Development and Feasibility of a Novel Food Quality Classification System: The HISS.

Olivia Malamatenios

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

2022

School of Sport and Recreation

Abstract

Background:

Accurate quantification of diet is essential to understand the relationship between diet and health, as well as understanding the efficacy of interventions. Yet, inherent problems from commonly used dietary recall instruments include recall issues, bias, and misreporting, which are persistent in measuring nutrients and calories. Newer ways of understanding food are emerging, particularly regarding food quality. However, common food classification systems such as NOVA fail to quantify food quality aspects. This study aimed to develop a novel food classification system that quantifies food quality using a unique scoring system combined with digital photography.

Methods:

A modified food classification system based on the NOVA was developed: The Human Interference Scoring System (HISS), with quantitative measures and serving sizes used to identify the quality of digitally photographed food recalls. User testing was completed by nutritional professionals classifying five food records using the HISS to test the feasibility. The feasibility of the HISS was confirmed by identifying the inter-rater reliability using an intraclass correlation (ICC); by exploring the association between nutritional composition and HISS categories; and by conducting a thematic analysis from questionnaire responses.

Results:

The HISS showed a high degree of reliability between the unprocessed (.778, $p < .001$) and ultra-processed (.827, $p = .000$) categories. The measure provided strong concordance with the usual nutrient-based measures. The ultra-processed HISS category had a moderate to strong positive association with total energy r_{rm} (51) = .55, $p < .001$, total sugar r_{rm} (51) = .79, $p < .001$, and carbohydrates r_{rm} (51) = .74, $p < .001$, and negatively correlated with dietary fibre r_{rm} (51), = -.39, p = .004, these were all statistically significant. The unprocessed HISS category had a weak to moderate negative correlation with total energy r_{rm} (51) = -.14, $p = .309$, and total sugar r_{rm} (51) = -.21, $p = .135$, and these were not statistically significant. For the unprocessed HISS category and carbohydrates, there was a moderate negative correlation r_{rm} (51) = -.56, $p <$ .001 and a positive correlation with dietary fibre r_{rm} (51) = .44, $p < .001$, both statistically significant.

Conclusion:

The HISS is a reliable and feasible instrument to use in reporting digital photography food recalls and can be used to quantify food quality by trained nutrition professionals. Energy intake, total sugar, and carbohydrates were significant predictors of foods in the ultra-processed category and quantifying food quality with the HISS was a reasonable proxy for nutrient measures. The HISS has the potential to develop nutritional epidemiology and assess the quality of dietary patterns. However, further research and development is needed to make it scalable.

Contents

List of Figures

List of Tables

List of Appendices

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.

___________________________	22/04/2022
Signature	Date

Acknowledgements

I would like to extend my deepest gratitude to my supervisor Prof Grant Schofield, for the ongoing support and assistance throughout my research journey. All the constructive feedback shared extensive knowledge in this area, and the unwavering guidance to complete my dissertation would not have been possible without your experience and support. The encouragement and your profound belief in my work and abilities has helped me get to this point, and it has been a pleasure working with you and the Human Potential team.

Special thanks to Dr Caryn Zinn, Taylor Nicol, and the Co-op students involved, for their contribution towards the HISS classification system and their feedback.

Many thanks to the nutrition professionals who took the time to take part in this research and give their valuable feedback and recommendations.

I would also like to extend my gratitude to my friends who proofread my dissertation and their support along this journey.

Ethics Approval

Ethics approval was granted by the Auckland University of Technology Ethics Committee (AUTEC) on the 23rd of September 2021.

- AUTEC: 21/326 Feasibility of using digital photography with a food processing classification system to improve quantification of food quality

Introduction

Poor diet quality contributes to the disease burden worldwide and is causal for several non-communicable diseases (NCDs) including obesity, diabetes, mental illnesses, and some cancers. The global burden of malnutrition includes undernutrition, overnutrition, and inadequate vitamins or minerals which are resulting in diet-related NCDs and mental illnesses. Diet-related NCDs is having serious and lasting medical, social, and economic impacts on society (World Health Organization, 2021). The shift in global food systems and economic developments in agribusiness and food manufacturing has changed humans' food consumption over recent centuries and now is a major cause of ill health and a huge global health burden. Humans have had to constantly adapt to new food environments: from raw to cooked foods, traditional to processed foods, and processed to ultra-processed foods (Fardet, 2018). Eating pattern shifts are collectively referred to as the 'nutrition transition', linking dietary changes to wealth, with informing analyses of NCDs and the association with overnutrition (Gouel & Guimbard, 2019). Food systems do not focus on delivering optimal food for humans' diets but instead are driven to maximise profits (Stuckler & Nestle, 2012). The modern methods of food production and the 'Big Food' industries are rising the consumption of processed foods and sugar-sweetened beverages, and are driving the increasing levels of NCDs worldwide (Stuckler & Nestle, 2012). In countries with stronger economies, the food supply is dominated by a modern food system with packaged, ready-to-eat food products such as snacks, soft drinks, sweets, and fast food restaurants (Coad & Pedley, 2020). The food industry is displacing the traditional dietary patterns with processed food products that are low-quality, nutrient-poor, and energy-dense. The food industry has a profound influence on food consumption outcomes and diets, with the food availability and accessibility influenced by globalisation, urbanisation, socioeconomic status, disposable income, and marketing and consumer attitude (Haile et al., 2017). In the US diet the average content of vitamins, fibre, and calcium has decreased significantly across quintiles of the energy contribution of ultra-processed foods (UPFs), while added sugar and carbohydrates (CHO) have increased (Martínez Steele et al., 2017). Most food processing techniques reduce nutritional quality to increase the palatability, shelf-life, and transportability of food (Stuckler & Nestle, 2012). Highly palatable foods have increased in this nutrition transition and are typically high in energy, lipids and simple CHO that trigger increased food intake and overeating, despite energy needs. The food matrix and combination of sugars, refined starches, fats and additives in processed foods stimulate metabolic and hormonal responses, including the involvement of reward-motivated behaviours driven by central neural pathways (Bodnaruc et al., 2016). Dietary patterns that contain highly processed foods have poor nutritional quality and are getting a lot of attention in literature with links to obesity, and an array of other diseases.

In nutritional epidemiology, dietary intake instruments and assessments combine macronutrients into singular categories and overlook the metabolic effects of the different macronutrient quality and food-related compounds. The quality of CHO and consumption of low, medium, and high glycaemic index (GI) food products need to be captured in dietary assessment. The food matrix of macronutrients have different metabolic and hormonal responses due to insulin secretory responses post-meal and release of incretin hormones, known as the “incretin effect” (Salvatore et al., 2019). Incretin hormones are stimulated to be released by nutrients in the small intestine and augment the glucose-induced secretion of insulin (Efendic & Portwood, 2004). The GI of foods and the quality of ingested CHO stimulate different metabolic effects with the secretion of incretin hormones, glucagon-like peptide1 (GLP-1) and glucose-dependant insulinotropic polypeptide (GIP) which release insulin and regulate responses (Salvatore et al., 2019). Diet composition, especially CHO quality, influences the secretion of incretin hormones, with GLP-1 regulating the homeostasis of food intake, and GIP promoting inflammation and insulin resistance (Bodnaruc et al., 2016; Ludwig et al., 2021). Consumption of food products with a high dietary glycaemic load (GL) influences a fast absorption of glucose that increases insulin secretion, suppresses glucagon secretion and stimulates a GIP response (Ludwig et al., 2021). This anabolic state postprandial from a high GI diet with large intakes of processed foods are driving these hormonal responses and are affecting humans’ metabolic health status. The quality of macro- and micronutrients consumed influence nutrient absorption and have different metabolic outcomes. Having robust nutritional instruments to study dietary intake and capture the quality of food is essential to assess the diet and disease relationship, identify trends, and influence and inform policy.

