An Exploration into Diet Quality Assessment and Food Processing

A dissertation submitted to Auckland University of Technology in partial fulfilment of the requirements for the degree of Master of Sport, Exercise and Health

The School of Sport and Recreation

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2022

Abstract

The presence of food processing techniques has expanded rapidly over the last two decades with the intake of ultra-processed foods increasing subsequently. Nutrition epidemiology research demonstrates the implications of food processing levels and ultra-processed food intake on health outcomes including the increased risk of obesity, type 2 diabetes, and cardiovascular disease. Currently, existing assessment and appraisal tools for overall quality of dietary intakes face significant gaps. Firstly, traditional diet quality indices based on food groups or nutrient density fail to differentiate between untouched and processed foods, and as a result, likely contribute to the misclassification of healthy items as the extent of food processing is often not considered. Secondly, current food classification systems that classify intakes based on food processing, lack an established quantitative measure that employs recommended dietary serving sizes to quantify the levels of intake respective to the classifications of intake.

This research investigates the relationship between assessing dietary quality and existing diet quality indices and food classification systems in two distinct chapters. Firstly, an extensive narrative review of diet quality indices and food classification systems highlights the variation between assessment measures seeking the same outcome of overall diet quality. Specifically, it evaluates the extent of diet quality assessment and the formulation of assessment tools. Secondly, five hypothetical meal plans were analysed for diet quality using four established diet quality indices along with the Human Interference Scoring System (HISS), a diet quality tool recently developed by the Human Potential Centre nutrition staff. The HISS aims to classify dietary intake based on food processing levels and quantify overall diet quality via proportionate servings of unprocessed and processed foods. The classification system is based off the well-known NOVA system with some key modifications to the categories and classifications.

In Chapter One, an extensive narrative review of existing diet quality indices and food classification systems reveals several key areas of concern, including the variance in the construction and composition of diet quality assessment tools and the resulting implications. In Chapter Two, an exploratory analysis shows positive correlations between diet quality indices across each of the meal plans, albeit varying strengths. The analysis of dietary intakes supports the oversimplistic and reductionist flaws of existing diet quality indices, while simultaneously demonstrating the HISS can provide a simple, yet comprehensive dietary appraisal tool.

To conclude, diet quality indices are useful assessment tools to appraise dietary quality given the appropriate population and settings. The HISS presents a food classification system with

the ability to classify dietary intake according to food processing levels and quantify the overall diet quality via the total servings of unprocessed and processed foods. As a result, the HISS provides researchers and health professionals with a simple dietary appraisal tool that allows for straightforward translation of dietary analysis messages. Future research may consider further testing of the HISS with a larger sample size to test for the reliability and validity of the system and increase the generalisability of the results.

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Attestation of Authorship

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.

Acknowledgements

There are a number of people I would like to acknowledge for their involvement in this study. Firstly, to my academic supervisor, Caryn Zinn. I am extremely grateful and appreciative for your ongoing support and guidance over the last year. Thank you for leading me through this challenge that was completing my dissertation amongst the Covid-19 pandemic. This dissertation would not have been possible without your advice, encouragement, and invaluable feedback.

I would also like to express my thanks to the other members of our research team, Grant Schofield and Olivia Malamatenios, for their ongoing support, constructive feedback and guidance in our weekly meetings. A special thanks to Olivia for her assistance with the data collection and consistency checks. Without their help, this dissertation would not have been what it is now. Thanks to Dr Tom Stewart for his advice and feedback on my statistical analysis, and to Andrew South for his guidance with my literature searching.

Lastly, a personal thank you, to my family and friends who have continuously supported and motivated me. To Finn, a special thank you for your love, support, understanding and encouragement, especially when I needed it most. To Mum, Rob, and my siblings Tegan and Kyle, thank you for the endless support and encouragement, with a special thanks to my Mum for the consistent reminders to back up my computer.

Introduction

Currently a pandemic of noncommunicable chronic diseases (NCCDs) progresses within both developed and developing countries, despite several accessible worldwide dietary recommendations and guidelines (Gil et al., 2015). Epidemiological evidence has displayed the importance of quality dietary intake in the prevention and management of diseases and premature mortality induced by noncommunicable diseases (Guerrero et al., 2017). This progressive pandemic highlights the increasingly critical role of physical activity and in particular, nutrition and dietary quality, in decreasing and preventing the escalation of disease development (Gil et al., 2015). Over the past two decades, dietary quality has gained considerable attention bringing attention to the fact dietary quality is an extremely intricate and multidimensional concept (Alkerwi, 2014). Within recent literature, more notably nutritional epidemiology, the concept of diet quality has emerged to analyse the dietary habits of populations and the efficacy of nutritional interventions (Alkerwi, 2014). In addition, dietary quality has also been proposed as a risk assessment measure to predict health outcomes such as cardiovascular disease (CVD), cancer risk and all-cause mortality (Alkerwi, 2014). Since dietary quality started gaining attention, the associations between physiological function, diet, and disease have advanced rapidly. Poor quality nutritional intake is now widely recognised as a significant contributor to the development of chronic illness and noncommunicable diseases (Mackerras, 2020; Monteiro et al., 2018). Epidemiological research has further identified dietary selections and intake to impact several risk factors for metabolic health, therefore indicating poor dietary habits to be a modifiable driver contributing to obesity, diabetes, and cardiovascular disease, the leading causes of mortality worldwide (Mackerras, 2020; Monteiro et al., 2018; Rico-Campà et al., 2019). The highlighted importance of quality dietary intake in preventing noncommunicable diseases emphasises the requirement to undertake dietary appraisal and/or assessment.

While the idea of diet quality has gained popularity within the research and clinical practice community, it is difficult to capture, measure and quantify all respective elements (Alkerwi, 2014). Given the increasing use of the concept, the phrase “diet quality” still remains loosely defined due to the concept’s complex and multifaceted characteristics (Alkerwi, 2014). Owing also to the complexity, is the several different definitions and interpretations of ‘diet quality’ across the literature. It has been noted that the definition should ideally incorporate factors relevant to a variety of sectors, such as economics, toxicology, and the nutrition and food industry (Guerrero et al., 2017). Rather, the phrase and concept of diet quality often refers to overall dietary intake and the respective impact on human health (Gicevic et al., 2020), with the extensive phrase typically referring to dietary patterns or measures of variation across key food groups indicated within recommended dietary guidelines (Dalwood et al., 2020). The multifaceted idea encompasses eating a variety of healthy foods in adequate quantities, restricting unhealthy food intake, and maintaining an overall macronutrient balance (Gicevic et al., 2020). Thereby, obtaining more desirable nutrient intake profiles and a lower risk of diet-related noncommunicable diseases demonstrates high diet quality (Dalwood et al., 2020). Notably, quality of dietary intake can be heavily influenced by confounding factors such as socioeconomic status, cultural and food environments, family dietary preferences, and appropriate nutritional recommendations relative to sex, age, country and/or culture of the individual (Dalwood et al., 2020). Although general agreement on the concept has yet to be established, a high-quality diet may also be characterised as one that is hygienically safe, nutritious, balanced, and tailored to individual needs to prevent disease and promote a good state of health for optimal growth and development (Guerrero et al., 2017).

In recent years, methods for measuring diet quality have evolved and a number of scoring systems or indices to this effect have emerged (Wirt & Collins, 2009). Two approaches to dietary patterning have been distinguished: theoretically defined dietary patterns and empirically derived dietary patterns. Theoretically defined dietary patterns are constructed 'a priori,' meaning they are based on theoretical deduction and therefore current nutrition knowledge. They often consist of nutritional variables, typically foods and/or nutrients thought to be essential to health, that are quantified and summed to provide an overall assessment of dietary quality. (Waijers et al., 2007). The latter, on the other hand, are created 'a posteriori,' meaning they are observation or experience based. Empirically derived dietary patterns are typically comprised of statistically derived dietary patterns from collated dietary intake data based on correlations within intakes of various dietary components (Waijers et al., 2007).

Methods for assessing diet quality has sparked increased attention ever since Patterson produced the first dietary quality index in 1994 (Patterson et al., 1994). This considerably new concept involves evaluating both the quality and diversity of the complete diet, allowing for investigation of correlations between whole foods and health, in contrast to solely nutrients (Wirt & Collins, 2009). Assessing the association between health and nutrition wholly, as opposed to individual nutrients, foods, or food groups has universal appeal as free-living people often eat combinations of foods that typically include a variety of nutrients and non-nutrients. This results from individual dietary selections being heavily influenced by a mixture of genetic, social, cultural, health, lifestyle, environmental, and economic factors (Kant, 2004).

There has been extensive research on methods used to measure overall diet quality with an increasing array of scenarios to identify healthy eating patterns. To represent diverse elements of diet quality, a wide variety of dietary indicators have been devised, evaluated, and validated. These range in complexity from basic methods that simply measure adherence to dietary guidelines to intricate indices that need extensive analysis of macronutrient and micronutrient intakes (Alkerwi, 2014). The more basic approaches to the measurement and assessment of diet quality often consist of grading dietary intake patterns based on how well they adhere to the relevant dietary guidelines, and how extensive the range of healthy options are within key food groups or comparable international classifications (Wirt & Collins, 2009). Diet quality indices, such as Patterson's (Patterson et al., 1994), are largely mathematical algorithms used in nutritional epidemiology to quantify the degree of adequacy between the actual nutrient or food group intakes of populations and the respective reference intakes (Guerrero et al., 2017). Reference intakes are typically established based on current scientific evidence to ensure an optimal state of health while protecting consumers from chronic diseases.

Typically, diet quality indices are an assessment method or tool used to assess the quality of an individual's overall dietary intake by scoring intakes of foods and nutrients, occasionally lifestyle characteristics, based on how well they correspond with certain dietary patterns or guidelines (Dalwood et al., 2020). Often indices of dietary quality are employed to enable the analysis of a whole target population's dietary patterns and consumption habits also (Guerrero et al., 2017). Dietary guidelines or recommendations, in which indices are based off, are intended to inform the general public, as well as health experts and policy makers, about nutrition to promote overall good health and minimise the occurrence of chronic diseases (Bälter et al., 2012). Diet quality assessment can offer information on dietary behaviours, which as a whole, encompass various components that operate synergistically on health and diseases (Asghari et al., 2017). Therefore, indices of dietary quality are employed in attempt to analyse the whole diet and categorise individuals based on how 'healthy' their eating habits are (Gil et al., 2015). Although, there are several diet quality indices that utilise various scoring matrices to determine this. Some employ frequency of consumption for foods or food groups, while others utilise nutrient intakes that must be estimated prior to scoring, with some incorporating both (Dalwood et al., 2020). Notably, more precise scoring algorithms enable the identification of both unfavourable intakes and protective dietary patterns (Wirt & Collins, 2009).

Far into the 1900s, the principal diet-related public health concern was of nutrient deficiencies identified within industrialised nations as well as eventually, globally (Moubarac et al., 2014). Given this, beginning in the 1950s and 1960s, the incidence of cardiovascular disease began to escalate quickly within the United States, the United Kingdom, and other high-income countries before spreading elsewhere. This was supposedly thought to be related mostly to increases in saturated fat consumption in addition with declines in physical activity (Moubarac et al., 2014). As a result, the United Nations and other authoritative dietary guidelines diverted priorities, therefore highlighting the importance of reducing saturated fat, salt, and sugar intake, while increasing dietary fibre intake in comparison to typical amounts consumed within those higher-income settings (Moubarac et al., 2014). However, recent research literature on the relationship between cardiovascular disease and saturated fat intake has provided much controversy and uncertainty around the subject. The impact of saturated fat is one of the most contested subjects with recent research findings indicating there is an absence of significant evidence to conclude consumption of saturated fat is indeed associated with a heightened risk of cardiovascular disease or coronary heart disease (Heileson, 2020; Siri-Tarino et al., 2010). This has highlighted the importance of recent revisions of dietary guidelines and/or diet quality indices to reflect newer research and update priorities accordingly. In the 1960s, a critically important public health concern of adult obesity was recognised as a serious problem within the United States and other industrialised countries, including territories such as Native American reservations and the Pacific Islands, where the dietary intake is mainly comprised of imported convenient ‘store’ food. Since the 1980s, the incidence of children and adult overweight, obesity, and directly linked diseases, most notably diabetes, have increased enormously across the world, amounting to an uncontrollable pandemic (Moubarac et al., 2014).

For almost two million years, food processing techniques have had a high presence and importance within human diets enabling methods such as cooking, salt preservation/brine, and fermenting. However, food processing methods developed during the industrial revolution that now occur on a large scale, are fairly new and modern (Bleiweiss-Sande et al., 2019). As a result, industrial food processing is not without its flaws, and the respective impacts of industrial food processing on health, wellbeing, and disease is becoming an emerging science itself. The transition of humans dietary patterns comprised of freshly-made meals and artisanal products to dietary intakes primarily based on ready-to-consume industrially processed food and beverages, is widely recognised as a source of concern (Moubarac et al., 2014). There are significant distinctions between the two dietary patterns. Domestic methods, such as preparing and cooking meals at home and artisanal processing techniques, are typically constructed of unprocessed and minimally processed foods, along with culinary components also often processed (Moubarac et al., 2014). On the other hand most ready-to-eat items are ultra-processed indicating they have not been modified, but rather combinations of industrial additives containing little-to-no whole foods (Moubarac et al., 2014). As a result, industrial food processing has become a more significant determinant of dietary quality, dietary habits and patterns, and influence on health, wellbeing, and diet-related diseases, than it was 200 years or even a few decades ago.

Nonetheless, existing food classification systems, epidemiological research and publications concerned with nutrition, health and dietary intake proceed to frame their results and recommendations on the chemical configuration and nutritional profile of foods and beverages, with minimal and sporadic attention paid to the place or extent of food processing undertaken (Moubarac et al., 2014). Food processing is defined by the United States Department of Agriculture (USDA) as any method that modifies food from its natural condition. As a result, any food other than raw, agricultural items is classified as processed (Bleiweiss-Sande et al., 2019). Terms such as 'processed foods' or 'highly processed' are frequently used without definition, while essentially imprecise labels such as 'fast food,' 'convenience food,' and 'junk food' are used to characterise various types of processed food items (Moubarac et al., 2014). Due to the significant variation among industrially processed consumables, researchers have created frameworks aimed at classifying foods based on the complexity or extent of processing, spanning from minimally processed to ultra-processed (Bleiweiss-Sande et al., 2019).

Variations and inconsistencies between these classification methods have led to conflicting conclusions around the associations between processed food intake and dietary quality (Bleiweiss-Sande et al., 2019). Advocates for frameworks based on food processing claim traditional food classifications, for instance food groups and/or nutrient density, fail to differentiate between untouched and formulated types of foods likely contributing to misclassification of healthy items. However, the translation of nutrient-based aims to food-based suggestions within dietary guidelines may have encouraged the food industry to extensively fortify foods to depict highly processed foods as healthful (Bleiweiss-Sande et al., 2019). Although various food classification systems based on food processing levels have been developed and excel at categorising foods, the extent to which the quality of dietary intake is quantified is non-existent. After classification of dietary intake into the appropriate processing category, there is an absence of further scoring or quantification of meal plans that could be employed to distinguish overall dietary quality through quantifying the classifications of category intakes, for instance servings of whole foods vs ultra-processed foods. This presents a gap within developed diet quality assessment methods. Firstly, current diet quality indices are reductionist by attempting to compress substantial amounts of nutritional advice into minimal dietary components to classify dietary intake. Secondly, food classification systems lack an appropriate scoring criterion that could enable the quantification of dietary intake quality. As a result, there is an absence of a diet quality assessment tool capable of assessing and quantifying the quality of meal plans and translating this output into straightforward advice for consumers on how to improve their diet.

Nutrition as a dimension has long proved complex to quantify in an individual's diet owing to its multidimensional nature. Despite multiple diet quality indices and food classification systems developed over the past two decades, they still have various limitations and rely on questionable assumptions between nutrients and health. This dissertation is structured in two distinct chapters, with each chapter structured as a stand-alone study, containing an introduction, methods, results, and discussion section. Chapter One is a critical narrative review of all existing diet quality indices and food classification systems, highlighting the extent of diet quality assessment and index formulation. Chapter Two is an application of dietary quality tools on a range of sample meal plans. Finally, a conclusion and set of recommendations will be presented to draw this work to a close.

Chapter One

Diet Quality Indices and Food Classification Systems: A Narrative Review

Introduction

Throughout the human lifespan, achieving good health and optimal functionality are realistic goals. Though to achieve this a particular lifestyle approach is essential including an energy-balanced nutrient dense dietary intake, paired with frequent physical activity to aid in counterbalancing energy intake and regulating body weight, along with several other physiological functions (Gil et al., 2015). Existing food systems currently are under growing pressure to provide nutritious meals for all while also being sustainable and equitable. Poor quality diets are the leading contributors to morbidity and mortality worldwide, far outweighing the burdens associated with many other global health concerns (Trijsburg et al., 2021). The World Health Organisation (WHO) reports that the global burden of chronic disease is quickly escalating, with cardiovascular disease accounting for over half of total chronic disease mortality (Guerrero et al., 2017). While considerable success has been achieved in reducing the incidence of malnutrition and undernutrition, deficiencies of micronutrients continue. The incidence of overweight, obesity, and diet-related noncommunicable diseases is increasing globally with low-incomes countries experiencing the fastest incline (Trijsburg et al., 2021). Individual nutrients and nutrient combinations are well-established contributors to risk factors for noncommunicable disease and serve as the foundation for the establishment of dietary recommendations and guidelines (Gibney, 2019).

To determine whether populations consume 'healthy' diets, several diet quality indices are accessible, albeit a large portion are produced for specific regions or countries, and some are also frequently intended for usage in higher-income areas (Trijsburg et al., 2021). As a result, there is an abundance of studies on methods used to assess overall diet quality with an increasing number of scenarios to discover healthy eating patterns (Alkerwi, 2014). Notably, dietary quality is an umbrella phrase that is widely used in literature often to indicate how well an individual's dietary intake adheres to the dietary standards (Alkerwi, 2014). Therefore, to assess dietary conformity to national recommendations or a priori set diets, a variety of dietary indices have been proposed as summary measures of overall dietary quality (Fransen & Ocké, 2008). Ambiguity still surrounds the term as general agreement has yet to be reached on how to define diet quality or establish a defined framework for developing an appropriate diet quality indicator (Alkerwi, 2014). Unsurprisingly, diet quality index construction typically relies on qualities chosen by researchers in accordance with the research aims (Alkerwi, 2014). Constructing an index of dietary quality requires numerous critical decisions. These often include selection of what components to utilise, how many to include, the corresponding cut-off values defining ideal dietary intake, and the respective scoring criteria (Alkerwi, 2014;

Burggraf et al., 2018). However, varied perspectives and intrenched interests when creating an index can often impact their relevance, resulting in different formulations of the index composition and interpretations of 'diet quality' as a result, therefore limiting the reliability of the index (Alkerwi, 2014; Burggraf et al., 2018).

Depending on the construction of the index, there are many distinct forms of diet quality indices. One major category consists of 'nutrient-based' indicators which require the use of food-nutrient conversion tables (FCTs) to convert the food weights to nutrient content, comparison to requirements, adequacy ratios and others (Gil et al., 2015). Another main type of indicator is 'food or food group based,' where they employ dietary recommendations for suggested quantities or frequency, or simply count foods and food groups consumed (Gil et al., 2015). The majority of diet quality indices fall into the category of 'combination' indices which typically consist of; a measure of dietary variety within and across food groups, a measure of adequacy for nutrients (compared to requirements) or food groups (quantities to servings), a measure of nutrients and/or foods to consume in moderation, and an overall balance of macronutrients (Gil et al., 2015). Adequacy alludes to consuming sufficient quantities of dietary components that are favourable to health. Whilst, moderation refers to restricting the consumption of nutrients or foods that are harmful to health (Burggraf et al., 2018). Many indices take into account a 'balancing' dimension that addresses the ratio of energy-yielding macronutrients (proteins, carbohydrates and fats) and/or fatty acids (saturated fatty acids, monounsaturated fatty acids, polyunsaturated fatty acids) (Burggraf et al., 2018). This is due to the fact dietary guidelines and nutritional advice, such as recommended appropriate distribution ranges of macronutrients, emphasise the significance of a well-balanced macronutrient consumption within the diet (Burggraf et al., 2018).

There are four 'original' diet quality indices that have been referred to and validated most extensively, these are best known as the Healthy Eating Index (HEI) (Kennedy et al., 1995), the Diet Quality Index (DQI) (Patterson et al., 1994), the Healthy Diet Indicator (HDI) (Huijbregts et al., 1997), and the Mediterranean Diet Score (MDS) (Trichopoulou et al., 1995) (Waijers et al., 2007). Several indices have since been updated and altered with many more developed subsequently (Gil et al., 2015). Despite the vast amount of developed diet quality indices, all are reductionist approaches in the sense they attempt to condense a large body of dietary components and analysis into minimal elements to classify and appraise dietary intake. Furthermore, these approaches tend to disregard whether the factors are intake of markers of cuisine styles, nutrients, or the presence of additives in food (Mackerras, 2020).

A priori indices of diet quality, based on theoretically defined dietary patterns, are composed of nutritional factors – typically nutrients and food or food groupings that are considered to be either healthy or unhealthful. Quantification and summation of index components produces an overall estimate of diet quality assessment, although the elements chosen by researchers influence how diet quality is defined. Typically, a priori diet quality indices are based around existing nutritional education or theory, or dietary patterns or intakes shown to be healthful, such as the Mediterranean diet (Waijers & Feskens, 2005). Majority of the earlier diet quality indices were designed for the adult population, with regards to the American Dietary Guidelines (Haines et al., 1999; Patterson et al., 1994) or the Mediterranean diet (Trichopoulou et al., 2003). Over the years, several different indices have arisen, with some alteration to suit dietary recommendations and advice from nations all over the world. Numerous dietary indices have also been specifically developed for other populations (Gil et al., 2015), such as children and adolescents, pregnant women, and the elderly.

Although, over the last several decades accelerated progress has been recognised in urbanisation, industrialisation, and scientific and economic development. Improvement of living conditions has been accompanied by greater availability of foods and range of options (Alkerwi, 2014). Recently, the concern is no longer on adequate consumption of calories to prevent malnutrition, but rather ensuring sufficient dietary intake to maintain good health and prevention of disease (Alkerwi, 2014; Trijsburg et al., 2021). The prominence of the diet quality notion has shifted owing to this transformation. Slimani et al., (Slimani et al., 2009), for example, discuss how the industrial and agricultural revolutions resulted in increased intake of particular foods, such as refined sugars. According to the authors, an increasing amount of evidence-based literature implies higher intakes of industrialised foods elevates the risk of various chronic illnesses (Sadler et al., 2021). Furthermore, Fardet (Fardet, 2018) defines the arrival of ultra-processed consumables throughout the 1980s as the “fourth nutrition shift” referring to the period of fractionated and recombined foods enriched with multiple substances and additives.

