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Participant insights from SYNERGY – a residential nutrition intervention trial targeting prediabetic consumers

Gan I

April 2024

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High-Value Nutrition National Science
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Contents

- Executive summary1**
- 1 Introduction3**
- 2 Research method and data collection5**
- 3 Findings6**
 - 3.1 Meanings of healthy eating6
 - 3.2 Confused or inspired: experiencing the trial 10
 - 3.3 Actionable inspiration 14
- 4 Discussion 17**
- 5 Implications 20**
- Appendix 1. Participant profile 21**

Executive summary

Participant insights from SYNERGY – a residential nutrition intervention trial targeting prediabetic consumers

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April 2024

This report summarises findings from interviews/focus groups with participants of the SYNERGY study, a two-week residential dietary intervention trial targeting prediabetic consumers. The SYNERGY trial was part of the Metabolic Health Research Programme of High-Value Nutrition National Science Challenge (HNV). Collaborating with the SYNERGY clinical team, the Consumer Insights Programme of HNV conducted qualitative research with trial participants to gain an understanding of consumer behaviour regarding their dietary habits, perceptions, and attitudes towards healthy foods, as well as their personal experiences in the trial. The aim was to generate insights regarding barriers and motivators for adopting eating habits and food products that are beneficial for prediabetic conditions. These insights will inform the food and beverage industry in new product development and communication strategies.

In total, 30 participants, comprising 20 Asian Chinese and 10 European Caucasians spread across 15 cohorts, were interviewed either individually or with fellow participants from the same cohort on the 7th or 8th day during the trial. All interviews were conducted face-to-face at the Human Nutrition Unit at the University of Auckland, where the residential trial was hosted. Thematic analysis was performed to generate results.

The findings reveal a diverse and fragmented understanding of nutrition and healthy eating, with focuses on nutrient intake, proportion of different food categories, overall portion sizes, and cooking methods. Participants, being aware of their overweight/obese and prediabetic status, were motivated to participate in the trial to gain a better understanding of their bodies and acquire knowledge about healthy eating beneficial for their health conditions.

During the trial, participants were exposed to eating patterns significantly different from their normal eating habits. While attempting to believe the meals in the trial were healthy, they found some aspects of the meals not in line with their perceptions of a healthy diet, such as large portion sizes, high carbohydrate staples, substantial amounts of sweet-tasting snacks and desserts, and limited supply of fresh fruits and vegetables. However, they considered the cooking methods and the structure of set mealtimes and fixed portions beneficial.

Participants' intention to replicate the meal patterns in their normal life was relatively low due to various barriers. Perceptually, some participants disagreed with the large portions and carbohydrate-rich foods presented in the trial, thus were not convinced about the healthiness of such eating patterns. Many participants did express interest in applying the principles of light cooking and more

structured mealtimes and fixed portions. However, dietary changes require long-term effort, and personal taste preferences and busy lifestyles could pose challenges for them to stay motivated.

Overall, findings from interviews showed that participants seek a meaningful understanding of healthy eating relevant to their personal situations, as well as practical guidelines for managing their eating habits that could be applied to different lifestyles.

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1 Introduction

The SYNERGY study is a residential dietary intervention trial with pre-diabetic Asian Chinese and European Caucasian cohorts. This study is part of the Metabolic Health Programme for High Value Nutrition National Science Challenge (HVN). The primary objective of SYNERGY is to investigate the effect of dietary intervention on biomarkers of type 2 diabetes (T2D) in a high risk pre-diabetic population, through a 2 week, residential, full dietary control, 3 treatment intervention in 2 x 10 Asian Chinese and 1 x 10 European Caucasian cohorts.

The trial was carried out at the residential metabolic facility at the University of Auckland Human Nutrition Unit (HNU) between March 2022 and November 2023. Two types of intervention diet were used in three treatments, namely:

Macronutrients	Healthy diet (Control)	SYNERGY diet
Fat	30% (<10% saturated fats)	30% with increased ω -3 fatty acids (<10% saturated fats)
Carbohydrate	55% (<10% added sugars)	45% (<10% added sugars)
Protein	15% (<120g red meat)	25% (<120g red meat)

The intervention diet was based on a typical Asian Chinese-style diet with adherence to New Zealand Ministry of Health healthy eating guidelines¹ and national dietary guidelines of China (Chinese Food Guide Pagoda²). Matched to the control arm, the SYNERGY diet was optimised for improved metabolic health through inclusion of a combination of New Zealand origin foods comprising five to seven food products in SYNERGY.

The diet contained both animal and plant products, hence vegetarian and vegan participants were excluded. All foods, snacks and beverages were provided and prepared by the HNU, and had to be consumed on a daily basis, with all foods for the day consumed before 12 am/midnight. No other foods or beverages were allowed during the 14-day study. The diet comprised a 5-day rotating menu, repeating throughout the trial.

In the trial, participants were kept in energy balance through the intervention, to ensure body weight remained stable. Daily energy intake was calculated based on 1.4 x predicted basal metabolic rate (BMR) and was personalised for each individual with respect to energy (kJ/MJ) content. All participants were provided with three meals per day comprising breakfast, lunch and dinner; and between-meal snacks. Breakfast and dinner were consumed under supervision of the HNU research team to ensure 100% compliance. However, in order for participants to attend work or study if required, lunch and snacks were provided by the HNU but could be eaten away from the research HNU. Independent assessment of dietary compliance was carried out using the urine nitrogen balance method.

¹ Ministry of Health. (2015). *Eating and Activity Guidelines for New Zealand Adults*. Wellington: Ministry of Health.

² <https://www.fao.org/nutrition/education/food-dietary-guidelines/regions/china/en/>, retrieved 19 February 2019.

