Sweetkick: a qualitative investigation into the effect of Gymnema sylvestre on motivations to consume sweet foods

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Abstract

3.1 Abstract

Background: Although excessive sugar-sweetened food (SSF) consumption increases obesity risk, global consumption is inappropriately high. Complex motivations to eat these foods may contribute to high sugar intakes. The herb Gymnema sylvestre (GS) has been shown to reduce SSF consumption, but its effects on motivations to eat SSF are currently unknown.

Objectives: To conduct a qualitative investigation into the motivations of adults to eat SSF whilst participating in a placebo-controlled randomised cross-over trial investigating the effects of GS on SSF consumption.

Methods/Design: Placebo-controlled randomised cross-over trial with seven participants (mean age of 34.7 ± 13.8 years, two males, five females). Participants tested a placebo (administered three times a day in between meals, i.e., administered systematically, i.e., PLAC-SYS) for an initial 14 days, before they were randomly allocated to one of two GS treatment groups for a second 14-day period. Treatments consisted of administration of GS-containing mints systematically (three times a day in between meals, i.e., GS-SYS treatment), or administration of GS-containing mints ad-libitum (up to six times a day, at times completely controlled by participant, i.e., GS-ADLIB treatment). Participants were then crossed over to the treatment they had not tried yet for a final 14-day period. Each participant completed four interviews at baseline and after each 14-day testing period to capture thoughts, feelings and opinions about how motivations changed, how in control participants felt about SSF intake, and how effective treatments were at changing SSF intake. Interview transcripts were uploaded to NVivo for analysis. Themes and sub-themes were identified, linked and explored to ascertain how participants' motivations to eat SSF were affected during each arm of the trial, and what was influencing their motivations.

Results: At baseline, adult motivations to eat SSF were psychological, external, habitual, hedonistic and physiological in origin; adults were also motivated to avoid SSF for the same reasons (except none avoided SSF out of habit). Baseline motivations to eat and avoid SSF were influenced by deliberate decisions to change lifestyles and external factors such as occupations. During the different testing phases of the study (i.e., PLAC-SYS, GS-SYS and GS-ADLIB) participants' motivations were affected by the treatments (GS and placebo), as well as external factors (such as occupations) but at all stages participants were still motivated to eat

SSF because of pleasure-seeking reasons. Compared to PLAC-SYS, the GS-SYS and GS-ADLIB treatments affected motivations more because they reduced the pleasure derived from SSF to a greater degree, and because they enhanced the participants' mindful eating. Four of seven participants preferred GS-SYS to GS-ADLIB because they felt it tasted better and was more effective at changing behaviours related to SSF intake. Participants also reported their self-control levels of SSF intake changed by administration of GS-ADLIB and through the influence of external factors (but not GS-SYS or PLAC-SYS). However, participants overall reported varying levels of control during the study, mostly because of changes in their lives (i.e., external factors) rather than the effects of GS-ADLIB.

Conclusion: Compared to placebo, GS administered systematically and ad-libitum may increase motivations to avoid SSF. The herb may be a useful addition to interventions that already utilise mindful eating, as it could help enhance these practices by increasing the time frame between initially being motivated to eat SSF and actually eating the SSF. Gymnema sylvestre may also be useful when used as part of larger interventions because there are many external factors that affect how in control individuals feel over SSF intake, and when administered ad-libitum, GS may help enhance self-control levels. Therefore, lifestyle interventions that provide holistic support to navigate changing external factors combined with GS may be particularly effective in reducing total SSF intake.

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<u>Abbreviations</u>

Ad-libitum – ADLIB

Body mass index – BMI

Body weight – BW

Diabetes mellitus – DM

Diagnostic and Statistical Manual of mental disorders – DSM-5

Gastrointestinal tract – GIT

Gymnemic acid – GA

Gymnema sylvestre – GS

Non-communicable disease – NCD

Placebo – PLAC

Sugar-sweetened food – SSF

Systematic – SYS

Visual analogue scale – VAS

World Health Organisation – WHO

Chapter 1: Introduction

1.1 Background

Obesity has a complex aetiology with high caloric diets being a key risk factor (World Health Organisation, 2022b). Calorically dense foodstuffs are often high in free sugars, which are not naturally present and are added to the food during processing to improve flavour (World Health Organisation, 2015a). Obesity treatment and prevention could include efforts to increase adherence to low-energy diets, which are classically difficult to stick to long-term (Torres-Fuentes et al., 2015). Low adherence may be a result of the intricate motivations humans have for wanting and eating sugar-sweetened food (SSF) (Swinburn & Egger, 2002). These motivations mean the knowledge that excessive SSF is not healthy will not necessarily mean individuals simply stop wanting them, or indeed consuming them (Aguiar-Bloemer & Diez-Garcia, 2018).

An emerging intervention to help this issue may be administration of Gymnema sylvestre (GS). This herb possesses properties which decrease perception of sweetness (Turner et al., 2020). A SSF without its sweet properties is usually no longer pleasant, and if GS makes SSF less palatable, it could help decrease consumption of these foods (Tiwari et al., 2014). Some evidence indicates that GS could help reduce sweet food intake short-term (Devi & Jain, 2015; Kashima et al., 2020; Nobel et al., 2017; Stice & Yokum, 2018; Stice et al., 2017; Turner et al., 2020). However, for positive long-term health outcomes, an impact on actual desire to consume sweet food could be beneficial (Nobel et al., 2017). If GS affected the motivations to consume sweet, energy-dense, processed food, it may prove a potent tool in combating the global obesity rise. This thesis aims to contribute to this novel research by investigating the effect of GS on motivations to consume SSF.

1.1.1 Obesity and the contribution of motivations to eat SSF

Overweight and obesity is defined by the World Health Organisation (WHO) (2022b) as abnormally high body fat levels. This is associated with increased morbidity (including cardiovascular and metabolic diseases) and mortality (World Health Organisation, 2022b). Global obesity increase is occurring at such a rate that it is predicated by 2025, 18% of men and 21% of women worldwide will be classified as obese (NCDRF Collaboration, 2016). Disease aetiology is multi-factorial; overconsumption of energy-dense foods (high in sugar and fat) are key contributors (Torres-Fuentes et al., 2015). Environmental factors exacerbate these risks by promoting energy intake but reducing energy expenditure (Swinburn et al., 2011). Examples include ready access to energy-dense foods in developed nations; and technological advances which increase convenient travel and reduce laborious occupations, but decrease physical activity (Cutler et al., 2003). Environments with these characteristics are described as 'obesogenic' because they promote obesity (Blades, 2001).

Low-calorie, nutrient-dense diets are a key preventive measure for overweight and obesity development (Swinburn & Egger, 2002). In particular, the WHO has iterated the importance of minimising sugar intake, stating that no more than 10% of total energy intake should be made up of sugars (World Health Organisation, 2015a). Sugars are not only energy-dense (providing 4 kcal per g), but they are also linked to other deleterious health conditions including dental caries and type 2 diabetes mellitus (DM) (World Health Organisation, 2015a). Diets low in sugar are notably difficult to adhere to, and not just because of the obesogenic environments of developed countries (Blades, 2001). There are a number of complex physiological and neurological factors driving oral intake of all foods in humans (Plassmann et al., 2022). The daily process of deciding to and ultimately consuming a food ensures provision of energy and nutrients for survival (Eaton & Konner, 1985). Humans are theorised to be naturally drawn to calorie-dense foods (including those containing sugar) because their prehistoric ancestors existed in an environment where food was scarcer than today (Eaton & Konner, 1985). Global mechanisation rates exceeded the ability of the human genome to adapt in time, making humans still innately driven to consume food for a famine that most developed nations will never face (O'Keefe Jr & Cordain, 2004). The motivation to eat energy-dense foods overall increases the propensity to gain weight (Mann et al., 2007). Already existing obesity-management interventions could be supported through reducing motivations to eat SSF. Some pharmaceutical options (e.g., appetite suppressant drugs) are available for managing obesity and supporting attainment of a normal body mass index (BMI), but many are associated with undesirable side-effects such as dependency and gastrointestinal distress (Torres-Fuentes et al., 2015). Research into herbal medicine poses an interesting option – many herbs have not yet been extensively investigated for their effects on sugar intake and obesity risk (Hasani-Ranjbar et al., 2009). However, they are generally perceived as more natural (Torres-Fuentes et al., 2015), and may represent untapped potential in the effort to manage global obesity prevalence.

An added aspect of this research that is still unclear, is whether having a sweet tooth, or an increased penchant for SSF, (Drewnowski, 1997) increases the risk of developing obesity. Strong preferences for SSF could hypothetically increase their intake, and therefore the risk of developing NCD but the association is currently undefined (Armitage et al., 2021).

1.1.2 Gymnema sylvestre

Gymnema sylvestre has been called 'gurmar' in Hindi, or 'sugar destroyer' (Tiwari et al., 2014). This name refers to GS being able to stop a consumer tasting sweet flavours (Nobel et al., 2017) for a period of time (30 minutes – 2 hours) (Bone, 2002). Gymnemic acids (GA) are the biochemical component of GS responsible for this property, with a similar molecular structure to glucose (Khan et al., 2019). By acting as an antagonist, GA binds to glucose receptors on the tongue (Devi & Jain, 2015) and reduces perception of sweet flavours (Stice et al., 2017). This has piqued interest in GS for its potential in facilitating decreased intake of SSF by making them less appealing (Nobel et al., 2017). Researchers propose GS could increase adherence to low-calorie diets low in free sugars to help manage weight, and therefore contribute to obesity management (Preuss et al., 2004).

The extent to which GS can affect motivations to eat SSF is a novel topic (Turner et al., 2020). Much of the current evidence concerning GS relates to its effect on insulin release and DM management (Tiwari et al., 2014). More recent research investigates effects of GS on amounts of SSF consumed, but not specifically on motivations to eat these foods (Devi & Jain, 2015; Kashima et al., 2020; Nobel et al., 2017; Stice & Yokum, 2018; Stice et al., 2017; Turner et al., 2020; Turner et al., 2022). Most studies used the herb acutely, and administered GS once during a testing session. Arguably, these studies used a sysematic, or fixed, dosage of GS because the dose was given in the same amount, at the same time, and was compulsory for all participants. Turner et al. (2022) investigated longer-term effects (over a 14-day trial), in addition to using non-laboratory settings (i.e., testing GS in participants' homes). During the 14-day trial, participants took the GS treatments in a semi-systematic manner (i.e., three times a day, either in between meals or when a craving for SSF was experienced). Purely ad-libitum administration of GS treatments (i.e., at the participants' discretion, when they feel they need to take GS) has not been assessed in non-acute testing periods. In addition, although Turner et al. (2022) administered three GS treatments daily for 14 days during their study, the administration was not purely systematic (i.e., fixed administration times) as participants had the option to take GS when they felt a craving.

Research is required in this area to support the theory that GS could decrease motivations to consume SSF. This thesis is the first study investigating the effect of GS on motivations to consume SSF. It is also the first study taking a qualitative approach to ascertain the effects of GS on intake of SSF. The study design uses a unique combination of laboratory and non-laboratory settings over 14 days to assess how GS affects SSF intake when administered both systematically (i.e., three times a day, in between meals only) and ad- libitum (i.e., up to six times a day, whenever the participant experiences a craving for SSF).

1.2 Aims and objectives

Aim:

To investigate the effect that GS intake compared to placebo has on motivations to consume SSF over 14 days in a placebo-controlled randomised cross-over trial when administered systematically (three times a day at mid-morning, mid-afternoon and mid-evening) or ad-libitum (up to six times a day but at the participants' discretion) in adults who have a sweet tooth.

Objectives are to investigate and assess changes over the course of the trial:

- What motivates adults to eat SSF
- Factors that may influence adult motivations to eat SSF
- What effect GS-containing mints have on adults' motivations to eat SSF when administered both in a systematic and ad-libitum manner compared to placebo
- How in control adults feel over their intake of SSF after testing GS-containing mints compared to placebo

1.3 Structure of the thesis

This thesis is comprised of four chapters and two appendices. Chapter 1 presents an introduction to and rationale for undertaking this thesis. Chapter 2 presents an in-depth critical literature review which aimed to critique evidence that GS affects motivations to eat SSF. Google Scholar and Scopus was used to search for literature and search terms included ‘motivation’ AND ‘Gymnema sylvestre’ OR ‘gymnemic acid*’ AND ‘sweet food’ OR ‘sugar*’ NOT ‘anti-diabetic’. Chapter 3 is a manuscript where the results of the thesis have been presented. The manuscript presents an abstract, introduction, methods, results, discussion and conclusion. Chapter 4 concludes the thesis by providing a summary of the study, including the strengths and weaknesses of the research as well as opportunities for future investigation. Appendix A contains supplementary methods information that did not fit in the manuscript. Appendix B contains materials used in conducting the research, including the screening questionnaire and recruitment materials. A thesis style format using APA version 7 was used throughout this thesis.

1.4 Contributors to the research

Contributor	Contribution to thesis
Imogen Nelson	Data collection (anthropometric measurements, sensory testing, questionnaires, interviews); statistical analysis; data interpretation; thesis author
Prof Ajmol Ali	Main thesis supervisor; advisor for study design; recruitment; advisor for data collection, statistical analysis and data interpretation; thesis revision
Prof Rozanne Kruger	Thesis co-supervisor; advisor for study design; recruitment; advisor for data collection, statistical analysis and data interpretation; thesis revision
David Hsiao	Advisor for study design; recruitment; data collection (anthropometric measurements, sensory testing, questionnaires)
Sophie Turner	Advisor for study design and data collection, facilitation of pilot testing
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Dr Warrick Wood	Advisor for study design
Charlotte Bertasius, Chloe Nunn, Danielle Oakes, Rebecca Sidford	Assistance with data collection (anthropometric measurements, sensory testing, questionnaires)

Chapter 2: Literature Review

2.1 Introduction

American physiologist Ancel Keys is responsible for originally correlating heart disease with total cholesterol (DiNicolantonio et al., 2016; Keys, 1970). Keys's recommendations included reducing total saturated fats and replacing them with polyunsaturated fats (Keys, 1970). Western total dietary fat intakes decreased from 1980 – 1990 (Austin et al., 2011; Billingsley et al., 2018) and inversely, intakes of processed carbohydrates increased as did cardiovascular disease and obesity prevalence (Benjamin et al., 2018; Billingsley et al., 2018; Gregg et al., 2004; Gross et al., 2004; Menke et al., 2015). Subsequent research linked high sugar intakes (in addition to high saturated fat) with non-communicable disease (NCD) risk (Malik et al., 2013). Sugar intakes <10% of total energy are encouraged (World Health Organisation, 2015b) to reduce NCD risk (World Health Organisation, 2022b). Promisingly, sugar intakes have declined or stabilised in many countries (Wittekind & Walton, 2014), including the United States (Marriott et al., 2019). However, average intakes remain above World Health Organisation (WHO) recommendations (Wittekind & Walton, 2014). For example, ~58% of New Zealanders consumed >10% of their total energy from sugar in 2008 (Kibblewhite et al., 2017). Global anti-obesity efforts include sugar taxes (Blades, 2001), lifestyle changes (Johnson et al., 2017), and pharmaceuticals such as appetite suppressants (Torres-Fuentes et al., 2015). Long-term efficacy of these initiatives remains unclear (Blades, 2001; Powell et al., 2013), and these may also be unsustainable (Kirkpatrick et al., 2018). Sugar is highly palatable (Swarna Nantha, 2014), and motivations driving its consumption are not well targeted by current sugar-reduction initiatives (Kirkpatrick et al., 2018; Raine, 2005).

Physiological, psychological, and behavioural processes determine food choice (Bédard et al., 2020; Leib, 2018; Macht, 2008; Macht & Simons, 2000; Plassmann et al., 2022). Conscious reductions of sugar-sweetened foods (SSF) are subsequently challenging, even if their ill-effects are known (Blades, 2001; Chu et al., 2018). Effects of herbal medicines on sugar intake have not been thoroughly investigated (Hasani-Ranjbar et al., 2009), but these may be desirable additions to current sugar-reduction initiatives (Brown & Bussell, 2011; Torres-Fuentes et al., 2015). Some herbs, such as Gymnema sylvestre (GS), make SSF less pleasurable (Nobel et al., 2017; Turner et al., 2020). Chemicals within GS prevent perception of sweet flavours and have been shown to lower SSF consumption (Devi & Jain, 2015; Kashima et al., 2020; Nobel et al., 2017; Stice & Yokum, 2018; Stice et al., 2017; Turner et al., 2020; Turner et al., 2022). Research into effects of GS on motivations to eat SSF merits consideration to investigate whether the herb could contribute to reduced global sugar consumption (Turner et al., 2020); no such research has been completed yet.

This review aimed to critique evidence that GS affects motivations to consume SSF. Literature was sought using Google Scholar and Scopus to identify recent studies from 2000 – 2023. Search terms included 'motivation' AND 'Gymnema sylvestre' OR 'gymnemic acid*' AND 'sweet food' OR 'sugar*' NOT 'anti-diabetic'. One study assessing physiological motivations to consume SSF was identified (Kashima et al., 2020), in addition to six studies assessing effects of GS desire for, and pleasure and intakes of SSF (Devi & Jain, 2015; Nobel et al., 2017; Stice & Yokum, 2018; Stice et al., 2017; Turner et al., 2020; Turner et al., 2022). This review subsequently evaluates research investigating the effect of GS on physiological (and pleasure-related) motivations to eat SSF.

2.2 Motivations to eat SSF

Factors affecting consumption of all foods are interrelated, and have physiological, psychological, and external origins (Jackson et al., 2003; Macht & Simons, 2000; Pollard et al., 2002; Schupp & Renner, 2011). Hunger, satiation (eating to satisfaction during meals) and satiety (feeling satisfied between meals) are fundamental motivations for eating (Leib, 2018; McCrickerd & Forde, 2016). Relationships between SSF and appetite are currently unclear (Kashima et al., 2020). Some evidence suggests initially tasting SSF promotes hunger (Blundell & Hill, 1986; Rogers & Blundell, 1989; Rogers et al., 1988; Tordoff & Alleva, 1990); other studies have found no link between SSF and hunger stimulation (Canty & Chan, 1991; Drewnowski et al., 1994; Holt et al., 2000; Mattes, 1990; Rolls et al., 1990). Crosstalk between the brain and gastrointestinal tract (GIT) enables identification of energy needs or lack thereof; subsequent feedback elicits sensations of hunger or satiety as appropriate (Simon et al., 2017; Tack et al., 2021). Other factors also contribute to hunger and satiety (Hawton et al., 2018), including mastication and swallowing rate (Hawton et al., 2018), and a meal's nutrient composition (Aguilera, 2019). These factors impact food transit time through the GIT, as meals eaten leisurely, or meals high in fibre, protein, or lipids, are digested slowly and thus sustain satiety for longer (Hawton et al., 2018; Tack et al., 2021).

Hunger may be experienced as an initial motivator to eat, before experience of secondary motivations specifically for SSF (or other palatable foods) (Tuorila et al., 2001). Despite having physiological feedback systems, physiological triggers are not required in humans to start or stop eating (Leib, 2018). Anticipatory consumption of perceived future energy needs can occur (Stricker & Hoffmann, 2007), as well as consumption that disregards physiological signals (Leib, 2018). For example, satisfied individuals can consume foods purely for pleasure (Espel-Huynh et al., 2018; Harington et al., 2016). Pleasure refers to sensations experienced from activation of neural reward pathways (Bédard et al., 2020). Sweetness level contributes significantly to palatability consumption (Sylvetsky & Rother, 2016). Sweet molecules (including glucose and non-nutritive sweeteners) activate specific taste buds, triggering neurons which integrate information from the taste buds with other senses to elicit experiences of sweetness and consequently, pleasure (Fernstrom et al., 2012; Yarmolinsky et al., 2009). Pleasure may have evolved for survival, as prehistoric food access was scarce and required preparation for potential famine (Eaton & Konner, 1985; Haber & Knutson, 2010; O'Keefe Jr & Cordain, 2004). Sweet foods, including honey (Dunne et al., 2021), were innately perceived as calorically dense rarities (Kashima et al., 2020). Perhaps they were also considered safe (Reed & McDaniel, 2006; Reed et al., 2006; Schroeder & Flannery-Schroeder, 2005) compared to bitter and sour flavours inherently associated with toxic vegetation (Morrison & Berthoud, 2007). Perception of pleasurable textures also occurs in humans but reasons for selection are less clear (Cox et al., 1998). Fatty, smooth textures in foods like milk chocolate may also indicate caloric density (Drewnowski, 1998); crispy or crunchy textures may indicate freshness (Szczesniak, 2002).

