recently come to realise that high levels of insulin are also toxic.16 Even if you keep blood glucose levels low with insulin sensitising drugs and injected insulin, the level of inflammation and rate of complications from diabetes is still high.17

Once we understand what caused the problem we can do the opposite to treat the problem rather than simply taking drugs to mask the symptoms. Doctor Fung’s recommendation for addressing obesity is summarised in Table 1.

<table>
<thead>
<tr>
<th>Things that lead to diabetes</th>
<th>Things that reverse diabetes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excessive sugar and simple carbohydrates in the diet generate high insulin load</td>
<td>Reduce foods in your diet that require insulin18</td>
</tr>
<tr>
<td>Constant food intake and high insulin levels</td>
<td>Periods of reduced insulin levels (e.g. intermittent fasting)</td>
</tr>
</tbody>
</table>

---

14 http://www.nature.com/ejcn/journal/v61/n1/full/1602486a.html
15 https://www.youtube.com/user/drjasonfung
17 https://www.youtube.com/watch?v=4oZ4UqtbB_g
18 http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2716748/
After watching Dr Fung’s videos and scouring through his extensive blog I was left wondering what our family should be eating to minimise insulin load to optimise blood glucose control while maximising fibre and nutrition.

The journey to try to answer this question for myself and my family has been interesting. I hope you’ll stick with me to understand the response which is detailed in this document.

2.2 Food Insulin index

The initial research into the food insulin index is detailed in a 1997 paper by Susanne Holt et al who tested the insulin demand of thirty eight different foods.19

The food insulin index data was determined by feeding 1000kJ (or 239 kcal) of a particular food to non-diabetics and measuring their insulin levels in response over three hours. Insulin secretion for a particular food was compared to the insulin secretion for white bread, which was assigned a value of 100%, to arrive at a value for each food.

I found it surprising that there hadn’t been much discussion of about the insulin index data considering how significant it could be for “low carbers” trying to minimise the insulin effect of foods and for type 1 diabetics who have to calculate insulin doses every time they eat.

Doing a bit more searching on the topic I found a few references and occasional discussions in podcast, but no one was quite sure what to do with the information, partly due to the small number of foods that had been tested.

Table 2 shows that the foods lowest on the insulin index are generally high in fat. If we abandon the authority of the food pyramid and our fear of fat, the logical extension of this is that the ideal diet for diabetics or people wanting to lose weight by reducing insulin load would be to prioritise foods lowest on the insulin index such as butter, oils and bacon.

<table>
<thead>
<tr>
<th>Food</th>
<th>protein (g/MJ)</th>
<th>fat (g/MJ)</th>
<th>carb (g/MJ)</th>
<th>fibre (g/MJ)</th>
<th>Insulin index (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Butter</td>
<td>0</td>
<td>27</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Olive oil</td>
<td>0</td>
<td>27</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Bacon</td>
<td>16</td>
<td>19</td>
<td>1</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>Peanut butter</td>
<td>9</td>
<td>20</td>
<td>7</td>
<td>5</td>
<td>11</td>
</tr>
<tr>
<td>Bologna</td>
<td>24</td>
<td>9</td>
<td>13</td>
<td>3</td>
<td>11</td>
</tr>
<tr>
<td>Peanuts</td>
<td>10</td>
<td>20</td>
<td>5</td>
<td>2</td>
<td>15</td>
</tr>
<tr>
<td>Tuna</td>
<td>24</td>
<td>15</td>
<td>2</td>
<td>0</td>
<td>16</td>
</tr>
</tbody>
</table>

Bob Briggs has a YouTube video “Butter Makes Your Pants Fall Off”20 with more than 100,000 views where he explains the mechanisms of controlling carbohydrates, how insulin promotes fat storage and how reducing carbohydrates and eating healthy fats leads to a reduction in appetite and can help people lose weight. The food insulin index explains why this is the case, with butter being the lowest of all foods measured on the insulin index.

19 http://ajcn.nutrition.org/content/66/5/1264.short
20 https://www.youtube.com/watch?v=h6aMN6NLOTQ
The ranking of olive oil in the food insulin index (along with the intermittent fasting practiced by the Greek Orthodox Church on Crete, their relative proximity to the equator with increased vitamin D and consumption of significant amounts of fatty fish) may go some way to explaining the success of the Mediterranean diet which is widely advocated for heart health and longevity.

It may be a stretch, but the food insulin index may be part of the reason why Rich Froning keeps winning the CrossFit Games and looking so ripped in spite of consuming an inordinate amount of peanut butter which is also low on the food insulin index.

2.3 Latest food insulin index data

After more searching I hit the jackpot (at least when it comes to food insulin index data), and came across a recent PhD thesis from the University Of Sydney titled Clinical Application of the Food Insulin Index to Diabetes Mellitus (Kristine Bell, September 2014). The main findings of the thesis were that:

- calculating insulin dose based on the food insulin index data rather than carbohydrate counting provided better blood glucose control for type 1 diabetics, and
- type 2 diabetics improved blood glucose control by choosing foods with a lower insulin index, independent of calories or carbohydrates.

Figure 1 shows a comparison of the insulin response to a low versus high food insulin index diet in type 2 diabetics. The carbohydrate levels and calories were kept fixed for both scenarios and hence the blood sugar response was similar for both approaches but we can see that the high insulin index foods (i.e. higher protein, lower fat) required significantly more insulin across the day.

![Figure 1 Comparison of insulin profile – high FII versus low FII diet](image)

The low and high FII dietary approaches were designed around the standard dietary recommendations for carbohydrate and the impact of a reduced carbohydrate diet in insulin levels

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21 [http://journals.cambridge.org/download.php?file=%2FPHN%2FPHN8_06%2FS1368980005000881a.pdf&code=1832170c277dbf975e74d9e8bd98c77]
22 [https://www.youtube.com/watch?v=S8-69xA6ics&feature=youtu.be&t=1601]
24 [http://ses.library.usyd.edu.au/handle/2123/11945]
was not tested. This left me wondering whether this data could help inform which foods would require less insulin and hence may be more ideal for diabetics or people struggling with obesity.

Appendix 3 of the thesis contained an extensive database of foods that had now been tested. The original paper on the food insulin index tested only thirty eight foods and the implications were not clear, however with more than one hundred foods now tested the story become a little bit clearer.

Figure 2 shows a plot of the carbohydrates versus the insulin index for the various foods tested. The relationship between insulin demand and carbohydrate ingested is not straightforward. The most perplexing observation from this data is that there are a number of low carbohydrate, high protein, foods that still cause a high insulin response (e.g. white fish, steak and tuna).

![Figure 2: Carbs ingested versus insulin index (taken from Bell, 2014)](http://ses.library.usyd.edu.au/bitstream/2123/11945/2/Bell_KJ_thesis_2.pdf)

### 2.4 Carbs, protein, type 1s and canaries

Quantification of insulin demand is of particular interest for type 1 diabetics who have to inject insulin to manage their blood glucose. Insulin is also the master regulator hormone that governs fat storage and conversely usage of body fat for fuel.

Before diagnosis, a type 1 diabetic whose pancreas is failing will have extremely high blood glucose levels and will be losing weight fast because they can’t access the sugar in their blood without insulin.

The body kicks into what some call a backup survival mechanism called ketosis in which it uses body fat for fuel rather than sugar from dietary carbohydrates. When combined with very high levels of glucose, this scenario is called diabetic ketoacidosis and can be a life threatening if left untreated.

After commencing insulin therapy a type 1 diabetic will regain weight. Sometimes more weight is gained than desired if additional carbohydrates are required to raise blood glucose driven low by
excess insulin. Diabetics can even get localised fat deposits around their insulin injection sites if they don’t rotate them and / or are taking large amounts of insulin.

The picture below shows “JL” one of the first type 1 diabetics to receive insulin in 1922. The photo on the left is after diagnosis but before insulin. The photo on the right is the same child three months after starting insulin injections.

An example a bit closer to home is my children who were born after spending nine months in a high insulin environment. Even though they deliver children of type 1 diabetic mothers earlier than normal they were much fatter than a normal newborn (check this blog post for photos). These days they look just perfect (I may be biased) eating a moderately high fat diet. It’s a bit hard to argue the calories in / calories out theory saying that the in-utero kids should better manage their portion sizes and exercise more in utero!

Carbohydrates raise blood glucose and insulin works to remove the sugar from the blood to store as fat. In practice it’s impossible to perfectly match the insulin action with the rate of carbohydrate digestion.

While type 1 diabetics are an extreme case, I think type 1 diabetics can be considered to be the “canary in the coal mine” of weight maintenance and metabolic health.

To some extent everyone’s body is working to balance the effect of carbohydrates and protein driving up blood glucose and with the pancreas secreting insulin to bring the blood glucose back down.

2.5 Protein and the foods insulin index... Atkins versus the vegans

One thing that’s not well understood is how type 1 diabetics should deal with protein. Conventional wisdom is that type 1 diabetics should dose with about half the insulin for protein containing foods, however the basis of this is not clear. On diabetic forums I see type 1 diabetics struggling to know what to do to deal with the blood glucose response to protein even if they are using a low carbohydrate diet.

With the food insulin index data now available perhaps we might be able to better understand the insulin requirements of protein containing foods?
Dr Fung notes that the Atkins approach often doesn’t work over the long term because things other than carbohydrates stimulate insulin secretion.\textsuperscript{26}

The irony of low carbers eating protein to avoid carbs to minimise insulin secretion has not been lost on the vegan community.\textsuperscript{27}

In response to this, Gary Taubes has acknowledged that protein does stimulate insulin release, however “the assumption has always been that this effect is small compared to that of carbohydrates, and that it is muted because it takes considerably longer to digest protein from meat.”\textsuperscript{28}

Is protein a significant issue for people trying to control blood glucose and reduce the insulin load of their food? Perhaps the food insulin index data can help us find the answer.

\textsuperscript{26} http://intensivedietarymanagement.com/atkins-decline-hormonal-obesity-part-xx/
\textsuperscript{27} http://nutritionfacts.org/video/paleo-diets-may-negate-benefits-of-exercise/
\textsuperscript{28} http://www.healthcentral.com/diabetes/c/36758/20088/gary-round-3/
3 Analysis of food insulin index data

3.1 How much insulin is required to cover protein?

Given that the food insulin index data appears to indicate that protein appears to contribute to insulin demand I ran a number of scenarios to see if insulin requirement is better predicted by carbohydrate in a food plus some proportion of the protein. The highest correlation was achieved with carbohydrate plus 56% of the protein. That is, the food insulin index data indicates that the body responds with a little more than half the insulin in response to carbohydrates compared to carbohydrate.

Figure 3 shows that the correlation of food insulin index with carbohydrate plus 0.56 times protein is better than carbohydrate alone. More importantly thought we no longer the high protein foods such as steak, white fish and tuna sitting on the vertical axis.

3.2 What about fibre... net carbs or total carbs?

Looking at the foods sitting above the trend line in Figure 3 it appears that the foods with the greatest insulin response compared to what would be predicted by carbohydrate and protein tend to be the ones that are more processed such as ice-cream, baked beans, pancakes and Jelly Beans. On the lower side of the trend line we tend to have less processed foods (e.g. full cream milk, navy beans, porridge and All Bran with added fibre).

It appears that the degree of processing of a food may have an effect on the insulin response of foods. Could we use fibre as a proxy for the level of processing to help refine the prediction of insulin demand by different foods?
In order to test whether fibre is a useful predictor of insulin demand I tested the relationship between carbohydrates plus different amounts of the fibre in the various foods. The best correlation was achieved by removing all of the fibre.

As shown in Figure 4, using net carbs gives an increased correlation compared to the carbohydrates alone. Considering the carbohydrates, protein and fibre in a food enables us to more accurately predict insulin demand.

![Figure 4: Net carbohydrates (g) versus food insulin index](image)

When you think about it, it sort of makes intuitive sense that indigestible fibre doesn’t raise blood glucose or insulin but rather is used to feed our gut bacteria.

This concept is often referred to as “net carbs”. If you’re trying to count carbohydrates to manage insulin people are often advised to consider the total carbohydrates minus the fibre as fibre cannot be digested but is rather digested by our intestinal bacteria.

I recently came across a podcast and blog post by Chris Kresser where he discussed whether low carb, high meat or high fat diets can negatively affect gut bacteria which can adversely affect insulin sensitivity. Chris points to a paper by Ian Spreadbury which highlights the negative effect of dense acellular carbohydrates (i.e. processed carbs with a large amount of carbohydrates per weight of the

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29 This seems to work in practical application as well. We recently tried a low carb quesadilla recipe where the only carbohydrates used are psyllium husk to replace the flour in a normal recipe. My wife, who is a type 1 diabetic, dosed insulin for the total carbohydrates, without taking into account the fact that the psyllium is 100% fibre, and ended up with a low blood glucose due to excess insulin. In future with low carb meals it would be better to only dose with insulin for the net carbs, particularly for lower carbohydrate meals.

30 One of the emerging areas is the realisation that fibre, which is carbohydrates that cannot be digested and used by the body, actually acts as food for healthy gut bacteria. One hypothesis is that fibre feeds the bacteria in the gut called bacteroides while sugars feed fermicutes and people with the highest bacteroides : fermicutes ratio tend to be leaner.

31 [http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3402009/#_jmp0_](http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3402009/#_jmp0_)

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26 June 2015
food) as promoting inflammation in the gut and possibly the primary cause of leptin resistance and obesity.

This finding also aligns with the observation from the food insulin index data that fibre effectively negates the insulinogenic effect of carbohydrates. It’s hard to go wrong with high fibre, low insulin, nutrient dense foods!

Processed foods tend to contain less fibre, while carbohydrates in their original state typically contain more fibre. Fibre is indigestible carbohydrate and hence does not raise blood glucose or require insulin. Fibre is also important for our gut health and feeds the good bacteria in our digestive tract.32

This aligns with the understanding that carbohydrates consumed with the packaging that they came with (i.e. fibre) do not have as big an effect on insulin. As suggested by Spreadbury,33 this relationship might be part of the reason why many populations have maintained good health on a higher level of carbohydrate consumed in their raw natural state compared to when they come from the supermarket in boxes with barcodes.

There is some disagreement out there on how to deal with fibre on a restricted carbohydrate approach:

- Some people say you should ignore fibre because “net carbs” is just a marketing ploy and that it is more “intellectually honest” to count all dietary fibre.
- Some people choose to count half the fibre as carbs as a middle ground.
- Experienced type 1 diabetics who monitor their blood glucose religiously using continuous glucose meters will tell you that the fibre in their veggies will not raise their blood glucose however they ignore the fibre in packaged foods because it does raise their blood sugar.

Increasing the amount of fibre (e.g. by increasing your non-starchy veggies such as spinach, broccoli, mushrooms, Brussel sprouts and kale) will help to decrease your insulin load. The major problem that I see with encouraging people to consider total carbohydrates is that it will mean that people will avoid vegetables which not be optimal for health in the long term.

People like David Permutter,34 Paul Jaminet and Terry Wahls35 are talking more and more about the importance of a healthy gut microbiome for maintaining insulin sensitivity and preventing diabetes. It’s also important to keep in mind that fibrous foods often come packed with vitamins that are hard to get from food that are primarily fat or protein.

3.3 How do you like your veggies... cooked or raw?

One consideration when it comes to veggies is the impact of cooking or processing. If you boil something to a mush then it’s probably not going to have the same amount or quality of fibre as if you were to eat it in its raw unprocessed form. It’s also going to be easier to eat a lot more of something that’s cooked or processed than if it’s in its raw natural form.

http://www.skinnygutdiet.com/
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3402009/#_jmp0_
http://blog.primalblueprint.com/episode-70-dr-david-perlmutter/
Table 3 shows a comparison of the fibre content of one hundred grams of cooked and raw vegetables sorted by the percentage of insulinogenic calories.

**Table 3 Comparison of fibre content raw versus cooked vegetables**

<table>
<thead>
<tr>
<th>food</th>
<th>raw</th>
<th>cooked</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>carbs</td>
<td>fibre</td>
</tr>
<tr>
<td>spinach</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>broccoli</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>eggplant</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>artichoke</td>
<td>11</td>
<td>5</td>
</tr>
<tr>
<td>mushroom</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>carrots</td>
<td>10</td>
<td>3</td>
</tr>
</tbody>
</table>

Based on the data from [http://nutritiondata.self.com](http://nutritiondata.self.com), spinach and broccoli don’t seem to lose a lot of their fibre through cooking. Eggplant seems to lose some fibre relative to carbohydrates and end up with an increased percentage of insulinogenic calories.

Somehow artichoke, mushroom and carrots actually gain fibre relative to the overall level of carbohydrate, which is interesting. I’m not sure how this would happen or maybe it’s just an anomalies in the data?

When it comes to carbohydrate counting and vegetables it’s worth noting that you could eat 600g of spinach or 300g of broccoli and still have a Bernstein-compliant lunch or dinner with no more than twelve grams of net carbohydrates.

Regardless of the data, lightly steamed is probably your best bet to retain the nutrients and fibre in your veggies. If you want to check out how your favourite veggies fare before and after cooking you can find out at [nutritiondata.self.com](http://nutritiondata.self.com).

### 3.4 Putting it all together... protein and net carbs

So far we’ve learned from the food insulin index data that:

1. carbohydrate alone isn’t a fantastic predictor of insulin demand, particularly because low carbohydrate high protein foods still require significant insulin,

2. understanding that protein requires about half as much insulin as carbohydrate helps to improves our estimation of insulin demand, and

3. understanding that indigestible fibre neutralises insulin demand helps further refine our prediction of the insulin requirement.

If we combine the concept of net carbohydrates the understanding that protein requires about half as much insulin as carbohydrate we get the plot shown in Figure 5 which has an even better correlation.
Figure 5 Net carbs plus 0.56 x protein versus food insulin index

This relationship also does a good job of helping to predict the blood glucose response to foods as well as shown in Figure 6.

Figure 6 Net carbs plus 0.56 x protein versus food insulin index
Using net carbohydrates with an allowance for about half the protein gives us a better way to estimate insulin requirement of food compared to using carbohydrates alone. This refined understanding could be very useful for:

1. type 1 diabetics wanting to more accurately calculate their insulin dose, and
2. enabling people to prioritise foods that have a lower insulin requirement.

3.5 Is sugar really toxic?
You may have noticed that there are a lot of people quitting sugar or declaring that it is toxic. But what does the food insulin index data have to say about sugar? Is it any different to other forms of carbohydrate?

I ran a similar analysis to the process described above to see if sugar had a unique effect on insulin compared to non-sugar carbohydrate which indicated that sugar does not generate more insulin than other forms of carbohydrates. If anything, sugar requires slightly less insulin on a gram for gram basis compared to carbohydrates (say about 90%).

This could be because sugar is metabolised quickly and the body pushes out a short burst of insulin to clear the sugar from the blood rather than the long persistent effort that might occur with a lower glycemic index carbohydrate.

This is not to say that sugar is good for you. You should keep in mind that:

1. Refined carbohydrates have no fibre and are very calorie dense. You can eat a lot without feeling full.
2. Refined sugar has a very low nutrient density. Your body is left searching for adequate nutrition and will be prone to over consume calories.
3. Sugar will cause your blood glucose to rise quickly. Your body will produce a burst of insulin which will cause your blood glucose to crash after the insulin surge and leave you feeling hungry again, craving more sugar.
4. Refined sugar will promote the overgrowth of undesirable gut bacteria such as candida.

By contrast, the carbohydrates in non-starchy veggies (e.g. spinach, kale, avocado, and asparagus) come packaged with fibre, high levels of nutrition and digest slowly and will leave you feeling full, raise your blood glucose gently and are very hard to overeat.

3.6 Is dairy and red meat more insulinogenic?
The original 1997 paper by Susan Holt et al looking at the food insulin index suggested that dairy and meat proteins may be more insulinogenic than vegetable proteins. You may have also heard it said in health circles that dairy products have some special hormonal property that requires more

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36 https://iquitsugar.com/
37 https://www.youtube.com/watch?v=dBnniu6-oM
38 https://www.youtube.com/watch?v=siOr5PMsQsk
39 I’m not going to deliver into the fructose / glucose issue. If you want to go there check out https://www.youtube.com/watch?v=dBnniu6-oM or the condensed Shaun Croxton version at https://www.youtube.com/watch?v=tdMjKEncojQ
40 http://ajcn.nutrition.org/content/66/5/1264.abstract
Optimising nutrition, managing insulin

insulin than other foods.\textsuperscript{41} In order to test whether particular groups of foods might have some unique insulinogenic properties I have plotted the insulin reaction for various types of proteins separately.

Figure 7 shows that fish (based on only four data points) and dairy (based on thirteen data points) seem to have the greatest insulin response, while vegetables and animal protein have the lowest insulin response.

\begin{figure}
\centering
\includegraphics[width=\textwidth]{chart.png}
\caption{Comparison of insulin reaction to different types of protein}
\end{figure}

This initial analysis seems to support the idea that a vegetarian diet would have a lower insulin demand compared to a diet containing meat. However if we account for the indigestible fibre (i.e. net carbs) then it appears that legumes (based on only five data points) now require more insulin while fruit and vegetables require less insulin as shown in Figure 8.

\textsuperscript{41} \url{http://www.marksdailyapple.com/dairy-insulin/}
Figure 8 Comparison of insulin reaction to different types of protein - net carbs

It appears to me that there is currently inadequate data to demonstrate that insulin response of a food is influenced significantly by anything other than carbohydrates, fibre and protein.
4 The most ketogenic foods

4.1 General

This section looks at the proportion of insulinogenic calories for various food groups to help us understand which foods might be better than others based on the USDA foods database of nearly 8000 foods.42

I have calculated the percentage of insulinogenic calories for each food in the USDA data base using the following formula based on our observations from the food insulin index data.

\[
\text{% insulinogenic calories} = \frac{\text{carbohydrates} - \text{fibre} + 0.56 \times \text{protein}}{\text{total calories}} \times 4 \text{ cal/g}
\]

In essence this formula compares the proportion of the energy from the food that will generate glucose that will require insulin compared to the total number of calories in the food.

This list has created the most interest on the blog43 and has received more than half of the page views.44

4.2 Least insulinogenic foods

As you might expect, foods with the lowest insulinogenic percentage are the fats and oils that don’t contain any carbohydrate or protein such as butter, coconut oil, olive oil, butter, flax seed oil and lard.

If we drop out the foods that are primarily fats and oils and sort by the proportion of insulinogenic calories we end up with a list of decadent full fat foods shown in Table 4.

<table>
<thead>
<tr>
<th>food</th>
<th>% insulinogenic</th>
</tr>
</thead>
<tbody>
<tr>
<td>olives</td>
<td>3%</td>
</tr>
<tr>
<td>cream</td>
<td>4%</td>
</tr>
<tr>
<td>pecans</td>
<td>5%</td>
</tr>
<tr>
<td>Macadamia nuts</td>
<td>5%</td>
</tr>
<tr>
<td>sesame seeds</td>
<td>7%</td>
</tr>
<tr>
<td>sausage</td>
<td>8%</td>
</tr>
<tr>
<td>flaxseed</td>
<td>8%</td>
</tr>
<tr>
<td>pepperoni</td>
<td>10%</td>
</tr>
<tr>
<td>frankfurter</td>
<td>11%</td>
</tr>
<tr>
<td>duck</td>
<td>12%</td>
</tr>
<tr>
<td>pork sausage</td>
<td>13%</td>
</tr>
<tr>
<td>mackerel</td>
<td>13%</td>
</tr>
<tr>
<td>bacon</td>
<td>15%</td>
</tr>
</tbody>
</table>

4.3 Most insulinogenic foods

If we take this ranking system to the other extreme we get this list of high sugar foods that everyone these days seems to agree we should be avoiding. So this approach to ranking foods based on percentage of insulinogenic calories seems to makes sense intuitively.

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42 http://www.ars.usda.gov/Services/docs.htm?docid=24912
43 https://optimisingnutrition.wordpress.com/
44 https://optimisingnutrition.wordpress.com/2015/03/23/most-ketogenic-diet-foods/
### Table 5 Most insulinogenic foods

<table>
<thead>
<tr>
<th>Food</th>
<th>% insulinogenic</th>
</tr>
</thead>
<tbody>
<tr>
<td>molasses</td>
<td>100%</td>
</tr>
<tr>
<td>maple syrup</td>
<td>100%</td>
</tr>
<tr>
<td>cranberry juice</td>
<td>100%</td>
</tr>
<tr>
<td>sugar</td>
<td>100%</td>
</tr>
<tr>
<td>grape juice drink</td>
<td>100%</td>
</tr>
<tr>
<td>mango nectar</td>
<td>100%</td>
</tr>
<tr>
<td>apricot nectar</td>
<td>100%</td>
</tr>
<tr>
<td>peach nectar</td>
<td>100%</td>
</tr>
<tr>
<td>watermelon</td>
<td>100%</td>
</tr>
<tr>
<td>honey</td>
<td>100%</td>
</tr>
<tr>
<td>marmalade, orange</td>
<td>99%</td>
</tr>
<tr>
<td>jellies</td>
<td>98%</td>
</tr>
<tr>
<td>jams and preserves</td>
<td>98%</td>
</tr>
</tbody>
</table>

### 4.4 Eggs

Eggs are a staple for low carbers, ketogenic dieters and diabetics. Not only are they nutritious they are also low in carbohydrates.

Eggs do contain protein which requires insulin, so eating the whole egg or even the egg yolk (rather than white which has more protein) is a good option if you’re trying to optimise blood glucose rather than build muscle.

### Table 6 Insulinogenic percentage – eggs

<table>
<thead>
<tr>
<th>Food</th>
<th>% protein</th>
<th>% carbs</th>
<th>% insulinogenic</th>
</tr>
</thead>
<tbody>
<tr>
<td>egg yolk</td>
<td>20%</td>
<td>5%</td>
<td>15%</td>
</tr>
<tr>
<td>whole egg</td>
<td>35%</td>
<td>3%</td>
<td>21%</td>
</tr>
<tr>
<td>egg white</td>
<td>84%</td>
<td>6%</td>
<td>51%</td>
</tr>
</tbody>
</table>

As you read through the remainder of this section keep in mind the fact that eggs have about 20% insulinogenic calories as a reference.

### 4.5 Dairy products

#### 4.5.1 General

While cheese and cream are often favoured by people trying to restrict carbohydrates, many people say that they have more success with their weight loss if they limit dairy.

But should we avoid all dairy? Is some dairy better than others if we are trying to reduce our insulin levels?

Rather than simply dismiss all dairy, it may be more useful to think of individual dairy products in terms of the proportion of insulinogenic calories for each food.

#### 4.5.2 Cheese

The calculated proportion of insulinogenic calories for various cheese products is shown in Table 7.

Higher fat cheeses such as brie, limburger, camembert, cheddar, and cream cheese will require little insulin. On the other end of the scale is pretty much anything that is low fat or skim. It appears that cheese can be part of a ketogenic diet if we choose the higher fat, lower protein options.
Table 7 Insulinogenic percentage – cheese

<table>
<thead>
<tr>
<th>cheese</th>
<th>% insulinogenic</th>
</tr>
</thead>
<tbody>
<tr>
<td>cream cheese</td>
<td>8%</td>
</tr>
<tr>
<td>brie</td>
<td>14%</td>
</tr>
<tr>
<td>limburger</td>
<td>14%</td>
</tr>
<tr>
<td>camembert</td>
<td>15%</td>
</tr>
<tr>
<td>Monterey</td>
<td>15%</td>
</tr>
<tr>
<td>cheddar</td>
<td>15%</td>
</tr>
<tr>
<td>gruyere</td>
<td>16%</td>
</tr>
<tr>
<td>Colby</td>
<td>16%</td>
</tr>
<tr>
<td>blue</td>
<td>16%</td>
</tr>
<tr>
<td>edam</td>
<td>17%</td>
</tr>
<tr>
<td>gouda</td>
<td>18%</td>
</tr>
<tr>
<td>feta</td>
<td>18%</td>
</tr>
<tr>
<td>mozzarella</td>
<td>19%</td>
</tr>
<tr>
<td>Swiss</td>
<td>21%</td>
</tr>
<tr>
<td>ricotta, whole milk</td>
<td>21%</td>
</tr>
<tr>
<td>parmesan</td>
<td>23%</td>
</tr>
<tr>
<td>mozzarella, skim milk</td>
<td>25%</td>
</tr>
<tr>
<td>cream cheese, low fat</td>
<td>25%</td>
</tr>
<tr>
<td>ricotta, part skim milk</td>
<td>33%</td>
</tr>
<tr>
<td>Swiss, low fat</td>
<td>43%</td>
</tr>
<tr>
<td>mozzarella, non-fat</td>
<td>53%</td>
</tr>
<tr>
<td>cottage cheese, low fat</td>
<td>55%</td>
</tr>
<tr>
<td>cream cheese, fat free</td>
<td>63%</td>
</tr>
</tbody>
</table>

4.5.3 Milk

Table 8 shows the insulinogenic percentage for various types of milk and cream.

Milk requires a lot more insulin than the high fat cheeses due to their carbohydrate and protein content. If you are going to drink milk, keep it to a minimum if you’re struggling to optimise your blood sugars, and choose full fat milk, not skim.

The other issue with dairy is that it is typically very calorie dense, meaning that it is easy to consume a lot of energy calories quickly. This is great if you’re a growing baby, an athlete trying to replenish energy or a body builder trying to spike insulin for muscle growth. However the moderate insulin load and high palatability are not a good combination if you’re trying to lose weight.

Table 8 Insulinogenic percentage – milk

<table>
<thead>
<tr>
<th>milk</th>
<th>% insulinogenic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full cream milk, 3.7% fat</td>
<td>32%</td>
</tr>
<tr>
<td>Human milk</td>
<td>40%</td>
</tr>
<tr>
<td>Skim milk, 1% fat</td>
<td>52%</td>
</tr>
<tr>
<td>Chocolate milk, low fat</td>
<td>65%</td>
</tr>
</tbody>
</table>

4.5.4 Yogurt

Table 9 shows the percentage of insulinogenic calories for various yogurts.