Apart from all clinical aspects of control and compliance, the SYNERGY trial also provides a good opportunity for further exploration of participants' perceptions related to health and food and their experiences in the trial. Therefore, the Consumer Insights Programme of HVN collaborated with the SYNERGY team to conduct qualitative research with participants of the trial in order to enhance understanding of consumer behaviour regarding their dietary habits, perceptions and attitudes towards foods, and personal trial experiences, and to generate insights regarding barriers and motivators for adopting healthy diets and maintaining healthy lifestyles.

Furthermore, insights from trial participants will also inform strategies for communicating clinical results in a way that aids uptake of new products that are beneficial for the general public with metabolic health concerns, in particular pre-diabetic conditions. In addition, a deep understanding of the concerns, wants and demands of participants when coping with pre-diabetic situations will inform new product development opportunities for the food and beverage industry.

2 Research method and data collection

Use of focus groups was the planned method for data collection, given the initial aim of the trial to host three to five participants at a time in the facility. However, due to restrictions and disruptions caused by COVID-19 during research recruitment and execution, cohorts ended up with varied sizes, consisting of one to four participants at a time. Nevertheless, all participants were interviewed either individually or with fellow participants of the same cohort, on the 7th or 8th day of the trial.

To be eligible for this study, participants needed to be either Asian Chinese or European Caucasian male or female, aged between 18–60 years, with a BMI between 24–40 kg/m² (i.e. overweight or obese), and with raised fasting plasma blood glucose indicative of prediabetes (i.e. 5.6 – 6.9 mmol/L). Participants were otherwise healthy as per self-report and medical history. In total 30 participants successfully completed the trial, with 10 administered into each study arm, spreading out into 15 cohorts.

Interviews/focus groups were conducted between March 2022 and November 2023. Interviews were conducted either in English or Chinese, according to participants' preference for language. All interviews/focus groups lasted between 50–90 minutes, were audio-recorded, transcribed, and thematically analysed by the research team.

Ethics approval for interviewing participants was included in the overall study protocol (ref: 20/STH/51/AM01, approved by the Health and Disability Ethics Committees, Ministry of Health, New Zealand). Participant profiles are supplied in Appendix 1.

3 Findings

Findings from interviews/focus groups are summarised and presented below, with illustrative quotes from participants. Pseudonyms were used for these quotes to protect participants' personal information.

3.1 Meanings of healthy eating

Motivations and expectations for participation

Participants acknowledged that one of the primary motivations for participating in the trial was to gain a better understanding of their bodies through comprehensive body checks and scans conducted during the trial. Additionally, they expressed interest in the opportunity to experiment with so-called healthy diets first hand and learn how such diets could help them manage their eating behaviours for better health outcomes. Given that the trial was residential and involved controlled diets, some participants also viewed it as an opportunity to break the cycle of unhealthy eating habits they had identified, such as late-night snacking, excessive caffeine consumption, and high alcohol intake, with the hope of establishing new, healthier habits post-trial.

The Chinese cohort exhibited greater concerns about their prediabetic status and seemed to be more cautious about progressing to diabetes. Many cited a family history of diabetes and believed that they were predisposed to developing the condition at some point in their lives. Consequently, their aim was to postpone the onset of diabetes for as long as possible. Therefore, one of the main expectations for Chinese participants was to understand what types of diets could help them manage their blood glucose levels effectively. In contrast, some Caucasian participants appeared to be more concerned about being overweight or obese rather than being prediabetic.

Most importantly I have diabetic genes, you know, my dad my uncles and my brother who's 3 years younger than me all got diabetes, all type 2 diabetes. ... so for me, I'm putting on weight and that makes me really cautious... (P12, Chinese female, healthy diet arm)

I wanted to see how it differs from what I usually do. I think the research here must be more scientific and systematic than what I know, because I'm not an expert in this, and my knowledge mainly comes from the Internet and my GP. I think the research done here should be very professional and sort of authentic. (P21, Chinese female, SYNERGY diet arm)

GP always reminds us that we are at the border of being diabetic, you know, just a little bit further we'll get there. So I don't want to be diagnosed as diabetic because once diagnosed you'll be diabetic for the rest of your life. So I'm doing this trial to see if I can learn anything that's helpful, so that I can follow what I do here in order to postpone being diabetic to a later stage, or to avoid being diabetic at all. (P22, Chinese male, SYNERGY diet arm)

It's (the trial) about nutrition for those that are close to being diabetic, that's what interests me as well. Because my father, when he was dying, he actually got full blown diabetes... And I thought, okay, I know, I'm starting to get a bit close. And if I can get some information out of this, that will give me at least the ability to find more information, then that'll be great. (P6, Caucasian male, healthy diet arm)

When we're here I'm hoping to have broken habits, like having my Friday wine. You know, I think it's good to have a break from normality, because then when you go back, you can think about things that you did or didn't do here. (P4, Caucasian female, healthy diet arm)

It's an interesting thing, because this study is about the markers for diabetes...But generally, target audience of people that are suitable for this trial are generally people that are heavier, and they've got their focus probably more on weight management and weight loss, rather than something that's diabetes on the sidelines. So that's kind of what's coming through here in the answers I've heard as well, about losing weight, knowing more about healthy food, things like that, whereas the whole diabetes thing never kind of picture for any of us. (P2, Caucasian male, healthy diet arm)

Perceptions of healthy diet

When asked about their pre-existing understanding of healthy diets, participants expressed diverse perceptions regarding what constitutes healthy foods and eating patterns. The first common interpretation emphasised the importance of nutrient intake from foods, particularly protein and fibre. Given the awareness of their prediabetic status, many participants believed that a healthy diet should prioritise protein retention while minimising carbohydrate and sugar consumption, especially in refined forms. Additionally, fat was commonly perceived as unhealthy and should be minimised in consumption too.