Aside from addressing fundamental dietary demands, proper nutrition is essential for optimal physical and mental development, and good overall health (Alkerwi, 2014). Some interest has been made in recent decades to the growing relevance of food processing in food supply worldwide and the respective dietary patterns, often including the impact towards the pandemic of diet-related noncommunicable diseases. Despite this, processed foods are typically commended for the ease, taste and innovation, however, their healthful aspects are now progressively being questioned (Sadler et al., 2021). Nonetheless, food processing is critical in providing safe, delicious, and nutritionally dense foods to communities, for instance in food preservations (Sadler et al., 2021). Given this, the subject is complicated. Adding to the complexity, several distinct forms of processing that alter dietary qualities and thus disease risk – either adversely or favourably – are often not properly characterised (Monteiro et al., 2016; Sadler et al., 2021).

In order to understand the relationship between nutrition and public health, it is critical to pay close attention to the extent of food processing and its respective impact on health (Monteiro et al., 2018). To begin with, food production and resources are vastly shifting internationally, influencing changes in dietary purchases and intake (Alkerwi, 2014; Monteiro et al., 2018). Secondly, data and education on the association between the extent of food processing and negative health impacts has been progressively growing (Monteiro, 2009). Trans fat, for example, is now recognised as a contributor of cardiovascular disease owing to the partial hydrogenation procedure utilised in the production of various items also (Monteiro et al., 2018). Lastly, traditional food classifications, for example food groups or nutrient density, are no longer effective as they typically categorise foods according to their animal or botanical species, as well as the nutrients they are comprised of. As a result, they frequently categorise foods together that have differential impacts on health and disease (Fardet et al., 2015; Monteiro et al., 2018).

Owing to the vast increase in industrial food processing over the years, the term “ultra-processed food” (UPF) is becoming more widely accepted in authoritative publications and nutritional literature as a descriptor for harmful food in dietary intake patterns (Elizabeth et al., 2020). Ultra-processed foods, as characterised by Moodie et al. (Moodie et al., 2013), are often energy dense, with a high-glycaemic load, deficient in dietary fibre, micronutrients, and phytochemicals, and are high in harmful kinds of dietary fats, salt, and free sugars. Therefore, dietary intakes rich in ultra-processed foods are widely recognised to be nutritionally inadequate, imbalanced, and harmful to health (Monteiro, 2009). Evidently, numerous countries have experienced an increase in the accessibility and intake of ultra-processed foods identified by an energy dense, poor nutritional quality dietary intake (Monteiro, 2009; Rico-Campà et al., 2019). As a result, it is now widely recognised that one of the main sources of the present obesity and accompanying chronic disease pandemic is overconsumption of ultra-processed foods such as convenience meals, in particular ready-to-eat and pre-prepared foods (Monteiro, 2009).

The knowledge surrounding ultra-processed foods and the influence on dietary quality as well as their role as a risk indicator for diet-related illnesses, syndromes and conditions is quickly evolving. Given this, ultra-processed foods receives little attention in community health efforts (Elizabeth et al., 2020). Recent reports indicate there is a lot of scepticism and misinformation about processed food in the media and among consumers (Sadler et al., 2021). Concerns regarding the health implications of industrial food processing, diet quality, and noncommunicable disease have resulted in the creation and establishment of food categorisation systems that differentiate between various types of processed foods (Sadler et al., 2021). Food classification systems categorise food and beverage items based on their 'degree of food processing' and have been created and utilised over time to predict an individual's diet quality and health implications, along with guiding nutritional recommendations, dietary guidelines, and food product development. The growing number of classification systems are established by addressing concerns regarding the dietary shift towards industrially produced items, but also the subsequent increasing incidence of chronic disease (Asfaw, 2011; Fardet, 2018; Monteiro, 2009; Monteiro et al., 2019; Slimani et al., 2009).

Several food classification systems have been developed worldwide to analyse dietary data through classification of foods based on the level of food processing. These food classification systems are extremely critical in determining and appraising human's dietary patterns as the transition towards ultra-processed food consumption rapidly progresses. As many of these systems have primarily been used in research only, they are often not named and are acronyms of the respective developers – leaving only two named. These include NOVA – a name, not an acronym (developed in Brazil at the University of Sao Paulo) (Monteiro et al., 2018), IFIC (developed in the US by the International Food Information Council - IFIC) (Eicher-Miller et al., 2012), IARC-EPIC (developed in Europe by the International Agency for Research on Cancer - IARC) (Slimani et al., 2009), IFPRI (developed in Guatemala at the International Food Policy Research Institute - IFPRI) (Asfaw, 2011), POTI-UNC (developed in the US at the University of North Carolina (UNC) at Chapel Hill by Poti (POTI) and colleagues) (Poti et al., 2015), and SIGA – also a name, not an acronym (developed in France) (Fardet, 2018). The most widely recognised and utilised system across international research is the NOVA system, and as a result NOVA has been used as the basis for several countries dietary recommendations and guidelines (Sadler et al., 2021). Both the IFIC and IARC-EPIC systems have been used within research to investigate the nutrient quality of consumed foods by processing categories, although within different populations (Eicher-Miller et al., 2012; Slimani et al., 2009). The IFPRI system is a lesser-known tool used primarily in research studies (Asfaw, 2011), whereas the POTI-UNC system is more recent and categorises all barcoded products sold in the US supermarkets (Poti et al., 2015). Similarly, the SIGA index scores and categorises items sold within stores awarding graded medals to products based on the level of processing or the 'degree of transformation' (Fardet, 2018).

There is extensive literature published that discusses overall diet quality, measurement and assessment of diet quality, and health implications. Despite a significant and quickly growing body of research associating ultra-processed foods to adverse health implications, the number of reviews on diet quality assessment and appropriate assessment methods has been limited. This review adopts a narrative approach with an aim to explore and investigate similarities and differences between existing diet quality indices and food classification systems used to assess dietary quality, highlighting the extent of dietary quality assessment and index formulation.

Methods

A systematic search and narrative review approach was used with three primary steps, i. a systematic search procedure using the inclusion and exclusion criteria application detailed below; ii. extraction of data and collation of results; and iii. a narrative review analysis of significant findings. The strategy enabled a comprehensive search for existing literature, as well as the incorporation and evaluation of data from various research types, demographics, health outcomes, and dietary measures and assessments.

Search Strategy

To identify relevant a priori diet quality indices of human diets, a review of published English-language literature was conducted. A proximity search across CINAHL, MEDLINE and SCOPUS yielded 742 results using the following search terms; ("diet* indic*" "diet* quality" "diet* pattern*" "diet* index*" "diet* score" "diet* measure") n10 (develop* or create* or creation or design or validate*) and (nutrition* and epidemiolog*). Furthermore, citation searches and reference lists were hand searched for further relevant studies. After application of the inclusion and exclusion criteria detailed below, a total of 134 diet quality indices or their variations were identified; they are primarily based on the Diet Quality Index, the Healthy Eating Index, and the Mediterranean Diet Score.

To identify relevant food classification systems on food processing for human adult diets, a review of published English-language literature was conducted. A search across CINAHL, MEDLINE and SCOPUS yielded 1310 results using the following search terms: ("food process*" or "processed food*" or "ultra-processed food*" or "unprocessed food*" or "minimally processed food*" or "industrial* food*") AND (classification*). Furthermore, citation searches and reference lists were hand searched for further relevant studies. After application of the below inclusion and exclusion criteria, a total of 7 indices of their variations have been identified.

Inclusion and Exclusion Criteria

Studies were included if; participants were human adults aged 18 years or over, literature was published in English, the use of theoretically defined dietary patterns (food indices/scores/classifications) or a measure of diet quality created a priori based on current nutrition knowledge, and for the purpose of this review, indices were included if they were developed for the New Zealand or Australian populations. The exclusion criteria were as follows: studies conducted on animals, studies conducted among children, adolescents, pregnant and/or lactating women, or people with specific dietary intakes (e.g., plant-based, elite athletes). Literature was also excluded if the studies were non-English publications, used primarily dietary patterns derived a posteriori from food consumption data, based or defined empirically or statistically such as factor analysis (principal component analysis) or cluster analysis, and indices developed for the prevention of specific diseases (such as the DASH diet score by Fung et al., or the Heart Disease Prevention Eating Index by Lee et al.) were not included as they are designed for people with specific health risks but are likely to be inappropriate for assessing and guiding overall dietary quality in individuals in an unspecified population.

Results

Since Patterson published the first dietary index in 1994 there have been 134 diet quality indices created that met this review's eligibility criteria. Combination-type indices make up the large majority of diet quality indices with 95 out of 134 identified eligible indices identified within this review containing a combination of food and nutrient components, including the DQI-I (Kim et al., 2003), MDS-f (Trichopoulou et al., 2003), and AHEI-2010 (Chiuve et al., 2012). **Table 1** presents the combination diet quality indices and their respective scoring criteria. Several of the indices emphasise nutrient indicators first and foremost, however they frequently employ food groups of 'whole grains' in the adequacy component and 'empty calories' within the moderation component (Burggraf et al., 2018).

Table 1. Diet Quality Assessment Measures and Scoring Criteria

Diet Quality Measures; And Author	Type of Measure (Purpose)	Dietary Principles	Dietary Assessment Method	Dietary Components	Scoring Criteria
Based on Dietary Guidelines					
Australian Diet Quality Score (ADQS); (Froud et al., 2019)	Nutrient & Food Index Purpose: Predicting Risk Of Depression.	Reflects adherence to recommended dietary intakes by Australian Dietary Guidelines (ADG).	FFQ – Dietary Questionnaire for Epidemiological Studies (DQES v2).	10 categories: vegetables; fruit; wholegrains; processed grains; dairy; protein; nuts; seafood, fats ratio; extras ratio.	0 – 24, points are awarded for each category and summed.
Baltic Sea Diet Score (BSDS-Q-2014); (Kanerva et al., 2014)	Nutrient & Food Index Purpose: Nutrition Epidemiology	Reflects adherence to the healthy Nordic diet and Baltic Sea Dietary Pyramid Guidelines.	131-item FFQ	9 categories: fruits and berries; vegetables; cereals; low-fat milk; fish; meat products; total fat; fat ratio; alcohol.	0 – 25, points are calculated by nutrient analysis and servings, and summed.
Modified Indexes Adapted from the BSDS-Q; *Modified Baltic Sea Diet Score – BSDS-M-2014 (Kanerva et al., 2014)*					
Chinese Diet Quality Divergence Index (DQD); (Zhou et al., 2020)	Food-Based Index Purpose: Diet Quality	Reflects adherence to the 2016 Chinese Dietary Guidelines (CDG) and Chinese Food Pagoda (CFP)	3x consecutive 24hr dietary recalls.	8 categories: cereal and potatoes; fruits; vegetables; eggs; aquatic products; meat and poultry; legumes and nuts; milk and milk products	0 – ∞, average daily consumption of categories calculated. The divergence value between average consumption and CFP was computed. The total DQD obtained by summing all eight divergences for the food categories.
CSIRO Healthy Diet Score (CSIRO-HDS); (Hendrie et al., 2017)	Nutrient & Food Index Purpose: Dietary Score Component	Reflects adherence to the 2013 ADG and Australian Guide to Healthy Eating (AGHE).	2 x 38-item online short food survey (SFS), and 3 x 24hr dietary recall by phone.	11 categories: 7 Food Groups (fruit; vegetables; breads and cereals; meat and alternatives; dairy; beverages; discretionary foods) and 4 Food Choices (whole grains; reduced fat dairy; healthy fats; variety).	0 – 100, points are awarded for each category and summed.

Danish Diet Quality Index (D-DQI); (Knudsen et al., 2012)	Nutrient & Food Index Purpose: Diet Quality	Reflects adherence to the 2005 Denmark Food-based Dietary Guidelines (FBDG).	7-day pre-coded food diary.	6 categories: contribution of energy from fat; saturated fat; energy from added sugar; intake of potatoes, rice, pasta and wholemeal bread; intake of fruit and vegetables; intake of fish.	0 – 6, points are calculated by nutrient analysis and servings, and summed.
Danish Healthy Diet Index (D-HDI-2003); (Dynesen et al., 2003)	Nutrient & Food Index Purpose: Socio-Demographic Characteristics	Reflects adherence to the 1995 Danish Food-based Dietary Guidelines (FBDG).	FFQ performed by computer-assisted telephone interview (CATI).	5 categories: cooked vegetables; green salad/shredded raw vegetables; fruit; fish (fish with sandwiches and fish as a main meal); types of fat spread used on bread.	0 – 15, points are calculated by nutrient analysis and servings, and summed.
Diet Quality Index (DQI); (Patterson et al., 1994)	Nutrient & Food Index Purpose: Nutrient Intakes	Reflects adherence to the 1989 US Dietary Recommendations.	24hr dietary recall, 2-day food record.	8 categories: 6 Nutrients (total fat; saturated fatty acids (SFA); cholesterol; protein; sodium; calcium); 2 Food Groups (fruit and vegetables; grains and legumes)	0 – 16, points are awarded for each category and summed.
Updated Diet Quality Index Revised (DQI-R); (Haines et al., 1999)	As above Purpose: As above	Reflects adherence to the 1992 USDA Food Guide Pyramid, 1995 US Dietary Guidelines and Dietary Reference Intakes.	2 x 24hr dietary recalls performed by interviewer, removed 2-day food records.	10 categories: *Exchanged protein category for iron *Inclusion of a Dietary Diversity Score as a category. *Inclusion of a Dietary Moderation Score as a category.	0 – 100, points are calculated by nutrient analysis and servings, and summed.
Updated Diet Quality Index (DQI-2005); (Zamora et al., 2010)	As above: Purpose: As above.	Reflects adherence to the 2005 Dietary Guidelines for Americans.	Interviewer administered Dietary History Questionnaire.	10 categories: *As above employing updated dietary guidelines recommendations	As above.
Diet Quality Index International (DQI-I); (Kim et al., 2003)	Nutrient & Food Index Purpose: Nutrient Intakes	Reflects adherence to 1996 WHO Dietary Guidelines, USDA Dietary Guidelines, and the Food Guide Pyramid.	2 – 3 x 24hr dietary recalls performed by trained individuals.	4 categories: Variety (meat, poultry, fish, egg; dairy and beans; grains; fruits; vegetables); Adequacy (vegetables; fruits; grains; fiber; protein; iron; calcium vitamin C); Moderation (total fat, saturated fat; cholesterol; sodium; empty calorie	0 – 100, points are calculated by nutrient analysis and servings, and summed.

				foods); Overall Balance (macro-nutrient ratio; fatty acid ratio).	
Modified Indexes Adapted from the DQI; *Alternate Diet Quality Index – a-DQI I (Drewnowski et al., 1996; Drewnowski et al., 1997); Australian Diet Quality Index – Aussie-DQI (Zarrin et al., 2013); Brazil DQI with DFG (Caivano & Domene, 2013); Canadian Diet Quality Index – DQI–C (Dubois et al., 2000); Chinese Diet Quality Index – INFH-UNC-CH-DQI (Stookey et al., 2000); Comprehensive Diet Quality Index – cDQI (Keaver et al., 2021); Diet Quality Index – Swedish Nutrition Recommendation – DQI-SNR-2011 (Drake et al., 2011); Malaysian Diet Quality Index –* MDQI *(Fokeena et al., 2016); Mediterranean Diet Quality Index – MED-DQI (Gerber et al., 2000); Mediterranean Diet Quality Index with tobacco use – MDQI-f (Gerber et al., 2000); Updated Mediterranean Diet Quality Index – MED-DQI (Gerber, 2006).*					
Dietary Guidelines for Americans Adherence Index (DGAI-2005); (Fogli-Cawley et al., 2006)	Nutrient & Food Index Purpose: Nutrient Intakes	Reflects adherence to the 2005 US Dietary Guidelines.	Semi-quantitative FFQ	20 categories: dark green vegetables; orange vegetables; legumes; other vegetables; starchy vegetables; fruits; variety; meat and beans; milk and milk products; all grains; discretionary energy; wholegrains; fiber; total fat; saturated fat; trans-fat; cholesterol; percent serving of lean meat and low-fat milk products; sodium; alcohol.	0 – 20, points are calculated by nutrient analysis and servings, and summed.
Updated Dietary Guidelines for Americans Adherence Index (DGAI-2015); (Jessri et al., 2016)	Nutrient & Food Index Purpose: Obesity Risk	Reflects adherence to the 2015 USDA Food Patterns and Dietary Guidelines for Americans.	Modified version of USDA multiple-pass method to collect 2 x 24hr dietary recalls.	19 categories: *Removed trans-fat category as data was not available.	0 – 19, points are awarded for each category and summed.
Dietary Guidelines Index (DGI); (Harnack et al., 2002)	Nutrient & Food Index Purpose: Incident Cancers	Reflects adherence to the 2000 Dietary Guidelines for Americans.	~ 127 item semi-quantitative FFQ, self-administered.	9 categories; weight status; engage in moderate or vigorous physical activity; Food Guide Pyramid guided food choices; grains and whole grains; fruits and vegetables; saturated fat, cholesterol and total fat; sweets and sugar-sweetened beverages; sodium; alcohol.	0 – 18, points are awarded for category and summed.
International Indexes Adapted from the DGI; *Australian DGI - AU-DGI (McNaughton et al., 2008).*					
Food Standard Agency Nutrient Profiling System	Nutrient & Food Index	Reflects compliance to French Nutritional Recommendations.	3 x 24hr dietary recalls.	7 categories: content in energy; total sugar; saturated fatty acids; sodium;	All foods consumed characterised by FSA nutrient profile, the

Dietary Index (FSA-NPS-DI); (Julia et al., 2014)	Purpose: Characterise Diet Quality			fruits, vegetables and nuts; fibers; proteins.	energy intake from each food was used to compute FSA-derived aggregated scores. Scores were then computed with the FSA-NPS-DI equation.
Healthy Dietary Habits Index (HDHI); (Wong et al., 2017)	Nutrient & Food Index Purpose: Nutrient Intakes, Biomarkers	Reflects adherence to the New Zealand Food and Nutrition Guidelines.	Multiple-pass 24hr recall by interviews, and a 25-item Dietary Habit Questionnaire (DHQ).	15 categories; red meat; chicken; fish or shellfish; milk spread; low-fat foods; fries; bread; fruit; vegetables; soft drinks; breakfast; fast foods; added salt; low-salt foods.	0 – 60, points are awarded for each category and summed. Likert scale rankings are assigned to component measures.
Healthy Diet Indicator (HDI); (Huijbregts et al., 1997)	Nutrient & Food Index Purpose: Mortality	Reflects adherence to WHO Guidelines for the prevention of chronic disease.	Cross check diet history.	9 categories: saturated fatty acids (SFA); polyunsaturated fatty acids; cholesterol; protein; complex carbohydrates; monosaccharides and disaccharides; dietary fiber; fruits and vegetables; pulses, nuts and seeds.	0 – 9, points are awarded for each category and summed.
Updated Healthy Diet Indictor (HDI-2011); (Cade et al., 2011)	As above. Purpose: Breast Cancer Risk	Reflects adherence to the 2003 WHO Dietary Guidelines.	219- item self-administered FFQ.	10 categories: *Additional category for total fat, salt. *Combined complex carbohydrates	0 – 10, points are calculated by nutrient analysis and servings, and summed.
Updated Healthy Diet Indicator (HDI-2013); (Berentzen et al., 2013)	As above. Purpose: Cancer Risk	As above.	FFQ.	7 categories: *Removed categories for monosaccharides and disaccharides, complex carbohydrates; pulses nuts and seeds. *Excluded category for salt.	0 – 7, points are calculated by nutrient analysis and servings, and summed.
Updated Healthy Diet Indicator (HDI-2014); (Jankovic et al., 2014)	Nutrient & Food Index Purpose: Mortality	Reflects adherence to the 2003 WHO Dietary Guidelines	FFQ and validated dietary history method.	7 categories: *Removed total fat and carbohydrates categories. *Replaced mono- and disaccharides with free sugars.	0 – 70, points are calculated by nutrient analysis and servings, and summed.

International Indexes Adapted from the HDI; *Canadian Healthy Diet Indicator – HDI-C (Dubois et al., 2000).*					
Healthy Diet Score (HDS); (Maynard et al., 2005)	Nutrient & Food Index Purpose: Diet Quality	Reflects adherence to Healthy Eating recommendations by the UK Committee on Medical Aspects of Food Policy (COMA).	113-item FFQ.	12 categories: saturated fatty acids; polyunsaturated fatty acids; protein; total carbohydrates; dietary fiber; fruits and vegetables; pulses and nuts; total non-milk extrinsic sugars; cholesterol; fish; red meat and meat products; calcium.	1 – 10 for men, 1 – 11 for women, points are calculated by nutrient analysis and servings, and summed.
Healthy Eating Index (HEI); (Kennedy et al., 1995)	Nutrient & Food Index Purpose: Nutrient Intakes	Reflects adherence to serving recommendations of USDAs 1992 Food Guide Pyramid.	24hr dietary recall, 2-day food record.	10 categories: 6 Adequacy (total fruit; vegetables; grains; milk; meat and beans; dietary variety) and 4 Moderation Nutrients (sodium; total fat; saturated fat; cholesterol).	0 – 100, points are calculated by nutrient analysis and servings, and summed.
Adapted Indexes from the Original HEI; *Modified HEI – mHEI (Carpenter et al., 2004).*					
Updated Healthy Eating Index 2005 (HEI-2005); (Guenther et al., 2008)	As above Purpose: As above	Reflects adherence to the 2005 US Dietary Guidelines and Food Patterns found in USDA's 1992 MyPyramid.	24hr dietary recall, removed 2-day food record.	12 categories: 9 Adequacy and 3 Moderation. *Additional adequacy categories: whole fruit; dark green and orange vegetables and legumes; wholegrains; and oils. *Specified grains category to include total grains. *Additional moderation category: calories from solid fats, alcohol and added sugars replaces total fat and cholesterol.	As above.
Updated Healthy Eating Index 2010 (HEI-2010); (Guenther et al., 2013)	As above Purpose: As above	Reflects adherence to the 2010 US Dietary Guidelines, and revised USDA Food Patterns.	As above.	12 categories: 9 Adequacy and 3 Moderation. *Additional adequacy category: seafood and plant proteins. *Renamed milk category to dairy. *Renamed meat and beans category to total protein foods.	As above.

