Association Between Meal Dietary Inflammatory Potential and Postprandial Sleepiness

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ASSOCIATION BETWEEN MEAL DIETARY INFLAMMATORY POTENTIAL AND POSTPRANDIAL SLEEPINESS

A Thesis

Presented to

The Faculty of the Department of Nutrition, Food Science, and Packaging

San José State University

In Partial Fulfillment

of the Requirement for the Degree

Master of Science

by

Samantha Beth Kalb

December 2021
The Designated Thesis Committee Approved the Thesis Titled

ASSOCIATION BETWEEN MEAL DIETARY INFLAMMATORY POTENTIAL AND POSTPRANDIAL SLEEPINESS

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ABSTRACT

ASSOCIATION BETWEEN MEAL DIETARY INFLAMMATORY POTENTIAL AND POSTPRANDIAL SLEEPINESS

by Samantha Beth Kalb

The amount and composition of food that is consumed are known to contribute to inflammation and may affect how we feel in the following hours. The aim of this research was to determine if the inflammatory potential of a single meal is associated with level of postprandial sleepiness. Participants (n = 70) recorded intake of one of their meals, then reported their degree of postprandial sleepiness (Stanford Sleepiness Scale), average activity level, average hours of nightly sleep, and daytime sleepiness (Epworth Sleepiness Scale). The Dietary Inflammatory Index (DII) of the meal was estimated by adjusting DII parameters by 26%, reflecting the amount of daily intake from one meal. While no correlation between the meal inflammatory score and the postprandial sleepiness was observed, there was an inverse relationship between postprandial sleepiness and average hours of nightly sleep ($\rho = -0.410, P = 0.001$) and average activity level ($\rho = -0.418, P < 0.001$). Additionally, daytime sleepiness was inversely correlated with average activity level ($\rho = -0.346, P = 0.004$). These findings suggest that lower levels of physical activity and nightly sleep may affect daytime and postprandial sleepiness in healthy adults.
ACKNOWLEDGEMENTS

I would first like to acknowledge my thesis committee; this manuscript was a team effort, and everyone brought their valuable expertise. I would like to give special thanks to Dr. John Gieng for guiding me through the entire research process and supporting me through the many hurdles. Your curiosity and tenacity are the backbone of this research project.

Thank you to the Circle of Friends for their support in this research and the resources made available through their generosity, and to the students who participated in this study, as well as the faculty who supported the recruitment process.

Thank you to my mom for your consistent support and willingness to read and edit my work, and to my dad, thank you for always encouraging me and providing your sound words of wisdom over these last few years, I would not have been able to do it without you both. To Amy, for teaching me it is not about the destination, but enjoying the journey. To Jerry Maletsky, thank you for always making time to support me with the data analysis, and for making me laugh.

Finally, to my cohort, Grace, Regina, Helen, and Elise, I am so grateful we had each other for constant support throughout this rigorous program.
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LIST OF ABBREVIATIONS

ASA-24 - The Automated Self-Administered 24-hour Dietary Assessment Tool
BMI - Body Mass Index
CRP - C-Reactive Protein
DII - Dietary Inflammatory Potential
EDIP - Empirical Dietary Inflammatory Pattern
EEG - Electroencephalogram
ESS - Epworth Sleepiness Scale
HFM - High Fat Meal
hsCRP - High Sensitivity C-reactive protein
IL-1 - Interleukin-1
IL-6 - Interleukin-6
IL-8 - Interleukin-8
kcals - Kilocalories
LPS - Lipopolysaccharide
Meal IQ - Meal Index of Dietary Quality
MMQI - Main Meal Quality Index
MSLT - Multiple Sleep Latency Test
SSS - Stanford Sleepiness Scale
TNF-α - Tumor Necrosis Factor
Chapter 1

Literature Review

Introduction

Constant focus and attention are often required of productive members of society. Yet, there are moments throughout the day when this is interrupted by feelings of fatigue and sleepiness. There are many factors that influence focus and attention such as sleep deprivation (Alhola & Polo-Kantola, 2007), physical activity (Pontifex et al., 2019), and inflammation (Esteban-Cornejo et al., 2016). One factor that people may be familiar with is the relationship between eating a “heavy” meal and the feeling of sleepiness afterwards. Colloquially, this is sometimes referred to as a “food coma.” Scientists refer to this phenomenon as postprandial somnolence. The physiological connection between eating and sleepiness is likely inflammation. Identifying the relationships among diet, inflammation, and sleepiness could empower dietary choices that would support a postprandial state in which productivity and stamina are present.

It is established that diet can influence inflammation by increasing cytokines and other inflammatory proteins depending on the composition of what is consumed (Monfort-Pires & Ferreira, 2016; Shivappa et al., 2017; Tabung et al., 2017). Furthermore, there is a direct relationship between inflammatory cytokines and an immune response (Krueger & Majde, 1990; Moldofsky et al., 1986). Some studies suggest that inflammation in response to eating (i.e., postprandial inflammation) may be part of the innate immune response (Lehrskov et al., 2018; Moldofsky et al., 1986). Additionally, there is a clear link between inflammation (and its associated cytokines) and fatigue or sleepiness (Jewett & Krueger, 2012; Payne et al., 1993; Roerink et al., 2017). Inflammatory cytokines are hypothesized to interact with the
central nervous system and affect sleepiness by signaling other immune cells or through the vagal nerve, a neuronal pathway between the brain and the major organs (Roerink et al., 2017). Based on this framework, it is likely that consuming foods that induce postprandial inflammation can lead to increased fatigue or sleepiness. Although many people report experiencing postprandial fatigue or sleepiness, the physiological mechanism explaining this experience is understudied (Chaturvedi et al., 2021; Roerink et al., 2017).

In this literature review, the connections among diet, inflammation, and sleepiness are discussed in more detail. Additionally, instruments used to assess dietary inflammation and sleepiness will be described.

**Diet Composition and Postprandial Inflammation**

Inflammation is one of the body’s responses to external and internal insults to the system (Castellon & Bogdanova, 2016; Emerson et al., 2017). When physical damage is detected by the immune system, cytokines (e.g., interleukins) are synthesized by specialized immune cells and sent to the site of insult to coordinate defense and recovery (Krueger & Majde, 1990). Therefore, specific cytokines are often used as biomarkers of inflammation in the body (Hébert et al., 2019; Herieka & Erridge, 2014; Jewett & Krueger, 2012). When certain cytokines are present in high concentrations or for prolonged periods, they are often associated with tissue damage and cardiometabolic risk (Castellon & Bogdanova, 2016).

Evidence details the relationship between the consumption of various dietary components and inflammation, which in the hours following a meal is referred to as postprandial inflammation (Emerson et al., 2017, 2019; Herieka & Erridge, 2014; Lehrskov et al., 2018; Monfort-Pires & Ferreira, 2016). For example, a typical Western diet (high in fat) has been shown to contribute to a rise in interleukin (IL)-6 (Blackburn et al., 2006) and IL-8 (Emerson...
et al., 2019). Other common biomarkers of systemic inflammation such as C-reactive protein (CRP) and tumor necrosis factor (TNF-α) (Emerson et al., 2019) have yielded mixed results in postprandial measures. A review of the timing and concentration of inflammatory biomarkers after a high fat meal (HFM) found that TNF-α and CRP were inconsistent in the postprandial period and tended to reach peak concentration 24 hours after ingestion (Emerson et al., 2017). Additional studies observed inconsistent results in postprandial TNF-α as well (Emerson et al., 2019; Milan et al., 2017). While it is still unclear which inflammatory biomarkers are best at predicting postprandial inflammation, there is agreement that their elevated concentration for prolonged periods is harmful (Calle & Andersen, 2019; Castellon & Bogdanova, 2016; Shivappa et al., 2017).