Again, the full fat plain yogurts have the lowest proportion of insulinogenic calories while the sweetened and low fat options are extremely insulinogenic and should be avoided.
Optimising nutrition, managing insulin

### Table 9 Insulinogenic percentage – yogurt

<table>
<thead>
<tr>
<th>yogurt</th>
<th>% insulinogenic</th>
</tr>
</thead>
<tbody>
<tr>
<td>full fat Greek yogurt</td>
<td>25%</td>
</tr>
<tr>
<td>low fat</td>
<td>76%</td>
</tr>
<tr>
<td>plain, skim milk</td>
<td>78%</td>
</tr>
<tr>
<td>fruit, low fat</td>
<td>83%</td>
</tr>
<tr>
<td>fruit, non-fat</td>
<td>90%</td>
</tr>
</tbody>
</table>

### 4.6 Fruits

It’s interesting to note that there are only a handful of fruits that rank well in terms of their proportion of insulinogenic calories. Once we move beyond olives and avocados the insulinogenic ratio shoots up as shown in Table 10.

### Table 10 Insulinogenic percentage – fruits

<table>
<thead>
<tr>
<th>fruit</th>
<th>% insulinogenic</th>
</tr>
</thead>
<tbody>
<tr>
<td>olives</td>
<td>3%</td>
</tr>
<tr>
<td>avocados</td>
<td>6%</td>
</tr>
<tr>
<td>blackberries</td>
<td>47%</td>
</tr>
<tr>
<td>raspberries</td>
<td>42%</td>
</tr>
<tr>
<td>gooseberries</td>
<td>51%</td>
</tr>
<tr>
<td>rhubarb, raw</td>
<td>55%</td>
</tr>
<tr>
<td>pears</td>
<td>63%</td>
</tr>
<tr>
<td>strawberries</td>
<td>67%</td>
</tr>
<tr>
<td>oranges</td>
<td>73%</td>
</tr>
<tr>
<td>apples</td>
<td>75%</td>
</tr>
<tr>
<td>bananas</td>
<td>84%</td>
</tr>
</tbody>
</table>

### 4.7 Vegetables

Vegetables have a low to moderate proportion of insulinogenic calories. When we account for the non-insulinogenic fibre carbohydrates, all of the vegetable shown Table 11 have a lower percentage of insulinogenic calories than whole eggs. We can use the most nutrient dense of these to make sure we are obtaining adequate vitamin and mineral. It’s hard to overeat non-starchy veggies as they have a very low calorie density and are very filling.

### Table 11 Insulinogenic percentage – vegetables

<table>
<thead>
<tr>
<th>vegetable</th>
<th>% insulinogenic</th>
</tr>
</thead>
<tbody>
<tr>
<td>endive</td>
<td>15%</td>
</tr>
<tr>
<td>dock</td>
<td>21%</td>
</tr>
<tr>
<td>mustard greens</td>
<td>22%</td>
</tr>
<tr>
<td>chrysanthemum leaves</td>
<td>24%</td>
</tr>
<tr>
<td>broccoli</td>
<td>29%</td>
</tr>
<tr>
<td>coriander</td>
<td>29%</td>
</tr>
<tr>
<td>artichoke</td>
<td>29%</td>
</tr>
<tr>
<td>asparagus</td>
<td>33%</td>
</tr>
<tr>
<td>sauerkraut</td>
<td>34%</td>
</tr>
<tr>
<td>Chinese cabbage</td>
<td>35%</td>
</tr>
<tr>
<td>lettuce</td>
<td>36%</td>
</tr>
<tr>
<td>bamboo shoots</td>
<td>38%</td>
</tr>
<tr>
<td>alfalfa</td>
<td>41%</td>
</tr>
<tr>
<td>parsley</td>
<td>42%</td>
</tr>
<tr>
<td>mushroom</td>
<td>42%</td>
</tr>
<tr>
<td>cauliflower</td>
<td>49%</td>
</tr>
<tr>
<td>spinach</td>
<td>51%</td>
</tr>
</tbody>
</table>
4.8 Nuts and Seeds

Table 12 shows that most of the nuts and seeds have a low proportion of insulinogenic calories, with macadamias, pecans, flax seeds, Brazil nuts, walnuts and coconut landing at the top of the list. However unlike non-starchy veggies, it’s easy to eat too many nuts and overdo the calories.

It’s also worth noting that coconut milk and coconut cream, which have a low insulinogenic percentage, can be used as milk alternatives in your coffee. I have also peanuts which are a legume they are cheap, nutrient dense and reasonably good when it comes to the proportion of insulinogenic calories if you can tolerate them.

Table 12 Insulinogenic percentage – nuts, seeds and legumes

<table>
<thead>
<tr>
<th>nuts, seeds legumes</th>
<th>% insulinogenic</th>
</tr>
</thead>
<tbody>
<tr>
<td>macadamia</td>
<td>5%</td>
</tr>
<tr>
<td>pecans</td>
<td>5%</td>
</tr>
<tr>
<td>coconut meat</td>
<td>6%</td>
</tr>
<tr>
<td>Brazil nuts</td>
<td>7%</td>
</tr>
<tr>
<td>coconut cream</td>
<td>7%</td>
</tr>
<tr>
<td>coconut milk</td>
<td>7%</td>
</tr>
<tr>
<td>flaxseed</td>
<td>8%</td>
</tr>
<tr>
<td>walnuts</td>
<td>9%</td>
</tr>
<tr>
<td>pine nuts</td>
<td>9%</td>
</tr>
<tr>
<td>sesame butter (tahini)</td>
<td>11%</td>
</tr>
<tr>
<td>peanuts</td>
<td>13%</td>
</tr>
<tr>
<td>chia seeds</td>
<td>13%</td>
</tr>
<tr>
<td>pumpkin seeds</td>
<td>14%</td>
</tr>
<tr>
<td>almonds</td>
<td>14%</td>
</tr>
<tr>
<td>sesame seeds</td>
<td>14%</td>
</tr>
<tr>
<td>sunflower seeds</td>
<td>15%</td>
</tr>
<tr>
<td>pistachio nuts</td>
<td>19%</td>
</tr>
<tr>
<td>cashew butter</td>
<td>22%</td>
</tr>
</tbody>
</table>

4.9 Fish

Table 13 shows that the proportion of insulinogenic calories for fish ranges from 3% to 30% insulinogenic calories. If you can, stick to the fattier deep sea fish at the top of the list. Fish is also a great source of omega-3 and DHA which are very important.

Table 13 Insulinogenic percentage – fish

<table>
<thead>
<tr>
<th>fish</th>
<th>% insulinogenic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mackerel</td>
<td>13%</td>
</tr>
<tr>
<td>Halibut</td>
<td>17%</td>
</tr>
<tr>
<td>Herring</td>
<td>19%</td>
</tr>
<tr>
<td>Salmon</td>
<td>24%</td>
</tr>
<tr>
<td>Sardine</td>
<td>26%</td>
</tr>
<tr>
<td>Anchovy</td>
<td>31%</td>
</tr>
<tr>
<td>Swordfish</td>
<td>31%</td>
</tr>
<tr>
<td>Trout</td>
<td>31%</td>
</tr>
<tr>
<td>Carp</td>
<td>32%</td>
</tr>
</tbody>
</table>

45 http://superhumanradio.com/blog/to-peanut-or-not-to-peanut.html
4.10 Meat

Table 14 shows that the insulinogenic percentage for meats are generally low, with fatty sausage and fattier cuts of meat being less insulinogenic.

Table 14 Insulinogenic calories - lamb and beef and poultry

<table>
<thead>
<tr>
<th>meat</th>
<th>% insulinogenic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foie gras (goose liver pate)</td>
<td>9%</td>
</tr>
<tr>
<td>Pepperoni</td>
<td>10%</td>
</tr>
<tr>
<td>Pork, ham</td>
<td>11%</td>
</tr>
<tr>
<td>Bologna</td>
<td>11%</td>
</tr>
<tr>
<td>Frankfurter</td>
<td>11%</td>
</tr>
<tr>
<td>Duck</td>
<td>12%</td>
</tr>
<tr>
<td>Liver pate</td>
<td>12%</td>
</tr>
<tr>
<td>Salami</td>
<td>12%</td>
</tr>
<tr>
<td>Chorizo</td>
<td>13%</td>
</tr>
<tr>
<td>Beef, ribeye</td>
<td>15%</td>
</tr>
<tr>
<td>Bacon</td>
<td>15%</td>
</tr>
<tr>
<td>Pork, blade, hocks &amp; shoulder</td>
<td>23%</td>
</tr>
<tr>
<td>Turkey</td>
<td>23%</td>
</tr>
<tr>
<td>Lamb mince</td>
<td>24%</td>
</tr>
<tr>
<td>Chicken</td>
<td>24%</td>
</tr>
<tr>
<td>Quail</td>
<td>24%</td>
</tr>
<tr>
<td>Veal</td>
<td>31%</td>
</tr>
</tbody>
</table>

4.11 Summary

This list is an abridged summary from the USDA foods list. If you want to see the % insulinogenic calories for the nearly 8000 foods in the database you can download it from here [here](#).

Or if you have the nutritional properties for a food you can calculate the % insulinogenic calories using [this calculator](#) designed by Ted Naiman.
The percentage of insulinogenic calories is a useful quantitative measure that can help us prioritise our food selection. If you just ate foods with a percentage of insulinogenic calories less than 25% you’d probably stay pretty healthy. Is that all I need to know?

But you still might be thinking:

1. Can you really live healthily on all that fat?
2. Won’t I miss out on vitamins and minerals from higher carbohydrate foods such as grains?
3. Will I get enough protein?

These are all valid questions and concerns that will be addressed in the remainder of this document in an effort to combine the insulinogenic properties of food with ensuring that we obtain adequate nutrition.
5 Diet wars... which one is best

5.1 Do we really need carbs?

Current mainstream dietary guidelines recommend that we get 45 to 65% of our calories from carbohydrates.\(^{46}\) In line with these recommendations carbohydrate intake has increased progressively (as shown in Figure 9) as people have endeavoured to minimise fats.

![Figure 9 Change in macronutrient consumption over time\(^{47}\)](image)

More and more researchers in the area of nutrition are coming out and saying that health authorities got it wrong about fats and that our fear of fat has led us to the consumption of more carbs which has caused to the current obesity epidemic.\(^{48,49,50,51}\)

There are essential fats that the body cannot produce, such as alpha-linoleic acid and linoleic acid, which we need to obtain from our diet. The body also needs protein which forms the building blocks for the cells which it can’t make from other foods. The body can however produce glucose from protein via gluconeogenesis.

Consequently, often asked (and debated) questions are:

- If there is no such thing as an *essential* carbohydrate why do we need to be eating any carbohydrates?
- If we took food insulin theory to its logical extreme, could or should we live off just fat and “adequate” protein?
- How low (carb) can we go while still getting adequate nutrition?

---


\(^{47}\) [http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5304a3.htm](http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5304a3.htm)


\(^{50}\) [http://www.peterbrukner.com/category/diet/](http://www.peterbrukner.com/category/diet/)

5.2 The great carbohydrate debate

5.2.1 The low carbohydrate / ketogenic side
On the low carbohydrate end of this debate you have people like Dr David Perlmutter, Nora Gedgaudas, Ron Rosedale and Dr William Davis arguing that you should restrict carbohydrate for metabolic and brain health as well as the prevention and cure of a range of diseases.

Figure 10 shows one of the more confronting charts from Dr Perlmutter’s Grain Brain showing that the rate of brain shrinkage with age increases dramatically once we get an HbA1c of more than 5.2%.

![Figure 10: HbA1c versus annual rate of brain shrinkage](http://www.drperlmutter.com/important-blood-test/)

Figure 10 shows that an increase in HbA1c is correlated with an increased risk of cancer, particularly once we get an HbA1c over about 6% (i.e. average blood glucose of 7.0mmol/L or 126mg/dL).

![Figure 11: HbA1c (%) versus hazard ratio for cancer](http://www.drperlmutter.com/important-blood-test/)

Figure 11: HbA1c (%) versus hazard ratio for cancer

52 [http://www.drperlmutter.com/important-blood-test/]
The chart in Figure 12 chart shows that there is a very close relationship between insulin secretion and body mass index (BMI).\textsuperscript{53}

![Figure 12 Body mass index versus insulin secretion](image)

Figure 12 shows that the risk for cardiovascular disease, coronary heart disease and stroke increase once we get an HbA1c greater than 5.0% and especially over 5.4%. It’s also worth noting that being on antidiabetic medication, even if it reduces your blood glucose, doesn’t help reduce your risk of heart disease.

![Figure 13 HbA1c versus risk of cardiovascular diseases](image)


http://www.cardiab.com/content/12/1/164
Keeping your blood glucose under control is perhaps the most important thing you can do to manage our health and slow the aging process regardless of whether you have been formally diagnosed with diabetes.

If you’re not getting your HbA1c checked regularly you can use the average blood glucose results from your blood glucose meter (i.e. fasting, before meals and after meals).

The conversion between HbA1c and average blood glucose are shown in Table 15. I have also added risk levels based on the HbA1c values based on the cardiovascular disease data shown in Figure 13.

Table 15 HbA1c and blood glucose ranges

<table>
<thead>
<tr>
<th>risk level</th>
<th>HbA1c (%)</th>
<th>average blood glucose (mmol/L)</th>
<th>average blood glucose (mg/dL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>optimal</td>
<td>4.5</td>
<td>4.6</td>
<td>83</td>
</tr>
<tr>
<td>excellent</td>
<td>&lt; 5.0</td>
<td>&lt; 5.4</td>
<td>&lt; 97</td>
</tr>
<tr>
<td>good</td>
<td>&lt; 5.4</td>
<td>&lt; 6.0</td>
<td>&lt; 108</td>
</tr>
<tr>
<td>danger</td>
<td>&gt; 6.5</td>
<td>&gt; 7.8</td>
<td>&gt; 140</td>
</tr>
</tbody>
</table>

One of the most extreme proponents of the restricted carbohydrate dietary approach is Dr Ron Rosedale55 who says that carbohydrates cause oxidation in the body, and that we should do everything we can to minimise oxidation by minimising carbohydrates ingested. While the body does need glucose it is preferable to have the body make it via gluconeogenesis rather than directly feeding the body carbohydrates which will lead to oxidation.56

5.2.2 Mainstream recommendations

On the other extreme you have dieticians recommending the USDA food pyramid telling us that we can’t survive without our ‘heart healthy whole grains’ and that our brains run on glucose and hence we need to eat carbs or else.

The generally accepted diagnosis levels for type 2 diabetes are shown in Table 16. Currently one in twelve adults worldwide are classified as diabetic based on this criteria. This number is forecast to grow by more than half over the next two decades to 592 million people by 2035.57

Diabetes is expensive. In 2012 it cost the US a quarter of a trillion dollars in hospital costs and lost productivity58 and the cost of “diabesity” is forecast to triple by 2050 grow and become a major burden on the economies of the western world!

Table 16 Type 2 blood glucose diagnosis levels

<table>
<thead>
<tr>
<th></th>
<th>Fasting (mg/dL)</th>
<th>Fasting (mmol/L)</th>
<th>After meal (mg/dL)</th>
<th>After meal (mmol/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>“normal”</td>
<td>&lt; 100</td>
<td>&lt; 5.6</td>
<td>&lt; 140</td>
<td>&lt; 7.8</td>
</tr>
<tr>
<td>pre-diabetic</td>
<td>100 – 126</td>
<td>5.6 to 7.0</td>
<td>140 to 299</td>
<td>7.8 to 11.1</td>
</tr>
<tr>
<td>type 2 diabetic</td>
<td>&gt; 126</td>
<td>&gt; 7.0</td>
<td>&gt; 200</td>
<td>&gt; 11.1</td>
</tr>
</tbody>
</table>

55 http://drrosedale.com/
56 https://vimeo.com/52872503
58 http://care.diabetesjournals.org/content/36/4/1033.full
Comparing these diabetes diagnosis criteria with the optimal levels shown in Table 15 it’s clear that blood glucose that are considered “normal” are far from optimal. By the time you’re “pre-diabetic” you’re well into the danger zone!

If you want to actively manage your health my strong suggestion is that you do what it takes to keep your blood sugars in the excellent range before you become officially ‘pre-diabetic’ or officially ‘diabetic’.

5.2.3 The middle ground?

Somewhere between the dieticians and the low carb community you have people such as Paul Jaminet, Chris Kresser and Robb Wolf who advocate for some carbohydrates for the majority of the population.

When you listen to the argument a little closer it’s interesting to find that even these respected health experts are all talking about a level of carbohydrates much less than the typical western dietary intake and the typical mainstream recommendation.

Chris Kresser recommends 20 to 30% carbs for healthy people and says that a lower carb ketogenic approach will likely be beneficial for people with Alzheimer’s, dementia or neurodegenerative disorders.59

Paul Jaminet’s definition of “low-carbohydrate” means eating less than the body’s glucose utilisation which forces the body to make up some deficit from protein via gluconeogenesis.60 That the body typically runs on about 30% glucose for fuel (or about 600 calories per day) and that while the body can get the glucose it needs from protein via gluconeogenesis Jaminet argues that it’s less demanding for the body to get that glucose from carbohydrate containing foods rather than having to make it from protein.

Figure 14 shows this concept graphically. If we eat more than around 30% carbohydrates the liver will end up with more glucose than it can store and we will end up with excess glucose in the blood. The pancreas will secrete insulin to remove this excess sugar and store it as body fat. If we eat less than around 30% carbohydrates the body will convert protein to glucose through gluconeogenesis, and the risk of excess sugar in the blood is reduced.

59 http://chriskresser.com/how-to-feed-your-brain from 9:25
60 http://perfecthealthdiet.com/2011/10/jimmy-moore%E2%80%99s-seminar-on-%E2%80%9Csafe-starches%E2%80%9D-my-reply/
5.2.4 The big picture

When you stand back and look at the big picture, I think what you see is that the Paleo / LCHF scene are arguing over the minutia. Most health advocates are recommending the general population consume significantly less carbohydrates than the typical western diet.

There’s no perfect diet or level of carbohydrates that suits everyone. Active people or people who are not metabolically broken will be able to tolerate more carbohydrates because they will be burning them. People who are sedentary or obese (i.e. 70% of the western population these days) or those with blood glucose dysregulation should opt for a carbohydrate restricted approach in order to reverse the damage done to their metabolism by decades of processed foods.  

The body has a number of failsafe mechanisms to make sure blood glucose levels do not drop too low, and hence the only people who have a serious concern with low blood glucose levels are diabetics who inject too much insulin. Overwhelmingly the greater problem is people who are eating more glucose than their body can store in their liver or muscles, with the excess spilling over into their blood stream and subsequently being cleaned up by insulin and stored as fat.

5.3 Why is this so important?

Below is a post on the TYPEONEGRIT Facebook group from a mother of a type 1 diabetic child describing their interaction with her health care team to give you a taste for what it’s like to try to go against the main stream dietary advice:

'We had our team meeting today to discuss LCHF... they are so terrified of this, even though we have great normal BG readings, behaviour improvements and learning improvements (noted by us, family, friends and his school) which they didn't even acknowledge.

The nutritionist is concerned that he won't be getting the micronutrients that only come from grains and the higher carb vegetables (grains are fortified), then her concern was the B vitamins 1, 3 and 6. We did our research and 3 and 6 we have an abundance of and B1 we may be deficient of but it doesn't matter so much because B1 job is to help turn carbs into fuel.'

Then the concern about Iron (what?! have you seen the meat and spinach listed?). Then it was calcium and magnesium (clearly they don’t have a clue about LCHF).

They said they are afraid this diet may cause future developmental harm. We said your diet WILL cause future harm and way more than developmental. Back and forth and on it went. We addressed their concerns with peer reviewed research, and respect to their limited knowledge.

We will be an open book and comply because I want them to learn that T1D care can be so much better than it has been up to now, and pave the way for the next families that wishes to do LCHF.

They will check for vitamins and minerals at his 3 month blood work (again special for our case, which we have to pay for).

For the general population this isn’t such a big deal, but for diabetics and their carers it is a matter of life and death, or at least a decision that will greatly affect their quality and length of life.

It breaks my heart to see diabetics living with a highly diminished quality when there is the potential to greatly reduce the impact of diabetes by more informed food choices.

In addition to the cost of diabetes on individuals, the cost of diabesity on our economy is phenomenal and threatening to cripple western economies through spiralling health cost costs!62

5.4 Comparison of dietary approaches

In order to understand the differences between various dietary approaches I have compared a range of dietary approaches as shown in Table 17. The shaded rows in the table are the scenarios evaluated in section 7.

The dietary approaches have been sorted based on the sum of the scores from their insulinogenic properties, their nutrient and vitamin score and their amino acid score. The shaded rows are discussed in more detail in section 7.

Table 17 Comparison of various dietary approaches

<table>
<thead>
<tr>
<th>approach</th>
<th>carbs %</th>
<th>protein %</th>
<th>fat %</th>
<th>fibre (g)</th>
<th>net carbs (g)</th>
<th>% insulin</th>
<th>vitamins &amp; minerals</th>
<th>protein</th>
</tr>
</thead>
<tbody>
<tr>
<td>diabetic / ketosis – w/ liver</td>
<td>7%</td>
<td>29%</td>
<td>64%</td>
<td>26</td>
<td>9</td>
<td>17%</td>
<td>84</td>
<td>146</td>
</tr>
<tr>
<td>low calorie, high bulk, weight loss – w/ liver</td>
<td>16%</td>
<td>34%</td>
<td>50%</td>
<td>36</td>
<td>44</td>
<td>27%</td>
<td>95</td>
<td>146</td>
</tr>
<tr>
<td>ketosis with BPC &amp; liver</td>
<td>7%</td>
<td>21%</td>
<td>72%</td>
<td>17</td>
<td>18</td>
<td>15%</td>
<td>79</td>
<td>140</td>
</tr>
<tr>
<td>low calorie, high bulk, weight loss</td>
<td>16%</td>
<td>32%</td>
<td>52%</td>
<td>36</td>
<td>44</td>
<td>26%</td>
<td>92</td>
<td>143</td>
</tr>
<tr>
<td>diabetic / nutritional ketosis</td>
<td>8%</td>
<td>23%</td>
<td>69%</td>
<td>26</td>
<td>14</td>
<td>15%</td>
<td>76</td>
<td>136</td>
</tr>
<tr>
<td>Bernstein template</td>
<td>7%</td>
<td>24%</td>
<td>69%</td>
<td>17</td>
<td>18</td>
<td>17%</td>
<td>68</td>
<td>149</td>
</tr>
<tr>
<td>high fat, low carb – w/ liver</td>
<td>3%</td>
<td>10%</td>
<td>87%</td>
<td>6</td>
<td>9</td>
<td>7%</td>
<td>53</td>
<td>144</td>
</tr>
<tr>
<td>Whals’ Paleo Plus</td>
<td>18%</td>
<td>13%</td>
<td>69%</td>
<td>37</td>
<td>53</td>
<td>18%</td>
<td>77</td>
<td>129</td>
</tr>
<tr>
<td>athlete</td>
<td>25%</td>
<td>27%</td>
<td>48%</td>
<td>45</td>
<td>80</td>
<td>31%</td>
<td>83</td>
<td>138</td>
</tr>
<tr>
<td>ketosis with bacon and eggs</td>
<td>7%</td>
<td>18%</td>
<td>75%</td>
<td>11</td>
<td>24</td>
<td>15%</td>
<td>57</td>
<td>141</td>
</tr>
<tr>
<td>high veggies / paleo</td>
<td>17%</td>
<td>28%</td>
<td>55%</td>
<td>24</td>
<td>61</td>
<td>27%</td>
<td>72</td>
<td>140</td>
</tr>
<tr>
<td>high fat, low carb</td>
<td>3%</td>
<td>10%</td>
<td>87%</td>
<td>6</td>
<td>9</td>
<td>7%</td>
<td>38</td>
<td>146</td>
</tr>
<tr>
<td>Atkins diet</td>
<td>9%</td>
<td>32%</td>
<td>59%</td>
<td>9</td>
<td>36</td>
<td>24%</td>
<td>59</td>
<td>145</td>
</tr>
<tr>
<td>Mediterranean</td>
<td>45%</td>
<td>21%</td>
<td>34%</td>
<td>34</td>
<td>191</td>
<td>50%</td>
<td>71</td>
<td>142</td>
</tr>
<tr>
<td>Dr Axe – vegetarian</td>
<td>16%</td>
<td>17%</td>
<td>67%</td>
<td>11</td>
<td>69</td>
<td>23%</td>
<td>48</td>
<td>109</td>
</tr>
</tbody>
</table>

62 http://ndt.oxfordjournals.org/content/26/1/28.full
Table showing nutritional values for different dietary approaches:

<table>
<thead>
<tr>
<th>dietary approach</th>
<th>carbs (%)</th>
<th>protein (%)</th>
<th>fat (%)</th>
<th>fibre (g)</th>
<th>net carbs (g)</th>
<th>% insulin</th>
<th>vitamins &amp; minerals</th>
<th>protein</th>
</tr>
</thead>
<tbody>
<tr>
<td>high fibre vegetarian</td>
<td>70</td>
<td>23</td>
<td>7</td>
<td>143</td>
<td>207</td>
<td>54</td>
<td>94</td>
<td>93</td>
</tr>
<tr>
<td>Zone</td>
<td>40</td>
<td>30</td>
<td>30</td>
<td>44</td>
<td>156</td>
<td>47</td>
<td>69</td>
<td>108</td>
</tr>
<tr>
<td>nutritional density on a budget</td>
<td>49</td>
<td>30</td>
<td>21</td>
<td>19</td>
<td>226</td>
<td>61</td>
<td>47</td>
<td>117</td>
</tr>
<tr>
<td>grains on a budget</td>
<td>62</td>
<td>14</td>
<td>24</td>
<td>25</td>
<td>285</td>
<td>65</td>
<td>54</td>
<td>107</td>
</tr>
<tr>
<td>fruitarian</td>
<td>91</td>
<td>3</td>
<td>6</td>
<td>54</td>
<td>401</td>
<td>82</td>
<td>55</td>
<td>64</td>
</tr>
</tbody>
</table>

Figure 15 shows the total score for the approaches graphically showing the components that make up the total score (insulin load, vitamins and minerals, and protein).

5.5 Summary

The key learnings from this analysis are:

- The highest ranking dietary approaches involve organ meats.
- If you’re not into liver then non-starchy vegetables are your next best option to maximise nutrients while keeping the insulin load low.
- The extreme high fat approach (3% carbs from spinach and 10% protein) does not provide optimal levels of vitamins and minerals. This style of approach may be useful for more extreme therapeutic treatments for epilepsy, Parkinsons, or cancer. Supplementation may be required if this approach were used over the long term.
- A diet with 80% calories from fat and 7% of calories from carbohydrates can meet most of the recommended daily intake values for vitamins and minerals.
- A diet with 75% fat and 10% carbohydrates from non-starchy vegetables achieves an optimal balance between vitamins and minerals and insulin load.
- The fruitarian and budget grains approaches both score very poorly across the board.

- Dietary approaches without animal products struggle to provide adequate amino acids, vitamins and minerals.

- Optimal nutrition can be provided using a range of macronutrient profiles. When we consider the insulin load, nutrients and protein quality the highest scoring dietary approaches used between 50 to 80% fat, 13 to 34% protein and 7 to 16% carbohydrates. Within this window we can then refine the diet based on the goals of the individual whether they be weight loss, blood glucose control / ketosis or athletic performance.
6 Nutrient Density

6.1 General

A number of attempts have been made to rank foods in terms of nutrient density. This section reviews some of these systems, discusses their limitations, and outlines a method for ranking foods based on nutrient density along with their insulinogenic properties to help quantitatively prioritise food choices depending on one’s goals.

Different weighting systems have been developed for the following scenarios:

1. Weight loss,
2. Blood sugar control and / or nutritional ketosis,
3. Nutrient density on a budget, and
4. Athlete of metabolically healthy.

6.2 Mat Lalonde’s nutrient density

Most recently Dr Mat Lalonde undertook a ranking of foods based on nutrient density in terms of nutrients per weight of food consumed.

Lalonde’s calculations used the full USDA food database of nearly eight thousand foods and devises a ranking based on what he considers to be the essential nutrients per 100g of food. This analysis identified organ meats as one of the more nutritious foods, with vegetables coming in second. Fruits and grains landed much further down the list. The findings of Lalonde’s approach aligns well with the Paleo community’s approach to nutrition and hence was well received in these circles.

In his presentation at the 2012 Ancestral Health Symposium Lalonde noted that people wanting to lose weight may wish to prioritise in terms of nutrient density per calorie, however he had chosen to analyse nutrient density in terms of weight as that might be more relevant for athletes (Lalonde is a CrossFit athlete as well as a biochemist) who need to refuel with nutrient dense foods rather than not getting enough energy from low calorie density foods.

As someone who would like to perhaps lose a bit more weight I was left wondering what the ranking might look like in terms of calories, or maybe other possible measures.

6.3 Aggregate Nutrient Density Index (ANDI)

Joel Fuhrman’s Aggregate Nutrient Density Index (ANDI) ranks foods based on their micronutrients per calorie but excludes a number of essential vitamins and minerals while placing extra emphasis on the oxygen radical absorbance capacity.

As noted by Chris Masterjohn, this approach heavily biases plant foods and seems to ignore the nutritional benefits of animal foods. Kale ranks at the top of the list with the maximum score of 1000, largely due to its massive amount of vitamin K. Unfortunately a massive dose of vitamin K isn’t much use to us in the context of a low fat diet if vitamin K (along with A and D) is a fat soluble vitamin.