				*Renamed calories from solid fats, alcohol and added sugars to empty calories. *Greens and beans category replaces dark green and orange vegetables and legumes. *Fatty acids category replace oils and saturated fat categories. *Refined grains replaces total grains category.	
Updated Healthy Eating Index 2015 (HEI-2015); (Krebs-Smith et al., 2018)	Nutrient & Food Index Purpose: Nutrient Intakes	Reflects adherence to the 2015-2020 US Dietary Guidelines.	24hr dietary recall.	13 categories: 9 Adequacy (total fruit; whole fruit; vegetables; greens and beans; whole grains; dairy; total protein foods; seafood and plant proteins; fatty acids) and 4 Moderation (refined grains; sodium; added sugars; saturated fats)	0 – 100, points are calculated by nutrient analysis and servings, and summed.
International Indexes Adapted from the Original Healthy Eating Index (HEI); *Australian Healthy Eating Index - Aust-HEI (Australian Institute of Health and Welfare, 2007); Healthy Eating Index for Australians - HEIFA-2013 (Roy et al., 2016); Brazilian Healthy Eating Index – BHEI (Fisberg et al., 2004); Revised Healthy Eating Index for Brazilians – BHEI-R (Previdelli et al., 2011); Canadian-Adapted Healthy Eating Index – HEI-C (Dubois et al., 2000); Canadian Healthy Eating Index – C-HEI (Shatenstein et al., 2005); Canadian Healthy Eating Index – HEI-C (Tait et al., 2020); Chinese Healthy Eating Index - CHEI (Yuan et al., 2017); Diet Quality Index Adjusted for Energy Requirements – DQI-a (Jaime et al., 2010); Dutch Healthy Diet Index – DHD-Index (van Lee et al., 2012); Dutch Healthy Diet Index 2015 – DHD15-Index (Looman et al., 2017); Ethiopian Healthy Eating Index – EHEI (Bekele et al., 2019); Korean Healthy Eating Index - KHEI (Yook et al., 2015); Healthy Eating Index for Malaysians - HEI-MA (Lee T. T., 2011, March 24-25); Malaysian Healthy Eating Index – MHEI (Teng et al., 2013); Standardised Malaysian Healthy Eating Index - S-MHEI (Jailani et al., 2021); Healthy Eating Index in Thailand - THEI (Taechangam et al., 2008)*					
Alternate Healthy Eating Index (A-HEI); (McCullough et al., 2002)	Nutrient & Food Index Purpose: Chronic Disease Risk	Reflects adherence to 1995 US Dietary Guidelines and MyPyramid.	FFQ	9 categories: fruits; vegetables; nuts and soy proteins; ratio of white meat to red meat; cereal fiber; trans fats; polyunsaturated fat to saturated fat ratio (P:S); duration of multivitamin use; alcohol.	2.5 – 87.5, points are calculated by nutrient analysis and servings, then summed.

Updated Alternate Healthy Eating Index (A-HEI-2010); (Chiuve et al., 2012)	Nutrient & Food Index Purpose: Chronic Disease Risk	Reflects adherence to the 2005 US Dietary Guidelines and MyPyramid.	FFQ	11 categories: fruits; vegetables; wholegrains; sugar-sweetened beverages and fruit juice; nuts and legumes; red and processed meats; trans fats; long-chain fats; alcohol; polyunsaturated fatty acids; sodium.	0 – 110, points are calculated by nutrient analysis and servings, then summed.
Healthy Food and Nutrient Index (HFNI); (Bazelmans et al., 2006)	Nutrient & Food Index Purpose: Mortality	Reflects adherence to the 2003 National Nutrition Council Dietary Guidelines.	24hr dietary recall.	9 categories: saturated fats; monounsaturated fats; polyunsaturated fats; protein; dietary fibers; fruits and vegetables; carbohydrates; dietary cholesterol; beta carotene.	0 – 8, points are calculated by nutrient analysis and servings, and summed.
Korean Diet Score (KDS); (Lee et al., 2013)	Nutrient & Food Index Purpose: Biochemical Factors.	Reflects adherence to the 2010 Korean Food Balance Wheel Guide and Dietary Guidelines.	24hr dietary recall questionnaire.	6 categories: grain dishes; fish and meat dishes; vegetable dishes; fruits; milk and milk products; oils and sugars.	0 – 60, points are awarded by nutrient analysis and servings, then summed.
New Zealand Women's Healthy Diet Indicator (NZW-HDI); (Fenner, 2015)	Nutrient & Food Index Purpose: Nutrient Intake	Reflects adherence to the Eating and Activity Guidelines for NZ adults (EAGNZA)	220-item semi-quantitative FFQ (NZWFFQ), and 4-day weighed food records (WFR).	17 categories: fruit variety; vegetable variety; fruit; vegetables; grains; wholegrains; milk and milk products; the combined (legumes, nuts, seeds, eggs, poultry and red meat, grain foods and milk components); red meat; type of milk; trimming of meat; sodium; takeaway intake; sugar; fluids; proportion of water; alcohol.	0 – 115, points are awarded for each category and summed.
Planetary Health Diet Index (PHDI); (Cacau et al., 2021)	Nutrient & Food Index Purpose: Overall Diet Quality	Reflects adherence to the Dietary Recommendations.	114-item semi-quantitative FFQ.	16 categories: nuts and peanuts; legumes; fruits; vegetables; whole cereals; eggs; fish and seafood; tubers and potatoes; dairy; vegetable oils; ratio of dark green vegetables: total vegetables; ratio between energy intake of red or orange vegetables: total vegetables; red meat; chicken and substitutes; animal fats; added sugars.	0 – 150, points are awarded by nutrient analysis and servings, then summed.

Prime Diet Quality Score (PDQS); (Fung et al., 2018)	Nutrient & Food Index Purpose: Diet Quality and Risk of Ischemic Heart Disease (IHD).	Reflects the ability to differentiate healthy foods from unhealthy foods.	~135-item FFQ	21 categories: vitamin A-rich fruits and vegetables; dark green leafy vegetables; cruciferous vegetables; carrots; potatoes; citrus fruits; other fruits and vegetables; legumes; nuts; red meat; processed meat; poultry; fish; eggs; low-fat dairy; whole grains; refined grains; oils; fried foods; sweets and desserts; sweetened beverages.	0 – 42, points are awarded for each category and summed.
Programme National Nutrition Santé Guideline Score (PNNS-GS); (Estaquio et al., 2009)	Nutrient & Food Index Purpose: Dietary Adequacy	Reflects adherence to French National Recommendations of the PNNS Guides.	6 x 24hr dietary recalls.	13 categories: fruits and vegetables; bread, cereals, potatoes and legumes; whole grain foods; milk and dairy products; meat, poultry, seafood and eggs; seafood; added fats; vegetable added fats; sweetened foods; water and soda; alcohol; salt; physical activity.	0 – 15, points are awarded for each category and summed
Updated Programme National Nutrition Santé Guideline Score (PNNS-GS2); (Chaltiel et al., 2019)	As Above. Purpose: As Above.	Reflects adherence to the 2017 French Dietary Guidelines.	9 x 24hr dietary recalls.	13 categories: *Food group categories were refined, legumes is an independent category. *Adequacy animal products were divided into two moderation categories. *Additional category for nuts.	-17 – 13.5, points are awarded for each category and summed
Adapted Indexes from the PNNS-GS2; sPNNS-GS2 (Chaltiel et al., 2019); mPNNS-GS2 (Chaltiel et al., 2019).					
Recommendation Compliance Index (RCI); (Mazzocchi et al., 2008)	Nutrient & Food Index Purpose: Dietary Trends	Reflects compliance to the WHO Dietary Recommendations.	Food Balance Sheets of the Food & Agriculture Organisation of the United Nations (FAO).	7 categories: intake of fats; proteins; carbohydrates; saturated fats, trans fats, raw sugar, fruits and vegetables.	0 – 1, points are awarded for each category, then normalised to the dichotomous scale.

Recommended Finnish Diet Score (RFDS); (Kanerva et al., 2013)	Nutrient & Food Index Purpose: Obesity	Reflects adherence to the 2004 Finnish Nutrition Recommendations.	131-item FFQ	8 categories: fruits; vegetables; ratio of white meat to red and processed meat; rye; ratio of PUFA: SFA + trans fatty acids; salt; sucrose; alcohol.	0 – 24, points are calculated by nutrient analysis and servings, and summed.
Spanish Food Pyramid Score (SFP); (Molina-Montes et al., 2014)	Nutrient & Food Index Purpose: Chronic Disease Risk and Obesity	Reflects adherence to the 2011 Spanish Dietary Guidelines.	Dietary History Questionnaire administered through personal interviews.	15 categories: potatoes, rice, pasta, bread; whole-meal; vegetables; fruits; olive oil; milk and milk products; fish; lean meat; legumes; nuts; processed meat; sweets; butter; alcohol; physical activity.	0 – 140 plus 30 extra points, points are awarded by nutrient analysis and servings, then summed.
Total Diet Score (TDS); (Russell et al., 2013)	Nutrient & Food Index Purpose: Mortality Risk	Reflects adherence to 1998 AGHE and 2003 DGAA.	145-item semi-quantitative FFQ, and 3 x 4-day WFR.	10 categories: vegetables and fruits; cereals; meat and meat alternatives; dairy foods; saturated fat; sodium; alcohol; sugars; extra foods; physical activity.	0 – 20, points are calculated by nutrient analysis and servings, then summed.
Based on the Mediterranean Diet					
Mediterranean Adequacy Index (MAI); (Alberti-Fidanza et al., 1999)	Nutrient & Food Index Purpose: Nutrient Intakes	Reflects extent of adherence to the Mediterranean Dietary Pattern.	FFQ and Weighed Food Record (WFR).	4 categories: Carbohydrates (bread, cereals, legumes, raw-dry potatoes); Protective Food Group (vegetables, legumes, raw-fresh fruit, fish, alcoholic beverages: red wine, vegetable oils); Land Animal Food Group (milk, cheese, meat, eggs, animal fats, margarines); Sweet Food Group (sweet beverages, cakes, pies, cookies, sugar)	0 – X, scores are obtained by dividing the sum of Groups 1 and 2 by the sum of Groups 3 and 4.
Updated Mediterranean Adequacy Index (MAI); (Knoops et al., 2006)	Nutrient & Food Index Purpose: Mortality	Reflects adherence to the Mediterranean Dietary Pattern	Dietary recall interviews performed by trained dieticians.	2 categories: Mediterranean Food Groups and non-Mediterranean Food Groups. *Combined vegetable oils and margarines. *Replaced vegetable oils with intake of monounsaturated fatty acids *Replaced animal fats and margarines category with saturated fatty acids.	0 – X, scores are computed by dividing the sum of Mediterranean food groups by the sum of non-Mediterranean food groups.

Mediterranean Adherence Diet Screener (MEDAS); (Schröder et al., 2011)	Nutrient & Food Index Purpose: Nutrient Intakes	Reflects adherence to the Mediterranean Dietary Pattern.	2 x FFQs	14 categories: is olive oil principal source of fat for cooking; intake of olive oil; vegetables; fruit; red meat, hamburger, sausage; butter, margarine cream; carbonated, sugar-sweetened beverages; wine intake; pulses; fish, seafood; intake of commercial cakes, pastries; chicken, turkey, rabbit intake; boiled vegetable, pasta, rice, with sauce of tomato, garlic, onion, leeks sauteed in olive oil intake.	0 – 14, points are awarded for each category and summed.
Updated Mediterranean Diet Adherence Screener (MEDAS); (Domınguez et al., 2013)	As above. Purpose: Mortality, CVD Incidence	As above.	136-item FFQ	As above: *MEDAS was weighted by proposed contribution of each component to CHD protection.	As above.
Mediterranean Diet Score (MDS); (Trichopoulou et al., 1995)	Nutrient & Food Index Purpose: Mortality	Reflects adherence to the Mediterranean dietary pattern.	190-item semi-quantitative FFQ.	8 categories: mono-unsaturated: saturated fatty acid ratio; legumes; cereals (including bread, potatoes); fruits and nuts; vegetables; meat and meat products; milk and dairy products; alcohol.	0 – 8, points are awarded for each category and summed.
Updated Mediterranean Diet Scale (MDS-f); (Trichopoulou et al., 2003)	As above Purpose: Mortality	As above	150-item FFQ performed by trained interviewers.	9 categories: *Additional category: fish	As above but 0 – 9 points.
Additional Indexes Adapted from the MDS; *Alternate Mediterranean Diet Score – a-Med (Fung et al., 2005); Italian Mediterranean Index – IMI (Agnoli et al., 2011); Japanese-Adapted Mediterranean Diet Score – jMD (Kanauchi & Kanauchi, 2016); Mediterranean Diet Score – a-MDS I (Haveman-Nies et al., 2001); Mediterranean Diet Score – a-MDS II (Haveman-Nies et al., 2002); Mediterranean Diet Score – a-MDS III (Schröder et al., 2004); Mediterranean Diet Score – a-MDS IV (Pitsavos et al., 2005); Mediterranean Diet Score – a-MDS V (Cade et al., 2011); Mediterranean-Like Dietary Score – MLDS (Benítez-Arciniega et al., 2011); Modified Mediterranean Diet Score – mMDS (Trichopoulou et al., 2005); Modified Mediterranean Diet Score – mMDS-I (Yang et al., 2014); Modified Mediterranean Diet Score – mMED (Byberg et al., 2016).*					

Mediterranean Dietary Pattern (MDP); (Sánchez-Villegas et al., 2002)	Nutrient & Food Index Purpose: Nutrition Epidemiology	Reflects adherence to the traditional Mediterranean Dietary Pattern.	Semi-quantitative FFQ.	9 categories: legumes; cereals; fruit; vegetables; alcohol; monounsaturated fatty acids and saturated fatty acids; trans-fat; meat; milk	0 – 100%, adjusted intakes standardised to a z value, entered into an algorithm. The MDP is converted to a relative percentage of adherence.
Mediterranean Food Pattern (MeDiet); (Sánchez-Taínta et al., 2008)	Nutrient & Food Index Purpose: CVD Risk	Reflects adherence to the traditional Mediterranean Dietary Pattern.	14-item FFQ, and 137-item FFQ.	14 categories: *Content not available	0 – 14, points are awarded for each category and summed.
Mediterranean Score (MS); (Goulet et al., 2003)	Nutrient & Food Index Purpose: Plasma Lipids, Lipoproteins.	Reflects adherence to the typical Mediterranean Diet.	FFQ performed by trained dietician.	11 categories: grains; fruits; vegetables; legumes; nuts and seeds; olive oil; dairy products; fish; poultry; eggs; sweets and red and processed meat.	0 – 44, points are awarded for each category and summed.
Mediterranean-Style Dietary Pattern Score (MSDPS); (Rumawas et al., 2009)	Food-based Index Purpose: Overall Diet Quality	Reflects adherence to the traditional Mediterranean-style Diet and the Mediterranean Diet Pyramid.	126-item FFQ.	13 categories: whole-grain cereals; fruits; vegetables; dairy; wine; fish; poultry; olives, legumes, nuts; potatoes; eggs; sweets; meats; olive oil.	0 – 100, points are awarded for each category, summed and then standardised to the scale.
Relative Mediterranean Diet Score (rMED); (Buckland et al., 2009)	Nutrient & Food Index Purpose: CHD Risk	Reflects degree of adherence to a Mediterranean Diet.	Dietary History Questionnaire interviewed in person.	9 categories: vegetables; fruit; legumes; fish; cereals; olive oil; alcohol; meat; dairy products.	0 – 18, points are awarded for each category and summed.
Adapted Relative Mediterranean Diet Score (arMed); (Buckland et al., 2013)	As above. Purpose: Breast Cancer Risk	As above.	FFQs, FR, Diet History Questionnaires via personal interviews.	8 categories: *Removed alcohol category.	0 – 16, points are awarded for each category and summed.

(ADG – Australian Dietary Guidelines; ADGE – Australians Guide to Healthy Eating; DQI – diet quality index/indices; FFQ – food frequency questionnaire; FBDG – Food-Based Dietary Guidelines; FR – Food Record; UK – United Kingdom; US – United States; USDA – United States Department of Agriculture; NZ – New Zealand; WHO – World Health Organisation; 24hr – 24 hours).

Following those, food-based indicators are the second most common type of diet quality indices with 13 various eligible diet quality indices recognised within this review, such as the DBS-2009 (Kant et al., 2009), DQS-2007 (Toft et al., 2007), HFI-2001 (Osler et al., 2001), FBQI (Lowik et al., 1999), mmDS-2014 (Yang et al., 2014), and MEDAS-2013 (Schröder et al., 2011), all comprising entirely of food-group indicators. **Table 2** presents food or food group-based diet quality indices and corresponding scoring criterions.

Table 2. Food or Food Group-based Diet Quality Indices

Diet Quality Measures; And Author	Type of Measure (Purpose)	Dietary Principles	Dietary Assessment Method	Dietary Components	Scoring Criteria
Diet Quality Score (DQS-2007); (Toft et al., 2007)	Food-Based Index Purpose: Cardiovascular Disease Risk	Reflects adherence to the 1995 Danish Dietary Guidelines.	48-item FFQ	4 categories: fish; fruits; vegetables; fats.	1 – 12, points are calculated by nutrient analysis and servings, and summed.
Dietary Behaviour Score (DBS); (Kant et al., 2009)	Food-Based Index Purpose: Mortality	Reflects adherence to the 2005 US Dietary Guidelines.	FFQ	6 categories: servings of vegetables; servings of fruit; usual intake of whole-grain cereals and breads; usual intake of lean meat and poultry without skin; usual intake of low-fat dairy; usual practice of adding solid fat after cooking	0 – 36, points are calculated by nutrient analysis and servings, and summed.
Healthy Foods Index (HFI); (Osler et al., 2001)	Food-Based Index Purpose: Mortality	Reflects adherence to the 1992 dietary recommendations by the National Food Agency.	28-item FFQ	4 categories: not consuming butter, margarine or lard daily; intake of raw or boiled vegetables at least once daily; consuming coarse white or rye bread at least once daily; intake of fruit at least once daily.	0 – 4, points are awarded for each category and summed.
International Indexes Adapted from the Original HFI; *Healthy Nordic Food Index – HNFI (Olsen et al., 2011)*					
Food-Based Diet Quality Score (DQS); (Masip et al., 2019)	Food-Based Index Purpose: Obesity Measures and Nutrient Intakes.	Reflects adherence to the 2012 Nordic and 2014 Finnish Nutritional Recommendations.	14-item FFQ.	12 categories: dark, rye or crisp bread; white bread, baguette or toast; fruits and berries; vegetables; fish; whole grains; fast food; fat-free or reduced-fat milk or yoghurt; sugar-sweetened soft drinks or juices; energy drinks; butter; margarine or vegetable oil.	0 – 12, points are awarded by nutrient analysis and servings, then summed.

Food-Based Diet Quality Score (DQS); (Nishimura et al., 2015)	Food-Based Index Purpose: Metabolic Risk Factors	Reflects adherence to the 2005 Japanese Food Guide Spinning Top and 2000 Dietary Guidelines.	Self-reported Dietary History Questionnaire.	6 categories: grain dishes; vegetables dishes; fish and meat dishes; milk; fruits; snacks and alcohol.	0 – 60, points are awarded by nutrient analysis and servings, then summed.
Updated Food-Based Diet Quality Score (DQS); (Kuriyama et al., 2016)	Food-Based Index Purpose: Nutrient Intakes	As above.	As above.	7 categories: *Additional category for seasoning and salt intake.	0 – 70, points are awarded by nutrient analysis and servings, then summed.
Food-Based Quality Index (FBQI); (Lowik et al., 1999)	Food-Based Index Purpose: Overall Diet Quality	Reflects adherence to the Food-Based Dietary Guidelines by the Netherlands Bureau for Nutrition Education.	1987 & 1992 Dutch National Food Consumption Survey (DNFCS).	7 categories: bread (including cereals); potatoes (including rice, pasta, pulses); vegetables; fruit; milk and milk products; cheese; meat, fish and eggs.	0 – 7, points are awarded when the quantity consumed was at least the lowest recommended level, and summed.
Food Pyramid Index (FPI); (Massari et al., 2004)	Food-Based Index Purpose: Coronary Heart Disease Risk	Reflects adherence to USDA's 1992 Food Guide Pyramid.	32-item FFQ	2 categories: Group 1: cakes and puddings; meat with visible fat; giblets; pork; poultry with skin; salami; ham with visible fat; sausages; bacon; meat sauces; soft cheese; fat cheese; eggs; fried food. Group 2: bread; pasta and rice; legumes.	A ratio is used to compare intakes of fattier food (Group 1) to another group with minimal fat (Group 2). Denominators reflect numbers of items where scores were available, with numerators reflecting the sum of item score.
Food Quality Score (FQS); (Fung et al., 2016)	Food-Based Index Purpose: Predicts Coronary Artery Disease (CAD) Risk.	Reflects adherence to the 2015 US Dietary Guidelines	135-item FFQ	14 categories: vegetables; fruits; nuts and legumes; wholegrains; yoghurt; sugar sweetened beverages; red meats; processed meats; refined grains; desserts and ice creams; potatoes; potato chips; butter; fried takeaway food.	14 – 70, Intakes are ranked into quintiles, reverse quintile rankings are assigned to lesser healthy items, points are awarded and summed

Global Diet Quality Score (GDQS); (Bromage et al., 2021)	Food-Based Index Purpose: Nutrient Intake and Diet-Related NCD Risk	Reflects Diet Quality Compliance with Globally Important Contributors to Nutritional Adequacy.	FFQ and 24hr dietary recall.	25 categories: dark green leafy vegetables; deep orange fruits; deep orange vegetables; deep orange tubers; white roots and tubers; cruciferous vegetables; other vegetables; citrus fruits; other fruits; fish and shellfish; poultry and game meat; red meat; processed meat; legumes; nuts and seeds; low-fat dairy; high-fat dairy; eggs; whole grains; refined grains and baked goods; sugar-sweetened beverages; juice; sweets and ice cream; purchased fried foods; liquid oils.	0 – 49, points are awarded by nutrient analysis and servings, then summed.
Pro-Healthy Diet Index-8 (pHDI-8) & Non-Healthy Diet Index-8 (nHDI-8) (Hawrysz et al., 2016)	Food-Based Index Purpose: Nutrition Knowledge and Cancer Risk	Reflects Frequency of Recommended Foods by the World Cancer Research Fund (WCRF) and American Institute for Cancer Research (AICR).	16-item Questionnaire of Eating Behaviours (FFQ).	pHDI-8: 8 categories: fruits; vegetables; wholemeal bread; fermented milk drinks; milk; cottage cheese; fish or fish-based dishes; legumes-based dishes. nHDI-8: 8 categories: sweets or confectionery; fried food; alcoholic beverages; sweetened carbonated drinks, canned: meat, fish and vegetables-meat, instant or ready-to-eat concentrated soups, fast food, energy drinks .	pHDI-8: 0 – 16, score is calculated by summing the daily frequency of intakes of selected foods. nHDI-8: 0 – 16, score is calculated by summing the daily frequency of intakes of selected foods.

(FFQ – food frequency questionnaire; US – United States; USDA – United States Department of Agriculture; NCD – Non-communicable disease; 24hr – 24 hours).

Closely behind, are nutrient-based indicators resulting in a total of 11 eligible diet quality indices detected and included in the review, such as the DQINB-1999 (Lowik et al., 1999), the DQS-2002 (Fitzgerald et al., 2002), and FQS-2008 (Kennedy, 2008), incorporating all solely nutrient indicators. **Table 3** presents the nutrient-based diet quality indices and various scoring methods.