The composition of a meal influences the degree of the inflammatory response. For example, Monfort-Pires and Ferreira (2016) tested isocaloric meals with different fat and fiber content on postprandial inflammation over a 10-week crossover trial. Participants showed an 86% increase in the inflammatory biomarker IL-8 two hours after consuming the breakfast high in saturated fat (33.3 g), compared to the mono and polyunsaturated, and fiber-rich breakfast in which participants showed a 38% decrease in IL-8. The rise in IL-8 following the meal higher in saturated fat underscores how specific meal composition contributes to inflammation (Monfort-Pires & Ferreira, 2016; Raz et al., 2013).

High fat meals are used frequently in research to induce postprandial inflammation. The HFM’s utilized typically contain at least 30 g of fat and have been shown to increase concentrations of the inflammatory biomarker IL-6 in participants postprandially (Herieka & Erridge, 2014). One study measured the effects of an HFM on adults who differed by age and average activity level and found that the inflammatory biomarker IL-8 increased six hours
after eating the HFM (Emerson et al., 2019). When high amounts of triglycerides are present in the blood, such as after an HFM, they can damage endothelial tissue (van Oostrom et al., 2004). In response to this damage, immune cells, including leukocytes and monocytes, will be activated in an effort to protect the tissue from further damage, and subsequently inflammatory cytokines are released to assist in the protective reaction (Lundman et al., 2007; van Oostrom et al., 2004).

**Inflammation and Sleepiness**

Inflammation has been correlated with sleepiness as a biological immune response (Krueger et al., 1984; Lasselin et al., 2017; Moldofsky et al., 1986). Inflammation and the resulting sleepiness are experienced by the body while working to protect against harmful substances or biological invaders (Krueger & Majde, 1990). There are several hypothesized mechanisms by which inflammatory cytokines contribute to sleepiness. There is strong evidence supporting the relationship between IL-1 and sleepiness, initially discovered when rabbits showed increased sleepiness, specifically non-rapid eye movement sleep, after being infused with IL-1 (Krueger et al., 1983, 1984). Increased levels of IL-1 during fever were correlated with slow wave sleep in humans as well (Moldofsky et al., 1986). Additionally, IL-1 was recognized as a key mediator during the acute phase response to illness and said to promote sleep through interactions with the endocrine system, specifically growth hormone (Obal et al., 1992). However, reviews on the mediating effects of IL-1 on sleep note that the correlation between IL-1 and growth hormone is not direct (Payne et al., 1993).

Inducing inflammation using proinflammatory compounds increases sleepiness in humans. To produce an inflammatory response, participants that were observed for changes in motivation were injected with lipopolysaccharide (LPS), the principal endotoxin of gram-
negative bacteria (Lasselin et al., 2017). The LPS injection activated the immune system and caused the production of proinflammatory cytokines. Lasselin et al. (2017) then measured a cluster of behavioral and neurological effects termed, “sickness responses,” including sleepiness, which increased 3 hours after the LPS injection compared to those who received saline. Even though the inflammation was not induced by dietary components the findings support the association between inflammation and sleepiness.

**Postprandial Sleepiness**

The concept of postprandial sleepiness is commonly known as a “food coma.” The connection between this sleepiness feeling and the preceding meal is actively being researched. Postprandial sleepiness has been associated with the intake of a heavy meal (> 900 kcal) (Reyner et al., 2011) which may contribute to sleepiness through hormone signaling. Chaturvedi et al. (2021) and Wells et al. (1997) hypothesized that postprandial sleepiness is influenced by the satiety hormone cholecystokinin activating areas of the brain associated with sleep. Tryptophan, an amino acid, is also hypothesized to contribute to sleep (Chaturvedi et al., 2021). As insulin is taken into the cells following a meal, so are amino acids. Tryptophan is a precursor to serotonin which can be converted to melatonin, the hormone responsible for the sleep-wake cycle (Chaturvedi et al., 2021).

Postprandial sleepiness has been associated with a decline in work performance (Reyner et al., 2011). A study measuring the effects of meal size on simulated driving tasks utilized 12 sleep restricted male participants (Reyner et al., 2011). The men were given both a lighter meal (305 kcal, 7.7 g fat) and a heavier meal (922 kcal, 35.7 g fat) in the two phases of the experiment which were one week apart. Lane deviations and eye movement (representing sleepiness) were measured during the driving tasks following each meal (Reyner et al.,
Eye movements such as eyes closing, or rolling upward were considered sleepiness-related incidents, as they indicated dozing off. Incidents that were non-sleep related were determined if drivers were distracted and chose to look elsewhere. When the two different meals were given to the sleep restricted participants, consumption of the high-kcal meal generated an average of about 4 lane deviations in the driving simulation, 37% higher than the average of 3 lane deviations when participants consumed the lighter calorie meal (Reyner et al., 2011). Sleepiness measured after the high-kcal meal also trended higher than sleepiness measured after the lighter kcal meal. Even though the participants were already sleep deprived, the increased lane deviations following the heavy meal versus the lighter meal show the effects of postprandial sleepiness on work performance.

The relevance of postprandial sleepiness to learning and productivity was highlighted in the observational study by Chaturvedi et al. (2021). The study measured awareness of postprandial sleepiness by surveying 330 students and 40 lecturers (Chaturvedi et al., 2021). They identified factors that students believed contributed to postprandial sleepiness. Lecturers were asked to describe differences in responsiveness and body language of students during post-lunch lectures. The students completed subjective evaluations of awareness and lethargy following an afternoon meal. The students agreed that drowsiness, lethargy, and indigestion may result from a heavy meal thus affecting their performance in class. Lecturers agreed that students are both more disruptive (62.5%), and less responsive and participative (75%) in post-lunch lectures (Chaturvedi et al., 2021).

Sleepiness can be measured subjectively and objectively. Wells et al. (1998) correlated both measures in a study to determine influences on postprandial sleepiness. This experiment was composed of an equal number of men and women. The researchers utilized objective
measures of brain waves, blood oxygen levels, heart rate, breath, and leg and eye movement in addition to subjective measures, such as surveys, to measure postprandial sleepiness. Isocaloric meals were used with varied compositions of fat and carbohydrates. Regardless of meal composition, participants fell asleep more quickly (1.5 hours) after meal consumption compared to before, verifying the relationship between meal consumption and sleepiness (Wells et al., 1998). The post-meal experience of sleepiness, while familiar, is still being researched to better understand the specific biological and physiological mechanisms. To date, there is supportive evidence associating dietary intake with the experience of sleepiness.

**Postprandial Inflammation and Sleepiness**

If inflammation is a major factor in postprandial sleepiness, meals or dietary patterns that are known to cause inflammation can also be said to contribute to sleepiness. Being sleepy during the day may negatively impact energy level, productivity, and stamina.

Only one study to date has evaluated these connections. Lehrskov et al. (2018) measured how a meal contributed to postprandial inflammation and postprandial sleepiness. Inflammation was induced in lean and obese men by feeding them an HFM (57% fat, 88.9 g), then postprandial sleepiness was measured using the Stanford Sleepiness Scale (SSS) (Lehrskov et al., 2018). There was an increase in sleepiness at 1.5 hours after consuming the meal in both groups of men. To test the role of IL-1, an inflammatory molecule, in postprandial sleepiness, men were either given saline or the IL-1 blocker IL-1Ra before the meal. Both groups were sleepier after the meal, but the men given saline were sleepier at 1.5 hours after the meal compared to the men given the inflammatory inhibitor (Lehrskov et al., 2018). The use of the inflammatory blocking injection prior to the meal compared to saline showed that inflammation was a key contributing factor to participants’ level of postprandial
sleepiness. Research is limited on the relationship between postprandial inflammation and sleepiness, leaving room for future exploration.

