Transcript

Danny Lennon: Hello, and welcome to another episode of Sigma Nutrition Radio. This is episode 458 of the podcast. Today we're going to be talking all about satiety, appetite, hunger, and the impact of various foods and nutrients. Of course, alongside me today is Dr. Niamh Aspell. How are you today, Niamh?

Niamh Aspell: Yeah. Good. Good to be back. It's been a while.

Danny Lennon: Yeah it has been a while owing to a variety of circumstances, including our travels, which we've just been talking about. And of course, then also here is Dr. Alan Flanagan. Alan, how are you?

Alan Flanagan: I'm good. I'm good. I'm fully back accustomed to UK time. I'm the odd one out actually.

You're now both in Spain, so you're on central European time because Franco wanted to align the clocks in Spain with Germany during the 1930s.

Danny Lennon: There you go, that is your history tidbit for the day from our resident historian.

Alan Flanagan: There's another useless fact in my head.

Danny Lennon: It's debatable. I think that's probably more useful than many of the facts we talk about nutrition most weeks, so I'm sure many people will be more interested in hearing general Franco, then some of the things we end up spending our time talking about. Yeah,

Alan Flanagan: Some good old nutritional nihilism to start

Danny Lennon: So with that, maybe let's start jumping into today's topic and just as a note for people. There are many things that, of course, impact satiety, and there are many aspects to appetite, which we'll discuss in a moment. But many of those go beyond some of the nutrients and diet directly per se that we won't be discussing today.

So if we think about the variety of foods people consume, sleep palatability, genetic factors, social situations, all of these can get tied into this conversation. We won't be able to get into in depth on much of those today. Much of our focus is going to be around certain macronutrients, different food types, maybe different food forms, and then some aspects of meal timing.

And even within that, there is a lot of scope. So we may not be able to get into the level of detail that each, individually, these topics could take, but we will do our best nevertheless. So as always, maybe the best place to start here is getting everyone listing on board and on the same playing field when it comes to some of the terminology we're going to use today.

And already I've mentioned things like appetite satiety, we have the closely related satiation and there's a few other sub components of those. So maybe I'll ask Univ to kickstart us today with some of those key terms that we'll mention throughout this episode. Can you maybe give a quick explanation so people can frame these correctly in their mind of what exactly these things we're referring to?

Niamh Aspell: Yeah. So I'll run through a couple of them. So satiety is one component of the entire control system. So when we think about appetite, this is quite broad and it covers a whole concept of food intake, selection of

what food you want to have when you're going to eat it, your motivation to eat, your preference of what kind of food that you want to eat.

And it refers specifically to sensory aspects or responsiveness to different like environmental stimulations around food. And it can be contrasted a little bit from more traditional ideas around this homeostatic view that we have an energy deficiency or, we require more calories because we need to continue to keep moving forward in the day.

So that's changed quite a lot when it comes to appetite. I don't know how we manage hunger and satiety. So satiety it's a process that leads to. Not eating anymore food. So it's inhibition of further eating. This will be like a decline in your hunger, an increase in fullness after a meal or after large snack has finished.

And it's also known as post ingestive satiety. So it's once you've consumed the food and started to ingest it and it's reached your gut. And then you've got tion. And this is obviously tightly linked to satiety, but this is the process of how you get from being hungry or starting a meal and not feeling very.

to determination of that meal. So over the course of eating and ingesting that meal, you'll become more satiated until you reach complete satiety. So this is also known as intra-meal satiety. So the process of getting to that point. Hunger then is essentially just our drive to eat.

So it, it's more difficult to measure hunger. It's usually quite subjective, but it can be linked to different physical changes in the body. So typical things like feeling lightheaded weakness, feeling this emptiness like a physical emptiness in your stomach. So I think they're the four, probably the four main terms that we'll probably refer to when we look at some of the.

Danny Lennon: Fantastic. And certainly we'll probably revisit some of the measurement for these different factors in a bit, which I'll ask you about. But for the moment, maybe let's turn to some of the physiological regulation o of appetite. And indeed this is one of the areas where we could probably spend hours just discussing some of the details here, which we need and get into everything.

But when it comes to some of these physiological mechanisms and a I maybe get you to walk us through some of this, what are some of the few things you think are worth noting about appetite, regulation and humans that will be relevant to our conversation for diet later on?

Alan Flanagan: Yeah, there, there's maybe a couple of levels that we can think of this. And by levels I mean almost levels in the body. The first is the brain. And we have various mechanisms and regions of the brain that are involved in the regulation of energy balance. And that regulation of energy balance is also influenced by an interaction with metabolic hormones like insulin, for example. Gut derived peptides like ghrelin, leptin, and also circulating levels of substrates, glucose free fatty acids. And these can feed back then to these regions in the brain essentially communicating to the brain in relation to energy status and also in relation to mechanisms of appetite regulation and satiety. And so we can have the regions of the brain. There is this kind of competing activity between or exogenic and anor exogenic neurons. So these are regions of the brain, primarily the hypothalamus and the brain stem that are involved in a balance of factors that increase drive to eat and factors that reduce drive to eat.

And those factors in the brain in hypothalamus and brain stem, like I said, are sensitive to circulating levels of nutrients and hormones. And these reflect both nutritional status and then peripheral energy stores like body fat levels. And so, There's this, obviously this, we're talking about a bidirectional relationship that in effect can be influenced by composition of diet, it can be influenced by properties of specific foods, it can be influenced by time of day. And many of these brain regions are also regions of the brain that exhibit robust circadian rhythmicity. And that's something that we can open a tab on and come back to later. So I think as far as the processes that regulate this, we have obviously what people, very broadly term, homeostatic and hedonic aspects of eating within homeostatic regulation.

We obviously then have those factors that are just described as competing or exogenic and anor exogenic. Neurons in the brain that relate to feedback from circulating nutrients and hormones. And then we have the kind of cannabinoid and dopaminergic systems in the brain as well, which have been studies ex extensively as it relates to more hedonic responses to food intake.

And these are primarily driven or often colloquially, termed, the "wanting" and "liking" parts of the brain. And this is the desire to eat. And then the hedonic response to that actual to that actual food intake. So there's, yeah, essentially multiple kind of sites in the brain that would express these... or multiple sites in the brain that would be responsive to the increase in circulating levels of nutrients and hormones.

And then also processes in the brain that would mediate processes that make people more prone, for example, to either an increase or decrease in relative satiety. And we can discuss the phenotype concept I think maybe later on.

Danny Lennon: Niamh, maybe I'll revisit that. Alan's outlined that there is a variety of these different hormones that are involved. You've already mentioned that certain things like hunger have a subjective component to them. And so later on when we look at the impacts of various different foods or diet on either satiety or even on hunger, but even if we just focus on satiety for now, there's maybe a variety of different ways which people may see that evaluated based on the type of study they're looking at, which ranges from objective to subjective measure, measures to impacts, or maybe later food intake. Can you maybe just give us a quick overview of different ways that satiety may be measured within research, and what are the most commonly used markers that would be used?

Niamh Aspell: Yeah. For measuring satiety, they're usually done in kind of acute food intake studies or acute food intake models, they'd call them. So most of them would First initially look at kind of the setting. So you've either got free living individuals or you have them done in lab type setting. So in this like appetite research studies, most of them will be done in some of these purpose built live-in facilities where they bring in the participants and they can very tightly control how they measure they're satiety or their hunger, how much they eat.

In general, the validity studies are quite strong in terms of measuring intakes, but it's not, necessarily translatable to what we're like when we're released into the world and we've to work and we've different exercise regimes and are eating behaviors are then like very different.

But I think some of these studies are done in combination, so they compliment each other in that way. So depending on the type of study, most

of the papers I think I came across were focused on these preload study designs. So these would be typically very standardized. So they would usually have bring in the participants that get them to control their previous day before they come into a certain degree.

So stop eating at a certain time. Eat your normal diet during the day before. Maybe don't exercise in the evening time or exercise at a, if you're going to exercise the day before the test to make sure that you follow the same pattern the next week if we bring you back in for a follow up kind of test.

But they would standardize the conditions for all of the participants and then they would give them either a standardized pre-load meal or they would allow them just to eat whatever they want and they would assess their satiety typically using a fast scale. So measuring on a scale of you just of a certain of a certain size, how full they.

So typically it's says, anchored with those two points, not hungry at all, or I'm not full. So there's variable times that they would do this in. So they'd give you the pre-load meal and usually assess how full do you feel at the start before the meal. They give you the meal, they'll ask you again to mark on the scale, how full do you feel, and then they'll allow variable times between then to assess that again.