Effects of body weight (BW) on pleasure received from eating SSF have been mixed in literature, and BW management interventions have been shown to have varying effects on neural reward pathways (Oustric et al., 2018). Overall, dietary, pharmacological, behavioural, and cognitive interventions elicit reduced preferences for energy-dense foods (including SSF), which may be due to decreased neural reward activation (Oustric et al., 2018). The ‘reward surfeit theory of obesity’ concept is a model also supported by some recent studies (Stice & Yokum, 2017). This theory hypothesizes that obesity causes over-sensitivity to pleasure elicited with energy-dense food consumption, causing amplification of neural reward pathways and subsequent perpetuation of food seeking and consumption (Stice & Burger, 2019). The ‘reward deficiency syndrome thesis’ describes a contrasting idea, where obesity causes lower levels of neural reward activation, and a reward deficit that prompts food seeking behaviour (Stice et al., 2008). Future research investigating how BW affects pleasure elicited from SSF is merited given these uncertainties (Oustric et al., 2018).

Both positive and negative emotions affect food intake differently (Macht & Simons, 2000; van den Tol et al., 2019). Different moods have been shown to both stimulate and inhibit food consumption, depending on the individual (van den Tol et al., 2019; van Strien et al., 2019). Underlying mechanisms for how and why psychological motivations affect consumption are undefined (Evers et al., 2013; Macht, 2008; Reichenberger et al., 2020). Current research mostly focuses on eating out of negative emotions (Macht, 2008), and shows low moods may increase consumption because reward payoffs of eating palatable foods (e.g., SSF) are perceived as sufficient to neutralise negative emotions (Booth, 1994). This concept is supported by evidence showing emotional eaters do not overconsume nutrient-dense foods, instead selecting palatable, high sugar or fat foods (Aguiar-Bloemer & Diez-Garcia, 2018). Emotional eating may also be the result of learned approaches practised through infantile experiences, where caregivers used food as placation (Slochower & Kaplan, 1980).

Emotional eating exemplifies formation of habits (Reichenberger et al., 2020), which are also motivators on food choice (Teixeira et al., 2011). Frequently repeated behaviours formed through learning and established through rewarding reinforcement form habits (van’t Riet et al., 2011), which are subsequently performed automatically (Ouellette & Wood, 1998). Sugar-sweetened foods have been significantly associated with habit formation, with repeated and thoughtless consumption (de Bruijn & van den Putte, 2009; Kuźbicka & Rachoń, 2013; Zhen et al., 2011). In today’s developed nations, exposure to SSF is high (Cutler et al., 2003). High exposure combined with sensitive neural reward systems and the influence of emotions highlights the ease at which habitual SSF intake is formed (Fernstrom et al., 2012; Kuźbicka & Rachoń, 2013). Habitual SSF consumption may contribute significantly to obesity development, as their repeated intake can result in caloric surplus and subsequent weight gain (van’t Riet et al., 2011; Zhen et al., 2011). Replacing triggers of inappropriate behaviours (e.g., habitual SSF intake) with triggers for new habits, combined with mindfulness techniques to inhibit old ways, are possibilities for helping to reduce unhealthy eating (Teixeira et al., 2011; van’t Riet et al., 2011).

Many external factors affect drives to eat (Renner et al., 2012), including social cues (Galef Jr, 1996) and an individual's physical environment (Fisher & Birch, 2002). External motivators can increase or decrease meal volume and choice (Wansink, 2004). Humans have been shown to be affected by their observations of, and interactions with eating partners (Nisbett & Storms, 2017). For example, individuals are more likely to eat more if their eating partner also eats a large meal (Cruwys et al., 2015). Large meals are also likely to be consumed when dining occurs in a group compared to solo dining (Herman, 2015), or if an individual has a close relationship with their eating partner (Messer, 1984). Familiarity at the table may promote relaxation and ease, which could subsequently promote food intake (Stroebele & De Castro, 2004). In contrast, unfamiliarity could increase stress, inhibiting food intake (Stroebele & De Castro, 2004). Other external factors motivating food intake are related to meal environments (Stroebele & De Castro, 2004). Distractions in the environment (e.g., smartphones at the table) increase food intake as the distraction diverts attention from hunger and satiety cues (Pereira & Van der Bilt, 2016; Smith & Ditschun, 2009). Presence of environmental food cues also contribute to oral intake (Ridley-Siegert et al., 2015), as exposure to sights and smells of food instigates desire and consumption (Fisher & Birch, 2002).

Motivations for eating SSF are clearly wide-ranging and complex (Plassmann et al., 2022). Achievement of appropriate global sugar consumption will require interventions that account for and challenge these motivations (Kirkpatrick et al., 2018; Torres-Fuentes et al., 2015). Gymnema sylvestre may have potential for helping manage pleasure-seeking, or hedonistic motivations to eat these foods, given it decreases the ability to taste sweet flavours (Nobel et al., 2017).

2.3 Gymnema sylvestre

2.3.1 Background

Gymnema sylvestre is a woody vine belonging to the Asclepiadaceae family that thrives in the humid forests of India, Australia, Malaysia, Japan, Vietnam and Sri Lanka (Saneja et al., 2010; Tiwari et al., 2014). The scientific name *Gymnema* originates from the Hindi term 'gurmar' meaning 'destroyer of sugar' (Di Fabio et al., 2013; Saneja et al., 2010). This name refers to the plant's ability to prevent perception of sweetness (Laha & Paul, 2019). Ayurvedic medicines value this property, and use the dried leaves and roots in teas, drinks and candies for traditional treatment of conditions including hyperglycaemia, insulin insensitivity and SSF cravings (Dixit & Pandey, 1984; Laha & Paul, 2019; Pandey, 2021; Parveen et al., 2020). By reducing the penchant for eating SSF, GS has also been prescribed to aid BW loss (Reddy, 2022).

2.3.2 Chemical properties

An estimated 75 – 80% of worldwide populations utilise herbal therapies (Pal & Shukla, 2003; World Health Organisation, 2022c). Traditional use of GS for treatment of health conditions has prompted study of its pharmacological properties (Srivastava et al., 2019). Many of the herb's phytochemicals and micronutrients (including saponins, glycosides, gymnemanol, gurmarin flavonoids, tannins, alkaloids, phenols, cinnamic acid, folic acid, ascorbic acid, butyric acid and tartaric acid) have beneficial effects when isolated, including anti-inflammation (Kang et al., 2012; Khan et al., 2019; Rachh et al., 2010; Rose & Bode, 1993). Saponins known as gymnemic acids (GA) are major chemical components in GS responsible for the herb's sweetness-blocking properties (Khramov et al., 2008; Stoecklin, 1969). By binding to gustatory cells responsible for perception of sweetness, GA prevents sugar from binding and subsequent perception of its flavour (Pothuraju et al., 2014).

2.3.3 Uses in diabetes and obesity treatment

In vitro and *in vivo* studies show GS may have potential for clinical management of NCD and obesity (Tiwari et al., 2014). Current evidence is derived largely from *in vitro* and animal studies (Kumar et al., 2013; Li et al., 2019; Luo et al., 2007; Sugihara et al., 2000). There is insufficient evidence from human clinical trials to confirm clinical use of GS (Devangan et al., 2021; Pothuraju et al., 2014).

Rats with DM exhibit decreased fasting blood glucose levels and increased insulin levels when administered GS extracts, indicating potential for GS use in DM clinical trials (Li et al., 2019; Sugihara et al., 2000). Results from *in vitro* studies also support GS use in DM treatment, as GA have been shown to promote insulin release in pancreatic beta cells (Li et al., 2019). Other studies have aimed to investigate effects of GS on BW, hyperlipidaemia and overall obesity severity (Kumar et al., 2013). Rats with high-fat-diet-induced obesity, when treated with oral GS extracts, have exhibited reduced total BW, visceral fat pad weight, total cholesterol, low-density lipoprotein cholesterol, high-density lipoprotein cholesterol, triglycerides, apolipoproteins A1 and B (Kumar et al., 2013; Luo et al., 2007). These animal trials are limited because the aetiology of both DM and obesity in rat models does not mimic that of the intended diseases. Streptozotocin injections are commonly used to destroy pancreatic islet beta cells responsible for insulin production in studies investigating DM, which mimics type 1 DM more accurately than type 2 DM, but does not reflect the aetiology's autoimmune aspects (Cefalu, 2006; Gao et al., 2015). Similarly, rats with high-fat-diet-induced obesity only reflect genetic multi-factor syndrome-related obesity; and cannot account for aetiological factors such as poor sleep and cigarette smoking (Luo et al., 2007). Aetiological differences between rat models and humans with obesity and DM indicate the need for robust human trials to investigate potential for GS in obesity and DM management. Human studies on this matter are limited, but research has been completed on direct effects of GS on SSF intake, which could indicate whether GS could contribute to reduced risk, rather than treatment, of obesity and DM (Kashima et al., 2020; Nobel et al., 2017; Stice & Yokum, 2018; Stice et al., 2017; Turner et al., 2020; Turner et al., 2022).

2.4 Effects of Gymnema sylvestre on food intake in humans

Links between high sugar intake and NCD and obesity (World Health Organisation, 2015a, 2022b) indicate reducing SSF intake is necessary for improved global health and healthcare costs (Te Morenga et al., 2013; World Health Organisation, 2022a). Preventing perception and therefore appeal of sweetness means GS presents a novel method for reducing sugar intake (Pothuraju et al., 2014). Related to the aforementioned multifactorial drivers of food intake, a significant motivator for eating is the perceived pleasure from the consumed food (Higginson et al., 2012). If SSF is no longer pleasurable, they may no longer be appealing, and humans may be less motivated to consume them. Seven studies assessing effects of GS on consumption of SSF were identified for this review; their methodologies and main findings are presented in Table 2.1.

Table 2.1. Summary of human studies investigating the effects of Gymnema sylvestre on different aspects related to consumption of SSF

Authors and year	Study design, aim and group	Methodology	Main findings
(Devi & Jain, 2015)	Clinical evaluation **Aim:** optimise a GS formula for participant compliance and efficacy of reducing high-sugar food intake • n = 8 • Genders, BMI and age: not described	• **Treatments:** 20 mg GS extract (amount of GA unspecified). All tablets contained the same quantity of GS but different quantities of other ingredients • **Mode of treatment delivery:** tablet, administered once orally, after rinsing mouth with distilled water. Participants were given specific instructions to hold tablets in the mouth and roll it against the upper palate (without chewing) until dissolved • **Outcome measures:** perceived bitterness; mouthfeel; and sweetness of oral tablet • **Testing food:** sucrose • **Testing timeframe:** unspecified • **General experimental design:** ○ Six out of nine prepared oral tablets were randomly selected for testing	• The most palatable GS tablet contained 6% crospovidone. This tablet decreased sweetness of sucrose by 100% after 5 min, 80% after 10 min, 60% after 20 min and 20% after 25 min. Sweetness perception subsequently returned to baseline • **Conclusion:** sweetness of sucrose was not perceived for 30 min after taking the GS tablet with 6% crospovidone. This GS tablet may be beneficial for reducing sugar cravings and intake of SSF

Authors and year	Study design, aim and group	Methodology	Main findings
		○ The most palatable tablet from testing was further tested (after participants were trained to evaluate sweetness) for anti-sweet effects with sucrose ○ Intensity of sucrose was measured with a six-point scale	
(Nobel et al., 2017)	Double-blind placebo controlled, crossover **Aim:** investigate whether GA-lozenges lessen desire to consume, and total	• **Treatments:** 3 mg GA (Crave Crush^{TM}), or isocaloric placebo • **Mode of treatment delivery:** lozenge, taken once orally after an initial serving of testing food without rinsing mouth. It was unspecified whether participants were given instructions on lozenge administration • **Outcome measures:** pleasantness of high-sugar food; desire to consume high-sugar food; and total intake of high-sugar food	• Desire ratings were significantly reduced with GA-lozenge compared to placebo (p = 0.009) • Consumption of GA-lozenges resulted in less participants eating a second serving of confectionary compared to placebo (p = 0.008) • Consumption of GA-lozenges resulted in participants finding

Authors and year	Study design, aim and group	Methodology	Main findings
	intake of high-sugar food • n = 44 • Genders: 55% male, 45% female • BMI: range of 18 – 32 kg/m^2 • Age: range of 18 – 65 years	• **Testing food:** self-reported favourite lollies (six options) • **Testing timeframe:** two separate testing days (seven days apart). Participants were randomly allocated to one treatment during visit one; then crossed-over treatments during visit two • **General experimental design:** ○ Small meals (caloric density unspecified) were eaten 45 min before sensory testing occurred ○ **Sensory testing:** ▪ 1. Initial hunger was assessed (using a 100-point visual analogue scale (VAS) rating) ▪ 2. A serving of testing food was consumed. Pleasantness of it and desire for a second serving was rated (using 100-point VAS ratings)	confectionary less pleasant compared to placebo ($p = 0.003$) • **Conclusion:** The GA-lozenge may help reduce sugar intake, and could be useful for reducing total BW

Authors and year	Study design, aim and group	Methodology	Main findings
		▪ 3. Treatments were administered. Desire for a second serving was rated again ▪ 4. Up to five additional servings were offered, which participants could accept (pleasantness and desire for another serving was rated again) or decline (at which point testing finished). Testing automatically finished when a maximum of five servings were accepted	
(Stice et al., 2017)	Single-blind placebo controlled, randomised trial	• **Treatments and dosage:** 3.5 mg GA or placebo • **Mode of treatment delivery:** lozenge, taken once orally after an initial serving of testing food without rinsing mouth. Participants reportedly let lozenges	• The GA-lozenge reduced total intake of high-sugar food compared to placebo (p = 0.017)

Authors and year	Study design, aim and group	Methodology	Main findings
	Aim: investigate whether GA lessens desire to consume and total intake of high-sugar food • n = 67 • Genders: 38% male, 62% female • BMI: self-reported mean of	dissolve completely on tongues before proceeding with testing, but whether instructions on administration were given was unspecified • **Outcome measures:** pleasantness of high-sugar food; desire to consume high-sugar food; hunger level; total intake of high-sugar food • **Testing food:** self-reported favourite chocolate bars and lollies (six options) • **Testing timeframe:** one testing day • **General experimental design:** ○ Involved a **sensory testing protocol** in an identical process to that by Nobel et al. (2017) (described on page 26), except: ▪ Instead of VAS ratings, 100-point scales were used	• The GA-lozenge reduced desire for confectionary compared to placebo (p = 0.136) • The GA-lozenge reduced how pleasant second servings of confectionary were compared to placebo (p = 0.001) • **Conclusion:** the GA-lozenge can reduce consumption and desire for confectionary, therefore blocking sweet taste receptors may reduce desire for sweetness

Authors and year	Study design, aim and group	Methodology	Main findings
	23.8 ± 4.0 kg/m^2 • Age: mean of 21.4 ± 3.5 years	▪ In addition to initial hunger rating, initial desire for selected testing food was also rated before eating a serving	
(Stice & Yokum, 2018)	Double-blind crossover **Aim:** investigate effects of GA on neural reward regions with anticipation of and consumption	• **Treatments and dosage:** 3.5mg GA or placebo • **Mode of treatment delivery:** lozenge, taken once orally after a serving of milkshake without rinsing mouth; then taken again a second time before eating confectionary ad-libitum. Participants were given specific instructions to let lozenges dissolve completely on the tongue • **Outcome measures:** Neuroimages from fMRI scans to show level of neural activation from anticipation and taste of milkshakes; cravings for milkshakes; dietary	• The fMRI scans showed that anticipation of the milkshake activated specific brain areas in all participants • Crave rating 2 was higher than crave rating 1. No significant differences between the GA and placebo groups were seen • Milkshake tasting resulted in activation of specific brain areas

Authors and year	Study design, aim and group	Methodology	Main findings
	of high-sugar food	behaviours related to attempts to lose or maintain BW; disinhibited eating; preference for sweet foods	for all participants. The GA resulted in significantly smaller activation compared to placebo

	• n = 40
	• Genders: 27.5% male, 72.5% female
	• BMI: mean of 25.8 kg/m^2
	• Age: mean of 21.6 ± 4.0 years
		• **Testing food:** high-sugar, moderate-fat milkshakes
		• **Testing timeframe:** two separate testing days (seven or more days apart). Participants were randomly allocated to one treatment during visit one; then crossed-over treatments during visit two. Scans occurred at both visits
		• **General experimental design:**
		  ○ Breakfasts or lunches were provided to standardise satiety. Exact caloric contents were unspecified but foods were:
		    ▪ Breakfast: one piece of toast (or two if participant > 150 lbs BW), one tbsp peanut butter, one apple, one string cheese
			• All participants experienced significant brain interactions when anticipating milkshakes. These interactions were significantly reduced with GA compared to placebo
			• Differences between crave ratings 1 and 2; and 2 and 3, were not statistically different between GA and placebo. Changes in crave ratings (between crave ratings 2 and 3) did not match fMRI scans showing brain activation for anticipated taste

Authors and year	Study design, aim and group	Methodology	Main findings
		▪ lunch: one peanut butter and jelly sandwich (or two if participant was > 150 lbs), one string cheese, one apple). Hunger ratings was then taken using a 20-point VAS rating ○ Thirty min post-meal, participants underwent fMRI sessions to assess neural responses to high-sugar, moderate-fat milkshakes ▪ Participants were shown images of chocolate milkshakes (i.e., picture 1) and asked to anticipate its taste. Crave rating 1 was taken using a five-point scale ▪ Milkshake samples were given to taste in four cycles (i.e., taste 1)	• A second dosing of GA-lozenge resulted in participants eating less confectionary compared to when given a second dose of placebo ($p = 0.02$) • Overall milkshake intakes were lower with GA compared to placebo • **Conclusion:** Using GA might help decrease intake of high-sugar foods by reducing activation of neural reward pathways associated with consumption of sweet flavours

Authors and year	Study design, aim and group	Methodology	Main findings
		▪ Participants were shown milkshake images again 2 (i.e., picture 2) for anticipation of taste. Crave rating 2 was taken ▪ Allocated treatments were given ▪ Participants were shown milkshake images again (i.e., picture 3) for anticipation of taste 2. Crave rating 3 was taken ▪ Four cycles of milkshake samples given to participants to taste (i.e., taste 2) before fMRI sessions ended ○ A second dose of allocated treatment was administered. Participants completed surveys to assess other outcome measures and were invited eat ad-libitum confectionary from a bowl while doing so. The bowl of confectionary	