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64 [https://www.youtube.com/watch?v=HwbY12qZcF4](https://www.youtube.com/watch?v=HwbY12qZcF4)
It’s also not much use having a food that is extremely high in one nutrient but not so good in a number of other areas. It would be best to find foods that provide a good spread of nutrients by limiting the maximum score from any one nutrient.

Another criticism that has been levelled at ANDI is that simply using nutrition per calorie prioritises very low calorie density foods that may not be viable for anyone doing a significant amount of activity.67

6.4 Dave Asprey’s Bulletproof Diet

Dave Asprey has developed the Bulletproof Diet Infographic68 which is a simple ranking of foods to avoid and focus on based on both nutritional density and toxins.

The downside of this simple visual guide is that it shows only a select range of foods and doesn’t explain why each of the foods has the ranking that is has been given (though there is some discussion of the toxins and various issues in the book).

Most people would be happy with this visual list of foods to preference and avoid, however I wanted to see the numbers to understand why one food ranked above another.

6.5 JJ Virgin’s Sugar Impact

Another ranking system that I came across recently was in JJ Virgin’s Sugar Impact Diet69 which ranked foods according to the amount of sugar in each food. While this is useful the list was limited and doesn’t consider nutrient density or other forms of carbohydrate which also raise blood glucose. And as discussed in section 3.5, I believe that the discussion needs to shift towards non-fibre carbohydrates rather than

6.6 Soylent

A couple of years back I came across Soylent,70 a food product designed by software engineer Rob Rheinhart.

Rheinhart, who doesn’t much like to cook, developed a formula-based food that theoretically covered all the recommended daily nutrient allowances (RDA) along with a few other ‘nice to haves’ like as sulphur.

What started with a blog post describing Rheinhart’s personal journey to create a cheap hassle free gruel71 quickly captured peoples’ imagination and attracted $1M in crowdsourced funds and millions of dollars of external investment to develop the product for the mass market.

It was interesting to see how, in the absence of widespread distribution of Soylent, a number of websites and blogs started up with people sharing their recipes for their own version of Soylent tailored for their personal micronutrient and macronutrient preference.72

It was clear that hundreds, if not thousands of people had designed their own brew, ordered the ingredients online and made their own version of Soylent in their own kitchen. Some of these DIY

67 https://www.bulletproofexec.com/cdc-superfoods-andi-score-debunked/
70 http://www.soylent.me/
71 http://robrhinehart.com/?p=298
products consisted primarily of chemicals and supplements, while others were more like green smoothies on steroids. Some were high carb, some were ketogenic, depending on the goals of the person trying to develop them. All were analysed and optimised in a spreadsheet or a database to ensure that they ticked all the boxes of nutrient sufficiency across a wide range of nutrients.

You probably wouldn’t be surprised that I had a go at developing my own Soylent-style shake. The ingredients included protein powder, coconut oil, egg, almonds and chia seeds plus a number of chemical and supplement style additives that arrived on my doorstep via the eBay and Amazon.

I was impressed by this community of people who were so passionate about and enamoured by developing a tailored dietary approach and then sharing it with the rest of the community for them to use and improve on. It was like an open source nutrition competition!

Wouldn’t it be great if people with similar goals (e.g. paleo, LCHF, low carb, ketogenic, and diabetic communities) pooled their intellect and passion to develop an optimised approach to nutrition? What if there was a way that people could rank dietary approaches based on their own goals rather than always against the US Department of Agriculture food pyramid?

6.7 Nutrient density versus cost

After searching to try to find Lalonde’s spreadsheet online I came across a food ranking system in terms of nutrient density per dollar.

Building on the work of Mat Lalonde, Dale Cumore of the blog Solving Nutrition had created a ranking based on nutrient density per dollar cost of that food to arrive at the cheapest way to get nutrition for around 1000 foods that he could find cost data for.

If we simply rank by nutrients divided by cost we end up with tea, coffee, liver, parsley and oat bran bagels up the top of the list along with things like condensed juices and then fortified milks. This is interesting, however we really need to drop out the fortified and condensed products to get a better picture of things that a normal person would eat and drink on a regular basis.

After dropping out the fortified products, we get the following list of foods based on nutrient density per dollar:

---

While grains are a cost effective way to get calories and nutrients, we also need to consider other negative effects of foods. Many people believe that most if not all grains should be avoided.\footnote{https://www.youtube.com/watch?v=VvfTV57iPUY}

My ten year old daughter knows that if she eats bread she will end up with a stomach ache and dark circles around her eyes.

### 6.8 Cost per Calorie

Cost will always be a consideration to some degree - some people may not have the finances to buy grass fed and organic while others will have the means to invest in food as medicine.

Listed below are the cheapest foods in terms of cost per calorie. Not surprisingly grains (including white rice), candy and sugar rank up there with some of the cheapest ways to get calories\footnote{If you wanted to view this cynically you could say that the fact that grains and sugars have the lowest cost per calorie enables food manufacturers to place the largest mark up on these foods when reselling them in cardboard boxes in the supermarket. It’s harder to put a bar code on generic vegetables and meat products that are already relatively expensive.}.

1. pumpernickel rolls
2. croissants
3. bagels
4. canola oil
5. French rolls
6. margarine
7. wheat muffins
8. coconut oil
9. granulated sugar
10. rice
11. brown sugar
12. mayonnaise
13. doughnuts
14. tortillas
15. cake mix
16. peanut butter
17. cranberry juice
18. spaghetti
19. sausage
20. corn starch
21. graham cracker

One of the criticisms of LCHF and Paleo dietary templates is that these foods are expensive. However it’s worth noting that a number of fats and oils also rank highly in the calories per dollar list, including coconut oil in the list above.

While it’s true that grass fed beef, salmon and organic vegetables can be more expensive than boxed cereals and sugar, obtaining a significant proportion of your calories from fats such as coconut oil and butter can actually be very cost effective on a per calorie basis.
6.9 Nutrient density per calorie

Nutrient density per calorie is a useful metric for someone wanting to lose weight, maximise nutrition and minimise calorie intake.

One line of health and weight loss thinking says that once the body obtains adequate nutrients it will stop searching for food and unnecessary hunger will be minimised.

In chapter 17 of the Perfect Health Diet Paul Jaminet notes that “a nourishing, balanced diet that provides all nutrients in the right proportions is the key to eliminating hunger, minimising appetite and eliminating hunger with a minimal caloric intake. This is the key to long term weight loss”.

Using this rationale, vegetables shoot to the top of the list, with things like spinach, turnip, lettuce, kale, mushrooms and asparagus ranking really well. Less common foods such as beef liver and chicken liver, spices, oysters, and cod also rank high in this list.

1. spinach 8. goose liver 15. dandelion greens
2. chicken liver 9. turnip greens 16. basil
3. beef liver 10. mustard greens 17. caviar
4. beet greens 11. parsley 18. kale
5. veal liver 12. chard 19. broccoli
6. pork liver 13. oyster 20. All bran
7. duck liver 14. coriander 21. collards

6.10 Fibre per calorie

Obtaining adequate fibre is important, especially if on a diet that doesn’t restrict carbohydrates or sugar.\textsuperscript{76}

Typical daily fibre intake for those in western civilisations is around 17g. It is said that African hunter gatherer children obtain more than 150g of fibre per day from eating unprocessed foods in their natural state\textsuperscript{77} and before the invention of fire and cooking foods to increase the caloric density of our foods our ancestors were eating between 100 and 300 grams of fibre per day.\textsuperscript{78}

As discussed in section 3.2 fibre is not digestible by the human gut and hence it does not provide energy or cause a rise in blood glucose or insulin.

The mainstream recommendation is to get at least 30g of fibre per day to improve your blood glucose and cholesterol levels. Most people don’t achieve these levels even when eating “healthy whole grains”, largely due to the high level of processing in most popular foods.

Ironically the primary recommended source of fibre is from “healthy whole grains”. While whole grains will be marginally better than processed grains such as white bread, they will have a higher glycemic load and hence be much more insulinogenic than other options such as non-starchy

\textsuperscript{76} One of the more exciting concepts in the diet space recently is the concept that what you eat could possibly change your gut bacteria for better or worse. While this area is still in its infancy the thinking is that lean people have a higher bacteriodes : fermenti ratio and that this can be influenced by eating more fibre / prebiotics. At the same time it is not clear if just eating high fibre vegetables will lead you to being lean and having good gut bacteria at the same time.

\textsuperscript{77} \url{http://www.abc.net.au/catalyst/stories/4067184.htm}

\textsuperscript{78} \url{http://www.gregdavis.ca/share/paleo-articles/academic/The%20Ancestral%20Human%20Diet%20by%20S.%20Boyd%20Eaton.pdf}
vegetables. The end result in increased blood glucose and higher cholesterol levels, thus exacerbating the issue that fibre was meant to be assisting us with.

If we rank for fibre per calorie we end up with a few spices such a cinnamon, curry powder, or cocoa at the top of the list along with vegies such as turnip, artichoke, sauerkraut, cauliflower. Cereals and grains (which are typically recommended to increase fibre) are much further down the list.

1. cinnamon  6. cauliflower  11. oregano
2. turnip greens  7. raspberries  12. wheat bran
3. artichoke  8. lettuce  13. eggplant
4. curry powder  9. blackberries  14. basil
5. sauerkraut  10. lemon peel

Many people will say that carbohydrates aren’t as much of a problem if they are eaten in their natural form and that it’s not carbohydrates per se that impacts the body negatively - it’s the quality of the food and the level of processing that matters. Most people tolerate carbohydrates better in their natural form.\textsuperscript{79} The fibre content appears to be a good proxy for their quality and level of processing. We have also seen that the fibre in foods reduces the insulin reaction and offsets the effect of carbohydrates and protein. This is all packaged into the following formula:

\[
\text{insulin load (g)} = \text{carbohydrates (g)} - \text{fibre (g)} + 0.56 \times \text{protein (g)}.\]

\textsuperscript{79} \url{http://chriskresser.com/is-the-glycemic-index-useful}
7 Your personalised food ranking system

7.1 General
This section discusses how we can combining the range of measurements from section 5 and the insulin load concept from section 4 can be combined to prioritise food choices to suit an individual's goals.

As discussed in section 5.2 a lot of the division and argument in nutrition circles revolves around minutia. People argue passionately for their approach that they have had personal success with. At the same time someone else will argue just as passionately for a different approach that they have had successful.

A certain approach will work well in the right situation, you just have to match the right tool to the task at hand.

In this section we look how we can use the food ranking system to prioritise food selection for a range of different people who may have one of the following goals:

1. weight loss,
2. diabetes or nutritional ketosis,
3. nutrition on a budget; and
4. metabolically healthy or athletic performance.

For each of these scenarios I have developed an example meal plan with a nutritional analysis that demonstrates how each approach could be applied (though there are a wide range of food choices highlighted that one could choose from based on personal taste).

7.2 Scenario 1 – Weight loss through reduced calorie density, high bulk

Figure 16 shows the macronutrient ratio of four phases of a ketogenic diet according to Steve Phinney. In the early phases of a ketogenic diet when people try to restrict carbohydrates they will naturally reduce their overall calorie intake due to increased satiety. With total calories and insulin levels low and excess body fat to burn, a lot of the energy expenditure will come from stored body fat. As time passes and weight is lost, people will naturally progress to a maintenance stage with slightly higher calorie intake and more dietary fat.

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80 https://www.youtube.com/watch?v=8NvFyGGXYil&index=1&list=PLrVWtWmYRR2BIAsGG9tr6T-B4xSum8SCc
Figure 16 Phinney’s four phases of a ketogenic diet

This scenario is designed for someone wanting to lose weight by selecting high nutrient density, high fibre, and low calorie density foods. The food selection will ensure the dieter is kept full and satisfied by eating a large volume of high fibre foods with low calorie density.

The weighting of the various metrics used in this scenario are shown in Table 18, with an emphasis on high nutrient density (20% weighting), high fibre (10% weighting), and low calorie density (30% weighting).

Some attention is paid to the insulinogenic properties of the foods (25% weighting) though not as much as if we were designing a diet for a diabetic or someone looking to achieve nutritional ketosis without intentionally restricting calories.

Retaining a 5% weighting for the cost parameters avoids prioritising obscure foods that are harder to obtain and/or are not typically eaten in large quantities as well as keeping costs down which is important if a diet is going to be maintained in the long term.

Table 18 Weighting – weight loss scenario

<table>
<thead>
<tr>
<th>nutrient density / calorie</th>
<th>fibre / calorie</th>
<th>nutrient density / $</th>
<th>nutrient density / weight</th>
<th>insulin (%)</th>
<th>calories / 100g</th>
<th>$ / calorie</th>
</tr>
</thead>
<tbody>
<tr>
<td>15%</td>
<td>10%</td>
<td>10%</td>
<td>5%</td>
<td>20%</td>
<td>30%</td>
<td>10%</td>
</tr>
</tbody>
</table>

The top 25% of foods highlighted by this ranking are listed below, in order of priority, sorted using the above weighting. This weighting brings high fibre, nutrient dense, non-starchy vegetables to the top of the list and looks a lot like a healthy vegetarian diet with some added fish and meat to achieve the required protein and amino acid intake.

This weightings does not prioritise added fats and oils as fat would ideally be coming from the body fat stores due to the reduced calorie intake that would be caused by the low calorie density foods. The list of nuts and seeds is also quite short in view of their high calorie density.

7.2.1 Vegetables
- spinach
- chives
- turnip greens
- coriander
- mushrooms
7.2.1 Vegetables
- broccoli
- Brussel sprouts
- kale
- artichokes
- Bok choy
- peas
- kidney beans
- lettuce
- sweet potato
- carrots
- lima beans
- seaweed
- asparagus
- celery

7.2.2 Animal products
- organ meats
- oyster
- herring
- sardine
- pork sausage
- ham
- chicken
- pork
- turkey
- salmon
- mackerel
- anchovy
- crab
- lobster
- trout
- beef

7.2.3 Fruits
- avocado
- guavas
- olives
- raspberries
- kiwifruit
- oranges

7.2.4 Eggs & dairy
- whole egg
- egg yolk
- ricotta cheese
- parmesan cheese
- feta cheese

7.2.5 Nuts, seeds & legumes
- lentils
- chick peas
- mung beans
- kidney beans
- lima beans
- coconut milk
- peanut butter
- peanuts
- sunflower seeds
- brazil nuts
- pumpkin seeds
- coconut meat

7.2.6 Fats and oils
- butter
- coconut oil
- olive oil
- fish oil
- flaxseed oil

7.2.7 Example daily diet - Low calorie, high bulk, weight loss
Table 19 shows an example daily meal plan for someone wanting to lose weight by reducing calorie density and maximise nutrition using the prioritised list of foods above.

The macronutrients and calories in this scenario are based on the “adjust” stage of the ketogenic diet shown in Figure 16. Protein is adequate to support muscle maintenance at 30% of dietary intake or 20% of total expenditure.

This approach will likely produce ketosis due to the low caloric content. Having low levels of carbohydrates and thus low insulin levels will enable body fat stores to be accessed for energy, particularly if someone has a lot of fat to lose.

Some added fat is used for cooking, though not excessive amounts are required to reach the ketogenic macronutrient ratio. There are no snacks and no calorie dense nuts and seeds.
Table 19  Daily meal plan – weight loss, high nutrient density, high bulk

<table>
<thead>
<tr>
<th></th>
<th>Calories</th>
<th>Carbs</th>
<th>Fat</th>
<th>Protein</th>
<th>Potass</th>
<th>Sugar</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Breakfast</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eggs - Fried (whole egg), 3 large</td>
<td>277</td>
<td>1</td>
<td>21</td>
<td>19</td>
<td>203</td>
<td>1</td>
</tr>
<tr>
<td>Spinach - Cooked, boiled, drained, without salt, 3 cup</td>
<td>124</td>
<td>20</td>
<td>1</td>
<td>15</td>
<td>2,516</td>
<td>2</td>
</tr>
<tr>
<td>Espresso - Espresso, 80 ml</td>
<td>12</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>79</td>
<td>0</td>
</tr>
<tr>
<td>Avocados - Raw, 0.5 avocado, NS as to Florida or California</td>
<td>161</td>
<td>9</td>
<td>15</td>
<td>2</td>
<td>487</td>
<td>1</td>
</tr>
<tr>
<td>Oil - Vegetable, coconut, 1 tbsp</td>
<td>117</td>
<td>0</td>
<td>14</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Add Food</td>
<td>Quick Tools</td>
<td>691</td>
<td>31</td>
<td>51</td>
<td>37</td>
<td>3,276</td>
</tr>
<tr>
<td><strong>Lunch</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dulano - Chiaze, 50 g</td>
<td>213</td>
<td>1</td>
<td>16</td>
<td>11</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Feta - Feta, 20 g</td>
<td>57</td>
<td>0</td>
<td>5</td>
<td>3</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>Carrots - Raw, 25 g</td>
<td>10</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>89</td>
<td>1</td>
</tr>
<tr>
<td>John Yiesl - Tuna Olive Oil Blend, 95 g (71g drained)</td>
<td>139</td>
<td>1</td>
<td>8</td>
<td>17</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Klamata Olives - Klamata Olives, 8 olives</td>
<td>25</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Spinach - Baby Spinach, 200 grams</td>
<td>46</td>
<td>7</td>
<td>1</td>
<td>15</td>
<td>1,116</td>
<td>1</td>
</tr>
<tr>
<td>Oil - Olive, 1 tablespoon</td>
<td>119</td>
<td>0</td>
<td>14</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Add Food</td>
<td>Quick Tools</td>
<td>689</td>
<td>13</td>
<td>49</td>
<td>47</td>
<td>1,208</td>
</tr>
<tr>
<td><strong>Dinner</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peas - Green, cooked, boiled, drained, without salt, 8.5 cup</td>
<td>67</td>
<td>13</td>
<td>0</td>
<td>4</td>
<td>217</td>
<td>5</td>
</tr>
<tr>
<td>Mushrooms - Portobella, raw, 100 g</td>
<td>26</td>
<td>5</td>
<td>0</td>
<td>3</td>
<td>484</td>
<td>2</td>
</tr>
<tr>
<td>Broccoli - Cooked, boiled, drained, with salt, 200 g</td>
<td>56</td>
<td>10</td>
<td>1</td>
<td>8</td>
<td>588</td>
<td>3</td>
</tr>
<tr>
<td>Fish - Salmon, chinook, smoked, 200 g</td>
<td>234</td>
<td>0</td>
<td>9</td>
<td>37</td>
<td>350</td>
<td>0</td>
</tr>
<tr>
<td>Butter - Salted, 1 tbsp</td>
<td>102</td>
<td>0</td>
<td>12</td>
<td>0</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Add Food</td>
<td>Quick Tools</td>
<td>485</td>
<td>28</td>
<td>22</td>
<td>50</td>
<td>1,649</td>
</tr>
</tbody>
</table>

7.2.8  Nutritional analysis

In order to understand the nutrient sufficiency of this dietary approach I have analysed the daily meal plan using SELFNutritionData.\(^{81}\)

The outputs from the nutritional analysis shown below demonstrate that we achieve excellent scores in both nutrient balance and the protein quality using this approach. The overall ranking for this approach does quite well in the overall ranking of dietary approaches shown in Table 17.

This daily plan also has an impressive 36g of fibre per day and involves eating nearly two kilograms of food which would leave you feeling full, if you could get through it all, in spite of the reduced number of calories.

With the high amount of fibre, the net carbs are low, and we would meet our goal of less than 45g of carbs in the adjust phase of the ketogenic diet according to Steve Phiney’s macronutrient breakdown.

If you were really serious about maximising nutrient density you could substitute the meat at one of the meals for a nutrient dense organ meat (e.g. liver, heart, kidney etc.). Subbing out the salmon at dinner for chicken liver increases the nutrient balance score from 92 to 95 and the protein quality

Optimising nutrition, managing insulin

score from 143 to 146. This exchange would make this approach the second highest scoring in the comparison in Table 17.

7.3 Scenario 2 - Diabetic / nutritional ketosis / weight maintenance

This scenario uses a weighting system designed for a diabetic or someone trying to achieve nutritional ketosis through lowering insulin while keeping nutrient density high. The macronutrients and calories are based on the “maintain” phase of the ketogenic diet cycle as shown in Figure 16 which is more in line with what you would expect from a higher fat ketogenic diet.

While someone who is overweight and insulin resistant may find that they lose weight due to lowered insulin, decreased fat storage and increased satiety, this approach is not designed specifically for weight loss. If someone wants to lose weight and does not have success on this approach they might benefit from decreasing calorie density and reducing added dietary fats as per scenario 1.

One of the most famous diet studies looking at low carb diets is Dr Chris Gardner’s A to Z Study. Gardner, a practicing vegan, was surprised to find that it was the Atkins dieters who lost the most weight in his study. More interestingly though were the results of a follow-up analysis where he compared the subjects’ insulin resistance and found that it was the people who were insulin resistant that lost the most weight on the low carb diet while the insulin resistant lost nothing on the higher carbohydrate diets. People who are not insulin resistant can lose weight on a high or low carbohydrate diet, however if you are insulin resistant then you’ll likely need to reduce your insulin load.

How do you know if you’re insulin resistant? Your weight and waist line are pretty good indicators, but your average blood sugar is even better. If you want to know what diet is right for you, pick up a blood sugar metre from your local chemist and do some testing. If your average blood sugar is...
above 5.4mmol/L or 100mg/dL then you will probably benefit from a diet with a reduced insulin load.

The nutrients per calorie (15% weighting), nutrient density per 100g (10%) and calories per 100g (10%) are emphasised in this scenario in order to find the most nutrient dense carbohydrates and proteins to enable the insulin lowering fats to be maximised in the rest of the diet. The dominant weighting in this scenario however is the proportion of insulinogenic calories (50% weighting) which takes into account the insulinogenic effects of the carbohydrates protein and the fibre.

### Table 20 Weighting – diabetes and nutritional ketosis

<table>
<thead>
<tr>
<th>nutrient density / calorie</th>
<th>fibre / calorie</th>
<th>nutrient density / $</th>
<th>nutrient density / weight</th>
<th>insulin (%)</th>
<th>Calories / 100g</th>
<th>$ / calorie</th>
</tr>
</thead>
<tbody>
<tr>
<td>15%</td>
<td>5%</td>
<td>5%</td>
<td>10%</td>
<td>50%</td>
<td>10%</td>
<td>5%</td>
</tr>
</tbody>
</table>

The foods prioritised by this weighting are listed below in order of priority. Vegetables again rate well, with fats and oils coming up in priority with the increased focus on the insulinogenic properties of the foods. Fruits however are limited to avocados and olives. There are a lot of egg and dairy options available if you can tolerate them along with a long list of nuts, seeds and legumes.

It’s interesting to note that animal products are acceptable but the standard fare of beef and chicken (i.e. lean protein) don’t rank at the top of the list. Organ meats and seafood appear to be better choices due to their higher nutrient and fat content. The omega 3 / DHA content of these foods are not included in the ranking system, however this would be another reason to prioritise seafood.

#### 7.3.1 Vegetables
- turnip greens
- coriander (cilantro)
- rosemary
- spinach
- parsley
- peppers / capsicum
- chives
- mustard greens
- collards
- mushrooms
- Swiss chard
- artichokes
- brocoli
- Brussel sprouts
- Kale

#### 7.3.2 Fats and oils
- butter
- coconut oil
- olive oil
- fish oil
- flaxseed oil

#### 7.3.3 Fruits
- avocados
- olives

#### 7.3.4 Eggs & dairy
- whole egg
- goat cheese
- parmesan cheese
- cheddar
- cream
- camembert
- feta
- cream cheese
- blue cheese
- Colby cheese
- Swiss cheese
- edam cheese
- brie
- gouda
- mozzarella
- ricotta
- cottage cheese

#### 7.3.5 Nuts & seeds
- brazil nuts
- sunflower seeds
- pecans
- pumpkin seeds
- almonds
- macadamia nuts
- pine nuts
- coconut milk
- coconut meat
- pistachio nuts
- cashews

#### 7.3.6 Animal products
- organ meats
- polish sausage
- sardines
- chorizo
- bratwurst
- herring
7.3.7 Example daily diet

Table 21 shows an example daily meal plan using the foods identified by this weighting system.

Compared to the low calorie density weight loss approach, this scenario uses cream in coffees rather than black coffee, less spinach and vegetables and more calorie dense foods such as cheese and olives.

I've also added in some brazil nuts for afternoon tea. Overall this approach is may be more viable in the long term as it involves a wide range of luxurious foods without as many restrictions as the low calorie density approach which emphasises more non-starchy vegetables. In reality most people would probably benefit from consuming a diet somewhere between scenario 1 and scenario 2 in the long term.
7.3.8 Nutritional analysis
The nutritional analysis of this meal plan shows that this approach gives us an excellent nutritional profile, though it does not score quite as highly on the vitamins and minerals and protein as the previous approach due to the reduced amount of vegetables. However, for someone struggling to manage their blood glucose levels this approach has a much lower glycemic load and a much lower proportion of insulinogenic calories than scenario 1.

This approach also achieves a very low 14g of net carbs per day due to the high amount of fibre from the vegetables. A diabetic using this approach would find their insulin requirement was substantially reduced and their blood glucose would stabilise. Higher levels of ketones and weight loss would most likely ensue naturally after a period of time.

Some people on a restricted carbohydrate diet find that they get what is called “physiological insulin resistance” where the muscles preference glucose for the brain and this leads to higher blood glucose. If you find that you are getting increased fasting blood glucose you may want to look at increasing your carbohydrate

---

Table 21 Daily meal plan – diabetic / nutritional ketosis / weight maintenance

<table>
<thead>
<tr>
<th>Breakfast</th>
<th>Calories</th>
<th>Carbs</th>
<th>Fat</th>
<th>Protein</th>
<th>Potass</th>
<th>Sugar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Espresso - Espresso, 80 ml</td>
<td>12</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>70</td>
<td>0</td>
</tr>
<tr>
<td>Eggs - Fried (whole egg), 3 large</td>
<td>277</td>
<td>1</td>
<td>21</td>
<td>19</td>
<td>203</td>
<td>1</td>
</tr>
<tr>
<td>Cadet - Bacon, 2 Slices (40 gr)</td>
<td>220</td>
<td>0</td>
<td>20</td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Spinach - Cooked, boiled, drained, with salt, 1 cup</td>
<td>41</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>639</td>
<td>1</td>
</tr>
<tr>
<td>Avocados - Raw, 0.5 avocado, NS as to Florida or California</td>
<td>181</td>
<td>9</td>
<td>15</td>
<td>2</td>
<td>487</td>
<td>1</td>
</tr>
<tr>
<td>Cream - Heavy whipping (whipped), 20 g</td>
<td>69</td>
<td>1</td>
<td>7</td>
<td>0</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>Add Food</td>
<td>Quick Tools</td>
<td>780</td>
<td>19</td>
<td>63</td>
<td>31</td>
<td>1,614</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Lunch</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil - Olive, 1 tablespoon</td>
<td>119</td>
<td>0</td>
<td>14</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Spinach - Baby Spinach, 260 grams</td>
<td>46</td>
<td>7</td>
<td>1</td>
<td>16</td>
<td>1,116</td>
<td>1</td>
</tr>
<tr>
<td>Klamata Olives - Klamata Olives, 8 olives</td>
<td>25</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>John West - Tuna Olive Oil Blend, 95 g (71g drained)</td>
<td>139</td>
<td>1</td>
<td>8</td>
<td>17</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Feta - Feta, 20 g</td>
<td>57</td>
<td>0</td>
<td>5</td>
<td>3</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>Dulano - Chirizo, 50 g</td>
<td>213</td>
<td>1</td>
<td>18</td>
<td>11</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Add Food</td>
<td>Quick Tools</td>
<td>599</td>
<td>11</td>
<td>49</td>
<td>47</td>
<td>1,281</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dinner</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pork sausage - Fresh, cooked, 1 serving (2 links)</td>
<td>193</td>
<td>0</td>
<td>14</td>
<td>9</td>
<td>141</td>
<td>0</td>
</tr>
<tr>
<td>K-Classic - Caramelett, 100 g</td>
<td>299</td>
<td>2</td>
<td>24</td>
<td>26</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Butter - Salted, 1 tbsp</td>
<td>102</td>
<td>0</td>
<td>12</td>
<td>0</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Broccoli - Cooked, boiled, drained, with salt, 200 g</td>
<td>58</td>
<td>10</td>
<td>1</td>
<td>6</td>
<td>586</td>
<td>3</td>
</tr>
<tr>
<td>Add Food</td>
<td>Quick Tools</td>
<td>620</td>
<td>12</td>
<td>51</td>
<td>35</td>
<td>730</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Morning Tea</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cream - Heavy whipping (whipped), 1 tbsp</td>
<td>52</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>Espresso - Espresso, 40 ml</td>
<td>6</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>35</td>
<td>0</td>
</tr>
<tr>
<td>Add Food</td>
<td>Quick Tools</td>
<td>58</td>
<td>1</td>
<td>6</td>
<td>0</td>
<td>46</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Afternoon Tea</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Macro Organic - Brazil Nuts, 15 g</td>
<td>105</td>
<td>1</td>
<td>10</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Add Food</td>
<td>Quick Tools</td>
<td>105</td>
<td>1</td>
<td>10</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>
If we substitute the pork sausages at dinner for chicken liver this scenario would achieve an exceptional nutrient balance score of 84 with a protein quality score of 148.

7.4 Scenario 3 - Nutrient density on a budget

This scenario prioritises nutrient density per dollar (30% weighting) and cost per calorie (30% weighting) without as much attention to calories, carbohydrates or keeping insulin levels low.