**Assessment of a Single Meal**

Assessing the quality of a single meal is not typical practice when considering the larger picture of health. Meal assessment is typically performed to determine if recommended needs are being met in individual populations (Sabinsky et al., 2012). If a “food coma” is directly related to the level of postprandial inflammation, it would be important to measure the inflammatory potential of the various food components in a meal. One way to directly assess postprandial inflammation is by measuring the level of inflammatory cytokines, like IL-1 in the blood, in response to a meal challenge (Tabung et al., 2017). This would provide insight into direct connections between foods consumed and inflammation. The inflammatory potential of the diet can also be estimated from its composition and consumption level. The metric developed for this analysis is called the Dietary Inflammatory Index (DII) (Shivappa et al., 2014). However, the DII was designed to estimate the inflammatory potential of a usual diet, not for a single meal.

To date, there are only a few instruments available to measure meal quality (Gorgulho et al., 2018; Sabinsky et al., 2012), but no validated tool exists to measure the inflammatory potential of a single meal. Therefore, adapting the DII for a meal could be useful. Ideally, a combination of these tools would be able to measure both the quality and inflammatory potential of a single meal, predicting its contribution to postprandial inflammation and thus postprandial sleepiness.
**Dietary Inflammatory Index**

The DII is a tool used to assess the inflammatory potential of the diet (Shivappa et al., 2014). Consumption of an inflammatory diet can contribute to chronic inflammation, a state in which the body is constantly trying to repair itself which can be very damaging to the body (Castellon & Bogdanova, 2016; Shivappa et al., 2017). Mitigating inflammation with an anti-inflammatory diet is a valuable tool and the DII makes this information available. The DII was designed by reviewing the literature on worldwide dietary consumption and identifying which dietary components contributed to the pro- or anti-inflammatory responses of the body (Shivappa et al., 2014). Pro-inflammatory responses are recognized by the presence of inflammatory biomarkers such as IL-1β, IL-4, IL-6, IL-10, TNF-α, and CRP (Shivappa et al., 2014). A total of 45 food parameters significant to the inflammatory or anti-inflammatory state were identified, after individual dietary data is collected the number of food parameters present can then be determined. Each food parameter is given a score based on its inflammatory status, and then the parameters are summed to produce a DII score (Shivappa et al., 2014). When some of the 45 parameters are not available, a subset is summed to represent the diet’s inflammatory potential. Positive effect scores represent more inflammatory food components, and negative effect scores reflect more anti-inflammatory food components (Shivappa et al., 2014).

In a comparison study, Tabung et al. (2017) tested the ability of the DII to predict the amount of circulating inflammatory biomarkers in adults. In the comparison, two methods were assessed; one used a score derived from food groups in the food frequency questionnaire, the Empirical Dietary Inflammatory Pattern (EDIP), the second was the literature derived DII. A higher score reflected a more inflammatory diet. Both indices were
shown to have a positive association between higher scores and the increased presence of inflammatory biomarkers, but the association between the EDIP and inflammatory markers had a higher magnitude than with the DII (Tabung et al., 2017). Notably, the DII has not been validated for assessing the inflammatory potential of a single meal. The DII is generally applied to individual dietary data collected over an entire day or longer. It would be valuable to know the inflammatory effect of a single meal because it may contribute to postprandial sleepiness with some immediacy.

**Measures of Daytime Sleepiness**

There are multiple methods for assessing the level of sleepiness. The following methods include both subjective and objective, quantitative measures, collected by participant surveys and multi-parametric tests.

*Stanford Sleepiness Scale*

The SSS is a subjective measure of current sleepiness, assessed using a survey scale. The scale from 1 to 7 varies from 1 = Feeling active, vital, alert, or wide awake, to 7 = No longer fighting sleep, sleep onset soon; or having dreamlike thoughts (Hoddes et al., 1973). The SSS was utilized by Wells et al. (1998) to measure subjective level of sleepiness after meals in tandem with objective measures such as the electroencephalogram (EEG), and the Multiple Sleep Latency Test (MSLT). The SSS produced results aligned with the EEG while the MSLT was able to detect sleepiness earlier compared to subjective measures (Wells et al., 1998). The SSS is a good measure of changes in sleepiness before and after an intervention, or at specific time intervals. The versatility of the SSS makes it ideal for both in-person and online applications.
**Epworth Sleepiness Scale**

The Epworth Sleepiness Scale (ESS) is another subjective measure of sleepiness used to assess the level of daytime sleepiness by asking participants how likely they are to doze off or fall asleep during common day-to-day activities (Johns, 1991). There are eight situational instances that can be ranked from 0 to 3. A score of 0 = would never doze, 1 = slight chance of dozing, 2 = moderate chance of dozing, and 3 = high chance of dozing. The situations range from sitting and reading or watching TV, lying down to rest in the afternoon when circumstances permit, to sitting quietly after a lunch without alcohol (Johns, 1991). The ESS has been used to measure daytime sleepiness in studies that also measured components of diet quality, making it useful to assess the general relationship between diet and daytime sleepiness (de Araújo et al., 2015; Farías et al., 2020). The ESS does not capture postprandial sleepiness specifically, but it is both easy to administer and applicable in capturing the level of daytime sleepiness.

**Multiple Sleep Latency Test**

The MSLT is an objective measure of sleepiness and considered the gold standard in determining sleepiness (Carskadon & Dement, 1982). It utilizes polysomnography; a multi-parametric test that measures brain waves, blood oxygen levels, heart rate, breath, and leg and eye movement. The MSLT measures the time it takes for a participant to fall asleep. To measure sleep latency, participants are usually situated in a nap-like setting and observed for sleep onset throughout the day while connected to electrodes (Carskadon & Dement, 1982). A participant that is more tired will have a shorter sleep latency, in other words, they will fall asleep more quickly. A participant that takes longer to fall asleep will have a longer sleep latency. Strengths of the MSLT include its multiple test design and quantitative and objective
measures of sleep latency that are collected throughout the day. Like the ESS, the MSLT is a good tool for measuring daytime sleepiness (Johns, 1991; Wells et al., 1998). This is important when considering the difference between pre- and postprandial sleepiness to capture the effect of a single meal. The MSLT must be conducted in person, it is time and labor-intensive, and requires special equipment, while the SSS and ESS provide a simple measurement of sleepiness quickly and with minimal labor.

**Conclusion**

Diets high in inflammatory foods including total fat or saturated fat have been associated with increased inflammatory biomarkers. Inflammation may cause sleepiness. Results of controlled feeding trials suggest that meals high in saturated fat and energy are associated with postprandial sleepiness. However, it is unclear if a meal composed of inflammatory foods increases postprandial sleepiness. Studies have shown that food affects sleepiness throughout 1.5 to 6 hours postprandial. The immediate effect of one meal on day-to-day performance and capabilities is unclear. Daily activities such as work, school, and social interaction are negatively affected by our level of sleepiness. By expanding the research on the connections among diet, inflammation, and sleepiness, more informed dietary choices can be made to support daily goals as well as long-term health.
CHAPTER 2

JOURNAL ARTICLE

ASSOCIATION BETWEEN MEAL DIETARY INFLAMMATORY POTENTIAL AND POSTPRANDIAL SLEEPINESS
ABSTRACT

Objective: To determine the association between the dietary inflammatory potential of a meal and postprandial sleepiness in healthy adults.

Methods: Dietary intake data from a meal were collected through the Automated Self-Administered 24-hour Dietary Assessment Tool and used to calculate a meal-adjusted Dietary Inflammatory Index (DII). Daytime and postprandial sleepiness, average hours of nightly sleep, and average activity level were assessed using an online survey.