Accurate quantification of diet is essential for epidemiological studies to investigate the relationship between diet and health and to understand the effects on diseases to identify the efficacy of interventions and the associated behavioural change (Hochsmann & Martin, 2020). Having accurate food intake measurements is crucial for epidemiology and public health for monitoring population health and identifying dietary patterns, interpreting research to identify trends and at-risk groups, and informing health policies. To date, self-reported dietary assessments are performed with recall instruments, such as dietary recall, diet diaries, and food frequency questionnaires, and these are the mainstay of nutritional epidemiology research (Ravelli & Schoeller, 2020b). The current self-report dietary assessments are problematic as they are prone to misreporting and tend to focus on the total energy content of foods and distribution of the sources of energy, without looking at the overall diet and quality of food. These methods do not capture the quality of the food content and instead focus on the total calories with an analysis of specific nutrients or food groups to identify deficiencies and energy balance. All three of these self-reported dietary instruments have shown evidence of systematic misreporting with under-reporting of energy intake (Ravelli & Schoeller, 2020a). There are many limitations of self-report recall methods and to avoid biases of misreporting, digital photography can be used to give more accurate dietary intake data. Digital photography can be used in free-living settings and can easily capture dietary intake throughout the day to improve diet recording.

Alongside measurements of food intake, having robust frameworks that can be applied to dietary data in research to examine the quality of foods is essential. In recent epidemiological research describing the pathological food environment by differentiating food by their level of processing is commonly used. Globally, researchers have proposed frameworks that classify foods in categories according to their degree of processing, ranging from unprocessed or minimally processed foods to UPFs. Several systems have been applied in research, with the NOVA system being the most commonly used framework. However, the food classification systems used and developed by researchers are not set up to accurately quantify the quality of food. Having a food classification system that can be applied to public health research in New Zealand, to accurately quantify food quality, would benefit nutrition epidemiology and its practice. The purpose of this research study is to test the feasibility of using a modified NOVA system that has been developed called the 'Human Interference Scoring System' (HISS) and to identify if this food classification system identifies the degree of processing, accurately reflecting food quality and different eating patterns when analysing digital images captured by the user.

Research Objectives

The first aim of this research was to determine the reliability of the HISS, when used by nutrition professionals to identify the level of processing and portion sizes, from looking at digital food images. The second aim was to identify the strength of the associations between the degree of food processing categories with usual nutrient composition variables. The third was to collect qualitative data via questionnaire responses, to identify what worked well when using the HISS to identify food quality, and what improvements can be made to the instrument. Taken together, the research in this dissertation offers an important first step in rethinking how nutritional epidemiology can be redefined using food quality.

Literature Review

The Nutrition Transition

Food processing has been important for human nutrition and evolution for millions of years, turning food into safe and digestible forms through heating, fermenting, drying, and smoking (Baker et al., 2020). The tools and technologies that have developed throughout the human evolution have improved food availability, digestibility, and safety. This has enabled humans to thrive as a species. For example, it is highly likely that humans could never have evolved a brain as large as we have without the ability to prepare and preserve foods to maximise calorie value and reduce digestive processing. Humans transitioned approximately 10,000 years ago into a new transition called the "agricultural revolution". The ability to improve food security through farming of domesticated animals and seasonal cropping allowed our population to start its exponential growth. This agricultural revolution had some profound effects on human health. There was a reduction in brain size and body stature, as well as a reduction in life expectancy (Scott, 2017). However, birth rates increased as infants could more easily be weaned from breast feeding to soft foods.

Our most recent transition has been the industrialisation and globalisation of food systems. This has moved food processing to an entirely different level with the mass production and global trade using processing techniques such as canning, refrigeration, dehydration and many more techniques, which have proven to be economically beneficial. An entirely new category of food called Ultra Processed Food (UPF) has been introduced to the human food supply. While these foods have improved the availability of food and improved food security for many, the net benefit is questionable in terms of human health. The 'nutrition transition' and significance of UPFs as a major source of dietary intake likely have a profoundly negative effect on human public health, and also on the environment (Baker et al., 2020). The coexistence of overnutrition and undernutrition, known as 'malnutrition,' is affecting most people in today's world. Environmental factors, food insecurity and access to nutritious food are some of the most significant factors causing malnutrition (Coad & Pedley, 2020). Populations have shifted from traditional diets to diets high in sugar, processed vegetable oils and refined CHO, with greater consumption of fast food and sugar-sweetened beverages (Hobbs et al., 2021). Diets including industrially processed foods, sugar-sweetened beverages, snacks, and fast foods are not recommended for prolonged consumption, however, the hyper-palatability and availability of these foods are increasing their regular consumption (Cuevas-Sierra et al., 2021).

Collectively, the corporations manufacturing the bulk of the world's UPFs are known as 'Big Food.' The Big Food multinational food and beverage companies are a driving force behind the rise in consumption of processed foods that are enriched in sugar, salt, and fat and are influencing higher consumption of sugar-sweetened beverages (Stuckler & Nestle, 2012). The availability of unhealthy food products that are convenient and affordable are promoting these unhealthy dietary patterns. Big Food are criticised for their focus on profit and disregard the impact it is causing on the health of the human population, both in terms of metabolic health and environmental health. Ultra-processed food products have a greater energy density, saturated and trans-fat content, and added sugars, for increased palatability, shelf-life, and stability of food, all of which are attributes of a pro-inflammatory diet (Silva et al., 2019). There are further unknown, but plausible, negative effects on human health as a result of the Big Food industry adding ingredients to foods such as: a range of additives that are industrially produced, such as High Fructose Corn Syrup (HFCS); Monosodium Glutamate (MSG); guar gum; artificial sweeteners and food colouring; sodium nitrate; and trans fats—just to name a few.

The food system in New Zealand is environmentally damaging and is also associated with inexpensive and low-quality foods, making UPFs more easily accessible (Coad & Pedley, 2020). In New Zealand supermarkets, there are over 80% of packaged food products classified as ultra-processed, and these items have a low nutrient profile (Luiten et al., 2016). The UPFs are ready to eat products that are energy dense, high in refined starches, sugars, fats, additives, and salt and have less fibre, macronutrients, and protein (Chen et al., 2020; Coad & Pedley, 2020). UPF consumption negatively affects the nutritional quality of diets; with UPFs correlated with an increase in sugars, fats, and a decrease in fibre, vitamins, protein, zinc, magnesium and niacin (Martini et al., 2021). Not only are UPFs easily accessible in supermarkets and convenience stores, but they are also highly marketed and promoted by food companies. Dominant food companies and their marketing power have the ability to promote and reinforce food environments with high degrees of processing towards susceptible individuals with their products highly marketed increasing consumption (Wood et al., 2021). Freshly prepared meals cooked at home are being replaced by convenient, highly processed food products that are ready to eat, and this is promoting overconsumption for susceptible individuals (Baker et al., 2020). The change in the food chain by food manufacturers, food retailers, food service companies, and agribusiness has been accompanied by increased consumption of UPFs purchases (Popkin et al., 2020). The purchases of UPFs have increased continuously, with increased sales of snacks and soft drinks in high-and middle-income countries from the year of 1998 to 2012 (Monteiro et al., 2013) . Analysis of household purchases in Canada and Brazil showed that UPFs are displacing staple foods such as potatoes, rice, legumes, milk, and fruit and vegetables (Monteiro et al., 2013). Thus, transforming the food culture and dietary patterns in high-income and middle-income countries. Sugar-sweetened beverages are one of the largest sources of calories and added sugar in the diet of millions, with evidence showing regular consumption increases the risks of obesity and overweight adults, adolescents, and children (Ferretti et al., 2021). Ferretti and colleagues (2021) illustrate how a diet based on energy-dense foods and beverages results in a vicious cycle of overconsumption, positive energy balance, and cognitive dysfunction, influencing the prevalence of obesity. A randomised control trial with subjects receiving an ultra-processed diet for two weeks, and then an unprocessed diet for two weeks has shown that diets with large proportions of UPFs increase energy intake and this leads to weight gain (Hall et al., 2019). With the ultra-processed diet, the energy intake was greater (508 ± 106 kcal/day; p = .0004) and was correlated with weight gain ($r = 0.8$, $p < .001$). Carbohydrate consumption also increased in the diet with UPFs (280 ± 54 kcal/day; $p < .0001$) (Hall et al., 2019). A study by Gupta et al. (2019) explored the nutrient and energy density of foods by the degree of processing and UPFs were found to be low-cost, nutrient-poor, and energy-dense compared to unprocessed foods. This study classified food using NOVA system and the ultra-processed category “captured mostly grains (91%), fats and sweets (73%), dairy (71%), and beans, nuts, and seeds (70%), but only 36% of meat, poultry, and fish, 26% of vegetables, and 20% of fruit” (Gupta et al., 2019, p.1.). The UPFs had a lower nutrient density, higher energy density, and they stated the low energy cost could be one mechanism linking UPFs with negative health outcomes (Gupta et al., 2019). The hyper-palatability of calorie rich, refined and highly processed foods is making choosing quality and healthy foods a challenge.