So, they've all varied. A lot of the studies have varied from every 15 minutes depending on the type of food they're given as well. Ingestion time would vary depending if it's, say, a protein shaker, if it's a complete meal, and then up to maybe two hours or up to four hours, and then they would allow them to have the test meal.

So for that, then they get to measure how much food the person will eat four hours after having this kind of standardized breakfast. The test meal can be either a very clearly defined meal where everyone's given a plate of a certain quantity of food, or it can be like more of a buffet style.

So it's go in, eat as much as you want and stop eating whenever you're finished. The test meal can either be very structured in that they're looking at, how does this food keep you full right up until say lunchtime? Or they can just let them be more free in terms of if you feel hungry, again, help yourself to, to more food.

So they want to be able to assess subsequent energy intakes after the period of not eating. And then they'll either record that by measuring the food that was consumed or by allowing them to report in a food diary if they're, if it's a free living study. And then they'll assess those subsequent intakes, and then they'll typically measure your intakes for the rest of the day, and maybe the next morning, depending on say like the energy density of the food that they've given beforehand.

So the timing of the meal can be quite different. The type of test meal we'll go back to looking at all of those different gut hormones. They're all released at variable times or variable degrees, depending on like the macronutrient content. So if they're particularly focused in saying, does protein have a greater satiating power?

Then they might choose to give a protein breakfast or something like that. But most of their reports, for satiety, are self-reported. So yeah, how full you are: "not at all" to "extremely". And then they would typically calculate, instead of just saying how long does it take somebody to get back to their baseline or return to their baseline their baseline level of hunger or feelings of fullness, sorry.

Then they would usually go for an area under the curve. So how long and what's that duration or period of satiety and how well is that maintained over the four hours as opposed to how long does it take before this person wants to eat again? So it's more of the strength of satiety and how it's sustained.

A lot of them look at that and then there's been improved formulas on how to measure satiety over the last couple of years. One of them is this satiety quotient or quotient, and this relates to suppression of hunger or change in fullness to the energy content of the meal that's been consumed.

So that's more widely used. They also aro and a lot of psychometric tests because there's obviously lots of different drivers that would make us want to eat or have a tendency to eat. So there's the three factor eating questionnaire or there's also behavioral questionnaires as well. Because they typically eliminate participants who maybe don't have who have maybe different approaches or different psychometric traits that would encourage them to either not eat so much or to eat so much. So if people say, were anorexic, and they might be avoiding food. Typically they wouldn't take part

in the study, but they want to eliminate people who maybe have more stronger drive to eat or not to eat.

Yeah, and that's typically most of the studies have been done. They've added extra elements to also measure all of these gut hormones and the peptides. So they want to see how long after you eat a meal does CCK or GLP-1 increase? And how long does that stay increased? And can we manipulate that feeling of fullness for longer?

And obviously that's then can support people to make functional foods if they can play around with some of those biomarkers. So that's also, they'll do those intermittent blood draws throughout the study as well.

Danny Lennon: Now in terms of the impact of diet or foods on satiety, as I noted at the start, we'll probably think of this in a few different categories.

One is certain macronutrients. Then we can look at foods themselves. We can look at food forms, so liquid versus solid, and then the impact of timing. But before getting into any of the. Dietary impacts are nutrient impacts. Just to get to one thing that you raised a moment ago, Alan, and that was that despite the average impact of some of these different nutrients and foods and timing that we're going to mention, there is some inter individual variation here.

And you mentioned differences in certain phenotypes. Do you just want to speak a bit more to that and explain to people that concept?

Alan Flanagan: Yeah, so this actually emerged in some research on eating behavior and binge eating disorder specifically. And what they found and it relates to the kind of sides of the brain we talked about earlier. So we have these two processes, right? We have the kind of homeostatic process on one side, and that's this process of feedback to these brain regions from things like leptin circulation. And then we've got the motivation/reward side of the brain.

And that's the kind of wanting, liking. So one side wanting, driven by dopamine. That's "I have an intense urge to seek" of food reward. And then the liking side, which is driven by the cannabinoid system, which is where you have a response, a pleasurable hedonic response to the properties of

food. And some of the research on binge eating disorder, for example, identified the concept of a low-satiety phenotype.

And what this was essentially describing was that there are certain individuals who exhibit in response to certain food based kind of stimuli a greater level of disinhibited eating. Disinhibited eating is where essentially people eat without inhibition. It is what it sounds like, but it's essentially an eating without regard for any other... a loss of control over the eating episode.

And they also reported that they had much less self control in relation to their food cravings. And this was in response to, similar kind of test meals, so to speak. And so there was a from this kind of identification that there are perhaps a certain phenotype of individual that are more susceptible to the influence of foods that we would suggest have hedonic properties.

And these tends to be foods from a satiety perspective that are quite rich in fat, certainly higher in salt. Added refined sugar and flour and what we might broadly using the NOVA categorization framework term "ultraprocessed foods" as well. And so what's not necessarily understood that well at this point is the direction of effect; i.e. Is there, for example, lower inhibition to dopamine responsiveness as a result of continued eating of foods or from some, essentially predisposition to that. So at that point some of the neurobiology becomes more speculative, but certainly in that literature, a low satiety phenotype has been identified and that will be characterized by someone that is predisposed to greater disinhibited eating in response to hedonic properties of food and lower ability to self regulate in relation to cravings for foods.

Danny Lennon: So, if we turn our attention to certain nutrients, I think maybe the most obvious place to start is with protein. And I think if you just ask people who are generally interested in nutrition about ways of eating to promote satiety, one of the most commonly suggested things is getting high protein meals or higher protein intakes or and indeed as we'll discuss, maybe there is something to this, but I think sometimes it can be overly simplistic to think it's just a kind of continuing linear thing and just keeping more and more protein and you'll never ever get hungry.

So we can dig into some of the context there, but from an initial standpoint, Niamh where's the research brought us to this point in relation to protein, its impact on satiety. Why are those two things so commonly discussed?

Niamh Aspell: Yeah, I think there's a lot of like research right back to like the fifties and sixties into this, where it's highlighting that, if you eat a snack or a meal that has a set number of calories and you change the macronutrient composition of that and somebody's eating the same mental calories, that boat meals won't deliver the same level of satiety.

So you'd see this kind of most commonly where you'd say " don't drink your calories. You won't feel the same level of fullness." So they have done so many different satiety studies where they have compared foods where they match them for their energy content, but they've either changed the composition or the delivery of it.

So there's a lot of evidence for high protein foods that they're more satiating than carbohydrates and fat typically in that order. The very kind of early study show that intakes of proteins obviously alleviated circulating amino acid concentrations and this reduced hunger and foods. Right back, I think this, that study was like 40 years ago. So a lot more work has been obviously done since then. There's lots of different mechanisms of why that might have, might be the case. And obviously GI responses to dietary proteins reach the brain as well in an indirect pathway and a direct pathway.

So through the vagus nerve and indications for these circula amino acids, and it is one of the main triggers for the primary inhibitory hormone as well. Cck. So there's lots of, there's lots of good solid kind of scientific reasoning why. Be beneficial to have protein at a meal. It differs in its digestion and absorption rates and obviously those hormones all react and release at different times to delay satiety or delay gastric emptying as well. So you feel fuller, but it could be for a longer period.

Some of the early not early work, we'll talk about early two thousands or around 2010. There was a lot of work done at looking at the actual physiological changes when you induced or took in high protein intakes. And if they had any impact on these circulating hormones. So specifically, there was one paper published in obesity in 2013, and they looked at whether taking 60% energy from protein and you still had fats and carbs in that meal

would stimulate post meal GLP1 and P YY and they're the inhibitory... so they tell you're full, you can stop eating now. So they did a study, a very, a small group of participants. It was only eight volunteers in that study, but they were, it was a tree way crossover, so they were all served as their kind of uncontrolled, so almost triples the study sizes to that degree.

And they were all given very standardized meals. The calories were given in those pre-load studies at breakfast standardized for each participant. And so they were, it was very controlled and they took blood draws every 30 minutes for four hours after they had their pre-load meal. And what they were able to show was that the energy intake was the same for them all.

They had different components of the macronutrients in each of those foods, but when they were given the food that was higher in protein intake, that they seen greater increases in GLP1 and PYY and their area under the curve. There was no differences in hunger scores or fullness scores, but the area under the curve for these different proteins or these different hormones was a better profile in terms of satiation.

So it showed that within the body something was happening, but the subjective ratings of fullness didn't match up to those what they've seen in those blood draws in terms of how your body should be responding if these different hormones are increasing. And that was just one study that kind of had those kind of conflicting, you would anticipate, if these hormones are circulating for longer, that you should feel more associated for longer.