<table>
<thead>
<tr>
<th>Table 22 Weighting – nutrient density on a budget</th>
</tr>
</thead>
<tbody>
<tr>
<td>nutrient density / calorie</td>
</tr>
<tr>
<td>10%</td>
</tr>
</tbody>
</table>

This approach is not necessarily recommended, but rather as a comparison of what happens if we prioritise cost over nutrition or optimisation of blood glucose management.

This weighting prioritises grains, along with peanuts, potatoes, legumes and liver. While grains and legumes do not provide optimal nutrition they are cheap. However they may not be ideal if you are conscious of your weight, blood glucose control or long term health.

7.4.1 Legumes
- Peanut butter
- Lentils
- Chickpeas

7.4.2 Grains
- Peanuts
- Kidney beans
- Mung beans
- Refried beans
- Tortillas

levels to a minimum of 30g per day (as recommended by Dr Bernstein). Other people however find that this is a stage and which passes after a longer period of adjustment to using fat for fuel.
7.4.3 Vegetables
- Peppers
- Parsley
- Cowpeas
- Chives
- Spinach
- Dandelion greens
- Sweet potato
- Mushroom

7.4.4 Nuts and seeds
- Sunflower seeds
- Pumpkin seeds
- Brazil nuts
- Pistachio nuts
- Almonds

7.4.5 Dairy and egg
- Whole egg
- Reduced fat milk
- Egg yolk

7.4.6 Animal products
- Organ meats (Liver, heart, giblets)
- Herring

7.4.7 Fats and oils
- Margarine
- Corn oil
- Mayonnaise

7.4.8 Breakfast cereals
- Corn flakes
- All bran

7.4.9 Fruit
- Orange
- Avocado
- Banana

7.4.10 Daily meal plan
An example daily meal plan is shown below. Many people would see this as a reasonably healthy daily meal plan with cornflakes and a banana for breakfast, peanut butter sandwich for lunch (on multigrain bread), an orange for afternoon tea, and spaghetti and mince for dinner. In fact, it’s not too dissimilar to the meal plan that was recommended to me the one time I went to a nutritionist for dietary advice.
The nutritional analysis indicates that this approach gives us a macronutrient profile that is about half carbohydrates (which is about average for most people these days\(^8\)). Using fruit instead of vegetables gives us a much lower nutrition score and the protein score is relatively low.

The major concern however with this approach is the glycemic load at 160 and the nearly 300g of carbohydrates per day. This approach would present a problem for a diabetic trying to manage their blood glucose and would likely promote diabetes over time for a lot of people.

7.5 Scenario 4 – Athlete or a metabolically healthy person

This scenario is designed for an athlete who may want more carbohydrates before or after an intense workout while still maximising nutrient density.

Paleo nutrition guru Robb Wolf says that he is a fan of the low carbohydrate ketogenic dietary approach combined with intermittent fasting, however the people that seem to do it are not the overweight sedentary office workers who might benefit most from it, but rather the people who are doing intense workouts combined with intermittent fasting and then trying to cram massive amounts of high fat calories into their compressed eating window.84

If you’ve got weight to lose, have elevated blood glucose and / or are not doing a lot of intense exercise then carbohydrate loading is probably not for you. However some people who are doing a lot of exercise may benefit from a greater amount of carbohydrates during recovery as well replenishing glycogen stores before a competition where burst power is required.

Ben Greenfield recommends that athletes stay low carb (i.e. 10% of calories) most of the time and then have a higher carbohydrate meal after workouts (i.e. 30% of calories). This is conceptually similar to John Kiefer’s Carb Backloading85 or Carb Nite86 which is designed for physique competitors wanting the benefits of ketogenic diet without burning themselves out. Most of us though with day jobs who do a bit of exercise don’t have this problem.

---

85 http://carbbackloading.com
86 http://carbnite.com/
This approach emphasises nutritional density per 100g (40% weighting), with a lesser weighting towards the insulinogenic properties (25%) and nutrient density per calorie (15%).

**Table 23. Weighting – Athlete or a metabolically healthy**

<table>
<thead>
<tr>
<th>Nutrient density / calorie</th>
<th>Fibre / calorie</th>
<th>Nutrient density / $</th>
<th>Nutrient density / weight</th>
<th>Insulin (%)</th>
<th>Calories / 100g</th>
<th>$ / calorie</th>
</tr>
</thead>
<tbody>
<tr>
<td>15%</td>
<td>10%</td>
<td>10%</td>
<td>30%</td>
<td>20%</td>
<td>5%</td>
<td>10%</td>
</tr>
</tbody>
</table>

The prioritised food rankings are shown below. Again Rich Froning’s favourite calorie and nutrient dense peanut butter rates well along with a wide range of nutrient dense nuts and seeds. Vegetables do well.

A number of grain based foods make it in at the bottom of the list, such as oats. Organ meats, as always, rank highly.

It’s interesting to note that bacon ranks as the first non-seafood meat, whereas it ranked further down the list in the other approaches which prioritised lower calorie density. Perhaps living on bacon rather than vegetables may not be ideal if your primary aim is weight loss.

7.5.1 Nuts, seeds and legumes
- peanut butter
- sunflower seeds
- peanuts
- brazil nuts
- pumpkin seeds
- pistachio nuts
- pecans
- cashews
- almonds
- pine nuts
- macadamia nuts
- lentils
- kidney beans
- mung beans
- chick peas
- coconut meat
- cinnamon
- ginger
- broccoli
- lentils
- Brussel sprouts
- Kale
- asparagus
- Sweet potato

7.5.2 Vegetables and spices
- spinach
- mushrooms
- chives
- coriander
- chard
- turnip greens
- rosemary
- spirulina

7.5.3 Dairy and egg
- egg yolk
- whole egg
- cheese
- milk

7.5.4 Animal products
- organ meats (Liver, heart, giblets)
- sardine
- oyster
- anchovy
- cod
- herring
- bacon
- oyster
- chorizo
- mussel
- trout
- salmon
- tuna
- beef jerky
- turkey
- ground beef
- lamb

7.5.5 Fats and oils
- olive oil
- coconut oil
- butter

7.5.6 Fruit
- avocado
- olive
- raspberries
- blackberries
- oranges
- banana
- dates
- strawberries

7.5.7 Grains
- tortilla
- oats
- white bread
- multi grain bread
- croissants
- oat bran muffins
- rice
### 7.5.8 Daily diet

A possible daily meal plan using the highest ranking foods and using this weighting is shown below. For breakfast we have bacon with spinach and eggs, a salad with tuna for lunch, salmon and veggies for dinner with nuts for snacks. I’ve used full cream milk in the coffees to get the carbs up, although milk doesn’t rank well on the nutrient density compared to the other options and not everyone who follows the paleo template will want to drink milk.

#### Breakfast

<table>
<thead>
<tr>
<th>Food</th>
<th>Calories</th>
<th>Carbs</th>
<th>Fat</th>
<th>Protein</th>
<th>Potass</th>
<th>Sugar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coffee - Brewed from grounds, 1 oz(a)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>Eggs - Fried (whole egg), 2 large</td>
<td>165</td>
<td>1</td>
<td>14</td>
<td>13</td>
<td>135</td>
<td>1</td>
</tr>
<tr>
<td>Milk - Whole, 2.25% milkfat, 1 cup</td>
<td>146</td>
<td>11</td>
<td>6</td>
<td>8</td>
<td>349</td>
<td>13</td>
</tr>
<tr>
<td>Bread - Oatmeal toasted, 2 slice</td>
<td>146</td>
<td>26</td>
<td>2</td>
<td>5</td>
<td>77</td>
<td>4</td>
</tr>
<tr>
<td>Spinach - Cooked, boiled, drained, with salt, 2 cup</td>
<td>83</td>
<td>14</td>
<td>1</td>
<td>11</td>
<td>1,678</td>
<td>2</td>
</tr>
<tr>
<td>Cadet - Bacon, 3 Slices (40 gr)</td>
<td>330</td>
<td>0</td>
<td>30</td>
<td>8</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>**Add Food</td>
<td>Quick Tools**</td>
<td>890</td>
<td>52</td>
<td>55</td>
<td>45</td>
<td>2,263</td>
</tr>
</tbody>
</table>

#### Lunch

<table>
<thead>
<tr>
<th>Food</th>
<th>Calories</th>
<th>Carbs</th>
<th>Fat</th>
<th>Protein</th>
<th>Potass</th>
<th>Sugar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duano - Chirto, 50 g</td>
<td>213</td>
<td>1</td>
<td>18</td>
<td>11</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pota - Pota, 20 g</td>
<td>57</td>
<td>0</td>
<td>5</td>
<td>3</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>John West - Tuna Olive Oil Blend, 95 g (71g drained)</td>
<td>139</td>
<td>1</td>
<td>6</td>
<td>17</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Spinach - Baby Spinach, 200 grams</td>
<td>46</td>
<td>7</td>
<td>1</td>
<td>16</td>
<td>1,116</td>
<td>1</td>
</tr>
<tr>
<td>Klamata Olive - Klamata Olive, 5 olives</td>
<td>25</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Carrols - Raw, 25 g</td>
<td>20</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>**Add Food</td>
<td>Quick Tools**</td>
<td>490</td>
<td>13</td>
<td>36</td>
<td>47</td>
<td>1,268</td>
</tr>
</tbody>
</table>

#### Dinner

<table>
<thead>
<tr>
<th>Food</th>
<th>Calories</th>
<th>Carbs</th>
<th>Fat</th>
<th>Protein</th>
<th>Potass</th>
<th>Sugar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broccoli - Cooked, boiled, drained, with salt, 200 g</td>
<td>56</td>
<td>10</td>
<td>1</td>
<td>6</td>
<td>585</td>
<td>3</td>
</tr>
<tr>
<td>Butter - Salted, 1 tbsp</td>
<td>102</td>
<td>0</td>
<td>12</td>
<td>0</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Mushrooms - Portabella, raw, 200 g</td>
<td>52</td>
<td>10</td>
<td>0</td>
<td>5</td>
<td>908</td>
<td>4</td>
</tr>
<tr>
<td>Eristoe - Mashed Sweet Potatoes, 2 cup</td>
<td>571</td>
<td>110</td>
<td>12</td>
<td>6</td>
<td>645</td>
<td>30</td>
</tr>
<tr>
<td>Fish - Salmon, dainook, smoked, 250 g</td>
<td>293</td>
<td>0</td>
<td>11</td>
<td>46</td>
<td>438</td>
<td>0</td>
</tr>
<tr>
<td>**Add Food</td>
<td>Quick Tools**</td>
<td>1,074</td>
<td>130</td>
<td>36</td>
<td>63</td>
<td>2,840</td>
</tr>
</tbody>
</table>

#### Morning Tea

<table>
<thead>
<tr>
<th>Food</th>
<th>Calories</th>
<th>Carbs</th>
<th>Fat</th>
<th>Protein</th>
<th>Potass</th>
<th>Sugar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuts - Brazil, 20 g</td>
<td>210</td>
<td>3</td>
<td>21</td>
<td>4</td>
<td>659</td>
<td>1</td>
</tr>
<tr>
<td>**Add Food</td>
<td>Quick Tools**</td>
<td>210</td>
<td>3</td>
<td>21</td>
<td>4</td>
<td>659</td>
</tr>
</tbody>
</table>

#### Afternoon Tea

<table>
<thead>
<tr>
<th>Food</th>
<th>Calories</th>
<th>Carbs</th>
<th>Fat</th>
<th>Protein</th>
<th>Potass</th>
<th>Sugar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuts - Almonds, 1 oz(a)</td>
<td>164</td>
<td>6</td>
<td>14</td>
<td>6</td>
<td>208</td>
<td>1</td>
</tr>
<tr>
<td>**Add Food</td>
<td>Quick Tools**</td>
<td>164</td>
<td>6</td>
<td>14</td>
<td>6</td>
<td>208</td>
</tr>
</tbody>
</table>

### 7.5.9 Nutritional analysis

This dietary approach gives a good nutrient and protein score that is similar to the low carb and the low calorie density approaches. However the glycemic load is significantly higher compared to scenarios 1 and 2 with 25% of calories coming from carbohydrates.
This approach may be useful for an athlete preparing for an athletic event where they need additional explosive power, or need to replenish glycogen stores after an intense workout, however in the long term there is the risk that it would place additional load on their pancreas and that may lead to diabetes.

It may be beneficial for an athlete to train with a low carb approach to build their mitochondria and then occasionally ‘carb up’ with this moderate carb approach.  

Tim Noakes has stated that he believes that no athlete needs more than 200g of carbohydrates per day. Minimising carbs will minimise inflammation and hence minimise injuries and maximise an athlete’s longevity rather than simply improving short term performance.

7.6 Scenario 5 - Therapeutic ketosis

You may have noticed that there are plenty of claims out there that a ketogenic diet can be helpful for a range of chronic conditions.

Domonic D’Agostino is doing interesting research into the possible uses for ketosis, both through diet and supplementation. His initial funding was from the US Military to research the applications of ketosis for navy seal divers in order to avoid oxygen toxicity seizures. He has continued this research into how ketosis can starve cancers and be used in conjunction with normal treatments to aid recover from chemotherapy and slow tumour growth. His more recent research, funded by

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88 [https://www.youtube.com/watch?v=3fM9o72ykww](https://www.youtube.com/watch?v=3fM9o72ykww)
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Quest Nutrition, demonstrates that power to weight ratio and recovery can be maximised using a ketogenic approach.

Dr Mary Newport has got a lot of coverage after treating her husband’s advanced Alzheimer’s with coconut oil.99

Terry Whals is undertaking clinical trials of her high nutrient density ketogenic diet that has worked to reverse her own multiple sclerosis.90

The ketogenic diet for epilepsy has made a recent resurgence since director Jim Abrahams91 found success with the ketogenic diet for his son Charlie and then made a movie of his experience.92 The Charlie Foundation (with partner site ketocook.com) supports families working to use a ketogenic dietary approach to manage epileptic seizures.93

Jimmy Moore’s Keto Clarity94 spends three chapters profiling the various conditions that the ketogenic diet has been proposed to be beneficial for:

- **Solid science for using ketogenic diets therapeutically (chapter 16)**
  - Epilepsy
  - Diabetes mellitus
  - Weight loss
  - Polycystic ovary syndrome (PCOS)
  - Irritable bowel syndrome (IBS)
  - GERD and heartburn
  - Non-alcoholic fatty liver disease (NAFLD)

- **Good evidence (chapter 17)**
  - Alzheimer’s disease
  - Parkinson’s disease
  - Dementia
  - Schizophrenia, bipolar and other mental illnesses
  - Narcolepsy and other sleep disorders
  - Exercise performance

- **Emerging areas of research (chapter 18)**
  - Cancer
  - Fibromyalgia
  - Chronic pain
  - Migraines
  - Traumatic brain injury
  - Stroke
  - Gum disease and tooth decay
  - Acne
  - Eyesight

99 https://www.youtube.com/watch?v=feyydeMFWy4
90 https://www.youtube.com/watch?v=KLjgBLwH3Wc
91 http://www.imdb.com/name/nm0000720/
92 https://www.youtube.com/watch?v=HyeC9iiFkw
93 http://www.charliefoundation.org/
94 http://www.amazon.com/Keto-Clarity-Definitive-Benefits-Low-Carb/dp/1628600071
Optimising nutrition, managing insulin

- Amyotrophic lateral sclerosis (ALS)
- Multiple sclerosis (MS) and Huntington’s disease
- Aging
- Kidney disease
- Restless leg syndrome (RLS)
- Arthritis
- Alopecia and hair loss
- GLUT1 deficiency syndrome

The therapeutic ketogenic diet is similar to the LCHF approach but more severe, with net carbs typically restricted to 25g per day and protein restricted to the minimum necessary for muscle repair. If we assume a 10% protein and 25g net carbs in a 2000 calorie per day diet this would equate to an insulin load of 125g per day or 25% insulinogenic calories.

People trying to slow or reverse cancer growth or reduce seizures will often also resort to more aggressive measures including supplementing with larger amounts of butter, coconut oil, MCT oils and ketones salts to drive their ketone levels up.

Table 24 shows the weighting I have used for this ranking of foods for therapeutic ketosis. Obviously this approach gives the greatest weighting to minimising the insulinogenic properties of foods. However still considering nutrient density, cost and calorie density will help to optimise these other elements of nutrition even though we are primarily targeting a low insulin load approach.

Table 24 Weightings to determine optimal foods for therapeutic ketosis

<table>
<thead>
<tr>
<th>ND / cal</th>
<th>fibre / cal</th>
<th>ND / $</th>
<th>ND / weight</th>
<th>insulinogenic (%)</th>
<th>cal / 100g</th>
<th>$ / cal</th>
</tr>
</thead>
<tbody>
<tr>
<td>5%</td>
<td>5%</td>
<td>5%</td>
<td>5%</td>
<td>70%</td>
<td>5%</td>
<td>5%</td>
</tr>
</tbody>
</table>

I have also used a filter using Wilders’ formula to show only foods that have a ratio of ketogenic to anti ketogenic calories greater than 1.5. This is the commonly accepted parameter in therapeutic ketosis circles to determine whether a food or a meal is sufficiently ketogenic.

$$\frac{\text{Ketogenic}}{\text{Anti-ketogenic}} = \frac{0.9 \times \text{Fat} + 0.46 \times \text{Protein}}{1.0 \times \text{Carbohydrate} + 0.1 \times \text{Fat} + 0.54 \times \text{Protein}}$$

The resultant foods are listed below. This approach will obviously prioritise liberal use of fats and oils along with fatty dairy products and meats.

Not all of the vegetables have a Wilder’s ketogenic ratio greater than 1.5 however it would still be desirable to include some vegetables for nutrition. Someone using this approach may choose to supplement vitamins and minerals or use organ meats in order to minimise the carbohydrate load that would occur from the vegetables.

I hope that these lists will be useful for people who need to maximise ketosis for therapeutic purposes as well as possibly others such as diabetics or people looking to lose weight who want to use a more intensive approach for a period.

7.6.1 Fats and oils
- butter
- coconut oil
- olive oil
- fish oil
- flaxseed oil
- lard
- bacon grease

7.6.2 Nuts, seeds & legumes
- brazil nuts
- pecan nuts
- peanuts
- macadamia nuts
- sunflower seeds
- coconut milk
- pine nuts
- almonds
- coconut meat
- almond butter
- pumpkin seeds
- almonds
- pistachio nuts

### 7.6.3 Fruit
- avocado
- olives

### 7.6.4 Dairy and egg
- egg yolk
- whole egg
- cream
- cream cheese
- goat cheese
- cheddar cheese
- Monterey cheese
- camembert
- muenster cheese
- Colby cheese
- brie
- blue cheese

### 7.6.5 Animal products & fish
- Edam
- Gruyere
- parmesan cheese
- feta cheese
- mozzarella cheese
- gouda
- Provolone
- Monterey cheese
- ricotta cheese
- cottage cheese
- turkey
- chicken liver
- anchovy
- salmon
- ham
- carp
- trout
- clam
- catfish
- shrimp
- oyster
- squid
- lobster
- cod
- haddock

### 7.6.6 Vegetables
- polsk sausage
- link sausage
- chorizo
- frankfurter
- bratwurst
- beef sausage
- duck
- knackwurst
- bacon
- bologna
- herring
- ground lamb
- chicken
- chuck eye steak
- herring
- sardine

### 7.7 Limitations
The prioritised lists of foods in this section are based on the analysis of the raw data and do not account for anti-nutrients and toxins or foods that you may personally have an issue with. Useful resources to help you refine your choices include Dave Asprey’s *Bulletproof Diet book,*[^95] Chris Kresser’s *Personal Paleo Code*[^96] or Paul Jaminet’s *Perfect Health Diet.*[^97]

Many of us are delicate petals in our own way:

- Some people choose to avoid peanuts or lentils because they are legumes or contain lectins.
- Many people will avoid oats and bread because they are grain based and lead to leaky gut.

[^96]: http://my.chriskresser.com/books/tpc/
[^97]: http://perfecthealthdiet.com/
Many people avoid nuts because they find it hard to stop eating them.

Many people find they do better if they limit the casein or lactose proteins from dairy.

Many people avoid tofu and soy due to their oestrogenic properties.

Buying organic is another consideration and people will need to endeavour to buy foods that do not contain pesticides, depending on their goals, health and budget. See David Suzuki’s Dirty Dozen (foods that should ideally be organic) and Clean Fifteen (foods that don’t need to be organic).

The issue of genetic modified foods is also something you may want to consider for yourself. If you can afford it, grass fed and wild caught contain less toxins and more good fats and taste great too.

I hope you can build on these food lists and refine them based on your experience to see what works best for you.

7.8 Cheat sheets

I’ve developed a range of cheat sheets that summarise the learnings for each scenario outlined in this section that you can stick on your fridge as a reminder of ideal food choices or use for inspiration for your next shopping expedition. They can be downloaded here.

7.9 Meal rankings

Similar to analysis of the various dietary approaches I have also undertaken an analysis of close to two hundred different meals to identify the most nutritious options for my family and hopefully a wider audience of people trying to optimise nutrition and manage insulin.

The meals have been ranked based on the following properties:

1. proportion of insulinogenic calories,
2. vitamin and mineral sufficiency score,
3. protein sufficiency score,
4. fibre per calorie, and
5. calorie density.

Check out the meal rankings here and find out more details on the background of the ranking system here.

7.10 Summary

- The multi criteria weighting enables prioritised food selection to suit different goals.
- Someone wanting to lose weight can use the ranking system to prioritise low calorie density, high fibre, low carbohydrate foods as per scenario 1.
- A diabetic can follow scenario 2 to prioritise for foods that will minimise insulin load while still obtaining good levels of nutrition.

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• Prioritising cost over nutrition as per scenario 3 leads to a grain-based high glycemic load diet which may lead to diabetes and should ideally be avoided if you can afford to approach food as preventative medicine.

• The ranking system can also be used to prioritise high nutrient foods for athletes as per scenario 4 wanting to replenish glycogen stores with a bit more carbohydrate before or after a workout.

• Scenario 5 outlines how we can also prioritise foods for therapeutic ketosis for people battling more severe health situations.
8 Trends, outliers, insulin and protein

8.1 Background

Back before the GFC I used to dabble in share trading.

I don’t know that much about financial systems, but I spent a good deal of time designing and testing “trend following” trading systems.

One of the pitfalls for newbies is to design a system with excessive “curve fitting”. That is, to design a complex system that would work fantastically on a specific set of historical data. If you ran an overly curve fitted system on another set of data or tried to trade it in real time it would fail because it was too finely tuned to the discrete set of historical data.

“Everything should be as simple as possible, but no simpler.”

Albert Einstein

Another lesson from trading is that you should be able to describe simply why a good system works. My trading system scanned the market for stocks that were moving up quickly over a number of time periods with minimal volatility so that I could place a close ‘stop loss’ that would take me out of the trade quickly if the trend turned.

Once the GFC hit things got too volatile and I got out of the market. It was no longer fun.

However the skills I learned dabbling in trying to be a quantitative trader (along with my day job running multi criteria analyses to identify motorway alignments) have given me an interesting angle on nutrition that I hope people find useful.

In this document and on the blog I have tried to describe a system to manage nutrition that makes sense to me that I wish someone had shown me when I started dabbling in the top of diabetes and nutrition.

If we want to understand and predict the behaviour of insulin, the master regular hormone of the human body, we need to first determine what we know that is accurate, significant and useful.

Kristine Bell’s PhD thesis Clinical Application of the Food Insulin Index to Diabetes Mellitus99 (Sept 2014) details the results of the latest food insulin test data for more than 100 foods. It also examined the relationship between insulin demand and macronutrients, glycaemic index, glycaemic load, indigestible fibre, individual amino acids and blood glucose.

In section 3 we looked at how the food insulin index data can be used to determine the insulinogenic properties of foods. Since posting the most ketogenic diet foods article the page has received nearly 50,000 views over two months and I have had a lot of questions which has prompted me to think about things further. Given how fundamentally important it is to understand how our food choices influence insulin response I thought it would be worth delving into the topic in a little more detail.

This article looks in more detail at what can be learned from the food insulin index data from the various parameters with a view to better manage blood glucose and insulin demand. In this discussion I have included the statistical significance calculations for those people who are more used to that sort of approach.

99 http://ses.library.usyd.edu.au/handle/2123/11945
8.2 Carbohydrate
Most people know is that carbohydrates require insulin. As shown in the chart below, carbohydrates goes some way to explaining insulin response. However it is far from a perfect relationship ($R^2 = 0.44$, $r = 0.67$, $p < 0.05$).

![Figure 17 Carbohydrate versus insulin index]

8.3 Indigestible fibre
Taking indigestible fibre into account (i.e. net carbohydrates) improves the relationship ($R^2 = 0.48$, $r = 0.69$, $p < 0.05$). The best correlation is achieved when we subtract all the indigestible fibre from the total carbohydrate value. However we can see from the cluster of data points on the vertical axis there is something going on that is not explained by carbohydrates alone.
The importance of dietary fibre should not be underestimated, especially when trying to reduce insulin demand. Some people recommend that diabetics and low carbohydrate limit total carbohydrates (rather than considering net carbohydrates or non-fibre carbohydrates). The danger here is that people will avoid fibrous non-starchy vegetables that provide vitamins and minerals that cannot be obtained from other foods (unless you’re consuming a significant amount of organ meats) as well as feeding the gut bacteria which is also important to improve insulin sensitivity and the body’s ability to digest fats.\footnote{http://www.amazon.com/Brain-Maker-Power-Microbes-Protect/dp/0316380105}
8.4 Fat

The food insulin index data indicates that foods that are largely comprised of fat (e.g. butter and olive oil) have a negligible insulin response ($R^2 = 0.38$, $r = 0.631$, $p < 0.001$).

![Figure 19: Fat versus insulin index](image)

In order to think of this from another angle, the chart below shows the sum of carbohydrate plus protein (i.e. the non-fat content of foods) versus the insulin index ($R^2 = 0.38$, $r = 0.62$, $p < 0.001$) indicating that:

- the greater the proportion of fat in a particular food the less insulin is required; and
- the more carbohydrates and / or protein ingested the more insulin is required.

Based on this it appears that in order to reduce insulin demand we need to reduce carbs and / or protein!
Figure 20  Non-fat macronutrients versus insulin index

The figure below shows a similar chart for the glucose score (i.e. the area under the curve of the blood glucose rise over three hours after ingestion of the food). Again, this indicates that the blood glucose response is lowest for foods that contain a higher proportion of calories from fat ($R^2 = 0.45$, $r = 0.68$, $p < 0.001$).

Figure 21  Non-fat macronutrients versus glucose score
While it appears that insulin demand is triggered by carbohydrates and protein, what is not clear is the relative degree to which carbohydrates and protein contribute to insulin demand. Are they equivalent or does protein have some lesser insulin response?

### 8.5 Protein

Another learning from my trading days is that you can learn a lot by considering outliers. You have to decide whether the data points that don’t quite fit the trend are garbage or real.

In the carbohydrate vs insulin relationship the outliers are the high protein foods that trigger a higher insulin response than can be explained by considering carbohydrates alone.

As shown in this plot, high protein foods are typically lower in carbohydrates which produce the greatest amount of glucose. Choosing higher protein foods will generally reduce insulin ($R^2 = 0.10$, $r = 0.47$, $p < 0.001$). Thought to some extent this will be simply because higher protein foods have a lower carbohydrate content.

![Protein versus insulin index](image.png)

**Figure 22 Protein versus insulin index**

Protein is critically important for many bodily functions. It’s vital to eat adequate protein. Increasing protein will also typically lead to a spontaneous reduction in calories which will lead to weight loss.\(^{101}\)\(^{102}\)

However protein in excess of the body’s needs for growth and repair can be turned into glucose. The fact that protein can turn to glucose represents a potential ‘hack’ for diabetics trying to manage their blood glucose as they can get the glucose required for brain function without spiking blood glucose as much as carbohydrates.

Choosing higher protein foods will generally lead to better blood glucose control. Although high protein foods still raise the blood glucose to some degree, particularly if you are not insulin sensitive,

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the blood glucose response is gentler and hence the pancreas can secrete enough insulin to balance blood glucose.

![Figure 23 Protein versus glucose score](image)

**Figure 23 Protein versus glucose score**

For most people, transitioning to a reduced carbohydrate whole foods diet will give them most of the results they are after. However for type 1 diabetics or people trying to design a therapeutic ketogenic diet, consideration of protein may be important to fine tune the process to achieve the desired outcomes.

For a healthy bodybuilder the glucogenic and insulinogenic effect of protein might be an anabolic advantage with the post workout protein shake provide an insulin spike to help build muscle. However for someone struggling to lose weight on a low carb diet considering the insulinogenic effect of protein might just be what they need to push through to reach their goals. At least I know that has been my experience.

**8.6 Glycemic index**

As shown in Figure 24 the glycemic index is a reasonable predictor of insulin demand in terms of correlation ($R^2 = 0.54, r = 73, p < 0.01$), however the ‘elephant in the room’ again is the high protein low carbohydrate foods.

The other issue is that the glycemic index is an empirical measurement that has to be measured in humans “in vivo” and can’t easily be calculated based on commonly available food properties.

Again, the glycemic index doesn’t deal with the insulin response form high protein foods.
8.7 Glycemic load

The same issue applies to glycaemic load. Figure 25 shows that there is a reasonable correlation between glycaemic load and insulin demand. However it still doesn’t explain the insulin effect of high protein foods ($R^2 = 0.57$, $r = 0.75$, $p < 0.01$). And you have to run these tests in real people “in vivo”. 
8.8 Glucose score

Like the food insulin index, the glucose score is measured “in vivo” based on the area under the curve of a healthy person’s glucose rise due to a particular food. Glucose score is interesting in that it actually achieves an excellent correlation with insulin demand ($R^2 = 0.75$, $r = 0.87$, $p < 0.001$) as shown in Figure 26, however there is still a disconnect when it comes to high protein foods.