Food Processing

In the last nutrition transition, moderate processing techniques such as canning or fermentation were used to make food edible and reduce wastage; whereas ultra-processing foods was aided by technology for the benefit of gaining profit and increasing palatability, and have increased single-use plastic wastage (Fardet, 2018). Most food processing techniques reduce the nutritional quality to increase shelf-life, transportability, and palatability (Stuckler & Nestle, 2012). It is also important to highlight that some food processing techniques provide benefits for consumer safety. Food processing reduces harmful pathogens to safe levels, preserves nutritional quality, avoiding spoilage of microorganisms and enzymes, and allows supply during off-seasons (Petrus et al., 2021). However, the mechanical food processing techniques developed in the mid-20th century enabled mass manufacture and distribution of UPFs, such as white bread, sauces, cakes, biscuits, and meat products (Monteiro et al., 2013). Following this, there was a revolutionary development in food processing, where food science techniques enabled food products to become more palatable with additives and cheap ingredients (Monteiro et al., 2013). Food processing is the procedure that changes foods from their natural state, and relates to transformations such as cooking, preservation, and enables storage. UPFs have additional additives and flavourings which alter the ingredients and nutrients, producing artificial foods that have been modified to adapt to technological and profit constraints (Fardet, 2018). Gearhardt and Schulte (2021) define UPFs as:

> industrial formulations made entirely or mostly from substances extracted from foods (oils, fats, sugar, starch, and proteins), derived from food constituents (hydrogenated fats and modified starch), or synthesised in laboratories from food substrates or other organic sources (flavour enhancers, colours, and several food additives used to make the product hyper-palatable) (p.388).

The processed ingredients that are present in processed foods are mainly refined CHO, fats (e.g., high-fructose corn syrup, white flour) and additives (e.g., flavour enhancers) and these have a faster absorption rate into the cells (Gearhardt & Schulte, 2021). According to Fardet (2018), food processing affects antioxidant, lipotropic and satiety potential by removing micronutrients and macronutrients such as fibre and proteins. The composition and makeup of UPFs induce metabolic responses, and epidemiological research reflects the risk and impact poor diet quality is having on humans' health with the rise in UPFs.

Ultra-Processed Foods: Impact on Health

Poor diet quality is a major determinant of NCDs and the rise in processed foods has increased simultaneously with an increase in NCDs. Recent reviews and meta-analyses have provided evidence of the association of UPFs with increased risk of varying NCDs, such as obesity, diabetes, cardiovascular disease (CVD), metabolic syndrome, depression, and all-cause mortality (Lane et al., 2021). A systematic review of epidemiological studies by Chen et al., (2020) also revealed positive associations between consuming UPFs and the risk of health outcomes. Consumption of UPFs was associated with the NCDs mentioned above along with coronary heart disease, cerebrovascular disease, hypertension, irritable bowel syndrome, overall cancer, postmenopausal breast cancer, gestational obesity, adolescent asthma, dental caries and frailty (Chen et al., 2020). Having a poor diet quality and a lack of nutrients leads to the development of these NCDs and poor mental health. Research has shown diets low in fruit and vegetables and a higher intake of processed foods are related to higher rates of depression and anxiety (Rucklidge et al., 2015). Dietary guidelines and a shift in the global food system is needed to slow the prevalence of NCDs (Chen et al., 2020). Longitudinal studies evaluating the association of UPFs intake and mortality among individuals with CVD has shown a linear dose-response relationship with diets rich in UPFs associated with increased hazards of all-cause and CVD mortality (Bonaccio et al., 2022). Similarly, Zhong et al., (2021) found participants had higher risks of death from CVD and heart disease if they were in the highest vs. lowest quintiles of UPFs consumption. In the US population, there was also an increased risk of mortality and a harmful association from UPFs for women than in men ($p < .05$) (Zhong et al., 2021). These epidemiological studies suggest consumption of UPFs is a public health concern and limiting UPFs in dietary guidelines is needed for prevention. Eating a healthy unprocessed and whole food-based diet enables essential metabolic reactions to occur, supports energy function, reduces inflammation, and provides nutrients to optimise brain health (Rucklidge et al., 2021). UPFs increase the risk of NCDs, brain, and health problems largely because of the metabolic responses to low-quality food and the lack of nutrients in a processed foods diet.

Metabolic Effects of Processed Foods: Hormonal Responses

Consumption of highly processed foods causes physiological and metabolic responses that perpetuate consumption, cause metabolic dysregulation, and promote insulin resistance. The carbohydrate-insulin model provides a physiological perspective on the obesity pandemic, showing how metabolic responses from modifiable factors such as diet and the quality of food consumed is crucial. Processed food that has CHO that is rapidly digested, acting through insulin and other hormones, drives fat deposition and promotes a desire for more high-calorie foods (Ludwig et al., 2021). UPFs and refined starch causes high glucose excursions, raising insulin and with this constant hormonal response comes metabolic dysregulation. UPFs that have a high sugar content or high GI (potato products, processed grains) cause glucose to rapidly absorb, increasing insulin secretion, and suppressing glucagon secretion (Ludwig et al., 2021). Post-meal hyperglycaemia (high blood sugar) causes secretion of insulin and incretin hormones, resulting in the incretin effect (Salvatore et al., 2019). Following post-meal hyperglycaemia, there is a post-meal hypoglycaemia (low blood sugar) which results in more hunger from the overshoot of insulin. When low GI foods are consumed, blood sugars are stabilised and have the satiety potential to discourage snacking in between meals. The incretin hormones GLP-1 and GIP have an additive effect on insulin secretion when nutrients such as glucose, other CHO (sucrose and starch), triglycerides, and some amino acids stimulate incretin secretion (Salvatore et al., 2019). These incretin hormones regulate postprandial homeostasis and have variable responses to the source of food. Consumption of high GI CHO results in anabolic actions, affecting the metabolic fuel concentration in the blood (Ludwig et al., 2021). This causes oxidation of energy-sensing tissues that drive a positive energy balance in the postprandial phase (Ludwig et al., 2021). Low GI CHO are digested more slowly and bypass the upper intestinal K-cells that produce GIP reaching the L-cells in the gastrointestinal tract that secrete and increase concentrations of GLP-1 (Salvatore et al., 2019). Therefore, the quality of CHO stimulates different hormone secretion and evidence shows enhancing GLP-1 secretion has beneficial effects on blood glucose and several markers of cardiometabolic health (Bodnaruc et al., 2016). Conversely, if GIP is dominant, there are inflammatory effects, promoting insulin resistance, preadipocyte differentiation, and fat storage (Ludwig et al., 2021). Cellular CHO remain intact, and the cells have fibre, thus, take longer to be absorbed and are healthier than acellular CHO. In comparison, acellular CHO do not contain a cell structure as they are removed during processing, and the dense refined grains that are in modern foods are obesogenic and are proinflammatory (Spreadbury, 2012).