But in more recent years, since 2020, there's one particular lab; (Antonello) Rigamonti is the name of the investigator, and they've looked more deeply into trying and understand the types of protein, but specifically the me amino acids that are available from the proteins or, So they've done lots of studies where they've looked at either giving initially they did casing and what you study, so they show that, it's more, one protein is more easily absorbed than the other.

But then they wanted to know is it the particular components of these that are having the impact on those GI peptides? And then the subsequent then intake of foods. So they conducted one study in, in 2020 and they concluded that certain amino acids when they were adminis administered to obese teenagers would've fixed dose meal.

So they were all given a similar the same measured calories in the meal that they were able to provide a greater response in terms of releasing, again, these hormones. So GLP one, which is released from the gut. So this is there's four different amino acids in particular, L-arginine, L-leucine, glutamine, and also tryptophan.

Okay. And there's a lot of work that's been done as well, looking at glutamine and giving supplement of glutamine and how that can maybe increase push your glucose-insulin system to almost indicate that you've had you've taken on food. So they're, they've demonstrated some benefits to that so that we know that protein generally increases satiety to a certain degree, but it might be down to the types of protein as well.

And the combinations of what you're eating with that protein source as well. But it seems to be going from their research that it's good sources, good quality sources with high concentrations of certain amino acids may keep you fuller for longer. It also can delay p YY as well.

They've showed in other studies previous to that, that it's delayed the inhibiting feeding hormone as well and for about two hours post feed. So it's always interesting to consider the time periods where they're looking at the post feeding, because some of the meals that they've given in these studies are quite large meals anyway, so there's a high energy density and there's not a massive window of follow up as well for when you're feeling hungry. .

Danny Lennon: Yeah. So I mean, it's interesting. This is we have a general view that higher protein in a meal has this beneficial impact for satiety.

But this opens up then many interesting questions of the type, the dose and so on that, that you just outlined Niamh. And Alan, in fact, one of our recent conversations we've had on the podcast in relation to protein on a different measure, for example, muscle hypertrophy or repair, we discussed many of the nuances in the area relating to different types of amino acid profiles different sources of protein, and even the outcome measures that we're using to assess whether it's having an effect.

And I'm wondering from your kind of sense of the literature around protein and satiety, do some of the same issues rear their head in relation to. Thinking about these questions of different types of protein, different

measures of how we're assessing satiety in response to them. And where is your kind of general sense of what's happened in this particular area?

Alan Flanagan: Yeah, I think there are similar, Niamh outline some of the methodological approaches that are typically used in this area. And it opens up some of these similar concepts that we might think about for outcome measures in studies. One of the challenges with preload studies is that you are essentially measuring two things.

You've got the actual effect of the preload itself, depending on what you've gone for in terms of macronutrient, composition, sensory properties, total energy content, and otherwise. And then, You've got the actual effect of the meal that is served following the preload. And again, it's sensory properties, macronutrient, composition, and otherwise.

And so I think over the short term in acute studies that there may be in terms of those factors potential differentiation. In terms of protein sources, and particularly if there is to be a relationship with amino acidemia that might favor some fasting proteins. If you're doing an acute study and you're measuring subjective appetite over a two hour period but I think there are some general open questions within this area as far as outcomes go.

One just simple example of that is, although visual analog scales which need described in the, talking about the methodology where you're, you have a say a 10 centimeter horizontal line, zero being I'm not hungry at all and 10 being I'm extremely hungry, or zero being I'm not full and 10 being I'm as full as I've ever been. And you mark along there. And they are well validated, but those scales don't necessarily accurately predict energy intake, if that's one of your outcomes. And then we could look at objective measures of circulating, appetite related hormones like grum and in and that's where even from a protein perspective the correlation certainly with grilling doesn't necessarily seem to be that strong at all.

So, although, yes, there is a satiating effect of dietary protein that's broadly accepted in the literature there's potentially. Other mechanisms going on that are not related necessarily to some of the objective markers that we have. And I think in terms of the more broad characterization of plant versus animal protein and, animal protein sources are also sources of fiber and otherwise you're not really getting a direct test from a food based

perspective of isolated protein in the way that's a lot more easily achieved with animal sources.

Although possibly surprising to people would be the fact that, the effect of fiber on sata is not necessarily that. I guess what people might expect in terms of, I think people would assume there's this really robust effect of fiber on Satie, and that also really depends on the type of fiber and other factors or the influence with other nutrients in a test meal, particularly the fat content and gastric empty.

So as it relates to protein, I think yes, some of these issues do potentially raise their head whereby the type of protein if it favors fast acting amino acidemia in the circulation afterwards. And if there's this correlation with some of these amino acids and satiety, then certainly in an acute study with subjective measures of appetite, it could lead to one, to sources of protein looking superior to faster proteins looking superior, but it may not necessarily really reflect the effect of a total protein intake in the context of a total daily diet.

Danny Lennon: Yeah. So, so with that, I suppose just to think of questions people may have at this point, and particularly ones for practitioners or people looking for some pragmatic application here, which we'll probably discuss a bit later on anyway.

But in relation to protein, specifically based on the current evidence we have Niamh do you think what might be a set of recommendations. That either practitioners or someone as an individual that is thinking "Okay, I want to try and maximize satiety" or "I want to mitigate some of the hunger I feel between meals" for whatever reason.

Based on what we've said about protein potentially having this effect, what does that actually mean in terms of what those meals might need to look like? Amounts? Do we see a certain point where it becomes no added benefit? Is there a certain threshold to pass? Do we have answers to many of these questions?

Niamh Aspell: I think there's a couple of things there. They're interest in terms of like practical application and how you should maybe approach it. I'd over complicating it to a certain degree. So I think obviously we. Different

foods differ in their digestion rate. So if you are going to have some protein with a meal, that's better to have that whole source of protein with the meal.

In terms of remaining satiated for longer compared to having drinking the protein in a protein shake, what I noted in one of the studies where they were looking at trying to increase these tidy factories was the amount of protein that they gave at a single meal and based on the calories taken in that entire meal, it was a very large amount of protein.

It was 60% of their full meal was made of protein. And that can be difficult in terms of getting good quality sources of protein. Not everybody will have access to have 60% of their energy from their meal coming from protein. I think when we go back to that calorie for calorie, not having the same output in terms of satiety.

If you were to take a, a hundred calories of fat in the form of, say, butter wears a hundred calories of protein in terms of a chicken breast, you're going to be more associated by the quantity of protein you can get from that chicken breast compared to what you would get from having, butter on that piece of bread.

So I think in a practical sense and a very simple way, the protein is a little bit better. And then there's also timings around how you eat the protein meal. , if you are, say, sitting down and you have all of the different components in your meal and you have your protein, your fat and your carbohydrates, if you need to get that energy in quickly and if you need that energy source, you need to eat your carbohydrate as obviously can be ingested quite quicker.

Whereas if you're looking for sati and keeping you later, keeping you feeling fuller to later in the day or later in the kind of meal, it's better to start eating your protein and your fibers forehand or eating as a combined meal, so like a sandwich or something. So you're consuming them all takes a little bit longer for it to break down, but it's those other components that I think are added to it that increase that, feeling of fullness to distension in the gut.

There's lots of other, making sure that you're. All of those factors contribute to it as well. So when it gets to the more specific details of it now where they're focusing very specifically on which amino acid is going to increase a

tidy or make you feel less hungry, or they are given pharmacological doses of these amino acids, so you're not necessarily going get it from a protein shake.

They're giving these amino acid pre-prepared mixes that are at very high doses that you can't pick up off a shelf. So, that can be a little bit misleading as well. And the thing with satiety is it might improve like Alan has said, it might improve your sati that might feel more full, doesn't mean I'm going to stop eating.

So when it comes to energy balance and a lot of the health claims around foods now, if it's a breakfast cereal bar, but now it's got added protein, so you'll feel fuller for longer. That doesn't necessarily mean that you'll stop eating as well. You're like, Okay, this tells me I'll feel fuller for longer, but it doesn't necessarily mean that I'm going to eat less. I'll still consume the same amount or more. So I think it, it's to be careful around some of those claims as well. Particularly they might have more calories and more protein but not necessarily have the impact. I think sometimes we confuse fullness or satiety with it will, this food will stop me for eating. Whereas that's still very much a motivation. Your desire to eat is intrinsic.

Alan Flanagan: Yeah, that desire to eat, like we can put someone like Niamh described this methodology where, you take people into a lab, you give them a preload, you look at how much say for example, their area under the curve of subjective appetite was after an hour or two hours, four hours, you may be present them with a subsequent meal.