Authors and year	Study design, aim and group	Methodology	Main findings
		was weighed before and after ad-libitum consumption to measure confectionary intake	
(Turner et al., 2020)	Single-blind, placebo-controlled crossover **Aim:** investigate acute effects of GS-mints on desire to consume high-sugar food • n = 56 • Genders: 35.7%	• **Treatments and dosage:** 4 mg GA or isocaloric placebo • **Mode of treatment delivery:** mint (dissolvable tablet), taken once orally after an initial serving of testing food without rinsing mouth. Participants were given administration instructions to place mints on the tongues and suck until dissolved • **Outcome measures: w**hether participants self-identified as having a sweet tooth; hunger level; perceived enjoyment of testing food; desire for more servings of food • **Testing food:** self-reported favourite chocolate bars (11 options) • **Testing timeframe:** two separate testing days (seven days apart) where participants were	• Total consumption of chocolate at each visit was lower with GS-mints compared to placebo ($p = 0.006$) • Desire for another serving of chocolate was lower with GS-mints compared to placebo ($p = 0.011$) • Pleasantness of chocolate was lower with GS-mints compared to placebo ($p <0.0001$) • Hunger ratings were not significantly affected with GS-mints compared to placebo ($p = 0.715$) • Participants with a sweet tooth experienced more significant

Authors and year	Study design, aim and group	Methodology	Main findings
	male, 64.3% female • BMI: mean of 23.2 ± 3.1 kg/m^2 • Age: range of 18 – 47 years	randomly allocated to one treatment during visit one; then crossed-over treatments during visit two • **General experimental design:** Involved a **sensory testing protocol** in an identical process to that by Nobel et al. (2017) (described on page 26)	decreases in pleasantness of and desire for high-sugar foods with GS-mints • **Conclusion:** Compared to placebo, GS-mints reduce consumption of high-sugar foods. They also reduce pleasantness of and desire for high-sugar foods. Duration of adherence to and effects of GS-mints are unknown
(Kashima et al., 2020)	Randomised crossover **Aim:** investigate effects of GS oral sweet sensation	• **Treatments and dosage:** 2.5% GS solution (amount of GA unspecified; 2.5% equates to 625 mg GS in 25 mL of solution) or distilled water i.e., placebo • **Mode of treatment delivery:** oral mouth rinse taken seven times, without pre-rinsing with distilled water. Participants were given specific administration	• All foods became less sweet and were liked less with administration of GS compared to placebo ($p<0.05$) • Participants reported liking all testing foods significantly less after

Authors and year	Study design, aim and group	Methodology	Main findings
	suppression on consumption of sweet-tasting foods as well as post-prandial physiological responses • n = 15 • Genders: 40% male, 60% female • BMI: mean of 21.2 ± 2.4 kg/m^2	instructions to rinse their mouths for 30 secs with 25mL solution and to not swallow • **Outcome measures:** motivations to eat as indicated by level of hunger, fullness and prospective consumption; taste intensity and liking; total food consumption; gastric emptying; blood glucose; plasma insulin • **Testing food:** muffin, yogurt and banana • **Testing timeframe:** two separate testing days where participants were randomly allocated to one treatment during visit one; then crossed-over treatments during visit two. For males, at least seven days separated testing days. For females, testing days occurred during the same phase of menstrual cycles • **General experimental design:** ○ Pre-treatment: participants used allocated treatments twice then gargled distilled water	taking GS compared to control ($p<0.05$) • No significant effects on hunger, fullness and prospective consumption were seen ($p>0.05$). After the 4^{th} min, hunger and prospective consumption for both GS and placebo were significantly reduced compared to initial ratings ($p<0.05$). Ratings of hunger increased for both GS and placebo compared to initial ratings ($p<0.05$). Overall, no significant differences between GS and placebo were seen for hunger, fullness and prospective consumption ($p>0.05$)

Authors and year	Study design, aim and group	Methodology	Main findings
	• Age: mean of 22 ± 3 years	○ Participants consumed muffin, followed by distilled water with 12.5 mg of ^{13}C-sodium acetate (i.e., utilisation of a ^{13}C breath test) to enable investigation of gastric emptying rate ○ Following 180 sec rest periods, participants repeated the following seven times: treatment mouth rinse, gargling with distilled water, ingested a ^{13}C-sodium acetate solution, consumption of one testing food ○ Breath samples were taken at the trial's onset, every six min during the prandial phase, and then every five min during post-prandial phases. After each breath sample was taken, participants reported taste intensities of sweet, sour and salty flavours (using 100-point scales)	• Gastric emptying rate was not affected by GS ($p>0.05$) • **Conclusion:** suppressing perception of sweet flavours with GS mouth rinses does not affect gastric emptying, glycaemic response or appetite, both during and after consumption of sweet foods

Authors and year	Study design, aim and group	Methodology	Main findings
		○ Hunger, fullness level and prospective consumption were rated (using 100-point scales) ○ Baseline, prandial and post-prandial bloods measured blood glucose and insulin	
(Turner et al., 2022)	Double-blind randomised **Aim:** investigate whether GS-mints reduce high-sugar food intake when administered for 14 days • n = 58	• **Treatments and dosage:** fibre and vitamin supplement; healthy eating guide; 4 mg GA or isocaloric placebo • **Mode of treatment delivery:** mint (dissolvable tablet) taken once orally, three times a day. Participants were given administration instructions to place mints on the tongue and suck until completely dissolved • **Outcome measures:** number of chocolates consumed; food intakes (ascertained using food frequency questionnaires); hunger level; perceived pleasantness of chocolate; desire for chocolate, whether or not	• Total amounts of chocolate eaten on day zero decreased with GS (p = 0.022). No significant differences in amount of chocolate eaten were seen between INT and CON on day 15 • Having a sweet tooth resulted in larger decreases in pleasantness and desire for chocolate after consuming GS • On days zero and 15, noticeable effects were seen in pleasantness

Authors and year	Study design, aim and group	Methodology	Main findings
	• Genders: 32.8% male, 67.2% female • BMI: 26.1 ± 6.6 kg/m^2 • Age: 29.5 ± 7.8 years	participant described themselves as having a sweet tooth • **Testing food:** self-reported favourite chocolate bars (13 options) • **Testing timeframe:** 14-day testing period, in addition to three visits to testing centre (days zero, 15 and 44) • **General experimental design:** ○ The 14-day testing period involved taking allocated treatments three times a day in between meals or when experiencing cravings for sweet foods (i.e., a combination of systematic (fixed) and ad-libitum (at the participants' discretion) prescriptions); taking fibre and vitamin supplements every morning; and completing daily adherence diaries ○ Day zero testing: random allocation to treatment group (INT for GS mint, or CON for	and desire ratings. The INT group experienced slight increases in pleasantness and desire; CON participants experienced slight decreases • Over nine food categories, no significant differences in consumption between treatments and timepoints were seen • No habituation to GS-mints occurred over the 14-day trial • **Conclusion:** the GS-mint reduces desire for, pleasantness of and total intake of high-sugar food over a 14-day period. Duration of adherence and effects of the GS-mint are unknown

Authors and year	Study design, aim and group	Methodology	Main findings
		placebo). Allocated treatments, supplements and healthy eating were distributed. Testing included baseline anthropometric measures, sensory testing, and questionnaires ○ Day 15 testing: included final anthropometric measures, sensory testing and questionnaires ○ The **sensory testing protocol** followed an identical process to that by Nobel et al. (2017) (described on page 26) except: ▪ After first serves of testing food were given, hunger was assessed again in addition to initial pleasantness and desire ▪ After initial two servings of testing foods were given, up to four additional servings were offered instead of five	

2.4.1 Effect of treatment dosage

Gymnemic acids in GS prevent perception of sweetness (Devi & Jain, 2015), but studies mentioned in this review sometimes used GA interchangeably with GS when describing treatment dosages. Dosages are mostly provided in milligrams of GA (amounts of GA are unspecified by Devi & Jain (2015) and Kashima et al. (2020)). Advantages or disadvantages of using GA over GS have not been studied, so no comment can be made on this. Studies using specifically GA used a similar treatment dosage range (3 – 4 mg). Kashima et al. (2020) used 625 mg GS; Devi & Jain (2015) used 20 mg GS. There were no significant differences between study results, regardless of difference in dosages. Perhaps a minimum of 3mg GA was all that was required to prevent perception of sweet flavours. Higher doses of GA or GS did not elicit stronger responses, or for longer durations.

2.4.2 Effect of treatment delivery method

Most of the studies used dissolvable tablets (including lozenges or mints) to deliver GS, apart from Kashima et al. (2017), who used an oral mouth rinse. Considering the herb's method of action as a glucose tongue receptor antagonist, either delivery method is appropriate provided binding of GS to receptors is ensured (Devi & Jain, 2015). Both dissolvable tablets and oral mouth rinses allow this, if taken properly. Devi & Jain (2015), Stice & Yokum (2018), Turner et al. (2020), Kashima et al. (2020) and Turner et al. (2022) specified that researchers provided participants instructions on proper administration. Whether Nobel et al. (2017) and Stice et al. (2017) provided their participants any administration instructions was unspecified. Devi & Jain (2015) also required participants to rinse their mouths with distilled water pre-treatment administration, which probably cleansed the oral cavity and increased GS's binding capability. No other studies required pre-treatment administration mouth rinses. Despite the slight differences in GS delivery method between the studies, there was not a significant difference in results. Overall, using dissolvable tablets versus mouth rinses was not more or less effective, nor was using distilled water as a mouth rinse pre-treatment versus not using a pre-treatment mouth rinse (Devi & Jain, 2015).

2.4.3 Effect of treatment on amount of SSF eaten

Five studies identified assessed effects of GS on total consumption of SSF (Nobel et al., 2017; Stice & Yokum, 2018; Stice et al., 2017; Turner et al., 2020; Turner et al., 2022), and all found that GS treatments resulted in statistically significant reductions of SSF eaten. All studies strengthened their findings by standardising hunger before testing for effects of GS. Aforementioned motivations that affect intake of SSF (Blades, 2001) include physiological hunger (Jackson et al., 2003; Schupp & Renner, 2011). Ensuring participants had been fed at least a snack, pre-testing, decreased the extent to which participants were eating SSF out of hunger, during testing (Nobel et al., 2017). In this case, the true outcome measure is how participants' intake of SSF, when they are not hungry, was affected and standardising satiety was key to ensuring accurate assessment (Nobel et al., 2017).

Energy density of meals used by the studies differed slightly, ranging from small snacks of wholegrain chips (22g, 438 kJ) (Turner et al., 2020; Turner et al., 2022) to light meals (e.g., meals used by Stice & Yokum (2018) were estimated in this review to range from 1757 – 2803 kJ using a food exchange list (Caso, 1950)) (Nobel et al., 2017; Stice & Yokum, 2018). All the studies utilised wait periods of 45 – 60 minutes post-meal for hunger standardisation. Other meals participants had eaten in the day were not accounted for in any of the studies in terms of their contribution to hunger level prior to testing. Time taken for meal digestion varies depending on factors such as mastication and swallow rate (Hawton et al., 2018); as well as the meal's nutrient profile (Aguilera, 2019). The degree to which the studies attempted to standardise hunger before testing the effect of GS on consumption of SSF was therefore fair, but does not account for intricacies of hunger and satiety signalling.

Turner et al. (2022) presented another notable effect of GS on total consumption of SSF, as results showed an overall reduction in consumption of chocolate on initial and final testing days. Consistent results on both testing days indicates participants were not habituated to GS treatments, and it was just as effective on day zero as it was on the final day. This obviously has important implications for long-term adherence; if GS is to be used as part of a lifestyle intervention to reduce SSF intake, finding it effective long-term is essential to optimal health outcomes (Turner et al., 2022).

2.4.4 Effect of treatment on palatability and desire of SSF

Studies in this review which assessed effects of GS on pleasure derived from SSF all found that GS made several SSF taste less pleasant compared to control treatments (Kashima et al., 2020; Nobel et al., 2017; Stice & Yokum, 2018; Stice et al., 2017; Turner et al., 2020; Turner et al., 2022). All studies used quantitative designs, and participants' in-depth perceptions were not captured (e.g., specific reasons why participants found SSF unpleasant).

Stice and Yokum (2018) added particularly strong support to these findings by using fMRI scans. All participants experienced activation of brain areas, including the orbitofrontal cortex (which has been associated with neural reward pathways (Frank et al., 2008; Smeets et al., 2011; Stice et al., 2013; Stice & Yokum, 2017; Yeung et al., 2018)). However, participants given GA exhibited significantly smaller neural activation compared to placebo, highlighting how GS blocks neural reward through preventing perception of sweetness. Stice & Yokum (2018) were limited by utilisation of a block design with a small number of trials within each block for their fMRI paradigms, which reduced sensitivity of the fMRI results (Dale & Buckner, 1997). These studies also used cohorts with wide ranges of body mass indexes (BMIs). Exact effects of weight on neural reward pathways, as previously mentioned, is undefined (Oustric et al., 2018), but being obese may promote SSF intake because of either overactive (Stice & Yokum, 2017) or underactive (Stice et al., 2008) neural reward circuitries. The findings of these studies support existing literature that GS reduces pleasure received from SSF (Ulbricht et al., 2011). Turner et al. (2022) is also the first study to investigate longer-term effects to find GS reduces pleasure of SSF during a 14-day timeframe. The findings may indicate GS has similar effects on people with a range of BMIs, but as Stice and Yokum (2018) discuss, using participants with such a wide variety of body mass may have inadvertently added excess noise to the data in this research. Future studies may benefit from using participants from set BMI ranges (i.e., healthy or overweight, but not both).

Nobel et al. (2017), Stice et al. (2017), Stice & Yokum (2018), Turner et al. (2020) and Turner et al. (2022) also assessed effects of GS on desire or cravings for SSF. All studies found GS reduced desire or cravings for servings of SSF after taking an initial serving. These studies concluded GS could be useful in decreasing pleasantness of, and desire for, SSF, possibly contributing to lower intakes. Stice & Yokum (2018) provided additional evidence, showing GA administration resulted in significantly reduced neural activation associated with both anticipation for milkshakes, and reward after tasting milkshakes compared to placebo. Interestingly, Turner et al. (2022) found effects of GS on participants who identified as having a sweet tooth were similar to the findings by Turner et al. (2020), further supporting the idea that GS may especially benefit individuals with a sweet tooth (Reed & McDaniel, 2006). Turner et al. (2022) also showed mixed findings on GS supplementation long-term: despite effects on those with a sweet tooth, GS resulted in slight increases in pleasantness of and desire for chocolate over the 14-day trial. In contrast, the placebo group exhibited slight decreases. The authors postulate this effect may be a result of the placebo group participants consciously attempting to reduce SSF intake. A hypothesis as to why a decrease was not also seen with GS treatment was not provided, but many factors could have culminated in this result. Perhaps those given GS had lower adherence to taking the herb compared to those taking placebos – GS has a characteristic bitter taste (Schroeder & Flannery-Schroeder, 2005) which may not have been effectively masked in the treatments used by Turner et al. (2022). Or, because adherence to treatment administration was not monitored (i.e., whether instructions given on day zero were followed), participants may have taken the GS treatments incorrectly, reducing its effectiveness.

2.4.5 Effect of treatment motivations to consume SSF

Kashima et al. (2020) was the only study to specifically investigate motivations to eat as outcome measures. Hunger, fullness, and prospective consumption of SSF were used as indicators of motivations. Overall, GS did not significantly affect motivations to eat SSF. Hunger and prospective consumption for both the GS treatment and control were significantly reduced by the fourth minute of the trial compared to initial ratings; and the opposite effect was seen for fullness for both treatments. The researchers referred to previous research which found effects of SSF on hunger are mixed (Blundell & Hill, 1986; Drewnowski et al., 1994; Holt et al., 2000; Rogers & Blundell, 1989). Their findings support the idea that SSF (or GS) does not affect appetite indices (Kashima et al., 2020). Their results also further suggest GS may not affect physiological motivations to eat SSF. Although previous evidence indicates physiological motivations to eat SSF are significant (Jackson et al., 2003; Schupp & Renner, 2011), many other motivations to eat, unrelated to hunger or satiety, also exist. As such, findings by Kashima et al. (2020) do not encompass the effects of GS on all motivations to eat SSF, but they do show that GS may not affect physiological ones.

As previously mentioned, studies by Nobel et al. (2017), Stice et al. (2017), Stice and Yokum (2018), Turner et al. (2020), Kashima et al. (2020) and Turner et al. (2022) all found GS made SSF less pleasant or enjoyable compared to placebo. Rating systems were used to assess liking of the SSF, or how pleasant they found them, post-GS administration. Motivations to eat SSF out of pleasure were therefore not a specific outcome measure. Because the studies found that GS made the SSF less pleasurable, there is the potential for GS to affect motivations to eat SSF because they are inherently pleasurable. However, exact effects of GS on hedonistic motivations are unknown. None of the studies investigated effect of GS on other motivations to eat SSF, such as habit-related or psychologically related motivations. Therefore, no comment can be made on whether GS can affect these drivers to eat SSF.

2.4.6 Effect of systematic versus ad-libitum administration

Six of the seven studies delivered GS treatments systematically (i.e, a fixed dose was used under identical circumstances at every administration). Devi and Jain (2015), Nobel et al. (2017), Stice et al. (2017) Turner et al. (2020) and Kashima et al. (2020) administered their treatments once after an initial taste of a SSF and before a second taste. Stice and Yokum (2018) notably administered treatments twice, initially after a serving of milkshake, then taken again before eating confectionary ad-libitum). Because treatment administration was identical for every participant and occurred under identical circumstances, this form of treatment delivery can be classified as SYS. Turner et al. (2022) used an administration with SYS and ADLIB (at the participants' discretion) aspects. Three treatments a day were compulsory (i.e., SYS), but they could be taken either in between meals or when cravings for SSF were felt (i.e., systematically or ADLIB depending on the participant). Turner et al. (2022) noted participants kept daily adherence diaries, but otherwise no comment was made on how many participants took their treatments in between meals, or cravings were experienced. Adherence to the three daily treatments appeared more important than the treatment administration, but Turner et al.'s (2022) methodology highlights how dosage timing could have made significant differences to cravings and desire for SSF. Overall, effects of SYS administration of GS compared to ADLB administration has not yet been thoroughly investigated. However, the studies in this review (all except for Turner et al.'s (2022) study) show how a single SYS dose of GS (or a few) can reduce desire for, and total intake and pleasantness of SSF. Turner et al. (2022) is the first study to administer GS treatments in a dual SYS-ADLIB method, and highlights future studies would benefit from assessing effects of GS when administered in distinct, separate ways. Doing so would allow investigation of how best to administer GS for maximum impact on SSF intake.

2.5 Conclusion

The consumption of SSF is complex, with motivations for their consumption being ingrained in human behaviour geared towards survival. This complexity is one reason these foods are eaten abundantly, even with knowledge of their detriment to human health. Targeting motivations directly may be a useful intervention in improving global health outcomes; this is where significance of GS lies. So far only one study has directly used the term 'motivation' as an outcome measure to investigate effects of GS on SSF; specifically physiological motivations were assessed (Kashima et al., 2020). Gymnema sylvestre was found to not significantly affect physiological motivations to eat SSF. Remaining studies identified in this review highlight how GS affects pleasure from SSF, as well as desire for more. Findings indicate GS reduces pleasantness of, and desire for these foods, suggesting GS may be useful in reducing pleasure-related motivations. Gymnema sylvestre may not affect physiological motivations (i.e., hunger and satiety). Due to the limited research completed on these matters, further study is required to link GS and changes in motivations to eat SSF.

Chapter 3: Research manuscript

3.1 Abstract

Background: Although excessive sugar-sweetened food (SSF) consumption increases obesity risk, global consumption is inappropriately high. Complex motivations to eat these foods may contribute to high sugar intakes. The herb Gymnema sylvestre (GS) has been shown to reduce SSF consumption; but its effects on motivations to eat SSF are currently unknown.

Objectives: To investigate effects of GS, administered systematically (three times a day in between meals, i.e., GS-SYS treatment) or ad-libitum (up to six times a day at participants' discretion, i.e., GS-ADLIB) over 14 days, on adult motivations to eat SSF compared to placebo.

Methods/Design: Placebo-controlled randomised cross-over trial with seven participants (mean age of 34.7 ± 13.8 years, two males, five females), using three 14-day test phases to assess effects of a placebo (administered systematically, i.e., PLAC-SYS), GS-SYS and GS-ADLIB. Interviews occurred at baseline and after each testing phase to monitor motivations to eat SSF.