A preliminary study by Fardet (2016) showed how the food structure plays a role in health potential, with strong correlations between the glucose load, satiety, and the degree of processing. These results showed the more processing the food has been through, there is a higher glycaemic response, and a lower satiety potential, suggesting more consumption of natural and minimally processed foods should be a focus in health promotion (Fardet, 2016). Not only do high GI foods and UPFs alter metabolic responses with rapid absorption into the system, UPFs with refined CHO and added fat also implicate addictive food behaviours. Having a diet with a high intake of calorie-dense ingredients (e.g., sugar, fat) that are mostly present in UPFs activates reward and motivation systems, enhancing the subjective pleasure of regular consumption (Gearhardt & Schulte, 2021). The prominent levels of fat, refined CHO, sodium, and other flavour enhancers and additives in the modern food environment, effectively activate the reward and motivation systems in the brain. These reward and motivation systems are associated with addiction, binge eating, and increase the intake of processed foods (Gearhardt & Schulte, 2021). The delayed drop in blood glucose following the postprandial spike triggers cravings to continue consuming CHO (Gearhardt & Schulte, 2021). The release of insulin after consumption of refined CHO interacts with striatal dopamine, heightening the rewarding nature of these processed foods and has an influence on the successive consumption (Gearhardt & Schulte, 2021). Fats (e.g., saturated, trans) are associated with rewarding somatosensory properties enhancing the palatability and additive potential, and the combination of both high fat and CHO foods downregulate dopamine receptors causing binge eating (Gearhardt & Schulte, 2021). The combination of both high fat and CHO are not seen in natural foods; however, they are common ingredients in processed foods.

The food structure and its characteristics are important because of the effect of nutrient bioavailability and the feeling of satiety (Fardet et al., 2015). When food is processed, it leads to the breakage of the cell walls and this affects the bioavailability in the small intestine (Zinöcker & Lindseth, 2018). These pathologies are also affecting gut microbiota diversity and composition in individuals who consume low-fibre diets with a higher contribution of UPFs. These diets are contributing to the pro-inflammatory characteristics of metabolic diseases with imbalances in the production of short-chain fatty acids (Cuevas-Sierra et al., 2021). Research has shown that consuming more than five servings per day of UPFs may affect gut microbiota and its composition, with sex also being a factor (Cuevas-Sierra et al., 2021). Western diets are promoting inflammation and affecting the gut microbiota from increased ingestion of UPFs and acellular CHO. This is caused by the accessible acellular nutrients facilitating altered composition and metabolism of the gut microbiota and increased growth potential (Zinöcker & Lindseth, 2018). Deconstruction of the original food matrix and additives added to food products are associated with changes in the composition and metabolic behaviour of the gut microbiota, thus promoting inflammatory diseases (Bonaccio et al., 2022). The quality of food is important to capture, to document eating patterns and conduct epidemiological research. Researchers have proposed food classification systems that look at the level of processing the food has been through, shifting away from the traditional food grouping paradigm. Replacing established paradigms in nutrition is a gradual process that needs to be adjusted, tested, and publicised and known as valuable, useful, and plausible by scholars and organisations (Cannon & Leitzmann, 2022). Shifting the paradigm will change the focus of food and nutrition science to production, validating whole and minimally processed foods, and can be applied to all countries (Cannon & Leitzmann, 2022). Industrialisation of food has resulted in the majority of what people eat becoming ultra-processed and this has implications in almost every chronic disease risk and progression. A nutrition transition towards a healthier diet and lifestyle and improved dietary choices, with reversing the rapid shift to diets dominated by UPFs can reduce the increasing prevalence of nutrition-related NCDs (Popkin & Ng, 2022). The multiple hormonal and neurological effects insulin, glucose, incretin hormones, leptin resistance and dopamine pathways have, result in harming the human condition. These neural dysregulation responses are causing increased weight gain and associated metabolic comorbidities leading to overnutrition, obesity and poor quality of life (Timper & Brüning, 2017). There needs to be urgent action taken to resolve some of these food policies and in practice issues, yet decades into this transition we have made little to no progress and arguably things are just getting worse. Part of the problem may the way in which health systems and policies are approaching the problem. Health professionals have tended to single out nutrients and not look at the overall quality of the diet. The low-fat revolution based on Ancel Keys diet heart hypothesis, which combined perverse behaviour from Big Foods caused more harm than good (Teicholz, 2014). There needs to be a wider view on promoting quality food and using educational tools to educate the population. Food classification systems are tools that are used in research and have the potential to be used by individuals to make healthier food choices if they are easily understood.

Food Classification Systems

Classification systems have been developed to predict diet quality and health outcomes by categorising food according to their degree of processing. Several food classification systems have been applied to dietary data in research, aiming to classify foods according to the levels of processing, with categories ranging from minimally processed too highly processed. These include the NOVA system, developed in Brazil, which is used internationally; a system developed by the International Food Information Council (IFIC), a system in Europe developed by researchers at the Intentional Agency for Research on Caner (IARC), a system developed in Mexico by researchers from the National Institute of Public Health in Mexico (NIPH), one by researchers at the University of North Carolina at Chapel Hill (UNC) and the Poti classification that was developed in consultation with food scientists and dieticians (Bleiweiss-Sande et al., 2019; Moubarac et al., 2014; Poti et al., 2015). Each food classification system has key differences based on the number of categories they used to classify, the definitions, and their application to the population used in research. Most food classification systems are country specific besides NOVA, the internationally used food classification system. NOVA has been most applied in scientific literature to describe populations dietary patterns, the change overtime with UPFs, and also nutrient analyses with health outcomes (Monteiro et al., 2018). NOVAs was used in 95% of the studies on the topic of food processing published between 2015 and 2019 and has recently been used to guide public health decisions (Braesco et al., 2022). NOVA classifies food into four food groups: unprocessed and minimally processed foods, processed culinary ingredients, processed foods and ultra-processed food and drinks products. The food is grouped according to the extent and purpose of industrial processing they have been through (Monteiro et al., 2018). NOVA clearly defines how formulations of ingredients, and additional ingredients with the use of salt, sugar, oils, fats, additives, and preservatives determine which category the food is classified. NOVA coherently defines the four groups and definitions, displaying each type of processing and the additional ingredients used to make processed foods, as shown below in Table 1. This classification system has been a work in progress, initially developed in 2009 and later revised in 2012 (Monteiro et al., 2012). A recent guidance report was published in 2019 by Monteiro and his colleagues, which concludes all the latest evidence from the research that used NOVA and provides additional recommendations.

Monteiro and his research team have made an outstanding contribution to research in food processing with this food classification. More recently Monteiro and colleagues published a commentary containing an easy guide to help researchers, policy makers, health professionals and consumers identify UPFs (C. A. Monteiro et al., 2019) .