Results: The meal-adjusted DII was not correlated to any measure of sleepiness (n = 70). However, sleepiness after a meal (ρ = -0.418, P < 0.001) and daytime sleepiness (ρ = -0.346, P = 0.004) were inversely correlated with average activity level. Average hours of nightly sleep were also inversely correlated with sleepiness after a meal (ρ = -0.410, P = 0.001).

Conclusions and Implications: No association was detected between meal-adjusted DII and postprandial sleepiness. It is likely the meal-adjusted DII was not sensitive enough to measure the inflammatory potential of a meal. Experimentally inducing inflammation with a challenge meal may be necessary to evaluate this relationship.

Key Words: Postprandial, Inflammation, Dietary Inflammatory Index, Sleepiness
INTRODUCTION

The postprandial state is the period following the consumption of food. Feeling sleepy after a meal, referred to as postprandial sleepiness, could be inhibiting performance.¹ Sleepiness contributes to impaired cognition, increased work-related, automobile accidents, and decreased productivity.¹–⁴ The relationship between dietary consumption and postprandial sleepiness is not completely understood but likely linked by inflammation.⁵

Sleep is said to be a physiological process that is regulated by immune substances (e.g., interleukins) interacting with the central nervous system.⁶,⁷ Interleukin (IL)-1, an inflammatory cytokine used to assess postprandial inflammation, also contributes to the onset of slow wave sleep, the deepest phase of non-rapid eye movement sleep.⁸,⁹ Postprandial inflammation is most commonly assessed by plasma levels of IL-6.⁸,¹⁰,¹¹ In addition to IL-6, the inflammatory cytokines IL-1 and TNF-α are used to assess postprandial inflammation and have been characterized as sleep regulating substances.⁷,⁹ Specifically, meals containing a high percentage of fat, or a large number of kilocalories (kcal) have been shown to contribute to postprandial inflammation.⁵,¹⁰,¹²,¹³

To assess the connection between diet and inflammation, a method to assess the dietary inflammatory potential of the diet was developed and updated in 2014, called the Dietary Inflammatory Index (DII).¹⁴ When measuring inflammatory potential of the diet, the DII utilizes specific intake levels of up to 45 dietary components to calculate how pro or anti-inflammatory the diet is.¹⁴ This index has been used extensively to assess overall dietary inflammatory potential.¹⁵–¹⁷ However, the DII has not been connected to postprandial sleepiness.
To better understand the relationship between dietary composition, inflammation and fatigue, the present study aimed to determine if there is an association between the dietary inflammatory potential of a meal and the level of postprandial sleepiness in healthy adult subjects. It was hypothesized that there is a positive correlation between a meal’s DII score and level of postprandial sleepiness.

METHODS

Study Design

This correlational study was conducted online during the months of January-August 2021. Non-probability convenience sampling was utilized to recruit a sample size of at least 105 participants based on a Power Analysis of medium strength ($r = 0.3$) for the correlation of two variables using the GPower software, with an additional 25% to account for dropouts.¹⁸

Participants

Participants were recruited online through social media outlets: Facebook, LinkedIn, Instagram, as well as the global recruitment websites FindParticipants and SurveyCircle. Emails of interested participants were gathered via Google Form sign up which was distributed online through the recruitment sites and social media mentioned previously.

Inclusion criteria were adults 18 years or older with no serious medical conditions, and able to read and understand English. Participants were excluded if they had been diagnosed with a medical condition such as diabetes, Crohn’s disease, celiac disease, irritable bowel syndrome, eating disorders, cancer, any other thyroid, kidney, or digestive diseases (self-reported). Additionally, participants who were pregnant or breastfeeding were excluded from the study.
Measures of Sleepiness

The Stanford Sleepiness Scale (SSS) was utilized to quantify the level of postprandial sleepiness using a 7-step scale of statements corresponding to increasing levels of sleepiness. A score of 1 = feeling active and wide awake, 2 = functioning at high levels, but not peak, 3 = awake but relaxed, 4 = foggy, somewhat let down, 5 = losing interest in staying awake, 6 = fighting sleep, prefer to lie down, 7 = no longer fighting sleep, having dreamlike thoughts. The SSS has been utilized in tandem with objective measures of sleepiness and it can be used at any time of day, making it ideal for the online survey setting.19,20

To measure general daytime sleepiness the Epworth Sleepiness Scale (ESS) was utilized to measure participant’s likelihood of dozing in eight different scenarios using a scale from 0 to 3 (0 = would never doze, 1 = slight chance of dozing, 2 = moderate chance of dozing, 3 = high chance of dozing).21

A web-based survey (Qualtrics, Provo, Utah) was administered to collect data on age, gender, ethnicity, education, average activity level, average hours of nightly sleep, and measures of sleepiness (SSS and ESS).

Dietary Recalls

Dietary intake was collected using the multi-pass, Automated Self-Administered 24-hour Dietary Assessment Tool (ASA-24), version (2020), developed by the National Cancer Institute, Bethesda, MD. The ASA-24 is an accessible online tool, administered by the participant. The ASA-24 is validated to collect 24-hour dietary recalls. The standardized script collects food type, preparation method, and quantity of each food and beverage consumed. Participants were instructed to eat their usual lunch or dinner meal and complete the survey 1–2 hours after. Following the survey, participants were prompted to recall their
dietary intake for the current day starting at 12 AM until they completed the survey. Time of meal intake was not controlled to increase generalizability and improve response rate. For example, if participants completed the survey at 3 PM, they would have logged all intake that day from 12 AM up until 3 PM. Output data from ASA-24 was grouped by mealtime and the nutrient and energy composition of each meal was calculated by the United States Department of Agriculture’s nutrient database.

**Defining a Meal**

To define a meal occasion, food items that were consumed prior to the survey were assessed. Based on our evaluation of food items, meals were generally defined as multiple food items consumed in the same mealtime, or a stand-alone item that represented a meal, such as pizza. In the case of a single or few food items that were less substantial, such as an apple and/or crackers, data was excluded. The meal occasion closest to the time that the survey was completed was used to calculate the meal-adjusted DII. In the case where multiple meals were recorded, the meal closest to one hour prior to the survey was chosen.

**Physical Activity**

Physical activity was measured using the five physical activity/stress factors established to determine total daily energy expenditure for the Harris-Benedict equation. Participants were asked what their average level of activity was, 1 = Sedentary: little or no exercise, desk job, 2 = Lightly active: little exercise/sports 1–3 days/week, 3 = Moderately active: moderate exercise/sports 6–7 days/week, 4 = Very active: hard exercise every day, or exercising 2x day, or 5 = Extra active: hard exercise 2 or more times per day, or training for a marathon, triathlon, etc.
Nightly Sleep

To measure participants’ nightly sleep, we asked how many hours of sleep they average per night. The three possible choices were 1 = 6 hours or less, 2 = 7–8 hours, or 3 = 8+ hours.

Data Analysis

An adjusted DII was used to quantify the inflammatory potential of a meal. The DII is a validated tool based on a global pool of 45 food parameters determined by an extensive literature review of diverse populations and used extensively in research to understand the effects of diet on inflammation.\textsuperscript{14,17,23} We utilized 28 of the food parameters to calculate meal-adjusted DII scores. Each food parameter was standardized to a world database using the mean and standard deviation for the average daily intake of each dietary component. The parameters are then summed to produce the meal-adjusted DII score. Food parameters not included in our assessment were eugenol, garlic, ginger, onion, saffron, trans fat, turmeric, green/black tea, flavan-3-ol, flavones, flavonols, flavonones, anthocyanidins, isoflavones, pepper, thyme/oregano, and rosemary.