Results: The GS-SYS and GS-ADLIB treatments made SSF unpleasant to eat and increased mindful eating patterns, subsequently increasing motivations to avoid SSF. External factors could increase or decrease motivations, depending on the individual. Levels of self-control over intake of SSF changed during the study, mostly because of external factors but also in part to GS-ADLIB.

Conclusion: Systematic and ad-libitum GS administration may increase motivations to avoid SSF, and could be used as part of larger interventions to reduce total SSF consumption.

Key Words: Gymnema sylvestre, motivations, SSF, influences, mindfulness, behaviour

3.2 Introduction

High intakes of energy-dense foods, including sugar-sweetened foods (SSF), promote obesity (Torres-Fuentes et al., 2015) (abnormal body fat with associated increased morbidity and mortality (World Health Organisation, 2022b)). Colonialism, sugar cane exportation, and mass production contributed to high SSF intakes in modern developed nations (Moise et al., 2011; O'Rourke & Raff, 2010; Popkin & Hawkes, 2016; Sample et al., 2015). Another inadvertent contributing factor to high SSF was the correlation of coronary heart disease with total cholesterol and subsequent recommendations that saturated fats be limited and replaced with polyunsaturated fats (Austin et al., 2011; Billingsley et al., 2018; Keys, 1970). Although total Western fat intakes fell, they were replaced with high amounts of processed carbohydrates between 1980-1990 (Austin et al., 2011; Billingsley et al., 2018). Prevalence of cardiovascular disease and obesity subsequently remained high (Benjamin et al., 2018; Gregg et al., 2004; Menke et al., 2015), prompting further research on non-communicable disease (NCD) aetiology (Temple, 2018). Refined carbohydrates were subsequently identified as additional risk factors (Malik et al., 2013).

Daily sugar intakes <10% of total energy intake are recommended (World Health Organisation, 2015a) for decreased NCD risk, and in many countries (e.g., United States) sugar intakes have promisingly decreased and stabilised (Brisbois et al., 2014; Marriott et al., 2019; Wittekind & Walton, 2014). However, worldwide intakes still exceed recommendations (Wittekind & Walton, 2014). Scrutiny of sugar-reduction initiatives (including sugar taxes, pharmaceuticals including appetite suppressants and dietary sugar restriction (Blades, 2001; Torres-Fuentes et al., 2015)) indicates that independent initiatives are inadequate to combat motivations to consume SSF (Kirkpatrick et al., 2018; Raine, 2005). For example, isocaloric low sugar diets (sugar intake <6% of total energy) may lower triglycerides, low-density lipoprotein levels, body weight (BW), waist circumference and fat mass, but adherence to dietary restriction is usually insignificant long-term (Ahmad et al., 2020; Kumar et al., 2022). Low adherence occurs even with increased extrinsic willpower (Heatherton & Wagner, 2011).

Motivations to eat SSF may have prehistoric origins, when calories were scarce and gustatory detection of sweetness signalled valuable energy-density (Eaton & Konner, 1985; O'Keefe Jr & Cordain, 2004; Olszewski et al., 2019). Today’s developed nations rarely face famines requiring fat stores to survive (O'Keefe Jr & Cordain, 2004), but urbanisation rates exceed the ability of human genomes to adapt concurrently so preferences for sweet foods remain today (Wiss et al., 2018). Motivations to eat SSF can be classified as having physiological, psychological, or external origins (Jackson et al., 2003; Macht & Simons, 2000; Pollard et al., 2002; Schupp & Renner, 2011). Having a sweet tooth, or an enhanced penchant for sweetness (Drewnowski, 1997) is an additional aspect related to SSF intake; why some individuals have a sweet tooth and others do not is unclear, but genetic and lifestyle factors may contribute (Reed & McDaniel, 2006). Theoretically, having a sweet tooth could increase risks associated with negative side-effects of high sugar intake, but associations between the two are also currently undefined (Armitage et al., 2021). However, having a sweet tooth has been shown to increase pleasure derived from SSF compared to not having a sweet tooth (Turner et al., 2020).

Interest in herbal medicines has risen due to perceptions they are holistic alternatives to pharmaceuticals (Torres-Fuentes et al., 2015). The herb Gymnema sylvestre (GS) has been used traditionally for >2000 years (Di Fabio et al., 2013; Saneja et al., 2010), with the scientific name *Gymnema* originating from the Hindi term 'gurmar' meaning 'destroyer of sugar' (Saneja et al., 2010). This refers to GS's ability to block sugar, resultant from its saponins (called Gymnemic acids (GA)) attaching to gustatory cells to prevent perception of sweetness (Khramov et al., 2008; Pothuraju et al., 2014). Acutely administered, GS has been shown to reduce pleasantness of, desire for and total intake of SSF (Nobel et al., 2017; Stice et al., 2017; Turner et al., 2020; Turner et al., 2022). Gastric emptying, glycaemic response and appetite have been shown to not be affected by GS (Kashima et al., 2020). Gymnemic acids have also reduced activation of neural reward pathways with consumption of SSF (Stice & Yokum, 2018). Sugar cravings may be reduced by GS, highlighting its potential for reducing BW through decreased SSF intake (Devi & Jain, 2015; Nobel et al., 2017). Turner et al. (2022) assessed the effects of GS intake over 14 days and found the herb reduces desire for, pleasantness of and total intake of SSF over this longer time frame as well. Whether GS reduces desire for, and intake of SSF after 14 days is unknown. Turner et al. (2020) and Turner et al. (2022) also assessed effects of GS in people with a sweet tooth and found larger decreases in pleasantness and desire ratings for SSF in these individuals, suggesting those with a sweet tooth are particularly sensitive to GS. Should GS target motivators for SSF intake, it could be valuable for combating global high sugar intakes and subsequent obesity prevention. This study investigates effects of GS administered both systematically (i.e., fixed administration three times a day) or ad-libitum (i.e., administration up to six times a day at participants' discretion) over 14 days, on motivations to eat SSF in adults with a sweet tooth.

3.3 Subjects and methods

A single blind randomised cross-over study design with a novel qualitative approach was used to investigate effects of GS on motivations to eat SSF. This study represents a separate arm of a larger trial that explores the effects of GS on both desire to consume, and total intake of SSF; these results will be published separately (Hsiao, Master's thesis, manuscript in preparation).

3.3.1 Participants

All participants (adult males and females) needed to have a sweet tooth, be healthy (i.e., not have any health conditions, including those affecting smell or taste), and not be taking medications affecting smell or taste. A demographics and health questionnaire that we developed assessed sweet tooth and health status; this was part of a general eligibility quiz using Qualtrics software (Qualtrics Experience Management, Provo, Utah). Consistency of sweet tooth status was ensured using the sugar addiction questionnaire (Fawzy & El-Deen, 2018) and the Dutch eating behaviour questionnaire (Van Strien et al., 1986), also part of the eligibility quiz. Eligible participants were those who scored ≥25 in the sugar addiction and Dutch eating behaviour questionnaires, were 18 – 60 years old (to reduce effects of age-related taste and smell changes (Schiffman, 2000; Wiriyawattana et al., 2018)), had English as a spoken language, and were able to give informed consent. Exclusion criteria included being outside age range; having impaired capacity to consent; not having a sweet tooth or scoring <25 in the sugar addiction and Dutch eating behaviour sections of the eligibility questionnaire; current smokers; and not passing the health section of the eligibility questionnaire.

Recruitment occurred between July and October 2022 across North Shore, Auckland. Advertising posters (attached in Appendices B.1 and B.2) with scannable QR codes were placed in public areas (including gyms, libraries, shopping malls and supermarkets), in addition to social media posts in various North Shore community Facebook groups (the text used for these posts is attached in Appendix B.3). Potential participants who scanned the QR code were directed to the eligibility quiz; anyone who contacted researchers directly were emailed a link to the eligibility quiz. A complete copy of the eligibility quiz used for screening is attached in Appendix B.4. The larger trial recruited 32 participants (Hsiao, Master's thesis, manuscript in preparation). From this cohort seven participants (22 – 55 years, mean age of 34.7 ± 13.8 years; two males and five females) accepted invitations to be interviewed and were therefore recruited into this study. All interviews were arranged at pre-set times and dates via email, with email reminders sent the day beforehand.

3.3.2 Ethical considerations

Ethical approval was granted by the Massey University Human Ethics Committee: Southern A (Application SOA 22/21). Registration of the trial was completed with the Australian and NZ Clinical Trials Registry (ACTRN12622001023741) (http://www.anctr.org.au/ accessed on 21 July 2022).

Gymnema sylvestre may cause hypoglycaemia (Jamadagni et al., 2021; Li et al., 2019; Sugihara et al., 2000), a health risk people with diabetes mellitus (DM) (Jamadagni et al., 2021). To mitigate this, people with DM were excluded. A study by Nobel et al. (2017) also found 4% of its participants experienced mild transient stomach upset with GS treatment. Side-effects have not been noted in other trials, but its risk was dealt with in this study by reminding participants to contact the researchers or their general practitioners if they experienced this.

To manage ethical issues during interviews, participants were reminded of their rights at the onset as previously indicated in the information sheet (attached in Appendix B.5). Participants could decline to answer any question and withdraw at any time. All aspects of the interview were also reiterated as being completely confidential and de-identified.

3.3.3 Procedures

The study design and process is presented in Figure 3.1 (created using Miro software (Miro, 2023). Each participant was required to attend four data collection appointments at the Massey University Auckland campus: one at baseline, and one after each of three 14-day testing periods. At visit one, the study was explained to participants and they were also invited to ask any pertinent questions.

At each appointment, participants completed the sweet food-food frequency questionnaire (Jayasinghe et al., 2017) and the beverage questionnaire (Hedrick et al., 2010), which were compiled into a single questionnaire using Qualtrics and accessed on tablets (iPad, Apple Inc, Cupertino, CA, USA). Anthropometrical measurements occurred at every appointment; sensory testing occured at the first three appointments. Anthropometry, the results of the sweet food food frequency questionnaire and the beverage questionnaires, and sensory testing results were not required for this study; these procedures are described by Hsiao (Master's thesis, manuscript in preparation).

Each 14-day testing period tested one treatment. Participants were led to believe they would be testing three different mints all containing different dosages of GS, and were blinded to the true study protocol. Only two mints were used: one GS-containing mint used in two testing periods, and a placebo (identical to the GS-containing mints but excluding GS). Both were provided by Nu Brands Inc. (Los Angeles, CA, USA). All participants were treated with the placebo mint for the first 14 days systematically (PLAC-SYS): three times a day at mid-morning, mid-afternoon, and post-dinner. Participants were then randomly allocated to a treatment using a random number generator: systematic treatment (GS-SYS) or ad-libitum treatment (GS-ADLIB). Allocated treatments were followed for 14 days, after which each participant crossed over to the other treatment for a final 14 days. The GS-SYS treatment involved taking GS-mints in an identical manner to the PLAC-SYS protocol. The GS-ADLIB treatment involved taking GS-mints ad-libitum, or at the participants' discretion up to six times a day (they were advised to take it when they 'felt they needed it'). All participants were required to complete daily compliance diaries to track mint adherence and what – if any – food and drink was consumed within an hour after taking the mints (the adherence diaries were not required for this study, these findings are described by Hsiao (Master's thesis, manuscript in preparation)).

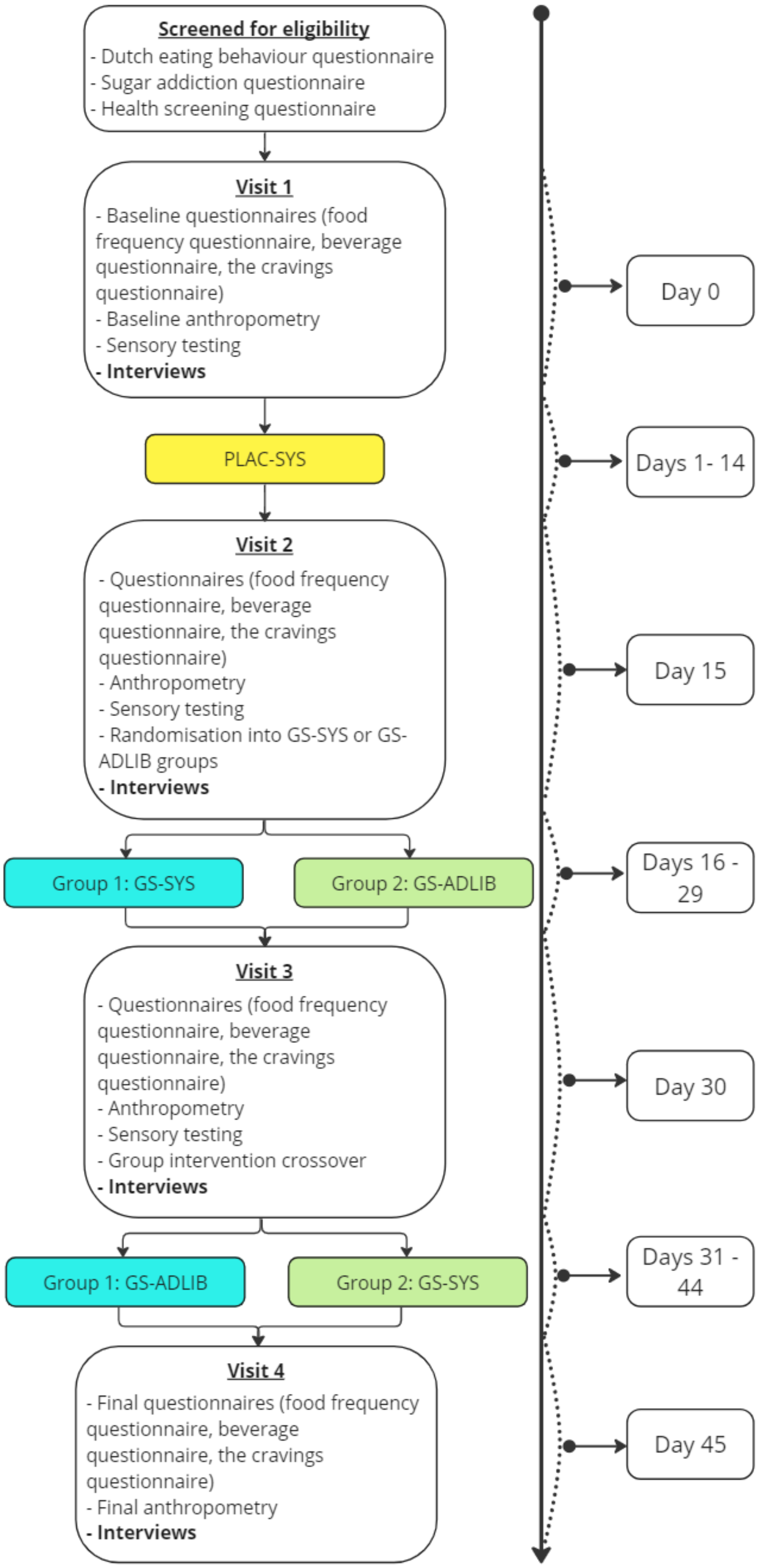

Figure 3.1 Flowchart of study design from recruitment to data collection

NOTE: PLAC-SYS – systematic administration of placebo mint three times a day; GS- ADLIB – ad-libitum administration of GS mint up to six times a day, at participants' discretion; GS-SYS –systematic administration of GS mint three times a day

3.3.3.1 Interviews

Interviews assessed motivations related to SSF consumption, and effects of GS-mints on motivations. Each participant completed four 30-minute interviews: one at baseline, and one after each treatment. Initial interviews identified baseline motivations; post-testing interviews identified changes from baseline, and allowed comparison between treatments. Interviews occurred either in-person (recorded using a digital voice recorder (Sony ICDPX470 Digital Voice Recorder, Japan)) or using Zoom software (Zoom Video Communications, SJ, California, USA) (recorded using Zoom recording software), depending on participant preference. Open-ended questions were mostly used to discourage one-word answers. Interview guides are attached in Appendix A. Conscious effort was made to ask all questions in these guides but occasionally due to interview error, questions were missed. Notes were taken to backup recordings.

Before initial interviews, aims of the discussions were provided. Icebreaker questions designed to build rapport were used to transition into the interviews proper. Preliminary explorations focused on motivations to eat or avoid SSF, and reasons for these. Participants also rated their level of control over SSF consumption from 1 to 10, with 1 indicating no control and 10 indicating complete control.

Interviews after each treatment involved reiterations about interview aims. Previously established rapport was supported with icebreakers before participants described how they found the past 14 days with the treatment just tested. Participants evaluated how they found each mint (e.g., likes and dislikes). Insight into mint administrations (i.e., SYS or ADLIB) was sought before participants were asked to detail motivations to consume and avoid SSF during the past 14 days. The interviewer explored reasons for motivations during this timeframe, and why any changes occurred. Participants also rated self-control levels of SSF intake over the past 14 days with the 1 to 10 rating. Interview guides used for the second and third interviews are attached in Appendix A.2.

Final interviews (the guide for which is attached in Appendix A.3) also involved additional questions after a review of completed interventions. Participants identified their favourite treatment and why. They were asked which mint they would take if they were given a free supply, and they were also asked if they would pay for them. Insights into experiences in the trial, and additional feedback, were finally sought.

3.3.4 Data handling and analysis

Zoom software enabled auto-transcription of Zoom interviews, which were then edited for corrections. In-person interviews were transcribed from recordings by both the author and using Flixier transcription software (Ruscior, 2023). Recordings for three interviews were lost; corresponding transcriptions were completed using interview notes. Completed transcriptions were uploaded to NVivo (QSR International, Burlington, Massachusetts).

A flowchart depicting analysis of interview transcripts is presented in Figure 3.2 (created using Miro (2023)). At data analysis onset, four major **themes** emerged as each transcript was read: 1. external influences on motivations to eat SSF; 2. motivations to eat or avoid SSF; 3. findings relevant to treatment arms PLAC-SYS, GS-SYS and GS-ADLIB; and 4. control over SSF intake. NVivo uses **codes** to collate data, so after themes emerged, four **parent codes** were created in NVivo to reflect these and begin data analysis proper**:**

1. external influences;
2. motivations;
3. treatment arms; and
4. control over SSF intake.

Relevant discussion points in transcripts were highlighted and added (i.e., coded) to the parent code they were relevant to.

Further coding identified that parent codes 1., 2., and 3. could be further dissected, as they were rich with data. Creation of **children codes** ranked underneath the parent codes enabled this. The parent code, 1. external influences could be sub-divided into three children codes to highlight the three significant influences affecting participants during the trials:

1.1 influences of lifestyle changes;

1.2 influences of external factors; and

1.3 influences of being in one of three arms of the study.

From the parent code, 2. motivations, fourteen children codes emerged (presented fully in Figure 3.2). Each child code represented a motivation to eat or avoid SSF identified by participants. The parent code, 3. treatment arms, was further subdivided into four children codes:

3.1 free mints;

3.2 purchasing mints; and

3.3 perspectives on mints,

to help build a picture of participants' opinions on the treatments. In addition, the children code 3.3 perspectives on mints could be dissected into even lower ranking children codes for:

3.3.1 negative opinions;

3.3.2 positive opinions; and

3.3.3 mixed opinions on the treatments.

The parent code, 4) control over SSF, was not expansive enough to warrant subdivision into children codes. The theme, 5) intake of SSF, and sub-themes also presented in Figure 3.2 (Miro, 2023) will be discussed in further detail in 3.4 Results, as these concepts emerged after NVivo data analysis occurred. Full descriptions of all themes, parent codes and children codes are presented in Appendices A.4 and A.5.