The second understanding focused on the types of food ingredients that provide essential nutrients and the importance of balancing their intake. Participants commonly endorsed beliefs such as 'more vegetables and fruits, and less meat,' and 'more fresh whole foods and less processed foods'.

For some participants, cooking methods were also considered integral to healthy diets. Properly cooked meals can retain most nutrients, while overcooking, such as deep frying, may lead to nutrient loss. Similarly, incorporating unhealthy ingredients such as mayonnaise was seen as compromising the healthiness of a meal. Excessive use of oil and salt was associated with unhealthy cooking practices, which can transform healthy ingredients into unhealthy dishes.

In addition, overeating of healthy foods was recognised as potentially leading to negative health outcomes. Some participants identified overeating as the primary issue in their eating patterns, as they believed their food choices were healthy. Other personal beliefs included moderation in all foods and intermittent fasting, which was mentioned by several participants as a potentially healthy eating pattern.

You have your dinner plate, half of it should be veggies, quarter carbohydrate, quarter protein - to me that's kind of healthy eating, and chucking in green wherever possible. So if I have an egg for breakfast, I'll have it with spinach, and if I you know, if I've got some lettuce in sandwiches or whatever ...But I think it's also portion size, which is probably where I fall down. (P4, Caucasian female, healthy diet arm)

A healthy diet to me is portion control. And lots of greens. Lots of salads. Okay, a bit meat. Some carbs and lots of water. (P5, Caucasian female, healthy diet arm)

Well, for me, at least mostly sort of minimally processed food, like fresh vegetables, fruits, nuts, those kinds of things. And I do like them, I'll probably just eat too many of them. (P2, Caucasian male, healthy diet arm)

Yeah, making sure you've got plenty of fibre in your diet, a balanced and significant amount of protein to help for your muscle mass and try and limit to healthy fats. And the balance of complex carbs, that's got the fibre in them to keep you full. (P7, Caucasian female, healthy diet arm)

For me, it's always lots of green lots and lots of vegetables, lots of different colours. I think meat is a good way to provide a lot of the nutrients we need so I'm happy with that. And for me, personally, it's actually to reduce carbohydrate intake to a minimum. (P19, Chinese male, healthy diet arm)

I'll have vegetables and fibres and high quality protein. Carbohydrate must be restrained to a very low level, like less than 15% in the diet. But if I'm running out of time I'll just eat whatever.... We always say that vegetables are healthy. But cooking method is an important fact for determining whether it's healthy or not. Healthy ingredients, like chicken is actually quite healthy. Cooking method determines whether the food is healthy or not, not the ingredients per se. (P30, Chinese female, SYNERGY diet arm)

Linkage between eating habits and health outcomes

Many participants recognised the importance of food for their health and considered their eating habits to be a significant factor in their overall well-being, alongside other lifestyle factors such as stress, busy schedules, and lack of exercise. However, they admitted to often straying from their perceived 'healthy diets' for various reasons. Some cited busyness and a preference for convenience over healthiness, while others prioritised taste over healthiness. Late-night snacking, though acknowledged as unhealthy, was still adopted by some participants. Stress was also identified as a trigger for unhealthy eating behaviours such as emotional eating. Additionally, some participants confessed to simply not prioritising healthy eating habits.

We tried, you know, we fall into the trap of my wife and I have been very busy and run out of steam at the end of the day. So we probably need too much takeaways. Sometimes it's easier. So that's probably not my ideal of a healthy meal. But having said that, we do cook. I like doing a lot of roast veggies, roasted broccoli things like that. (P9, Caucasian male, healthy diet arm)

I have a lot of, sort of, more convenience food. ... I think probably mental barriers like making it (eating healthily) a priority because I get busy with other things and I just don't... it's not in the forefront of my mind. (P1, Caucasian female, healthy diet arm)

I know being in binge-eating episodes is one of my bad habits. But sometimes when under stress you'll crave for rubbish foods. Usually I don't eat a lot and can maintain that for two weeks, then all of a sudden I'm stressed and start to eat rubbish, which is a vicious cycle. You can maintain the good habits when you're ok, but when the bad moods come you'll break that habit and feel guilty and a bit angry too, why I'd be like this, and start to self-blame which don't give you a good mind to keep the good habit. (P21, Chinese female, SYNERGY diet arm)

I find it frustrating because I feel like I know this stuff you know, you know...trim the fat from the chicken blabla... but it tastes good. Yeah. (P3, Caucasian female, healthy diet arm)

I actually don't care much about being fat or slim, being healthy or unhealthy. I only care about this moment and eat what I want to eat, not thinking much about the consequences. (P22, Chinese male, SYNERGY diet arm)

We've gone through years of education and we know what's healthy and what's not. But sometimes you just give in to the satisfaction of taste and can't stop yourself from eating even though you know it's not healthy. (P27, Chinese female, SYNERGY diet arm)

Many participants acknowledged that they were not always practising their ideal 'healthy eating' and could readily identify areas for improvement. However, some asserted that their eating habits were not overly poor. They justified this assertion by highlighting instances where they had reduced their consumption of unhealthy foods or opted for healthier alternatives. Such a mindset may be a way of addressing cognitive dissonance between their theoretical knowledge of healthy eating and their actual dietary practices. While some participants expressed serious concern about their prediabetic/obese status, others perceived themselves as relatively healthy, and were inclined to deny the urgency of changing their current eating habits and lifestyles.