And you see how much of that meal they eat. But those acute studies are designed to minimize the types of environmental inputs that influence this other side of the picture, which is the kind of motivation reward side. So a lot of those studies are essentially looking very much at more of the kind of, the homeostatic regulation and people's short term responsiveness, independent of environmental stimuli.

And as Niamh said, that doesn't necessarily translate to the factors that might cause someone to continue to eat in the real world just because we've measured their satiety and we go, Oh this, these foods are quote satiating. And so we have to be quite mindful of what these experimental designs are in terms of their external validity to a world and an environment that we know is designed to get us to eat.

Danny Lennon: Absolutely. So we have these many other factors that drive us to consume food that are going to go far beyond changes. We might see in a certain number of gut hormones as an example, which is often what we may measure here. One of the other difficulties I think with this is that when we're trying to look at the impact of a certain nutrient, this is sometimes can be difficult to tease out if it's down to that nutrient per se, or just types of foods or diets that contain that.

And I think this is maybe where some of the over emphasis on fiber that you mentioned comes from Alan. Because we can note that things like high fiber foods and high fiber diets are commonplace to recommend if someone is aiming to have a more satiating and diet and higher levels of satiety throughout the day.

However, whether this is actually down to fiber per se, or just whether it's down to other components like the energy density of which high fiber foods tend to have lower energy densities is tricky to pull apart. So in relation to, to fiber itself, can you maybe just speak a bit more to that, Alan of what you mentioned a moment ago that the evidence may not be as overwhelming as it is sometimes presumed?

Alan Flanagan: So there's maybe two ways we can think about it. Fiber, obviously itself as a kind of nutrient and, fitting within the consideration of the differential macronutrient effects of satiation and we'll put fiber into the kind of carbohydrate umbrella, and then potentially the effects of foods themselves and their individual properties as a standalone food that, that may or may not relate to for fiber, for example.

So one example that I'll mention is in relation to oats. So we know that fiber's not digestible and there is associations with, satiety and perhaps reduced food intake. But we don't necessarily know, for example, whether that's directly related to an effect on fiber. Like everything Niamh was just discussing in relation to protein is very much a kind of direct effect of protein, right?

It's related to circulating amino acids, potentially it's related to other properties of protein on metabolism, thermogenesis and these other, and potentially impacts on gut derived hormones and peptide hormones. So this is direct effects of protein, but with dietary fiber it, one factor could be that

it's the effect of fiber in the context of mixed meals slows, for example, the gastric emptying rate of other nutrients.

And there's, there was a meta-analysis a couple of years ago which looked specifically at fat and fiber. And we know necessarily that fat does not have a particularly strong satiating effect. And that ne used the example of the butter in the chicken, and that highlights why.

And it's because on a per calorie basis, it's high energy density really means that per gram of food for a unit of energy fat is, doesn't particularly have a much of a satiating effect. But that, that meta analysis ultimately found not a particularly overwhelming effect of fiber.

And that could have been due to the fact. Again, there's a kind of lack of, perhaps a common issue with nutrition. Meta analysis is what do we mean by fiber as a kind of broad term? What foods are delivering that fiber? Is there a difference between soluble, viscous and viscous fibers?

So I think that overall there, when I look at some of the food based interventions, there's been a number of nice studies that have looked at the viscosity of oat fibers the bead of and other fiber types in oats, which tend to hold water as they're moving through the bowel. And there's been.

Interesting studies on those on oats specifically, which showed quite a strong satiating effect of that food. And that may relate to the viscosity of the fibers in those foods. So there may be specifically an effect of more viscous fibers, which hold water and as a result of that holding water an expansion as food is transiting through the bowel, maybe has a satiating effect.

And that would be then a direct effect of fiber. But there's potentially indirect effects as well. So it's not to say that there is not an effect on fiber on sata, it's possibly that the research designs used to look at fiber make it somewhat difficult to tease out or to identify either direct effects or indirect effects.

And perhaps, It's more, there's more utility to looking specifically at different fiber rich foods to try and determine whether they have an effect. But because fiber can't commit, then travels with foods that are, have carbohydrate, often have protein as well. If you're talking about legumes, it can be hard to disentangle the respective of contributions of of these

macronutrients. Some of which we know have more direct influences on satiety.

Niamh Aspell: I'm just in agreement. I think that when it comes to fiber, they obviously have those textural, bulking properties and they're also very typically low energy density foods. So if they're incorporated into a meal, they can take a little bit longer to chew.

They increase gastric distension, they make you feel a little bit fuller. So if people are reducing, say, an energy density of their meals or their reducing calories over the course of a day, some of these foods can then physiologically and also just physically make you feel a little bit fuller for longer.

A lot of the studies I've seen, they're hard to compare because some of them look at like whole fibers. So they might look at like different cereals or oats or then they might look at isolated fibers like add added fibers to certain kind of foods. And obviously that makes a bit more tricky because they're usually added to things like snack foods to try and make them, to encourage people to get more protein or to try and make a snack food seem like a bit of a more healthy alternative. And then when they did intervention studies of adding additional fiber to the diet and it's effected kind of changing satiety or reducing say glucose response after a meal, they used quite large amount. Of fiber as well. So there's one study that added an extra 250 grams of raw spinach to a meal, which is like a full bag of spinach, isn't it?

That's like quite a lot of spinach. So I would reduce satiety then as well because I'd get fed up of chewing, I don't eat anymore. And that comes to the sensory stuff as well like how much you want to eat this meal and how much would you continue to eat this meal every day. There was another one that I thought was quite funny where they looked at in a dose response of fiber and they gave you either a 100 grams of carrots raw, 200 grams or 300g. And the result of that was that more carrots make you more full. And I was like yeah, like 300g is quite a chunk of carrots to get through. So it comes, I think there is as well. Then looking at the fermentable and non-fermentable, there's a lot more work. That focuses on what happens when you break down those foods, the gut microbiome, fatty acid release, and how they improve the environment of the gut to a certain degree, which might help the release or

the response of some of those gut hormones to move up to the brain and let you know that you're full.

So that's I think, where some of the more interesting work is done. But we know if you increase your fiber intake, it's typically true adding more vegetables, which also have a higher water content. So they will initially make you feel fuller for longer.

But what. Will they have that same prolonged society until the kind of the next meal? Or do you kinda direct saying, Oh, that meal I filled a half a spinach anyway so I can, I can eat more again sooner. I am going to be hungrier soon because it wasn't as energy dense. So there's there's preference involved I think, as well in terms of whether you want to bulk out some of your meals or extra fibers.

Danny Lennon: Yes. So, thinking of some of those issues, the difference between direct and indirect effects there's different types of fiber and therefore they may have differential impacts or the way the, or where we're getting that fiber from, whether it's an added supplemental fiber versus part of a certain type of food that has these other characteristics as an impact.

Probably some of those things may map on then to thinking about dietary fat because this is a macronutrient that we can, we've. Already said, generally probably has a lesser of a satiety impact than say protein. But of course, this dietary fat can be broken down into different types of fat how it's consumed can come in different forms, whether it's part of a larger meal or isolated whether it's in a, an oil or part of an actual, something like a not.

So we've all these different issues that have been similar to some of the things we discussed about fiber. So, and even relation to dietary fat, what are some of the things you would flag to people about, again, how we think through what is the impact of consuming fat on satiety?

Niamh Aspell: Yeah, I suppose it, it probably starts with the quality of the fat taken as well. So obviously if you're eating like highly processed foods that have lots of kinda like additional trans fats or lots of extra added calories to a meal that typically won't make you feel fuller. These types of foods as well also encourage you to eat more in terms of like they're extremely tasty and maybe more of an addictive kind of eating behavior around them.

But if there's lots of studies done as well that look at better quality fats. So you're oleic acids, linoleic acids and then they also looked at saturated fast acids in a couple of studies. A lot of this work is done by the University of Leeds and they were the first to describe this ' Satiety Cascade' as well.

And that's been updated quite a bit in terms of what makes us satiated. But they did one particular study was published two years ago looking at the degree of saturation of fatty acids post ingestive satiety. How it influences that. And that was published by Claire Lawton. They did two studies and they presented them both in the same paper.

They, but they were carried out to understand the contribution of fatty acid structures on satiety in human subjects as well. So these experiments were designed to see if those, there's a relative contribution to how full they felt after a meal, depending on the fats. And they were particularly interested in looking at kinda short chain or long chain fatty acids.