Table 1
NOVA Internationally Used Food Classification System

Groups and definition	Examples
1: Unprocessed and minimally processed foods *Unprocessed:* Edible parts of plants (fruit, seeds, leaves, stems, roots, tubers) or of or from animals (muscle, fat, offal, eggs, milk), and also fungi, algae, all after separation from nature. Spring and tap water. *Minimally processed:* Unprocessed foods altered by industrial processes such as removal of inedible or unwanted parts, drying, powdering, squeezing, crushing, grinding, fractioning, steaming, poaching, boiling, roasting, and pasteurization, chilling, freezing, placing in containers, vacuum packaging, non-alcoholic fermentation, and other methods that do not add salt, sugar, oils or fats or other food substances to the original food. The main aim of these processes is to extend the life of unprocessed foods, enabling their storage for longer use, or to make them edible, and, often, to make their preparation easier or more diverse. Infrequently, minimally processed foods contain additives that prolong product duration, protect original properties, or prevent proliferation of microorganisms.	Fresh, squeezed, chilled, frozen, or dried fruit and leafy and root vegetables; grains such as brown, parboiled or white rice, corn cob or kernel, wheat berry or grain; legumes such as beans, lentils, and chickpeas; starchy roots and tubers such as potatoes, sweet potatoes and cassava; fungi such as fresh or dried mushrooms; meat, poultry, fish and seafood, whole or in the form of steaks, fillets and other cuts; fresh, powdered, chilled or frozen eggs; fresh, powdered or pasteurized milk; fresh or pasteurized fruit or vegetable juices (with no added sugar, sweeteners or flavours); grits, flakes or flour made from corn, wheat, oats, or cassava; tree and ground nuts and other oily seeds (with no added salt or sugar); herbs and spices used in culinary preparations, such as thyme, oregano, mint, pepper, cloves and cinnamon, whole or powdered, fresh or dried; fresh or pasteurized plain yoghurt; tea, coffee, and drinking water.

2: Processed culinary ingredients Substances obtained directly from group 1 foods or from nature by industrial processes such as pressing, centrifuging, refining, extracting, or mining. Used to prepare, season, and cook group 1 foods. May contain additives that prolong product duration, protect original properties, or prevent proliferation of microorganisms.	Vegetable oils crushed from seeds, nuts, or fruit (notably olives); butter and lard obtained from milk and pork; sugar and molasses obtained from cane or beet; honey extracted from combs and syrup from maple trees; starches extracted from corn and other plants; vegetable oils with added antioxidants; salt mined or from seawater, and table salt with added drying agents.
3: Processed foods Products made by adding salt, oil, sugar, or other group 2 ingredients to group 1 foods, using preservation methods such as canning and bottling, and, in the case of breads and cheeses, using non-alcoholic fermentation. Processes and ingredients here are designed to increase the durability of group 1 foods and make them more enjoyable by modifying or enhancing their sensory qualities. They may contain additives that prolong product duration, protect original properties, or prevent proliferation of microorganisms.	Canned or bottled vegetables and legumes in brine; salted or sugared nuts and seeds; salted, dried, cured, or smoked meats and fish; canned fish (with or without added preservatives); fruit in syrup (with or without added antioxidants); freshly made unpackaged breads and cheeses.

4: Ultra-processed foods Formulations of ingredients, mostly of exclusive industrial use, made by a series of industrial processes, many requiring sophisticated equipment and technology (hence 'ultra-processed'). Processes used to make ultra-processed foods include the fractioning of whole foods into substances, chemical modifications of these substances, assembly of unmodified and modified food substances using industrial techniques such as extrusion, moulding, and pre-frying; use of additives at various stages of manufacture whose functions include making the final product palatable or hyper-palatable; and sophisticated packaging, usually with plastic and other synthetic materials. Ingredients include sugar, oils or fats, or salt, generally in combination, and substances that are sources of energy and nutrients that are of no or rare culinary use such as high fructose corn syrup, hydrogenated or interesterified oils, and protein isolates; classes of additives whose function is to make the final product palatable or more appealing such as flavours, flavour enhancers, colours, emulsifiers, and sweeteners, thickeners, and anti-foaming, bulking, carbonating, foaming, gelling, and glazing agents; and additives that prolong product duration, protect original properties or prevent proliferation of microorganisms. Processes and ingredients used to manufacture ultra-processed foods are designed to create highly profitable products (low-cost ingredients, long shelf life, emphatic branding), convenient (ready-to consume) hyper-palatable products liable to displace freshly prepared dishes and meals made from all other NOVA food groups.	Many ready-to-consume products such as carbonated soft drinks; sweet or savoury packaged snacks; chocolate, candies (confectionery); ice-cream; mass-produced packaged breads and buns; margarines and other spreads; cookies (biscuits), pastries, cakes, and cake mixes; breakfast 'cereals', 'cereal' and 'energy' bars; 'energy' drinks; milk drinks, 'fruit' yoghurts and 'fruit' drinks; 'cocoa' drinks; 'instant' sauces. Many pre-prepared ready-to-heat products including pies and pasta and pizza dishes; poultry and fish 'nuggets' and 'sticks,' sausages, burgers, hot dogs, and other reconstituted meat products; and powdered and packaged 'instant' soups, noodles, and desserts. Infant formulas, follow-on milks, other baby products; 'health' and 'slimming' products such as meal replacement shakes and powders

Note. Adapted from Monteiro et al., 2019.

This classification system has received some scrutiny, with many researchers critically analysing the system and its reliability. Moubarac et al. (2014) evaluated food classification systems used in research and found there were incomplete distinctions between domestic and industrial processing, and an unclear criterion for degree of processing, with overlaps in their criteria used to define the categories. The NOVA system was ranked the highest based on an evaluation of quality and is noted to have coherent categories, covering a range of food products, and has been successfully applied to many studies (Moubarac et al., 2014). However, this poses a conflict of interest with the same research team who created NOVA conducting the systematic review. In contrast, newer research found that the NOVA, IFIC and UNC food systems have a considerable overlap when looking at the nutrient concentration between moderately processed and other processing categories, with NOVAs processing categories least aligned with nutrient concentration (Bleiweiss-Sande et al., 2019). Including the nutritional component and its relation to processing into classification systems are important to understand the health effects. NOVA also makes no distinction between whole and refined grains, while the IARC-EPIC and the Poti classification systems classify them more distinctively. Additionally, only a few classification systems classify foods that are processed at home (IARC-EPIC, IFIC) (Sadler et al., 2021) which is important to identify when looking at overall diets. A more recent validation study assessed NOVAs feasibility for categorisation with raters using the USDA Food and Nutrient Database. The agreement between the two independent raters was only moderate with a Cohens Kappa of 0.58, with the disagreements coming from the mixed dishes (Lorenzoni et al., 2021). The evidence presented here suggests this will be one of the limitations when using processing classifications to categorise more complicated dishes that involves multiple ingredients. Similarly, Braesco et al., (2022) found NOVA does not allow for robust and functional food assignments, with the low consistency among evaluators using the system. With NOVAs descriptive nature, it can cause ambiguity and differences in interpreting the categories, and even with ingredients provided, personal knowledge and subjective feelings determine how the food is classified into the system (Braesco et al., 2022).

From a food science perspective, some foods could not be consumed safely if processing was not involved, and food classification systems need to reflect this. Some ingredients are important for food preservation and safety and having both a food science and health science aspect incorporated into a classification system is necessary to avoid conflict. Collaboration with a dietician and food scientist, like Poti et al. (2015) have done is a way to incorporate other confounding factors in food processing classification systems. However, the Poti food classification was more based on the convenience of food. Food engineering and science need to be taken into consideration if food processing is used for classification (Petrus et al., 2021).