Table 3. Nutrient-based Diet Quality Indices and Profiling Systems

Diet Quality Measures; And Author	Type of Measure (Purpose)	Dietary Principles	Dietary Assessment Method	Dietary Components	Scoring Criteria
Diet Quality Score (DQS-2002); (Fitzgerald et al., 2002)	Nutrient-Based Index Purpose: Cancer Incidence	Reflects adherence to the US & Canada Recommendations for Nutrients and Dietary Reference Intakes (DRIs)	24 hr dietary recalls, face-to-face interviews	17 categories: carbohydrates; fat; saturated fat; protein; vitamin A; vitamin C; vitamin E; thiamine; niacin; riboflavin; vitamin B6; vitamin B12; phosphorus; magnesium; iron; zinc; selenium.	0 – 17, points are calculated by nutrient analysis and servings, and summed.
Diet Quality Index Nutrient-Based (DQINB–1999); (Lowik et al., 1999)	Nutrient-Based Index Purpose: Diet Quality	Reflects adherence to the Food-Based Dietary Guidelines by the Netherlands Bureau.	1987 & 1992 Dutch National Food Consumption Survey (DNFCS)	5 categories: total fat; saturated fat; cholesterol; carbohydrates; monosaccharides and disaccharides.	0 – 5, points are calculated by nutrient analysis and servings, then summed.
Deficient Index (DI) & Excess Index (EI); (Thiele et al., 2004)	Nutrient-Based Index Purpose: Socio-Economic Determinants	Reflects adherence to a Balanced Diet Based on the Consumption of Nutrients.	Comprehensive Interviews performed by Trained Nutritionists using a Computerised Dietary History Software (DISHES 98).	<u>Deficient Index</u> - 30 categories: 13 vitamins (Vitamin A, D, E, K, B1, B2, Niacin equivalents, Vitamin B6, Folate equivalents, Pantothenic acid, Biotin, Vitamin B12, Vitamin C); 12 Minerals & Trace Elements (sodium, chloride, potassium, calcium, phosphorus, magnesium, iron, iodine, fluoride, zinc, copper, manganese); Proteins; Carbohydrates; Linoleic Acid (n – 6); Linolenic acid (n – 3); Dietary Fibre. <u>Excess Index</u> - 6 categories: fat; cholesterol; ratio of saturated to unsaturated fatty acids; sugar; alcohol; sodium.	Deficient Index: 0 – 3000, points are calculated by nutrient analysis and servings, then summed. Excess Index: 0 – 600, points are calculated by nutrient analysis and servings, then summed.
Adapted Indexes from the Deficient and Excess Index: *Adapted Thiele Score (Dolman et al., 2014)*					
Food Compass (FCS);	Nutrient Profiling System (NPS)	Intended to guide healthy choices and	8032 unique items within the	9 categories: nutrient ratios; vitamins; minerals; food-based ingredients;	1 – 100, points are awarded for each

(Mozaffarian et al., 2021)	Purpose: Assess food and nutrients to guide healthy choices.	industry reformulation via assessment of food characteristics and processing.	Food & Nutrient Database for Dietary Studies (FNDDS).	additives; processing; specific lipids; fibre and protein; phytochemicals.	category and summed.
Food Quality Score (FQS); (Kennedy, 2008)	Nutrient Profiling System (NPS) Purpose: Nutrient Intakes	Reflects adherence to the 2005 US Dietary Guidelines.	~ 7146-item USDA SR18 Nutrient Database.	2 categories: Shortfall Nutrients: fiber; vitamins A; B12; E; C; D; folate; calcium; magnesium; iron; potassium; and Avoidance Nutrients: calories; saturated fats; cholesterol; sodium; trans fats.	Three FQS algorithms based on the; ratio of shortfall nutrients to avoidance nutrients. FQS1: (Universal) %DV (fiber, vitamins, A, C, E, D B12, folate, calcium, magnesium, iron, potassium)/11 FQS2: (Food-Group) Fruit and Vegetables: %DV (fiber, vitamins A, C, E, folate, iron, calcium, potassium)/8 Grains: %DV (fiber, vitamins A, E, folate, potassium, calcium, iron, magnesium)/8 Dairy: %DV (calcium, potassium, vitamins A, D, magnesium)/5 FQS3 (Expanded): Plus nutrients in FQS1: %DV (protein, zinc, copper, phosphorous, niacin thiamine, riboflavin, vitamin K, B6, pantothenic acid, manganese, selenium, vitamin)/23

					ALL Denominators = %DV (calories, sat. fats, cholesterol, sodium, trans fat calories)/5.
Health Star Rating (HSR); (Australian Government, 2020)	Nutrient Profiling System (NPS) Purpose: Assess nutritional quality to assign health star ratings	Intended to be applied for product comparisons within food categories.	Mintel Global New Product Database (GNPD)	6 categories: non-dairy beverages; dairy beverages; oils and spreads; cheese and processed cheese; all other dairy foods; all other non-dairy foods.	0.5 – 5.0 stars, points are awarded for each category. The resulting HSR Profiler Points are then converted to a HSR.
Nutrient Adequacy Ratio (NAR: MAR); (Madden & Yoder, 1971)	Nutrient-Based Purpose: Nutrient Intakes	Reflects adherence to Recommended Daily Amounts (RDA) proposed by the Food and Nutrition Board of the National Research Council.	24hr dietary recall.	10 categories: energy; protein; vitamin A; ascorbic acid; niacin; riboflavin; thiamine; calcium; phosphorus; iron.	NAR: ratio of intake of a nutrient relative to the RDA. MAR: the average of the sum of NARs.
Nutrient-Rich Foods Index (NRF); (Drewnowski, 2009)	Nutrient-Based Purpose: Assess nutrient content and rank foods to identify nutrient-rich foods.	Reflects adherence to 2005 US Dietary Guidelines and MyPyramid.	National Health and Nutrition Examination Survey (NHANES) 1999 – 2002.	12 total nutrients: 9 Nutrients to Encourage (protein; fiber; vitamins A, C, D; calcium; iron; potassium; magnesium) and 3 Nutrients to Limit (saturated fat; added sugar; sodium)	NRF9.3 algorithm; unweighted sum of % daily values (DVs) for 9 nutrients to encourage, minus the sum of % maximum recommend values (MRVs) for 3 nutrients to limit, calculated per reference amount and capped at 100% DV.
Nutritional Quality Index (NQI); (Gedrich & Karg, 2001)	Nutrient-Based Purpose: Nutrient Intakes	Reflects adherence to the corresponding reference values by the German, Austrian and Swiss	EVS 1993 (German Household Budget Survey)	3 categories: nutrients with maximum requirements (fat, saturated fatty acids, cholesterol, and alcohol), nutrients with minimum requirements (protein, vitamins, minerals, and trace elements); and nutrients with an	Intakes are rated with an Intake Quality Score (IQS). IQS = (1 -|1 – actual intake/corresponding reference value|)·100

		Scientific Societies for Nutrition.		equality requirement (poly-unsaturated fatty acids)	NQI = 0 – 100, calculated by the IQS harmonic mean.
Overall Nutritional Quality Index (ONQI); (Katz et al., 2009)	Nutrient-Based Purpose: Nutrient Intakes	Reflects adherence to the 2005 US Dietary Guidelines.	National Health and Nutrient Examination Survey (NHANES) 2003 – 2006.	3 categories: Numerator Nutrients (fiber; folate; Vitamin A; C; D; E; B12; B6; potassium; calcium; zinc; omega-3 fatty acids; total bioflavonoids; total carotenoids; magnesium; iron); Denominator Nutrients (saturated fat; trans-fat; sodium; sugar; cholesterol); and Macronutrient Factors (fat quality; protein quality; energy density; glycaemic load).	0 – 100, points are calculated by nutrient analysis then entered into the final ONQI algorithm. Resultant scores are converted for consumer use.
International Nutrient Profiling Systems; *Nutri-Score – France (Chantal et al., 2017); Nordic Keyhole – Sweden (Asp & Bryngelsson, 2007); Guiding Stars - North America (Fischer et al., 2011); PAHO Nutrient Profile Model – South America (Pan American Health Organisation, 2016); Chile Stage III Nutrient Profiling System – Chile (Corvalán et al., 2019); Healthier Choice Symbol – Singapore (Singapore Government, 2021); Weqaya - Middle East (United Arab Emirates Government, 2022); Nestle Nutritional Profiling System – Switzerland (Nestle, 2022).*					

(US – United States; USDA – United States Department of Agriculture; 24hr – 24 hours).

Lastly, dietary diversity and variation-based indices make up a small handful of diet quality indices with 7 various eligible diet quality indices identified in this review, including the DDS (Kant et al., 1993), DVS (Fanelli & Stevenhagen, 1985), and the RFS (Kant et al., 2000). **Table 4** presents diet quality indices based on dietary variety and/or diversity to evaluate nutritional intake and the corresponding scoring methods.

Table 4. Dietary Variety-based Diet Quality Indices and Scoring Criteria

Diet Quality Measures; And Author	Type of Measure (Purpose)	Dietary Principles	Dietary Assessment Method	Dietary Components	Scoring Criteria
Dietary Diversity Score (DDS); (Kant et al., 1993)	Food-Based Index Purpose: Dietary Variety and Mortality.	Reflects adherence to USDA's 1990 Dietary Guidelines for Americans.	24hr dietary recall, administered by a trained dietary interviewer.	5 categories: dairy; meat; grain; fruit; vegetable.	0 – 5, points are awarded for each food group consumed, and summed.
Dietary Variety Score (DVS); (Fanelli & Stevenhagen, 1985)	Food-Based Index Purpose: Dietary Variety	Reflects adherence to USDA's 1980 Dietary Guidelines for Americans.	1977 – 1978 Nationwide Food Consumption Survey, 24hr dietary recalls and 2-day food records.	18 categories: high-fat milk products; low-fat milk products; high-fat meats; low-fat meats; soups; mixed dishes; legumes, nuts, seeds; whole-grain products; refined/presweetened grain products; desserts; salty snacks; vitamins A- and C-rich fruits and vegetables; other fruits and vegetables; animal fats; vegetable fats; sugar and sweets.	Cumulative DVS (DVS_n), where *n* = 1 – 3. i.e., DVS_1 is number of different foods consumed in 1 day, DVS_2 was the total number of different foods consumed over 2 consecutive days.
Dietary Variety Score for Recommended Foods (DVSR); (Kant & Thompson, 1997)	Food-Based Index Purpose: Overall Diet Quality	Reflects adherence to USDA's 1992 Food Guide Pyramid.	68-item FFQ, administered by trained interviewers.	5 categories: dairy; meat, nuts and beans; grains; fruits; vegetables.	0 – 27, points are awarded for each recommended food consumed at least weekly.
Recommended Food Score (RFS); (Kant et al., 2000)	Food-based Index Purpose: Mortality	Reflects adherence to the 1989 Dietary recommendations from the US National Academy of Sciences, and the 1995 US Dietary Guidelines.	62-item FFQ	5 categories: fruits; vegetables; whole grains; lean meat or alternatives; low fat dairy.	0 – 23, points are awarded for each recommended food consumed at least weekly, and non-recommended foods consumed less than

					once weekly, then summed.
Not Recommended Food Score (NRFS); (Michels & Wolk, 2002)	Nutrient & Food Index Purpose: Mortality	Reflects adherence to the Sweden Dietary Guidelines.	60-item FFQ, self-administered, and 4 x 7-day weighed food records.	2 categories: RFS (apples and pears; citrus fruit; bananas; lettuce, and cucumber; spinach, kale; tomatoes; cabbage; root vegetables (carrots, beets etc.); beans and peas; milk with 0.5% or 1.5% fat; yoghurt with 1.5% fat; whole grain bread; crisp bread (high fiber content, no fat); oats; salmon, herring and tuna; other fish (excluding shellfish). NRFS (meat; meat stew; minced meat; bacon; sausages; blood pudding, sausages; cold cuts; pate; liver or kidney; fried potatoes; French fries; chips; cheese; butter; margarin; white bread; pancakes or Belgian waffles; cookies; ice cream; candy; sugar.	RFS: 0 – 17; NRFS 0 – 21, points are awarded each time foods are consumed at least 1 – 3 times per month (more often than never)
International Indexes Adapted from the RFS; *Australian Recommended Food Score - ARFS (Collins et al., 2008); Australian Recommended Food Score - ARFS-1 (Collins et al., 2015).*					

(FFQ – food frequency questionnaire; US – United States; USDA – United States Department of Agriculture; 24hr – 24 hours).

Finally, since Monteiro created the first food classification system based on food processing in 2009, NOVA, (Monteiro, 2009), there have been just 7 food classification systems developed that met this review's eligibility criteria. A few examples include IFIC (Eicher-Miller et al., 2012), IARC-EPIC (Slimani et al., 2009), SIGA (Fardet, 2018), and IFPRI (Asfaw, 2011). **Table 5** displays current food classification systems and their categorisations with **Table 6**.

Table 5. Food Classification Systems based on Food Processing Levels

System and Author	Country of Origin	Dietary Assessment Method	System Categories	Scoring/Analysis	Food Processing Definition
IARC-EPIC - International Agency for Research on Cancer - European Perspective Investigation into Cancer and Nutrition; (Slimani et al., 2009)	Europe	EPIC-SOFT computer programme to conduct 24-hour dietary recall face-to-face interview. Purpose: Epidemiology	3 main categories with subcategories. 1. Foods with unknown process 2. Non processed 3. Modestly or Moderately Processed a. Industrial and commercial foods b. Foods processed at home *4. Processed* *(Chajès et al., 2011) split category 4 to;* *4a. Processed staple basic foods* *4b. Highly processed.*	Nutrient intakes and derived patterns were calculated by means of standardised nutrient databases developed through the EPIC Nutrient Database (ENDB). Statistical methods were applied to identify the mean consumption of food and beverages and their percent contribution of the total diet according to their degree of food processing.	Transforming ingredients into products.
Adapted Food Classification System from the IARC-EPIC; *IARC-EPIC II (Chajès et al., 2011)*					
IFIC - International Food Information Council; (Eicher-Miller et al., 2012)	United States	24-hour dietary recall using USDA automated multiple-pass method. Purpose: Communications; also used in epidemiology	5 main categories with sub categories. 1. Minimally processed 2. Processed for preservation 3. Mixtures of combined ingredients 3.1 Packaged mixes, jarred sauce 3.2 Mixtures home prepared 4. ‘Ready to eat’ foods 4.1 Packaged ‘ready to eat’ foods 4.2 Mixtures, store prepared 5. Prepared foods/meals	Nutrient and energy content of foods were derived using various USDA food composition databases. Statistical methods were applied to identify the mean intake of nutrients and percent contribution provided by a specific IFIC category.	Any (deliberate) change to a food (since origin).
IFPRI - International Food Policy Research Institute; (Asfaw, 2011)	Guatemala	2 week dietary recall by trained enumerators Purpose: Epidemiology	Three main categories; 1. Unprocessed foods 2. Primary or partially processed foods 3. Highly processed foods	Nutrient analysis and classification of foods based on the degree of processing but not further explained.	N/A

POTI-UNC - Researchers of University of North Carolina at Chapel Hill; (Poti et al., 2015)	US	Nielson Home-scan Panel 2000 - 2012 Purpose: Epidemiology	2 main categories separated into 4 categories with sub categories on industrial processing, and 3 categories on convenience. 1. Less Processed 1.1 Unprocessed/ minimally processed. 2. Basic Processed 2.1 Processed basic ingredients 2.2 Processed for basic preservation 3. Moderately Processed 3.1 Moderately processed for flavour 3.2 Moderately Processed Grain 4. Highly Processed 4.1 Highly Processed Ingredients 4.2 Highly Processed Stand-alone Separately categorises convenience; 1. Cooking and/or preparation 2. Ready-to-heat (RTH) or minimal preparation 3. Ready-to-eat (RTE)	Nutrient analysis and classification of foods based on the degree of processing but not further explained.	Any procedure that alters food from its natural state and includes all processes and technologies that transform raw food material and ingredients into consumer food products
NOVA - Researchers of University of Sao Paulo; (Monteiro et al., 2019)	Brazil	24-hour recall, record food intake surveys Purpose: Epidemiology, later recommended as the basis for Dietary Guidelines.	4 main categories; 1. Unprocessed and minimally processed foods 2. Processed culinary ingredients 3. Processed food products 4. Ultra-processed products	Categorises foods according to the nature, extent and purpose of industrial food processing.	The methods used by food manufacturers and industries to make ‘raw,’ un-processed foods; less perishable, easier to prepare, eat, digest, more palatable and enjoyable, or if they transform them into food products.

Adapted Food Classification System from NOVA; *Louzada (da Costa Louzada et al., 2015)*					
SIGA – Researchers of University of Clermont Auvergne; (Fardet, 2018)	France	The SIGA index is a scientific score for assessing the degree of transformation. Purpose: Food Product Development and Consumer Guidance	8 technological groups with sub groups; <u>A – Un-/minimally processed</u> A1 – degraded raw matrix A2 – culinary ingredients <u>B - Processed</u> B1 – added salt, sugars, fat < official recommendations B2 – added salt, sugars, and fat > official recommendations <u>C – Ultra-processed</u> C1 – unprocessed industrial ingredients and/or limited additives C2 – processed industrial ingredients and/or high additives C3 – ultra-processed industrial ingredients and/or very high additives	Degree of Transformation + Evaluation of Risk + Nutritional Thresholds = the Siga Score Medals awarded to food and beverage products in each category to help consumers identify the simplest, most natural and therefore least processed foods within each product category.	N/A

(USDA – United States Department of Agriculture; IARC-EPIC – International Agency for Research on Cancer-European Perspective Investigation into Cancer and Nutrition; IFIC – International Food Information Council; IFPRI – International Food Policy Research Institute; POTI-UNC – Poti et al. and the University of North Carolina).

Table 6. Food Classification Systems Category Definitions

Category Definitions
IARC-EPIC (Slimani et al., 2009); **1.** Non-processed – foods consumed raw without any further processing, preparation, except washing, cutting, squeezing **2.** Modestly or Moderately Processed **2a.** Industrial and commercial foods involving relatively modest processing and consumed with no further cooking **2b.** Foods processed at home, prepared or cooked from raw foods or moderately processed foods. **3.** Processed – foods industrially prepared involving high degree of processing such as drying, flaking, hydrogenation, heat treatment, use of industrial ingredients and deep frying.
IFIC Foundation (Eicher-Miller et al., 2012); **1.** Minimally Processed – foods that require little processing or production, which retain most of their inherent properties. **2.** Processed for Preservation – foods processed to help preserve and enhance nutrients and freshness of foods at their peak. **3.** Mixtures of Combined Ingredients – foods containing sweeteners, spices, oils, colours, flavours, and preservatives used for promotion of safety, taste, visual appeal. **3a.** Packaged mixes, jarred sauces. **3b.** Mixtures home prepared. **4.** ‘Ready-to-eat’ foods – foods needing minimal or no preparation. **4a.** Packaged ‘ready-to-eat’ foods. **4b.** Mixtures possibly store prepared. **5.** Prepared foods/meals – foods packaged for freshness and ease of preparation.
IFPRI (Asfaw, 2011); **1.** Unprocessed foods – no formal definition **2.** Primary or partially processed foods – no formal definition **3.** Highly processed foods – undergone secondary processing into a readily edible form and likely to contain added sugars, hydrogenated fats and/or sodium.
NOVA (Monteiro et al., 2019); **1.** Unprocessed and minimally processed foods – unprocessed foods are of plant origin (leaves, stems, roots, tubers, fruits, nuts, seeds), or animal origin (meat, other flesh, tissue and organs, eggs milk), shortly after harvesting, gathering, slaughter or husbanding. Minimally processed foods are unprocessed foods altered in ways that do not add or introduce any substance, but that may involve subtracting parts of the food in way that do not significantly affect its use. Minimal processes include cleaning, scrubbing, washing; winnowing, hulling, peeling, grinding, grating, squeezing, flaking; skinning, boning, carving, portioning, scaling, filleting; drying, skimming, fat reduction; pasteurization, sterilizing; chilling, refrigerating, freezing; sealing, bottling; simple wrapping, vacuum and gas packing. Malting, which adds water, is a minimal process, as is fermenting, which adds living organisms, when it does not generate alcohol. **2.** Processed culinary ingredients – processed culinary ingredients are food products extracted and purified by industry from constituents of foods, or else obtained from nature, such as salt. Specific processes include pressing, milling, pulverizing. Stabilising or purifying agents and other additives may also be used.

3. Processed food products – manufactured by adding substances like oil, sugar or salt to whole foods, to make them durable, more palatable and attractive. Directly derived from the foods and recognisable as versions of the original foods. Generally produced to be consumed as part of meals, or may be used, together with ultra-processed products, to replace food-based freshly prepared dishes and meals. Processes include canning and bottling using oils, sugars or syrups, or salt, and methods of preservation such as salting, salt-picking, smoking and curing. **4.** Ultra-processed products – formulated mostly or entirely from substances derived from foods. Typically contain little or no whole foods. Durable, convenient, accessible, highly or ultra-palatable, often habit-forming, Typically not recognisable as versions of foods, although may imitate the appearance, shape and sensory qualities of foods. Many ingredients not available in retail outlets. Some ingredients directly derived from foods such as oils, fats, flours, starches, and sugar. Others obtained by further processing of food constituents. Numerically, the majority of ingredients are preservatives, stabilisers, emulsifiers, solvents, binders, bulkers, sweeteners, sensory enhancers, colours and flavours, processing aids and other additives. Bulk may come from added air or water. Micronutrients may fortify the products. Most are designed to be consumed by themselves or in combination as snacks. They replace food-based freshly prepared dishes, meals. Processes include hydrogenation, hydrolysis, extruding, moulding, reshaping, pre-processing by frying, baking.
POTI-UNC (Poti et al., 2015); Industrial food processing categories; **1.** Less processed **1.1.** Unprocessed/ minimally processed – single-ingredient foods with no or very slight modifications that do not change inherent properties of the food as found in its natural form. **2.** Basic Processed **2.1.** Processed basic ingredients – single isolated food components obtained by extraction or purification using physical or chemical processes that change inherent properties of the food. **2.2.** Processed for basic preservation or precooking – single minimally processed foods modified by physical or chemical processes for the purpose of preservation or precooking but remaining as single foods. **3.** Moderately Processed **3.1.** Moderately processed for flavour – single minimally or moderately processed foods with the addition of flavour additives for the purpose of enhancing flavour; directly recognisable as original/plant animal source. **3.2.** Moderately processed grain – grain products made from whole-grain flour with water, salt, and/or yeast **4.** Highly Processed **4.1.** Highly processed ingredients – multi-ingredient industrially formulated mixtures processed to the extent that they are no longer recognisable as their original plant/animal source and consume as additions (condiments, dips, sauces, toppings, ingredients in mixed dishes) **4.2.** Highly processed stand-alone – multi-ingredient industrially formulated mixtures processed to the extent that they are no longer recognisable as their original plant/animal source and not typically consumed as additions Convenience categories; **1.** Cooking and/or minimal preparation – requires substantial input of consumer's time, energy, or attention to cook/prepare before consumption; not typically consumed as purchased. **2.** Ready-to-heat (RTH) or minimal preparation – requires a small amount of consumer's time or effort and no culinary skill or attention (such as heating, microwaving, thawing, or adding water); not typically consumed as purchased. **3.** Ready-to-eat (RTE) – can be consumed immediately with no preparation

SIGA (Fardet, 2018); **A** – Un-/minimally processed foods with intact raw initial matrix **A1** – Un-/minimally processed foods with degraded raw matrix **A2** – Culinary ingredients used at home **B** – Processed foods **B1** – Processed foods with added salt, sugars, and fat in proportions in agreement with official recommendations **B2** – Processed foods with added salt, sugars, and fat in proportions above official recommendations **C** – Ultra-processed foods (UPFs) **C1** – UPFs with loose of matrix effect and/or with added unprocessed industrial ingredients and/or limited number of additives **C2** – UPFs foods with loose of matrix effect and/or with added processed industrial ingredients and/or a high number of additives **C3** – UPFs with loose of matrix effect and with added ultra-processed industrial ingredients and/or a very high number of additives. Degree of Transformation of all ingredients according to European regulations and technical documentation. Evaluation of Risk ingredients and additives on the basis of opinions issued by WHO, European Food Safety Authority and the French Agency for Food, Environmental and occupational Health & Safety. Nutritional Thresholds set by the Food Standard Agency, UK in case of addition of fat, sugars, or salt to the food.