I think I eat okay. But I think in the weekends, you know, probably, lots of takeaways in the weekend. (P5, Caucasian female, healthy diet arm)

I think we're sticking with it (healthy diet) quite a bit. I think most of our issues are around portion sizes. (P8, Caucasian male, healthy diet arm)

I feel I'm actually quite healthy. I may want to lose some weight, but other than that... personally I don't think I've got any issue with my health. Except for that, you know, occasionally when I stay up late I may have some snacks, which is not a good habit. (P24, Chinese male, SYNERGY diet arm)

I know some of the things that I need to do, but I haven't done it. Yeah, enjoy, gotta enjoy, right? I guess, I think because it's pre diabetic, so it hasn't worried me as much. (P25, Chinese male, SYNERGY diet arm)

We're kind of healthy and cautiously control what we eat at home. But you know, as northern Chinese we love braised pork and eggplants, we do have these at home. It's impossible to have boiled vegetables and poached eggs every day for us, they are tasteless. (P27, Chinese female, SYNERGY diet arm)

Some were also frustrated about not achieving a desired health outcome (e.g. weight loss) even though they had adopted some healthy eating habits.

I like to think we eat quite well, you know, try to keep healthy as much as possible, we don't do a lot of takeaways and that sort of thing. ... I feel like I'm more conscious of what I'm putting in and eating a lot healthier than I've ever eaten before. But still, I keep putting on weight. So I'm finding that frustrating. ... so I'm feeling like my diet at the moment is okay, really, I mean, there's always ways you can sort of sharpen it up a little bit, but I'm not eating desserts anymore, not much of that sort of thing. It's frustrating. (P3, Caucasian female, healthy diet arm)

I don't understand why I keep putting on weight because I don't eat badly and I don't eat a lot... I don't eat sweets, I don't drink alcohol. Yes, okay, I am addicted to Coke Zero - I haven't measured but you know it's not sugary. I don't know why I put on weight. It doesn't make sense to me. (P10, Caucasian female, healthy diet arm)

I don't drink tea or coffee. I live like a robot, you know, except that I love eating meat, but not even red meat, not beef or lamb, yet I'm still getting very fat, I don't know why... Of course I

hope I can eat healthily, but when you're young, like under 25, you gotta eat whatever you like to eat, otherwise you got no chance to do this when you get old. (P18, Chinese male, healthy diet arm)

3.2 Confused or inspired: experiencing the trial

Quantity and portion size

One of the most commonly shared experiences among trial participants was the 'shocking' and 'overwhelming' amount of food provided during the trial, coupled with the expectation to finish all of it within the day. Many participants expressed that they struggled, particularly at the beginning of the trial. They reported that they were not accustomed to consuming such large volumes of food in their normal lives, and some experienced physical discomfort, such as feeling bloated, after consuming so much food. While the majority of participants gradually adapted and became better at coping with the amount of food after a few days in the trial, some still found it challenging to consume all the food even after a week of adhering to the prescribed eating pattern in the trial.

It's really hard the first few days, like, we're all a bit shaken up.... it just seemed like a big volume of food. ... I have an ability to eat a whole lot in a binge situation, but my normal week, you know, I'm not actually eating that much. (P9, Caucasian male, healthy diet arm)

We all think the quantity is too big for us, and like every day we all feel we are too full and couldn't finish everything. (P30, Chinese female, SYNERGY diet arm)

I feel like every meal is bigger than what I normally eat, and usually I couldn't eat that much for dinner. Nevertheless, when I eat outside, and binge eat and drink, I may end up with eating more than this. (P29, Chinese male, SYNERGY diet arm)

I'd believe the meals here are absolutely healthy, the only thing confuses me is the quantity of the meals. (P28, Chinese male, SYNERGY diet arm)

Because of my bodyweight they've given me these massive meals and I'm finding it really hard, just the volume of food to eat, like (I'm) completely stuffed after dinner tonight... I'm literally feeling quite sick because I'm... just too much too much food. (P1, Caucasian female, healthy diet arm)

Carbs and sugar

Another 'shocking' experience for participants was the significant proportion of carbohydrates included in the meals, along with the frequent presence of sweet desserts after meals. They noted that carbohydrate staples such as white rice, bread, potatoes, and various cereals and grains (such as quinoa and couscous) were used in large quantities in many meals. Many participants stated that they would not typically consume such high amounts of carbohydrates at home. Their home-cooked meals usually feature more protein, often in the form of eggs and meat, than carbohydrates. The carbohydrate-rich meals also appeared to conflict with many participants' perceptions of healthy diets, especially for those at risk of diabetes, who commonly avoid excessive carbohydrate intake. This discrepancy left participants curious or even sceptical about whether the meals in the trial were actually healthy for them.

Similarly, confusion arose regarding the provision of sweet-tasting desserts. This was particularly perplexing for prediabetics who were specifically concerned about sugar intake. Many participants viewed sweet snacks and desserts as items they typically restricted due to health concerns, or as items they personally did not crave.

(The meals) were quite different from what I've imagined, I think they gave me lots of staple, but very little meat and vegetables. Feels like this is the opposite proportion to what I normally eat, making me very curious. ... I can't figure out why it's about 80-90% of staples and rest of it was meat and vegetables. I found such proportion very weird. (P21, Chinese female, SYNERGY diet arm)

I'm a bit suspicious, are these meals really going to make us better? Because I feel like the proportion of carbs is really huge, like about 80% of the meal is carbs. Although it looks like good carbs but it is still carbs. Is it really good for my glucose? ... I do think these coarse grains are good for health but not in such big quantities. Because usually I think a healthy proportion of carbohydrate should be around 20% in a meal, protein of about 30-50%, and vegetables for the rest... But here I found it completely opposite to what I thought.... So like what I said before, why the quantity of carbohydrate is so much higher than protein, especially for us – we are exactly those who shouldn't take much carbohydrate, aren't we? We are all high in glucose. (P26, Chinese female, SYNERGY diet arm)