So for the test, They contained, they gave three different types in the first study, and then they followed up and did a second study as well with an additional combination of fats. These were in healthy individuals that actually free living individuals within the university. They had 20 people in both studies. They were quite young, they had a normal BMI, but both of the studies that they conducted were designed to compare the effects of either eight carbon atoms of fixed chain length fatty acids, or then after a high fat meal. So the effect on the profile of their motivation or their desire to eat or their energy intake for the rest of the day.

So they followed them up on the rest of the day and the following day after eating these high fat meals. So there was 55% contribution of these fats to each of their meals. And they wanted to see if different types of fats obviously had a more of a less of an impact. And then they did weight food records the next day as well. So was this were associated for even longer? Was this more, more prolonged? There was lots of different combinations of the fats and they all acted as their own controls. So there was a number of a number of different ones. But once they took part, once they were recruited in the study, they arrived, they did, like we said, that fast scale indicating how hungry they were before and after the meal.

And they were also allowed to drink and eat as freely as possible. And they were able to show that some omega (fatty acids) and certain amino acids as well, when they were ingested in the gut, produced different responses in terms of your satiety releasing hormones and then also the degree of satiety that you felt afterwards.

But it's not... From looking at the two studies, the initial study obviously provided more evidence that the longer chain fatty acids contributed. But in the second study, the results weren't quite as obvious. In the second study. So results showed that this short chain, the short term studies on the PUFAs makes, are is slightly stronger satiating effect than the the medium or the saturated fatty acids.

So these kind of the PUFAs or the polyunsaturated fatty acids were more preferred. So linoleic as opposed to some of the combination blends. But that's a more in depth, a very specific focus on certain forms of fats as well. And then I think most of the evidence has much more focused on the energy density of the foods. So fats typically, they are much higher in calorie content, so they are, you are more likely to eat more and feel less full.

Alan Flanagan: I was just going to see if Niamh is familiar with the work of Tucker Goodrich on linoleic acid? I was in a debate. It it wasn't a debate, it was a game of chess with a pigeon.

Niamh Aspell: God, you saying you've done a debate makes me nervous. ,

Alan Flanagan: It was a game of chess with a pigeon and the guy thinks that linoleic acid is responsible for obesity, diabetes, cardiovascular, blah, blah, blah, everything, basically everything. And one of his theories that he offered okay, was evidence from mice that linoleic acid, that there's a pathway, the mag two pathway in the brain that's involved with apparently they tried to develop an anti-obesity drug to target this pathway. But I think maybe... a linoleic acid metabolite is the substrate for this pathway. So he's joined the dots that linoleic acid is obesogenic due to this pathway. So when I saw that John Blundell's group had published that paper with linoleic acid having one of the strongest effects, I was delighted. Oh, I just feel so good.

Danny Lennon: A fantastic moment in internet history.

Alan Flanagan: Yeah.

Danny Lennon: Yeah. So we've noted here about fat has probably this lesser satiety effect, and we've mentioned them, the energy density, which will certainly come back to in a moment. And of course, most of these fat sources are going to have high calorie content relative to their volume.

But then there's this also the issue that sometimes gets raised here, and I'm sure you've been. Face with this a as well, that there actually seems to be at least some literature where people base this on where they say a high fat diet can actually provide the society response not directly because of the fat per se, but if you are in a ketogenic diet, then ketones themselves then can have a potential impact here and therefore can explain why people don't overeat on such a diet, or at least allegedly have the incapacity to overeat on this.

Now, of course there is something around some of the impacts of ketone metabolism that gets interesting here. What's your kind of sense on this area? And again, we don't have to get into all the details for the sake of time, but what you're going to sense of the area around ketones?

Alan Flanagan: Yeah I think that there is some interesting mechanisms by which fat may under certain circumstances influence satiety. And I think that perhaps when it comes to the evidence we've just discussed, for an overall lack of satiating effect of fat, I think as Niamh described, that probably relates the energy relates to the energy density of fat relative, on a gram or gram basis, the energy derived from fats being higher.

And so as a function of the characteristics of fat based foods like butter you don't have the properties that might confer the same side type of satiation that you would get. And again, that's born out when we just think about fat broadly in the research, a very weak, satiating effect. But there potentially is a role.

For individual fats, niamh mentioned linoleic acid there which with the, it was the satin study, wasn't that the acronym for that trial. And the potential correlation with circulating long chain PUFA and improved satiety. And I remember some research from Margriet Westerterp-Plantenga and looking at basically the like additional fatty acids into foods and looking at sensory satiety.

And when they added linoleic acid to foods that they also showed a kind of termination of eating, actually based on the linoleic acid content. So there's potentially some bits there. And then if we dip further into kind of physiological states associated with dietary fat like ketogenesis the, it's arguable that the protein content of a true ketogenic diet, because one thing when people in the general sense say, "I'm on a high fat diet, I'm really satiated", and you see this a lot in the kind of social media type conversations actually, when you look at food choices, they're eating quite a high protein diet, so it's impossible to disentangle the well established effect of protein versus the fat content of a steak, for example.

But with a ketogenic diet, it's arguable that protein intake, if they're averaging 15% of energy from protein, isn't quite high enough to have that confounding effect. And so what then becomes the question is the potential satiating effect of that diet, which is reported, self-reported, certainly and is evident in some of the literature related to the dietary fact com composition and content of that diet in the absence of significant contributions from protein or carbohydrate, or does it relate to the physiological state of ketosis and the production of ketone bodies?

And there is some very interesting, mechanisms offered to explain, particularly for beta-hydroxybutyrate (BHB) , a potential satiating effect of BHB. I mentioned earlier that when we've got this on the left side, we've got the homeostatic regulation processes, which is an interaction between brain regions and circulating hormones and metabolites. One of those is be a hydroxy. We know that there is feedback from circulating BHB to some of these areas in the brain responsible for homeostatic energy balance control. So it's a possibility. There's not great evidence in humans.

There is some interesting mechanistic explanations. We don't really have robust outcome data in relation to it. So I think to be fair to the ketogenic diet and the very interesting physiology that it entails there's probably a tab to be left open on that question for now.

And based on everything we know about dietary fat I would be leaning, although, again, leaning on the basis of very weak evidence, to suggest that if there is a satiating effect of a ketogenic diet, it may relate less to the dietary fat component and more to the physiology of ketogenesis, specifically

circulating BHB and its interaction potentially with brain regions involved in energy balance.

Danny Lennon: So need maybe just to complete the loop on the energy density piece that we've mentioned a couple of times up to now. Of course here we're referring to the number of calories of food has per gram of amount of that food. What is, from an overview level, like where are we in relation to energy density, how that relates to satiety and what do you think is a kind of fair conclusion in this area?

Niamh Aspell: So there's a lot of observational studies folks in on, people's preferences for certain foods and typical foods that, that people have found to be more energy dense is very much related to their calorie intake and the amount of kind of food consumed by the, by different groups.

There's been a number, there's been a number of studies, lot the US studies where they reported eating kind of lower energy density diets to help them eat fewer calories overall if they still consume more foods by weight than people who ate at a higher energy density. So I think there is and we know this, I think that a lot of the dietary recommendations around, have a small salad or have a kind of clear kind of soup or a vegetable soup before a meal improves satiety by adding kind of these lower energy density foods to help contribute towards feeling more associated, there's not a massive amount of, confident conclusions in terms of how much longer that will keep you satiated.

So therefore, how less are you going to eat over the course of a day? So in terms of energy intake, it doesn't seem to have the same translation in some studies. And then other studies, there's also like very demonstrated effect effects that if you're drinking water or having these smaller meals before larger meal that are, made predominantly of say vegetables or watered that you will typically eat less in the subsequent meal.

But then there's other studies showing that people overcompensate for that kind of later in the day. So it's more comes down to your habitual behaviors, I think as well. . There's obviously foods that stimulate you to eat more as well, which are more energy dense. So things like the fats are the highly processed foods as well.

But I think longer, more longer term studies will provide like a little better evidence around if you're reducing the energy density and if this will over time, significantly contribute to decreasing your calorie intake and maintaining that. Fullness. Because once that food is broken, then your body is still requiring that energy again or needing that energy again.

So, I think for some people they use it as a very good way of maybe controlling their in intake of food or keeping them full between meals, having these lower energy density snacks between eating events, bigger eating events.

Danny Lennon: Yeah, this is interesting and I think in the lead up to this episode one of the papers that was recently published that I came across, and I think I a link to you guys was a paper from Annika Flynn and the group in Bristol where it's quite interesting that they used data from a secondary analysis of Kevin Hall's ultra processed food study, which we may mention in a moment as well as some data from the National Diet and Nutrition Survey in the UK.