(IARC-EPIC – International Agency for Research on Cancer-European Perspective Investigation into Cancer and Nutrition; IFIC – International Food Information Council; IFPRI – International Food Policy Research Institute; POTI-UNC – Poti et al. and the University of North Carolina; UPFs – Ultra-processed foods).

Discussion

Diet quality indices have proved to be helpful tools in epidemiological research, nutritional strategy creation and implementation, tracking changes in dietary habits within specific populations, and monitoring compliance to dietary recommendations and guidelines (Guerrero et al., 2017). Many academics have worked to construct and develop measures of diet quality in the past, resulting in a plethora of diet quality indices (Gil et al., 2015). Over time, diet quality indices are becoming more specialised and suited to certain purposes and groups (Gil et al., 2015). They typically range in complexity from basic methods that appraise compliance to dietary guidelines to comprehensive indices that employ extensive macronutrient and micronutrient intake analysis (Alkerwi, 2014). The disparities in methods are primarily the result of arbitrary decisions made, owing to a lack of information regarding healthful diets and unresolved methodological concerns (Burggraf et al., 2018; Gil et al., 2015). The methods for assessing variances in energy intake, component scoring, and the merging of multiple components requires further investigation (Gil et al., 2015). Due to the significant heterogeneity within each diet quality index, comparing results is challenging (Guerrero et al., 2017). Despite their widespread usage, recent systematic studies have challenged current indices for multiple shortcomings, including the fact majority do not appear simple to use and apply from a clinician, practitioner, or researcher's perspective, along with most having poor predictive potential, raising doubts on the relevance and validity (Alkerwi, 2014; Burggraf et al., 2018; Waijers et al., 2007)

Construction and Composition of Diet Quality Indices

When creating an index to appraise or assess overall dietary quality, there are a number of essential decisions to be made on the factors or component items to be incorporated, the corresponding cut-off values, and their scoring criteria (Waijers et al., 2007). Previous research (Burggraf et al., 2018; Waijers et al., 2007) has established the important decisions made by each investigator when constructing indices of overall diet quality typically consisting of: the theoretical foundation reflecting the index intent and framework; component selection and attributes of components included in the score; allocation of foods into food groupings; selection of cut-off values; precise quantification of the selected index components assessed against the respective cut-off values; energy intake adjustment; and the contribution and weighting of individual elements towards the overall score. With no determined framework for the construction of an index, and the fact many individual decisions are to be made in the creation process, a great level of discretion occurs posing a restriction (Waijers et al., 2007). The reliability and accuracy of an a priori index method is restricted by the existing amount of dietary information available concerning the diet-and-health relationship. This adds to the ambiguity already associated with the creation process of an index, and therefore the assessment of overall diet quality (Burggraf et al., 2018).

In terms of the purpose of diet quality indices, differentiation between indices intended to advise an individual's dietary intake regarding public health promotion initiatives, and indices used to examine and evaluate population diet quality, is essential (Burggraf et al., 2018; Guerrero et al., 2017). The first category seeks basic food group components which are typically based on the translation of dietary recommendations and guidelines into index components, for example, the updated Healthy Diet Indicator (HDI-2013) (Berentzen et al., 2013). The latter category warrants increasingly complex scores as a greater extent of clarification tends to enhance the capacity of the index to discriminate between differing ranks of diet quality among populations. These comprehensive scores result from an increased number of appropriate components within the indices, and/or better distinctive component scoring (Burggraf et al., 2018). Evidently, Wirt and Collins (Wirt & Collins, 2009) and Waijers et al. (Waijers et al., 2007) demonstrate that more intricate diet quality indices, which consider recent epidemiological findings and employ a comprehensive scoring range (e.g., AHEI, AHEI-2010) (Chiuve et al., 2012; McCullough et al., 2002), are superior predictors of diet-related disease risk than many of those developed to essentially assess compliance to the dietary guidelines concentrated on health promotion purposes (e.g., HDI-2013) (Berentzen et al., 2013) (Gil et al., 2015). Notably, the large majority of diet quality indices were developed to approach chronic diet-related diseases prominent in industrialised nations including the United States (e.g., DQI (Patterson et al., 1994), HEI-2005 (Guenther et al., 2008), DGAI-2005 (Fogli-Cawley et al., 2006)) or the Mediterranean area (e.g., MDS (Trichopoulou et al., 1995), mMDS-2005 (Trichopoulou et al., 2005)) (Burggraf et al., 2018; Gil et al., 2015; Guerrero et al., 2017).

Types of Indices

Ultimately, there are three primary types of diet quality indices: food-based, nutrient-based, and combination-based, all guided by epidemiological data on diet and disease. Index selection must be supported by recent research, current nutritional guidelines, and country-specific factors (Burggraf et al., 2018). Dietary aspects included in the scoring of diet quality are nutrients and foods or food groups considered to be healthful or harmful (Gil et al., 2015).

Food-or-Nutrient-based Indices

Dietary trends and patterns have received an increasing amount of attention over the last two decades. The key justification for the change is that food and nutrient intakes are linked as individuals typically do not consume single nutrients or foods, but rather combinations of foods and nutrients (Kant, 1996; Waijers et al., 2007). Food-based indices of total diet quality, which indicate the adequacy of food and food group consumption, utilise dietary guidelines for recommended quantities and frequency, while others merely count foods and food groupings (Gil et al., 2015; Guerrero et al., 2017). While there is some debate on the formation and inclusion of scores, there is no doubt about the significance of an adequate intake of fruits and vegetables within the diet (Waijers et al., 2007). Except for those that exclusively include nutrients, all diet quality indices contain the components fruits and vegetables either individually or together (Gil et al., 2015; Waijers et al., 2007). Food-group indices are valuable as they are simpler to use and consider nutritional relationships within items (Burggraf et al., 2018). However, indices based on a limited number of broadly defined food groups can present a shortcoming as composites may be derived that are unlikely to recognise the significant variation within the relevant food groups (Burggraf et al., 2018).

Despite that, the focus of nutritional epidemiology has historically been on the influence of specific dietary components, with nutrient-based indices used to measure the health potential of food items, depending on the quantity of selected nutrients (Waijers et al., 2007). Nutrient-based indices of diet quality, representing nutrient intake adequacy, employ ‘summary measures’ generated from a collection of nutrients or single-nutrients and utilise as indicators of intake of multiple nutrients (Kant, 1996). A ‘reductionist’ approach such as this is able to expose the function of foods or nutrients in disease development, but not without its shortcomings (Alkerwi, 2014; Waijers et al., 2007). Saturated fat is an example of this, with its historical linkage to heart disease often resulting in penalisation within diet quality indices, particularly with the recent controversy surrounding the topic. In contrast to food-based indices, nutrient-based indices require significantly more data as translating dietary consumption into nutrient intake demands assessing the quantities of individual foods (Burggraf et al., 2018). As a result, converting foods to nutrient intakes may increase the chance of measurement error due to the incorrect use of food composition tables posing a shortcoming (Burggraf et al., 2018). Although, food-based indices are not without their shortcomings too. The fundamental drawback of food-group based indices is foods typically contain a mixture of nutrients that are meant to be beneficial, and nutrients when excessively consumed, may raise the risk of developing chronic disease (Burggraf et al., 2018). Therefore as a result, given the simplicity of food-based indices and the complexity of nutrient-based indices, it appears appropriate to employ dietary aspects from both types (Burggraf et al., 2018).

Combination-based Indices and Dietary Variety

Diet quality indices based on combinations of food categories and nutrient intakes are the most common method seeing as individuals do not ingest single foods or nutrients in isolation. Investigation into the possible relationship between food or nutrients and illness should concentrate on the entirety of the diet as opposed to singular foods or nutrients (Guerrero et al., 2017). As a result, public health professionals and dietitians have long advocated for diversity or variation within dietary patterns as a method for promoting an adequate dietary intake. The core premise was that no singular food item supplied all necessary elements required for a balanced diet (Gil et al., 2015). Several researchers incorporate a component indicating dietary diversity within the index representing the multitude of distinct foods or food categories ingested over a specific time period, as intake of a wider range of foods is deemed favourable when compared to repetitive diets (Waijers et al., 2007). Nonetheless, while the decision between nutrient and food category indices is not simple, several fundamental concepts may be developed that accommodate for the strengths and shortcomings of each method (Burggraf et al., 2018).

Cut-off Values and Scoring Systems

A key concern with diet quality indices is the ongoing debate regarding the portions or quantities of various nutrients and/or food groupings which should preferably be consumed (Guerrero et al., 2017). Although the assessment of dietary requirements and their cut-offs is a complex and difficult task (Alkerwi, 2014; Guerrero et al., 2017), most countries have published their own dietary recommendations and advice based on expert academic group results representing typical features of their population(s). Specialised guidelines and advice is created for specific groups depending on age, gender, and physiological state, such as breastfeeding or pregnant women (Guerrero et al., 2017). The degree to which a specific nutrient is utilised, the presence of precursors, the bioavailability, possible associations with alternate compounds, and potential modification or loss throughout preparation, processing, storing, and transportation, all factor and contribute to the nutritional recommendations (Guerrero et al., 2017).

After determining which properties will be incorporated within the index, quantification is required. The simplest way is to assign points based on a pre-determined cut-off value for every component. However, this is a fairly straightforward and unambiguous methodology, and the inquiry concerning how to select cut off numbers still remains unanswered (Waijers et al., 2007). Notably, the majority of the Mediterranean Diet Score (MDS) indices employ the group median intake to function as the component cut-off numbers. Utilising cut-off values determined by group medians largely vary among populations and are therefore often not associated with recommended or desirable levels of dietary intake. (Burggraf et al., 2018; Waijers et al., 2007). Other indices categorise or rate items depending on current perceptions on what constitutes a healthful level of consumption and are generally focused on dietary recommendations (Burggraf et al., 2018; Waijers et al., 2007). Rather than simply one cut-off value, as included in the MDS (Trichopoulou et al., 1995), HDI (Huijbregts et al., 1997), DQI-a (Drewnowski et al., 1996), FBQI (Lowik et al., 1999), and HFI (Osler et al., 2001), various other indices employ a three-tiered range with a lower cut-off, intermediate range, and an upper limit (e.g., DQI (Patterson et al., 1994), MDQI (Gerber et al., 2000), DQI-R (Haines et al., 1999), DGI (Harnack et al., 2002)) (Waijers et al., 2007). Many indices also employ scoring for each item by the proportionality of how well the dietary recommendations are satisfied, such as the HEI (Kennedy et al., 1995), AHEI (McCullough et al., 2002) and DQI-I (Kim et al., 2003) (Burggraf et al., 2018; Waijers et al., 2007).

Another crucial, yet often overlooked, concern is the proportional contribution of the various components to the final dietary score. Many indices provide equal weighting across individual components, implying each component contributes equally to the overall diet quality score. However, it is unlikely all components within indices will have the same health implications. As a result, it might be preferable to assign higher weightings to components with known beneficial impacts on health (Burggraf et al., 2018; Waijers et al., 2007). Several indices include numerous components that comprise similar or closely associated dietary factors so then collectively, they provide a greater weighting component to the score (Waijers et al., 2007). Although, commonly many academics do not address this issue as proving the selection for various weighting of index components is challenging. However, not weighting components leads to all index components weighing equal, which must also be substantiated (Waijers et al., 2007).

Overall, the variation in scoring and absence of consistency within the factors utilised to establish and develop a diet quality index highlight the uncertainty and lack of a globally agreed upon definition. This is reflected in the variety of techniques, each not without its benefits and limitations (Alkerwi, 2014). Despite an abundance of established indices, food processing is frequently disregarded in such methods, which presently influence several government education and awareness initiatives, as well as nutrition and food public health frameworks (Monteiro, 2009). This reductionist approach of several diet quality indices is a significant constraint. More so, existing diet quality indices solely examine nutritional content and sufficiency of foods, neglecting to address food structure, composition, or degree of processing, posing an additional constraint (Fardet et al., 2015). This is due in part to the wide variety of foods seen within a single food category. As a matter of fact, diet quality indices combine foods with various processing attributes within the same food categories, for example whole fruit and fruit juice, wholegrain and sweetened cereals, and red and processed meat (Fardet et al., 2015). However, numerous processed foods may have differing health implications to unprocessed foods within the same food category. As a result, when acknowledging the processes employed on food, certain processed foods are unlikely to simultaneously raise and lower chronic disease risk (Fardet et al., 2015), which might also impact the evaluation or perception of one's overall diet quality.

Food Classification Systems

In principle, researchers developed these categorisation systems to investigate the correlations between industrial goods and dietary intake, health, and disease risk (Asfaw, 2011; Eicher-Miller et al., 2012; Fardet, 2018; Monteiro, 2009; Monteiro et al., 2019; Monteiro et al., 2018; Poti et al., 2015; Slimani et al., 2009). The NOVA system has been widely employed in research on availability of food, dietary intake quality, and health implications, most notably obesity (Monteiro et al., 2019; Monteiro et al., 2018; Moubarac et al., 2014). The NOVA categorisation system established the phrase “ultra-processed food,” that has since impacted or directed dietary recommendations in a number of nations, including Brazil, Belgium, Ecuador, France, Uruguay and Peru (Sadler et al., 2021). Developed in France by academics, the SIGA classification system aims to build and advance upon NOVA by serving as a resource to support industries in revising their offered products and guiding consumers – it is comparable to food labelling systems (Fardet, 2018). While the International Food Information Council (IFIC) categorisation system has been employed within studies, it was designed as a medium of communication to convey facts, explain misconceptions, and assist consumers. As a result, it highlights the advantages of food processing (Eicher-Miller et al., 2012). Furthermore, the International Agency for Research on Cancer (IARC-EPIC) created a categorisation system to examine and evaluate the nutritional content of consumables in European contexts (Slimani et al., 2009). An academic at Guatemala’s International Food Policy Research Institute (IFPRI) devised a categorisation system that has been employed in later studies (Asfaw, 2011), and experts at the University of North Carolina at Chapel Hill (POTI-UNC) created one that classifies all barcoded consumables sold in the United States retailers (Poti et al., 2015). The dimensional approach towards food categorisation according to extent of processing dismisses developed nutrient-based techniques and shifts from conventional food categories, such as ‘dairy and dairy products’ and ‘cereal and cereal products’, resulting in increased debate regarding the concepts and defining terms encompassing processed consumables (Sadler et al., 2021).

System Classifications and Categories

While all these systems aim to classify dietary intake according to processing, there are substantial differences between them. NOVA system classifies consumables into four categories (Monteiro et al., 2019), IFIC into five (Eicher-Miller et al., 2012), and POTI-UNC into seven processing categories (Poti et al., 2015). IFPRI and IARC-EPIC systems are organised into three categories (Asfaw, 2011; Slimani et al., 2009), whereas SIGA is divided into two primary categories with a further four sub-categories (Fardet, 2018). The presence of varying numbers of classification categories across all food classification systems suggests the terminology and classification frameworks of processed consumables vary between systems. **Table 6** presents the food classification systems and the respective category definitions. The classification criteria utilised are unclear, contradictory, and frequently assign lesser weight to current evidence-based information on nutritional and food processing impacts. Unsurprisingly, careful examination causes debates among academics (Sadler et al., 2021). The principle of food classification systems is typically not described beyond the "degree of processing" (Asfaw, 2011; Slimani et al., 2009). When additional information is provided, it refers to the magnitude of change from the natural condition (Eicher-Miller et al., 2012; Poti et al., 2015). It is unclear however how this is calculated. The definitions of the categories suggest consumables are classified depending on the nature of alteration, such as modifications to a product's intrinsic qualities or the inclusion of substances such as sugar, fat, salt, or food additives (Sadler et al., 2021). The classifications within the systems essentially represent the degree of change from component to product (Sadler et al., 2021).

Extent of Food Processing

The nature and extent of alteration indicates the degree to which the natural state has been transformed, spanning from unchanged consumables in their natural state to industrially manufactured items (Sadler et al., 2021). This definition is utilised directly or indirectly by many categorisation systems, including IFIC (Eicher-Miller et al., 2012), IARC-EPIC (Slimani et al., 2009), POTI-UNC (Poti et al., 2015), NOVA (Monteiro et al., 2019) and SIGA (Fardet, 2018). The 'unprocessed category' is defined in certain categorisation systems by utilising the terms 'natural,' 'wholesome' and 'raw.' (Sadler et al., 2021). There are strong discrepancies over which characteristics indicate the degree of processing, highlighting disparities in how processed consumables are described (Sadler et al., 2021). Many categorisation systems, with little rationale or coherence, allocate certain types of processing procedures to distinct processing classifications (Sadler et al., 2021). For instance, IARC-EPIC considers fermentation, pasteurisation, curing, smoking (of especially meat), and salting to be highly processed (Slimani et al., 2009), whereas NOVA considers such to be either minimally processed or processed (Monteiro et al., 2019). The NOVA and POTI-UNC food classification systems are also said to examine the 'purpose' or goal of undergone processing (Monteiro et al., 2018; Poti et al., 2015), which looks to correspond with dietary habits and consumer cooking or intake of natural foods, although these attributes are not comprehensively analysed. Various categorisation systems, such as IFIC (Eicher-Miller et al., 2012), POTI-UNC (Poti et al., 2015), NOVA (Monteiro et al., 2019) and SIGA (Fardet, 2018), allude to the nature of alteration, classifying consumables based on how processing impacts the qualities of the natural food (Sadler et al., 2021).

Simply, addition of ingredients is considered processing. Food classification systems NOVA and POTI-UNC classify minimally processed items as singular foods, as opposed to numerous-ingredient processed consumables (Monteiro et al., 2010; Poti et al., 2015; Sadler et al., 2021). Various categorisation systems take into account the additional ingredients, alluding to the quantity or kind of substances used, notably food additives are classified independently from sugar, fat, and salt (Sadler et al., 2021). NOVA derivations examine the addition of fat, sugar, or salt, claiming these elements are not included among minimally processed consumables (da Costa Louzada et al., 2015). Addition of oil, syrup or sauce when canning implies highly processed consumables according to the IARC-EPIC categorisation system, as opposed to canning, in water, juice, or brine, that is classified moderately processed (Slimani et al., 2009). It is unclear whether this distinction is made across other alternate categorisation systems. Many categorisation systems are employed to evaluate the usage of additives although numerous have differing viewpoints on how these factors are to be acknowledged when determining the 'degree of processing' (Sadler et al., 2021). The key issues regard why the additives are utilised and to what quantity as the main constituents of ultra-processed foods are thought to be additives (Moubarac et al., 2014). The inclusion of substances such as, 'flavours, colours, emulsifiers, sweeteners, thickeners, bulking, carbonating foaming, glazing agents', and so on, can then be utilised to detect ultra-processed consumables, as per Monteiro et al. (Monteiro et al., 2019). Whereby, POTI-UNC classify foods including flavouring additives as moderately processed (Poti et al., 2015). The SIGA classification system, which considers the food matrix, additionally classifies additive amount, quantity, and role, along with risk (Fardet, 2018). IARC-EPIC, on the other hand, identifies fortification and enhancement as characteristics of highly processed consumables (Slimani et al., 2009).

Modification of Intrinsic Properties

According to reports, the IFIC and POTI-UNC categorisation systems consider the physical and chemical alterations that occur in foods owing to food processing (Eicher-Miller et al., 2012; Poti et al., 2015). Employing the IFIC system, Eicher-Miller et al. (Eicher-Miller et al., 2012) implies minimally processed consumables maintain many of their inherent characteristics, although taking into account the lowest category is 'minimally processed' within the IFIC system as it does not incorporate 'unprocessed.' In a similar manner, NOVA literature discuss' the preservation of nutritional qualities among minimally processed consumables (Monteiro, 2009). Pasteurisation and sterilising are instances of minimal processing procedures listed by NOVA that have insignificant impact on nutritional content (Moubarac et al., 2014; Sadler et al., 2021). SIGA, which evaluates the food matrix's integrity, expands on the notion of whole foods (Fardet, 2018). Whereas NOVA, on the other hand, does not account for the food matrix when defining whole foods, as it claims that minimal processing is primarily physical, that could likely alter the food matrix (Monteiro et al., 2010). Changes in intrinsic properties are not utilised to categorise objects in a systematic way. Therefore, different processes with distinct impacts on foods are frequently grouped together within the same processing classification (Sadler et al., 2021). For example, NOVA classifies methods such as boiling, crushing, drying, fractioning, freezing, grinding, roasting, vacuum packing, non-alcoholic fermentation, and more all within 'minimal processing' (Moubarac et al., 2014). Various processing procedures may have greater impacts on the nutritional content of some foods, than on others. Procedures such as crushing and grinding impact the food matrix's integrity, however, drying, vacuum packing and freezing are believed to have minor impacts (Sadler et al., 2021). Although, certain processes may indeed be allocated to several categories depending on the authors. The notion of 'whole foods' and the food matrix function in regard to healthful dietary intakes requires additional explanation, as does the risk assessment and management of food additives (Sadler et al., 2021).

Processing Location

Furthermore, various food classification systems, including IARC-EPIC, NOVA, and a derivation, Louzada, differentiate among residential, artisanal and industrial processing, incorporating the location where processing takes place, by whom, and the accompanying techniques and materials (da Costa Louzada et al., 2015; Monteiro et al., 2019; Sadler et al., 2021; Slimani et al., 2009). Both POTI-UNC and NOVA describe food processing definitions limited to industrial processes (Monteiro et al., 2019; Poti et al., 2015). Only IARC-EPIC, IFIC and Louzada classification systems tend to identify processed foods prepared at home, with home-made items classified as 'minimally' or 'moderately processed' (Chajès et al., 2011; da Costa Louzada et al., 2015; Eicher-Miller et al., 2012; Slimani et al., 2009). The emphasis on industrial processing is one commonality between the food classification systems. The majority of categorisation systems do not distinguish between home-made or artisanal products, nor recognise them as less processed. Furthermore, it has been highlighted that some ultra-processing procedures have 'no domestic counterparts' (Monteiro et al., 2018; Moubarac et al., 2014). Therefore, ultra-processed products typically contain elements frequently utilised only by the industry and thus are not commonly seen in consumer markets (Monteiro et al., 2019; Monteiro et al., 2018; Moubarac et al., 2014). The inclusion of industrial substances in highly processed products is mentioned within the IARC-EPIC system (Slimani et al., 2009).