For example the chocolate ball, in our life we wouldn't have it after lunch and then have a lot of it again as a dessert for dinner. But here I got one for lunch and another for dinner. So I don't understand this. ... I'd like to make it really clear (regarding why it is so), otherwise from my personal understanding, I think this is very unhealthy, and I don't eat this, I never eat such thing. ... There have been some energy bars too, which sounds very calorie-dense, and are in smaller size, given for tea break... usually I won't eat such things unless I'm going for a hike and doing some training. (P18, Chinese male, healthy diet arm)

I found two things here, the meals here contain a lot of carbohydrate, which I don't usually eat a lot, and I eat more protein; and the biscuits here are too sweet, not something I'll normally go for. So there are the two things I found, and I think my cooking is healthier than the meals here, just that I have bigger quantities. ... I thought this may be part of the trial and these sweets were given for a purpose. I thought so, so I didn't ask, and just eat everything that I've been given, but I don't think they are healthy. (P11, Chinese male, healthy diet arm)

Initially I've always sort of thought that having a banana every day was kind of bad for you. But I'm getting bananas I think every day in this trial. I just thought they are full of sugar and I just didn't think bananas are all that good, like all that healthy for you. But yeah, I've noticed here that I'm getting a lot of bananas and so I'm thinking, oh maybe I should be eating more bananas in my diet and oats and a lot of rice. (P1, Caucasian female, healthy diet arm)

Fresh vegetables and fruits

Participants noticed the relatively small proportion of vegetables in the trial meals due to the large quantities of carbohydrate staples. Many believed that vegetables should constitute a larger portion of a healthy plate compared to carbohydrate staples. The limited presence of fresh produce led participants to feel that the overall healthiness of the trial meals was compromised to some extent. Furthermore, they expressed their intention to revert to their preference for buying and consuming fresh produce once they returned to their normal lives after the trial.

I definitely would like to believe we are given healthy meals. But in our perceptions, vegetables are healthy, but I feel I have had very few vegetables, like only some greens in the sandwich... (P27, Chinese female, SYNERGY diet arm)

I just find there's a lack of green veggies. Like I'd have lots of courgettes and onions and broccoli and all that celery, and you know, chopped all up and yeah, I'll throw in more spinach or something and yeah, there's just I don't see much of those in these meals (in the trial). (P7, Caucasian female, healthy diet arm)

I also agree that on a healthy plate, green vegetables must account for a half. So we don't get a lot vegetables here. Even when there were some – we had carrots but very mushy, in a western way of cooking. We didn't see a lot of vegetables, barely any leafy greens. (P30, Chinese female, SYNERGY diet arm)

I think what I've really missed is fresh food, though. Because, I mean, apart from apples, the apples are lovely, but apart from sort of apples and bananas, there's not really, no fresh food. So I miss things like salad and yeah... you know, I would have far more vegetables. Yeah, and more protein and much less carbs. (P10, Caucasian female, healthy diet arm)

Additionally, some expressed a preference for fresh fruits and vegetables over frozen or canned options, stating that they would prefer to incorporate more fresh vegetables into their own cooking. Canned fruits were considered as not healthy not only because they are processed and not fresh, but also sweet-tasting and high in sugar. Such perceptions were primarily shared among Chinese participants.

They gave me canned fruits, I would never touch those, because in my opinion they are not healthy. (P13, Chinese male, healthy diet arm)

I see we have some half-processed stuff, like in my mind, fruits and vegetables should be fresh, yeah, fresh and healthier. ... Like the corns in the fried rice must be frozen corns, or canned, and the beans are supposedly canned too. At home we usually don't have these stuff. (P21, Chinese female, SYNERGY diet arm)

I never eat canned fruits, I mean for decades I don't eat those, and surely I don't buy frozen vegetables. I don't understand why a so-call healthy diet would include things like canned fruits which will make your glucose level soar. (P26, Chinese female, SYNERGY diet arm)

Could there possibly be anything good in those canned fruits? The peach must have been soaked in loads of preservatives. (P29, Chinese male, SYNERGY diet arm)

Meal schedules

The meal schedule implemented during the trial differed greatly from the typical habits of many participants. Throughout the trial, they were provided with three main meals, i.e. breakfast, lunch, and dinner, as well as two snacks between meals and desserts after each meal. Although participants were not required to strictly adhere to a set timeline, they found themselves compelled to eat more frequently or in shorter intervals in order to consume all the provided foods within a day. Several participants noted feeling hungry at specific points during the trial, which they interpreted as a potentially positive indication of improved metabolic and digestive responses. Acknowledging the benefits of having meals at predetermined times with fixed quantities, some participants considered

adopting it into their own lives whilst others viewed this as challenging due to a different lifestyle outside of the trial.

I think one of the big differences here is that all meals come with fixed amount. ... it's not like usually when eating with others, you may see that others are still eating, then you'll eat more as well. And like being at parties, you may eat a lot. I think the total amount eaten in that way is actually way more than the fixed amount given here. (P23, Chinese male, SYNERGY diet arm)

I think it's quite scientific about the three meals and the snacks between meals, which means eating about every three hours to never let you being too full or too hungry. I used to eat three meals quite regularly but with a bigger interval between meals, so I may end up eating too much for each meal. (P20, Chinese male, healthy diet arm)

Yeah, eating all the time (during the trial)... not enjoying it, I think I don't normally have a full schedule of eating. (P25, Chinese male, SYNERGY diet arm)

I have that same issues that I over eat. I even though I know theoretically, it's alright to feel hungry. I don't allow myself to feel hungry. I've got used to it and the body's got used to it as well like now, about half an hour before the designated time I'm starting to get hungry whereas normally I don't get hungry during the day. Yeah, so it'll be probably a little bit tricky for me afterwards because I won't have time for lunch and I don't normally eat lunch. (P19, Chinese male, healthy diet arm)

Cooking methods

Most participants reported having different home-cooking styles compared to the meals provided in the trial. However, they generally agreed that the cooking in the trial was healthy, although not necessarily accustomed to their taste preferences. One of the main aspects of the cooking that contributed to its perceived healthiness was the light use of oil and salt, and being simple in processing the ingredients. Several participants commented that the meals were 'bland' or 'tasteless' as a result of this cooking style.