To evaluate one meal, the mean and standard deviation for each food parameter were adjusted by 26\% to reflect the typical meal size, based on kcal, of one North American meal.\textsuperscript{24} The z-score was calculated by subtracting the adjusted mean from the actual intake and dividing this by the adjusted standard deviation. To alleviate the effects of right skewness, z-scores were converted to percentile values and centered on zero by doubling the percentile and subtracting one (-1). These values were then multiplied by the literature derived inflammatory effect score for each food parameter, and the 28 parameters were summed to establish the meal-adjusted DII score for each participant. Based on the original
DII parameters, negative scores reflect an anti-inflammatory diet, and positive scores reflect a more pro-inflammatory diet.

All data were analyzed using IBM SPSS Statistics version 27.0 for Mac (IBM Corp., Armonk, NY, USA). Data for each variable was tested for normality using the Shapiro-Wilk tests. Conditions were not met to use parametric tests; therefore, Spearman’s Rho (rank order) analysis was used to assess unadjusted correlations between variables. Additionally, Bonferroni’s correction was used to account for multiple comparisons and statistical significance was set at $P \leq 0.004$. To account for confounding variables on measures of sleepiness such as average activity level, average hours of sleep per night, and the time between meal and survey, nonparametric Spearman’s partial correlation analyses was performed. Additional partial correlations were conducted to control for effects on sleepiness by intakes of carbohydrates, caffeine, fat, saturated fat, and total calories of the meal.

The San José State University Institutional Review Board approved the study protocol (#21050) and all participants agreed to participate in the study via informed online consent notice prior to completing the survey and dietary recall.

RESULTS

Of the 255 subjects recruited for this study, 70 met all inclusion and exclusion criteria and completed both the survey and dietary intake record (completion rate of 27%). There were 185 participants who did not complete all steps of the study or whose data were not within a relevant time frame to be considered in the analyses. Most participants were female (76%) and had obtained a bachelor’s degree or higher (61%) (Table 1).
### Table 1. Mean Sleepiness, Physical Activity, and Nightly Sleep Scores in Healthy Adult Participants

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>SSS ± SD</th>
<th>ESS ± SD</th>
<th>PA Score ± SD</th>
<th>Avg Sleep Score ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>All</strong></td>
<td>70</td>
<td>2.6 ± 1.2</td>
<td>12.8 ± 3.4</td>
<td>2.4 ± .81</td>
<td>1.9 ± 0.62</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18–49</td>
<td>58</td>
<td>3.0 ± 1.4</td>
<td>12.6 ± 2.9</td>
<td>2.4 ± 0.67</td>
<td>1.8 ± 0.56</td>
</tr>
<tr>
<td>50+</td>
<td>12</td>
<td>1.9 ± 0.99</td>
<td>12.7 ± 4.7</td>
<td>2.6 ± 0.99</td>
<td>2.3 ± 0.62</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>15</td>
<td>2.4 ± 0.91</td>
<td>11.8 ± 4.4</td>
<td>2.5 ± 0.74</td>
<td>2.2 ± 0.56</td>
</tr>
<tr>
<td>Female</td>
<td>53</td>
<td>2.7 ± 1.2</td>
<td>13.2 ± 3.0</td>
<td>2.4 ± 0.83</td>
<td>1.9 ± 0.64</td>
</tr>
<tr>
<td><strong>Non-Conforming</strong></td>
<td>2</td>
<td>1.5 ± 0.71</td>
<td>10.0 ± 0</td>
<td>3.0 ± 0</td>
<td>2.0 ± 0</td>
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<td><strong>Education</strong></td>
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<td></td>
</tr>
<tr>
<td>Up to AA</td>
<td>27</td>
<td>3.1 ± 1.2</td>
<td>14.5 ± 2.7</td>
<td>2.0 ± 0.80</td>
<td>1.7 ± 0.70</td>
</tr>
<tr>
<td>BA and Above</td>
<td>43</td>
<td>2.6 ± 1.3</td>
<td>12.4 ± 2.9</td>
<td>2.6 ± 0.90</td>
<td>1.9 ± 0.54</td>
</tr>
</tbody>
</table>

*Note. Scores represent mean ± standard deviation, SSS, Stanford Sleepiness Scale; ESS, Epworth Sleepiness Score; PA, average physical activity level; Avg Sleep, average hours of nightly sleep; AA, associate’s degree; BA, bachelor’s degree; SSS score ranges from 1 to 7; 1, feeling active, vital, alert; 7, no longer fighting sleep, sleep onset soon; ESS score, sum of eight instances ranked 0–3, 3 being very likely to fall asleep; PA, average level of activity: 1, sedentary; 2, lightly active; 3, moderately active; 4, very active; 5, extra active; Avg Sleep, 1, <6 hours; 2, 7–8 hours; 3, >8 hours.*

The majority of participants (61%, n = 43) reported getting 7–8 hours of sleep per night, defined as a score of 2, followed by 21% (n = 15) reporting less than 6 hours per night (score = 1), and 17% (n = 12) reporting 8+ hours per night (score = 3).

Most participants (61%, n = 43) completed the survey within 0–3 hours of eating a meal, data was also collected for participants (27%, n = 19) who completed the survey 3–6 hours after consuming a meal. When comparing the two groups there was no difference in postprandial sleepiness detected between the two different time frames (data not shown) therefore, the time frame of 0–6 hours was chosen for increased inclusion of participants in the study.

Participants had an average meal-adjusted DII score of -0.57 ± 2.3, the average kcal per meal was 672 ± 425, and average fat was 28 ± 21 g (Table 2).
Table 2. Mean Dietary Inflammatory Index Scores and Mean Nutrient Components in a Single Meal

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Meal DII</th>
<th>kcal</th>
<th>Carbohydrate</th>
<th>Fat</th>
<th>Protein</th>
<th>Saturated Fat</th>
<th>Caffeine</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>All</strong></td>
<td>70</td>
<td>-0.57 ± 2.3</td>
<td>672 ± 425</td>
<td>72 ± 50</td>
<td>28 ± 21</td>
<td>33 ± 24</td>
<td>9 ± 7</td>
<td>16 ± 44</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18–49</td>
<td>58</td>
<td>-0.76 ± 1.9</td>
<td>662 ± 405</td>
<td>70 ± 39</td>
<td>28 ± 23</td>
<td>30 ± 23</td>
<td>9 ± 8</td>
<td>17 ± 30</td>
</tr>
<tr>
<td>50+</td>
<td>12</td>
<td>1.19 ± 1.7</td>
<td>317 ± 215</td>
<td>32 ± 24</td>
<td>12 ± 11</td>
<td>31 ± 21</td>
<td>5 ± 5</td>
<td>40 ± 86</td>
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<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>15</td>
<td>-1.86 ± 2.1</td>
<td>915 ± 467</td>
<td>95 ± 54</td>
<td>38 ± 25</td>
<td>36 ± 28</td>
<td>11 ± 9</td>
<td>9 ± 27</td>
</tr>
<tr>
<td>Female</td>
<td>53</td>
<td>-0.15 ± 2.2</td>
<td>608 ± 399</td>
<td>66 ± 49</td>
<td>25 ± 20</td>
<td>32 ± 22</td>
<td>8 ± 7</td>
<td>18 ± 48</td>
</tr>
<tr>
<td>Non-Conforming</td>
<td>2</td>
<td>-2.2 ± 0.31</td>
<td>595 ± 94</td>
<td>69 ± 38</td>
<td>21 ± 4</td>
<td>38 ± 47</td>
<td>5 ± 0.8</td>
<td>6 ± 8</td>
</tr>
<tr>
<td><strong>Education</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Up to AA</td>
<td>27</td>
<td>-1.28 ± 2.2</td>
<td>910 ± 292</td>
<td>103 ± 38</td>
<td>36 ± 24</td>
<td>29 ± 22</td>
<td>11 ± 9</td>
<td>8 ± 15</td>
</tr>
<tr>
<td>BA and Above</td>
<td>43</td>
<td>-0.60 ± 2.2</td>
<td>664 ± 343</td>
<td>68 ± 46</td>
<td>30 ± 19</td>
<td>36 ± 25</td>
<td>10 ± 7</td>
<td>27 ± 58</td>
</tr>
</tbody>
</table>