<u>Implications and Recommendations</u>

Although there are some similarities between the evidence of food processing, disease epidemiology, and food classification system design, they frequently lack a strong foundation (Sadler et al., 2021). Epidemiological research typically gathers limited data on how foods are processed, and current food composition databases lack comprehensive information regarding processing, or the substances present in processed products (Sadler et al., 2021; van Boekel et al., 2010). Notably, food processing and the extent are often viewed differently by various individuals. The established food classification systems cover various components of industrial products along with dietary culture (Sadler et al., 2021). Differences of opinion between these food classification systems has led to conflicting results concerning the association between intake of processed foods and dietary quality (Bleiweiss-Sande et al., 2019). Many classification schemes lack the ability to quantify and communicate proportions of dietary intake under the food processing categories, instead implying an association between the processing of food and nutrition (Sadler et al., 2021). While food classification systems tend to be simpler than the complex algorithms, they still fail to translate simple dietary analysis messages. The SIGA index, created in France, is the first food categorisation system incorporating a quantitative formula for determining the 'degree of transformation' (Fardet, 2018). Albeit, this classification system is intended for food product formation and consumer usage, as opposed to an overall individual dietary quality evaluation. Future research should investigate further developing diet quality indices and a corresponding framework to ensure indices are regularly developed and updated to reflect recent epidemiological research findings, for instance intakes of saturated fats and processed foods. Further research should also explore the inclusion of quantification among food classification systems based on food processing, applying an appropriate scoring or ranking method to provide quantification of results. Finally, additional research surrounding the food matrix function in regard to healthful dietary intakes could be beneficial providing insight into the importance of food matrix inclusion among diet quality indices and food classification systems.

Conclusion

Over time, there has been a significant number of indices or tools created to aid in appraising or assessing quality of dietary intake across various populations. Although, the lack of quantitative metrics succeeding categorisation of foods according to levels of processing, is a significant disadvantage shared by all food classification systems. The absence of suitable quantitative scoring criteria across food classification systems limits the capacity to measure intakes of processed foods and appraise or assess an individual's overall diet quality. In addition to this, the flawed oversimplified and reductionist approach of diet quality indices, along with the discrepancies in cut-off values, scoring, and lack of consistency among included components, emphasise the uncertainty and need for a widely agreed-upon definition of dietary quality. Presently, there is no suitable assessment instrument for diet quality available yet that can categorise consumable items respective to the level of processing and offer quantification of overall healthfulness and dietary quality.

Chapter Two

Application of Diet Quality Assessment Tools on Sample Meal Plans

<u>Introduction</u>

There is growing awareness around the role ultra-processed foods play in the development of diet-related diseases, becoming widely accepted that quality of nutritional intake is critical for prevention of diet-related diseases. As a result, it is essential to ensure there are appropriate appraisal and assessment tools for dietary quality that take into consideration the complex and multidimensional nature of nutritional quality. Although several diet quality indices and tools have been created to assess the healthfulness of dietary intakes, not only within specific countries for monitoring purposes but also across countries for comparative work, each established index or system is substantially different to another despite seeking the same outcomes. This can typically be explained by many factors, including the differential dietary guidelines or recommendations on which the system is based, the components in which is included, and the cut-off values and respective scoring.

Some key findings and points of critique that have arisen include that existing diet quality indices are generally oversimplified in the way that they condense large amounts of dietary advice into few components to classify and score dietary intake. As a result, factors such as the intake of different cuisine styles, the presence of additives in foods, and the extent of food processing is often disregarded despite being a crucial element to many dietary intakes today. Existing food classification systems that are centered on the extent of food processing excel at classifying dietary intake, although there is absence of succeeding quantitative metrics (i.e., applying a quantitative score to a single or multiple meal plans) following classification of dietary intake. The inclusion of a quantitative scoring criteria following classification of dietary intake provides the ability to measure intakes of processed items, and as a result, appraise an individual's overall quality of dietary intake. This approach is relevant as it allows for future research to investigate any associations and guide public health messages where necessary.

To address this, researchers at AUT's Human Potential Centre have created a nutritional classification system, known as the 'Human Interference Scoring System' (HISS) (see Appendix A). The system is currently in the development and testing stage. The HISS aims to classify dietary intake based on food processing levels and quantify overall diet quality via total servings of unprocessed and processed foods. The system is based off NOVA although with some key modifications to the categories and classifications. HISS initially classifies dietary intake across four categories – unprocessed and minimally processed, processed I, processed II, and ultra-processed. Although, different to other classification systems, HISS utilises recommended dietary serving sizes to quantify the classification of dietary intake. To score the HISS, there are two processes. First, to categorise the food into each of the four categories, and second, to tally the scores in each category. Output can be presented as a number or a percentage of serves from each HISS category relative to total serves from that day. Therefore, the aim is to apply four well-established diet quality indices, alongside the newly developed Human Interference Scoring System (HISS), to assess the overall healthfulness and diet quality of sample meal plans.

Methods

For this component of the research, a post-positivist paradigm is applied with a quantitative descriptive research design. The new food classification system, the Human Interference Scoring System (HISS), was developed by this research team for another project, though is used within this project (see Appendix A). Five hypothetical meal plans were also developed intentionally by the research team to portray different dietary styles and eating patterns (see Appendix B). The development of these meal plans by the research team was not a part of this current particular project; however the meal plans are used within this project. The selection of meal plans were based on dietary intakes that represented different eating patterns, including intakes with a high representation of; convenience and fast foods, whole-foods, or intakes complying with the Ministry of Health (MOH) dietary guidelines. The meal plans were entered into the FoodWorks software (Xyris, Version – 10.0.4266) for nutrient analysis (see Appendix C). To ensure consistency with the data, entry of the meal plans into FoodWorks was conducted by two researchers. Each meal plan was compared by both researchers across nutrient output and adjusted for any discrepancies beyond 60 kcal energy intake or 15 grams of any macronutrient (<10% of total intake). Where there were discrepancies larger than the threshold, the entries were checked and changes were made where errors were either detected in the entries themselves, or decision points for data entry.

The respective FoodWorks nutrient relating to each meal plan was then analysed using four diet quality indices (HEI-15, DQI-I, MDS-f, and HDI-2014) alongside the newly developed Human Interference Scoring System (HISS), to assess the overall healthfulness and overall diet quality of the meal plans. To compare the alignment of dietary quality of the meal plans across each index, a spearman's rho statistical test was applied using a SPSS Statistics software (Brand IBM, Version – 1.0); correlation coefficients between the four diet quality indices were generated.

Results

The overall diet quality scores for the five assessment tools are shown in **Table 7.** The scores of two diet quality indices (HDI-2014 and MDS-f) have been converted to a percentage to standardise the results. The spearman rho correlation coefficients for the four-diet quality index assessment tools are shown in **Table 8.**

Table 7. Overall Diet Quality Scores across Assessment Tools

	HEI-15	DQI-I	HDI-2014	HDI-2014	MDS-f	MDS-f	HISS Total Number of Servings (% contribution to total)			
	/ 100	/ 100	/ 70	as a %	/ 9	as a %	Un/Minimal. Processed	Processed I	Processed II	Ultra-Processed
MP1	54	68	63	90	6	67	4 (16)	8 (32)	5 (20)	8 (32)
MP2	39	51	15	21	3	33	5.5 (19)	2 (7)	0 (0)	22 (75)
MP3	43	51	33	48	1	11	4.75 (36)	3 (23)	0 (0)	5.5 (42)
MP4	37	54	47	68	6	67	3 (12)	3 (12)	0 (0)	19 (76)
MP5	59	55	45	65	7	78	20.5 (75)	1.5 (5)	2 (7)	3.5 (13)

(HEI-15 - Healthy Eating Index (2015); DQI-I - Diet Quality Index - International; HDI-2014 - Healthy Diet Indicator (2014); MDS-f - Modified Mediterranean Diet Scale; HISS - Human Interference Scoring System; MP – Meal Plan).

Table 8. Spearman Rho Correlation Coefficients Between Diet Quality Measures

Index	HEI-15	DQI-I	HDI-2014	MDS-f
HEI-15	**-**	.56	.20	.46
DQI-I	**-**	**-**	.87	.78
HDI-2014	**-**	**-**	**-**	.56
MDS-f	**-**	**-**	**-**	**-**

(HEI-15 - Healthy Eating Index (2015); DQI-I - Diet Quality Index - International; HDI-2014 - Healthy Diet Indicator (2014); MDS-f - Modified Mediterranean Diet Scale).

Across all assessment tools, meal plan 1 was scored consistently with a high diet quality score within the sample. The Healthy Diet Indicator (HDI-2014) and the Diet Quality Index International (DQI-I) strongly correlate, with both scoring meal plan 1 as the highest quality of dietary intakes. Similarly, all assessment tools align in scoring meal plan 2 with low scores of diet quality. Consistently, the strongly correlated HDI-2014 and the DQI-I both score the meal plan as the lowest quality of dietary intakes. Shown across most tools, meal plan 3 was similarly ranked with lower diet quality scores. Minor disparities across the tools resulted in the Healthy Eating Index (HEI-15) scoring the meal plan slightly higher, consistent with the Human Interference Scoring System (HISS) indicating the meal plan had an average intake of ultra-processed foods with the second-highest intake of unprocessed and minimally processed foods. There were some discrepancies in the level of similarity between the scoring of tools for meal plan 4. The HDI-2014 and Modified Mediterranean Diet Scale (MDS-f) tools scored them as being high diet quality, while the HEI-15 and HISS identify the intake in this meal plan to be of low quality comprising mostly of ultra-processed foods. Portrayed across all tools, meal plan 5 was consistently ranked with higher scores of diet quality. In fact, mostly all assessment tools score the dietary intake as the highest quality across the sample with some minor disparities in the HDI-2014 and DQI-I.

Discussion

To appraise the diet quality scores of the five hypothetical meal plans across systems, four diet quality indices were employed alongside the HISS. Despite each assessment tool seeking the same outcome, the construction of assessment tool has a major influential part in the resulting score, which can have implications thereafter. The results show varied diet quality scores across the meal plans identifying the diversities and inconsistencies between the tools. This indicates each diet quality assessment tool has different values and interpretations of what a quality dietary intake resembles depending on the construction of the tool. As earlier mentioned, diet quality index construction typically relies on qualities chosen by the researcher in line with the research aims with the above results confirming that varied perspectives and entrenched interests do impact the index composition and resulting diet quality scores.

Meal Plan Diet Quality Scores

The resulting data suggests the Healthy Diet Indicator (HDI-2014) has the highest average diet quality score among the sample indicating the meal plans better aligned with the dietary guidelines in which the index was based on, those being the 2003 World Health Organisation (WHO) dietary guidelines. This indicates the hypothetical meal plans closely reflected the most recent international dietary guidelines the best. Closely followed in average was the Diet Quality Index International (DQI-I) which in turn is not overly surprising as the index is also based off World Health Organisation (WHO) dietary guidelines as is the Healthy Diet Indicator-2014, although the older 1996 revision. Consistent with the Healthy Diet Indicator (HDI-2014), the Diet Quality Index International (DQI-I) scored meal plan 1 with the highest score, reflecting the best adherence to dietary intakes that resemble the World Health Organisation dietary guidelines and recommendations. In addition, meal plan 2 was consistently scored with the lowest diet quality scores when employing the Diet Quality Index International (DQI-I) and the Healthy Diet Indicator (HDI-2014). These results highlight the strong correlation between the two diet quality indices. Owing to the overall higher average of diet quality scores across both indices, the results suggest the WHO dietary guidelines may be easier to satisfy and achieve compared to the other indices. Although, the higher averages may be a direct result of the index composition employing dietary guidelines and principles directed towards the whole human population, as opposed to guidelines focused on specific countries and the populations within. Notably, the Healthy Eating Index (HEI-2015) produced the lowest average of diet quality scores across the sample while being focused around the most recent revision of dietary guidelines, although directed mainly to the United States (US) population. In addition to this, the lower average in score may also be a result of the 'density-scoring' approach that is utilised by the Healthy Eating Index (HEI).

Our exploratory analysis identified positive correlations between the diet quality indices though all varying in strength. This is expected given each index similarly seeks to measure the same overall diet quality. The strongest positive correlation (r = .87) was between the Diet Quality Index International (DQI-I) and the Healthy Diet Indicator (HDI-2014) which is also to be expected given the indices are both based off the World Health Organisation dietary guidelines, despite different versions. Notably, the two weaker positive correlations presented between indices both included the Healthy Eating Index (HEI-15), which may be a result of being the only index to employ a 'density-scoring' approach. Given this, the weakest correlation (r = .20) was between the Healthy Eating Index (HEI-15) and the Healthy Diet Indicator (HDI-2014) which is surprising given these are the two most recent and updated diet quality indices. These results highlight the extent of variance and discrepancies among diet quality indices and the dietary guidelines around which they are centered.

Index Construction and Composition

Although all diet quality indices are seeking to assess the same outcome of diet quality, the varied diet quality score results have demonstrated the significant influence and impact construction and composition of the index has on the resulting outputs. This is important to note as interpretations of overall dietary quality from the index may not always be appropriate due to the variance and inconsistency within the dietary quality assessment tools. There were two instances where one complication emerged whereby the appropriate dietary data information was not available from the completed nutrient analysis to enter into the respective diet quality index restricting a complete and accurate analysis. For instance, when scoring the nutrient analysis data employing the Diet Quality Index International (DQI-I), the component of 'Empty Calories' was left incomplete as there was not appropriate and accurate data available from the Food Works software output to include, and as a result, the component was excluded. Similarly, this was also the case for the 'Added Sugars' component in the Healthy Eating Index (HEI-2015). As there was not appropriate and accurate data to determine the total energy percent from added sugars, it was also left incomplete and therefore excluded in the analysis. The result of excluding components due to unavailable appropriate data produces an inaccurate and not entirely true representation of the dietary quality. Thereby, it is important to keep in mind when constructing or choosing an index, to ensure selection and inclusion of dietary components that are easily accessible and applicable for researchers, and clinicians. Exclusion of categories, such as the 'Empty Calorie' in the Diet Quality Index International (DQI-I), presents a significant limitation of this system as many foods such as oils, sauces, and dressings may not be considered despite some of them having negative effects on health if consumed in excess. Therefore, the resulting diet quality scores from the Diet Quality Index International are not an entirely accurate representation of the overall diet quality and must be interpreted accordingly. This was also the case for the 'Added Sugars' category in the Healthy Eating Index (HEI-2015). The exclusion of this component also creates a significant limitation as consuming excess amounts of added sugars is known to have harmful implications on health and should therefore be essential in the dietary intake analysis (DiNicolantonio et al., 2016). For this reason, the resulting Healthy Eating Index (HEI-2015) diet quality scores are also not an entirely accurate representation of the quality of overall dietary intake and therefore must be interpreted accordingly.

Selection of Dietary Components

In addition to the limitation of excluding dietary components due to unavailable appropriate dietary data, this also presents a substantial limitation on the case of diet quality indices being simple to use and easy to apply from a clinician, practitioner, or researcher's perspective. As necessary data is not always available from nutrient analysis software used in tertiary and clinical settings, the relevance, usability, and credibility of the diet quality indices are limited, and therefore may not provide an accurate and reliable determination of overall diet quality, as observed in the results. As accessibility and usability is a key element for any assessment tool or system, particularly in nutritional epidemiology, it is essential to ensure the selected and included components mirror those elements. This further highlights the importance of the selection of dietary components as they are essentially major indicators towards determining how healthful or quality the nutritional intake is. The selection and inclusion of dietary components is known to influence the resulting outcomes, which can therefore affect the overall reliability and credibility of the assessment tools, as observed in the results. Selection of relevant and appropriate components when constructing a diet quality index allows for a valid and reliable assessment of the overall consumed dietary intake. However, keeping in mind there is currently a lack of agreement on an existing available framework to assist in determining the appropriate dietary indicators to include and the respective amounts to enable assessment of the overall quality of dietary intake. This is further reinforced when employing the alternate diet quality indices (HDI-2014 and MDS-f). As although whole components are not having to be excluded like in the DQI-I and HEI-15 dietary analysis, the included components within the indices themselves are considerably specific and precise, meaning many foods and beverages within the dietary intake do not actually fit within the specific traditional categorisations and are therefore also excluded from the analysis as a result. Again, presenting another limitation impacting the ability to truly determine the overall quality of dietary intake.

A key element behind the selection and inclusion of appropriate dietary components is the respective dietary guidelines in which they are based off. Many authoritative and governmental dietary guidelines and recommendations are frequently updated to coincide with the most recent research and education surrounding the topic. Although, with newer research comes new findings and evidence that may contradict or change the direction the existing diet quality indices follow. An example of this is the recent controversial research emerging around dietary fat consumption, particularly saturated fat intake, and the respective implications on health. The impact of saturated fat is one of the most disputed and challenged topics with recent research findings revealing a lack of significant evidence to infer that saturated fat intake is in fact linked with an increased risk of cardiovascular diseases (DiNicolantonio et al., 2016; Heileson, 2020; Siri-Tarino et al., 2010). A large portion of existing dietary quality indices include at least one fat-related aspect. However, it should be noted that incorporating 'total fat' within the scoring is *not* the same as considering 'fatty acid composition' (Waijers et al., 2007). The contribution of fatty acids within dietary intake is perceived as a key health factor with saturated fatty acid consumption being widely regarded as harmful, and therefore employed as a singular component in many indices, including the HEI, DQI, HDI, DGI, and the Mediterranean Diet Quality Index (MED-DQI). Given this, recent research indicates increased intake of monounsaturated fatty acids and polyunsaturated fatty acids has also been linked to a decreased cardiovascular disease risk (Waijers et al., 2007), which lends more to the recent controversial research around dietary fat intake and respective heart disease (Heileson, 2020; Siri-Tarino et al., 2010).

Notably, utilising a ratio of fatty acid contribution has been employed in a few diet quality indices already. For instance, the Mediterranean Diet Score (Trichopoulou et al., 1995) employs a ratio of monounsaturated fatty acids to saturated fatty acids, with the Alternate Healthy Eating Index (AHEI) (McCullough et al., 2002) including the ratio of polyunsaturated fatty acids to saturated fatty acids (Waijers et al., 2007). However, despite the use of fatty acid ratios lending more to the recent research findings, the calculation of a ratio involves a highly complicated component, which may or may not be preferred in a dietary score, particularly for simplicity's sake. As a result, the incorporation of more basic components, such as monounsaturated fatty acid and saturated fatty acids intake, is encouraged (Waijers et al., 2007). The implications of increasing consumption of trans fatty acids are now widely recognised, and therefore the inclusion of this dietary component can also be beneficial (Waijers et al., 2007), as demonstrated in several indices already including the; Dietary Guidelines for Americans Adherence Index (DGAI-2005) (Fogli-Cawley et al., 2006), Alternate Healthy Eating Index (HEI) (McCullough et al., 2002), Updated Alternate Healthy Eating Index (AHEI-2010) (Chiuve et al., 2012), Recommended Finnish Diet Score (RFDS) (Kanerva et al., 2013), Mediterranean Dietary Pattern (Sánchez-Villegas et al., 2002), Recommendation

Compliance Index (RCI) (Mazzocchi et al., 2008), and the Food Quality Score (FQS) (Fung et al., 2016). Despite significant examination of each diet quality component and given recent controversial research surrounding fat intake and health outcomes, numerous unanswered questions remain requiring further investigation to address them, particularly given the respective relevance of polyunsaturated fatty acids and/or monounsaturated fatty acids against saturated fatty acid intake (Burggraf et al., 2018).

Cut-off Values and Scoring Systems

With the selection and inclusion of appropriate dietary components comes the choice of selecting corresponding cut-off values and the respective scoring criteria for quantification. There have been several different approaches to establishing the preferable quantities of selected various nutrients and/or food groups. One approach, often employed within many of the Mediterranean-based indices, is utilising the group median intakes to function and serve as the corresponding cut-off values for the dietary components. However, the concern with this method is that is does not appraise dietary intake against optimally consumed quantities and the values will largely vary across samples. This poses a limitation when employing the diet quality indices as the resulting 'diet quality' score is centered around the intake distribution of the sample, rather than the recommended dietary intakes and servings for optimal health. Similarly, the Healthy Diet Indicator (HDI-2014), used in the analysis, also employs cut-off values based on the samples' intake distribution to determine the 'upper limit' values, however the standards for the optimal and lower limits of cut-off values are determined in accordance with the 2003 WHO dietary guidelines. This scoring approach presents a limitation within the diet quality index as it determines the 'upper limit' cut-off value by defining the 85th percentile of the population's intake distribution, as opposed to recommended portion and serving sizes for optimal health. The assessment of dietary requirements and their corresponding cut-offs is an extremely complex and difficult task, partially owing to the lack of established construction framework, which may explain why there are such discrepancies in diet quality scores for intakes that are mostly comprised of similar quality foods.

Another approach, used more commonly, is to categorise or rate the food intake based on current perceptions around what constitutes a 'healthful' level of intake, typically based off authoritative dietary recommendations. This approach is more extensively used with many indices, such as the HEI and DQI-I used in analysis, utilising scoring by the proportionality of how well the dietary guidelines or recommendations are met. Although the Healthy Eating Index (HEI-15) poses a substantial limitation having to exclude the 'Added Sugars' component due to inadequate data, the diet quality index employs a density-scoring approach whereby each components intake is calculated per 1000kcal in the total intake of foods and then scored proportionally to the selected cut-off values. This method allows for standardisation of the intake within a variety of caloric intake levels while also enabling researchers to apply the index within various settings. Whereas, the DQI-I presents a limitation by having to exclude the 'Empty Calories' component owing to insufficient dietary data, the diet quality index further restricts an accurate analysis of nutritional and dietary quality by utilising a range for the ratio of macronutrient and fatty acid intake distribution. These dietary components and respective intake distribution and scoring approaches do not consider other important dietary factors that play a role in overall dietary quality such as micronutrient intakes. The easiest approach to this is to allocate points for each dietary component based on pre-determined cut-off values. However, this is a relatively challenging process, and the question regarding how to select and determine appropriate cut-off values remains complex, controversial, and unanswered.

Adjustment of Energy Intake

Individuals with higher energy requirements and, as a result, a higher overall caloric intake, find it easier to achieve the recommendations for a variety of cut-off values or food group servings. Consequently, they may return a higher diet quality index score yet their intake may not always be well balanced or in the intended direction in relation to their needs (Waijers et al., 2007). To address this, many indices have factored and adjusted for energy intake when appraising and scoring the dietary intake. Calculation of the first Mediterranean Diet Score (MDS) requires adjustment of each component's intake to daily intakes of 2000kcal for women and 2500kcal for men. This issue has been treated differently by the Healthy Eating Index (HEI) (Kennedy et al., 1995) and the Revised Diet Quality Index (DQI-R) (Haines et al., 1999) (Waijers et al., 2007). The first Healthy Eating Index (1995) provides cut-off values for five different energy intake levels, with other indices applying nutrient density measures to account for the different energy intakes, including the later revisions of the Healthy Eating Index from 2005. The suggested number of serves within these scores is determined by the required energy intakes, with scores across all index components representing intake as a percentage of the number of serves suggested for the respective level of energy intake, depending on age and gender (Waijers et al., 2007). Therefore, for normalising data, cut off values should be country or area specific to apply recent scientific data available for the population under investigation. Additionally, cut-off values should be tailored to age, gender, weight, and physical activity levels, as these groups vary in terms of total or energy-adjusted nutritional requirements (Burggraf et al., 2018).