The meals here, like, mainly staples, little meat, no veggies, and other stuff were like no oil and salt added, yeah, just tasteless. There were spices like herbs used, but still, just tasteless, or just not salty. ... Yeah just a bit bland in terms of the taste. (P21, Chinese female, SYNERGY diet arm)

We believe that meals provided here are healthy, yeah. The cooking style I have at home, like, we are overly processed in our cooking, compared to the meals here, which were cooked in the simplest way... we try our best to be healthier in our cooking, yeah, but stir fry does need a lot of oil, and I have tried to use less oil, yeah, less oil, less sugar, and less salt, but still more than the amount used here. (P29, Chinese male, SYNERGY diet arm)

I think they use quite a bit of spices to flavour things. But I've noticed a lack of salt. Normally, I think I probably use more salt in my cooking. I don't know how much salt they do here. (P1, Caucasian female, healthy diet arm)

They don't use a lot of oil, so I think the cooking method here is quite good. They roast a lot too, and like the noodles here, looking healthy and light, also taste good. Without a lot of oil

and spices but still the taste is quite nice, which is something that I should learn. (P17, Chinese male, healthy diet arm)

One of the things I don't like about the food here is that it's pretty bland...even the fish or that steak thing, it's quite soft and there's no crispy skin. Everything just tastes the same texture. (P25, Chinese male, SYNERGY diet arm)

3.3 Actionable inspiration

Overall, participants found the trial experience to be very different from their own eating habits, and sometimes not aligned with their perceptions of healthy eating. By the time of the interviews, participants were either on the 7th or 8th day of the trial, allowing them to observe some positive physical responses. Despite the large portion sizes provided daily, participants were 'surprised' not to have gained extra weight thus far during the trial. Some also reported experiencing better sleep and feeling more energetic during the day.

However, in general, participants' intention to replicate the eating patterns trialled into their own lives was low due to a range of barriers. For Chinese participants, the most challenging barriers were the temptation of taste, including cooking methods, use of oil and salt, and unhealthy ingredients, as well as the social aspects of food when having meals with others. On the other hand, for Caucasian participants, the major barrier was integrating a healthy eating habit into their lifestyle.

To be honest I feel western cooking is healthier, but as a Chinese, I don't quite like the way how meals were cooked here, you know, everything chopped up and mixed up in one pot, nah, I don't like that. I may also increase the number of meals, but I won't eat what I have been eating here, you know, either puffed foods or energy bars, are there any fresh ingredients? (P13, Chinese male, healthy diet arm)

Now I'm having these meals which do good to my bowels and I don't feel uncomfortable. But this is completely full of coarse grains, you know, in the trial, which no way can be replicated in real life. The trial may give some figures and results, but the trial and the results are to apply to life, only when it's applied to life it's a true success. ...So I don't quite get it, is it only for trial results, or with a goal to apply that to real life. If it aims to be applicable in real life situations I think the trial model can't sustain. (P27, Chinese female, SYNERGY diet arm)

It takes a lot of energy and a lot of time to eat well, so often you take the easy option. And the easy option isn't always that healthy.... (and) it's hard to keep getting motivated, and it's often not sustainable in the way our lives work, it's just not sustainable because there's not the time. So it's so much easier to take the easier, quicker option, than the more disciplined, hard work option. And eating healthy with busy lives is, you know, for some lot of people is a real challenge. (P9, Caucasian male, healthy diet arm)

Although some positive physical responses were reported, the knowledge backing the meal design was absent and many participants felt challenged to accept that a large-portion, carbohydrate-rich meal could be better for diabetic people than a meal rich in high-quality protein and with large amounts of fresh vegetables and limited carbohydrates.

The fact that I'm not gaining so much weight does surprise me, so I guess it can't be bad for me, but it still doesn't feel that healthy, and especially because I'm eating so much of it, just doesn't feel like it's such a healthy diet. (P1, Caucasian female, healthy diet arm)

Nevertheless, depending on the final results of their body checks and the overall trial, as well as a compelling explanation regarding the ‘counterintuitive’ aspects of the eating patterns in the trial, participants were keen to try adopting some learnings from the trial into their normal life.

Firstly, a number of participants reflected on their attitudes towards carbohydrates and sugar, and felt they could be less anxious about foods that are rich in carbohydrates and sweet-tasting, if there was a way to consume these foods whilst also maintain a stable and reasonable blood glucose level. This was evident particularly among Chinese female participants.