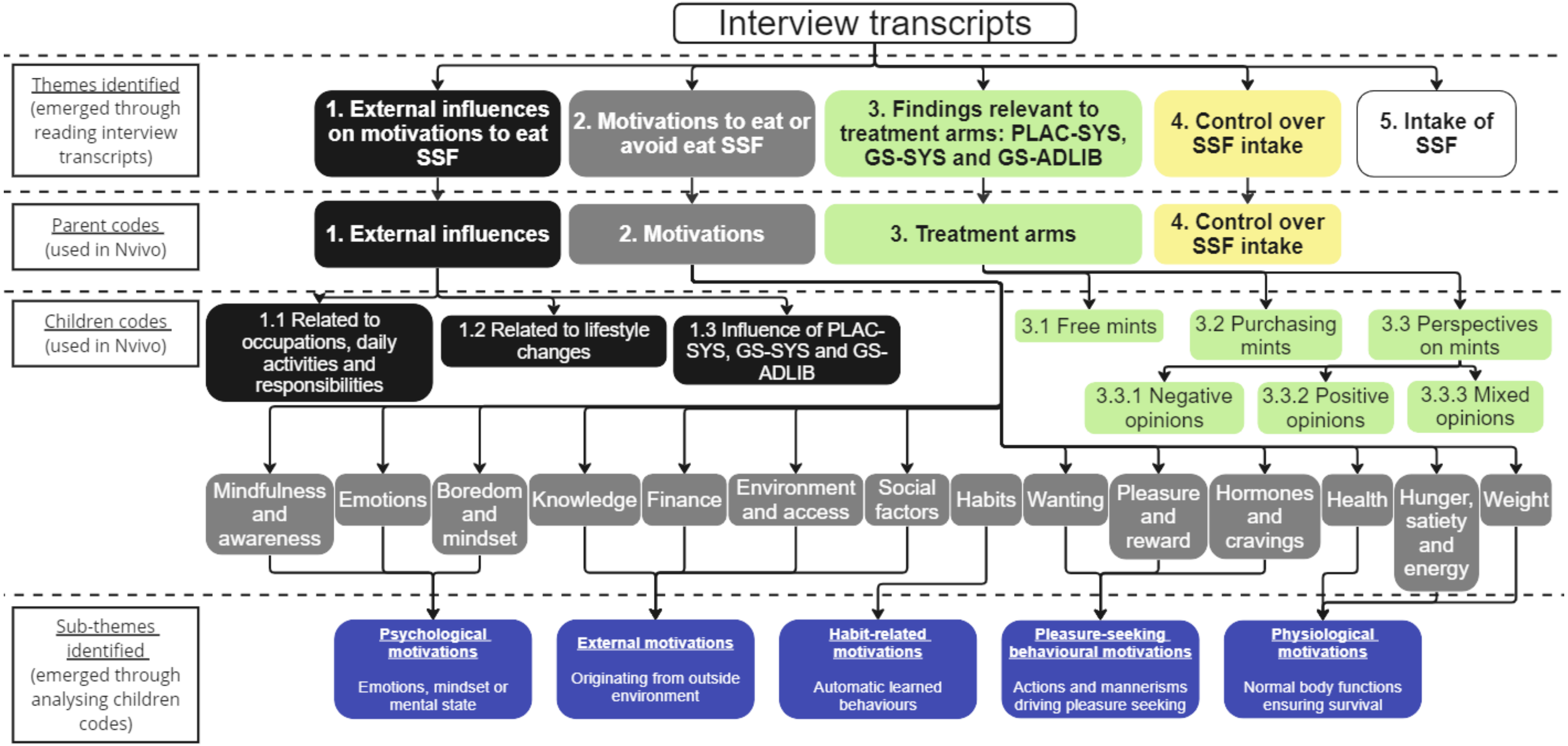

Figure 3.2 Categorisation of interview transcript data into different codes in Nvivo

NOTE: PLAC-SYS – systematic administration of placebo mint three times a day; GS- ADLIB – ad-libitum administration of GS mint up to six times a day, at participants' discretion; GS-SYS –systematic administration of GS mint three times a day; SSF – sugar-sweetened food

In addition to, and independent from code allocation, each of the interviews for each testing phases were divided into four **cases**:

1. baseline interview;
2. PLAC-SYS interviews;
3. GS-SYS interviews; and
4. GS-ADLIB interviews.

Cases represent ‘units of observation’ (Quality Solutions and Research International, n.d.,), enabling assessment of information from testing phases. For instance, if baseline data was the focus, the case, 1. baseline interviews, was utilised so that only baseline interviews were shown.

From here, matrix coding queries were used to enable ideas to be assessed at each stage of the study. Matrix coding queries enabled a case (i.e., a stage of the trial) to be intersected with a code (i.e., a major identified theme). A total of 11 matrix coding queries were run and saved; a complete list of which is presented in Table 3.2.

Table 3.2 Complete list of matric coding queries run on Nvivo as part of data analysis

Matrix coding query number	**Matric coding query title**
1	Influences during initial interviews
2	Influences for PLAC-SYS
3	Influences for GS-SYS
4	Influences for GS-ADLIB
5	Motivations to eat or avoid SSF during initial interviews
6	Motivations to eat or avoid SSF for PLAC-SYS
7	Motivations to eat or avoid SSF for GS-SYS
8	Motivations to eat or avoid SSF for GS-ADLIB
9	Other information for PLAC-SYS (including positive, negative and mixed opinions; and level of control over SSF intake)
10	Other information for GS-SYS (including positive, negative and mixed opinions; and level of control over SSF intake)
11	Other information for GS-ADLIB (including positive, negative and mixed opinions; and level of control over SSF intake)

NOTE: PLAC-SYS – systematic administration of placebo mint three times a day; GS- ADLIB – ad-libitum administration of GS mint up to six times a day, at participants' discretion; GS-SYS –systematic administration of GS mint three times a day; SSF – sugar-sweetened food. Table 3.2 displays all the matrix coding queries used during analysis in NVivo to enable major concepts at each point of the trial to be analysed conveniently. Codes (i.e., the major identified topics during analysis of interview transcripts) and cases (i.e., each stage of the trial) were queried against each other using these matrix coding queries.

All pertinent information from interview transcripts that was relevant to a topic being investigated could be viewed in the saved matrix coding query results. For instance, to analyse influences affecting baseline motivations to eat SSF, the matrix coding query result for 'influences during initial interviews' was viewed. For each matrix coding query result, the excerpts from the interviews were viewed and interesting themes and concepts, especially recurring ones, were noted.

3.4 Results

3.4.1 Influences and motivations

Similarities in different children codes ranked under the parent code, 2. Motivations, allowed the children codes to be clustered into motivation **sub-themes** (fully described in Appendix A.6). As parent and child codes were assessed (for baseline; PLAC-SYS; GS-SYS; and GS-ADLIB stages of the trial), a flow emerged from themes, 1. external influences, and 2. motivations, to participants' described SSF intake. Therefore, a fifth theme emerged (i.e., 5. Intake of SSF). The decision to eat SSF was found to be non-linear, involving, 1. external influences, on an individual which affect, 2. motivations (to eat or avoid eat SSF), and therefore actual intake of SSF (because this theme was identified last, it is numbered fifth.). Figure 3.4 (created using Miro (2023)) highlights how this process can occur chronologically, with an external influence driving a motivation ultimately deciding SSF intake. The process may also occur in the opposite direction, and may occur in a way where influences or motivations work independently of each other to affect SSF intake.

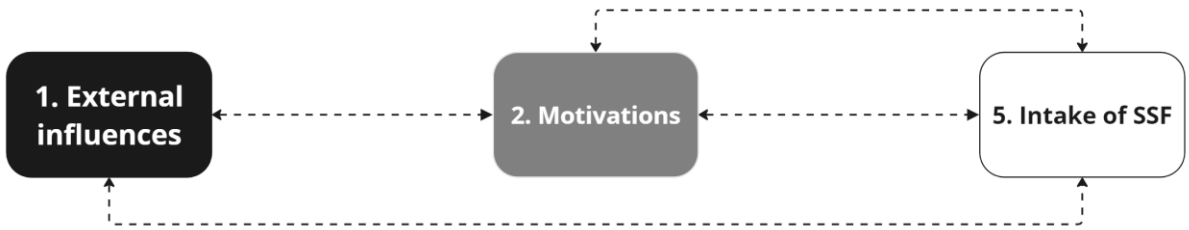

Figure 3.4 Relationship between three main themes identified during interviews

NOTE: SSF – sugar-sweetened foods.

It is prudent to reiterate this study design involves a single-blind protocol – the interviewer was aware of the reality of the design: GS-SYS and GS-ADLIB were identical mints and PLAC-SYS was a placebo. Participants thought they were taking three different mints, all with a different amount of GS.

<u>Phase 1: Baseline influences and motivations</u>

Out of seven participants, four reported being influenced by conscious decisions to reduce SSF intake before even trying any treatment (i.e., they were influenced by lifestyle changes). These originated from desires to improve physical or mental health, or to change BW. No participants used lifestyle changes to increase their intake of SSF.

> *'I do try not to eat them too much … I find that I'll possibly overeat … them… I do like, have a bit of a … very bad relationship around that with food, and it definitely makes me feel really guilty when I get into those moods. So, it's not great … that's why I prefer to* [not] *eat* [SSF] *during the day, because I know that it can like, set me up for … a bad day.'* (Participant 2)

> '*I know it's not good for me … I'm well aware of yeah, just what it is and how much it kind of takes over if you let it take over … I'm very cognitively thinking about everything. I'm like "oh, this does have a bit of sugar in it, probably shouldn't have eaten that" or "nah, I don't need that because I don't need the sugar".'* (Participant 3)

Six of seven participants felt occupations influenced SSF intake. Occupations increased motivations (because of hunger, or because of workplace habits) or decreased motivations (because work was a distraction). For one participant working full time, sometimes there was less motivation, other times (for instance during meetings where SSF were available) there was increased temptation to eat SSF because they were easily accessible.

> *'If I … get busy, and I haven't had like, my next meal that I usually would have; like a lunch whatever, that can usually mean that I'll just… eat anything.'* (Participant 2)

> *'I suppose, the least* [I] *want to eat it is actually… just because I'm busy.'* (Participant 7)

Overall, the most identified motivation was pleasure-seeking-related; all participants wanted to eat SSF because they 'tasted good'. Several motivations were also found to have no identifiable influence. Four participants identified they were habitually motivated to eat SSF, whilst five were motivated physiologically (e.g., hunger or perceived low energy levels). All participants also identified psychological motivators (e.g., experiencing boredom, eating nonmindfully or out of positive or negative emotions). All participants identified reasons to avoid SSF, mostly physiological (e.g., a desire to attain a certain weight or because of health concerns) or psychological-related (e.g., trying to practice more mindful eating).

> *'It's all around… habit probably… I've always had a cup of tea and a biscuit, so … it's my go-to … growing up was … dessert after dinner. Biscuits for morning and afternoon tea.'* (Participant 1)

> *'… Obviously when I cut [weight], I look a lot better than a normal maintenance* [weight]. *I keep that in mind.'* (Participant 4)

<u>Phase 2: Influences and motivations during testing of PLAC-SYS</u>

At baseline, only one participant felt lifestyle changes influenced them to eat less SSF; following the first 14 days of the trial, three others also agreed this was relevant to them.

> *'Last week … it was pretty good… But that could be that subconscious thing of … knowing it's like, a trial, and I probably … want to stop eating this stuff.'* (Participant 3)

> *'If you're doing a food diary… you have to document what you're eating. I definitely find that that changes what I eat because I have to start 'confessing'.'* (Participant 5)

Similarly to baseline, participants were motivated to eat SSF because of perceived palatability; they were psychologically or physiologically driven; it was habitual; or due to external factors (e.g., SSF being readily accessible). Six participants reported changes to motivations to avoid SSF, and that PLAC-SYS motivated this avoidance because they were now unpleasurable. This was directly attributed to PLAC-SYS by producing a minty after-taste, making SSF unpalatable, being sufficiently sweet to satiate SSF desire, or reducing cravings for SSF directly.

> *'Knowing that there's like, no point in having anything after* [PLAC-SYS], *is a good motivator for me. … nothing's going to taste good, anyway, so you may as well just leave it alone.'* (Participant 2)

> *'It's just that taste was so strong in my mouth … definitely it did have a negative effect. … I haven't had big cravings … and then whenever I do, I just have* [PLAC-SYS] *and an hour later I don't have* [them] *anymore.'* (Participant 4)

Two participants thought PLAC-SYS decreased motivations to eat SSF because it promoted mindfulness and, in some cases, they appreciated savoury flavours more. Two other participants reported PLAC-SYS influenced them to eat SSF less habitually, as it would provide a break from the temptation of SSF.

> *'I'm trying to assess* [what PLAC-SYS] *is doing … so I'd have* [PLAC-SYS]*, and then the next thing I eat I'm going like, '… Is this least sweet than usual?' …I was… really trying to assess it … I think I definitely became more aware of the taste of the food that as I was eating.'* (Participant 5)

> *'I looked at the sweet chili sauce… I'm actually eating a lot more sugar than what I think I'm eating because all of these extras. And then I took* [PLAC-SYS] *… the sweet chili sauce wasn't as pleasurable… and then the next day, I thought, 'you know what, I don't actually need that sweet chili sauce at all'. So, I had* [PLAC-SYS]*, didn't have sweet chili sauce, just had the quiche and I was fine.'* (Participant 7)

After the first 14 days, all participants reiterated that external influences (e.g., family matters, changes in work, out-of-town trips) significantly affected motivations. Stress often rose, motivating participants to eat out of emotion; or the physical food environments changed (i.e., access to SSF) to shift motivation.

> *'There's been a lot of stress … maybe there's been a bit of sugar-eating stress relief.'* (Participant 1)

> *'I did go away for… a week. So, I wasn't around roommates offering me* [SSF].' (Participant 4)

<u>Phase 3 / 4: Influences and motivations during testing of GS-SYS</u>

Six of seven participants reported GS-SYS affected motivations due reduced pleasure. Some participants experienced mild taste changes; for others it was severe. Three participants also felt that GS-SYS reduced cravings for SSF.

> '[GS-SYS] *wasn't as strong as* [GS-ADLIB] *… it took the shine off food, but not like* [GS-ADLIB]*.'* (Participant 1)

'I did test out having different foods with [GS-SYS], *and it was awful. So, I think I had like, a piece of chocolate once, and I was like, this is so gross.'* (Participant 2)

One participant manipulated timing of SSF consumption around the time when the effects of the treatment had elapsed, so that the foods were still pleasurable. Although the unpleasurable tase did initially influence SSF intake, it was not enough to affect motivations and therefore actual intake of food.

'It didn't have a massive effect on my intake of sugary foods … I would just wait for the time frame of [GS-SYS] *to wear off, then I'd have something sweet… so overall it didn't affect how or what I ate.'* (Participant 5)

Despite the effects of GS-SYS, pleasure-related motivations were still commonly identified as motivators to eat SSF. Notably, three participants found taking GS-SYS affected SSF even outside of the timeframe they were administered, making SSF excessively sweet and therefore unpleasurable, even to the point of feeling sick.

'It's definitely given me an appreciation for how sweet some things are. Like, to have something that you normally have, and then take all the sensation of sugar out of it, and then bring it back in… it's like, whoa. Like, sometimes that's quite a lot … almost to the point where you're like, oh, this makes me feel a bit a bit peaky.' (Participant 6)

Two participants also reported GS-SYS directly increased motivations to avoid SSF due to an increased awareness of food intake (i.e., mindfulness). The treatment was taken as prescribed and when the anti-sweet effects elapsed, participants consider if they still wanted SSF. This strategy allowed cravings to pass and decreased the volume of SSF consumed.

'I didn't have as much as I'd normally have. I was able to probably stop myself after a few [servings]*, be like, 'aw, I've had enough'.'* (Participant 4)

'You also know that the food you eat after it won't be quite as satisfying. So, you're like, OK, this is OK. I can wait or I cannot [have any SSF] *at all.'* (Participant 6)

Two participants also felt less motivated to habitually eat SSF, which they also attributed to using GS-SYS. Systematic GS acted like a trigger to cease the behaviour of eating SSF.

> *'What's that um experiment, or the study or they'd ring the bell and it would make the dog salivate or whatever? … Pavlov's dog, yeah. That's me with* [GS-SYS]. *Eat* [GS-SYS]*, and then that's it, times up.'* (Participant 2)

All participants' external influences significantly affected emotions or access to food, which in turn would increase motivations to eat due to hunger or increased availability.

> *'Where I work, there's lots of lovely, yummy goodies … whereas this week being at* [my second job], *I have occasionally had, like, a little biscuit with my cup of tea. But … the access is a lot more limited because you're with people all the time.'* (Participant 6)

Five participants were influenced by lifestyle changes (e.g., being in the trial or weight loss for the summer), which motivated them to eat less SSF.

<u>Phase 3 / 4: Influences and motivations during testing of GS-ADLIB</u>

All participants found SSF less pleasurable after taking GS-ADLIB, motivating them to eat less because of this unpalatability.

> *'I found the effect of the mint so horrible … I found that I just didn't want to eat anything after* [GS-ADLIB]*. Like, I had … a biscuit, and I put half of it back because it was just so revolting…* [I'd] *rather give up* [the SSF] *than take* [GS-ADLIB]*.'* (Participant 1)

Four participants discussed how GS-ADLIB psychologically motivated them to avoid helping them assess their true want for SSF (i.e., increased mindfulness.

> *'It was almost like a self-test. … How badly do I want this sweet thing? Like, you know, am I prepared to have* [GS-ADLIB]*, and then make a specific trip back downstairs in an hour's time to have* [SSF]*? … so, it was a little bit like a test.'* (Participant 1)

> *'In some ways, it's kind of helped me … learn to not give into the craving straight away. … It does sort of give me that time to go through that process; you know, not be so reactive.'* (Participant 5)

Four participants were motivated to avoid SSF as part of a lifestyle change due to health or weight concerns. Only one of these felt the trial itself influenced motivations. Six of seven participants felt stress from occupations, work trips or vacations, and changes in access to SSF affected their motivations to eat SSF. Vacations were considered a time to appreciate SSF, which meant not taking GS-ADLIB to fully enjoy these foods.

> *'Life is a bit stressful, so there's a lot of stress-related eating.'* (Participant 1)

> *'I went on holiday for a few days, had some alcohol and desserts. I wanted to enjoy the holiday, so I didn't worry about taking* [GS-ADLIB] *or avoiding* [SSF] *for those days.'* (Participant 3)

3.4.2 Opinions on each treatment arm

Six of seven participants liked PLAC-SYS and reported it had a similar flavour to commercially available mints. One participant felt that when taken on an empty stomach, PLAC-SYS elicited unpleasant mild nausea; another expressed ambivalence towards PLAC-SYS because of uncertainty around whether it was appropriate to use long-term to influence intake of SSF. No participants said they would like a free sample of PLAC-SYS if offered.

Four of seven participants also reported liking GS-SYS, finding the treatment tasted better than GS-ADLIB (despite the treatments being identical). It was overall more effective than PLAC-SYS because it reduced motivations and cravings to eat, and total intake of SSF. Dislikes of G-SYS were mostly related to its taste, texture and effect on SSF being unpleasant.

> *'It tastes a little bit more like a mint and less like a herbal supplement* [compared to GS-ADLIB]. *… it was just better overall … you don't really want to eat food after it. But you also know that the food you eat after it won't be quite as satisfying.'* (Participant 6)

Two of seven participants would accept a free sample of GS-SYS. Systematic administration was what participants preferred, rather than the perceived dosage. Both participants also said they would pay for GS-SYS if it were commercially available (provided they were working full-time and the mints were not expensive).