*Note.* Scores represent mean ± standard deviation, Meal DII, Meal Dietary Inflammatory Index; AA, associate’s degree; BA, bachelor’s degree. Dietary Inflammatory Index was multiplied by 0.26 (26%) to account for average meal size in North America.24

Meal-adjusted DII and postprandial sleepiness were not correlated. Even after controlling for daytime sleepiness, average activity level, gender, and time between meal and survey, no correlations were found between meal-adjusted DII and participant’s level of postprandial sleepiness (SSS). Correlations were found between the SSS and average hours of nightly sleep, as well as average activity level and both daytime sleepiness (ESS) and postprandial sleepiness (SSS).

Spearman’s rho was used to assess the correlations between meal-adjusted DII and the level of postprandial sleepiness, measured by the SSS (Table 3).

Partial correlations were also performed to test the correlations found between postprandial sleepiness (SSS) and average activity level, as well as average activity level and both ESS and SSS. Participants’ average hours of nightly sleep was inversely correlated with their level of postprandial sleepiness (SSS) \( (\rho = -0.410, P = 0.001) \) (Table 3). After controlling for average activity level and daytime sleepiness the correlation remained \( (\rho = -\)
0.352, \( P = 0.004 \)). Average activity level and daytime sleepiness (ESS) were inversely correlated (\( \rho = -0.346, \ P = 0.004 \)) (Table 3). However, the correlation did not remain after controlling for average hours of nightly sleep. Average activity level was also inversely correlated with postprandial sleepiness (SSS) (\( \rho = -0.418, \ P < 0.001 \)) (Table 3) and remained correlated after controlling for average hours of nightly sleep (\( \rho = -0.363, \ P = 0.003 \)).

<table>
<thead>
<tr>
<th></th>
<th>Stanford Sleepiness Scale</th>
<th>Epworth Sleepiness Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>rho</td>
<td>p-value</td>
</tr>
<tr>
<td>Kcal</td>
<td>0.156</td>
<td>0.201</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>0.125</td>
<td>0.311</td>
</tr>
<tr>
<td>Fat</td>
<td>0.159</td>
<td>0.193</td>
</tr>
<tr>
<td>Protein</td>
<td>0.034</td>
<td>0.785</td>
</tr>
<tr>
<td>Saturated Fat</td>
<td>0.126</td>
<td>0.301</td>
</tr>
<tr>
<td>Caffeine</td>
<td>-0.126</td>
<td>0.301</td>
</tr>
<tr>
<td>Average Sleep</td>
<td>-0.410</td>
<td><strong>0.001</strong></td>
</tr>
<tr>
<td>Physical Activity</td>
<td>-0.418</td>
<td><strong>&lt;0.001</strong></td>
</tr>
</tbody>
</table>

**Note.** Bold\* indicates statistical significance \( P \leq 0.004 \); Spearman’s rho correlations were performed, and statistical significance was set accounting for multiplicity using Bonferroni’s correction. Rho and p-values reflect correlations prior to controls.

**DISCUSSION**

The aim of this study was to determine if there was an association between a meal’s dietary inflammatory potential and level of postprandial sleepiness. Using a meal-adjusted DII score and the SSS on self-reported data, we were not able to reject the null hypothesis that there was no correlation between these variables. However, secondary measures, average activity level and average hours of nightly sleep were correlated with sleepiness (both ESS and SSS) in our study population.
Contrary to our results, previous studies have shown a correlation between meal composition, postprandial sleepiness, and sleep quality, validating the relationship between a controlled meal and postprandial sleepiness. The meals most associated with postprandial sleepiness are high in fat and have also been used to invoke inflammation. In a double-blind crossover study assessing strategies to combat postprandial inflammation, the consumption of a large meal (1,404 kcal, 88.9 g fat) was associated with postprandial sleepiness measured as level 6 on the SSS. In comparison, the present study had an average meal size of 672 kcal, and 28 g of fat, followed by a postprandial sleepiness level of only 2 on the SSS. Additionally, a previous study that compared dietary inflammatory indices and their ability to predict plasma levels of inflammatory biomarkers, observed increased biomarkers with DII scores ranging from 3.72-6.55. The present study measured an average meal-adjusted DII score of –0.53, representing an anti-inflammatory meal.

Other markers of inflammation such as tumor necrosis factor (TNF)-α and interleukin (IL)-8 have been observed following the consumption of specific dietary components such as saturated fat in larger quantities within a meal (at least 30 g, or 63% of meal calories). When a traditional Brazilian breakfast (33.3 g saturated fat, 16.9 g mono and polyunsaturated fat) was tested against a modified breakfast (11.3 g saturated fat, and 40.3 g mono and polyunsaturated fat), an increase in the inflammatory biomarker IL-8 was observed following the higher fat, traditional Brazilian breakfast.

The studies that were aligned with our hypothesis typically used a challenge meal of varying composition known to induce inflammation and sleepiness. In the present study, a challenge meal was not utilized. Instead, participants were instructed to report only what they ate, and a meal-adjusted DII score was calculated to assess its inflammatory potential.
Overall, the meal-adjusted DII was negative, meaning that participants’ meals were anti-inflammatory. This likely explains why a correlation between the inflammatory potential of participants’ meals and sleepiness did not exist in the present study.

Other observational studies that did not control intake, saw similar results to ours. Chilean healthcare workers were observed for levels of daytime sleepiness (measured by the ESS). The diet of the night shift workers was lower in carbohydrates and higher in protein compared to the day shift, but they did not observe any correlations between diet and daytime sleepiness. A previous study found that a solid meal contributed to prolonged sleepiness compared to a liquid meal, but the composition of the meal did not affect the latency of participants’ sleep in the postprandial state.

Non-meal-specific variables (average hours of nightly sleep and average activity level) were correlated with measures of sleepiness (ESS and SSS). Participants reporting higher subjective sleepiness (ESS and SSS) when they completed the survey also reported having lower levels of average physical activity. This is consistent with studies in Brazilian youth, where higher daytime sleepiness was correlated with lower activity level. Other studies also showed that lack of sleep is associated with a decline in physical activity due to factors such as motivation and change in cognition following sleep deprivation.

Participants with a higher level of subjective sleepiness (SSS) when filling out the survey after a meal also reported less hours of average nightly sleep. Other studies have observed similar patterns where levels of sleepiness were increased after sleep deprivation compared to after sleep recovery according to the subjective sleepiness measure, the SSS. In the context of productivity, this is important because sleepiness may also be an indicator of declined performance at work. In the present study it is unclear if participants were sleep
deprived. Nonetheless, it is not surprising that sleepiness can reflect below-average hours of nightly sleep.

This study had several limitations. First, the use of the DII to assess the inflammatory potential of a single meal was developed as part of the present study and has not been validated. Second, there was potential for user errors when completing the survey or recording dietary intake. Lastly, there was inconsistency in the timing between the meal and survey, and a challenge meal known to induce inflammation was not used. A validation study should be conducted to determine if this meal-adjusted DII reflects the inflammatory potential of a meal (e.g., associated with IL-6 or IL-1). Reported meals of participants were overall anti-inflammatory and likely is one reason no correlation with sleepiness was observed. Future studies should use challenge meals known to induce inflammation.