Food Classification Systems

The most extensively known food classification system, NOVA (name), has been used in multiple countries to categorise foods and dietary intake according to the level of processing undergone. NOVA was initially created to address limitations referring to traditional nutritional methods concentrating solely on nutrients (Bonaccio et al., 2022). Given this, the NOVA system does not employ or assign scores or weights to foods or diets, instead implies ultra-processed foods are unhealthful and should therefore be restricted. As a result, NOVA is a simpler classification system with a different focus. Owing to the concentration on the levels of processing, the NOVA system has recently been gaining momentum and is being increasingly used in research (Mackerras, 2020; Marchese et al., 2022; Monteiro et al., 2019). Despite the wide use, NOVA is not without its shortcomings. The key limitation being the NOVA system itself has not been designed to be applied to meal plans for a dietary analysis. As a result, there are limitations when attempting to use NOVA to quantify dietary intake largely resulting from two aspects, firstly, including a category for only culinary ingredients, and secondly, the lack of an attached established quantification method to translate the dietary analysis. Building upon NOVA, the HISS aims to address these limitations by providing a system that classifies dietary intake based on food processing levels and quantifies overall dietary quality through servings of unprocessed vs processed foods.

Human Interference Scoring System (HISS) vs Diet Quality Indices

HISS enables identification of overall diet quality of the dietary intake composition in regard to processed foods. The HISS identified meal plan 4 as the dietary intake consuming majority of their intake from ultra-processed foods, with a minimal intake of unprocessed-minimally processed foods. In accordance with the HISS classifications, the Healthy Eating Index (HEI-15) scored meal plan 4 with the lowest diet quality score. Although, in contrast to this, meal plan four was scored with the second highest diet quality score using the Healthy Diet Indicator (HDI-2014) and the Modified Mediterranean Diet Scale (MDS-f). However, the discrepancies in the interpretation of diet quality are likely a result of the differential scoring approaches and cut-off values. For instance, the Healthy Eating Index (HEI-15) employs a density scoring approach whereby the Healthy Diet Indicator (HDI-2014) and the Modified Mediterranean Diet Scale (MDS-f) both employ cut off values that are determined by specific characteristics of the sample population, as opposed to recommended dietary guidelines or portion sizes. Rather than employing a scoring scale, HISS classifies dietary intake by categorising foods based on the level of processing using pre-determined serving sizes alongside to determine the quantity consumed. The healthfulness and quality of the dietary intake along with the amount of processed food serves consumed is then determined to identify the dietary patterns. As opposed to one overall score for dietary intake, HISS provides four values for each dietary intake identifying the total number of serves each category contributes to the overall dietary intake. This scoring approach eliminates the concerns around not appraising dietary intakes against optimal recommended consumed quantities as it employs governmental and authoritative dietary guidelines and recommended portion sizes to determine a ‘healthful’ or quality dietary intake.

It is no secret that many worldwide authoritative and governmental dietary guidelines and recommendations are based on encouraging a varied intake of fruits, vegetables, meats, and dairy, yet the dietary intake that best represented this intake (meal plan 5 according to HISS), only received the highest diet quality scores when using the Healthy Eating Index (HEI) or modified Mediterranean Diet Score (MDS-f). This may be a result of employing diet quality indices that are based on country or population-specific dietary guidelines as opposed to dietary guidelines applicable to everyone. This may also be the result from the inclusion of the density scoring approach in the Healthy Eating Index (HEI). The Mediterranean dietary pattern is well known for prioritising the intake of fruits, vegetables and wholegrains while typically including less meat and dairy than traditional Western diets, therefore resembling a dietary intake mostly consistent with meal plan 5, hence the high diet quality score from that index. However, the Modified Mediterranean Diet Scale (MDS-f) employs sex-specific median values for the scoring cut-offs which may take away from the integrity of the assessment. These results highlight the importance of employing cut-off values that are based on recommended portions or servings sizes from governmental or authoritative sources, as sample-specific cut-off values do not provide diet quality scores that are associated with healthful levels of consumption. These results also highlight the disconnect and limitations shared between the dietary quality assessment tools.

Notably, the HISS results identify that both meal plans 2 and 4 were similarly comprised of mostly ultra-processed foods although differential overall quantities. Given this, meal plan 4 received substantially higher diet quality scores than meal plan 2 across the diet quality indices, with meal plan 2 receiving some of the lowest diet quality scores. With that being said, meal plan 4 did have the largest caloric intake across the sample with meal plan 2 having the lowest, which therefore may have influenced the resulting diet quality scores depending on the index construction and composition. It is known that larger caloric intakes find it easier to satisfy the requirements of some diet quality indices, and therefore score higher as a result. Coinciding with this, both the Healthy Diet Indicator (HDI-2014) and the Diet Quality Index International (DQI-I) similarly scored meal plan 2, the lowest caloric intake, with the lowest diet quality scores suggesting the dietary intake was the least quality across the sample. These results highlight how differential the interpretations of 'diet quality' are across assessment tools despite dietary intakes being comprised of similar quality foods. The discrepancies in diet quality scores are owing to the differential selected dietary guidelines, cut off values and scoring employed in each index. Nonetheless, the HISS provides an appraisal tool that also allows for simple dietary messages to be relayed back to the individual.

Despite there being an abundance of developed diet quality indices, the diversities and inconsistencies across the tools substantially restrict the applicability to appraise or assess overall dietary quality. As a result, the diet quality scores resulting from a diet quality index assessment should be interpreted with a degree of caution. These results indicate there is large variation in 'diet quality scores' depending on what particular index is employed and what that researcher valued as a 'high quality dietary intake' when the index was constructed. This variation in 'dietary quality' presents a limitation for diet quality indices as a general assessment tool as each intake results in relatively differential scores based on what the particular index values as optimal dietary quality. This means to get an accurate and valid representation of an individual's dietary intake quality; it is essential to employ the diet quality index that directly applies to the circumstance. For instance, an individual living in New Zealand should apply the diet quality index based on New Zealand dietary guidelines for an accurate result as the index is constructed to score dietary intakes that best adhere to the New Zealand dietary recommendations. For this reason, the indices are limited with who they can apply too and therefore be used with to provide an accurate and valid representation of the dietary quality.

As diet quality itself is a fairly new and emerging topic, there can be a limited range of applicable diet quality indices for some countries also presenting a limiting factor. An example of this is in New Zealand, where one diet quality index is applicable to the adult population being the Healthy Dietary Habits Index (HDHI) (Wong et al., 2017), with another only applicable to the female adult population (NZW-HDI) (Fenner, 2015). Although, a limited choice of indices may be preferred on the side of consistency and comparability, it presents a restriction as the dietary recommendations and advice is often changing owing to newer research. Therefore, having only one to two applicable dietary quality indices available for the country highlights the recency of the dietary quality assessment notion. Minimal versions of applicable diet quality indices present a shortcoming of the assessment method as nutritional advice and recommendations that influence dietary guidelines tend to be updated often. However, without updated versions of the indices to reflect these changes, the diet quality indices inaccurately portray an optimal dietary intake restricting the reliability of the index. As a result, the accuracy of a priori (theoretically defined) index method is restricted by the existing amount of dietary information concerning the dietary intake and health connection, along with uncertainties associated with the index development process (Burggraf et al., 2018). Though at this stage, the minimal number of applicable indices can be mainly put down to the newness of the diet quality assessment concept.

This circumstance can also apply to populations that adhere to specific dietary patterns that may not typically align with the country's dietary guidelines but are not necessarily unhealthful either. This may include if an individual were to adopt a particular dietary pattern due to professional recommendations or evident research suggesting the dietary intake was healthful, for instance a vegan diet, or ketogenic or low-carbohydrate, high fat diet. An example of this is meal plan 5. The dietary intake consisted of a range of whole and minimally processed foods with little ultra-processed foods consumed, as identified by the HISS, however the macronutrient distribution did not typically comply with the dietary quality indices suggested cut-off values and as a result, was penalised for it. This is due to a dietary intake that has adopted a low carbohydrate, high fat diet which lends more to the recent controversial research around the intake of saturated fats (DiNicolantonio et al., 2016; Heileson, 2020; Siri-Tarino et al., 2010) than traditional dietary guidelines and recommendations. Owing to the penalisation of not conforming to specific cut-off values despite not necessarily being regarded as an unhealthful intake, meal plan 5 received lower dietary scores than meal plans with substantially higher amounts of processed and ultra-processed products. These results suggest that dietary intakes higher in ultra-processed foods comply better with dietary guidelines than a dietary intake comprised mostly of unprocessed and minimally processed foods yet is high in fats and lower in carbohydrates. This is where the oversimplistic and reductionist nature of the diet quality indices poses an issue. Several dietary components and aspects are condensed into only a handful, to then be scored based on selective values and criteria, however this presents a very one-size-fits-all approach to assessing dietary intake which is not the case, especially with a topic so complex such as nutritional quality. As the HISS does not grade or score foods or dietary intake, this eliminates the concern of wrongful penalisation towards dietary intakes that may not necessarily comply with traditional dietary guidelines, but at the same time, may not have an 'unhealthy' intake either. The HISS provides a simple dietary appraisal or assessment tool for clinicians and researchers that classifies intake according to food processing, quantifies overall dietary quality through total servings of unprocessed and processed foods, and enables translation of the dietary analysis to simple messages that can be relayed back to the individuals. Nonetheless, diet quality indices are still useful tools when used within the appropriate populations and settings.

Conclusion

By critically reviewing all existing diet quality indices and food classification systems, this research has shown how formulation of the assessment tool can shape the extent of diet quality assessment. In addition, this research aimed to provide a meal plan analysis employing several identified diet quality indices along with a newly developed food classification system (HISS), to highlight the differences and discrepancies between assessment tools. Nutrition has long proved challenging to quantify individual dietary intakes, likely due the complexity involved and its multifaceted nature. Ultimately, most diet quality assessment tools are seeking to produce the same outcome measure of overall dietary quality. Given that, there is large variation and discrepancies among several diet quality assessment tools owing to the flexibility and lack of established framework surrounding the ability to select and develop an appropriate measure of dietary quality. Therefore, the diet quality scores highlight the oversimplistic nature of diet quality indices as attempting to reduce such a complex topic like dietary components, adopts a one-size-fits-all approach which is not the case in an area so diverse like dietary intake and nutritional quality. As a result, many dietary components are typically neglected or oversimplified limiting the ability to provide an accurate appraisal of the dietary intake quality. Alternatively, food classification systems are emerging dietary tools known to excel at classification of foods and the categorisation of dietary intakes, however there is no further analysis to quantify the diet quality. Within the existing classification systems, there is an absence of established quantitative measures that employ recommended dietary serving sizes to quantify the levels of intake respective to the classifications of intake.

Therefore, the HISS presents a newly developed nutritional classification system that classifies dietary intake based on food processing level categorisations and quantifies the overall diet quality via total servings of unprocessed and processed foods. Unlike other classification systems, the HISS employs recommended dietary serves to quantify the classifications of the dietary intakes. The results demonstrate the HISS has the ability to appraise the healthfulness and quality of dietary intake, similar to that of the diet quality indices. As a matter of fact, the HISS was able to highlight the discrepancies between the resulting diet quality scores and dietary intakes, therefore suggesting the classification system may provide a more comprehensive analysis of the diet quality, when compared to diet quality indices. As a result, the system enables the ability to appraise and assess dietary intake through quantification of overall dietary quality, based on food processing categorisations. For this reason, the HISS can provide researchers, clinicians, and health professionals with a simple and easy to use dietary appraisal tool that accounts for the intake quantity and nutritional content, or absence of. The HISS also provides a clear representation of the dietary intake contributions enabling researchers or health professionals to relay simple and clear dietary analysis messages back to the individuals.

Implications and Recommendations

While previous research has focused on employing diet quality indices to assess diet quality, these results demonstrate that food classification systems may be superior when it comes to appraising diet quality owing to the concept's complexity and multifaceted characteristics. These results challenge existing diet quality index assessment tools by highlighting the extent of differences between each indices creation, composition, and resulting diet quality scores, while all are essentially seeking to achieve the same outcome measure of overall diet quality. Building on existing evidence, the results indicate that researchers ingrained interests and values can influence the construction and composition of the diet quality index, and in turn influence the resulting diet quality scores. These results support the theory that 'diet quality' is largely open to interpretation when constructing an index, as researchers select the dietary components and scoring systems to employ as a result of the lack of agreed upon diet quality definition and subsequent construction framework for diet quality indices. Therefore, this data contributes a clearer understanding towards the complexity of assessing dietary quality and the need for a comprehensive yet simple to use dietary appraisal tool.

As the HISS is a newly developed classification system, this research provides a new insight into the relationship between diet quality, diet quality assessment and processed foods. Although HISS does not produce a singular score for overall dietary quality, the classification system provides researchers and clinicians with a dietary appraisal tool that considers quantity of intake and nutritional content of consumed foods – or lack thereof, while being simple and easy to use. Rather than attempting to condense many dietary components and employ a scoring criterion, the HISS provides a clear representation of the dietary intake by classifying consumed foods according to the level of processing. Instead of scoring the intake, pre-determined serving sizes recommended by governmental organisations are employed to total the number of consumed servings respective to each processing category. This provides researchers and clinicians with a simple and easy-to-use dietary appraisal tool which provides detailed insights into an individual's dietary patterns and nutritional intake, without requiring the use of typical mathematical algorithms or extensive nutrient analysis.

Although the HISS addresses the concerns and shortcomings within existing diet quality assessment tools, the findings should be interpreted in light of several limitations. Firstly, the generalisability of the results is limited by the small number of hypothetical meal plans used in the analysis. Secondly, the HISS is currently in the developmental stage and is therefore not a published or tested dietary appraisal tool. As a result, the system is not yet validated and requires further testing, and for this reason the findings should be interpreted accordingly. Thirdly, the food categorisations are largely open to interpretation and are subjective based which may provide large discrepancies over time limiting the ability to provide an accurate representation of the diet quality. For instance, the HISS requires classification between items such as milk, UHT milk, and powdered milk, or products such as canned fish in spring water and canned fish in oil or flavouring. Without a fairly comprehensive understanding of nutrition, there is likely to be some misclassification of food items largely a result of the food categorisations being mostly open to interpretation. To minimise any chance of discrepancies, the Human Interference Scoring System is best applied with a clinician, researcher or dietitian who already have a detailed understanding around food classifications.

Researchers may look to refine and polish the distinct food classifications and the corresponding food categorisations within the HISS as an attempt to reduce the shortcomings. Future research should consider the emerging evidence surrounding nutritional epidemiology when developing or updating assessment tools used to appraise an individual's dietary intake. As the evidence supports the extensive multifaceted concept of diet quality, it is essential to ensure the corresponding assessment tools can reflect this and capture the diverse elements of dietary intake. Based on these conclusions, researchers should also consider establishing a foundation for the construction and revision of diet quality indices to ensure there are frequent updates reflecting recent nutrition epidemiology findings, such as the saturated fat debate and the more recent focus on sodium and processed foods. This may help in minimising the discrepancies between assessment tools as a result of the consistency provided within the foundation and structure when developing or revising an index. To better understand the implications of the results, future studies could address testing of the HISS with a larger sample of dietary intakes to increase the generalisability while testing the validity and reliability of the classification system. Future research may also consider implementing the food classification system with alternative recommended serving size intakes applicable to the circumstance or country.

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Appendix A: The Human Interference Scoring System (HISS)

Table 1: Human Interference Scoring System (HISS). Food Classification System

Food groups and definition	Example	= 1 serving size
1: Unprocessed and minimally processed Raw and whole foods with little or no processing. Foods that are fresh, canned, frozen, or dried to enhance nutrients and freshness at their peak. Unprocessed foods are of plant and animal origin. Minimally processed foods are unprocessed foods that are stored without additional substances.	Fresh and frozen raw fruit and vegetables; eggs; red and white meats; fresh, dried, canned beans and other legumes; raw nuts and seeds; honey; fresh, dried, smoked, frozen meat or fish; canned beans, fish, fruit, and tomatoes in spring water; broths; herbal teas.	**Fruit and Vege:** ½ cup of cooked vege 1 cup of leafy greens or raw salad vege ½ medium potato, or similar size piece of starchy root vegetable ½ cup of canned, or frozen vege 1 medium apple, pear, banana or other 2 small apricots, kiwifruits, or plums 1 cup of diced or canned fruit (drained) 1 cup of frozen fruit
2: Processed I Artisanal products that were typically available for consumption in pre-industrial societies. Products that require traditional processing techniques with bacteria fermentation (cultured products), yeast strains and natural ingredients.	Milk; butter; cheese; milk and coconut creams; unflavoured yoghurts; artisan bread; coffee beans; rice; pasta; rolled oats; fermented alcoholic beverages such as beer, cider, and wine; spirits; kombucha.	**Milk products:** 1 cup (250ml) of milk or plant-based alternatives (e.g., soy, rice, almond, oat) ¾ cup (200g) of yoghurt 2 slices (40g) of cheese
3: Processed II **3.1** Domestically assembled items, often prepared with separate ingredients including raw or whole food products with additional cooking agents. **3.2** Foods processed for preservation with additional flavouring and additives with no further cooking needed. Whole foods with added sugar to make them more palatable and durable. Includes canning and bottling using sugar or syrups, oil, or additional flavouring.	**3.1** Homemade breads; soups; granola and breakfast cereals; baking and biscuits. **3.2** Peeled or sliced fruit in syrup; canned fish in flavouring or oil; cured meat (beef jerky); dried fruit; hummus; pesto.	**Grain foods:** ½ cup of cooked rolled oats ¼ cup muesli ½ medium whole grain bread roll or flat bread 1 slice (40g) of wholegrain bread ½ cup cooked pasta or rice, quinoa, noodles, or buckwheat **Legumes, poultry, meat or other:** 1 cup (150g) of cooked or canned beans, lentils, or chickpeas 1 med fillet of cooked fish (100g) or one small can of fish 2 large eggs, 170g tofu 30g of nuts or seeds (small handful) 1 chicken drum or ½ chicken breast 65g of cooked lean meat ½ cup mince
4: Ultra-processed Industrially prepared items that are largely manufactured and packaged ready to eat. Undergone high degrees of processing entirely from substances that are derived from foods, with little or no whole foods present. Contain large amounts of preservatives, stabilizers, emulsifiers, bulkers, sweeteners, colours, and flavours.	Sweet or salty snack products (chips); reconstituted meats (ham, salami, chicken and sausage); breads and wraps; rice cakes; breakfast cereals; oats; biscuits; sodas and energy drinks; ice cream; sweetened fruit yoghurt; sweetened milk drinks; juice; packaged foods (pizza, burgers etc); fries; canned, dehydrated soups; baked beans or spaghetti; muesli bars; protein supplements and bars; cakes; pies; confectionery (chocolate, candy); baby formulas; dried soup; ready-to-drink alcoholic beverages; instant coffee sachets; dressings and sauces; spreads.	**Prepared items:** 2 breakfast wheat biscuits 2/3 cup cereal 3 (35g) crispbreads or crackers 2 tbsp (30g) of spreads and sauces 2 small biscuits 1 packet (25g) of snack item 1 can (250mL) of energy drink

Appendix B: Meal Plans and Food Records

Meal Plan 1

Meal 1

<u>Breakfast</u>
1 cup of blue-top milk
2 cups of Honey Weet-bix bites

<u>Beverages</u>
1 cup of instant black coffee, no milk or sugar added
1 lion red beer 330ml

Meal 2

<u>Lunch</u>
250g/ 1 packet of uncle bens rice medley
95g lemon pepper canned tuna

<u>Snacks</u>
1 medium banana
1 medium mandarin
1 protein nut bar
1 olive oiled seaweed packet

Meal 3

<u>Dinner</u>
1 and a ½ cups of cooked tomato basil and mozzarella ravioli
½ cup dolmio garlic pasta sauce
1 tsp of colby cheese
28g of chorizo
1 cup of cooked vegetables (peas, corn, spinach, mushrooms, capsicum)
⅓ store brought garlic bread

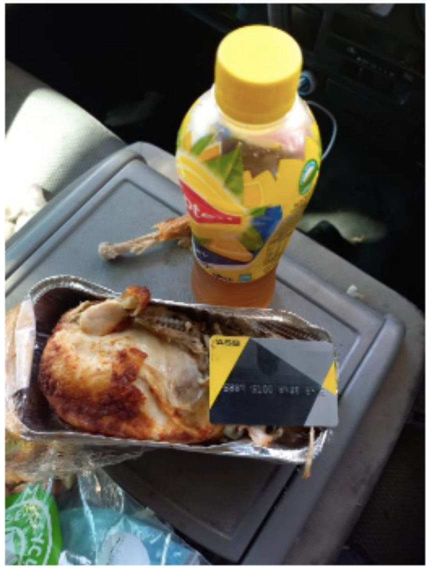
Snack / Other

Meal Plan 2

Meal 1

<u>Breakfast</u>
2 slices of white bread
2 tsp olivani margarine
2 tsp of raspberry jam

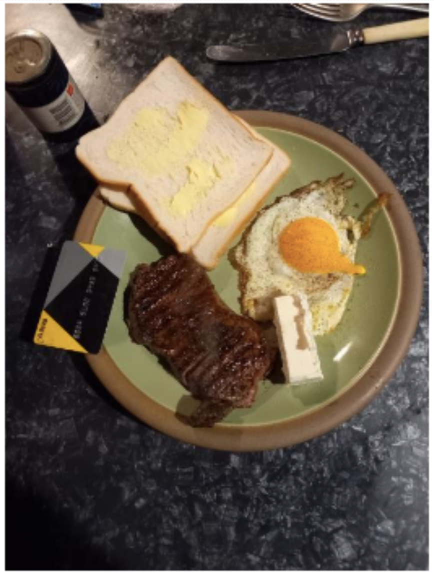
Meal 2



<u>Lunch</u>
Half an oven-baked chicken

<u>Beverages</u>
500ml Lipton iced tea
1.5litres of blackcurrant fruit drink

Meal 3



<u>Dinner</u>
2 slices of white bread
2 tsp of olivani margarine
1 fried egg
200g fried steak
1 slice of Feta