I seldom eat bananas - not that I don't like it, just that I'm really concerned about getting fat. ... If the glucose level ends up not changing a lot – because we have sweets here – so if it doesn't get worse after eating these sweet stuffs, I don't need to be too worried about eating sweets. I seldom have desserts because they are all high in sugar, I basically don't touch them at all. (P16, Chinese female, healthy diet arm)

I learned something that, I used to be very strict with my staple intake, and I barely eat staples, or just eat some coarse grains. Just very fearful of carbohydrate, yeah. ... Now I actually gain some confidence that in a balanced diet with nothing extremely too much, you'll be ok, you know, as long as everything is well-balanced. I feel I'm eased, more relaxed, yeah, not too anxious... My concern for sugar intake is kind of addressed, as well as the worries about staples. (P14, Chinese female, healthy diet arm)

If eating like this is healthier, is good for us, it will actually bring some happiness to me, because I can enjoy some desserts after meals – I have almost believed that desserts after meals had long gone for the rest of my life. (P26, Chinese female, SYNERGY diet arm)

Yeah, it challenged my thoughts like sugar is something definitely bad for us, it's of no good at all, At least it eased us a little bit, although you should be aware that you can never relax on that, otherwise you'll get diabetes. (P18, Chinese male, healthy diet arm)

Adopting a more structured meal schedule with multiple mealtimes and smaller intervals between meals where possible seem to be practical to some participants. Applying fixed portion sizes was also identified important alongside such meal schedules.

Before the trial I didn't have the mindset of morning teas and afternoon teas, just thought they were not for me. Then usually I started to feel hungry at noon, and I couldn't control myself when I'm hungry. If I had a sort of 'ok' lunch and didn't have some extra in the afternoon, I would be hungry and eat a lot at night, otherwise I would wake up at night because I was too hungry. But in this trial I experienced some improvement, like eating less for each meal but having more meals. So after the trial I plan to, say, I would prepare some healthy snacks for morning tea, so I can manage the hungry feelings better. Yeah, that's I've learned from there. (P18, Chinese male, healthy diet arm)

Sealed portion containers, they're quite good. ... Yeah, I think possibly having just that one 4 o'clock snack, I think, which is double the calories and portions that I would have, and maybe sealed in a pack. There's nothing until dinner time. I think that's a really big learning for me to just try and implement that. (P7, Caucasian female, healthy diet arm)

Having defined portions, and want to give a go at home, you know, just have a fixed amount of food fixed intervals, and try to stick with that. (P2, Caucasian male, healthy diet arm)

I may try to serve everyone at home using a plate with prescribed portions of everything if possible, so everyone got a certain amount of something and I also won't have to finish off things that they don't like and end up overeating. (P15, Chinese female, healthy diet arm)

A few participants also mentioned that they desired a detailed guideline with which they could better organise their meals under recommendation.

I wish that after the trial is finished, they can provide something like, how much you should eat for breakfast, maybe you will have a range of different foods, but a recommended portion, how much grams for breakfast, for morning tea and afternoon tea, lunch and dinner, and the overall amount for a day. Yeah, I'd wish they can provide something like that so we can follow in our own life to keep us healthy. (P12, Chinese female, healthy diet arm).

4 Discussion

Dietary perceptions and habits

This study reveals several important aspects of participants' dietary perceptions and habits relating to health risks such as diabetes.

As shown in the interviews/focus groups, participants' knowledge of healthy eating seems to be fragmented and sometimes conflicting. GPs and health check results were the important gatekeepers for participants to be aware of their blood glucose levels. However, many dietary suggestions were adopted from Internet searches and social media, and sometimes through word of mouth. Furthermore, personalised dietitian services for better glucose management through eating did not seem to be widespread yet. The insufficient nutrition literacy could lead to the adoption of unhealthy eating behaviours that they mistakenly perceive as healthy.

To control glucose, the common belief and practice amongst participants was to avoid or minimise the intake of carbohydrate and foods of high Glycemic Index. Some participants were frustrated about not being able to achieve or maintain desired results, e.g. weight loss, by practising some recommended dietary patterns, such as keto diet and intermittent fasting. This also contributed to their confusion regarding what and how to eat healthily and practically in an obese and/or prediabetic situation, and curiosity regarding how their body responds to what they eat.

Participants recognised that their eating habits are established around their lifestyle, shaped by the pace and demands of daily work and life schedules. This interplay influences various aspects of their dietary behaviours, including what, when, and how much they shop and eat, as well as the methods of food preparation, cooking, and storage. Caucasian participants frequently attributed their adoption of convenient yet unhealthy food choices, such as fast food and takeaways, to the path of least resistance resulting from their busy schedules. In contrast, Chinese participants tended to associate their taste preferences with unhealthy cooking methods, often featured by excessive use of oil and salt, and the consumption of less healthy foods like red meat and animal fat. In addition to personal taste, their eating behaviours were also influenced by social factors related to food, such as group gathering, business dinners, and festivals.

Although participants were concerned about their weight and the potential of developing diabetes, weight gain and changes in glucose levels are sometimes incremental, which may create a sense of psychological distance from this undesired chronic disease. In other words, the risk of diabetes may not be perceived as urgent and acute at the time of eating. Similarly, to manage weight and glucose though diet can be incremental and less visible, and thus requires long-term efforts, which could contribute to their lack of motivation in changing eating behaviours and sticking to healthy eating patterns. Evidently, sometimes participants would downplay their unhealthy eating habits and perceive themselves as relatively healthy, thus allowing them to maintain some of their unhealthy eating behaviours. As such, when life becomes busy and/or under pressure, immediate convenience can easily overtake the commitment to healthy eating.

Trial experience and inspirations

The two-week trial exposed participants to a diet that differed significantly from their usual eating habits in several aspects. Many participants noted that the meals provided in the trial were larger in portion size, higher in carbohydrate, and included an abundance of sweet-tasting snacks, desserts,

and fruits. These characteristics were perceived as contradictory to their beliefs about a healthy diet, especially for individuals at risk of diabetes.

Participants were surprised to find that they did not gain weight after a week in the trial. Consequently, some viewed this as an opportunity to alleviate their concerns about carbohydrate and sugar intake. However, others maintained that their own dietary patterns, characterised by lower carbohydrate and sugar consumption and higher meat and protein intake, represented a healthier alternative. Furthermore, both Chinese and Caucasian participants suggested that incorporating more fresh vegetables into the trial would enhance the overall healthiness of the meals. In addition, many Chinese participants expressed the view that frozen vegetables and canned fruits were perceived as less healthy compared to fresh ones.