**IMPLICATIONS FOR RESEARCH AND PRACTICE**

No correlation between meal-adjusted DII and postprandial sleepiness was discovered. However, the current study does provide grounds for future research validating and applying the DII to a single meal. The relationship between diet and inflammation is known, but the effects of an inflammatory meal remain to be utilized in measures of sleepiness. Using high-fat meals to invoke an inflammatory response is widespread in research and supports the inquiry of how one meal impacts objective and subjective changes in the postprandial state. This study contributes to the research on sleepiness and its relationship to physical activity, and nightly sleep patterns. To better understand the relationship between dietary inflammatory potential of a single meal and how it can impact postprandial sleepiness, a challenge meal known to cause inflammation could be used in larger samples where postprandial sleepiness is measured in tandem to postprandial inflammation.
REFERENCES


Chapter 3

Summary and Recommendations

Summary

The evidence of long-term inflammation having detrimental effects on health is growing. We know the diet is one tool that can be used to mitigate inflammation, but the time in which it takes effect is still being understood. Additional research exploring the relationship between the inflammatory potential of a meal and its effects on postprandial performance could empower daily dietary choices.

In the present study, no correlation was found between meal-adjusted DII and postprandial sleepiness. Our study was able to demonstrate that levels of daytime and postprandial sleepiness can coincide with other pillars of health. Our results are consistent with the literature showing that decreased average hours of nightly sleep contributes to feeling more tired during the day (Carskadon & Dement, 1981; Pejovic et al., 2013). Additionally, the negative relationship between sleepiness and physical activity were in alignment with previous studies which found a correlation between increased daytime sleepiness and decreased activity level (Baron & Culnan, 2019; Chen et al., 2006; Malheiros et al., 2021; Schmid et al., 2009). Given the existing relationship between increased daytime sleepiness and all-cause mortality, regular nightly sleep is without question an important pillar to overall wellness (Wang et al., 2020).

To address the gap in literature on the short-term effects of an inflammatory meal, our study aimed to associate the inflammatory potential of a single meal with the level of postprandial sleepiness. Measuring postprandial sleepiness is often done following a meal known to cause inflammation. Given the observational nature of our study, meal composition
was not controlled, and average inflammatory potential of a meal was negative. Additional limitations of this study include the potential for user errors while completing the survey or recording dietary intake, inconsistency in the timing between the meal and survey, and a non-representative sample size. With the number of uncontrolled factors, small sample size, and overall anti-inflammatory meal score, it was not surprising that no correlation was found between the meal-adjusted DII and postprandial sleepiness.

**Recommendations**

To better understand how a single meal can contribute to postprandial sleepiness the meal-adjusted DII should be validated for use in a controlled research setting. Improved methodology would include structured intake time where a challenge meal known to promote inflammation is utilized. Pre- and post-meal measures of subjective and objective sleepiness could be performed in addition to a control group whose meal is standard in composition. When feasible, biometric data could also be collected to compare levels of inflammatory biomarkers with postprandial sleepiness. Collection of anthropometric measures such as body mass index (BMI) could provide more context for interpretation of results given the differences observed in previous research (Emerson et al., 2019; Lehrskov et al., 2018; Schwander et al., 2014). Understanding how a single meal affects postprandial sleepiness can empower dietary choices for daily health goals such as productivity at work and focus on school. Future research utilizing a meal known to cause inflammation could determine the relationship between dietary inflammatory potential of a single meal and its effect on postprandial sleepiness in healthy adults.
References


APPENDIX A

SAN JOSE STATE UNIVERSITY
HUMAN SUBJECTS INSTITUTIONAL REVIEW BOARD

IRB Notice of Approval

Date of Approval: 2/22/2021

Study Title: Association between Meal Dietary Inflammatory Potential and Postprandial Sleepiness

Principal Investigator: Dr. John Gleave

Student(s): Samantha Kalb

Other SISU Team Members:

Funding Source: None

IRB Protocol Tracking Number: 21050

Type of Review

☒ Exempt Registration: Category of approval §46.104(d)(2ii)
☐ Expedited Review: Category of approval §46.110(a)(i)
☐ Full Review
☐ Modifications
☐ Continuing Review

Special Conditions

☒ Waiver of signed consent approved
☐ Waiver of some or all elements of informed consent approved
☐ Risk determination for device:
☐ Other:

Continuing Review

☒ is not required. Principal Investigator must file a status report with the Office of Research one year from the approval date on this notice to communicate whether the research activity is ongoing. Failure to file a status report will result in closure of the protocol and destruction of the protocol file after three years.

☐ is required. An annual continuing review renewal application must be submitted to the Office
APPENDIX B

CONSENT NOTICE

Association between meal dietary inflammatory potential and postprandial sleepiness

NAME OF RESEARCHERS
Samantha Kalb: San Jose State University graduate student
John Gieng, PhD Assistant Professor

PURPOSE
The purpose of the proposed research survey is to explore the relationship between meal quality, dietary inflammatory index, and the postprandial sleepiness of healthy adults. Dietary inflammatory index is measured using pro and anti-inflammatory food parameters from an individual’s diet. Postprandial sleepiness refers to the level of sleepiness one experiences after eating a meal.

PROCEDURES
Participants are asked to complete the Qualtrics Survey, and the ASA24 Dietary Record. In total, these surveys may take about 20 minutes to complete.

COMPENSATION
$100 Amazon gift cards will be distributed to randomly selected individuals who chose to participate in the drawing. Chance of winning is no less than (approximately) 1 in 40. Students in NUF 38 will receive 5 points extra credit for participating in addition to being entered in the drawing to win one of five gift cards.

CONFIDENTIALITY
Participant emails will be decoded using a randomized number. No personal identifying information will be used in the research findings. Decoded study data may be used for future research studies. Only the researchers will have access to this information and it will be password protected.

YOUR RIGHTS
Your participation in this study is completely voluntary. You can refuse to participate in the entire study or any part of the study without any negative effect on your relations with San Jose State University. You also have the right to skip any question you do not wish to answer.

CONTACT INFORMATION
Questions can be sent to Samantha at Samantha.kalb@sjsu.edu, or Dr. Gieng at john.gieng@sjsu.edu.

AGREEMENT TO PARTICIPATE
Your completion of the study indicates your willingness to participate. Please keep this document for your records.
APPENDIX C

Attachment D1

Qualtrics Post Meal Research Survey

Start of Block: Intro: Consent and Demographics

Q48 Have you been diagnosed with any of the following medical conditions? Diabetes Mellitus, Crohn’s Disease, Celiac Disease, Irritable Bowel Syndrome, Eating Disorder, Cancer, any other thyroid, kidney or digestive diseases?
- Yes (1)
- No (2)

Skip To: End of Survey if Have you been diagnosed with any of the following medical conditions? Diabetes Mellitus, Crohn’s... = Yes

Page Break

Q49 Are you currently pregnant or breastfeeding?
- Yes (1)
- No (2)

Skip To: End of Survey if Are you currently pregnant or breastfeeding? = Yes

Page Break
Attachment D1

Q35
CONSENT NOTICE
Association between meal dietary inflammatory potential and postprandial sleepiness

NAME OF RESEARCHERS
Samantha Kalb: San Jose State University graduate student
John Gieng, PhD Assistant Professor

PURPOSE
The purpose of the proposed research survey is to explore the relationship between meal quality, Dietary inflammatory index, and the postprandial sleepiness of healthy adults. Dietary Inflammatory Index is measured using pro and anti-inflammatory food parameters from an individual's diet. Postprandial sleepiness refers to the level of sleepiness one experiences after eating a meal.