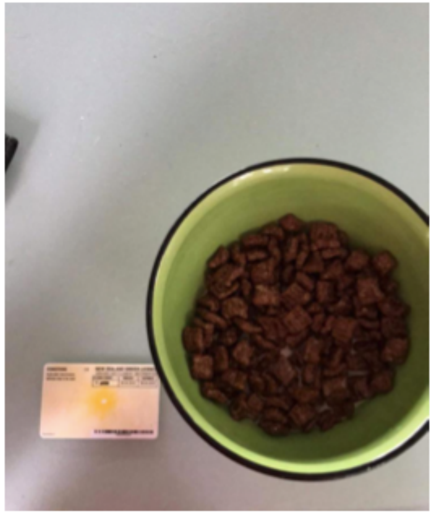
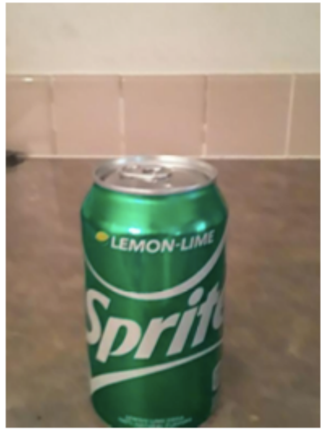
<u>Snacks</u>
2 cups of coco pops
1 cup of blue-top milk

Snack / Other

Meal Plan 3

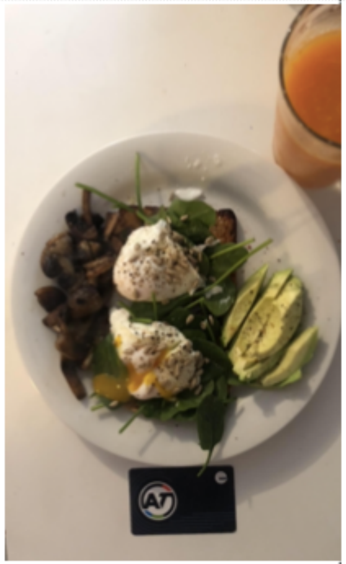
Meal 1	Meal 2	Meal 3	Snack / Other
			
<u>Breakfast</u> 2 weet-bix 1 cup of blue-top milk 1 small tub of sweetened fruit yoghurt	<u>Lunch</u> ⅓ bag of copper kettle bbq flavoured chips	<u>Dinner</u> 200g baked chicken breast 1 slice of bacon 2 slices of feta 1 baked potato ½ cup of salad leaves ¼ cup of pear and tomato	

Meal Plan 4

Meal 1	**Meal 2**	**Meal 3**	**Snack / Other**
 <u>Breakfast</u> 3 cups of milo cereal 2 cups of blue-top milk	 <u>Lunch</u> 4 muffin splits 2 tsp of margarine on each muffin	 <u>Dinner</u> 150g chicken mince ⅓ canned tomatoes 2 tbsp sour cream 2 handfuls of doritos salsa corn chips	  <u>Beverages</u> 500ml Large blue V 330ml Sprite

Meal Plan 5

Meal 1



<u>Breakfast</u>
2 thin vogels mixed grain toast
½ avocado
½ cup spinach
2 poached eggs
½ cup fried mushrooms
2 tsp sunflower seeds

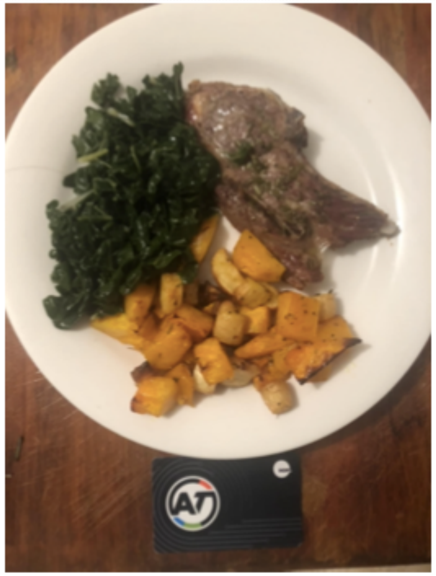
<u>Beverages</u>
500ml freshly squeezed orange, carrot, and apple juice

Meal 2

<u>Lunch</u>
1 scrambled egg with colby cheese
2 handfuls of roasted vegetables

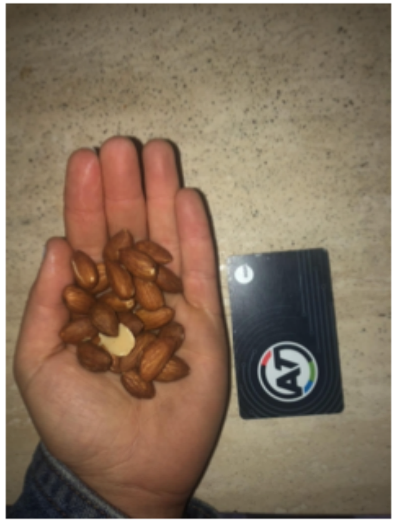
<u>Beverages</u>
Medium takeaway coconut milk cappuccino

Meal 3



<u>Dinner</u>
1 oven-baked lamb chop
1 cup of boiled silverbeet
1 cup of roasted kumara parsnip and butternut

Snack / Other



			 <u>Snacks</u> 2 brown rice cakes with quinoa 3 tsp of fix and fogs peanut butter 1.5 medium banana 1 handful of roasted unsalted almonds 1 small kiwifruit

Appendix C: Food Works Nutrient Analyses for Meal Plans

Meal Plan 1

General | Foods | NRVs/Goals | Notes

Outline

Meal	Food	Quan...	Note	Weight	Energy
Breakfast				377.5	2287
	Weet-Bix,Sanitarium,fortified	120g	Honey Weetbix Bites	120.0	1652
	Milk,cow,standard 3.3% fat,fl...	1 cup		257.5	635
Lunch				345.0	4178
	Rice,white,Uncle Ben's,parbo...	250g	Uncle Ben's Rice Medley	250.0	3647
	Tuna,canned in oil,assorted fl...	95g	Sealord Lemon Pepper	95.0	532
Dinner				646.3	3995
	Cheese,Colby	1 tsp		4.9	82
	Sausage,salami assorted mea...	28g	Chorizo	28.0	346
	Garlic Bread,made with butte...	0.3 lo...		66.8	1062
	Mushroom,fried in butter	0.25 c...		37.5	104
	Spinach,English,boiled,drain...	0.25 c...		37.5	30
	Capsicum,Red,boiled	0.25 c...		36.3	58
	Pea,green,frozen,boiled,drai...	0.125 ...		22.5	74
	Sweet corn,kernel,frozen,boi...	0.125 ...		22.8	66
	Pasta,fresh,ravioli,beef,bell ...	1.5 cup	Tomato, basil and mozzarella (no beef)	255.0	1872
	Sauce,pasta,tomato based,he...	0.5 cup	Dolmio garlic pasta sauce	135.0	301
Snacks				234.4	1316
	Banana,yellow,ripened,raw	1 frui...		110.8	439
	Mandarin,flesh,raw	1 ma...		86.0	188
	Nut bar,peanut & chocolate,C...	1 bar ...	Nice & Natural Protein Nut Bar - real dark chocola	32.6	651
	Seaweed,dried	5g	Jongga - olive oiled seaweed	5.0	37
Beverages				582.0	320
	Coffee beverage,instant,dry ...	1 cup	Jeds Instant Coffee	250.0	11
	Beer,mid-strength (4% alcoh...	1 reg...	Lion Red	332.0	309

1 of 29 rows.

All Components
Summary
Profile
NRVs
SDT
Goals

General
Macro-Nutrients
Sugar Alcohols
Vitamins
Minerals
Energy Ratios
Fat Ratios
Fatty Acids
Amino Acids
Miscellaneous

Show Sources

General	
Weight	2185.2 g
Macro-Nutrients	
Energy	12097.2 kJ
Protein	113.3 g
Nitrogen conversion factor	6.080
Total fat	65.3 g
Saturated fat	25.1 g
Trans Fatty Acids	>0.4 g
Polyunsaturated fat	10.1 g
Monounsaturated fat	22.4 g
Cholesterol	170.7 mg
Carbohydrate	420 g
Sugars	74.7 g
Glucose	17.1 g
Fructose	19.6 g
Sucrose	21.4 g
Lactose	14.3 g
Maltose	2.1 g
Starch	345.3 g
Maltodextrins	>1.0 g
Glycogen	?
Water	1475.6 g
Alcohol	10 g
Dietary fibre	40.5 g
Resistant starch	>5.0 g
Soluble non starch polysaccharides	>10.2 g
Insoluble non starch polysaccharides	>8.7 g
Fibre-Englest	>20.8 g
Organic acids	>0.5 g
Ash	19.2 g
Sugar Alcohols	
Sugar alcohols	?
Vitamins	
Thiamin	8.119 mg
Riboflavin	4.022 mg
Niacin	45.992 mg
Niacin equivalents	65.007 mg
Vitamin C	80.963 mg
Vitamin D (by summation)	3.420 µg
Ergocalciferol (Vitamin D2)	0 µg
Cholecalciferol (Vitamin D3)	3.4 µg
Vitamin E	8.905 mg
Tocopherol, alpha	>6.194 mg
Tocopherol, beta	>0.195 mg
Tocopherol, gamma	>0.526 mg
Tocopherol, delta	>0.009 mg
Vitamin B6 (by analysis)	4.659 mg
Vitamin B12	4.512 µg
Vitamin K	>35.8 µg
Pantothenic Acid	>1.834 mg
Biotin	>6.016 µg
Total folate	700.815 µg

Meal Plan 2

General | Foods | NRVs/Goals | Notes

Outline

Meal	Food	Quan...	Note	Weight	Energy
Breakfast				61.5	805
	Bread,white,toasted	2 me...		42.0	485
	Margarine,avocado,Olivani	2 tsp		9.3	196
	Jam,berry fruit	2 tsp		10.3	125
Lunch				2310.0	5219
	Chicken,deli cooked,flesh	250g		250.0	1564
	Soft drink,assorted tea flavou...	500 mL		515.0	622
	Fruit drink,blackcurrant,swee...	1.5 L		1545.0	3034
Dinner				346.0	3194
	Bread,white,sliced,prepacke...	2 me...		57.4	599
	Margarine,avocado,Olivani	2 tsp		9.3	196
	Egg,chicken,white & yolk,frie...	1 egg ...		43.7	383
	Beef,hindquarter rump steak,...	200g		200.0	1599
	Cheese,feta,from cows' milk,...	2 cub...		35.6	417
Snacks				365.0	2152
	Coco Pops,Kellogg's,fortified	2 cup		105.0	1659
	Milk,cow,lite 1.5% fat,fluid,A...	1 cup		260.0	493

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General
Macro-Nutrients
Sugar Alcohols
Vitamins
Minerals
Energy Ratios
Fat Ratios
Fatty Acids
Amino Acids
Miscellaneous

Show Sources

General	
Weight	3082.5 g
Macro-Nutrients	
Energy	11370.4 kJ
Protein	168.2 g
Nitrogen conversion factor	6.226
Total fat	58.6 g
Saturated fat	21.7 g
Trans Fatty Acids	>0.8 g
Polyunsaturated fat	6.1 g
Monounsaturated fat	21.2 g
Cholesterol	657.9 mg
Carbohydrate	371.1 g
Sugars	273.3 g
Glucose	31.3 g
Fructose	32.1 g
Sucrose	195.8 g
Lactose	12.4 g
Maltose	1.7 g
Starch	97.9 g
Maltodextrins	?
Glycogen	?
Water	2497.5 g
Alcohol	0 g
Dietary fibre	4.1 g
Resistant starch	?
Soluble non starch polysaccharides	>1.8 g
Insoluble non starch polysaccharides	>1.4 g
Fibre-Englyst	>3.1 g
Organic acids	?
Ash	15.3 g
Sugar Alcohols	
Sugar alcohols	?
Vitamins	
Thiamin	3.415 mg
Riboflavin	4.028 mg
Niacin	45.252 mg
Niacin equivalents	77.684 mg
Vitamin C	632.591 mg
Vitamin D (by summation)	2.134 µg
Ergocalciferol (Vitamin D2)	0 µg
Cholecalciferol (Vitamin D3)	2.1 µg
Vitamin E	5.519 mg
Tocopherol, alpha	>5.488 mg
Tocopherol, beta	?
Tocopherol, gamma	>0.244 mg
Tocopherol, delta	?
Vitamin B6 (by analysis)	1.849 mg
Vitamin B12	7.402 µg
Vitamin K	?
Pantothenic Acid	>1.880 mg
Biotin	>0.994 µg
Total folate	583.166 µg

Meal Plan 3

General | Foods | NRVs/Goals | Notes

Outline

Day	Meal	Food	Quan...	Note	Weight	Energy
	Breakfast				416.1	1586
		Milk,cow,standard 3.3% fat,fl...	1 cup		257.5	635
		Weet-Bix,Sanitarium,fortified	2 bisc...		33.6	463
		Yoghurt,Fresh 'n Fruity,assort...	125g	Fresh & Fruity - 1 Pottle	125.0	488
	Lunch				50.0	984
		Potato chip or crisp,assorted ...	50g	Copper Kettle, BBQ flavoured	50.0	984
	Dinner				458.5	2474
		Chicken,breast,flesh,roasted	200g		200.0	1240
		Bacon rasher,streaky,pan frie...	1 ras...		8.5	156
		Cheese,feta,from cows' milk,...	2 cub...	2 slices = 2 cubes?	35.6	417
		Potato,Rua,flesh,baked,salt a...	150g	1 potato = ~150grams?	150.0	582
		Salad,Mesclun,leaves,raw	0.5 cup		18.8	13
		Pear,flesh & skin,raw	1/8 cup		21.9	47
		Tomato,whole,raw	1/8 cup		23.8	20
	Snacks				0.0	0

1 of 18 rows (0 Days).

All Components
Summary
Profile
NRVs
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General
Macro-Nutrients
Sugar Alcohols
Vitamins
Minerals
Energy Ratios
Fat Ratios
Fatty Acids
Amino Acids
Miscellaneous

Show Sources

General	
Weight	924.6 g
Macro-Nutrients	
Energy	5044.7 kJ
Protein	84.9 g
Nitrogen conversion factor	6.261
Total fat	48.8 g
Saturated fat	21.5 g
Trans Fatty Acids	>0.6 g
Polyunsaturated fat	4.3 g
Monounsaturated fat	17.6 g
Cholesterol	221.2 mg
Carbohydrate	101.5 g
Sugars	31.8 g
Glucose	2.4 g
Fructose	3.3 g
Sucrose	10.6 g
Lactose	15.4 g
Maltose	0 g
Starch	69.7 g
Maltodextrins	>0.1 g
Glycogen	?
Water	660.3 g
Alcohol	0 g
Dietary fibre	9.1 g
Resistant starch	>2.4 g
Soluble non starch polysaccharides	>2.0 g
Insoluble non starch polysaccharides	>2.0 g
Fibre-Englest	>4.0 g
Organic acids	?
Ash	12.1 g
Sugar Alcohols	
Sugar alcohols	?
Vitamins	
Thiamin	2.363 mg
Riboflavin	2.127 mg
Niacin	23.405 mg
Niacin equivalents	40.535 mg
Vitamin C	22.883 mg
Vitamin D (by summation)	2.326 μg
Ergocalciferol (Vitamin D2)	0 μg
Cholecalciferol (Vitamin D3)	2.3 μg
Vitamin E	3.529 mg
Tocopherol, alpha	3.489 mg
Tocopherol, beta	>0.085 mg
Tocopherol, gamma	>0.081 mg
Tocopherol, delta	?
Vitamin B6 (by analysis)	1.984 mg
Vitamin B12	1.972 μg
Vitamin K	>25.5 μg
Pantothenic Acid	>3.560 mg
Biotin	>4.135 μg
Total folate	261.147 μg

Meal Plan 4

General | Foods | NRVs/Goals | Notes

Outline

Meal	Food	Quan...	Note	Weight	Energy
Breakfast				702.5	4095
	Milk,cow,standard 3.3% fat,fl...	2 cup		515.0	1276
	Breakfast cereals,rice puffed,...	3 cup		187.5	2819
Lunch				423.4	4291
	English muffin,bread-like,ass...	5 muf...		400.0	3680
	Margarine,polyunsaturated,7...	5 tsp		23.4	610
Dinner				335.0	2898
	Chicken,mince,pan fried,wit...	150g		150.0	1174
	Tomato,canned in tomato jui...	1/3 cup		91.7	82
	Cream,sour	4 tsp		18.3	169
	Corn chip,assorted flavours,s...	75g		75.0	1473
Beverages				854.9	1474
	Energy drink,assorted flavour...	500 mL		515.0	902
	Soft drink,carbonated,lemon ...	330 mL		339.9	572

18 of 17 rows.

All Components
Summary
Profile
NRVs
SDT
Goals

General
Macro-Nutrients
Sugar Alcohols
Vitamins
Minerals
Energy Ratios
Fat Ratios
Fatty Acids
Amino Acids
Miscellaneous

Show Sources

General	
Weight	2315.8 g
Macro-Nutrients	
Energy	12757.2 kJ
Protein	124.8 g
Nitrogen conversion factor	6.079
Total fat	65.2 g
Saturated fat	25.8 g
Trans Fatty Acids	>0.7 g
Polyunsaturated fat	10.9 g
Monounsaturated fat	22.4 g
Cholesterol	229.6 mg
Carbohydrate	469.6 g
Sugars	195.6 g
Glucose	20.7 g
Fructose	22.6 g
Sucrose	120.8 g
Lactose	24.6 g
Maltose	7 g
Starch	274 g
Maltodextrins	>0.2 g
Glycogen	?
Water	1586.9 g
Alcohol	0 g
Dietary fibre	29.7 g
Resistant starch	>1.8 g
Soluble non starch polysaccharides	>7.9 g
Insoluble non starch polysaccharides	>4.6 g
Fibre-Englyst	>12.5 g
Organic acids	>0.1 g
Ash	19.6 g
Sugar Alcohols	
Sugar alcohols	?
Vitamins	
Thiamin	5.471 mg
Riboflavin	7.151 mg
Niacin	74.607 mg
Niacin equivalents	97.520 mg
Vitamin C	7.058 mg
Vitamin D (by summation)	6.300 µg
Ergocalciferol (Vitamin D2)	0 µg
Cholecalciferol (Vitamin D3)	6.3 µg
Vitamin E	10.125 mg
Tocopherol, alpha	>9.932 mg
Tocopherol, beta	>0.099 mg
Tocopherol, gamma	>0.513 mg
Tocopherol, delta	?
Vitamin B6 (by analysis)	16.543 mg
Vitamin B12	7.610 µg
Vitamin K	?
Pantothenic Acid	>50.012 mg
Biotin	>20.293 µg
Total folate	1195.567 µg

Meal Plan 5

General | Foods | NRVs/Goals | Notes

Outline

Meal	Food	Quan...	Note	Weight	Energy
Breakfast				341.5	2250
	Bread,Mixed Grain & Toasted ...	2 slic...	Vogel's Mixed Grain Thin Toast	85.0	796
	Avocado,Hass,New Zealand	0.5 fr...		61.0	557
	Spinach,English,raw	0.5 cu...		21.5	16
	Egg,chicken,white & yolk,poa...	2 egg ...		94.0	546
	Mushroom,fried in butter	0.5 cup		75.0	208
	Seed,sunflower,dry roasted,n...	2 tsp		5.0	127
Lunch				369.1	1133
	Egg,chicken,white & yolk,mil...	55g	1 Scrambled Egg	55.0	411
	Cheese,Colby	10g	Unspecified Amount	10.0	166
	Pumpkin,flesh & skin,roasted	.4 cup		86.0	195
	Brussels sprout,steamed	1 cup ...		127.5	272
	Mixed vegetable,carrot & par...	30g		30.0	55
	Courgette,Green,unpeeled,r...	2 slic...		60.6	34
Dinner				435.6	2635
	Lamb,forequarter shoulder c...	150g	1 Lamb Chop?	150.0	1996
	Silverbeet,leaves & stems,fr...	1 cup ...		72.4	65
	Kumara,flesh,boiled,drained,...	1/3 c...		115.5	316
	Parsnip,flesh,baked without fat	1/3 c...		48.3	157
	Squash,butternut,flesh,raw	1/3 c...		49.3	102
Snacks				313.5	2358
	Kiwifruit,Zespri Gold (Hort16...	1 fruit		83.0	204
	Banana,yellow,ripened,raw	1.5 fr...		166.2	659
	Nut,almond,roasted with oil,...	24 al...	1 Handful	31.0	797
	Peanut butter,smooth & crun...	3 tsp	Fix & Foggs	17.7	468
	Spice,cinnamon,ground	.4 tsp		1.0	11
	Wafer,wholegrain rice	2 thin...	Brown Rice Cakes with Quinoa - Ceres?	14.6	219
Beverages				799.1	2173
	Coffee beverage,cappuccino,...	1 cup ...	Coconut Milk	201.6	448
	Juice,orange,raw	250 mL	Freshly Squeezed Juice - Orange, Apple & Carrot	257.5	453
	Apple,'Royal Gala',flesh & ski...	1 apple		130.0	279
	Carrot,flesh,fresh,raw	1 wh...		110.0	172
	Coconut,milk,standard	100 mL		100.0	821

24 of 34 rows. Source: New Zealand FOODfiles 2016

All Components
Summary
Profile
NRVs
SDT
Goals

General
Macro-Nutrients
Sugar Alcohols
Vitamins
Minerals
Energy Ratios
Fat Ratios
Fatty Acids
Amino Acids
Miscellaneous

Show Sources

General	
Weight	2258.8 g
Macro-Nutrients	
Energy	10548.6 kJ
Protein	94.7 g
Nitrogen conversion factor	6.051
Total fat	148 g
Saturated fat	56 g
Trans Fatty Acids	>3.2 g
Polyunsaturated fat	16.7 g
Monounsaturated fat	54.1 g
Cholesterol	677.5 mg
Carbohydrate	181.5 g
Sugars	113.2 g
Glucose	26.7 g
Fructose	33.8 g
Sucrose	43.5 g
Lactose	8 g
Maltose	1.6 g
Starch	68.3 g
Maltodextrins	?
Glycogen	?
Water	1744.1 g
Alcohol	0 g
Dietary fibre	47.4 g
Resistant starch	>6.2 g
Soluble non starch polysaccharides	>5.2 g
Insoluble non starch polysaccharides	>8.8 g
Fibre-Englyst	>16.2 g
Organic acids	>1.7 g
Ash	20.7 g
Sugar Alcohols	
Sugar alcohols	?
Vitamins	
Thiamin	1.145 mg
Riboflavin	2.993 mg
Niacin	20.158 mg
Niacin equivalents	37.899 mg
Vitamin C	292.317 mg
Vitamin D (by summation)	3.672 µg
Ergocalciferol (Vitamin D2)	0 µg
Cholecalciferol (Vitamin D3)	3.7 µg
Vitamin E	25.274 mg
Tocopherol, alpha	>18.945 mg
Tocopherol, beta	>0.512 mg
Tocopherol, gamma	>2.386 mg
Tocopherol, delta	>0.062 mg
Vitamin B6 (by analysis)	2.984 mg
Vitamin B12	5.238 µg
Vitamin K	>122.0 µg
Pantothenic Acid	>5.766 mg
Biotin	>8.612 µg
Total folate	627.518 µg