Absorption, Transport, Metabolism of Saturated Fats

GUT LUMEN

<table>
<thead>
<tr>
<th>Medium Chain Fats</th>
<th>Long Chain Fats</th>
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<tbody>
<tr>
<td>MCT</td>
<td>LCT - Long Chain Triglyceride</td>
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<tr>
<td>MCD</td>
<td>LCD</td>
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<tr>
<td>MCM - (MCM)</td>
<td>(LCT)</td>
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<tr>
<td>MCFA -</td>
<td>LCT IN VLDL/LDL</td>
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<td>LCM</td>
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<td>LCFA</td>
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<td>Fatty Acid</td>
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<td>Diglyceride</td>
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<td>Potential</td>
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<td>Monoglyceride</td>
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<td>Fatty Acid</td>
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INTESTINAL MUCOSAL CELL
Saturated Fat Metabolism

**Medium Chain**
- C6 - C12

**Digestion:**
- Easier; digested by intestinal mucosal cell lipases; pancreatic lipase not essential

**Absorption:**
- Faster (four-fold) absorption as free fatty acids
- No bile required

**Transport:**
- Via portal circulation to liver as free fatty acids

**Metabolism:**
- Rapid entry into mitochondria without Carnitine
- Oxidized rapidly to CO2 ketones and Energy
- Portion reenters systemic circulation as MCFA or monoglyceride responsible for systemic effects
- Little adipose tissue deposition

**Long Chain**
- C14 - C22

**Digestion:**
- Pancreatic lipase essential

**Absorption:**
- Slow; re-esterified by intestinal mucosal cell into triglycerides and incorporated into chylomicron or VLDL bodies

**Transport:**
- Chylomicron and VLDL bodies enter lymphatics and systemic circulation

**Metabolism:**
- Oxidized partially and carnitine required for LCFA entry into mitochondria
- Major portion incorporated by the liver into VLDL, released in blood circulation, transformed into IDL & LDL
- Adipose tissue deposition

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(1) Bloom, Chaikoff, Rembards, 1951
(2) Bennett, Holt, 1965
(3) Bennett, 1964
(4) Zurier, Hashim, van Itallie, 1965
(6) Bremer, 1980
(7) Schwabe, Bevernett, Bowman, 1964
(8) Zurier, Campbell, Hashim, van Itallie, 1967
Coconut Oil, a saturated fat, is predominantly Medium Chain Triglycerides (C8 to C12). These MCTs are transported directly into the liver where they are broken down into medium chain fatty acids thereby giving rise to ketone energy. We describe below how insulin plays its role in shuttling the normal glucose-based energy (from carbohydrate, glucose & long chain fatty acids) into cells and what happens in situation when this source of energy is compromised in its availability to the body. In such situation ketone-based energy becomes important.......

**What Is Insulin And What Does It Do?**

Insulin is a hormone and is found in even single-celled organisms and has been around for several billion years. Insulin is also a protein just like many other hormones. The pancreas has a group of cells called islet cells. It is the islet cells that secrete insulin.

The pancreas is an organ that sits behind the stomach and has many functions in addition to insulin production. The pancreas also produces digestive enzymes and other hormones.

When you eat, the food is digested and then broken down into glucose. Glucose is the simple sugar that is the body's main source of energy, otherwise known as blood sugar. Carbohydrates are broken down into glucose and are absorbed from the intestines into the bloodstream after you eat.

The pancreas then secretes insulin in response to the increase in blood sugar. Most cells of the body have insulin receptors which bind the insulin to the cell. When a cell has insulin attached to it, the cell then is able to activate the other receptors. These receptors are designed to absorb glucose from the bloodstream and move the glucose into the inside of the cell for energy.

Without insulin, the cells in our bodies would not be able to process the glucose and therefore have no energy for movement, growth, repair, or other functions. Insulin is key to unlocking the door of the cell to allow the glucose to be transferred from the bloodstream into the cell.

Ordinarily, when glucose enters our blood, the pancreas automatically produces the right amount of insulin to move glucose into our cells.

There are two types of insulin errors that the pancreas makes. The first is type 1 diabetes which produce no insulin. The second is type 2 diabetes. The pancreas in people with type 2 diabetes does not always produce enough insulin.

With the type 1 insulin deficiency, you can eat lots of food but your body can be actually in a state of starvation. This happens because without insulin our cells can not be easily opened in order to be able to extract the energy contained in the glucose that came from the food that was eaten.

This is why Type 1 diabetics who do not make insulin can become very ill without insulin shots. If the body's cells do not get fed, they become sick. Insulin is a necessary hormone for survival. Those who develop a deficiency of insulin must have it get into the body somehow. With type one diabetes, insulin can be added into the body through shots or pumps.

Type 2 diabetes is more common. According to the World Health Organization, over 90% of diabetic cases worldwide are type 2. Type 2 people will develop what is known as insulin resistance. This is not a true insulin deficiency. When this happens the levels of insulin in the blood are similar or even a little higher than in normal, non-diabetic bodies. The body's cells become resistant to the insulin almost like type 1 diabetes, but what happens is that because the body is resistant to insulin the body over secretes insulin in order to try to feed its cells. It can become an ever increasing cycle that can escalate out of control.