![Figure 26 Glucose score versus insulin index](image)

This data indicates that some foods that don’t raise blood glucose significantly hours still elicit an insulin response. High protein foods digest slowly although they do still require insulin to metabolise. In a normal healthy person the body’s insulin response to protein is balanced by release of glycogen from the liver, with blood glucose being kept in balance by insulin and glycogen.\(^{103}\)

In a normal person the insulin keeps up with this slow blood glucose rise from gluconeogenesis and hence we don’t see a pronounced blood glucose spike due to high protein foods.

The interesting outliers in Figure 26 here are processed low fat milk products that seem to require more insulin than would be anticipated by the blood glucose response. On the other side of the trend line we have brown rice, pasta and other less processed whole foods which raises the blood glucose but doesn’t require as much insulin as you might expect.

Accounting for fibre (i.e. net carbs rather than total carbs) goes some way to help anticipate the effect of processing. However the effect of processing foods is an interesting area for future study that is beyond the capacity of this dataset to address.

I ran a number of correlation analysis and couldn’t find a particularly explanation of why a certain food sat above or below the trend line, whether it be carbohydrates, sugar, fibre or protein. Maybe this difference is the ‘acellular carbohydrates’ that Ian Spreadbury talks about.\(^{104}\)

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\(^{104}\) [http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3402009/]
8.9  Sugar

Sugar is not a particularly useful predictor of insulin demand ($R^2 = 0.10, r = 0.32, p = 0.001$) compared with net carbohydrates ($R^2 = 0.48, r = 0.69, p < 0.05$) as shown in Figure 27. Quitting sugar is only part of the solution. Most people struggling with diabetes or obesity should ideally consider their total carbohydrate intake.

![Sugar versus insulin index](image)

**Figure 27  Sugar versus insulin index**

8.10  Curve fitting

Kristine Bells’ *Clinical Application of the Food Insulin Index to Diabetes Mellitus*\(^{105}\) documents the investigation of a number of formula to explain the relationship between food properties and the food insulin index response. The aim of this work was to build a better glycemic index\(^{106}\) to predict insulin response rather than just blood glucose rise.

Figure 28 shows the best relationship developed using a stepwise multiple linear regression analysis of the various parameters to forecast insulin demand documented in *Clinical Application of the Food Insulin Index to Diabetes Mellitus*.\(^{107}\) The correlation is excellent ($R^2 = 0.78, r = 0.89, p < 0.001$). However this relationship relies heavily on the glucose score (GS) which has to be tested “in vivo” (i.e. in human volunteers).

\(^{105}\) [http://ses.library.usyd.edu.au/handle/2123/11945](http://ses.library.usyd.edu.au/handle/2123/11945)

\(^{106}\) [http://www.glycemicindex.com/](http://www.glycemicindex.com/)

\(^{107}\) [http://ses.library.usyd.edu.au/handle/2123/11945](http://ses.library.usyd.edu.au/handle/2123/11945)
If we strip out the glucose score which cannot be obtained without testing then the best relationship achieved in the thesis is the one shown in Figure 29 using carbohydrates and protein with a correction factor \( R^2 = 0.46, r = 0.68, p < 0.001 \).

The problem with this approach is that it assumes that high fat foods have some insulinogenic effect. However we have seen above that high fat foods have a negligible insulin response. This formula also doesn’t account for indigestible fibre which should be subtracted from the total carbohydrate count. And according to this formula a food with zero carbohydrate and zero protein would still have a significant insulin index response of 10.4, which doesn’t make much sense.
8.11 Simple is true

If we take out indigestible fibre (net carbs), assume that fat has a negligible insulin response and refine the protein factor to maximise the correlation with the test data we end up with this chart which has an improved correlation compared to the model above ($R^2 = 0.49$, $r = 0.70$, $p < 0.001$).

**Figure 29 Best fit formula without glucose score**

**Figure 30 Net carbs + 0.56 protein versus insulin index**

This approach also does a good job of predicting blood glucose ($R^2 = 0.59$, $r = 0.77$, $p < 0.001$) as shown in Figure 31.
8.12 Practical application

Individual foods can be ranked and prioritised based on their proportion of insulinogenic calories using the following formula:

\[
\% \text{ insulinogenic calories} = \frac{[\text{carbohydrates} - \text{fibre} + 0.56 \times \text{protein}] \times 4 \text{ cal/g}}{\text{total calories}}
\]

Foods with the lowest proportion of insulinogenic calories will have the gentlest impact on blood glucose and have the lowest insulin demand.

You can find a detailed list of foods ranked by their proportion of insulinogenic calories here and with consideration of nutrients and other factors based on different goals here.

Diabetics and people wanting to reduce the insulin demand of their diet can track the total insulin load (as opposed to carbohydrate counting) using the following formula:

\[
\text{insulin load (g)} = \text{carbohydrates (g)} - \text{fibre (g)} + 0.56 \times \text{protein (g)}
\]

The total insulin load can be reduced (if necessary to improve blood sugar control or reduce body fat) by increasing fibre, decreasing carbohydrates, moderating protein and increasing fat until target blood glucose are achieved.

8.13 Can we design a “perfect” system?

There is still quite a degree of scatter in this real life data. This could be due to measurement error in the macronutrients, food quantity, the characteristics of the people that the food was tested on, real life measurement error or something else.

This approach considering the insulinogenic effect of protein and carbohydrates does however help to better predict insulin demand than carbohydrate alone.
The fact that there is still a high degree of variability in the data and hence limited ability to accurately predict the insulin response to food can be mitigated by keeping the overall insulin load of the diet reasonably low.

Dr Richard Bernstein talks about the ‘law of small numbers’ whereby the compounding errors in the calculation of insulin requirement and the mismatch of insulin response with the rate of digestion misalign means that it is impossible to accurately calculate insulin dose. The only way to manage this is to keep the overall insulin demand low. This is especially beneficial for type 1 diabetics, but also relevant for others wanting to normalise blood sugars or reduce body fat.

Bernstein also talks about the ‘Chinese Meal Effect’ whereby the body will release glucagon in response to any ingested food, including pebbles or a head of lettuce. This may be why things like butter cause some rise in glucose and insulin although they are mostly fat. This effect however seems to be negligible if consuming normal meals and not large quantities of bulky low calorie foods.

8.14 Recommendation

Building on the analysis of the food insulin index data, the key assumptions (or the “logical narrative”) that underpin this system are:

1. carbohydrates require insulin,
2. indigestible fibre does not require insulin, and
3. the glucogenic portion of protein that is not used for growth and repair and not lost in digestion also requires insulin.

In order to reduce our insulin load we should do the following, in order of priority:

1. Increase fibre from non-starchy vegetables (e.g. spinach, mushrooms, peppers, broccoli etc). These will provide vitamins and minerals as well as indigestible fibre that will feed the gut bacteria which will also improve insulin resistance. Increasing fibre in our diet will increase the bulk and the weight of our diet without increasing calories or insulin and tend to decrease or cravings for processed carbohydrates.

2. Reduce carbohydrates, particularly the ones that come processed in packages with a bar code.

3. If you’re still not getting the desired results, look to reduce your insulin load by moderating your protein intake until you are achieving excellent blood glucose control and / or your target HbA1c.

4. If you’re still not getting the results you want then look at some form of intermittent fasting to improve your insulin sensitivity and to kick-start ketosis.

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108 http://www.amazon.com/Brain-Maker-Power-Microbes-Protect-ebook/dp/B00MEMMS9I
9 The insulin index v2

9.1 Background
Since launching the optimising nutrition blog and posting the most ketogenic diet foods article I have had many interesting interactions with people and learned a great deal more about protein and how it affects insulin and blood glucose.

The idea that protein also has an insulin and glucose response is foreign to most people who have been taught that it’s only carbohydrates that raise blood sugars and require insulin.

In the previous section we looked at the relationship between the various parameters that we can use to understand and estimate the insulinogenic properties of foods. In this section we will look at why protein is glucogenic and requires insulin.

9.2 Time of digestion for protein versus carbohydrates
One of the limitations of the food insulin index data is that the insulin area under the curve was measured over only three hours. This is not a problem for carbohydrates which are generally fully digested within three hours. However protein can take much longer to digest. If we were to repeat the food insulin index testing over a longer period it is likely that the measured insulin response would be significantly greater.

9.3 Wilder’s ketogenic formula
Dr Russell Wilder of the Mayo Clinic was the first to coin the term ‘ketogenic diet’. Wilder developed the diet as an alternative to fasting in the treatment of epilepsy in the 1920s.

Wilder also developed the formula shown below to determine whether a diet would be ketogenic. If the number from this calculation was greater than 1.5 then the diet would be considered to be ketogenic and appropriate for the treatment of epileptics.

\[
\frac{\text{Ketogenic}}{\text{Anti-ketogenic}} = \frac{0.9 \times \text{Fat} + 0.46 \times \text{Protein}}{1.0 \times \text{Carbohydrate} + 0.1 \times \text{Fat} + 0.54 \times \text{Protein}}
\]

This formula is based on the premise that:

- 100% of carbohydrate is glucogenic (i.e. turns to glucose),
- 56% of protein is glucogenic,
- 46% of protein is ketogenic, and
- 10% of fat is glucogenic.

I had previously searched for detail on the basis of how Wilder had arrived at the 56% / 46% split for the glucogenic / ketogenic properties of protein. It appears that the 56% glucogenic potential of protein comes from the analysis of nitrogen in the urine of dogs.

---


According to George Cahill, Krebs also found that 57g of glucose may be derived from 100g of protein.\textsuperscript{112} Again this is similar to the insulin demand for protein observed in the food insulin index data.

### 9.4 Carbohydrate counting

The most straightforward approach is to assume that protein has no impact on insulin or blood sugars. Carbohydrate counting alone is a reasonable approach that is likely to work for most people, particularly if they are not particularly insulin resistant. The updated insulin index tables at the end of this section includes a scenario for carbohydrate only for comparison.

### 9.5 The thermic effect of food

You may have heard of the concept of the thermic effect of food which says that different foods require different amounts of energy to digest and process the foods. For example, a mushroom, which has a low calorie density and a lot of fibre and protein, may actually require more energy to digest than is obtained from the digestion of the mushroom. The maximum and minimum thermic effect (also known as “specific dynamic action”) for each of the macronutrients is shown in Table \textsuperscript{25}.\textsuperscript{113}

<table>
<thead>
<tr>
<th>macronutrient</th>
<th>min</th>
<th>max</th>
</tr>
</thead>
<tbody>
<tr>
<td>carbohydrate</td>
<td>5%</td>
<td>15%</td>
</tr>
<tr>
<td>protein</td>
<td>20%</td>
<td>35%</td>
</tr>
<tr>
<td>fat</td>
<td>5%</td>
<td>15%</td>
</tr>
</tbody>
</table>

Compared to carbohydrates and fat, protein only yields between 76% and 84% of the energy per calorie ingested because of losses in digestion. This is useful to know if you’re trying to minimise calorie intake.

In the updated insulin index data in section 9.10 I have assumed that protein has 76% of the effect of carbohydrates based on calorie yield alone. This is not a perfect approach but again an interesting comparison.

### 9.6 Steve Phinney’s well formulated ketogenic diet

Steve Phinney is probably the most well respected authority on the ketogenic diet. One of the key observations from this his well formulated ketogenic diet (WKFD) graphic shown in Figure 32 is that we need to strike a balance between carbohydrates and protein.

\textsuperscript{112} \url{http://www.ncbi.nlm.nih.gov/pmc/articles/PMC292907/pdf/jcinvest00272-0077.pdf} - Cahill references a 1964 paper by Krebs in this paper but I can’t find the original paper.

\textsuperscript{113} \url{http://en.wikipedia.org/wiki/Specific_dynamic_action}
Figure 32 Steve Phinney’s well formulated ketogenic triangle versus other dietary approaches

You can have 30% protein and 5% carbs or 20% carbs and 10% protein and still be within the bounds of a ketogenic diet. However if you have 30% protein and 20% carbs you will be well outside the realms of a ketogenic diet because you will be producing too much glucose.

According to Nuttall and Gannon\(^\text{114}\) the body requires between 32 and 46g of high quality dietary protein to maintain protein balance. This equates to around 6 to 7% of calories in a 2000 to 2500 calorie diet being taken ‘off the top’ for growth and maintenance, with everything else potentially available as ‘excess’ protein for gluconeogenesis.

The slope of the line along the face of the triangle corresponds with the assumption that 7% of protein goes to muscle growth and repair (protein synthesis) with 75% of the remaining ‘excess’ protein being glucogenic. This again is in the ball park of our previous estimate of the glucogenic potential of proteins based on the analysis of the food insulin index data.

9.7 Amino acid potential

More recently I came across more detail on which amino acids are glucogenic, which are ketogenic and which are a bit of both.\(^\text{115} \text{116} \text{117}\) Table 26 shows the categorisations of the various amino acids as well as which are essential versus non-essential.\(^\text{118}\)

Table 26 Classification of amino acids

<table>
<thead>
<tr>
<th>Glycogenic</th>
<th>Both</th>
<th>Ketogenic</th>
</tr>
</thead>
<tbody>
<tr>
<td>alanine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>arginine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>asparagine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>aspartate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>tyrosine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>cysteine</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^\text{114}\) http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3636610/

\(^\text{115}\) http://en.wikipedia.org/wiki/Glucogenic_amino_acid

\(^\text{116}\) http://en.wikipedia.org/wiki/Ketogenic_amino_acid

\(^\text{117}\) https://www.dropbox.com/s/4dki03mz2fci71v/The%20metabolism%20of%20surplus%2E2%80%9D%20amino%20acids.pdf?dl=0

\(^\text{118}\) http://www.medschool.lsuhsc.edu/biochemistry/Courses/Biochemistry201/Desai/Amino%20Acid%20Metabolism%20%2010-14-08.pdf
## Glycogenic, Ketogenic, and Both Amino Acids

<table>
<thead>
<tr>
<th>Glycogenic</th>
<th>Both</th>
<th>Ketogenic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glutamate</td>
<td>Glutamine</td>
<td></td>
</tr>
<tr>
<td>Glutamine</td>
<td>Glycine</td>
<td></td>
</tr>
<tr>
<td>Glycine</td>
<td>Proline</td>
<td></td>
</tr>
<tr>
<td>Proline</td>
<td>Serine</td>
<td></td>
</tr>
<tr>
<td>Essential</td>
<td>Histidine</td>
<td></td>
</tr>
<tr>
<td>Methionine</td>
<td>Isoleucine</td>
<td></td>
</tr>
<tr>
<td>Valine</td>
<td>Phenylalanine</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tryptophan</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Threonine</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Leucine</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lysine</td>
<td></td>
</tr>
</tbody>
</table>

Only two amino acids that are exclusively ketogenic. There is a handful that are both glucogenic and ketogenic. However most of the amino acids are glycogenic, meaning that they will most likely turn into glucose if not required for protein synthesis.

According to David Bender “In fasting and on a low carbohydrate diet as much of the amino acid carbon as possible will be used for gluconeogenesis – an ATP-expensive, and hence thermogenic process.” Based on this it appears that in a low carbohydrate diet situation the excess amino acids that fit under the “both” classification will be turned to glucose rather than ketones. While in a high carbohydrate diet the excess “both” amino acids will be used as ketones rather than glucose.

Figure 33 shows the cycle of catabolism of amino acids. I am not an organic chemist, however from what I understand this means that:

- The amino acids Leucine and Lysine cannot be converted back to glucose as they are ketogenic;
- Isoleucine, Tyrosine, Phenylalanine, Tryptophan, Threonine all enter into the amino acid catabolism cycle and can be used for various functions, such as muscle repair and growth, but can also be converted back into glucose if required (glucogenic) or turned into fatty acids (ketogenic); and
- The remaining amino acids enter the cycle and can be used for a variety of functions in the body, but cannot be converted into fatty acids. If they are not required they are turned into glucose and potentially stored as body fat.

In summary, the amino acids obtained from the digestion of protein have the potential to be turned into glucose through gluconeogenesis.

---

The reason that we don’t see a sharp rise in blood glucose is partly because amino acids from digestion circulate in the blood until they are required. By contrast, glucose from carbohydrates will be used to refill glycogen stores (liver and muscle) and then find their way quickly into the bloodstream. In most people the amino acid stores in the blood are not saturated and hence there is plenty of capacity to store amino acids until they are required.

The body does need glucose, and it is fine to get it from carbohydrates or protein via gluconeogenesis. However many people struggle to produce enough insulin and/or are insulin resistant and hence struggle to keep their blood sugars in normal range. For these people it makes sense to reduce the glucose load of the diet (that requires insulin) to a point that they can maintain normal blood sugars.

9.8 Tallying up the amino acids in the USDA foods database

We can use the glucogenic / ketogenic / both categorisations to better understand how much of the proteins in the 8000 foods listed in the USDA food database are glucogenic.

For each food in the USDA database I tallied up the weight of the glucogenic and ketogenic amino acids and the amino acids that fell onto the ‘both’ category and found that:

- somewhere between 78% and 89.5% of protein has the potential to turn into glucose, depending on whether you considered the amino acids in the ‘both’ column to be glucogenic or ketogenic, or somewhere in between.
- ketogenic amino acids make up only 12% by weight of the total protein across the 8000 foods in the database,
- glucogenic amino acids comprise 74% of the foods, and
- amino acids that fit in the “both” comprise 14% of the total weight of amino acids.

The implication of this is that in a low carbohydrate diet situation nearly 90% of ‘excess’ protein could be turned to glucose in the bloodstream.
Why is this different to the observation from the food insulin index testing which indicates that approximately 56% of protein raises insulin? Possible answers include:

1. When we consider the glucogenic potential of the individual amino acids we are considering the maximum potential of protein if it is not first used for protein synthesis or lost in conversion from protein to glucose (i.e. gluconeogenesis).

2. The insulin index testing is undertaken over only three hours. Protein takes much longer to digest hence the insulin index testing may underestimate the full glucogenic potential of protein.

9.9 Which foods have the most ketogenic protein?

So I bet you are wondering which forms of protein have the highest amount of ketogenic protein. Maybe not? Well, I was, and I am going to share it with you.

Table 27 shows the foods from the USDA database that have the most ketogenic protein (assuming the ‘both’ amino acids are split 50/50 glucogenic/ketogenic) in terms of grams of ketogenic amino acids per 100 grams of the food.

<table>
<thead>
<tr>
<th>Food</th>
<th>Ketogenic aminos (/100g)</th>
<th>% Ketogenic protein</th>
<th>% Insulinogenic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seal, Bearded Alaskan</td>
<td>19.4g</td>
<td>23%</td>
<td>72%</td>
</tr>
<tr>
<td>Whale, Beluga</td>
<td>17.6g</td>
<td>25%</td>
<td>64%</td>
</tr>
<tr>
<td>Cod</td>
<td>16.3g</td>
<td>26%</td>
<td>68%</td>
</tr>
<tr>
<td>Seaweed, spirulina</td>
<td>14.2g</td>
<td>25%</td>
<td>64%</td>
</tr>
<tr>
<td>White fish</td>
<td>13.6g</td>
<td>22%</td>
<td>53%</td>
</tr>
<tr>
<td>Parmesan cheese</td>
<td>12.3g</td>
<td>32%</td>
<td>28%</td>
</tr>
<tr>
<td>Beef, sirloin</td>
<td>10.0g</td>
<td>33%</td>
<td>50%</td>
</tr>
<tr>
<td>Beef, ribeye</td>
<td>9.7g</td>
<td>33%</td>
<td>44%</td>
</tr>
<tr>
<td>Bacon</td>
<td>9.3g</td>
<td>25%</td>
<td>22%</td>
</tr>
<tr>
<td>Egg yolk</td>
<td>9.2g</td>
<td>27%</td>
<td>18%</td>
</tr>
<tr>
<td>Lamb</td>
<td>9.0g</td>
<td>25%</td>
<td>39%</td>
</tr>
<tr>
<td>Chicken, breast with skin</td>
<td>7.8g</td>
<td>24%</td>
<td>48%</td>
</tr>
<tr>
<td>Salmon</td>
<td>7.0g</td>
<td>28%</td>
<td>45%</td>
</tr>
<tr>
<td>Egg, whole</td>
<td>3.3g</td>
<td>26%</td>
<td>29%</td>
</tr>
<tr>
<td>Milk</td>
<td>0.9g</td>
<td>29%</td>
<td>43%</td>
</tr>
</tbody>
</table>

It is hard to know exactly what to make of this list other noting then that the seal, whale and cod have the highest amounts of ketogenic protein. Perhaps there is something about cold water animals that cause them to store more ketogenic amino acids? This seems to align with what we see in the traditional diets of humans who may eat more fat if they are living further away from the equator but eat more carbohydrates from fruits if they live closer to the equator.

Although seal, whale and cod have high amounts of ketogenic amino acids, overall they are still quite insulinogenic due to the high protein content.
Because a large amount of protein can be converted to glucose through gluconeogenesis, it seems better to focus on foods that have a low percentage of insulinogenic calories rather than worrying about the quantity of ketogenic amino acids.

While there is no such thing as a glycemic index for proteins, it would make sense to target less processed meats as far as possible (i.e. avoid protein powders and the like) which are likely to take longer to digest, be more filling and have a more even blood sugar response.

9.10 The most ketogenic foods... updated

Table 28 shows a comparison of a range of glucogenic factors for protein relative to carbohydrate summarising the discussion above.

<table>
<thead>
<tr>
<th>Basis</th>
<th>% insulinogenic</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbohydrates only</td>
<td>0%</td>
<td>A lower end sensitivity assuming that no protein is converted to glucose (i.e. as per standard carbohydrate counting).</td>
</tr>
<tr>
<td>Food insulin index</td>
<td>56%</td>
<td>Based on testing of &gt; 100 foods in healthy individuals</td>
</tr>
<tr>
<td>Thermic effect of food</td>
<td>77%</td>
<td>Average of additional in digestion losses minus 7%.</td>
</tr>
<tr>
<td>Wilder’s formula</td>
<td>56%</td>
<td>Used in initial ketogenic formula</td>
</tr>
<tr>
<td>Krebs / Janney</td>
<td>57%</td>
<td>Based on nitrogen excretion in dogs</td>
</tr>
<tr>
<td>Glucogenic potential (min)</td>
<td>78%</td>
<td>Based on summing amino acids in USDA foods database, excluding “both” aminos.</td>
</tr>
<tr>
<td>Glucogenic potential (max)</td>
<td>89.5%</td>
<td>Based on summing amino acids in USDA foods database, including “both” aminos.</td>
</tr>
<tr>
<td>Steve Phinney WFKD</td>
<td>75%</td>
<td>Assuming that the first 7% of calories goes to growth and repair with 75% of the remaining amino acids being glucogenic.</td>
</tr>
</tbody>
</table>

The most ketogenic diet foods article has been the most popular post on the optimising nutrition blog by far. It was an exciting day when after the site had only been live for a few weeks, this page went viral and received more than 10,000 visitors in one day!

Given the importance of this concept I thought it was worth re-visiting the analysis using a range of approaches to see how they supported the original analysis from the food insulin index testing data. For completeness I have calculated the insulinogenic potential of the foods shown in this previous article using the following approaches:

- carbohydrates only;
- food insulin index data (i.e. protein is 56% insulinogenic);
- thermic effect (i.e. protein is 77% insulinogenic); and
- maximum glucogenic potential of the amino acids for each food (based on amino acid content data in USDA foods database).

This listing illustrates the difference in standard carbohydrate counting and the full insulinogenic potential of the food.
9.10.1 Least insulinogenic foods

<table>
<thead>
<tr>
<th>food</th>
<th>carb only (0%)</th>
<th>FII (56%)</th>
<th>thermic (77%)</th>
<th>glucogenic (max)</th>
</tr>
</thead>
<tbody>
<tr>
<td>olives</td>
<td>1%</td>
<td>4%</td>
<td>4%</td>
<td>4%</td>
</tr>
<tr>
<td>cream</td>
<td>3%</td>
<td>4%</td>
<td>6%</td>
<td>4%</td>
</tr>
<tr>
<td>pecans</td>
<td>2%</td>
<td>5%</td>
<td>8%</td>
<td>6%</td>
</tr>
<tr>
<td>Macadamia nuts</td>
<td>3%</td>
<td>5%</td>
<td>7%</td>
<td>6%</td>
</tr>
<tr>
<td>duck</td>
<td>0%</td>
<td>7%</td>
<td>4%</td>
<td>9%</td>
</tr>
<tr>
<td>pork sausage</td>
<td>2%</td>
<td>10%</td>
<td>19%</td>
<td>9%</td>
</tr>
<tr>
<td>sesame seeds</td>
<td>7%</td>
<td>7%</td>
<td>10%</td>
<td>11%</td>
</tr>
<tr>
<td>sausage</td>
<td>0%</td>
<td>9%</td>
<td>12%</td>
<td>14%</td>
</tr>
<tr>
<td>frankfurter</td>
<td>2%</td>
<td>11%</td>
<td>14%</td>
<td>14%</td>
</tr>
<tr>
<td>pepperoni</td>
<td>0%</td>
<td>10%</td>
<td>14%</td>
<td>15%</td>
</tr>
<tr>
<td>bacon</td>
<td>1%</td>
<td>16%</td>
<td>21%</td>
<td>21%</td>
</tr>
<tr>
<td>mackerel</td>
<td>0%</td>
<td>20%</td>
<td>28%</td>
<td>28%</td>
</tr>
</tbody>
</table>

9.10.2 Eggs

<table>
<thead>
<tr>
<th>egg</th>
<th>carb only (0%)</th>
<th>FII (56%)</th>
<th>thermic (77%)</th>
<th>glucogenic (max)</th>
</tr>
</thead>
<tbody>
<tr>
<td>egg yolk</td>
<td>16%</td>
<td>15%</td>
<td>20%</td>
<td>19%</td>
</tr>
<tr>
<td>whole egg</td>
<td>17%</td>
<td>21%</td>
<td>23%</td>
<td>25%</td>
</tr>
<tr>
<td>egg white</td>
<td>6%</td>
<td>53%</td>
<td>71%</td>
<td>72%</td>
</tr>
</tbody>
</table>

9.10.3 Dairy products

9.10.3.1 Cheese

<table>
<thead>
<tr>
<th>cheese</th>
<th>carbs only (0%)</th>
<th>FII (56%)</th>
<th>thermic (77%)</th>
<th>glucogenic (max)</th>
</tr>
</thead>
<tbody>
<tr>
<td>cream cheese</td>
<td>5%</td>
<td>9%</td>
<td>10%</td>
<td>9%</td>
</tr>
<tr>
<td>brie</td>
<td>1%</td>
<td>14%</td>
<td>20%</td>
<td>18%</td>
</tr>
<tr>
<td>limburger</td>
<td>1%</td>
<td>14%</td>
<td>19%</td>
<td>18%</td>
</tr>
<tr>
<td>camembert</td>
<td>1%</td>
<td>15%</td>
<td>21%</td>
<td>19%</td>
</tr>
<tr>
<td>Monterey</td>
<td>1%</td>
<td>15%</td>
<td>20%</td>
<td>19%</td>
</tr>
<tr>
<td>cheddar</td>
<td>1%</td>
<td>15%</td>
<td>20%</td>
<td>19%</td>
</tr>
<tr>
<td>gruyere</td>
<td>0%</td>
<td>17%</td>
<td>23%</td>
<td>20%</td>
</tr>
<tr>
<td>Colby</td>
<td>3%</td>
<td>16%</td>
<td>21%</td>
<td>20%</td>
</tr>
<tr>
<td>blue</td>
<td>3%</td>
<td>16%</td>
<td>21%</td>
<td>20%</td>
</tr>
<tr>
<td>edam</td>
<td>2%</td>
<td>17%</td>
<td>23%</td>
<td>21%</td>
</tr>
<tr>
<td>gouda</td>
<td>2%</td>
<td>18%</td>
<td>24%</td>
<td>22%</td>
</tr>
<tr>
<td>feta</td>
<td>6%</td>
<td>18%</td>
<td>23%</td>
<td>22%</td>
</tr>
<tr>
<td>ricotta, whole milk</td>
<td>7%</td>
<td>21%</td>
<td>27%</td>
<td>24%</td>
</tr>
<tr>
<td>mozzarella</td>
<td>3%</td>
<td>20%</td>
<td>26%</td>
<td>26%</td>
</tr>
<tr>
<td>cream cheese, low fat</td>
<td>16%</td>
<td>25%</td>
<td>28%</td>
<td>27%</td>
</tr>
<tr>
<td>parmesan</td>
<td>3%</td>
<td>21%</td>
<td>27%</td>
<td>28%</td>
</tr>
<tr>
<td>mozzarella, skim milk</td>
<td>4%</td>
<td>26%</td>
<td>34%</td>
<td>31%</td>
</tr>
<tr>
<td>Swiss</td>
<td>6%</td>
<td>22%</td>
<td>27%</td>
<td>34%</td>
</tr>
<tr>
<td>ricotta, part skim milk</td>
<td>15%</td>
<td>33%</td>
<td>40%</td>
<td>37%</td>
</tr>
<tr>
<td>cream cheese, fat free</td>
<td>29%</td>
<td>62%</td>
<td>75%</td>
<td>72%</td>
</tr>
<tr>
<td>Swiss, low fat</td>
<td>8%</td>
<td>45%</td>
<td>48%</td>
<td>73%</td>
</tr>
<tr>
<td>cottage cheese, low fat</td>
<td>17%</td>
<td>55%</td>
<td>69%</td>
<td>86%</td>
</tr>
<tr>
<td>mozzarella, non-fat</td>
<td>10%</td>
<td>60%</td>
<td>79%</td>
<td>95%</td>
</tr>
</tbody>
</table>