PROCEDURES
Participants are asked to complete the Qualtrics Survey, and the ASA24 Dietary Record. In total, these surveys may take about 20 minutes to complete.

COMPENSATION
5 $100 Amazon gift cards will be distributed to randomly selected individuals who chose to participate in the drawing. Chance of winning is no less than (approximately) 1 in 40. Students in NIFS 8 will receive 5 points extra credit for participating in addition to being entered in the drawing to win one of five gift cards.

CONFIDENTIALITY
Participant emails will be decoded using a randomized number. No personal identifying information will be used in the research findings. Decoded study data may be used for future research studies. Only the researchers will have access to this information and it will be password protected.

YOUR RIGHTS
Your participation in this study is completely voluntary. You can refuse to participate in the entire study or any part of the study without any negative effect on your relations with San Jose State University. You also have the right to skip any question you do not wish to answer.

CONTACT INFORMATION
Questions can be sent to Samantha at samantha.kalb@sjus.edu, or Dr. Gieng at john.gieng@sjus.edu.

AGREEMENT TO PARTICIPATE
Your completion of the study indicates your willingness to participate. Please keep this document for your records.

☐ I agree to participate in the research (1)
Attachment D1

☐ I do not agree to participate in the research (2)
Attachment D1

Q52 Please enter your name and the email address you provided to the research team for reference

☐ First name (1) ____________________________________________

☐ Last name (2) ____________________________________________

☐ Email (3) ________________________________________________

Q1 How old are you?

☐ 18-25 (1)

☐ 26-33 (2)

☐ 34-41 (3)

☐ 42-49 (4)

☐ 50+ (5)

Q2 Which gender do you identify with?

☐ Male (1)

☐ Female (2)

☐ Transgender Male (3)

☐ Transgender Female (4)

☐ Gender Variant/Non-conforming (5)

☐ Not Listed: Fill in below (6) ________________________________

☐ Prefer not to answer (7)
Attachment D1

Q3 What is your highest level of education. If you are a current student select the degree you have completed.

○ GED or some High School (1)
○ High School (2)
○ Associate's Degree (3)
○ Bachelors (4)
○ Masters (5)
○ PhD (6)

Q4 Are you currently living in the United States?

○ Yes (1)
○ No (2)

Q5 Do you identify yourself as Hispanic, Latino, or Spanish?

○ Yes (1)
○ No (2)
○ Other: Fill in below (3)_____________________________________
○ Prefer not to say (4)
Attachment D1

Q5 Which of the following do you most identify with?

- American Indian or Alaska Native (1)
- Asian (2)
- Black or African American (3)
- Native Hawaiian or other Pacific Islander (4)
- Caucasian (5)
- Prefer not to answer (6)

End of Block: Intro: Consent and Demographics

Start of Block: Non-Valid Qs

Q54 How many hours of sleep do you average per night?

- 6 hours or less (1)
- 7-8 hours (2)
- 8+ hours (3)
Attachment D1

Q33 What is your average activity level?

○ Sedentary: little or no exercise, desk job (1)

○ Lightly active: light exercise/ sports 1-3 days/week (2)

○ Moderately active: moderate exercise/sports 6-7 days/week (3)

○ Very active: hard exercise every day, or exercising 2x day (4)

○ Extra active: hard exercise 2 or more times per day, or training for a marathon, triathlon, etc. (5)

Page Break
End of Block: Non-Valid Qs
Start of Block: Epworth Sleepiness Scale

Q36 On a typical day how likely are you to doze off or fall asleep while sitting and reading?

○ Would never doze (1)

○ Slight chance of dozing (2)

○ Moderate chance of dozing (3)

○ High chance of dozing (4)
Attachment D1

Q37 On a typical day how likely are you to doze off or fall asleep while watching TV?
○ Would never doze (1)
○ Slight chance of dozing (2)
○ Moderate chance of dozing (3)
○ High chance of dozing (4)

Q38 If you are sitting inactive in a public place how likely are you to doze off or fall asleep?
○ Would never doze (1)
○ Slight chance of dozing (2)
○ Moderate chance of dozing (3)
○ High chance of dozing (4)

Q39 On a typical day how likely are you to doze off or fall asleep as a passenger in a car for an hour without a break?
○ Would never doze (1)
○ Slight chance of dozing (2)
○ Moderate chance of dozing (3)
○ High chance of dozing (4)
Attachment D1

Q40 On a typical day when time permits, how likely are you to doze off or fall asleep when you lie down to rest in the afternoon?

☐ Would never doze (1)

☐ Slight chance of dozing (2)

☐ Moderate chance of dozing (3)

☐ High chance of dozing (4)

Q41 On a typical day when you are sitting down and talking to someone how likely are you to doze off or fall asleep?

☐ Would never doze (1)

☐ Slight chance of dozing (2)

☐ Moderate chance of dozing (3)

☐ High chance of dozing (4)

Q42 On a typical day how likely are you to doze off or fall asleep when you're sitting quietly after a lunch with no alcohol?

☐ Would never doze (1)

☐ Slight chance of dozing (2)

☐ Moderate chance of dozing (3)

☐ High chance of dozing (4)
Attachment D1

Q43 On a typical day how likely are you to doze off or fall asleep while stopped in a car for a few minutes in traffic?

○ Would never doze  (1)

○ Slight chance of dozing  (2)

○ Moderate chance of dozing  (3)

○ High chance of dozing  (4)

Q45 What is your degree of sleepiness right now?

○ Feeling active, vital, alert, or wide awake  (1)

○ Functioning at high levels, but not at peak, able to concentrate  (2)

○ Awake, but relaxed; responsive but not fully alert  (3)

○ Somewhat foggy, let down  (4)

○ Foggy; losing interest in remaining awake, slowed down  (5)

○ Sleepy, woozy; fighting sleep, prefer to lie down  (6)

○ No longer fighting sleep, sleep onset soon; having dream like thoughts  (7)

End of Block: Epworth Sleepiness Scale
APPENDIX D

Participate in Nutrition Research

"Association between meal dietary inflammatory potential and postprandial sleepiness"

You’ll be entered to win a $100 Amazon gift card!

SCAN ME
To be added to the participant list

Presented by researchers at SAN JOSE STATE UNIVERSITY

Participate Now!
Help expand nutritional science research

You’ll be entered to win a $100 Amazon Gift Card

SCAN ME

Presented by:
SJSU | DEPARTMENT OF NUTRITION
FOOD SCIENCE AND PACKAGING
Participant Instructions

Thank you for volunteering to participate in this research project. Below you will find your instructions for participation. Please read carefully, and contact the student investigator samantha.buhl@jitsu.edu if you have any questions.

1. Eat your usual lunch or dinner

   1-2 hours after your meal, complete steps 2 and 3

2. Complete the Qualtrics Survey here

3. Log your daily intake using the personalized ASA24 link provided in email
   A. Navigate to the ASA24 website
   B. Use the provided username and password to log in
   C. You will be prompted to log all the food you ate today
   D. Begin by clicking Report a Meal in the bottom right corner
   E. Follow the prompts to log each meal or snack you consumed today
   F. Review meals, snacks, supplements, and beverages
   G. Submit!

Thank you for your participation!
Hello,

Thank you for providing your email to participate in the graduate nutrition research project. Attached you will find the participant instructions, as well as your personal login information for ASA 24 below. If you have any questions don’t hesitate to reach out!

Username: DQPS#####
Password: word####

Thank you so much,

Sam Kalb
Graduate Student
samantha.kalb@sjsu.edu
skalb13@gmail.com

*Participant Instructions Attached as PDF