For example, raw milk goes through homogenisation and pasteurisation before we can safely consume it. Listing raw milk in the unprocessed categories (as NOVA does) could potentially encourage consumers to seek it, or even process it at home, without having the safety measures and control in home environments (Petrus et al., 2021). With the focus of food products categorised by the degree of processing, NOVA bases some classification on the food ingredients listed, causing ambiguity.

NOVA and the other food classification system used in epidemiology have not been set up to quantify the quality of food, with no quantitative measures to assess the properties of food. Researchers have used additional measures of diet quality, such as the Healthy Eating Index (HEI), a tool developed by the United States Department of Agriculture and the National Cancer Institute and is used as a measure for assessing foods in alignment with the dietary guidelines for America (Krebs-Smith et al., 2018). The HEI is used alongside classification systems to find the association between processed foods and food quality. What previous food classification systems do not take into consideration is including any quantitative measures, scoring components, or quantification of foods in each of the categories. Sadler and colleagues (2021) point out that having the attention on food processing may not consider a balanced diet and portion sizes, emphasising the importance of having quantitative measures. Other points were examined among the current food classification systems used in research, with methods of processing determining the categories and not relying on the number of ingredients, the inclusion of artisanal processing, and aligning processed foods categories with health outcomes being some of the key takeaway messages of what is lacking in classification systems. Categories need to also avoid subjective and value-laden terms, with more attention on helping consumers understand food processing (Sadler et al., 2021). It has been identified it is doubtful to have a simple classification that addresses food processing and its consequences (Fardet et al., 2015) especially when a system's aim is to be used both in research and publicly.

Food classification systems based on the degree of processing has been noted to be more nutritionally relevant (Fardet et al., 2015). As noted by Fardet et al., (2005) when dietary patterns are emphasised, it considers a more realistic way of eating in comparison to traditional food groups, as different foods are often combined together in meals. The research presented thus far shows incorporating the food matrix, having a scientific accuracy of health-related risks, including nutrient components, and a quantitative measure into a food classification system is needed. However, such classification systems remain narrow in quantifying overall food quality while assessing and capturing dietary patterns.

Nutritional Epidemiology

Self-report recall methodologies are the mainstay of nutritional epidemiology research. Food recalls, food frequency questionnaires, and 24-hour recalls are used to assess food intake (Carolina Archundia Herrera & Chan, 2018; Hochsmann & Martin, 2020). These self-reported methods are associated with limitations, with the reliance on participants' recollection and declaration often presenting with differential under-reporting, misreporting, intentional over-reporting, and errors with estimating portion sizes of foods (Doulah et al., 2019; Hochsmann & Martin, 2020). Food recalls can often lead to a change in food behaviour patterns, resulting in differential reporting and an inaccurate representation of consumed foods, nutrients, and energy intake (Herrera & Chan, 2018). One of the first studies assessing dietary intake using the doubly labelled water (DLW) method was by Prentice et al. (1986); which found low self-reported energy intake reported by obese people using a 7-day food diary, and under-reporting was common among adults, with a correlation to increasing BMI. The average energy intake for the obese subjects averaged 1610kcal daily, reporting lower than the lean subjects and represented an underestimation of 835kcal/day (Prentice et al., 1986). This DLW method allowed validation of dietary assessment instruments against an objective measure of total energy expenditure and is the gold standard for this purpose (Pfrimer et al., 2015) . These findings of under-reporting of energy intake were confirmed with more recent studies showing higher body fatness associated with higher rates of under-reporting in older people (Pfrimer et al., 2015). Two dietary assessments were used in this study, with results showing 24-hr recall is associated with a lower prevalence of under-reporting compared to the FFQ, with a moderate correlation between energy intake as measured by both instruments ($r = 0.70$, $p < .005$) (Pfrimer et al., 2015). A meta- and pooled analysis of five large validation studies of dietary self-report instruments found a 28% average rate of under-reporting with a FFQ and 15% with 24-hour recalls (Freedman et al., 2014). A systematic review evaluating the validity of dietary assessments in adults' self-reported energy intake reported a significant ($p < .05$) under-reporting of energy intake, with a few over-reporting (Burrows et al., 2019). Energy intake was underestimated in the instruments, in the range of 4.6-42% for FFQs, 11-41% for food recalls, and 1.3-47% for dietary records, with 24hr recalls having the lowest level of variation and total amount, ranging between 8-30% (Burrows et al., 2019). These traditional self-reporting methods are inaccurate and prone to misreporting and underestimating energy intake. They also included food records using technology components in this review, with a handheld personal digital assistant and the Remote Food Photography Method (RFPM) found to have a lower degree of misreporting (Burrows et al., 2019). Ravelli & Schoeller (2020) report that technological tools including digital photography is an approach to reduce misreporting, as they provide detailed information about consumed foods, however, are still prone to misreporting. Inaccuracies of dietary assessments accentuate the diet-disease relationship, and more accurate approaches and tools need to be developed and used to study dietary intake in free-living settings (Ravelli & Schoeller, 2020a).

Using Digital Photography

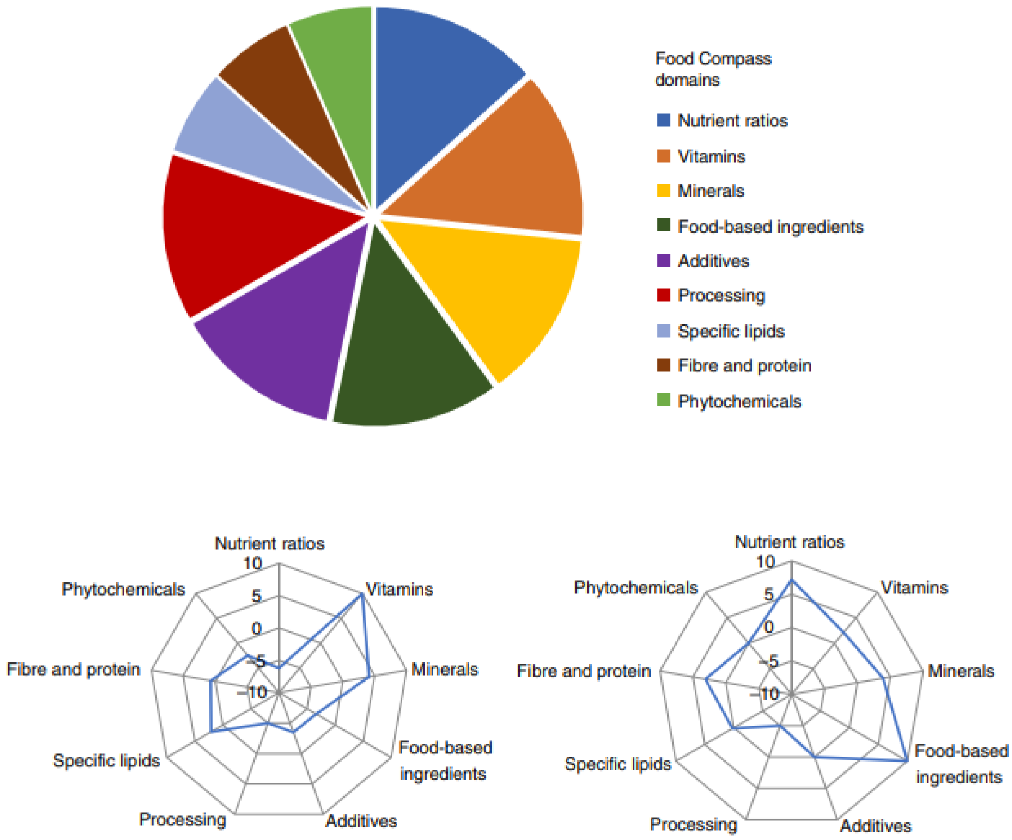
To achieve more accurate assessments of food intake, technology-driven methods are becoming more popular in research as a primary tool for dietary records (Fatehah et al., 2018). Technology-driven methods have emerged with the use of digital photography imaging apps from smartphones, and wearable devices used to capture food intake and related metrics. The ubiquitous availability of smartphones makes this an appealing strategy (Doulah et al., 2019). This method can be used in assessing free-living settings by easily capturing images of meals throughout the day and have been employed to improve diet recording (Fatehah et al., 2018). Image-assisted methods allow volume and portion size estimation, with identification of food type and ultimately nutrient values by manual review ideally from a trained nutritionist or automatic image recognition algorithm for accuracy (Doulah et al., 2019; Fatehah et al., 2018). Digital photography methods relying on images to identify and estimate food intake is an approach to quantify food intake that overcomes the many limitations self-reporting methods have. However, digital food intake monitoring tools have limited ability to assess variability and rarely consider types of food, nor the macro- or micronutrients consumed, and therefore, does not capture nutritional intake and change in the type of food over time (Herrera & Chan, 2018). Quantifying digital food photography still suffers from many issues with recall instruments. That is, quantifying food in terms of calories, added sugar, or proportions of macronutrients and is an issue. But for portion size estimates and complex meal composition, computing imaging algorithms can be employed to identify foods and estimate portion size (Martin et al., 2014). Using digital photography to capture food quality and intake that focuses on meals and food items instead of individual nutrients can be a solution to solve this issue and can be used in research to capture overall diet quality. To achieve this, identifying food quality through the degree of food processing with using a food classification system that includes quantitative measure could be a better lens.