And some of that, or what they've suggested based on some of those findings is that there's this like volume signal that is dominant at lower energy density foods. And then with higher energy density foods, it's more of the calorie content that is the primary signal towards satiety. So like these, this seems interesting and obviously there's a lot more questions to answer but again, it opens up then a discussion of not only the energy density, but some of the ways people view food volume and their use of those things to mitigate hunger and so on.

So yeah, I dunno if either of you would add anything to what we know and in relation to energy density and so on or we can move on from that component.

Niamh Aspell: I think it goes back to probably the studies done in like the 1950s where they initially looked at like distension of the stomach and the volume within the stomach and where it made people feel uncomfortable.

So I think they made people either swallow a balloon or they inserted a balloon and blew it up. And at what point did you not want to eat anymore? Did you feel uncomfortable? And I think it was around 400 mls. But if like

various, simply speaking, if you put 400 mls of an oil in somebody or 400 mls of water or grams of a fruit of vegetable, you're going to feel that distinction kind of quicker and obviously feel associated or full, straight away.

And a lot of these studies, if you're looking at measuring these post meal load, if they only follow up for two hours, you might continue to feel full for those two hours and have a similar curve or similar under the curve. But it's what's happening then after that? Obviously if you drink 400 miles of oil, that's going to make you feel.

A bit rough, but in terms of actual physical component and interacting with those neurons in your gut, the signals go into your brain. You're going to say I'm full now I'm full or feeling of that fullness before you then go eat an actual meal, making sure that you're hydrated beforehand.

Danny Lennon: Yeah. And on that note, if people listening are interested, I think back in, I've just checked, it was March of 2015 I did a podcast with Barbara Rolls in this area who most people who've looked at this area of research will know that name in her role in like volumetrics, satiety and so on.

So that might be one if people want to go and listen to probably a very poor interview on my behalf. I'm not too sure. I can't remember what I was like back then, but certainly, hopefully not as polished as now. So within that, let's continue to think about the impacts of these different foods. And one of the ways that most people have heard of maybe at this point is this idea of this satiety index, which was popularized based on research from the 1990s.

Niamh, do you want to lead us off into the kind of an early development of that index and then maybe anything practical from this point on.

Niamh Aspell: Yeah, so it's quite a useful tool. It wasn't it's quite old now. To a certain degree it's maybe was like in the early nineties, I think, where they conducted a study.

Susanna Hall conducted a study where they created or tried to create a sat entirety index of commonly consumed foods. So they gave each person a controlled portion. They had a controlled portion of energy, so 240 calories in

38 different food types. And they obtained satiety ratings after they were consumed for 15 minutes up to a two hour period.

And then the satiety index score was computed using area under the curve. And they used a reference. I thought it was potato was actually bread, so white bread. So the white bread had a satiety score of a hundred percent of that, of the test food. So it was expressed as if you have chicken, it has a certain percentage satiety compared to white bread.

So it could be like, you'll be 300% more sead or you'll be less associated if you eat this food compared to what you would be if you ate white bread. So the highest score was produced from boiled potatoe. , and that was over 300% in terms of its if you're talking about relative to white bread or the lowest was then a crosson.

So if you're focusing on carbohydrate, you'll feel least full if you have a crosson and most full, if you eat boiled potatoes, then that's comparative energy again. So at the same amount of calories. So, most foods had a score greater than that or equal to bread. I don't know if that's what kind of demonized white bread then.

But it keeps you kinda less, less flu. So it comes back to the fiber content and then energy intake after the two hours correlated than in a negative direction with the average satiety area under the curve response. So protein, fiber and water contents of the test food were positively associated with having a higher satiety score.

Danny Lennon: Awesome. And so yeah, notwithstanding some of the methodological issues that we've discussed earlier throughout this podcast and some of the nuance there, it has at least some initial utility of thinking about different foods have these differing effects and as. We maybe just touched on one of the areas that's become more scrutinized now of not only being deleterious to health, but particularly can easily promote over consumption for many potential reasons, is that of ultra processed foods.

So if we're to narrow in on ultra processed foods and specifically how they impact some of these measures of satiety Alan, what is your sense of the literature relating to ultra processed foods at the moment?

Alan Flanagan: Yeah, I think that there's so ultra processed foods are categorized by the NOVA classification system. And so the classification system relates to degree of processing and I think they, in the context of our current food supply then becomes an important distinction to make because if we say ultra processed foods, most people will likely think of a muffin or a donut, and that's correct. But for example, Quorn mince would be considered an ultra processed food because of its processing to produce the product.

But that doesn't necessarily mean that it's "unhealthy". And so while the NOVA classification system is useful for our current food environment and supply, it's also important that we don't assume that any food within that classification meeting that designation necessarily is all having a similarly equal effect.

The big lid in terms of ultra processed food as it relates to satiety and energy intake, was Kevin Hall's metabolic ward study, which compared a nonprocessed foods diet to an ultrapro foods diet. And they were looking to match the diets across all of these metrics of like calories, macronutrients and energy density indeed.

But it was an ad libitum study and there was significantly greater average energy intake on the Ultraprocessed food diet compared to the unprocessed food diet. And. One of, the conclusions coming from this then was if you're doing everything you can to match these foods for the kind of objective nutritional factors that we might consider are there properties of these foods themselves that inherently then precipitate over consumption?

And what's interesting about Kevin Hall's research is that he publishes like the meals the photographs of you can see what they were eating. And interestingly, I remember looking at the photographs of the diet and thinking, I mean, it wasn't like they were just eating donuts all day.

And I think the people can have that conception. So, I think that was, look it, it had all of the rigor of any of Kevin Hall's metabolic ward studies. It certainly suggestive that these foods are. Prone to over consumption which may relate to the sensory properties of the food itself. Remember that this was a lab study where patients were remaining as inpatients for the duration of the study.

And so it's minimized a lot of the environmental inputs that we might otherwise think could have an influence on over consumption. But there's also then suggestions that, some of the other classic, particularly meet alternatives, although they're designated, and Mark Messina had a paper about this basically considering meat-based alternatives as an ultrapro food probably isn't necessarily representative of their nutritional composition either.

And so although they would meet that categorization for the purposes of the NOVA system, it doesn't necessarily mean that. If, Kevin Hall's subjects were sitting down to a Quorn mince meal would the same effect of being observed? Of course, this is a very high protein food.

So are we then looking at satiating effects of protein again? So I think that. In terms of the typical foods we would designate as ultrapro foods, it does appear that there are properties of those foods that make them more vulnerable to over consumption. But we shouldn't necessarily assume that any foods that meets that categorization necessarily would have that effect and we should determine those foods based on their nutritional composition as well.

Niamh Aspell: Yeah I might just mention one other thing on those ultra process foods are that studied done by by Kevin (Hall) as well because it was a really nice study. I think one of the things that stood out most to me was like, like a had mentioned the types of ultra processed foods that they were consuming weren't what you might actually expect. And the participants did state on both sides that they both found the meals, irrespective of if it was the ultraprocessed or not, to be equally as tasty or to be as equally as enjoyable or as pleasant. But obviously I think the ate by 500 calories more if they were on the ultra processed and diet. And then the ultra processed food just came in as a lot cheaper.

I think it was about like a hundred percent cheaper. So it was like a hundred quid or a hundred dollars a week. To provide the same amount of calories on unprocessed meals was 150. So I think as well, that kind of comes back down to lifestyle choices whether you have the money, whether you have the time for certain meals.

And then when they were looking at different biomarkers, if you're looking at the ultra process foods, they're much more easily consumed. So they're like the energy density comes back into it again. So it's eating. It's, I think it's a lot of, it's very much so in, in practice outside of these lab conditions is dental lifestyle factors and.

There's other studies that have come quite recently from then as well, looking at specific types of additives that have been put into ultra processed foods, particularly. and multipliers, and I think that's where they're going to look at a lot more around satiety because the interaction of these emulsifiers that are added to certain foods to improve their stability or to allow them to be on a shelf for a longer period of time can have an impact then on, on your gut lining, and we obviously, if you're releasing gut hormones, that might be impeded if there is disruptions to your gut lining as well. So just wanted to drop that point in quickly as well.

Danny Lennon: So, so thinking about some of this as well and the types of foods we consume. There's a slightly related issue here around the form that a food can come in. And so this can either be studies looking at beverages versus solid foods, or it can be one type of food in these different forms.

So for example, a number of the studies are quite common to see a whole apple versus some apple sauce versus maybe some apple juice. And then ones within without fiber as a way of seeing, okay, we have the same thing here, but they've been processed in a different way to be either solid or liquid or something in between.