> '*In my opinion* [GS-SYS and GS-ADLIB] *worked pretty similarly* … [if I was given a free box of mints I would take] *probably* [GS-SYS] … *I don't know if you can tell but I love the schedules! …* [if I had to pay for the mints] *I wouldn't buy it now* [while I'm a

> student]… *I'm pretty broke… if I had a full-time job, and yeah, I felt like them then yeah, I'd probably pay.'* (Participant 2)

Three of seven participants preferred GS-ADLIB to GS-SYS; feeling it was more effective at making SSF less desirable, and reducing their intake. Negative opinions were related to GS-ADLIB making SSF taste unpleasant, GS-ADLIB itself tasting unpleasant, or because of an unpleasant after-taste left in the mouth post-administration. Although GS-ADLIB affected motivations to eat SSF, it was ultimately an unpleasant experience for some participants, which meant they preferred GS-SYS.

> *'I wouldn't say it's an appetite suppressant, but it definitely made me aware that I ate less… I don't know why. But I definitely reduced my consumption of food.'* (Participant 7)

> *'It was good at suppressing the 'want' for sugary food.* [GS-ADLIB] *itself is ok but it made food taste bad.'* (Participant 3)

Three participants would have accepted GS-ADLIB for free; of these, only one would pay money for the treatment. Others felt their sweet tooth wasn't significant enough to justify paying for GS-ADLIB. When compared to the participants' opinions on PLAC-SYS, participants felt GS-SYS and GS-ADLIB were more effective at making SSF unpalatable, and thus they preferred the GS treatments over PLAC-SYS.

3.4.3 Level of control over SSF intake

Baseline control levels over SSF intake varied. Three participants gave a level of 7 or 8 and felt disciplined about their baseline intakes. Three of seven described their control levels as a sliding scale, with daily variation.

> *'Majority of the time I'd say I'm pretty in control. But … there's a moment where there's zero control;* [I] *just eat whatever is in front of me.'* (Participant 4)

During testing of PLAC-SYS, there was not a large difference in control level. Three of five participants (two were not asked during the interviews due to interview error) reported no change in control level; the others felt their control level had increased directly because of PLAC-SYS.

> *'When I hadn't had the mint I'd say* [my level of control was] *probably like a four …* [and my level of control was] *ten once I'd had the mint.'* (Participant 4)

Two of six participants (one was not asked due to interview error) felt their control level decreased during testing of GS-SYS compared to baseline (possibly because of increased stress and hunger). One participant felt their control was higher than baseline while testing GS-SYS, but lower than when testing PLAC-SYS, possibly because of external influences. Only one participant felt their control had increased from baseline while testing GS-SYS.

During testing of GS-ADLIB, external factors contributed to changes in control for three of seven participants. Vacationing made two participants feel less controlled; finishing a semester of tertiary education for another participant resulted in higher control because she was spending less time in environments where SSF were readily accessible. Three participants had higher levels of control compared to baseline. One participant felt their control was even higher during testing of GS-ADLIB than when testing PLAC-SYS. Another participant felt their control level was similar to testing of GS-SYS, lower than testing of PLAC-SYS, but still higher than baseline. Just one participant felt her level of control was highest during testing of GS-ADLIB.

> *'This time it was one hundred percent: I was making all the decisions about the sugar I was taking.'* (Participant 7)

3.5 Discussion

This study aimed to investigate effects of GS, both when administered in a SYS and ADLIB way, compared to placebo on adult motivations to consume SSF. We found that (1) both GS treatments increased motivations to avoid SSF due to increased mindfulness and decreased palatability of SSF; (2) that motivations were also affected by external influences; (3) that GS-SYS was the favoured treatment; and (4) that participants' level of control over SSF intake varied throughout the trial.

3.5.1 Effects of GS on adult motivations to eat SSF

The first finding, that motivations to avoid SSF were higher with both GS treatments compared to PLAC-SYS, was attributed to SSF being less enjoyable or participants consciously deciding SSF intake was not needed. The latter was reported by four participants for GS-ADLIB and three for GS-SYS as an increase in mindful eating, which involves using physiological cues rather than emotions to dictate food choice, not restricting foods, and eating for taste satisfaction as well as physical satiation (Christoph et al., 2021; Warren et al., 2017). Mindful eating has been utilised professionally for treating eating disorders and obesity (Mantzios et al., 2018). Because GS negatively affects pleasure from SSF for 30 – 120 minutes (Bone, 2002), participants would heed hunger and satiation during this time. After effects of GS elapsed, participants may have decided SSF were not needed after all, despite initial high motivation to eat them. An additional aspect of being mindful (not just in relation to eating) is that many of its fundamentals are also foundations of initial phases of the Transtheoretical Model, or Stages of Change Model (DiClemente et al., 1999; Prochaska & DiClemente, 2005), which is used to assess inclination to behaviour change (Greene et al., 1999). The five stages include precontemplation, contemplation, preparation, action, and maintenance (Loma Linda University, 2023; Prochaska & DiClemente, 2005). In particular, the stage of contemplation involves weighing positives and negatives of behavioural change and requires conscious tuning to long-term goals to transition to the next stages (Loma Linda University, 2023). The findings of this study show that for participants to achieve lower SSF intakes they likely used mindful eating to execute beneficial actions classically seen only in the stage of action.

Two participants also found PLAC-SYS increased motivation to avoid SSF because of enhanced mindfulness. This indicates mindful eating, with or without GS, could help reduce motivation to eat SSF. Mindful eating has had varying effects on SSF intake (Mantzios et al., 2018; Mason et al., 2016) and has been linked to reduced intakes of confectionary and fasting blood glucose in obese adults over 12 months (Mason et al., 2016). Adults who eat without restriction may eat more vegetables and wholegrains, but they may also eat more SSF (Jackson et al., 2022). Short-term restrictive diets for weight loss are ineffective at changing BW long-term, let alone producing long-term maintenance to low-sugar diets (Kuchkuntla et al., 2018), which is one reason mindful eating may be a preferable intervention for long-term dietary change (Paolini et al., 2012).

Participants also felt both GS treatments changed motivation by making SSF unpleasant. Previous research has found GS significantly reduces pleasure derived from SSF (Kashima et al., 2020; Nobel et al., 2017; Stice & Yokum, 2018; Stice et al., 2017; Turner et al., 2020; Turner et al., 2022). Most of these studies also found GS reduces SSF intake (Nobel et al., 2017; Stice

& Yokum, 2018; Stice et al., 2017; Turner et al., 2020; Turner et al., 2022). Turner et al. (2022) was also the first study to assess longer-term effects of GS on behaviours related to SSF intake. After 14 days, participants with a sweet tooth administered with GS experienced greater decreases in pleasantness and desire ratings for SSF, suggesting GS is effective throughout this timeframe (Turner et al., 2022). Turner et al. (2020) found GS reduced pleasantness of SSF more in participants with a sweet tooth, compared to those who do not have a sweet tooth.

Evidence shows BW is unlikely to predict having a sweet tooth (Salbe et al., 2004), but obese individuals may be more likely to have a sweet tooth (Drewnowski et al., 1985). Overall, research on relationships between having a sweet tooth and NCD development is limited. However, hypothetically this group would benefit from interventions targeting SSF preferences as they have higher penchants for these foods which are already associated with NCD risk (Armitage et al., 2021). Turner et al. (2020) and Turner et al. (2022) found, previously, that GS reduced pleasantness of and desire for chocolate to a greater degree in participants that have a sweet tooth compared to those that do not have a sweet tooth. This study supports these findings and provides novel evidence that the reason GS is more effective in those with a sweet tooth may be because the herb increases motivations to avoid SSF. Therefore, GS presents a treatment for reducing SSF intake by affecting motivations to eat these foods which could be particularly effective for those with a sweet tooth.

Although GS reduced immediate motivations to eat SSF due to reducing their palatability, one participant would wait for the effects of GS to elapse before eating SSF, thus her motivation to eat SSF was not affected enough to bring about significant behavioural change. The stages of change model posits that only in the action stage are individuals said to be truly motivated to change behaviour, and be receptive to receiving and seeking support (DiClemente et al., 1999; Loma Linda University, 2023; Prochaska & DiClemente, 2005). Individuals are unable to earnestly change behaviour while in the phases of precontemplation and contemplation; partly because motivation levels are inadequate and mindfulness of long-term goals is still building (Loma Linda University, 2023). Participants were not assessed for their stage of change in this study. Waiting for effects of GS to wear off before enjoying SSF fully suggests only individuals truly ready to reduce SSF intake (i.e., in the action stage of change) may find GS intake beneficial (Greene et al., 1999). The participant who waited for the anti-sweet effects of GS to dissipate may have been in a stage where she was aware of the effects of SSF and admitted to wanting to decrease her intake, but even with GS utilisation she did not carry through with behavioural change. In addition, it is prudent to mention again that the exact stage the participant was in is unknown, as this was not assessed. Further research into whether GS can provide a synergistic effect with mindfulness to help individuals move through stages of change to undergo successful behavioural change is merited.

Notably, one participant likened using GS-SYS to the bell used in Pavlov's dog experiments on classical conditioning (Pavlov, 1906). Just as Pavlov found that using a conditioned stimulus (such as ringing a bell to indicate a meal is ready), elicits habitual responses (salivation in dogs) (Rehman et al., 2017; Stussi et al., 2019), the participant felt that taking GS-SYS acted as a conditioned stimulus to habitually cease SSF consumption post-meals (Rehman et al., 2017). Although only this participant specifically referred to concepts of classical conditioning, one other participant also mentioned GS-SYS reduced motivations to habitually eat SSF. This finding helps justify future research investigating how GS can be used as part of wider interventions for sugar-reduction, as the dual effects of GS as a conditioning stimulus, plus mindfulness or other coaching support, may have additive effects on SSF intake to promote long-term reduction.

3.5.2 Effects of external influences on motivations to eat SSF

The second main finding was that external factors significantly affected motivations throughout this study. Influences identified are similar to those previously highlighted, including individual experiences, circumstances, and environments (DiClemente et al., 1999; Simpson & Balsam, 2016). Food overconsumption and drug addiction have been previously paralleled, as both exhibit cravings, low self-control, high impulsivity, and dysregulated neural reward pathways (Davis & Carter, 2009; Shell & Firmin, 2017). Research on alcohol and drug abuse indicates internally originating influences (e.g., self-efficacy) may sustain motivation that results in long-term sobriety, more than externally originating influences (e.g., financial incentives) (Curry et al., 1991; Deci & Ryan, 1987). The latter may only improve short-term abstinence (Cunningham et al., 1994), but some evidence suggests internal and external influences together promote long-term sobriety (DiClemente et al., 1999; Krampen, 1989). Findings from drug and alcohol-related research may not be applicable to food overconsumption, which is not synonymous with addiction (Grosshans et al., 2011). 'Food addiction' is controversial, and not recognised by the Diagnostic and Statistical Manual of mental disorders (DSM-5) (Adams et al., 2019; Davis, 2017). Turner et al. (2022) likened nicotine patches for smoking cessation to GS for SSF reduction, and proposed that used over 14 days, GS is a short-term tool (in addition to other behavioural modification programmes) to reduce habitual SSF intake and build awareness around SSF. This study supports this hypothesis by showing that GS can be used to reduce SSF intake over 14 days through motivational change.

3.5.3 Efficacy of GS administered systematically and ad-libitum

The third main finding was that GS-SYS and GS-ADLIB were not only preferred more by participants than PLAC-SYS, but they were also reportedly more effective. Medication adherence may be lower if they are perceived negatively (Brown & Bussell, 2011). Preference of the GS treatments indicate they may be perceived as effective interventions for reducing SSF intake after the study's completion. There was not an apparent preference between GS-SYS and GS-ADLIB, but slightly more participants said that hypothetically, they would prefer to receive GS-ADLIB for free over GS-SYS. The study's small sample size may explain why a clear preference was unindicated. Individual preference of treatment administration may also be a contributing factor, possibly more so than the perceived dosages of the treatments (Brown & Bussell, 2011). For instance, one participant felt GS-SYS was more effective because the SYS administration worked well for her daily routine; another felt GS-ADLIB was more effective because she could take it as she needed.

Initially, it was hypothesised, a reason some participants preferred one GS treatment over the other may have been due to the order of treatments. Blinding to the study design means participants believed they were taking three GS treatments (instead of one GS treatment twice, and a placebo). Therefore, an initial taste of GS treatments during the third trial phase may have been strong, and subsequent tastes during the fourth stage may have seemed weaker because they had already tasted it. However, there was no indication the order of treatments affected final preference for GS treatments. This suggests that the deception was effective in blinding participants to the reality of the study, and the perceived taste of the GS mints and the order they were taken in was not an influence on preference; preference is more likely the result of individual preference. Overall, slightly more participants preferred ADLIB administration of the GS treatments, but more research is required to confirm which GS administration is most effective, or whether personal preference is most important.

3.5.4 Effects of GS on control over SSF intake

The fourth main finding was the report of varied control levels over SSF intake. Most participants did not feel control levels changed during testing of PLAC-SYS, nor were there large changes while testing GS-SYS. The biggest changes were seen during testing of GS-ADLIB and may be attributable to external factors as well as GS-ADLIB. Self-control has been shown to significantly affect morbidity and mortality (Shapiro Jr et al., 1996), and higher levels have been previously associated with higher intakes of nutrient-dense foods (e.g., fruits and vegetables), lower instances of overeating (Gerrits et al., 2010; Wills et al., 2007), and individuals feeling more confident about not engaging in behaviours contributing to weight gain (De Ridder et al., 2007). Participants in this study reported stress from external factors drove motivations to eat SSF and lowered their self-control. Lifestyle interventions designed to improve dietary quality (e.g., lower SSF intake) should consider individual stressors and how these might override intervention benefits, no matter how effective in theory the interventions are. Lifestyle changes may be more successful long-term if they have multi-targeted approaches that support self-efficacy, promote self-control and build resilience (Foreyt, 2005). As GS-ADLIB may contribute to higher self-control levels, but external factors are also strong determining factors of self-control, this study supports the proposal by Turner et al. (2022) that GS may be beneficial as part of larger lifestyle interventions, rather than used in isolation.

An opposing link that can be made is between the varying control levels of participants during this study and fundaments of the self-determination theory, a broad model used in motivational sciences that posits different motivations and overall physiological well-being determine successful behavioural change (Anderman, 2020; Ryan, 2017; Ryan & Deci, 2022). The theory supports the aforementioned evidence that external and internal influences have different effects on outcomes of drug and alcohol addiction interventions (Cunningham et al., 1994; Curry et al., 1991; Deci & Ryan, 1987; DiClemente et al., 1999; Krampen, 1989), and outlines all individuals (not just those undergoing treatment for addiction) can benefit from internally originating influences (Ryan, 2017; Ryan & Deci, 2022). 'Autonomous individuals' motivated by internally originating influences (including free choice) exhibit greater confidence, persistence and success compared to 'controlled individuals', who are motivated by externally originating influences (including anticipation of a reward or punishment) (Ryan, 2017). Conversely to the discussion in the previous paragraph, a fundamental component of the self-determination theory is that having a high level of control is not always beneficial to behaviour change, as often the level of control is an aspect of being 'controlled' externally (Ryan & Deci, 2022). Those who feel more in control of situations are more likely to experience negative emotions when this control is lost, and they also are at the mercy of external factors which affect the control level (Ryan, 2017; Ryan & Deci, 2022). The findings from this study suggest that having low levels of control, according to the self-determination theory, is not necessarily conducive to reduced success and may be indicative of higher levels of autonomy which is beneficial for behavioural change (Ryan & Deci, 2022). Indeed, the fact that external factors in this study were reported as strong influencers of control level indicates that interventions assisting the attainment of autonomy may be particularly beneficial when developing sugar-reduction intiatives.

3.5.5 Strengths and limitations

A strength of this study is the in-depth analysis into the effects of GS on motivation to eat SSF using qualitative methods; it is the first study to do this. Secondly, a strong rapport between interviewer and participants provided a comfortable environment for the latter to ''open up'' about their experiences in the study, which developed the breadth of the findings. Third, the health screening questionnaire was extremely detailed and excluded participants for an exhaustive number of reasons. Health was very consistent across participants and no participants had altered smell or taste, which would have affected the consistency of responses to GS treatments. There were several limitations as well, including the loss of three interview recordings. Second, some questions on the interview guides were not asked, which resulted in some data not being captured. Third, screening questionnaires did not assess whether participants were already undergoing or interested in lifestyle interventions prior to recruitment. These individuals may have different motivations, which would have allowed deeper analysis into adult motivations and influences on these.

3.6 Conclusion

The main findings of this study were (1) both GS-SYS and GS-ADLIB increased motivation (more than PLAC-SYS) to avoid SSF because the GS treatments increased mindful eating and decreased pleasure from eating SSF; (2) external influences affected motivations as well as GS intake; (3) participants preferred GS-SYS and GS-ADLIB over PLAC-SYS; and (4) the level of control participants felt over SSF intake changed during each arm of the trial. Mindful eating may have positive effects in the general population by promoting long-term healthy dietary changes. By promoting mindful eating patterns, GS has the potential to be used as part of larger interventions for reducing SSF. In addition, preference of GS indicates it has potential to be positively perceived and therefore be a well-adhered-to supplement. Motivations for eating SSF are highly complex, and consumption is affected by not just external influences but also self-control level. Behaviour change requires a multidisciplinary approach, and current interventions for reducing sugar intake may not target complex motivations appropriately. This study provides novel evidence that adults with a sweet tooth may experience motivation changes related to SSF consumption with GS-SYS or GS-ADLIB. Gymnema sylvestre may be used as part of larger interventions to reduce SSF intake, by promoting mindfulness of hunger and satiety cues. Further research is needed to confirm if GS has significant effects on adult motivations to eat SSF.

Chapter 4: Conclusions and Recommendations

4.1 Overview and conclusions

This study investigated effects that Gymnema sylvestre (GS) intake has on adults' motivation to consume sugar-sweetened foods (SSF) over 14 days in a placebo-controlled randomised cross-over trial when administered systematically (three times a day at mid-morning, mid-afternoon and mid-evening, i.e., GS-SYS) or ad-libitum (up to six times a day at the participants' discretion, i.e., GS-ADLIB). This study used a placebo-controlled randomised cross-over design, and a sample of seven adult males and females (two males and five females with a mean age of 34.7 ± 13.8 years) who identified as having a sweet tooth.

The first objective was to *"investigate and assess changes to what motivates adults to eat SSF"*. Baseline motivations were psychological, external, habit-related, pleasure-seeking and physiological in origin. Sugar-sweetened foods were avoided for similar reasons (except no participants avoided SSF out of habit).

Closely related to the first objective, the third objective was to *"investigate and assess changes to what effect GS-containing mints have on adult motivations to eat SSF when administered both in a systematic and ad-libitum manner"*. Results showed that motivations to eat SSF was influenced by all treatment arms and external factors (e.g., family matters and occupations). At all trial phases, participants were motivated to eat SSF out of pleasure, regardless of the treatment being tested. Compared to PLAC-SYS, GS-SYS and GS-ADLIB treatments increased motivations to avoid SSF more because they reduced pleasure derived from these foods, and because they promoted mindful eating. Decreasing palatability of SSF resulted in avoidance, and increased mindful eating allowed conscious attention to physiological (rather than emotional) consumption cues. A noticeable difference was not seen between effects of GS-SYS and GS-ADLIB treatments other than individual preference. These findings support previous evidence that motivation to eat SSF have physiological (Jackson et al., 2003; Schupp & Renner, 2011), psychological (Jackson et al., 2003; Macht & Simons, 2000) and external (Jackson et al., 2003; Pollard et al., 2002) origins. No other studies have assessed how GS affects motivations to eat SSF, but interest in herbal medicines (Torres-Fuentes et al., 2015) (such as GS) for health has highlighted potential for GS to reduce long-term intake of SSF.

These results suggest GS may lower SSF intake by reducing hedonistic, and habitual or psychological motivations.