Quantifying Food Quality

Recent research has contributed new ways of classifying food by assessing and profiling food quality. A nutrient profiling system developed by Mozaffarian, and colleagues (2021) called the Food Compass Score (FCS) is a good approach that represents a way to classify food according to nutritional composition and is related to preventing disease. This profiling system includes quantitative algorithms to score the food based on the beneficial attributes such as vitamins and the detrimental attributes with using nutrient analyses such as saturated fat and sugar (Mozaffarian et al., 2021). This comprehensive profiling system includes nutrient ratios, vitamins and minerals, food-based ingredients, additives, processing, specific lipids, fibre, and protein and also phytochemicals. This profiling system uses a scoring system ranging from 1 to 100 to calculate the FCS. Including a scoring algorithm or a quantitative measure is a good approach to help guide consumers, research, and food policy (Mozaffarian et al., 2021). This profiling systems provides a holistic assessment of food, including the nutritional aspects and health components which will be of beneficial use in research. The FCS also has a visually appealing scoring system (see Figure 1 below) that is easy for consumers to understand if used publicly.

Figure 1

Food Compass Score



Note. Food profiling system that scores food items across nine domains to calculate the Food Compass Score (FCS) ranging from 1 (least healthful) to 100 (most healthful). Reprinted from (Mozaffarian et al., 2021)

Another metric for assessing food quality with a focus on CHO is on the development stage for the purpose of improving diet quality and health outcomes. This approach to assessing CHO food quality proposes principles for developing improved metrics to assess and classify high-quality CHO foods (Comerford et al., 2021). The research team identified the intrinsic indicators that were of most interest for assessing CHO food and stated the importance of approaching it from both a nutrition science and physiological perspective. Comerford and colleagues (2021) developed the fundamental principles for CHO food quality assessment and metric development and is in the process of producing a valuable metric to be used in research and food policies. This metric based on nutrient profiling methods features food group classification and carbohydrate-fibre-sugar ratios to provide informative measures to help guide researchers, policymakers, and consumers. With more tools and metrics being developed to assess food quality, healthier food choices can be informed to improve human health and integrated into dietary guideline tools.

Summary

With diet being a major public health issue, epidemiological studies need instruments that are robust, valid, and thorough to move beyond single nutrient and calories-in calories-out models of human health. As few researchers have developed systems based on the processing and quality of food. This dissertation aims to quantify food quality using a quantitative measure and a modified NOVA food classification system. With the issues surrounding food epidemiology, shifting away from traditional dietary intake instruments and assessments, and narrowing the focus on the metabolic effects of food quality is needed. A paradigm shift towards food processing that moves away from the traditional food grouping is occurring. This will better reflect the affects of the food matrix and the quality and consumption of low, medium, and high glycaemic CHO. Incorporating food quality metrics and portion sizes to use alongside classification systems is needed not only for researchers but for consumers to easily understand dietary patterns. Sadler et al. (2021) point out the portion sizes, and a balanced diet may not be considered if the attention is on food processing. However, if digital photography and images are included in dietary records when assessing the degree of processing, portion sizes and quality of the diet will be visually shown.

Taken together, the literature reviewed for this dissertation point clearly toward the need for tools which can help people accurately report on what they eat and have these classified into a system which looks at the quality of their food. While some tools exist, such as NOVA, these fail to adequately quantify food quality, which is an essential part of nutritional epidemiology.

The work presented in this dissertation aims to develop a much-needed solution to these problems.

Research Objectives, Methodology, and Design

Research Methodology

This research methodology is mixed methods and presents a developmental and feasibility study aimed to assess the use of a new instrument to quantity food quality. There are three key phases in this research: the design and development of a food processing classification system, product evaluation and instrument testing using quantitative data, and user testing of the classification system using both quantitative and qualitative data. The instrument utilises digital food recalls and classifies the meals using a food classification and scoring system. The overall aim was to test the feasibility of using a modified NOVA food classification system, called the Human Interference Scoring System (HISS). To test the feasibility, there were three research focus questions:

i. Can nutrition professionals understand how to use the HISS to categorise food from digital food photography?
ii. Can the Human Interference Scoring System (HISS) be used to identify the degree of processing, eating patterns and accurately reflect food quality when analysing digital images?
iii. What is the usability of the HISS and what improvements can be made to the food classification system?

Design and Development of a Food Processing Classification System

The HISS was designed and developed in the AUT Human Potential Centre (HPC) by the research team to assess the degree of processing of food items and meals, with a clear focus on quantifying food quality. The development of the HISS instrument aimed to assess food quality and quantify with an accompanied scoring system. The HISS food processing classification system and categories were created by modifying the internationally used and most applied food classification system NOVA, developed by Monterio and colleagues (C. Monteiro et al., 2019). Literature assessing the commonly used food classification systems adopted in research was used to gain a detailed understanding of the use of categories, classifications, and included food and drink items. The HISS food processing classification system was developed with four categories, with each having clear descriptions of the categories, degree of processing, and provided examples of food and drink items in each category (refer to Table 2). The design of four categories was chosen because it allowed for an enhanced distinction between the level of food processing and the inclusion of home-cooked items. In comparison, other classification systems had eight categories with large crossovers of food items between the categories. Other classification systems were culturally specific, and HISS was created for use by all and can be applied globally. The food quality classification systems currently used in research do not have any quantitative measures, which is an important aspect to quantify food. The HISS defines food processing as any methods and processes that alter food from its raw and natural state, transforming the original food matrix into either safer, more digestible, or palatable food products. The development of the HISS included the addition of serving sizes in the instrument to assist with quantifying the chosen food item or meals split into individual ingredients. The Ministry of Health (MOH) serving sizes (see Appendix A) were selected for their reliability and validity and current use in nutritional epidemiology. Some additions were made to the serving sizes to quantify the ultra-processed foods. The inclusion of serving sizes and a scoring protocol with the food classification categories was adopted to allow for a detailed illustration of eating habits and food quality. The scoring protocol was created with the food classification system to identify the overall healthiness of meals and diets. The scoring protocol used was to identify each serving included in the food records, identifying the correct HISS category in relation to the degree of processing, and calculating the total servings in each category.