And this has a couple of implications. One is how we think about the role of just consuming calories from beverages. And that might be a bit more obvious, but then there's also maybe people having questions or worries of saying, Oh now is it a problem if I make a smoothie, for example, with my fruit and veg?

So as it relates to this issue of solids versus liquids or different forms of foods, where does some of the current literature point us at the moment do you think, Niamh? What are some of the studies you might want to outline or where do you think the current evidence is sitting?

Niamh Aspell: I think it's yeah, I think it all comes down to, if you look at the satiety cascade, it's all focused on the release of different hormones based on the, like pre absorption qualities within the system, and then the post absorption and what hormones are released and what degree they're released at and for how long.

So naturally, if you break down the structure of a food, it's going to be ingested a lot quicker. You're going to have a quicker either glucose response or release of these particular hormones, and then you'll reach your baseline of. Feeling hungry again more quickly. There's been a lot of if you're looking at like foods or particularly looking at liquids, there's also lots of interest and stuff for some liquids that can like suppress appetite in terms of drinking coffee that can have an impact.

And then also alcohol is probably reduces your inhibitions around dating and you might consume more. But I think if we're talking about actual food constitutes and the idea. Growing up and being told not to, drink your calories or drink added sugars. Again, if you look at like simple things like carbonated drinks, if you can easily drink, say, 500 milliliters of sugar or of drink sugary drinks and not have the same kind of impact if you were to have, say, 200 calories worth of a protein, of a raw protein in terms of like chicken or eggs or something like that.

There's lots of research done. This is looking a bit more specifically at the properties around the forms that foods are consumed in. So I found loads of research about almonds and how they improve satiety. But one of the particularly interesting ones is looking at in what form you eat almonds.

So whether it's in their raw form, whether they've been roasted and chopped, whether they are consumed as a an almond. spread. So completely broken down. And I thought this was particularly interesting cause I think a lot of people, typically when they're looking for a snack, they might go to add some kind of, a protein or sorry, a nut butter to certain foods to help, improve the fullness that they might feel from that.

And there's really interesting studies, I don't know if this was again, the University of Leeds. I don't think it was, that they've done obviously a lot of work in this area. The Almond Board of California. Funded so many studies,

they're really pushing people to almonds. But there was a full symposium on this and the Nutrition Society maybe this year, last year.

It was very recent. So they had a whole breakout of different investigations into looking at almonds. But they showed us essentially that these ation studies, So if you were to break down foods, so you're examining the structural properties of foods that the digestibility experiments show that you feel much more satiated if you eat raw almonds and then it's in a relative drop in terms of then if you eat roasted almonds, if it's then isolated almond oil or if you're eating fully broken down.

Almond spreads or almond pasts. And this directly relates then to the rates or the extent of then lipolysis afterwards. And they were observed in kind of in lab studies, but then replicated again when you were to look at the consumption patterns or satiety and the duration or the power of satiety, they've called it by eating foods in these different forms.

So whole almonds have a, like a nutritionally better profile in terms of keeping consistency with your satiety. So being the nu is ingested in its kind of highest form of protein and fiber in combination and that's a high, obviously a high fat food. So I think when it comes down to then looking at studies where if you consume.

Almonds as a snack compared to other particular snacks. Sometimes the results have been quite skewed. One of the studies showed that if you eat if you eat no almonds as a snack, then you're less likely to, you're more likely to eat more later in the day. And then they did another group who had a very small I think it was like 28 grams of almonds they had the least.

And then if you give someone a larger amount of almonds, they were eating more again. So there, there wasn't much consistency in terms of almonds as a snack. I think it's more so whether you have a snack or not in the middle of the day, but because they're high fat foods, I think a lot of times myself included a, like a portion of nuts is I usually halfway five in a sitting and because they're so high energy dense then as well the overall contribution of your energy intakes in a habitual way as opposed to when these really controlled ways is represented then these free living or randomized control trials.

Danny Lennon: So in general we see that a across some of that literature that is probably wholly unsurprising that, yeah apple juice is going to have a lower satiety response than eating a whole apple. I don't think that would surprise people.

And it probably ties in a number of the elements we've already mentioned already. Not only the form, but that of course relates to things like the fiber content the chewing, et cetera. So just for the sake of time, if I to make sure we have enough time, and maybe that's the appropriate word for the final section is on the impact of timing.

There are a number of components to this that we could look at. One you've brought up already Niamh around the food order. We can maybe spend a little bit of time on meal frequency, but probably maybe the best place to start. And I think, Alan, you're probably. So much as familiar with this literature more than most is around the impact of time of day as well as some of the circadian effects and how this relates to satiety.

So based on that, either these kind of time of day impacts circadian system and so on, what are the main things to highlight for people?

Alan Flanagan: Yeah, I think, without getting into all of the rather. Overwhelming amount of detail that exists for various brain regions and the role of the circadian clock in all of these brain regions.

There's an enormous body of animal model literature, which are the primary model to, to look at circadian behaviors and circadian rhythms in different aspects. And there's some really fascinating stuff there. When you knock out certain parts of the brain and mice or rats and what happens to their eating behavior, what happens to their regulation of energy balance?

But I think justifies it to say for people that a lot of these regions of the brain that we've been discussing earlier, in terms of homeostatic energy regulation and hedonic, motivation, reward systems, all of those brain regions, whether it's the arcuate nucleus or the lateral hypothalamus, they all appear to have robust circadian rhythmicity and projections.

So there is likely to be a circadian component to some of these processes. And indeed, if we think about just subjective hunger and appetite some of

frank skier's research looked at the rhythm in in, in subjective hunger. So this was not measuring something like ghrelin, this was subjective measures, and it found that independent of the behavioral cycle, there was a circadian rhythm in subjective hunger that peaked in the biological evening what would be around 7:00 PM clock time or local time for people.

And that's also interesting if we factor in, if you look at again, some of eating disorder, disordered eating literature, where you get in terms of the behavior of binge eating disorder in particular typically occurring in the evening. Now it's obviously not just related to a circadian peak and hunger, but it's, yeah, a convergence of multiple factors.

And this may be one it's just some thinking in that area. But what we've typically seen a big feature of this research area as you both know, is the idea that time of day energy loading could enhance aspects of energy, expenditure and metabolism as it related to weight loss. And really, they were starting to become, Little supporting evidence for that.

And I think that was quite concretely put to bed with the recent publication of the big breakfast study which Leone wrote at Collins Lead and Alec, Professor Alex Johnstone at the University of Aberdeen, and they've rigorously controlled diet, front loaded energy intake in the morning versus back loading energy in the evening.

So high energy breakfast, low energy dinner, low energy breakfast, high energy dinner. And they found no effect on energy expenditure, weight loss equal between groups. But they did find an effect on subjective hunger and appetite. And that was significantly decreased both when they looked at it in a kind of an acute response.

And also they measured it at the end of dietary interventions over a period of days. And this ties with other research that has looked at, the impacts of front loaded energy. There's... Daniela Jacubowicz led a paper back in 2012 looking at a hypocaloric weight loss diet and overweight women. But what they found was, and they measured ghrelin, so this wasn't looking at subjective appetite in response to kind of test meal. What was interesting about this study was they. Measured obviously baseline, the end of the 16 week dietary intervention. And then they came back at 32 weeks, the 16 weeks again into the maintenance period.

And what they found was that this group that was front loading energy and specifically consuming a high protein, high carbohydrate combination at breakfast with a high total energy content off that meal had quite a significant suppression of ghrelin that not just lasted the period of the weight loss 16 weeks, but was evident at 32 weeks into this maintenance period.

And what may relate to this is concept known as, So Niamh mentioned earlier that the satiety index is a concept of the satiety ratios developed by John De Castro in the early two thousands. And this factored in. The meal timing effects on appetite and satiation. But the, what the ratio was describing was the time someone takes to have another meal to eat again relative to the energy content of a preceding meal.

And what was interesting about his research was that they showed that the sat ratio decreased as the day went on. And the ramification of this was that despite people eating a larger meal later in the day, they would still actually eat again in relatively quicker succession to that previous meal with an increasing energy intake yet again.

So as the ratio decreased over the course of the day, the actual energy content of meals, Increased and the correlation between those two was very strong. So what this suggested was that a pattern of eating that we often typically see in, in kind of western busy populations is people delay initiation of eating to sometime later in the day, and then the they are may then in a free living context, end up just stacking higher energy meals on top of each but distributed to the, to later in the day and in and into the evening and night. So it may be that the level of ity that they're getting at a given level of the energy content of a meal has less effect later in the day than it does earlier in the day. And indeed the very tightly controlled recent publication from the group at Aberdeen would appear to tend to support that kind of effect of front loading energy on subsequent appetite and hunger.