The second objective was to *"investigate and assess changes to factors that may influence adults' motivations to eat SSF"*. Baseline motivations were influenced by conscious lifestyle changes and external factors, which influenced motivations to eat and avoid SSF throughout the study. All treatments that were tested also influenced motivation to eat SSF. Participants reported GS-SYS and GS-ADLIB affected their behaviours related to SSF intake more than PLAC-SYS. Previous research on alcohol and drug addiction treatment shows influences on motivations have both internal and external origins (Curry et al., 1991; Deci & Ryan, 1987; DiClemente et al., 1999). The results of this study suggest that although GS treatments may affect motivations to eat SSF, external influences are also significant and interventions (including those that utilise GS) addressing SSF should also account for these for optimal results.

The fourth objective was to *"investigate and assess how in control adults feel over their intake of SSF after testing GS-containing mints"*. Changes in self-control were therefore attributable to GS-ADLIB, as well as external factors such as participants' lifestyles and occupations which caused self-control to increase or decrease. Having higher self-control levels has been shown to increase consumption of nutrient-dense food such as fruits and vegetables, and reduce instances of overeating (De Ridder et al., 2007; Gerrits et al., 2010; Wills et al., 2007). Ad-libitum GS intake may increase self-control more than GS-SYS or PLAC-SYS, but external factors are a stronger contributor than any of the GS treatments used in the study.

4.2 Strengths of the research

This is the first study to thoroughly investigate how adult motivations to eat and avoid SSF are affected by GS, and the first to use a qualitative design to assess effects of GS on behaviours related to consumption of these foods. Previous quantitative research has identified how GS is able to reduce the desire for, and pleasantness from SSF consumption (Kashima et al., 2020; Nobel et al., 2017; Stice & Yokum, 2018; Stice et al., 2017; Turner et al., 2020; Turner et al., 2022), but no details concerning views on GS intake were gleaned using these methods. This study provides breakthrough insight into adults' perspectives that cannot be captured using quantitative methods. In relation to this, the strong rapport established between the interviewer and interviewees during data collection is another strength of this research. Creation of an open, non-judgemental environment encouraged participants to provide thorough details about their experiences during the study. Thirdly, this study was strengthened by the robust health screening questionnaire used during recruitment. This excluded participants for any health issues or medications that may have inadvertently affected taste and smell, and therefore the ability to test GS. All participants therefore had consistent levels of health, taste and smell, which was relayed into the results.

4.3 Limitations of the research

A significant limitation of this study was the loss of three interview recordings (and inadequate corresponding notes), which reduced the breadth of the results. Among data lost was information on which treatment participant 3 found most effective and whether he would accept free samples, or indeed pay for them; as well as how in control participant 5 felt about her consumption of SSF during testing of GS-SYS. Second, although a strong rapport was built with participants which meant interviews were often expansive and detailed, the lengthy discussions sometimes resulted in questions on the interview guides not being asked. For example, participants 1 and 7 were not asked how in control they felt over their consumption of SSF during the 14 days on PLAC-SYS. Third, participants were not asked during screening whether they were embarking on lifestyle changes prior to starting the trial (e.g., restrictive diets). Individuals who are actively involved in or want to undertake interventions for weight or health-related reasons, may have different motivations to those not interested in such interventions. At baseline, four participants noted they were consciously making lifestyle changes to reduce SSF intake prior to starting this study. Those who were already wanting to reduce SSF intake may have found the treatments had different effects on their motivations, compared to those who were not involved or interested in lifestyle changes at baseline. It is unknown why one participant, despite the anti-sweet effects of GS, waited for the effects to wear off before eating SSF; compared to participants who were able to not consume SSF when the anti-sweet effects wore off.

4.4 Recommendations for future research

- Research on GS intake should focus on its effects on behaviours related to SSF intake. Very little research exists here, and this is the first study to qualitatively assess the effects of GS on more behavioural aspects of SSF intake. Knowledge of negative side-effects of SSF is insufficient to reduce intake, further highlighting the complexity of drives to eat SSF, and the need for health interventions that target multiple behaviours (Kirkpatrick et al., 2018; Raine, 2005).
- Effects of interventions combining development of autonomy (such as support through dietetic counselling or coaching) (Ryan, 2017; Ryan & Deci, 2022) with GS on motivation to eat SSF. Gymnema sylvestre may be beneficial when used as part of larger interventions which support individuals through behavioural change (and changing external factors) to reduce SSF, but this has not yet been assessed.
- An exploration into effects of GS intake on behaviour related to SSF intake would benefit from combining qualitative and quantitative designs. This would enable assessment of how changes in behaviour relate to tangible changes in food intake.
    - Quantifiable changes in food intake would need to be established to prove that shifting motivations benefits SSF intake. Different motivations are significant contributors to dietary choices. Valuable quantitative outcome measures should include total amount of SSF eaten, total daily caloric intake, cravings for SSF (assessed using a validated questionnaire, such as the sugar craving assessment tool (Mahmood, 2017)), and overall behaviours related to SSF intake (also assessed using validated questionnaires, such as the sugar addiction questionnaire (Fawzy & El-Deen, 2018)).
    - Qualitative outcome measures should include (similarly to this study) motivations to eat and avoid SSF, influences on motivations, and level of self-control concerning intake of these foods. To ensure all aspects of qualitative interviews are covered (and questions are not missed by interviewers), care should be taken to ensure interview guides are adhered to and interviews are in general managed well in terms of time.
- Research into whether behavioural changes established during a GS intervention continue after the intervention has finished should be completed. It is also prudent to

investigate whether GS needs to be taken for longer periods of time (i.e., longer than 14 days) for more benefits to be seen (i.e., significantly reduced intakes of SSF, or significantly affected motivations).

- Healthy female participants should test GS treatments at the same stage of their menstrual cycle to account for any possible physiological changes because of hormonal fluctuation (Schmalenberger et al., 2021). During this study, it emerged that some female participants felt their motivation to eat SSF changed with menstruation. Some studies have found healthy females may have increased cravings for carbohydrates during the luteal phase (Cohen et al., 1987), while others have found no difference in craving levels for SSF across the menstrual cycles of healthy females (McVay et al., 2012); results on this subject are therefore still inconclusive.
- Future studies on GS should also account for pre-established pursuit of lifestyle changes prior study recruitment. As part of screening protocols, individuals could be divided into two testing groups: those undergoing lifestyle changes and those who are not. Not only will pre-established lifestyle changes introduce bias, but these participants may be in a different stage of change (DiClemente et al., 1999; Prochaska & DiClemente, 2005). According to the stages of change model, people have different motivation levels at different stages of change, which could also impact results (Greene et al., 1999; Loma Linda University, 2023). Participants could be asked to provide a reason for entering the study, which could help contribute to assessing their baseline attitudes to SSF.
- Participants could also be assessed for their current stage of change to account for different motivation levels already present prior to undergoing any interventions. If a particular stage of change is a focus of research, it should be used as a screening tool.

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Appendix A: Supplementary methods

A.1: Interview guide for initial interviews

Focus Area	**Questions**
Introduction Ice breaker / warm - up	● Thank you for volunteering. ● Initial ice breaker: 'how did you find out about our study?' ● Tell me a bit about why you decided to volunteer for this study. ● What's your favourite sugary food to eat? ● Describe your relationship with sugar-sweetened foods for me.
Motivations	● 'One really important part of this study is looking at the motivations to consume sweet food…' ● What would you say is your biggest motivator to eat sugar-sweetened food? ● *If asked what the interviewer means…* 'these are any foods that contain added sugar, so it would include things like coffee and sugar, cake, sugar-sweetened beverages, sauces with sugar etc.' ● How did you come to that decision? ● What does the phrase, 'dessert stomach' mean to you? ● Do sugar-sweetened foods bring you pleasure? ● We spoke just before about how you felt your motivations to eat sugar food were _______. What do you think would change these motivations? ● What would motivate you to not consume sugar-sweetened foods?

Desire	● What does having a 'sweet tooth' mean for you?
	● When would you say you most feel like eating sugar-sweetened foods?
	● *Probing tools / questions to elaborate.*
	    ○ Tell me a bit about that.
	    ○ What makes you say that?
	    ○ *Silence*
	● And when would you say you feel *least* like eating sugar-sweetened foods?
	● On a scale of 1-10, with 1 being no control at all and 10 being complete control, how in control do you feel over your consumption of sugar-sweetened foods?

Consumption of sugar-	● Tell me about your relationship with sugar-sweetened

sweetened food	foods right now.
Conclusion	• Thank you so much for your time. • Did you have any further questions for me about anything we just discussed or about the study?

A.2: Interview guide for second and third interviews

Focus Area	**Questions**
Introduction Ice breaker / warm - up	● Thank you for coming back in today. ● Ice breaker: 'how is your week going?'

How participants are finding the study?	● How have you found these past two weeks in the trial?
	● *Probing tools / questions to elaborate.*
	    ○ Tell me a bit about that.
	    ○ What makes you say that?
	    ○ *Silence*

Motivations	● Considering how you've been using the mint in the past two weeks, what would you say is your biggest motivator to eat sugar-sweetened food was? ● How did you come to that decision? ● How have you been finding the effects of the mint on what you eat? ● What was motivating you to not eat sugar-sweetened food?

Desire	● How has your 'sweet tooth' been in these past two weeks?
	● When would you say you most feel like eating sugar-sweetened foods at the moment?
	● *Probing tools / questions to elaborate.*
	    ○ Tell me a bit about that.
	    ○ What makes you say that?
	    ○ *Silence*
	● And when would you say you feel *least* like eating sugar-sweetened foods these past two weeks?

Consumption of sugar-sweetened food	● Tell me about how you've been finding sugar-sweetened foods in the past two weeks.
Conclusion	● Thank you so much for your time. ● Did you have any further questions for me about anything we just discussed or about the study?

A.3: Interview guide for final interviews

Focus Area	Questions
Introduction Ice breaker / warm - up	• Thank you for coming back in today. • Ice breaker.
How participants are finding the study?	• How have you found these past two weeks in the trial? • Are there any parts of the trial you've found difficult?
Motivations	• What would you say is your biggest motivator to eat sugar-sweetened food was? • How did you come to that decision? • How have you been finding the effects of the mint on what you eat? • What was motivating you to not eat sugar-sweetened food?

Desire	• When would you say you most feel like eating sugar-sweetened foods at the moment?
	• *Probing tools / questions to elaborate.*
	  ○ Tell me a bit about that.
	  ○ What makes you say that?
	  ○ *Silence*
	• And when would you say you felt *least* like eating sugar-sweetened foods these past two weeks?
	• How in control do you feel over your sugar consumption?

Consumption of sugar-sweetened food	• Tell me about how you've been finding sugar-sweetened foods in the past two weeks.
Motivations	• What would you say your biggest motivators to eat sugar-sweetened foods are now at the end of the study? • How did you come to that decision? • What would you say are your biggest motivators now to NOT eat sugar-sweetened foods? • Have sugar-sweetened foods brought you pleasure in the past two weeks?

Comparison treatment arms	• You've now used a few different kinds of mints. Tell me about how you found each of them.
	  ○ Which one did you like the most? The least?
	  ○ Was the one you liked the most also the most

	effective? ● If you could have any of the mints for free, which one would you like? ○ *Probing tools / questions to elaborate.* ■ Tell me a bit about that. ■ What makes you say that? ■ *Silence* ● What about if you had to pay for them? ○ *Probing tools / questions to elaborate.* ■ Tell me a bit about that. ■ What makes you say that? ■ *Silence* ● Do you feel like your motivations to eat sugar-sweetened food have changed at all over the study? ○ *Probing tools / questions to elaborate.* ■ Tell me a bit about that. ■ What makes you say that? ■ *Silence*
Conclusion	● Thank you so much for your time ● Did you have any further questions for me about anything we just discussed or about the study?

A.4: Descriptions of themes used in data analysis

Theme code title	Description
1. External influences on motivations to eat sugar-sweetened foods	How external factors in a participants' life affect motivations to eat or avoid sugar-sweetened foods
2. Motivations to eat or avoid sugar-sweetened foods	Reasons a participant wants to eat or avoid sugar-sweetened foods
3. Findings relevant to treatment arms	Information pertaining to different perspectives on each of the three different treatment arms: systematic administration of control (three times a day: mid-morning, mid-afternoon and mid-evening), systematic administration of Gymnema-sylvestre containing treatment, and ad-libitum administration of Gymnema-sylvestre containing treatment
4. Control over sugar-sweetened food intake	How in control participants feel over their intake of sugar-sweetened foods
5. Intake of sugar-sweetened food intake	Consumption of sugar-sweetened foods. This theme emerged after analysis in NVivo

A.5: Descriptions of parent and child codes used in data analysis

Code title	Description
1. External influences	How external factors in a participants' life affect motivations to eat or avoid sugar-sweetened foods.
1.1 Lifestyle changes	Influence of conscious decisions to change sugar-sweetened food intake through interventions such as restrictive diets or lifestyle changes. The decision to change sugar-sweetened food intake may be due to wanting a desired outcome, including improving health or weight
1.2 External factors	Influence of occupations, non-occupation-related daily activities (during both workdays and holidays, including hobbies and exercise), and non-occupation-related responsibilities (e.g., caring for family)
1.3 Influence of treatments of the study (I.e., PLAC-SYS, GS-SYS and GS-ADLIB)	Influence of each of the treatments being tested in the study and their effects on participants
2. Motivations	Reasons a participant wants to eat or avoid sugar-sweetened foods
2.1 Mindfulness and awareness	Mindfulness and awareness about authentic needs and wants in that particular moment
2.2 Boredom and mindset	Level of stimulation and resultant boredom
2.3 Emotions	Both positive and negative emotions
2.4 Environment and access	Access to sugar-sweetened food, and the presence or lack thereof of sugar-sweetened food in the physical environment

2.5 Finance	Financial factors, including available funds to purchase sugar-sweetened foods
2.6 Social factors	Relationships and interactions with friends, family and peers
2.7 Knowledge	Health literacy level, and education received prior to the study or during the study
2.8 Habits	Habits and practices formed through learned and / or repeated behaviours
2.9 Pleasure and reward	Level of pleasure derived from eating, or the sensation of reward derived from eating
2.10 Wanting	Innate wanting not described by any other code
2.11 Hormones and cravings	Self-described hormonal influences and cravings
2.12 Health	Desire to improve physical and / or mental health
2.13 Weight	Desire to attain a specific weight
2.14 Hunger, satiety and energy	Physiological cues related to hunger and satiety, as well as perceived low energy and physiological needs
3. Treatment arms	Information pertaining to different perspectives on each of the three different treatment arms: systematic administration of control (three times a day: mid-morning, mid-afternoon and mid-evening), systematic administration of Gymnema-sylvestre containing mint, and ad-libitum administration of Gymnema-sylvestre containing mint

3.1 Free mints	Participants' thoughts about which treatment they would take if they were given the option to take free treatments and why
3.2 Purchasing mints	Participants' thoughts about which treatment they would take if they were given the option to purchase mints and why.
3.3 Perspectives on mints	Participants' thoughts on the treatments in general, regarding aspects such as the taste and texture of the treatments
3.3.1 Negative opinions	Descriptions of a participants' experiences with food that are self-described or interpreted as negative.
3.3.2 Positive opinions	Descriptions of a participants' experiences with food that are self-described or interpreted as positive.
3.3.3 Mixed opinions	Descriptions of a participants' experiences with food that are self-described or interpreted as both positive and negative
4. Control over sugar-sweetened food intake	How in control participants feel over their intake of sugar-sweetened foods

A.6: Descriptions of sub-themes used in data analysis

Sub-theme title	Description
Psychological motivations	Comprised of motivation children codes 2.1, 2.2, and 2.3. Includes all motivations related to emotions, mindsets and mental states
External motivations	Comprised of motivation children codes 2.4, 2.5, 2.6 and 2.7. Includes all motivations that originate from the external environment
Habit-related motivations	Comprised of motivation child code 2.8. Includes all motivations originating from automatic learned behaviours
Pleasure-seeking behavioural motivations	Comprised of motivation children codes 2.9, 2.10, and 2.11. Includes all motivations related to seeking pleasure
Physiological motivations	Comprised of motivation children codes 2.12, 2.13, and 2.14. Includes all motivations related to normal body functions related to insurance of survival

Appendix B: Materials used in conducting research

B.1: First advertising poster used during recruitment

B.2 Second advertising poster used during recruitment

B.3: Social media posts

Kia ora! Our names are David Hsiao and Imogen Nelson - we are studying to become dietitians at Massey University and as part of our Masters degrees we are also completing research. We are investigating the effect of ingestion of different mints containing a special herb on total intake of sugar sweetened food.

Would you describe yourself as having a sweet tooth? Are you able to visit the Massey Albany campus for four different lots of data collection?

Then we want to hear from you! Follow this link to find out if you are eligible to take part in our study:
https://massey.au1.qualtrics.com/jfe/form/SV_eP3DohdA8MrMH9s?fbclid=IwAR2l0DktRERlgrrV3iaRy3OKD8lIbBair3l3MWc3FFpvbF5t_doWLDbthv0

Once all four visits have been completed you will receive $80 koha.

If you have any questions please feel free to email us (D.Hsiao@massey.ac.nz and I.Nelson@massey.ac.nz).

We look forward to hearing from you, ngā mihi nui!

B.4: Online eligibility screening questionnaire exported from Qualtrics

Liberate from sugar, Mate. w health screen

Start of Block: Health screening

Q61 What is your name?

- First name (1) ____
- Last name (2) ____

Q62 What is your gender?

- Male (1)
- Female (2)
- Non-binary / third gender (3)
- Prefer not to say (4)

Q70 What is your email address?

____

Page Break

Q57 Are you currently taking any of these medications below? If you are not taking any of these, please select "none of the above" at the end.

- ☐ Amoxicillin, azithromycin or ciprofloxacin (1)
- ☐ Amlodipine or enalapril (4)
- ☐ Atorvastatin, lovastatin, simvastatin or pravastatin (5)
- ☐ Levothyroxine (6)
- ☐ Furosemide, lisinopril, propranolol, hydrochlorothiazide or triamterene (7)
- ☐ Amphetamines (8)
- ☐ Metformin (9)
- ☐ Insulin (10)
- ☐ Albuterol (11)
- ☐ Ranitidine or omeprazole (12)
- ☐ Amitriptyline, bupropion, trazodone or diazepam (13)
- ☐ Prednisolone (14)
- ☐ None of the above (15)

Skip To: End of Survey If Are you currently taking any of these medications below? If you are not taking any of these, plea... = Amoxicillin, azithromycin or ciprofloxacin

Skip To: End of Survey If Are you currently taking any of these medications below? If you are not taking any of these, plea... = Amlodipine or enalapril

Skip To: End of Survey If Are you currently taking any of these medications below? If you are not taking any of these, plea... = Atorvastatin, lovastatin, simvastatin or pravastatin

Skip To: End of Survey If Are you currently taking any of these medications below? If you are not taking any of these, plea... = Levothyroxine

Skip To: End of Survey If Are you currently taking any of these medications below? If you are not taking any of these, plea... = Furosemide, lisinopril, propranolol, hydrochlorothiazide or triamterene

Skip To: End of Survey If Are you currently taking any of these medications below? If you are not taking any of these, plea... = Amphetamines

Skip To: End of Survey If Are you currently taking any of these medications below? If you are not taking any of these, plea... = Metformin

Skip To: End of Survey If Are you currently taking any of these medications below? If you are not taking any of these, plea... = Insulin

Skip To: End of Survey If Are you currently taking any of these medications below? If you are not taking any of these, plea... = Albuterol

Skip To: End of Survey If Are you currently taking any of these medications below? If you are not taking any of these, plea... = Ranitidine or omeprazole

Skip To: End of Survey If Are you currently taking any of these medications below? If you are not taking any of these, plea... = Amitriptyline, bupropion, trazodone or diazepam

Skip To: End of Survey If Are you currently taking any of these medications below? If you are not taking any of these, plea... = Prednisolone

Page Break

Q58 Are you currently affected by or have ever been affected by...