9.10.3.2 Milk

<table>
<thead>
<tr>
<th>milk</th>
<th>carbs only (0%)</th>
<th>FII (56%)</th>
<th>thermic (77%)</th>
<th>% insulinogenic (max)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full cream milk, 3.7% fat</td>
<td>29%</td>
<td>41%</td>
<td>41%</td>
<td>43%</td>
</tr>
<tr>
<td>Human milk</td>
<td>40%</td>
<td>43%</td>
<td>44%</td>
<td>43%</td>
</tr>
<tr>
<td>Skim milk, 1% fat</td>
<td>47%</td>
<td>65%</td>
<td>72%</td>
<td>69%</td>
</tr>
<tr>
<td>Chocolate milk, low fat</td>
<td>63%</td>
<td>72%</td>
<td>76%</td>
<td>70%</td>
</tr>
</tbody>
</table>
### 9.10.3.3 Yogurt

<table>
<thead>
<tr>
<th>Yogurt</th>
<th>Carbs only (0%)</th>
<th>FII (56%)</th>
<th>Thermic (77%)</th>
<th>% Insulinogenic (Max)</th>
</tr>
</thead>
<tbody>
<tr>
<td>plain, whole milk</td>
<td>30%</td>
<td>42%</td>
<td>48%</td>
<td>46%</td>
</tr>
<tr>
<td>Plain, low fat</td>
<td>44%</td>
<td>63%</td>
<td>70%</td>
<td>68%</td>
</tr>
<tr>
<td>Fruit, low fat</td>
<td>71%</td>
<td>81%</td>
<td>85%</td>
<td>83%</td>
</tr>
<tr>
<td>Plain, skim milk</td>
<td>55%</td>
<td>78%</td>
<td>87%</td>
<td>85%</td>
</tr>
<tr>
<td>Fruit, non-fat</td>
<td>70%</td>
<td>90%</td>
<td>97%</td>
<td>96%</td>
</tr>
</tbody>
</table>

### 9.10.4 Fruits

<table>
<thead>
<tr>
<th>Fruit</th>
<th>Carbs only (0%)</th>
<th>FII (56%)</th>
<th>Thermic (77%)</th>
<th>% Insulinogenic (Max)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Olives</td>
<td>1%</td>
<td>3%</td>
<td>4%</td>
<td>4%</td>
</tr>
<tr>
<td>Avocados</td>
<td>4%</td>
<td>8%</td>
<td>9%</td>
<td>7%</td>
</tr>
<tr>
<td>Raspberries</td>
<td>42%</td>
<td>42%</td>
<td>51%</td>
<td>45%</td>
</tr>
<tr>
<td>Blackberries</td>
<td>40%</td>
<td>42%</td>
<td>53%</td>
<td>47%</td>
</tr>
<tr>
<td>Strawberries</td>
<td>70%</td>
<td>75%</td>
<td>76%</td>
<td>69%</td>
</tr>
<tr>
<td>Oranges</td>
<td>77%</td>
<td>81%</td>
<td>83%</td>
<td>76%</td>
</tr>
<tr>
<td>Apples</td>
<td>88%</td>
<td>89%</td>
<td>89%</td>
<td>81%</td>
</tr>
<tr>
<td>Bananas</td>
<td>91%</td>
<td>91%</td>
<td>95%</td>
<td>86%</td>
</tr>
</tbody>
</table>

### 9.10.5 Vegetables

<table>
<thead>
<tr>
<th>Vegetable</th>
<th>Carbs only (0%)</th>
<th>FII (56%)</th>
<th>Thermic (77%)</th>
<th>% Insulinogenic (Max)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Endive</td>
<td>6%</td>
<td>22%</td>
<td>29%</td>
<td>24%</td>
</tr>
<tr>
<td>Dock</td>
<td>5%</td>
<td>27%</td>
<td>33%</td>
<td>27%</td>
</tr>
<tr>
<td>Mustard greens</td>
<td>7%</td>
<td>61%</td>
<td>43%</td>
<td>34%</td>
</tr>
<tr>
<td>Asparagus</td>
<td>36%</td>
<td>60%</td>
<td>69%</td>
<td>34%</td>
</tr>
<tr>
<td>Artichoke</td>
<td>22%</td>
<td>35%</td>
<td>39%</td>
<td>38%</td>
</tr>
<tr>
<td>Sauerkraut</td>
<td>30%</td>
<td>41%</td>
<td>45%</td>
<td>40%</td>
</tr>
<tr>
<td>Broccoli</td>
<td>3%</td>
<td>35%</td>
<td>47%</td>
<td>42%</td>
</tr>
<tr>
<td>Lettuce</td>
<td>28%</td>
<td>44%</td>
<td>50%</td>
<td>42%</td>
</tr>
<tr>
<td>Coriander</td>
<td>15%</td>
<td>36%</td>
<td>44%</td>
<td>43%</td>
</tr>
<tr>
<td>Chrysanthemum leaves</td>
<td>0%</td>
<td>32%</td>
<td>43%</td>
<td>44%</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>3%</td>
<td>42%</td>
<td>57%</td>
<td>47%</td>
</tr>
<tr>
<td>Parsley</td>
<td>34%</td>
<td>52%</td>
<td>59%</td>
<td>48%</td>
</tr>
<tr>
<td>Cauliflower</td>
<td>32%</td>
<td>50%</td>
<td>56%</td>
<td>48%</td>
</tr>
<tr>
<td>Spinach</td>
<td>24%</td>
<td>53%</td>
<td>63%</td>
<td>50%</td>
</tr>
<tr>
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<td>19%</td>
<td>50%</td>
<td>62%</td>
<td>51%</td>
</tr>
<tr>
<td>Mushroom</td>
<td>31%</td>
<td>56%</td>
<td>66%</td>
<td>55%</td>
</tr>
<tr>
<td>Turnip</td>
<td>17%</td>
<td>30%</td>
<td>34%</td>
<td>62%</td>
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<td>Onions</td>
<td>78%</td>
<td>85%</td>
<td>88%</td>
<td>82%</td>
</tr>
</tbody>
</table>

### 9.10.6 Nuts, seeds and legumes

<table>
<thead>
<tr>
<th>Nuts, seeds, legumes</th>
<th>Carbs only (0%)</th>
<th>FII (56%)</th>
<th>Thermic (77%)</th>
<th>% Insulinogenic (Max)</th>
</tr>
</thead>
<tbody>
<tr>
<td>pecans</td>
<td>5%</td>
<td>5%</td>
<td>5%</td>
<td>5%</td>
</tr>
<tr>
<td>Macadamia</td>
<td>5%</td>
<td>5%</td>
<td>6%</td>
<td>6%</td>
</tr>
<tr>
<td>Coconut</td>
<td>6%</td>
<td>6%</td>
<td>7%</td>
<td>7%</td>
</tr>
<tr>
<td>Coconut cream</td>
<td>7%</td>
<td>7%</td>
<td>8%</td>
<td>8%</td>
</tr>
<tr>
<td>Coconut milk</td>
<td>7%</td>
<td>7%</td>
<td>8%</td>
<td>8%</td>
</tr>
<tr>
<td>Brazil nuts</td>
<td>7%</td>
<td>7%</td>
<td>9%</td>
<td>9%</td>
</tr>
<tr>
<td>Flaxseed</td>
<td>8%</td>
<td>8%</td>
<td>11%</td>
<td>11%</td>
</tr>
<tr>
<td>Walnuts</td>
<td>9%</td>
<td>9%</td>
<td>11%</td>
<td>11%</td>
</tr>
<tr>
<td>Pine nuts</td>
<td>9%</td>
<td>9%</td>
<td>11%</td>
<td>11%</td>
</tr>
<tr>
<td>Sesame butter (tahini)</td>
<td>11%</td>
<td>11%</td>
<td>14%</td>
<td>14%</td>
</tr>
<tr>
<td>Sesame seeds</td>
<td>12%</td>
<td>12%</td>
<td>15%</td>
<td>15%</td>
</tr>
<tr>
<td>Chia seeds</td>
<td>13%</td>
<td>13%</td>
<td>16%</td>
<td>16%</td>
</tr>
<tr>
<td>Peanuts</td>
<td>13%</td>
<td>13%</td>
<td>18%</td>
<td>18%</td>
</tr>
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</table>
### 9.10.7 Fish

<table>
<thead>
<tr>
<th>Fish</th>
<th>Carbs only (0%)</th>
<th>FII (56%)</th>
<th>Thermic (77%)</th>
<th>% Insulinogenic (max)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tuna</td>
<td>0%</td>
<td>32%</td>
<td>44%</td>
<td>44%</td>
</tr>
<tr>
<td>Mackerel</td>
<td>0%</td>
<td>33%</td>
<td>46%</td>
<td>25%</td>
</tr>
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<td>Herring</td>
<td>0%</td>
<td>19%</td>
<td>26%</td>
<td>25%</td>
</tr>
<tr>
<td>Salmon</td>
<td>0%</td>
<td>24%</td>
<td>33%</td>
<td>34%</td>
</tr>
<tr>
<td>Sardine</td>
<td>0%</td>
<td>26%</td>
<td>36%</td>
<td>36%</td>
</tr>
<tr>
<td>Anchovy</td>
<td>0%</td>
<td>31%</td>
<td>42%</td>
<td>42%</td>
</tr>
<tr>
<td>Swordfish</td>
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</tr>
<tr>
<td>Trout</td>
<td>0%</td>
<td>31%</td>
<td>44%</td>
<td>43%</td>
</tr>
<tr>
<td>Carp</td>
<td>0%</td>
<td>32%</td>
<td>43%</td>
<td>43%</td>
</tr>
<tr>
<td>Yellowtail</td>
<td>0%</td>
<td>36%</td>
<td>49%</td>
<td>49%</td>
</tr>
<tr>
<td>Bass</td>
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<td>37%</td>
<td>51%</td>
<td>51%</td>
</tr>
<tr>
<td>Mullet</td>
<td>0%</td>
<td>37%</td>
<td>51%</td>
<td>51%</td>
</tr>
<tr>
<td>Squid</td>
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<td>41%</td>
<td>49%</td>
<td>51%</td>
</tr>
<tr>
<td>Abalone</td>
<td>23%</td>
<td>47%</td>
<td>55%</td>
<td>57%</td>
</tr>
<tr>
<td>Monkfish</td>
<td>0%</td>
<td>44%</td>
<td>59%</td>
<td>60%</td>
</tr>
<tr>
<td>Halibut</td>
<td>0%</td>
<td>47%</td>
<td>24%</td>
<td>61%</td>
</tr>
<tr>
<td>Mussel</td>
<td>17%</td>
<td>49%</td>
<td>60%</td>
<td>62%</td>
</tr>
<tr>
<td>Oyster</td>
<td>21%</td>
<td>46%</td>
<td>56%</td>
<td>63%</td>
</tr>
<tr>
<td>Crab</td>
<td>0%</td>
<td>48%</td>
<td>66%</td>
<td>65%</td>
</tr>
<tr>
<td>Shrimp</td>
<td>5%</td>
<td>48%</td>
<td>64%</td>
<td>65%</td>
</tr>
<tr>
<td>Hadock</td>
<td>0%</td>
<td>51%</td>
<td>68%</td>
<td>66%</td>
</tr>
<tr>
<td>Perch</td>
<td>0%</td>
<td>49%</td>
<td>65%</td>
<td>67%</td>
</tr>
<tr>
<td>Clam</td>
<td>14%</td>
<td>56%</td>
<td>67%</td>
<td>71%</td>
</tr>
<tr>
<td>Scallop</td>
<td>19%</td>
<td>59%</td>
<td>76%</td>
<td>80%</td>
</tr>
</tbody>
</table>

### 9.10.8 Meat

<table>
<thead>
<tr>
<th>Meat</th>
<th>Carbs only (0%)</th>
<th>FII (56%)</th>
<th>Thermic (77%)</th>
<th>% Insulinogenic (max)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bologna</td>
<td>6%</td>
<td>12%</td>
<td>17%</td>
<td>14%</td>
</tr>
<tr>
<td>Frankfurter</td>
<td>2%</td>
<td>11%</td>
<td>14%</td>
<td>14%</td>
</tr>
<tr>
<td>Duck</td>
<td>0%</td>
<td>14%</td>
<td>17%</td>
<td>17%</td>
</tr>
<tr>
<td>Chorizo</td>
<td>2%</td>
<td>15%</td>
<td>18%</td>
<td>17%</td>
</tr>
<tr>
<td>Beef, ribeye</td>
<td>0%</td>
<td>15%</td>
<td>26%</td>
<td>21%</td>
</tr>
<tr>
<td>Bacon</td>
<td>1%</td>
<td>15%</td>
<td>21%</td>
<td>21%</td>
</tr>
<tr>
<td>Pork, ham</td>
<td>6%</td>
<td>17%</td>
<td>38%</td>
<td>22%</td>
</tr>
<tr>
<td>Pork, blade, hocks &amp; shoulder</td>
<td>31%</td>
<td>23%</td>
<td>42%</td>
<td>31%</td>
</tr>
<tr>
<td>Turkey</td>
<td>0%</td>
<td>23%</td>
<td>29%</td>
<td>32%</td>
</tr>
<tr>
<td>Lamb mince</td>
<td>0%</td>
<td>24%</td>
<td>27%</td>
<td>34%</td>
</tr>
<tr>
<td>Chicken</td>
<td>0%</td>
<td>24%</td>
<td>34%</td>
<td>34%</td>
</tr>
</tbody>
</table>
10 The Goldilocks glucose zone

10.1 Background

Typically people discuss the ideal macronutrient split between carbohydrates, protein and fat.

In the previous sections we have laid the foundation for the concept that glucose can be obtained from both carbohydrates the glucogenic portion of protein in excess of the body’s requirement for growth and maintenance.

This section endeavours to take the discussion further to look at how we can optimise the split between glucose and fat.

10.2 The Goldilocks glucose zone

This article outlines a basis to inform the debate on the optimum balance between what are often polar extremes.

On the high glucose end of the argument we are faced with the following issues:

- high insulin levels (hyperinsulinemia),
- obesity and excess fat accumulation,
- high blood glucose levels (glucotoxicity),
- heart diseases risk, and
- the plethora of issues that accompany metabolic syndrome.

At the ketogenic extreme we have concerns about a range of issues including:

- inadequate fuel for the brain,
- limited food options,
- a possible lack of vitamins and minerals,
- low fibre and prebiotics for gut health,
- stunted growth,
- impaired athletic performance, and
- high cholesterol levels.\(^{121}\)

Somewhere in the middle there must be an optimal balance of fuel for each individual.

But how do we find this balance point? Then what do we monitor to ensure we stay there?

Not too hot. Not too cold.

Not too hard. Not too soft.

The “Goldilocks glucose zone”.

---

10.3 Safe starches debate

The ‘safe starches debate’ has been intriguing and informed my thinking on this controversial issue. The discussion started at the 2012 Ancestral Health Symposium with a panel hosted by Jimmy Moore. It continued on the blogs of the two lead representatives of each side of the argument, Paul Jaminet and Ron Rosedale.

10.4 Ron Rosedale... the case for limiting carbohydrates

I like Ron Rosedale, but I find his argument long winded, prone to hyperbole, and lacking definite parameters and actionable guidelines. I wish he would use simple dot points to frame his argument so people could grasp it without being overwhelmed by a wall of words.

So here goes my attempt to express the essence of Rosedale's argument.

Non-fibre carbohydrates are:

- detrimental as they lead to increased insulin levels, oxidation and accelerated aging, and
- unnecessary as we can obtain our glucose needs via gluconeogenesis from protein.

Glucose can be manufactured from glycerol or from lactate and pyruvate recycling. In some respects this is even better than making glucose from protein.

10.5 Paul Jaminet... the body's natural glucose utilisation

Paul Jaminet argues that the human body runs on a fuel mix of about 30 to 35% of calories from carbohydrates (say 600 calories per day). The remaining 70% or so of our fuel comes from fat.

Jaminet recommends that people follow a ‘low carb’ diet. Jaminet’s version of a low carb diet is a daily carbohydrate intake somewhere less than the body’s 30% requirement for glucose. This forces some proportion of the glucose needs to come from gluconeogenesis. Figure 34 from The Perfect Health Diet represents this concept graphically.

Jaminet says that for most people running at carbohydrate levels significantly less than this is unnecessary as converting protein to glucose is a more energy-intensive process than obtaining glucose from carbohydrates (though he does recommend ketogenic diets for specific situations).

122 https://www.youtube.com/watch?v=XyvlWUQAkxM
125 http://drrosedale.com/blog/2012/08/18/a-conclusion-to-the-safe-starch-debate-by-answering-four-questions/#ixzz3aDeqQijQ
Figure 34 Jaminet’s glucose utilisation
10.6 A bit of perspective

When you look at this in the context of the fact that the typical western diet has 40 to 50% of calories coming from carbohydrates, we are really arguing over whether a low carb diet or a very low carb diet is best for the metabolic health of the general population.

Jaminet’s glucose flux has a lot of similarities with Mark Sisson’s Primal Blueprint Carbohydrate Curve. Jaminet’s 600 calories equates to 150g of carbohydrates which aligns with the top end of Sisson’s ‘effortless weight maintenance zone’.

![Figure 35 Mark Sisson's Primal Blueprint carbohydrate curve](image)

But what if limiting carbohydrates to less than 150g per day is not working for you (e.g. your blood sugars are not in normal range or you are not achieving weight loss)?

What can we learn from the food insulin index data to help us build on traditional carbohydrate counting? How can we determine the optimum fuel mix for our individual situation and goals?

10.7 Minimum carbohydrate requirement

One of the concerns about low carbohydrate diets centres on the understanding that the brain needs carbohydrates.

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This seems to stem from Institute of Medicine’s advice that the brain needs about 400 calories per day from glucose. This equates to 100g of carbs which most people wind up to 130g to provide a safety factor.

The IOM however notes that a person who is fat adapted can run on lower amounts of carbohydrates as their brain is fuelled by ketones and there is no minimum requirement for carbohydrates, only glucose which can also be obtained by gluconeogenesis from protein.\textsuperscript{130} 131

In spite of this, nutritionists still recommend a minimum carbohydrate intake.

Jaminet makes a similar differentiation that a typical sedentary person requires about 600 calories for glucose per day, however this may decrease to 300 calories per day for someone on a ketogenic diet.

The understanding of the absolute minimum glucose requirement comes from research by George Cahill who undertook extreme starvation experiments and found that people could survive on as little as 40g of carbohydrates per day (i.e. 160 calories).\textsuperscript{132}

As shown in Figure 36 In the fed state the body will rely on glucose from ingested carbohydrates. After a period of fasting it transitions to using glucose form the glycogen stores in the liver and muscles. Once the glycogen stores are exhausted the body will obtain glucose via gluconeogenesis from cannibalising muscle.

\textsuperscript{130} \url{http://lcreview.org/main/130g-carbsday-rda/}
\textsuperscript{131} See also discussion in Chapter 7 of Richard Feinman’s “The World Turned Upside Down: The Second Low-Carbohydrate Revolution”.
\textsuperscript{132} \url{http://www.med.upenn.edu/timm/documents/ReviewArticleTIMM2008-9Lazar-1.pdf}
Figure 36 Fuel sources in different stages of starvation

At this point however the brain and the rest of the body have largely transitioned to being fuelled by fat so it only needs to obtain 40g of glucose per day from protein via gluconeogenesis (note: glucose not carbohydrate). This would equate to around 5% of calories from glucose.

I am not suggesting that starvation ketosis is optimal for most people. The point is that the body can survive on very little glucose if it needs to for quite a long time.

The longevity crowd will tell you that this is an evolutionary advantage so you can prolong life until a time when there is enough nutrition to reproduce and thrive. People who could use their fat and muscle for fuel survived to be your ancestors, and those that couldn’t, didn’t.\textsuperscript{133}

10.8 What is the minimum protein requirement?

According to Nuttall and Gannon\textsuperscript{134} the body requires between 32 and 46g of high quality dietary protein to maintain protein balance.

This equates to around 6 to 7% of calories in a 2000 to 2500 calorie diet being taken “off the top” for growth and maintenance, with everything else potentially available as excess that could potentially be used for gluconeogenesis.

\textsuperscript{133} https://en.wikipedia.org/wiki/Calorie_restriction
\textsuperscript{134} http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3636610/
The same paper notes that the American diet typically consists of between 65 and 100g of protein per day (i.e. 13 to 16% of calories).

10.9 Are there three macros or two fuel sources?

Something that I had not understood until recently was that protein is made up of glucogenic and ketogenic amino acids. Some amino acids can turn into either glucose or fat.\(^\text{135} \text{ 136}\) This has been discussed in detail in section 9, however in essence, what this means is that there are really only two fuel sources for the body, glucose and fat, with “excess” protein being turned into one or the other.

10.10 The “well formulated ketogenic diet”

Steve Phinney is probably the most well respected authority on the ketogenic diet. This figure shows a comparison of what Phinney calls the “well formulated ketogenic diet” (WFKD) as a triangle with a number of possible dietary approaches.\(^\text{137}\)

![Phinney's WFKD triangle](https://youtu.be/8NvFyGGXYiI?list=PLrVWtWmYRR2B1AsGG9tr6T-B4xSum8SCc&t=1234)

**Figure 37 Phinney’s WFKD triangle**

A WKFD can contain 30% protein and 5% carbs or 20% carbs and 10% protein. A WKFD however cannot however contain 30% protein and 20% carbs because we would get too much glucose which would increase insulin and suppress ketosis.

As shown in the WFKD figure above the protein content of a ketogenic diet can range between 0.8 and 2.4g/kg lean body mass. However if we are running higher levels of protein we will only achieve ketosis if we also limit carbohydrates.

Interestingly, the slope of the line along the face of the WKFD triangle corresponds with the assumption that 7% of protein goes off to muscle growth and repair with 75% of the remaining ‘excess’ protein being glucogenic. This also aligns nicely with the observations from the food insulin index data and the theoretical proportion of glucogenic amino acids in protein.

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\(^{136}\) [https://www.dropbox.com/s/4dkl03mz2fci71v/The%20metabolism%20of%20%E2%80%9Csurplus%E2%80%9D%20amino%20acids.pdf?dl=0](https://www.dropbox.com/s/4dkl03mz2fci71v/The%20metabolism%20of%20%E2%80%9Csurplus%E2%80%9D%20amino%20acids.pdf?dl=0)

\(^{137}\) [https://youtu.be/8NvFyGGXYiI?list=PLrVWtWmYRR2B1AsGG9tr6T-B4xSum8SCc&t=1234](https://youtu.be/8NvFyGGXYiI?list=PLrVWtWmYRR2B1AsGG9tr6T-B4xSum8SCc&t=1234)
10.11 The Goldilocks glucose zone

Table 29 shows the various levels of glucose requirement in terms of calories discussed above along with the equivalent carbohydrates and the percent of glucogenic calories in a 2250 calorie diet.

Table 29 Comparison of different degrees of ketosis with glucogenic calories, glucose load and % insulinogenic calories

<table>
<thead>
<tr>
<th>approach</th>
<th>glucogenic calories</th>
<th>glucose load (g)</th>
<th>Insulinogenic (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>glucose utilisation (Jaminet)</td>
<td>600</td>
<td>150</td>
<td>26.7%</td>
</tr>
<tr>
<td>ketogenic threshold (Phinney)</td>
<td>500</td>
<td>125</td>
<td>22.2%</td>
</tr>
<tr>
<td>ketogenic maintenance (Jaminet)</td>
<td>300</td>
<td>75</td>
<td>13.3%</td>
</tr>
<tr>
<td>starvation (Chaill)</td>
<td>160</td>
<td>40</td>
<td>7.1%</td>
</tr>
</tbody>
</table>

- The **glucose utilisation** is Jaminet’s approximation of the glucose calories used by a non-ketogenic person each day. If we run above this level our glycogen stores will become overfull, with excess glucose spilling into the blood, requiring insulin and being stored as fat. Below this level we need to obtain some of our glucose from protein via gluconeogenesis.

- The **ketogenic threshold** represents the theoretical boundary between the WFKD and the rest of the world according to Phinney’s protein vs carbohydrates plot. Below this point our glycogen stores will become depleted to a point that we be forced to rely on our protein and fat stores for energy rather than carbohydrate. After a period of consuming less carbs than required to keep our glycogen stores topped off we will start to show ketones in our blood and rely on ketones and fat more than glucose. This level is about 500 calories per day which is about 22% of a 2250 calorie per day diet.

- The **ketogenic maintenance** level is based on the 300 calories per day that Jaminet says we need from glucose if we are fat adapted. With a greater proportion of energy coming from fat in the form of ketones we require less glucose for brain function.

- The **starvation** level represents what people can survive on as an absolute minimum. In this extreme starvation state the body is cannibalising muscle via gluconeogenesis to convert to glucose to survive. This is not something I recommend you try at home. However it is useful to know that the body can survive (but not necessarily thrive) at very low levels of glucose for a significant period of time.

The chart below shows these glucose levels superimposed on a plot of protein versus carbohydrate. The points on the left hand side of the chart labelled with calorie values represent the point at which all glucogenic calories come from carbohydrates with only the minimum 7% protein for maintenance ingested (i.e. no “excess” protein).
As we move to the right we have increasing levels of protein and decreasing levels of carbohydrates to maintain the same total number of glucogenic calories (assuming that 75% of “excess” protein converts to glucose).

The only thing we can be certain of here is that the concepts shown graphically in this figure will not be accurate due to the fact that it is built on a number of layers of theory along with the fact that everyone’s body is different. However this chart gives us a conceptual framework with which to manipulate our diet to achieve our goals.

The take home message here is that, if we are trying to reduce the glucose load of our diet to the point at which our own pancreas can keep up, we need to think, not just in terms of carbohydrates or net carbohydrate, but in terms of total glucose (or insulin load) from carbohydrates plus excess protein.

I don’t think our bodies mind whether it gets glucose from carbohydrates or protein. My view is that it is better to maximise vitamins (generally from carbohydrate containing foods) and amino acids (from protein containing foods) while at the same time keeping our glucose load within our own pancreas’ ability to keep our blood sugars at normal levels.

The essence of the system that I am trying to design is a way to quantify and hence optimise the sometimes competing parameters (i.e. glucose load, nutrients and protein) in order to achieve excellent nutrition while reducing the various risks of excess insulin and blood sugar.

10.12 What about the Kitavans?

When faced with the hormonal theory of obesity many people are quick to point to hunter gatherer populations such as the Kitavans that do quite well on high levels of carbohydrates.

Some people seem to tolerate high levels of carbohydrate form whole food sources. Perhaps they are metabolically flexible such that they can store carbohydrates as fat and quickly use them again,

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138 Though it does take more energy to convert protein to glucose, hence a calorie is not a calories when it comes to protein being converted to glucose via gluconeogenesis.
or they are very active and hence using up their glycogen stores regularly, and are very insulin sensitive and adapted to handle significantly more than 600 carbohydrate calories per day from whole food sources.

It may also be that people eating predominantly unprocessed high fibre foods are less likely to be in a caloric excess meaning that they do not have a lot of left over calories to store as fat or to require excess insulin.

Whatever the case, Dr Jason Fung also points out the Kitavans still have low insulin levels. It would make sense that if you do have issues of elevated blood sugar and insulin resistance that reducing your insulin load would be the first approach to managing the inputs that drive elevated blood glucose, hyperinsulinemia and the consequential insulin resistance.

If you are highly active with great insulin sensitivity and you can consume high levels of carbohydrates while maintaining normal blood glucose and staying lean then good luck to you. I’m jealous. Enjoy, at least while it lasts!

It is worth noting that a number of the champions of the low carbohydrate movement such as Tim Noakes, Ben Greenfield and Sami Inkenen found that they had or were becoming diabetic after decades of extreme exercise on a high carbohydrate diet, hence the transition to a low carbohydrate approach to manage their blood sugars. Even if you’re a lean athlete periodically keeping an eye on blood sugars and modulating the diet to achieve optimal blood sugars by managing the glucose load is a prudent approach.

10.13 Comparison against different dietary approaches

To help make more sense of this concept I have shown a number of dietary approaches from the article Diet Wars… Which One is Optimal? on the protein vs carbohydrate in Figure 39 with the following observations on the various approaches:

- Bernstein’s approach is designed to be high protein, low carb, to provide diabetics with their glucose needs from protein which releases glucose more slowly than carbohydrate.

- This version of the Atkins diet is unlikely to be ketogenic due to the high levels of protein. Reducing carbohydrates and/or protein is likely to be necessary to achieve ketosis, and possibly the weight loss that is typically the aim of the Atkins diet.

- The Zone and Mediterranean diets, though generally thought to be moderate carbohydrate dietary approaches, are still well above Jaminet’s glucose utilisation threshold.

- Terry Whals’ Paleo Plus approach achieves a good balance between maximising nutrition through the use of high fibre vegetables and MCT oil without excess protein.

- The 80% fat diet approach is below the ketogenic maintenance level of 300 glucogenic calories per day but still above starvation ketosis. Personally I think it would be hard for most people to get optimal levels of vitamins, minerals, fibre and possibly protein at these levels without supplementation or focussing on nutrient dense organ meats. However it

139 [https://www.youtube.com/watch?v=4oZ4UqtbB_g](https://www.youtube.com/watch?v=4oZ4UqtbB_g)
141 [http://thenoakesfoundation.org](http://thenoakesfoundation.org)
142 [http://www.bengreenfieldfitness.com/2013/05/low-carb-triathlon-training/](http://www.bengreenfieldfitness.com/2013/05/low-carb-triathlon-training/)
may be desirable for someone using ketosis therapeutically for something like cancer or epilepsy.

![Diagram of protein versus carbohydrates with levels of ketosis and various dietary approaches.](image)

**Figure 39  Protein versus carbohydrates with levels of ketosis and various dietary approaches**

The figure below shows that between 1970 and 2000 carbohydrate intake increased from around 42% to around 49% for men while protein intake has largely stayed constant. During this period obesity increased from 14.5% to 30.9%.