Danny Lennon: Yeah, no, of course. This is something you've alluded to in some of our other episodes related to this topic that people can go and check out that probably some of the conversation that often happens in relation to meal timing or time restricted eating, or windows of time is often what gets left out sometimes this actual distribution of overall energy.

And in this case, you've just referenced this front loading of a higher proportion of en energy earlier in the day. And that distribution may be more instructive as opposed to just simply times per se. So, so another area that people may have questions about in relation to the timing of when we eat and how that may impacts sat society is the meal frequency.

So is this something that has as an impact whether someone chooses to have let's say a smaller number of larger meals or a larger number of smaller meals across the day? Does meal frequency seem to have an impact here?

Niamh Aspell: There has been, anyway, previously much more of a focus on moving away from that typical kind of three meal a day approach to having, four to six meals or having smaller meals throughout the day.

And that belief that if you just give consistent smaller portion, so keeping the energy intake the same, but keeping smaller portions throughout the day that people will never feel hungry. They'll always just feel, mildly associated throughout the days that goes on. But that's obviously very different depending on different just geographical factors where you live in the world.

There's obviously different, depending on your lifestyles or how you work or what your day to day is like. It's, there's a lot of variability and that's been published in a lot of studies I think in the US nans. I think it was a third right of their study had showed that Americans typical, typically eat four times a day.

And then in Europe it's very different as well. So I think in France they eat less than that. And then in, in other Scandinavian countries, they eat up to seven times a day. So it, it also depends on what you're typically used to, but they've done a lot of different studies. There's a lot of review papers looking at this three meal per day pattern.

And now that they augment that or give, say less meals a day. So if they were to give just two meals a day, those one study done in healthy meals. that examined if you were to give separate the calories. So in the morning time, if you end up having to instead have two large breakfasts and they're separated by three hours, so if you get up and you have something that eight o'clock and then again at 11 o'clock, the same high level of calories as well as Alan mentioned.

So for this study, I think they gave them almost 2000 calories in that early part of the day. And then they divided the remaining calories in smaller six smaller meals for the, Oh, sorry. In the other group they gave them six smaller meals, the same level of calories, and they're perceived.

Sensation in terms of appetite was also assessed. And it showed that those increases in satiety with those who were exposed to the two meal, two meals as opposed to being, giving those six smaller meals over the shorter period of time. So those greater kind of reductions in appetite in the morning, but those greater increases in their perceived satiety in their area under the curve responses compared to people who had those six smaller meals in the morning.

I dunno how you'd fit six smaller meals in the morning. Anyway it's probably a strange approach for them to have gone with. But then there's other studies that then focus looking at, okay, if you give all of your calories, so those reduced meals, if you're doing that fasting where you only maybe one meal per day and those studies have been quite positive, but I think they, these, this goes back to that phenotype then as well. And those kind of inter participant kind of differences as well. But they, there's other Publications that have looked at lowering the range of eating frequency and studies have been published that either remove one meal, and I think this kind of, Alan, you'll know a lot more about this than me, but that can influence or trick the body to a certain degree.

That if you if you typically have breakfast, lunch, and dinner, if some days you just, you miss the lunch and the next day you might miss dinner. That's been shown, I think in some studies to influence confusing the body to a certain degree that's not triggering you, that's lunchtime now you ready for a meal.

And they've shown that, they've demonstrated that I think as well in terms of looking at grin levels across the day. So those hunger hormones across the day that they can be manipulated to certain degree as well. So if you remove some of those triggers by reducing your meal frequency, but also changing up which meals then you're reducing.

So, not having lunch or not having dinner on a certain day, that can then make people kind, less internally and externally. Motivated to eat based on those cues that they should be eating or wanting to eat a little bit more. But

then there's, those are other things around that where it's like if you're eating 70% or more of your energy intake at one particular meal you're going to report obviously greater satiety and over a longer period of time is quite variable in the studies depending on the person.

So if you're looking at people are who are lean and abnormal weight or obese populations, the results can be quite different. It does. Okay. I'd say overall it would suggest that kind of increased. Eating frequency. So more than three meals a day does have an impact on more people in terms of appetite control and food intake and that comes down to whether if you're used to having particular meals on a day or depending on your behavior towards food, some people can see themselves as starving themselves or fasting for a full 23 hours just to get that one meal and then overloading on that meal. And then obviously that negatively affects then your appetite control and gives you quite a dysregulated approach towards eating behaviors.

Danny Lennon: It is an area where there's probably some degree of a learned response or at least I think you could probably point this in relation to some of the fasting stuff as well, of how people respond to fasting in the morning or not, and how much of it, once it becomes habitual, some of those things change in terms of the typical hunger someone may have had at breakfast, ends up shifting.

But of course this makes sense because now they're consuming more meals later in the day and there's finally been some degree of an adaptation to it. And it, I'm guessing maybe some of the same thing is at play with some of the meal frequency. If someone starts changing that up or down. In addition to, of course, they're just being individual response between people of what their preferences more than anything.

So with that, I think we willl start wrapping up then. I think that's pretty much everything that I made a note to get through, unless I'm missing anything. So maybe the final thing I'll ask both of you to answer is a question that may be left open for some people listening now or certainly will be of interest to others they may be talking to is, Okay, based on all of this stuff practically, what might this mean?

What would some of the main things that we could consider to have at least some degree of decent evidence behind that we could say would positively

promote satiety or what other eating choices might have a negative impact on society? What are the kind of few core things that people could practically do that we could say at least are relatively evidence based to some degree?

Maybe I'll start with you Niamh. What would be some of the things you would point to?

Niamh Aspell: Yeah, I think that the kind of, I suppose the strongest evidence in looking back at that kind of the, all of the drivers that encourage us to maintain our kind of energy balance, I think the, where the strongest evidence is good sources of protein less ultra processed foods, but also bulking foods with bulking meals to a certain degree with foods that are high in soluble and non soluble fibers, but also water as well.

I think one big point of a lot of the satiety and where it's moving towards health claims and how they're trying to create some functional foods around helping people feel fuller for longer, I think it's important to understand that they're. Claims about weight control. And these aren't claims for kind of weight control.

They're claims for the tide in your ability to maybe feel fuller. But I think humans work a little bit differently than that, and it's a little bit more more complex and saying, certain foods will keep you more associated. I think in general, ultra processed foods for the most part should be avoided, but I think in a lot of circumstances advice is not practical or suitable for a lot of people as well.

So, I think there's, there is circumstances where it's reducing the ultra processed foods in a diet is probably the direction you want to go for. And if you're going to eat high fat ultra process type foods, try and have them after you've had a meal that it comes, consumes all of these particular macronutrients that will create that fullness before you choose some of those more snack based foods.

Danny Lennon: Alan, some of your concluding thoughts that you want to leave people with.

Alan Flanagan: Given that I've just bought off by the Almond Board of California... "Big Nut" is in my pocket

Danny Lennon: To go with all your linoleic acid.

Alan Flanagan: Yeah. That's what I'm going to really encourage people to maybe do shots of sunflower oil to get that linoleic acid hit. No, I think Niamh outlined the real top line stuff. I think, quality dietary protein sources and a maybe a higher dietary protein intake if someone is actually actively. Trying to reduce energy intake would be more facilitative viscous fibers for their kind of bulking capacity.

And foods like oats can be quite satiating. I think the volume of foods so high protein, low volume low energy density, sorry, high volume foods as a combination. So, like your non-starchy vegetables and non-factor yogurts. And these types of foods appear to be beneficial as far as providing that sense of bulk to the diet without the added energy density.

And I do think on the totality of evidence, I really do think that there is probably a real benefit to starting the early part of the day with a very high energy and high protein first meal, whether that's breakfast in the traditional sense or just the first time that someone eats, I think that appears to be very, consistently associated with better appetite control, not just acutely really over the course of the whole day.

Danny Lennon: So we will leave it there. Thank you to both Alan and Eve, and then thank you to everyone listening in. I hope you have enjoyed this and found it informative in some way. Of course, if you are a Sigma Nutrition Premium subscriber, you can get the detailed study notes for this section to get a bit more detail over many of the things that we have discussed, as well as to revise over some of those concepts, get diagrams, graphs, all that type of good stuff.

That is over at sigma nutrition.com/episode458. And that is us for today. Thank you for listening in. We will back very soon with another episode, and until then, I hope you stay safe and take care.