The main problem with Type 2 diabetes is that the cells respond sluggishly to the insulin and that means the cells cannot absorb the glucose molecules well. This makes blood sugar levels run higher than they should be. When the body can no longer get the energy from the glucose into the cells, the body stores the extra energy in fat cells. This is why diabetics tend to gain weight easily and find it difficult to lose it. Most of the time this condition will correct itself, but sometimes type 2 diabetics will have to have an insulin shot.
Based on information from the World Health Organization, some of the effects of type 2 diabetes on the body are blindness and visual disability along with heart disease and diabetic foot disease which often ends in amputation of the lower limbs. Diabetes is also the leading cause of kidney failure.

The first line of defense against type 2 diabetes is diet and exercise. Just half an hour of walking a day will dramatically reduce the risk of developing type 2 diabetes.

What are ketones?

Ketones are a by-product/or waste product when your body burns stored fat for energy. Before we describe various situations in which a person might have ketones, let us provide a simple review of how the body works:

- The foods you eat break down into glucose (sugar). Glucose travels in the blood and into your cells. Insulin is a hormone (or "key") that "unlocks the doors of your cells" to allow glucose to enter your cells where it can be turned into energy. So without insulin, glucose wouldn't be able to get into the cells.
- Your brain (and the rest of your body) requires glucose to function. When you haven't eaten for a while, or during the night when you're asleep, your liver releases stored glucose to keep you supplied with energy.
- If you don't eat for several days, the stored glucose in the liver is depleted, and your body is in a starvation state. In this situation, the body will break down stored fat to get energy, (and ketones can show in the urine, indicating that fat was burned) and also the body will create sugar out of other substances in the body in order to supply the brain with glucose.

So if you keep in mind that fat burns when there isn't available glucose (that is, when the body is starving) and ketones indicate that fat was burned, then the following situations will be easier to understand.

Situations where you could have ketones:

- A non-diabetic can show ketones if he/she hasn't eaten for several days, or is on a severe weight reduction diet. In this situation the body is starving, and there isn't enough available glucose, so fat will burn for energy and the by-product, ketones, may show in the urine or blood.
- Pregnancy: During pregnancy, you are eating for two. If you aren't eating enough, your body will burn fat to get more energy. In gestational diabetes (temporary diabetes during pregnancy) and in pregnancy with pre-existing diabetes, women are advised to check ketones each morning. If the blood glucose is normal but there are ketones present, usually the mother will be advised to increase her bedtime snack (but you should first check with your healthcare professional).
- Hypoglycemia if you are taking diabetes medication: When no glucose is available, your body is in a starvation state and will break down stored fat to get energy. It is not necessary to check ketones during hypoglycemia and these ketones are harmless. When the blood glucose is low, it is most important to immediately correct it with proper treatment of a fast-acting sugar such as glucose tabs, fruit juice or a regular soft drink.
- High blood glucose: High blood glucose means you don't have enough insulin to allow the glucose to get into the cells, so the glucose is piling up in the blood and/or being excreted in the urine. Your body needs insulin to use glucose for energy. So if you don't have enough insulin, your body will start to burn fat for energy.
- Insulin pump malfunction or dislodged pump set: Insulin pumps provide a continuous delivery of background insulin. If the supply is disrupted due to a pump problem or a clogged/dislodged pump set, then no insulin would be available and, as noted above under "high blood glucose," you will start to burn fat for energy. Insulin pump users are trained to check ketones and to check the pump connections anytime there is unexplained high blood glucose, for the ketones may indicate a pump malfunction.
Illness/stress: When you are under physical or emotional stress, your body needs extra energy to fight it. Hormones are triggered, which tell the body to release stored glucose in an attempt to give you more energy. If you don't have enough insulin to help this glucose get into your cells, your body will again burn fat for energy.

Exercise: Exercise requires extra energy. If you haven't eaten enough or if you don't have enough insulin available to allow the glucose to get into the cells, again the cells are starving and will turn to fat for energy.

When ketones are a concern with high blood glucose:

If you don't have enough insulin available in your body, and the blood glucose rises, your body will eliminate the glucose by passing it into your urine. As your body takes fluid from everywhere it can to help dilute the urine and pass the sugar out, you'll get dehydrated. Because the glucose is passing out through the urine, the body is starving and fat will burn. If the body burns too much fat too quickly, ketones will accumulate in your bloodstream. Ketones make your body too acidic, which will upset the body's chemical balance. Your body might not be able to excrete the ketones adequately. In this setting, if your glucose is high, you are dehydrated, and your ketones are large, then your body's chemical balance is disrupted and you could develop a life-threatening condition called ketoacidosis. Usually only people with type 1 diabetes are at risk for this condition, but everyone should know the signs of Ketoacidosis.

Dietary Ketosis Is Often Confused with Ketoacidosis:

Dietary ketosis is often confused with Ketoacidosis - a life-threatening condition most often associated with uncontrolled insulin-deficient Type 1 diabetes. In Type 1 diabetes, a lack of insulin leads to a toxic build-up of blood glucose and an excessive break-down of fat and muscle tissue. Ketoacidosis doesn't occur in individuals who have even a small amount of insulin, whether from natural production or (if diabetic) artificially administered.

How are Ketones Removed?

When we burn a larger amount of fat than is immediately needed for energy, the excess ketones are discarded in the urine. Volatile ketones (like, acetone) can be expelled through the lungs. Diabetics are sometimes mistaken for being drunk by the odor on their breath.

Signs of Ketoacidosis:

- Increased thirst
- Increased urination
- Dry mouth
- Labored breathing
- Fruity breath
- Nausea/vomiting
- Stomach pain
- Loss of appetite
- Fatigue, drowsiness
- Dry, flushed skin or fatigue