![Graph showing change in macronutrient intake over time.](image)

**Figure 40  Change in macronutrient intake over time**

It’s fair to say that macronutrient composition is only part of the story, but perhaps if we moved the carbohydrate intake back towards the ketogenic corner (along with a shift to more whole unprocessed foods) this trend would turn around?

10.14 What is our light on the horizon to steer our boat towards?

So how do you decide what dietary approach is optimal for each individual? What is right for you? What is the lighthouse on the horizon that you can guide your boat of metabolic health towards?

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144 [http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5304a3.htm](http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5304a3.htm)
In section 5.2 we reviewed a number of risk factors that appear to be related to blood sugar control such as the heart disease risks shown in Figure 41. Ideally everyone should be striving for optimal blood sugar control in order to manage their overall health and reduce a plethora of risks.

![Figure 41 HbA1c versus incidence of cardiovascular disease, heart disease and stroke](image)

Building risk data I have identified the relationship between HbA1c, average blood sugar and ketone values for different heart disease risk categories.

<table>
<thead>
<tr>
<th>risk level</th>
<th>HbA1c (mmol/L)</th>
<th>average blood sugar (mg/dL)</th>
<th>ketones (mmol/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>low normal</td>
<td>4.1</td>
<td>3.9</td>
<td>70</td>
</tr>
<tr>
<td>optimal</td>
<td>4.5</td>
<td>4.6</td>
<td>83</td>
</tr>
<tr>
<td>excellent</td>
<td>&lt; 5.0</td>
<td>&lt; 5.4</td>
<td>&lt; 97</td>
</tr>
<tr>
<td>good</td>
<td>&lt; 5.4</td>
<td>&lt; 6</td>
<td>&lt; 108</td>
</tr>
<tr>
<td>danger</td>
<td>&gt; 6.5</td>
<td>7.8</td>
<td>&gt; 140</td>
</tr>
</tbody>
</table>

The point where you achieve excellent blood sugar control (i.e. average blood glucose less than 5.4mmol/L) is about where most people will start to show low levels of ketones in their blood. This is likely to be somewhere around Phinney’s ketogenic threshold (orange line in Figure 38 and Figure 39).

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145 http://www.cardiab.com/content/pdf/1475-2840-12-164.pdf
146 http://professional.diabetes.org/glucosecalculator.aspx
People with more severe issues such as very high insulin resistance, epilepsy, morbid obesity or cancer may choose to push deeper into ketosis beyond the point of simply achieving normal blood sugars and normal HbA1c. This may require more discipline, intentional supplementation and limitation of food selection than most people are willing to invest.

10.15 What gauges do we use to steer the boat?
The most successful diets are the ones that people can stick to.

To this end I have developed a list of optimal foods that prioritises low insulin load, high fibre, nutrient dense foods based on your personal goals (e.g. weight loss, blood sugar control, nutritional ketosis, athletic performance or therapeutic ketosis). I have also developed this database of optimal meals that will enable you to choose simple everyday meals that provide high levels of nutrition while achieving a low insulin load.

If you have diabetes or insulin resistance then I recommend that you track your blood sugars and ‘eat to your meter’. You will quickly learn what meals raise your blood sugars and hence what to avoid.

With the understanding that non-fibre carbohydrates plus excess protein raise blood sugar and require insulin you (as shown again in Figure 42) can work to manage your diet until you achieve the desired blood sugar levels.

Figure 42  Net carbohydrates + 0.56 x protein versus glucose score
Many people benefit from journaling or tracking food intake on an app such as MyFitnessPal or Cronometre. Rather than looking at calories or carbohydrates I encourage you to consider the total glucose load of your diet from carbohydrates plus excess protein.

As shown in Table 29, you will likely need to get below an insulin load of 150g per day to be under the blue line and under 125g per day to be within Phinney’s WFKD triangle.

147 http://www.diabetes.co.uk/blood-glucose/eat-to-your-meter.html
While I don’t think it is healthy, natural or normal to consciously monitor everything you eat for extended periods, many people find it useful for a period of time to retrain their habits or to help guide them toward a short term goal.

10.16 Some worked examples

10.16.1 Phinney’s four phases of a WFKD

Let’s look at how this might look in practice. Figure 16 shows Phinney’s four phases of a ketogenic diet showing how someone might initially restrict their dietary carbohydrates and protein with a large amount of calories coming from body fat being burned due to low insulin levels.

Table 31 shows the glucose load calculations for each of these scenarios numerically. It’s important to note that Phinney’s percentages are based on calories expended not calories ingested. Assuming that protein requires 56% as much insulin as carbohydrate I have also calculated the glucose load for each scenario. All of these are below the ketogenic threshold of 125g glucose (Phinney) and above the ketogenic maintenance level (Jaminet) as shown in Figure 43.

<table>
<thead>
<tr>
<th>phase</th>
<th>calories expended</th>
<th>carbs %</th>
<th>protein %</th>
<th>carbs (g)</th>
<th>protein (g)</th>
<th>glucose load (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>adapt</td>
<td>2800</td>
<td>5</td>
<td>20</td>
<td>35</td>
<td>35</td>
<td>55</td>
</tr>
<tr>
<td>adjust</td>
<td>2600</td>
<td>7</td>
<td>20</td>
<td>46</td>
<td>46</td>
<td>71</td>
</tr>
<tr>
<td>build</td>
<td>2400</td>
<td>9</td>
<td>20</td>
<td>54</td>
<td>54</td>
<td>84</td>
</tr>
<tr>
<td>maintain</td>
<td>2200</td>
<td>10</td>
<td>20</td>
<td>55</td>
<td>55</td>
<td>86</td>
</tr>
</tbody>
</table>

Figure 43 Phinney’s four stages of a ketogenic diet

10.16.2 Deshanta

I also calculated the insulin load, % insulinogenic calories as well as the % carbs and % protein for Deshanta from the Optimising Nutrition Facebook group who provided her MyFitnessPal food diary which is summarised in Table 32. A number of these points are outside the WFKD triangle as shown
graphically in Error! Reference source not found.. Denshanta has some long term insulin resistance issues and might benefit from reducing protein and carbohydrates in order to make her diet more ketogenic until normal blood sugars are achieved.

**Table 32 Worked example – Denshanta**

<table>
<thead>
<tr>
<th></th>
<th>carb (g)</th>
<th>fat (g)</th>
<th>protein (g)</th>
<th>fibre (g)</th>
<th>insulin load (g)</th>
<th>% insulinogenic</th>
<th>% carb</th>
<th>% pro</th>
</tr>
</thead>
<tbody>
<tr>
<td>143</td>
<td>92</td>
<td>113</td>
<td>42</td>
<td>164</td>
<td>39%</td>
<td>24%</td>
<td>27%</td>
<td></td>
</tr>
<tr>
<td>99</td>
<td>99</td>
<td>125</td>
<td>41</td>
<td>128</td>
<td>32%</td>
<td>14%</td>
<td>31%</td>
<td></td>
</tr>
<tr>
<td>129</td>
<td>102</td>
<td>134</td>
<td>40</td>
<td>164</td>
<td>36%</td>
<td>20%</td>
<td>30%</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>81</td>
<td>125</td>
<td>17</td>
<td>103</td>
<td>30%</td>
<td>10%</td>
<td>37%</td>
<td></td>
</tr>
<tr>
<td>86</td>
<td>88</td>
<td>125</td>
<td>19</td>
<td>137</td>
<td>35%</td>
<td>17%</td>
<td>32%</td>
<td></td>
</tr>
</tbody>
</table>

![Figure 44 Example – Denshanta](image)

**Figure 44 Example – Denshanta**

10.16.3 Sandy

Another example is Sandy who has used the ketogenic diet approach to stabilise her blood sugar levels over a number of years. Table 33 shows my analysis of a number of food diaries and Figure 45 shows how these daily diaries sit against the various ketogenic diet lines. All of Sandy’s food diary results are sitting between the starvation level (Cahill) and the ketogenic maintenance level (Cahill).

The second last row of the table and the highest point on the chart shows my attempt to increase the nutrient density of the diet with some spinach and mushrooms which she said she didn’t like and would raise her blood sugars.

The last line of the table is a revised approach with the addition of an egg. This both increased the nutrient density of the dietary approach while not increasing the carbohydrates beyond 5%.
Some people are able to achieve normal blood sugars through reducing the insulin load of their diet and disciplined intermittent fasting to improve insulin sensitivity. Some people however may not be able to achieve excellent blood sugar levels without some added insulin of the pancreas is not able to produce enough.

I understand that Dr Bernstein finds that, in spite of using a reduced carbohydrate approach, that the majority of his type 2 patients still need some insulin to achieve optimal blood sugars. Regardless of whether insulin is required it would be ideal to reduce the glucose load of the diet to reduce the quantity of insulin required.

Another thing to keep in mind is that maintaining excellent blood glucose levels are important it is also critical to ensure that you get adequate nutrition, both in terms of vitamins (often from carbohydrate based foods) as well as amino acids (typically from protein based foods). A future article I will be looking at how we can balance these sometimes competing demands to optimise nutrition.
10.17 Summary

- The body requires somewhere between 160 and 600 calories per day from glucose.
- This glucose can be sourced both from ingested carbohydrates as well as the glucogenic portion of protein not used for growth and repair.
- Rather than raising blood glucose immediately, amino acids from protein circulate in the blood until they are required.
- Excessive blood glucose will lead to increased insulin requirement, insulin resistance, diabetes, obesity and a range of other issues associated with hyperinsulinemia and metabolic syndrome.
- Someone who is insulin resistant and/or has diminished pancreatic function does not produce adequate insulin. Rather than using diabetes medications or exogenous insulin as the primary option a better option is to decrease one’s dietary glucose load (i.e. from carbohydrates and protein) to a point that the body’s natural insulin production can keep up.

10.18 Recommendation

If we want to reduce the insulin load of our diet we should do the following, in order of priority:

- Increase fibre from non-starchy vegetables (e.g. spinach, mushrooms, peppers, broccoli etc). These will provide vitamins and minerals as well as indigestible fibre that will feed the gut which will also improve insulin resistance. Increasing fibre in our diet will increase the bulk and the weight of our food without increasing calories or insulin and will tend to decrease our cravings for processed carbohydrates.
- Reduce carbohydrates, particularly ones that come in packages with a bar code.
- If you are not getting the desired results, look to reduce your protein intake until you are achieving excellent blood sugar control and/or your target HbA1c.
- If you are still not getting the results you want then look at some form of intermittent fasting to improve your insulin sensitivity and to kick-start ketosis.

Once you are achieving normal blood sugars you may want to occasionally test your blood ketones to confirm you have achieved nutritional ketosis; however tracking your blood sugars will generally be adequate for most people.

Once you have achieved your desired level of blood sugars, weight and metabolic health you can drop back to monitoring less frequently, just to make sure you are not regressing and then ramp up the efforts again if required.

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148 [http://www.amazon.com/Brain-Maker-Power-Microbes-Protect-ebook/dp/B00MEMMS9I](http://www.amazon.com/Brain-Maker-Power-Microbes-Protect-ebook/dp/B00MEMMS9I)
150 [https://intensivedietarymanagement.com/tag/fasting/](https://intensivedietarymanagement.com/tag/fasting/)
11 Why we get fat and what to do about it v2

11.1 Background

Gary Taubes\textsuperscript{151} has moved the needle in terms of the wider acceptance of the hormonal theory of obesity with his books \textit{Good Calories Bad Calories} and \textit{Why We Get Fat and What to Do about It}.

The hormonal theory of obesity revolves around the idea that the food we eat affects our insulin levels which in turn governs how much fat is stored or used for fuel.\textsuperscript{152, 153}

\begin{figure}
\centering
\includegraphics[width=\textwidth]{BMI_versus_insulin_secretion.png}
\caption{BMI versus insulin secretion over time}
\end{figure}

With his focus primarily on carbohydrate, Taubes hasn’t tackled the fact that protein also requires insulin. He says “the assumption has always been that the effect of protein has is small compared to that of carbohydrates, and that it is muted because protein takes considerably longer to digest.”\textsuperscript{154}

This may be true to some extent, but could a better understanding of the insulinogenic effects of other thing such as protein and fibre help us further refine the our understanding of obesity and our ability to improve blood glucose control, particularly for those who do not achieve their goals by simply reducing carbohydrates?

Recently people like Jimmy Moore\textsuperscript{155} and Steve Phinney\textsuperscript{156} have brought increased attention to the ketogenic diet which takes the low carbohydrate dietary approach to the next level. One of the learnings from people measuring blood ketones and trying to achieve nutritional ketosis is that, in addition to limiting carbohydrates, you also need to moderate protein in order to show meaningful blood ketone levels. Too much protein raises insulin and reduces fat burning.

\begin{flushleft}
\textsuperscript{151} \url{http://garytaubes.com/}
\textsuperscript{152} \url{https://intensivedietarymanagement.com/tag/hormonal-obesity-theory/}
\textsuperscript{153} \url{http://www.ncbi.nlm.nih.gov/pmc/articles/PMC329588/pdf/jcinvest00481-0161.pdf}
\textsuperscript{154} \url{http://www.healthcentral.com/diabetes/c/36758/20088/gary-round-3/}
\textsuperscript{155} \url{http://www.amazon.com/Keto-Clarity-Definitive-Benefits-Low-Carb/dp/1628600071}
\textsuperscript{156} \url{http://www.artandscienceoflowcarb.com/}
\end{flushleft}
So what does the food insulin index data\(^{157}\) tell us that would help us to ‘push the rock up the hill a bit further up the hill’ (to use a Gary Taubes analogy\(^{158}\))? 

11.2 Do calories count?

The antagonists to the hormonal theory of obesity point to studies that show that if you put people in a metabolic ward and feed them a set number of calories and make them exercise the same amount they will lose or gain the roughly same amount of weight regardless of the macronutrient composition of the diet\(^{159}\).

This may be largely true, other than some exceptions as discussed below. However in the real world most people eat when we are hungry and stop when full. Most people don’t count every morsel that goes into their mouth.

It shouldn’t be necessary to consciously control our appetite. As people in the Paleo community point out, somehow we seemed to do pretty well regulating our own appetite before recent times. Something seems to have changed as shown by the increase in obesity rates shown in Figure 47.\(^{160}\)

![Figure 47: Change in obesity rates over time](image)

**Figure 47: Change in obesity rates over time**

Most low carbohydrate diet studies allow the low carbohydrate group to eat to satiety while the low fat group has to count calories so they don’t exceed their target intake. Even under these conditions though the low carb typically usually wins out when it comes to weight loss as demonstrated by the results of Chris Gardner’s’ A to Z study shown in Figure 48.\(^{161,162}\)

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\(^{157}\) [http://ses.library.usyd.edu.au/handle/2123/11945](http://ses.library.usyd.edu.au/handle/2123/11945)


\(^{159}\) [https://www.youtube.com/watch?v=aRCv5RWXWx8](https://www.youtube.com/watch?v=aRCv5RWXWx8)


Isn’t finding a way of eating that will make us satisfied with less calories the dietary Holy Grail? When a ‘diet’ becomes enjoyable and self-regulating it is no longer a ‘diet’, it’s just a way of eating!

So what is it about higher fat dietary approaches that leaves people naturally satisfied on fewer calories?

11.3 What does insulin do?

The hormone insulin is a tangible reality in our family. We have vials of it sitting in the fridge! My wife has had type 1 diabetes for nearly three decades and wears a pump to deliver insulin through the day with extra doses at meals. Helping her to refine her insulin doses has become a common pastime for me, especially through our two pregnancies to try to give our kids the best chance of success.

Diabetics are a useful example when it comes to understanding insulin.

Type 1 diabetics, before they start insulin, are typically wasting away because their pancreas has stopped making enough insulin. Extremely low levels of insulin causes them to turn to their body fat and muscle for fuel to a point the waste away.

At the other extreme many diabetics find that they gain weight quickly when they start injecting insulin. Insulin in an anabolic hormone that regulates how we grow muscle and store fat.

After commencing insulin therapy the diabetic regains weight. The picture below shows “JL” one of the first type 1 diabetics to receive insulin in 1922. The photo on the left is after diagnosis but before insulin. The photo on the right is the same child two months after starting insulin injections.

Figure 48 Change in weight for different dietary approaches
Check out this post to see photos of my kids when they were born after spending nine months in a high insulin environment. It’s hard to argue that they were big because they should have eaten less and exercised more in utero!

If we are consuming relatively insulinogenic meals a little bit extra gets stored away each time we eat. This extra bit of food doesn’t help us feel full or provide us with more energy, it just gets stored as fat and we just have to eat more at the next meal. If we also try to restrict calories to lose weight we feel sluggish and have low energy and our metabolism down regulates to compensate!

The chart below from Richard Feinman’s *The World Turned Upside Down* illustrates the process of cumulative fat storage in a high insulin environment.

**Figure 49 Change in body fat before and after insulin therapy in type 1 diabetes**

**Figure 50 Accumulation of body fat due to excess insulin**

The goal here is to manipulate our insulin levels so that our fat mass is trending down or at least remains flat.
The Atkins approach recommends the reduction of carbohydrates to less than 20g per day during the two week ‘induction phase’ and then allows you to wind your carbohydrate back up slowly to the point that you stop losing weight.\textsuperscript{163}

With the Atkins approach however there is no consideration of the insulinogenic defect of protein, with unlimited fat and protein allowed as long as you are limiting carbohydrates. The problem is if you just increase protein and still fear fat you may not get the reduction in insulin required to allow your body to access fat for fuel.

Richard Feinman uses the analogy that insulin is like a tap that control fat storage. Without high levels of insulin we can’t store as much fat and thus we have more calories available therefore don’t need to eat as much.

Conversely, if we eat meals that generate less insulin we will be more likely to be able to access our body fat stores for fuel (i.e. ketosis). This net flow of energy \textit{from} (rather than into) our fat cells leaves us a little less hungry at each meal (because we are getting calories from our fat stores) and hence we are likely to eat less at the next meal without consciously trying.

If everything goes to plan obese people often find that they feel less compulsion to overeat on a higher fat diet until they reach a more ideal level of body fat.

\textbf{11.4 Meal timing}

In the past, the nutritional community has looked to the ‘healthy’ body building community as the model to follow. Bodybuilders often eat five or six meals a day to make sure they gain muscle and ‘keep their metabolism high’.

Food manufacturers have been only too willing to design foods for every occasion, with a burgeoning protein and supplement industry.

The problem is, unless you’re a body builder aiming for ‘mad gainz’, working out intensely, meticulously planning your meals and tracking every calorie, increased meal frequency may not be the right approach for you.

The plot below demonstrates how obese people generally have elevated insulin levels throughout the day. By contrast lean people tend to have more punctuated bursts of insulin with periods of lower circulating insulin when the body can access stored body fat for fuel.

\textsuperscript{163} \url{http://www.atkins.com/how-it-works/atkins-20/phase-1}
Like me with my caffeine addition, constant use of anything will lead to tolerance and insensitivity. Many people find they become insulin resistant due to a diet of quick digesting processed carbohydrate-based foods.

One option that has become more popular in recent times is intermittent fasting. Going for a period without food enables your body to decrease insulin levels and allows the body to access body fat for fuel. The increased use of body fat for fuel during the fasting period typically allows the total food intake across the day to be reduced.

Some people who have tried low carbohydrate diets with limited success find that intermittent fasting is what allows them to achieve the improved blood glucose and/or weight loss they’re after. I know for me it seemed to be intermittent fasting that helped me to improve my blood sugars, raise ketone levels and kick-start fat loss that I’d been striving for but not achieving even with a low carb Paleo type diet.

11.5 When a calorie is not a calorie

You may be aware that gluconeogenesis is the process where your body can produce glucose from protein. I only realised recently that protein is made up of glucogenic amino acids (approximately 78%), ketogenic amino acids (approximately 12%) and amino acids that can be either glucogenic or ketogenic (approx. 14%).

Digestion breaks protein down into amino acids which circulate in our bloodstream until they are required for muscle growth and repair (i.e. protein synthesis) or to balance blood sugars (i.e. via gluconeogenesis).

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164 My 23andMe genetic testing tells me that I am likely to be able to metabolise caffeine quickly however I am prone to type 2 diabetes and obesity!
165 https://intensivedietarymanagement.com/category/fasting/
166 http://www.eatstopeat.com/
167 http://thefastdiet.co.uk/
168 http://en.wikipedia.org/wiki/Glucogenic_amino_acid
When we don’t eat protein or carbohydrate for a long period the body can obtain glucose from our muscles via gluconeogenesis. This is how we can survive long periods of starvation and still supply adequate glucose to the brain.

“...in fasting and on a low carbohydrate diet as much of the amino acid carbon as possible will be used for gluconeogenesis.”¹⁶⁹ For someone on a low carbohydrate diet this means that nearly 90% of protein not used for muscle growth and repair can be converted to glucose!

The fact protein can turn to glucose just like carbohydrate at first sounds absurd, then scary. However its possible use the glucogenic properties of protein as a ‘hack’ to help you achieve weight loss and / or normal blood glucose levels.

The first benefit is that glucose from protein is accessed as required rather than raising blood sugar immediately (as is typically the case for carbohydrate, particularly if our liver and muscle glycogen is already full).

The second benefit is that it takes extra energy to convert protein to glucose before it can be used for energy. This is sometimes known as the ‘thermic effect of food’.¹⁷⁰

You’re likely aware that one gram of carbohydrate will digest into on gram of glucose that will provide four calories to be used by the body for energy. You are likely aware that if you burn one gram of protein in a calorimeter you’ll get four calories of heat. But what is interesting is that to convert one gram of protein to glucose takes approximately one calorie, so you only get three calories for energy or body fat storage.¹⁷¹

Viola! A calorie is not a calorie when it comes to protein being converted to glucose via gluconeogenesis.

11.6 Fat and insulin

When it comes to insulin demand and fat storage, fat is unique.

The major theme that reappears throughout Richard Feinman’s *The World Turned Upside down* is that “carbohydrate and protein can be turned to fat but, while glucose can be made from protein, with a few exceptions from, you can’t make glucose from fat.”

It’s the excess glucose from carbohydrate and protein that enters our blood stream and is removed with the help of insulin to be stored as fat.

The chart below shows that the higher the fat content of our food the less insulin is required.¹⁷²

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¹⁶⁹ [https://www.dropbox.com/s/4dkl03mz2fci71v/The%20metabolism%20of%20%E2%80%9Csurplus%E2%80%9D%20amino%20acids.pdf?dl=0](https://www.dropbox.com/s/4dkl03mz2fci71v/The%20metabolism%20of%20%E2%80%9Csurplus%E2%80%9D%20amino%20acids.pdf?dl=0)


¹⁷¹ If you want to dive into the detail on this I recommend you check out Chapter 14 of Richard Feinman’s *The World Turned Upside Down.*

¹⁷² [http://ses.library.usyd.edu.au/handle/2123/11945](http://ses.library.usyd.edu.au/handle/2123/11945)
If you turn things around to look at insulin demand in terms of non-fat calories (i.e. carbohydrates plus protein) we see that fat is the one thing that doesn’t require insulin as shown in Figure 53!

**Figure 52 Fat content versus insulin index**

**Figure 53 Non-fat content versus insulin index**
What this means is that the low fat foods we’ve all been eating to avoid getting fat and getting heart disease are the number one way to increase insulin which facilitates fat storage as well as increasing our insulin resistance which is the primary thing that drives heart disease!\(^{173} 174\)

If we eat less calories overall the body will use body fat for energy, but only if insulin levels are low enough. So if we are trying to lose weight the primary priority is to reduce the insulin load of our diet, eat fat to satiety while maximising nutrition and ideally a reduction in appetite and calories will follow naturally.

11.7 Can you eat too much fat?

So can eating too much fat make you fat? Yes and no.

If we eat a high fat diet that is also high in carbohydrates and protein we will have high insulin levels and most likely a calorie excess. This will lead us to store the glucose from the carbohydrates and protein as fat via lipogenesis\(^{175}\) (i.e. making new fat from glucose using insulin).

However if we eat a diet that is low in carbohydrate and moderate in protein such that our insulin levels are reduced we will be able to access our body fat for fuel, and therefore be less hungry.

In the absence of significant amounts insulin we typically don’t overeat fat. A low carbohydrate, moderate protein, high fat diet will typically lead to reduced hunger, reduced calorie intake and generally weight loss.

If we do not listen to the body’s satiety signals we can overeat fat which leads to a calorie excess which will mean that we do not need to access our body fat for fuel.

If you’re struggling to drop weight on a high fat diet a period of intermittent fasting or tracking your food in a food diary (e.g. MyFitnessPal or Cronometre) might help to check your macros are where you think they are and you’re not overdoing the calories. After this period of ‘retraining’ you should ideally be able to just eat when you’re hungry and stop when you’re full.

Figure 54 shows the macronutrient ratio of four phases of a ketogenic diet according to Steve Phinney.\(^{176}\) Note how in the early phases of this ketogenic approach the dietary fat percentage doesn’t necessarily have to be high and the carbohydrates are low enough to reduced insulin levels to the point that body fat can be used for fuel.

Once the desired weight loss is achieved the carbohydrate levels can come up a little bit with the fat coming up significantly to supply adequate calories for weight maintenance.

In the maintenance phase of the ketogenic diet we should be able to maintain normal blood glucose levels and body fat at optimal levels. If this is not the case you should revert to a lower insulin load and reduced calories.

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\(^{174}\) [http://www.cardiab.com/content/12/1/164](http://www.cardiab.com/content/12/1/164)


\(^{176}\) [https://www.youtube.com/watch?v=8NvFyGGXYiI&index=1&list=PLrVWtWmYRR2BIAsGG9tr6TB4xSum8SCc](https://www.youtube.com/watch?v=8NvFyGGXYiI&index=1&list=PLrVWtWmYRR2BIAsGG9tr6TB4xSum8SCc)
Figure 54  Phinney’s four phases of a ketogenic diet

11.8  Carbohydrate

The food insulin index data shown in Figure 55 demonstrate quantitatively that carbohydrates are the primary macronutrient that generates insulin.\(^{177}\)

Figure 55  Carbohydrates versus insulin index

\(^{177}\) Data from [http://ses.library.usyd.edu.au/handle/2123/11945](http://ses.library.usyd.edu.au/handle/2123/11945)
Carbohydrate is typically the body’s primary source of glucose. We need some glucose for the brain to function (about 40g or 160 calories per day as a minimum), however the body can obtain this from protein via glycogenesis if there is no carbohydrate available.\(^{178}\)

You may have heard that the body has no need for carbohydrate and that there is no such thing as an essential carbohydrate. This is true, however you should keep in mind that many important vitamins come packaged with carbohydrate (e.g. vegetables).

The optimal approach is to obtain high levels of nutrients while avoiding excessive insulin and normalising blood sugar. We can do this by selecting high nutrient density, low insulin, and high fibre vegetables such as those contained in the food lists here.

### 11.9 Fibre

While the low carbohydrate diet crowd avoid all carbohydrate containing foods to improve blood glucose levels and achieve weight loss, many people also find that they do well using a high fibre high vegetable approach.\(^{179}\)

Most people tend to agree that eating lots of vegetables is a good idea. As discussed in section there is a strong basis for a low calorie density, high nutrient density diet.

The insulin index data also supports this approach. As detailed in section 3.2, the insulin demand of foods is better predicted by net carbohydrates (i.e. total carbohydrates minus indigestible fibre) than by only considering carbohydrates.

Indigestible fibre effectively neutralises the insulinogenic effect of carbohydrates. Fibre also adds to the bulk of our food which helps to make us feel full and feeds our gut bacteria which is also highly beneficial.\(^{180}\)\(^{181}\)

Rather than taking fibre supplements, the ideal approach is to choose high fibre foods that also have a low insulin load. Some examples of these are spinach, mushroom, broccoli, and Brussel sprouts. Some more options are detailed in the lists of foods here.

High fibre foods also often have a high nutrient density and a low calorie density. By eating these sorts of foods we ensure we are getting excellent nutrition, tend to be fuller on less calories and also keep our insulin load down.

People who do not have blood sugar issues may do well on things like sweet potato, rice, lentils and tomatoes (these foods are included in the list of foods for the metabolically healthy in section 7.5). However if you’re struggling to control your blood sugars you should be mindful that these things will add to your insulin load and should be minimised (these lists of optimal foods for weight loss in section 7.2 or optimal foods diabetes and nutritional ketosis in section 7.3 may be more ideal).

In summary, maximising fibre is another tool that we can use, in addition to minimising carbohydrates, moderating protein, maximising nutrient density and eating fat to satiety, to manage blood sugars and obesity.

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\(^{179}\) [http://www.mangomannutrition.com/](http://www.mangomannutrition.com/)


11.10 Protein

As shown in Figure 56 high protein foods don’t generate a sharp rise in blood sugar compared to high carbohydrate foods because the digested amino acids circulate in the blood stream for use as required to raise blood sugar rather than directly spilling into the blood stream in the same way that simple carbohydrates would raise your blood sugar.

![Protein versus glucose score](http://ajcn.nutrition.org/content/82/1/1.full)

**Figure 56  Protein versus glucose score**

Protein is also very satiating and typically leads to a reduction in overall calories. Your body will to continue to search out food until it obtains enough protein. Once you obtain adequate protein you will be more likely to stop eating.

Protein also contains a range of essential and non-essential amino acids that are required for muscle growth and repair as well as mental function. Maximising the amount and variety of amino acids that from our diet is the ideal approach rather than trying to supplement.

Increasing your protein a possible ‘hack’ for diabetics to obtain glucose without spiking blood sugars. Diabetics and ‘low carbers’ will often limit carbohydrates but compensate by increasing protein. This is generally not a problem because protein is slower to digest than carbohydrate and hence the blood sugar rise from protein is slower and more manageable in comparison to carbs. The body also releases glucagon to offset the protein used in protein synthesis which also helps to stabilise blood sugars.