Although opinions on the taste of the meals in the trial were mixed, most participants perceived the meals as healthier in terms of cooking methods employed. This perception was particularly evident among Chinese participants. They described their own cooking as typically too oily, salty, and overly processed in order to achieve the desired taste, often sacrificing healthiness and nutritional value. Several Chinese participants reported prioritising taste over healthiness when making food choices or cooking meals, and they lacked the motivation and willpower to resist unhealthy food options that they enjoy. Nevertheless, there was interest in gradually reducing use of oil and salt in their cooking, and adoption of alternative cooking methods such as roasting vegetables instead of stir-frying.

Many participants were also intrigued by the structured approach of serving meals in fixed portion sizes and at set times during the trial, despite the common perception that the overall daily food supply was 'too much'. In Western societies, individual portion servings are common, whereas in Chinese culture, dishes are typically shared among family members, which can inadvertently lead to overeating as dishes remain available. As a result, some Chinese participants considered adopting the practice of serving fixed portions on individual plates as a means of better portion control at home. Additionally, there was interest among Chinese participants in incorporating snacks or tea breaks between meals to reduce overeating, particularly due to longer intervals between meals. Conversely, Caucasian participants perceived their work-life schedules to be more erratic, leading to irregular eating patterns with meals consumed at disproportionate intervals throughout the day. Although some of them viewed it beneficial to adopt a more organised meal schedule, they anticipated challenges will stem from their less structured work and life patterns.

While participants found inspiration and expressed interest in adopting some new eating behaviours from the trial, they generally did not consider the trial diet to be practical as an intact pattern to implement into their daily lives. The practicality and compatibility of the diet with their individual lifestyles and preferences remained significant obstacles to adoption of the entire diet they experienced during the trial.

Communicating and promoting healthy eating

As revealed in the interviews and focus groups, participants' knowledge regarding nutrition and healthy diets is fragmented and inconsistent. One of their expectations for participating in the trial was to learn more about healthy eating. However, the eating experience during the trial has, to some extent, exacerbated their confusion regarding healthy eating. Many participants expressed a strong desire for further explanations regarding the meal design and the underlying mechanisms, as well as the results of their biomarkers measured during the trial.

This presents an opportunity for participants to gain scientific knowledge about healthy eating that can be linked to their personal trial experience. Such understanding may further facilitate the adoption of healthy eating behaviours in personalised ways, making it more meaningful and practical for individuals to incorporate into their lifestyles. In addition to understanding of the underlying knowledge, Chinese participants expressed particular interest in receiving detailed dietary guidelines that they can easily follow in their personal life. They showed a higher tendency to follow guidelines provided by trusted health professionals and health research institutes, and were more likely to be motivated by benefits that are related to their own health conditions.

5 Implications

The findings provide practical implications for public education on healthy eating and for the food and beverage industry. The study shows that there remains a persistent gap in public knowledge surrounding nutrition and healthy eating. Despite the abundance of information available, many individuals find themselves lacking clear, actionable guidelines to navigate their dietary choices effectively. This gap poses the need for easily understandable knowledge accompanied by actionable guidelines from professional and authentic sources which are accessible for the public. There is also a need for more personalised nutritional and dietary guidance that is meaningful to individual health conditions and practical to apply to personal lifestyles. Participation in supervised nutrition intervention trials can allow for individuals to acquire knowledge from their own experiences. In the case of not disrupting the clinical design and execution, there exists an opportunity for disseminating scientific knowledge alongside such experience.

Consumer interest in managing prediabetes through suitable food choices is evident. The food and beverage industry plays a crucial role in facilitating healthier eating habits through product development. While health benefits are essential for consumer uptake, it is equally important for manufacturers to consider how product formats can be conveniently adapted to different lifestyles and eating situations. Products that seamlessly integrate into diverse lifestyles without requiring significant adjustments can empower consumers to make healthier choices effortlessly. Taste remains a paramount factor influencing consumer uptake of food products. Therefore, it is imperative for manufacturers to prioritise taste alongside functionality. Providing consumers with a variety of options and demonstrating how products can be incorporated into different situations enhances their appeal and encourages consumption. In addition, communicating the health benefits of the products alongside the scientific knowledge which backs such benefits is also important to convince consumers. This is particularly important for products and ingredients that are less familiar to consumers.

In conclusion, addressing the gaps in public knowledge of nutrition and healthy eating requires a multifaceted approach, and needs to take into consideration various lifestyle and personal situations. Providing easily understandable knowledge, actionable guidelines, and developing products that align with consumer preferences and lifestyles can assist individuals in making healthier choices and ultimately improve overall public health.

Appendix 1. Participant profile

Study arm	Participant ID*	Sex	Age
Caucasian – healthy diet	P1	Female	45
	P2	Male	49
	P3	Female	50
	P4	Female	55
	P5	Female	57
	P6	Male	57
	P7	Female	57
	P8	Female	57
	P9	Male	59
	P10	Female	59
Chinese – healthy diet	P11	Male	38
	P12	Female	47
	P13	Male	51
	P14	Female	52
	P15	Female	53
	P16	Female	56
	P17	Male	57
	P18	Male	58
	P19	Male	58
	P20	Male	60
Chinese – SYNERGY diet	P21	Female	30
	P22	Male	39
	P23	Male	40
	P24	Male	40
	P25	Male	41
	P26	Female	48
	P27	Female	52
	P28	Male	53
	P29	Male	56
	P30	Female	56

*Participant IDs were assigned according to participant age in ascending order, thus not reflecting the actual chronological order in which participants were interviewed.

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