- ☐ Injuries to the head or ear (1)
- ☐ Traumatic brain injury (4)
- ☐ None of the above (5)

Skip To: End of Survey If Are you currently affected by or have ever been affected by... = Injuries to the head or ear

Skip To: End of Survey If Are you currently affected by or have ever been affected by... = Traumatic brain injury

Page Break

Q59 Are you currently affected by any of the following? If you are affected by none of these, please select "none of the above" at the end

- ▢ Influenza (flu) (1)
- ▢ Common cold (4)
- ▢ Strep throat (5)
- ▢ Salivary gland infection (6)
- ▢ Gum (periodontal) disease (7)
- ▢ Dry mouth (xerostomia) (8)
- ▢ Parkinson’s disease (9)
- ▢ Multiple sclerosis (10)
- ▢ Nasal polyps (11)
- ▢ Deviated septum (12)
- ▢ Sinus infection (sinusitis) (13)
- ▢ Cancer (14)
- ▢ Cardiovascular disease (e.g. heart disease) (15)
- ▢ Respiratory disease (e.g. asthma, chronic obstructive pulmonary disease, pneumonia) (16)
- ▢ Diabetes (17)
- ▢ Alzheimer’s disease (18)
- ▢ Non-alcoholic fatty liver disease (19)
- ▢ Alcoholic Fatty liver disease (20)
- ▢ None of the above (21)

Skip To: End of Survey If Are you currently affected by any of the following? If you are affected by none of these, please... = Influenza (flu)

Skip To: End of Survey If Are you currently affected by any of the following? If you are affected by none of these, please... = Common cold

Skip To: End of Survey If Are you currently affected by any of the following? If you are affected by none of these, please... = Strep throat

Skip To: End of Survey If Are you currently affected by any of the following? If you are affected by none of these, please... = Salivary gland infection

Skip To: End of Survey If Are you currently affected by any of the following? If you are affected by none of these, please... = Dry mouth (xerostomia)

Skip To: End of Survey If Are you currently affected by any of the following? If you are affected by none of these, please... = Parkinson's disease

Skip To: End of Survey If Are you currently affected by any of the following? If you are affected by none of these, please... = Multiple sclerosis

Skip To: End of Survey If Are you currently affected by any of the following? If you are affected by none of these, please... = Nasal polyps

Skip To: End of Survey If Are you currently affected by any of the following? If you are affected by none of these, please... = Deviated septum

Skip To: End of Survey If Are you currently affected by any of the following? If you are affected by none of these, please... = Sinus infection (sinusitis)

Skip To: End of Survey If Are you currently affected by any of the following? If you are affected by none of these, please... = Sinus infection (sinusitis)

Skip To: End of Survey If Are you currently affected by any of the following? If you are affected by none of these, please... = Cancer

Skip To: End of Survey If Are you currently affected by any of the following? If you are affected by none of these, please... = Cardiovascular disease (e.g. heart disease)

Skip To: End of Survey If Are you currently affected by any of the following? If you are affected by none of these, please... = Respiratory disease (e.g. asthma, chronic obstructive pulmonary disease, pneumonia)

Skip To: End of Survey If Are you currently affected by any of the following? If you are affected by none of these, please... = Diabetes

Skip To: End of Survey If Are you currently affected by any of the following? If you are affected by none of these, please... = Alzhemer's disease

Skip To: End of Survey If Are you currently affected by any of the following? If you are affected by none of these, please... = Non-alcoholic fatty liver disease

Skip To: End of Survey If Are you currently affected by any of the following? If you are affected by none of these, please... = Alcoholic Fatty liver disease

Page Break

Q60 Are you currently seeking medical advice, receiving treatment or having investigations?

- Yes (4)
- No (5)

Skip To: End of Survey If Are you currently seeking medical advice, receiving treatment or having investigations? = Yes

Page Break

Q64 Please tick if, for whatever reason, you are currently affected by:

- Loss of taste (1)
- Loss of smell (2)
- None of the above (3)

Skip To: End of Survey If Please tick if, for whatever reason, you are currently affected by: = Loss of taste

Skip To: End of Survey If Please tick if, for whatever reason, you are currently affected by: = Loss of smell

Q65 Do you smoke tobacco?

- Yes (1)
- No (2)

Skip To: End of Survey If Do you smoke tobacco? = Yes

Page Break

Q68 Are you currently pregnant?

○ Yes (1)

○ No (2)

Skip To: End of Survey If Are you currently pregnant? = Yes

Q69 Do you have a pacemaker?

○ Yes (1)

○ No (2)

Skip To: End of Survey If Do you have a pacemaker? = Yes

Q71 Do you live in the Auckland region and are able to visit the Massey Albany campus on four different occasions for data collection (dates tbc)?

○ Yes (1)

○ No (2)

Skip To: End of Survey If Do you live in the Auckland region and are able to visit the Massey Albany campus on four differe... = No

End of Block: Health screening

Start of Block: Main

Page Break

Q3 What is your age?

▼ Under 18 years old (1) ... Over 60 years old (7)

Skip To: End of Survey If What is your age? = Under 18 years old

Page Break

X→

Q4 Do you consider yourself a sweet tooth?

○ No (0)

○ Sometimes (1)

○ Yes (2)

Skip To: End of Survey If Do you consider yourself a sweet tooth? = No

Page Break

X→

Q5 Does eating sugar-containing foods give you pleasure?
Note: sugar-containing foods in this context refer to those foods that have had sugar added to them e.g. cakes, cookies, sweets, chocolate, pastries etc.

○ No (0)

○ Sometimes (1)

○ Yes (2)

Page Break

Q6 Do you believe sugar can have a strong effect on someone's mental state?

- No (0)
- Sometimes (1)
- Yes (2)

Q7 Does eating sugar-containing foods make you feel better, even during a bad day?

- No (0)
- Sometimes (1)
- Yes (2)

Page Break

Q8 Would you buy sweet foods if you felt like eating them, even if it is late in the evening or inconvenient to do so?

- No (0)
- Sometimes (1)
- Yes (2)

Page Break

Q9 Do you ever experience feelings of guilt after eating sugar-containing foods?

- No (0)
- Sometimes (1)
- Yes (2)

Q10 Do you eat sugar-containing foods every day?

- No (0)
- Sometimes (1)
- Yes (2)

Q11 Do you prefer to eat sugar-containing foods in secret or alone (i.e. not around other people)?

- No (0)
- Sometimes (1)
- Yes (2)

Page Break

Q12 Do you ever think about what sugar-containing foods you would want to eat next?

- No (0)
- Sometimes (1)
- Yes (2)

Q13 Do you "stockpile" sugar-containing foods?
(Stockpile - collect a large amount of sugar-containing foods to hold in reserve for times of shortage)

- No (0)
- Sometimes (1)
- Yes (2)

Page Break

Q14 Do you feel exhausted after eating too many sugar-containing foods?

- No (0)
- Sometimes (1)
- Yes (2)

Q15 Do you find it hard to control or limit the amount of sugar-containing foods you consume?

- No (0)
- Sometimes (1)
- Yes (2)

Page Break

Q16 When you are deprived of sugar-containing foods for a long period of time, do you experience what you consider to be symptoms of withdrawal?

- No (0)
- Sometimes (1)
- Yes (2)

Page Break

Q17 Do you hide the amount of sugar-containing foods you've eaten from peers?

- No (0)
- Maybe (1)
- Yes (2)

Q18 Do you worry about how sugar-containing foods affect your health, but continue to consume them?

- No (0)
- Sometimes (1)
- Yes (2)

Page Break

Q19 Do you ever experience a "crash", or severe loss of energy, in the afternoon if you did not eat any sugar-containing foods prior in the day?

- No (0)
- Sometimes (1)
- Yes (2)

Q20 Could you open a packet of sweets / confectionary / chocolate and finish it in one sitting?

- No (0)
- Sometimes (1)
- Yes (2)

Page Break

Q21 Do you think celebrations must include sugar-containing food?

- No (0)
- Sometimes (1)
- Yes (2)

Q22 Would you choose sugar-containing foods over other foods that are offered to you (for example, savoury foods)?

- No (0)
- Sometimes (1)
- Yes (2)

Page Break

Q23 Do you think loving sugar-containing foods is a part of your personality?

- No (0)
- Unsure (1)
- Yes (1)

Q24 If you experience weight gain, do you eat less than you normally would?

- No (0)
- Sometimes (1)
- Yes (2)

Page Break

Q25 Do you try to eat less at meal times than you would like to eat?

- No (0)
- Sometimes (1)
- Yes (2)

Page Break

Q26 Do you refuse food or drink offered to you because you are concerned about your weight?

- No (0)
- Sometimes (1)
- Yes (2)

Q27 Do you watch what you eat?

- No (0)
- Sometimes (1)
- Yes (2)

Page Break

Q28 Do you deliberately eat foods that are considered slimming?

- No (0)
- Sometimes (1)
- Yes (2)

Q29 When you have eaten too much, do you eat less than usual the following days?

- No (0)
- Sometimes (1)
- Yes (2)

Page Break

Q30 Do you deliberately eat less in order to not gain weight?

- No (0)
- Sometimes (1)
- Yes (2)

Page Break

Q31 During the evening do you try not to eat because you are watching your weight?

- No (0)
- Sometimes (1)
- Yes (2)

Q32 Do you try not to eat between meals because you are watching your weight?

- No (0)
- Sometimes (1)
- Yes (2)

Q33 Do you take into account your weight with what you eat?

- No (0)
- Sometimes (1)
- Yes (2)

Page Break

Q34 Do you have the desire to eat when you are irritated?

- No (0)
- Sometimes (1)
- Yes (2)

Page Break

Q35 Do you have the desire to eat when you depressed or discouraged?

- No (0)
- Sometimes (1)
- Yes (2)

Q36 Do you have the desire to eat when you are feeling lonely?

- No (0)
- Sometimes (1)
- Yes (2)

Page Break

Q37 Do you have the desire to eat when somebody lets you down?

- No (0)
- Sometimes (1)
- Yes (2)

Page Break

Q38 Do you have the desire to eat when you are angry?

- No (0)
- Sometimes (1)
- Yes (2)

Q39 Do you have the desire to eat when you are anticipating something unpleasant will happen?

- No (0)
- Sometimes (1)
- Yes (2)

Page Break

Q40 Do you have the desire to eat when you anxious, worried or tense?

- No (0)
- Sometimes (1)
- Yes (2)

Page Break

Q41 Do you have the desire to eat when things are going against you or when things have gone wrong?

- No (0)
- Sometimes (1)
- yes (2)

Q42 Do you have the desire to eat when you are frightened?

- No (0)
- Sometimes (1)
- Yes (2)

Page Break

Q43 Do you have the desire to eat when you are disappointed?

- No (0)
- Sometimes (1)
- Yes (2)

Page Break

Q44 Do you have the desire to eat when you are emotionally upset?

- No (0)
- Sometimes (1)
- Yes (2)

Page Break

Q45 Do you have the desire to eat when you are bored or restless?

- No (0)
- Sometimes (1)
- Yes (2)

Q46 If food tastes good to you, do you eat more than usual?

- No (0)
- Sometimes (1)
- Yes (2)

Page Break

Q47 If you see or smell something delicious, do you have a desire to eat it?

- No (0)
- Sometimes (1)
- Yes (2)

Q48 If food smells or looks good, do you eat more than usual?

- No (0)
- Sometimes (1)
- Yes (2)

Page Break

Q49 If you have something delicious to eat, do you eat it straight away?

- No (0)
- Sometimes (1)
- Yes (2)

Page Break

Q50 If you walk past a bakery, do you have the desire to buy something?

- No (0)
- Sometimes (1)
- Yes (2)

Q51 If you walk past a snack bar or café, do you have the desire to buy something?

- No (0)
- Sometimes (1)
- Yes (2)

Page Break

Q52 If you see others eating, do you also have the desire to eat?

- No (0)
- Sometimes (1)
- Yes (2)

Q53 Can you resist eating delicious foods?

- No (0)
- Sometimes (1)
- Yes (2)

Page Break

Q54 Do you eat more than usual when you see others eating?

- No (0)
- Sometimes (1)
- Yes (2)

Q55 When preparing a meal, are you inclined to eat something?

- No (0)
- Sometimes (1)
- Yes (2)

End of Block: Main

B.5 Official study information sheet

MASSEY UNIVERSITY
COLLEGE OF HEALTH
TE KURA HAUORA TANGATA

Liberate From Sugar, Mate!

PARTICIPANT INFORMATION SHEET

Researcher Introduction

We are student dietitians completing Master's of Nutrition & Dietetics. Our supervisors and collaborators work in the areas of sport and exercise science, health science, nutrition and food technology at Massey University.

Invitation to Participate in Research Study

If you identify as having a 'sweet tooth', we would like to invite you to take part in our study. Gymnema sylvestre (GS) is a plant that contains ingredients that prevent sugar from activating sweet receptors on the tongue. This results in a reversible reduction in perception of sweet flavours for 30 – 60 minutes. Several GS-containing mints have been developed to reduce cravings for sugar-sweetened food products. You will need to be available to take part in **three separate interventions** during the course of the study (each 14 days long) i**n addition to four visits** to the Massey University Albany Campus.

Participant Recruitment

Healthy men and women (aged 18-60 years) not currently affected by medical conditions including (but not limited to) diabetes, heart disease or cancer; not currently smoking; and not currently taking medications that affect taste and smell are invited to participate in this study. Participants will undertake a general health screening questionnaire to ascertain whether they are able to be recruited into the study.

The four visits will each be of approximately 45 - 60 minutes duration. There will also be the (optional) opportunity for 10 participants to be interviewed as part of this study, which will increase the visit time by **30 minutes**.

Project Procedures and Participant Involvement

If you agree to participate, you will be asked to participate in **three 14-day experiments** that are designed to assess the effects of several GS-containing mint products on 1) motivations to consume sugar-sweetened food, 2) cravings for sugar-sweetened food and 3) total intake of sugar-sweetened food. In each 14-day trial you will be asked to undertake the following:

Take allocated mint orally three times per day at specified time points: between breakfast and lunch, between lunch and dinner, after dinner but before bed OR to take the allocated mint orally as many times as you like / need throughout the day (up to six mints per day) at times that suit you. The specific procedure will be explained to you prior to each trial. You will also need to complete a Compliance Diary each day during each of these 14-day interventions: the Compliance Diary will help researchers be able to see what time and the reason why you took the GS-containing mint, or alternatively any reason why the GS-containing mint was not taken (for example, you forgot to take the mint).

Possible side effects: Similar GS-containing mints have been used in many other studies and side effects are rare. Those that have experienced any reported mild gastrointestinal upset. Taste effects rarely last longer than 30 - 60 minutes. If you experience any persisting side effects during the study, we encourage you to get in contact with your health professional.

For **all four visits**, you will be asked to complete the following:

- A food frequency questionnaire: specifically developed for assessing sweet food consumption as well as related behaviours.
- A beverage questionnaire
- A food cravings questionnaire
- Bioelectrical Impedance Analysis (BIA)
    - A machine that assesses your body composition. The machine passes a small electrical current through your body. The conductivity of this current is higher through muscle and bone, and lower through fat mass.
    - You will be required to not eat for two hours before your scan.
    - The researchers will sanitise the machine before you use it, which will involve stepping onto the BIA machine with bare feet.
    - Your height (which will be take prior to stepping onto the BIA machine), age, gender and weight (which is measured by the BIA machine) will be entered into the machine by the researcher, and then you will hold onto two handles on either side of the machine and the analysis will begin. The machine will print out the results of the analysis, which the researchers will keep securely and allow you to see **after the research project has finished** if you wish**.**
    - **Risks:** The BIA does not involve exposure to radiation and is considered safe for most people to use. All body measurements will be taken in a private room for your comfort, and you are encouraged to discuss any feelings of discomfort with the researchers, your health professionals, or to contact any of the numbers listed below (Samaritans or Lifeline) if you experience psychological distress related to the body measurements.

For the **first three visits** you will also be asked to complete sensory testing with the different kinds of GS mints you will be taking for the three 14-day interventions. This will involve the following:

1. Record your hunger and desire for sugar-sweetened food
2. Consume a serving of confectionary
3. Record how pleasant you found the confectionary AND your desire for a second serving
4. You will be given a mint and instructed on how to take it orally
5. AGAIN record your desire for a second serving of confectionary
6. Consume a second serving of confectionary
7. Record how pleasant you found the second serving of confectionary AND your desire for a third serving
8. From this point, any further servings of confectionary are optional (with steps 5 to 7 being repeated in between consumptions). You can at any point decide you would not like another serving of confectionary, at which point sensory testing will stop.

Interviews: We will ask 10 participants to volunteer for interviews, **which will be taken at each of the four visits to campus**. The **same people** will be interviewed at each visit. We will ask questions related to nutrition, behaviour and sensory aspects related to sugar-sweetened food. Sessions will be audio-recorded. You will be asked to sign a separate consent form if you wish to be involved in the interviews and consent to having your answers recorded.

After each visit to the Massey University Albany Campus you will receive $20 koha.

Participant's Rights

You are under no obligation to accept this invitation. Should you choose to participate, you have the right to:

- Decline to answer any particular question
- Withdraw from the study at any time, even after signing a consent form (if you choose to withdraw you cannot withdraw your data from the analysis after the data collection has been completed)
- Ask any questions about the study at any time during participation
- Provide information on the understanding that your name will not be used unless you give permission to the researcher
- Be given access to a summary of the project findings when it is concluded

Good Practice and Cultural Safety for Massey University Research

We have considered the inclusion of Māori and indigenous values and concepts, allowing for the use of whānau support and appropriate Māori protocols. We acknowledge the concept of manaakitanga, respecting the participants' inherent dignity and acting in a caring manner towards them by way of:

- Taking full responsibility to perform research in a safe and ethical manner (aroha)
- Providing the participant with all of the critical information regarding the study in a clear way, so they can make informed decisions (tūmanako and whakapono)
- An awareness of the cultural significance and sensitivity for a culturally safe implementation of the study (māhaki)
- Respect for the privacy and confidentiality of Māori participants

Confidentiality

All data collected will be used solely for research purposes and has the possibility of being presented in an international journal. All personal information will be kept confidential by assigning numbers to each participant. No names will be visible on any papers on which you provide information. All data / information will be dealt with confidentiality and will be stored in a secure location for five years on the Massey University Albany Campus. After this time, it will be disposed of by an appropriate staff member from the School of Sport, Exercise and Nutrition.

Project Contacts

If you have any questions regarding this study, please do not hesitate to contact any of the following people for assistance:

Mr David Hsiao (student dietitian)

D.Hsiao@massey.ac.nz (021) 114 8776

Ms Imogen Nelson (student dietitian)

I.Nelson@massey.ac.nz (027) 614 4045

Prof Ajmol Ali

School of Sport, Exercise and Nutrition

A.Ali@massey.ac.nz (09) 213 6414

Prof Rozanne Kruger

School of Sport, Exercise and Nutrition

R.Kruger@massey.ac.nz (09) 213 6661

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W.Wood@massey.ac.nz (09) 213 6663

Ms Sophie Turner

School of Sport, Exercise and Nutrition

S.Turner1@massey.ac.nz (021) 208 2631

Dr Charles Diako

School of Food and Advanced Technology
C.Diako@massey.ac.nz (09) 213 663

Additional Contacts / Useful Links

If you have any concerns about your diet and / or your health during the project, or any allergic reactions to the products provided please contact your GP. You may also find the following contact information useful:

- Samaritans – 0800 726 666
- Lifeline NZ – 0800 543 354

Committee Approval Statement

This project has been reviewed and approved by the Massey University Human Ethics Committee: Southern A, Application 22/21. If you have any concerns about the conduct of this research, please contact Dr Negar Partow, Chair, Massey University Human Ethics Committee: Southern A, telephone 04 801 5799 x 63363, email humanethicsoutha@massey.ac.nz.