However just because protein does not spike blood sugars as aggressively as carbohydrate does not mean that it does not require insulin. The food insulin index data indicates that while the blood sugar response is less than carbohydrates, the insulin demand of protein is still substantial as shown in Figure 57.

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182 [http://ajcn.nutrition.org/content/82/1/1.full](http://ajcn.nutrition.org/content/82/1/1.full)

183 [http://jn.nutrition.org/content/137/6/1478.full](http://jn.nutrition.org/content/137/6/1478.full)
Figure 57  Protein versus insulin index

According to Nuttall and Gannon between 32 and 46g of high quality dietary protein is required to maintain protein balance. This represents around 6 to 7% of the calories in a 2000 to 2500 calorie diet being taken “off the top” for growth and maintenance. Protein in excess of will likely be available for gluconeogenesis.

The downside of protein is that it does contributes to the overall insulin load of your diet. Ingested protein not used for growth and repair of the body does not magically disappear. A small amount (approx. 12%) will be converted to ketones as used as it if were fat. About 14% can be used either as glucose or fat. But around 80% of protein can only be used as glucose. This glucogenic protein in excess of the body’s requirements will also require insulin to be used for energy in the mitochondria or to be stored in the fat cells.

High levels of protein which generates insulin will make it harder to achieve fat burning or ketosis. If your pancreas is struggling to supply enough insulin to maintain blood sugars then the insulin load from protein will make it harder for your pancreas to keep up and achieve optimal blood sugars.

If you are trying to lose weight then the excess insulin (over and above the amount used for protein synthesis that receives glycogen) will also promote fat storage rather than fat burning.

High levels of protein also requires additional insulin and having a robust method to estimate the insulin load from protein in addition to carbohydrate would be useful for type 1 diabetics.

11.11  Nutrient hunger

Similar to the concept of protein hunger, if you’re not giving your body the vitamins and minerals it needs it will keep on seeking out more food. In his Perfect Health Diet Paul Jaminet notes that “a nourishing, balanced diet that provides all the required nutrients in the right proportions is the key to eliminating hunger and minimising appetite and eliminating hunger at minimal caloric intake.”

It also makes sense that eating a nutrient dense diet would help our body to heal and recover from anything else that might be causing insulin resistance and obesity. Many people talk about the
benefits of various supplements for different ailments and performance enhancement, but surely your best bet is to maximise the quality and range of nutrition from the food you eat every day before investing in supplements?

11.12 Liver storage and insulin sensitivity

A healthy insulin sensitive person will store glucose in the liver as glycogen with minimal rise in blood sugars after eating, regardless of the macronutrients. A person with type 2 diabetes however will often spill excess glucose into the blood stream which will cause the blood glucose levels to rise and thus additional insulin will be necessary to clear excess glucose from the blood.

Excess protein not used for protein synthesis will also contribute to refilling the glucose stores in the liver and muscles.\(^{184}\) It makes sense in this situation that you would want to limit the insulin load (i.e. carbs and excess protein) to starve the liver (or ‘dry up the root’ to quote Bob Briggs\(^{185}\)) such that it is not over full in order to reduce spilling of excess glucose into the blood.

11.13 Practical application

Steve Phinney is probably the most well respected authority on the ketogenic diet. His ‘well formulated ketogenic diet’ versus other dietary approaches shown in the chart below is quite useful.

You’ll notice that the WKFD space is a triangle indicating that you need to balance your carbohydrates and protein levels in order to manage your insulin load and achieve nutritional ketosis.

You can have 30% protein and 5% carbs or 20% carbs and 10% protein and still be within the bounds of the WFKD triangle, however if you run with 30% protein and 20% carbs you will be well outside the realms of a ketogenic diet because you will be producing too much insulin meaning that you will be ‘kicked out of ketosis’ (i.e. your fat burning will be slowed).

\(^{184}\) https://www.dropbox.com/s/4dkl03ms2fci71v/The%20metabolism%20of%20surplus\%E2\%80\%9C%20amino%20acids.pdf?dl=0

\(^{185}\) https://www.youtube.com/watch?v=SDzJKaBvOGw
Understanding your insulin load and where you are in relationship to the WKFD triangle is important and may be the difference between achieving your desired goals from a low carbohydrate diet and not quite getting there.
12 The glucose : ketone relationship

12.1 Background

Since I wrote the article *ketosis... the cure for diabetes* in which I plotted my relationship between blood glucose and ketones I have had some interesting discussions and learned a lot.

Particular thanks go to Raymund Edwards from the Optimal Ketogenic Living Facebook group and Jeff Cyr of the Ketogenic Diabetics Facebook group for sharing their knowledge and experience.

Figure 58 shows a plot of my ketones versus blood sugar over a period of about nine months of trying to achieve nutritional ketosis to varying degrees. My hypothesis, in the absence of more data, was that, for me at least, excellent blood glucose aligned with ketone values of greater than 0.5mmol/L and optimal blood glucose aligned with ketone values of around 1.3mmol/L.

Armed with this information I figured that there was limited benefit in doing the more expensive ketone tests on a regular basis. Monitoring blood glucose to ensure that the average is less than 5.4mmol/L (100mg/dL) seemed like a pretty good way to track my metabolic control.

Table 34 shows the relationship I developed between HbA1c, average blood glucose and ketone values based on my n=1 data.

*Figure 58  Ketones versus blood glucose levels*

Armied with this information I figured that there was limited benefit in doing the more expensive ketone tests on a regular basis. Monitoring blood glucose to ensure that the average is less than 5.4mmol/L (100mg/dL) seemed like a pretty good way to track my metabolic control.

Table 34 Relationship between ketones, blood glucose, ketones and GKI

<table>
<thead>
<tr>
<th>risk levels</th>
<th>HbA1c (%)</th>
<th>average blood glucose (mmol/L)</th>
<th>average blood glucose (mg/dL)</th>
<th>ketones (mmol/L)</th>
<th>GKI</th>
</tr>
</thead>
<tbody>
<tr>
<td>low normal</td>
<td>4.1</td>
<td>3.9</td>
<td>70</td>
<td>2.1</td>
<td>1.9</td>
</tr>
<tr>
<td>optimal</td>
<td>4.5</td>
<td>4.6</td>
<td>83</td>
<td>1.3</td>
<td>3.5</td>
</tr>
<tr>
<td>excellent</td>
<td>&lt; 5.0</td>
<td>&lt; 5.4</td>
<td>&lt; 97</td>
<td>&gt; 0.5</td>
<td>11</td>
</tr>
<tr>
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<td>&lt; 5.4</td>
<td>&lt; 6</td>
<td>&lt; 108</td>
<td>&lt; 0.3</td>
<td>30</td>
</tr>
<tr>
<td>danger</td>
<td>&gt; 6.5</td>
<td>7.8</td>
<td>&gt; 140</td>
<td>&lt; 0.3</td>
<td>39</td>
</tr>
</tbody>
</table>
12.2 The importance of insulin levels

High levels of insulin (hyperinsulinemia) are dangerous and are linked to a wide range of health issues including obesity, heart attack, Alzheimer’s, impotence and cancer. People with higher insulin levels tend to be more obese (as shown in Figure 46). The insulin levels in an obese person tend to be more constantly raised rather than the more pulsative characteristics in a normal weight person (as shown in Figure 51).

The official reference range for fasting insulin pegs “normal” at less than 25 mIU/L, however given that the average insulin levels are 8.6 mIU/L and the western world is going through a crisis of metabolic health, it’s probably safe to say that this cut off level is too high.

Stephan Guyenet suggests that, based on healthy populations, optimal fasting insulin levels are likely to be between 2 to 6 mIU/L. Ron Rosedale says that the lower we have our insulin levels the better.

12.3 The glucose ketone index calculator

When I joined the Optimal Ketogenic Living I came across Raymund Edwards’ link to The glucose ketone index calculator: a simple tool to monitor therapeutic efficacy for metabolic management of brain cancer by cancer researcher Thomas Seyfried which looked at the relationship between ketones and blood glucose as a possible indicator of metabolic health.

The GKI value is calculated by dividing the glucose value by the ketone value measured at the same time (both in mmol/L). The paper suggest that if someone’s glucose to ketone ratio (GKI) is low then you are metabolically healthy and “fat adapted”. I have shown the GKI values in Table 34 based on the average corresponding blood glucose and ketone levels.

According to Seyfried, the goal for cancer patients using a therapeutic ketogenic diet is to have a GKI less than one while patients with chronic disease like cancer have index values of 50 or more.

For most people who are not trying to slow cancer growth or combat epilepsy through a ketogenic diet, a GKI value of less than ten is considered to be a “low insulin condition” and that you are not significantly insulin resistant.

12.4 My data over time

I have plotted my GKI over along with my blood glucose values in Figure 59. In January I managed to get my blood glucose values under better control with the ketones finally coming up. Once my blood glucose came down and I was showing some ketones my GKI value was sitting at around 10 which is indicative of a low insulin condition.

References:

- [http://www.nutritionandmetabolism.com/content/12/1/12](http://www.nutritionandmetabolism.com/content/12/1/12)
While your blood glucose are above 6.0mmol/L (or 108mg/dL) or so it’s hardly worth trying to measure ketones as they are going to be negligible and testing will be a waste of money. Once you are able to lower your blood glucose you will start to see blood ketones greater than 0.2mmol/L. Tracking GKI by measuring both blood sugars and ketones may be useful once your blood glucose are under control and you want to take your metabolic health to the next level.

Personally I’m simply after normal blood glucose and some ketones for health, weight management and optimal brain function, so I’m not too concerned with achieving extremely low GKI values. For me personally this would require too much discipline and limitation of foods. It might be hard to eat regularly with my family and have the sort of diet that would be required to achieve those levels.

However if you’re looking to manage extreme insulin resistance, epilepsy or cancer then pushing for very low GKI values may be something worth pursuing.

12.5 Crowdsourcing data

Through a number of Facebook groups I was able to obtain more blood glucose / ketone data to add to mine. The updated chart shown in Figure 60 has a lot more points sitting out to the bottom right with higher ketones and lower blood glucose.
Figure 60  Ketones versus blood glucose – expanded dataset

This data consists of:

- 60 data points from me through my journey from poor blood glucose control to improved blood glucose control and achieving my target weight,
- 35 data points from my dad who is in a similar position to me, refining his diet and experimenting with intermittent fasting to achieve better blood glucose control, and
- other 45 data points from ten other people, much more experienced in the ketogenic diet than me.

12.6 Updated ketone reference values

Table 35 shows the updated ketone and GKI values that correspond to the various HbA1c risk levels. With the additional of the extra data the ketone levels for “low normal” and “optimal” increase substantially.

<table>
<thead>
<tr>
<th>HbA1c (%)</th>
<th>average blood glucose (mmol/L)</th>
<th>average blood glucose (mg/dL)</th>
<th>ketones (mmol/L)</th>
<th>GKI</th>
</tr>
</thead>
<tbody>
<tr>
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<td>3.9</td>
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<td>4.5</td>
<td>4.6</td>
<td>83</td>
<td>2.5</td>
</tr>
<tr>
<td>excellent</td>
<td>&lt; 5.0</td>
<td>&lt; 5.4</td>
<td>&lt; 97</td>
<td>&gt; 0.3</td>
</tr>
<tr>
<td>good</td>
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<td>&lt; 0.3</td>
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<td>danger</td>
<td>&gt; 6.5</td>
<td>7.8</td>
<td>&gt; 140</td>
<td>&lt; 0.3</td>
</tr>
</tbody>
</table>

This seems to align reasonably well with Phinney and Volek’s optimal ketone chart shown in Figure 61. Based on the review of the blood glucose versus ketone data it appears that:

- low level nutritional ketosis generally aligns with your blood glucose being under good control,
- higher levels of ketones occur once you are highly fat adapted, and
• in someone who is highly fat adapted the body may hold the blood sugar relatively stable at the lower end of the normal range (using glucagon) while increasing ketones for fuel.

![Figure 61 Optimal ketone zone – Phinney and Volek](image)

12.7 Individual glucose : ketone relationships

The chart below shows the glucose values versus ketones plotted for each individual person as separate data sets with a separate trend line. I’m not sure what to make of this other than being able to see that people who are more fat-adapted have flatter lines with more points out to the right of the chart. Reviewing this data has certainly been eye opening for me to see what can be achieved once you are highly fat adapted.

![Figure 62 Ketones versus blood glucose – for each individual](image)

Table 36 shows the GKI for the range of individuals that I had a number of data points for. You can see that my dad (Merv) and I look pretty shabby next to the GKI values of the more experienced ketogenic dieters.
Andrew, with the lowest GKI value of 0.6, is using ketosis to fight cancer. Check out his amazing story [here](#).

Jeff has used the ketogenic diet to recover from extreme type 2 diabetes and now has a fasting insulin level of 2.2 uIU/mL and an HbA1c of 4.4%. Jeff says that he has also used keto to recover from an autoimmune liver disease called [Primary Sclerosing Cholangitis](#) which he was diagnosed with in 2011 and given eight to ten years to live before dying of total liver failure. His most recent bloodwork indicates that his liver tests are now normal. No more death sentence.

Hopefully there will be more research in the future to correlate in the future fasting insulin levels with the GKI values (are they approximately equivalent?). Or perhaps this dataset can be added to to enable people to get a better feel for what constitutes optimal ketone values.

If it turns out that fasting insulin is approximately equivalent to GKI then perhaps we should be aiming for a GKI of somewhere less than 6 for general health (based on Guyenet’s definition of optimal) with people battling more serious issues such as cancer or epilepsy targeting 2 or below? Interesting.

It appears that the GKI is another interesting tool to empower people in the self-quantification and self-management of their own health without relying on more expensive lab tests such as testing insulin.

### 12.8 Summary

So in summary:

- Insulin levels are an even better indicator of metabolic health than blood glucose.
- Reducing the insulin load of your diet (by reducing net carbs and moderating protein) will reduce blood glucose levels by reducing the glucogenic inputs.
- Reduced blood glucose will lead to reduced insulin and increased ketones.
- Once blood glucose levels are under control and you are reliably showing some level of ketones the glucose : ketone index (GKI) may be a useful indicator if you want to continue to fine tune your metabolic health.
- The GKI provides a more accurate approximation of your insulin levels.
- Tracking GKI may be useful for people who are already fat adapted.
- A GKI of less than ten is considered to be a low insulin state.
- A GKI of less than one is the goal for cancer patients using therapeutic ketosis.
13 The blood glucose, glucagon and insulin response to protein

13.1 Background

One of the perplexing issues regarding protein is that it doesn’t significantly raise blood sugars, at least compared to carbohydrates. However it is generally acknowledged (at least by type 1 diabetics) that protein requires insulin.

My aim here is not to knock protein, but to rather to better understand the insulin response to protein based on the recent food insulin index data.

My wife is a type 1 diabetic, hence anything that can be done to refine insulin dosing calculations or help inform food choices that will lead to more stable blood sugars is of interest to me.

Personally, I have a tendency towards obesity and pre-diabetes (based on my 23andMe\textsuperscript{192} testing and a lifetime of personal experience trying to keep the weight off) so I am also interested in how I can optimise my blood sugars and reduce the insulin load of my diet so that my pancreas can keep up. I would love to dodge the weight creep that seems to come with middle age for most people.

This has been a challenging topic to get my head around. It is complex and there is a lack of definitive research to provide clear guidance. Hopefully more data and discussion can help to progress the understanding and the practical application of the theory.

I do not claim to have all the answers, but rather plenty of observations and questions. I hope that by documenting some of these questions I can help move this discussion forward. If you have some thoughts or insights on this topic be sure to leave your comments below once you’ve finished reading this article to add to the discussion.

13.2 The blood glucose response to protein

The food insulin index data contained in Clinical Application of the Food Insulin Index to Diabetes Mellitus by Kirstine Bell (Sept 2014)\textsuperscript{193} continues to intrigue me. There is a lot to be learned from looking at the body’s insulin response to real foods and this relates to other parameters such as fat, protein, carbohydrates, fibre or blood glucose.

The data points on the right hand side of the plot of protein versus blood glucose score\textsuperscript{194} in Figure 63 shows that high protein foods (e.g. fish, tuna and steak) cause a rise in blood glucose (in healthy non-diabetics). However the blood sugar response to protein is small relative to high carbohydrate foods on the left hand side of the plot.

For most people, the discussion ends there. Protein doesn’t raise blood sugar that much, therefore it’s a non-issue. Pass the extra-large steak and the protein shake thanks.

\textsuperscript{192}https://www.23andme.com/
\textsuperscript{193}http://ses.library.usyd.edu.au/handle/2123/11945
\textsuperscript{194}“glucose score” is the area under the curve of the rise in blood glucose response over three hours relative to pure glucose.
One of the challenges I see for type 1 diabetics is that, even if they eat a low carbohydrate diet, they still struggle with high blood sugars after a high protein meal.

Looking at the plot of protein versus insulin index below we can see that the insulin response to protein is more significant than would be suggested by the blood glucose response. For example, the insulin index score for white fish is 42% while it’s only 20% on the glucose score (both the insulin index and glucose score are relative to the response to pure glucose which is 100%).

Figure 63  Protein versus glucose score

13.3 The insulin response to protein

But maybe there’s more to be learned from the foods insulin index data, particularly when it comes to managing insulin demand and optimising blood glucose levels.
Maybe there’s something going on that can’t simply be explained from the blood sugar response alone? If we plot the glucose score versus the insulin index as shown in Figure 65 we see that glucose response and insulin response are not directly proportional.\textsuperscript{195}

Low carbohydrate high protein foods such as chicken, cheese, tuna and bacon require a lot more insulin than would be anticipated if insulin was directly proportional to the blood glucose response. On the lower side of the trend line we have high carbohydrate foods from whole food sources such as raisins, wholemeal pasta, brown rice and water crackers having less of an insulin response than would be anticipated from the blood glucose response.

I ran a correlation analysis with different parameters but couldn’t find any strong relationships with any particular parameter in the available data (e.g. total carbohydrate, sugar, fibre, protein or fat). Perhaps this would be an interesting area for future study to see if there is some component of food processing or some other Paleoesque characteristic that influences the relationship between blood sugar and insulin, or maybe it’s just the scatter in the real life data? It seems the fibre is the best metric that we have to quantify the level of processing of a particular food.
13.4 The diabetic versus normal response to protein

Moving on to some other data, the Figure 66 compares the blood sugar and insulin response to 50g of protein (200 calories) in type 2 diabetics (yellow lines) and healthy non-diabetics (white lines).\textsuperscript{196}

- In both cases insulin is elevated for more than five hours, particularly for the insulin resistant type 2 diabetic.

- The diabetic requires a lot more insulin to deal with the same quantity of protein and it takes a lot longer for the insulin levels to peak and come down.

- Protein takes more than three hours to digest and metabolise. Hence it is likely that the food insulin index data (which is based on the measurement of insulin over only three hours) underestimates the insulin response to protein containing foods and that the insulinogenic proportion of protein is actually higher than predicted by the food insulin index data.

- Blood glucose remains fairly stable for healthy people after eating 50g of protein. However when the type 2 diabetic eats the high protein meal the insulin secreted seems to bring the blood sugar down from elevated levels.

\textsuperscript{196} http://www.ncbi.nlm.nih.gov/pmc/articles/PMC524031/
13.5 What happens when we eat a lot of protein?

Richard Feinman says that “…after digestion and absorption, amino acids not used for protein synthesis may be trashed. The nitrogen is converted to ammonia which is converted to urea and excreted. The remaining carbon skeleton can be used for energy either directly or converted to ketone bodies, particularly on a very low carbohydrate diet.”

The figure below shows a comparison of the blood glucose response to ingestion of glucose and 600g of lean beef (i.e. a very big steak!). During the more than eight hour period that the steak takes to digest you can see the nitrogen levels continue to rise. Meanwhile blood glucose rises only slightly up until around four hours after the meal and comes back down.

What appears to be happening here is that the amino acids from digestion are being progressively released into the bloodstream (over quite a long period of digestion) but are not necessarily converted to glucose straight away. It appears that the body can draw on the amino acids for muscle growth and repair or to raise blood sugar (via gluconeogenesis) depending on what is required at the time.

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197 Chapter 5 of *The World Turned Upside Down: The Second Low Carbohydrate Revolution.*
It would be interesting to see what happens in someone whose blood stream became saturated with amino acids from consistent long term consumption of high levels of protein. Would we see more protein excreted or perhaps a larger amount would be removed from the blood via gluconeogenesis?

13.6 What happens to “excess” protein?

The question of what happens to “excess” protein that is not required for muscle growth and repair is a controversial, and the science is not exactly clear.

Does the energy from unused protein magically disappear? If it did then protein would be the ultimate macronutrient that everyone should eat to lose weight. Does it turn to nitrogen and get excreted in the urine? Does it turn to glucose “like chocolate cake”?

As noted above, Feinman says that protein is not necessarily stored, but rather it seems that amino acids from digestion of protein circulate in the blood until they are required for protein synthesis or are converted to glucose or ketones. Feinman says that minimal protein is eventually excreted as nitrogen in healthy people.

The fact that we don’t see a sharp rise in blood glucose in response to protein indicates that excess protein doesn’t immediately turn into glucose however it occurs slowly over time with the amino acids being used up as required.

The consensus from the research is that gluconeogenesis is more a demand driven process rather than being driven by supply. Glucose is made from protein as required.

By comparison, when we eat carbohydrate we typically see the glucose causing a rise in blood sugar immediately. Sugars digest and enter the blood stream if it is in excess of the body’s ability to store in the liver.

Though perhaps this is also related to the fact that most peoples’ glucose stores are already full and that’s why we see the sugar going directly into the blood? Perhaps in most people their blood stream isn’t already saturated with amino acids like they are with carbohydrates?
13.7 Glucagon response

The body secretes both glucagon and insulin in response to a high protein meal (as shown in the figure below\textsuperscript{199}).

In a healthy insulin sensitive non-diabetic person the glucagon will effectively cancel out the insulin response to the protein used for protein synthesis. Thus we see a flat line blood glucose response in the insulin-sensitive non-diabetic.

![Glucagon, insulin, glucose and nitrogen response to a high protein meal](https://books.google.com.au/books?id=3FNYdShrCwIC&printsec=frontcover&dq=marks+basic+medical+biochemistry&hl=en&sa=X&ei=-ctaVcivOJfq8AXL84CAAw&redir_esc=y#v=onepage&q=glucagon&f=false)

**Figure 68 Glucagon, insulin, glucose and nitrogen response to a high protein meal**

The major advantage of protein over carbohydrate for energy is that a high protein meal causes the body to secrete glucagon which promotes fat burning. After ingestion of a high carbohydrate meal glucagon decreases as the insulin increases and the body moves into fat storage mode as shown in Figure 69.\textsuperscript{200}

\textsuperscript{199} https://books.google.com.au/books?id=3FNYdShrCwIC&printsec=frontcover&dq=marks+basic+medical+biochemistry&hl=en&sa=X&ei=-ctaVcivOJfq8AXL84CAAw&redir_esc=y#v=onepage&q=glucagon&f=false

\textsuperscript{200} https://books.google.com.au/books?id=3FNYdShrCwIC&printsec=frontcover&dq=marks+basic+medical+biochemistry&hl=en&sa=X&ei=-ctaVcivOJfq8AXL84CAAw&redir_esc=y#v=onepage&q=glucagon&f=false
I wonder if the glucogenic portion of protein requires insulin regardless of whether it is used for protein synthesis or gluconeogenesis however the body does not secrete glucagon to negate the effect of the “excess” protein which is over and above the body’s needs for protein synthesis (say 10% of calories)? If this is the case then the glucogenic proportion of excess protein will largely behave like a carbohydrate with no glucagon to counteract the insulin.

13.8 Glucagon, the antidote to insulin?
The observation that glucose does not rise significantly in response to protein is often taken to mean that protein is a non-issue.201 202

This may be largely true for someone who is insulin sensitive, however type 1 diabetics and type 2 diabetics with impaired pancreatic function may not be able to secrete adequate insulin to offset the effects of glucagon and keep their blood sugars stable.

If you’re a type 2 diabetic or someone with impaired insulin sensitivity is it better to keep your carbohydrate AND protein intake to the point where your body can keep up and maintain normal blood sugars? And perhaps after keeping the insulin load low for a period you will restore insulin sensitivity and improve your blood sugar control?

The image below shows the continuous glucose monitor (CGM) plot of a type 1 diabetic after ingestion of a protein shake (46.8g protein and only 5.6g of carbs) without insulin. Without insulin to blunt the effect of the protein there is a blood sugar rise over a period of more than eight hours, not dissimilar to what you would see from carbohydrates.

Figure 69 Glucagon, insulin, glucose and nitrogen response to a high carbohydrate meal

![Graph showing glucose, insulin, and glucagon response to a high carbohydrate meal](image-url)

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Is this blood glucose rise from gluconeogenesis of the protein or is the blood glucose rise from glucagon in response to the ingested protein? It’s hard to know.

What we do know is that there is a response that needs to be managed to achieve optimal blood sugar control, either by dosing with insulin and / or moderating the dietary protein intake.

**Figure 70 Blood sugar response to protein shake in a type 1 diabetic**

In the end this is complex. It’s impossible to know to what extent the glucagon released in response to protein cancels out the insulin. What we can measure is the body’s response to the food that we eat.

From the food insulin index data we know that the body’s blood sugar and insulin response are proportion to carbohydrate plus about half of the ingested protein. So we can balance our blood glucose response by managing the glucogenic inputs, that is, by moderating protein and keeping carbohydrates adequately low.

**Figure 71 Net carbs + 0.56 x protein versus insulin index**
For a diabetic who is insulin resistant and/or not producing adequate insulin from their own pancreas the issue is not just about keeping blood sugar low. The issue is that the total insulin load of their diet (from carbohydrates and the glucogenic component of protein) is in excess of their body’s ability to keep under control.

13.9 The high protein ‘hack’ for diabetics

Obtaining glucose from protein rather than carbohydrate is potentially a great “hack” for someone who is not able to manage their blood sugars in view of the following:

- eating higher levels of protein will ensure that the body’s needs for essential amino acids are met;
- the blood sugar rise from protein is much slower than for carbohydrate and hence it is easier to keep blood sugars under control; and
- protein is much more satiating than carbohydrates.

A diabetic on a high protein diet will then need to pay attention to limiting their carbohydrates in order to keep their total glucose load low enough to maintain optimal blood sugars.

13.10 So what is the optimum amount of protein and carbohydrates?

I find Steve Phinney’s WFKD chart helpful when it comes to understanding how we can optimise protein and carbohydrate intake to manage our glucose load with the following observations noted:

- The minimum protein intake is around 10% of calories or 0.8g/kg body weight. At this point the vast majority of the protein will go to muscle growth and repair.
- You might even be able to tolerate up to 20% carbohydrates and stay in nutritional ketosis. At this point you won’t have to worry too much about gluconeogenesis messing up your blood sugars because all of the protein will be used up by the body.
- If you’re active then you’ll likely want higher levels of protein, with 1.2 to 1.7g/kg body weight recommended for athletic performance. Higher levels of protein will ensure that you have enough amino acids for optimal mental function rather than just being adequate. Getting plenty of amino acids from a bit extra protein is similar conceptually to the way that you might want to ensure that you have adequate micronutrients by trying to eat fibrous green leafy vegetables.

- As we move to higher levels of protein above the minimum 10% of calories then we should consider reducing our carbohydrate intake due to the fact that the glucogenic portion of the protein that is over and above the basic needs for growth and repair will likely be turned into glucose and require increased levels of insulin (and glucose?) which will work against you if your goals are reducing your insulin load in order to stabilise blood sugars or to lose weight.

![Figure 73 Steve Phinney’s WFKD trinagle](https://www.dropbox.com/s/zelfo3n0q8kvtx/Phinney%20et%20al.%20(2015)%20The%20Ketogenic%20Diet%20and%20Sport%20A%20Possible%20Marriage.pdf?dl=0)

I have discussed this concept in much more detail in the [Goldilocks glucose zone](https://www.dropbox.com/s/zelfo3n0q8kvtx/Phinney%20et%20al.%20(2015)%20The%20Ketogenic%20Diet%20and%20Sport%20A%20Possible%20Marriage.pdf?dl=0) in section 10. However if you are tracking your dietary intake you can use the formula below to determine your insulin load.

\[
\text{insulin load (g)} = \text{carbohydrates (g)} - \text{fibre (g)} + 0.56 \times \text{protein (g)}
\]

If you are not yet achieving [normal blood sugar levels](https://www.dropbox.com/s/zelfo3n0q8kvtx/Phinney%20et%20al.%20(2015)%20The%20Ketogenic%20Diet%20and%20Sport%20A%20Possible%20Marriage.pdf?dl=0) then you could try to wind back your insulin load. Most people find that they will achieve stable blood sugars and nutritional ketosis with an insulin load of less than 125g, however your mileage may vary and you will likely have to tweak this level to find your optimum based on your goals and your situation.
13.11 Summary

In summary:

- The food insulin index data indicates that there is both a blood sugar and insulin response to the glucogenic component of protein.\textsuperscript{204}
- Generally higher dietary protein intake tends to lead to better blood sugar control, increased satiety and reduced caloric intake.
- While a portion of “excess” protein does turn into glucose, the release of glucose from protein via gluconeogenesis is much smoother and slower.
- Someone who is insulin resistant and / or whose pancreas is not producing adequate insulin (e.g. type 2 diabetic or obese) may benefit from higher protein levels with lower carbohydrate levels (LCHP) in order to smooth out the blood sugar response while still obtaining adequate glucose from protein.
- Someone wanting to minimise the overall insulin load of their diet to a point that their pancreas can maintain normal blood sugars unassisted by exogenous insulin or other medication may benefit by moderating their protein intake as well as limiting carbohydrate intake.

\textsuperscript{204} http://en.wikipedia.org/wiki/Glucogenic_amino_acid