Table 2

Human Interference Scoring System (HISS). Food classification system

Food groups and definition	Example
1: Unprocessed and minimally processed Raw and whole foods with little or no processing. Foods that are fresh, chilled, canned, frozen, or dried to enhance nutrients and freshness at their peak. Unprocessed foods are of plant and animal origin. Minimally processed foods are natural foods that are altered with removal of inedible or unwanted parts and preserved for storage. Foods that have not been through processing methods and are without added ingredients.	Fruit and vegetables; eggs; canned fish, meat, and legumes (beans, chickpeas, lentils) in spring water; red and white meats (beef, chicken, lamb, pork, venison); nuts and seeds; honey; herbal teas; water; soda water; herbs and spices.
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. Foods that have been processed for preservation and safe consumption but remain as single foods.	Milk; butter; cheese; milk and coconut creams; unflavoured yoghurts; sourdough, artisan bread; coffee beans; pasta, plain oats, shredded wheat; grains such as rice and corn; couscous and polenta; fermented alcoholic beverages (beer, cider, and wine); spirits; kombucha; broths; sauerkraut and picked vegetables.
3: Processed II **3.1** Domestically assembled items, often prepared with separate ingredients including raw or whole food products with additional cooking agents to produce meals, dishes, or snacks.	**3.1** Granola and breakfast cereals; baking and biscuits; homemade plant-based milk; soup.
3.2 Foods processed for preservation with additional flavouring and additives with no further cooking needed. Whole foods with more extensive methods of preservation such as salting, salt-pickling, smoking, and curing. Includes canning and bottling techniques using sugar or syrups, oil, or additional flavouring.	**3.2** Fruit preserved in syrup; canned vegetables and legumes preserved in brine; canned fish in flavouring or oil; processed and cured animal foods (ham, bacon, pastrami, beef jerky, bacon; salted or sugared nuts and seeds; hummus; pesto; aioli; nut butters; pasta sauces; fortified wine; plant-based milks.
4: Ultra-processed Industrially prepared items that are largely manufactured and packaged ready to eat at home or at fast food outlets. Undergone high degrees of processing entirely from substances that are derived from foods, with little or no whole foods present. Formulations of ingredients with industrial techniques and processes. Contain additives to prolong product duration, including varieties of sugars (Corn syrup, maltodextrin, dextrose, lactose), modified oils, and sources of protein (hydrolysed proteins, soya protein isolate, gluten, casein, whey protein). Contain large amounts of additives, preservatives, stabilizers, emulsifiers, bulkers, artificial sweeteners, thickeners, colours, and flavours.	**4.1** Ready to consume products: mass produced packaged breads, buns, and wraps; biscuits; baked beans or spaghetti; cakes; confectionery (chocolate, candy); instant coffee sachets; milo and hot chocolate; rice cakes; ice cream; breakfast cereals; packaged snack products (e.g., chips); fizzy and energy drinks; sweetened milk drinks; sweetened fruit yoghurt; juice; powdered and packaged soups and desserts; noodles; muesli bars; protein supplements and bars; instant dressings and sauces; spreads; margarine; baby formulas; ready-to-drink alcoholic beverages; tonic water. Pre-prepared ready-to-heat products: poultry and fish 'nuggets' and 'sticks;' sausages, burgers, hot dogs, and other reconstituted meats; packaged foods (pizza, burgers etc); fries; pies.

Product Evaluation and Instrument Testing

Within the HPC research team, piloting the HISS was completed using a variety of personal food records digitally captured by the research team and close relations. The food records were analysed using the first draft of the HISS (see Appendix B) to test the instrument and to identify if the presented food items could be classified by their degree of processing. From this evaluation, multiple adjustments and additions were made to the food classification system, to ensure all common food products were included in the table and ready for future use. The key items for reconsideration were the researcher's agreement of food categorised into the HISS, common food, and condiments to be included in the food classification system, and how the scoring was recorded. The scoring protocol was developed through discussion during piloting HISS through analysing the food records using the HISS for the first time.

For the use of this study and the user testing, five hypothetical 24-hour period food recalls were captured using digital photography methods. The food records had a range of low versus high-quality dietary patterns, demonstrating whole-food diets and diets including more processed foods to capture variability. Each photograph of the meal and food item included a standard business card next to the bowl, plate, or hand that displayed the food, for a size reference. This size reference approach was used to allow for easy identification of the serving sizes if needed. Each of the five food records was collated into a single document with each meal, snack item, and beverages included with serving sizes alongside. The serving sizes were included in the food recalls ensuring the focus was not on solely being able to identify the servings, and instead identify the level of processing of the different food and meal items presented. The primary researcher analysed the five food records with using the HISS and the related documents to ensure it was ready for the user testing and recorded the results. To conduct the user testing and data collection online, an online instructional video was created to demonstrate the use of the HISS food classification table, use of serving sizes, and the overall aim for the research and food classification activity.

User Testing of the Classification System. Food Classification Activity

The primary inclusion criteria for the 13 participants involved in the food classification activity were working nutrition health professionals. Participants were familiar with dietary records and have a robust food and nutrition knowledge. Ethical approval was obtained from AUTEC to conduct this research (see Appendix C). All participants were sent an Information Sheet (see Appendix D) and Consent Form (see Appendix E) to take part in this research. Participants provided written consent prior to participation and were sent the HISS instructional video, HISS table, and five food recalls. The instructional video was created to ensure validity of using the HISS classification system to analyse the food recalls, and to explain use of all related documents to avoid confusion. Once participants watched the instructional video, the five food recalls were analysed by each participant using the HISS. Each food recall had photographed meals from breakfast, lunch, and dinner and included snacks and beverages consumed throughout the day. The scoring sheet (see Appendix F) was completed by each participant with each serving of food and drink tallied and classified into the four food processing HISS categories (unprocessed and minimally processed foods [category 1], processed I [category 2], processed II [category 3], and ultra-processed [category 4]. With each food and drink item, the participants identified the extent of food processing according to the HISS category definitions and used the serving size examples listed for each food group, to quantify the amount. The total servings for each food recall were also recorded on the scoring sheet. Once this activity was completed, a questionnaire was then filled out answering three questions and all data was sent back to the researchers.

Participants' Feedback

This study used additional qualitative analysis following the food classification activity to gain insights into the usability of the HISS classification system with a thematic analysis used. A questionnaire was completed directly after the food classification activity. The questionnaire (see Appendix G) asked the participants to complete three open-ended questions that were designed to find out what was easy to use, what was difficult to use, and any suggestions for areas of improvement. The feedback received was used to modify the HISS to be more user-friendly and to identify what areas needed improvement for better data collection and scoring.

Analysis of Data

Descriptive statistics were used to examine the participant's serving scores in each HISS category for the five food records. Means and standard deviation values of the food and drink servings were computed in Excel for each HISS category and food record, with the total servings also presented. The mean percentage of food servings in each HISS category were computed for each food record to determine if the HISS reflected different eating patterns and the overall quality of the five diets.

To assess whether the nutrition professionals could be taught to categorise food from the digital food records, the percentage of overall servings in each HISS category was computed in Excel. This was analysed with the primary researcher's percentage of servings in each category to compare the results and identify the deviations across all HISS categories and total servings.

The nutrient composition of the five food records was used for the statistical analysis. The five food records were assessed using FoodWorks to analyse the nutritional value of all meals, snacks, and drinks displayed in the photographs. FoodWorks was used to identify the nutrient composition of each of the five food records, to analyse the total energy (Kcal), total sugars (g), total dietary fibre (g), and total CHO (g) to use for the statistical analysis. A second researcher also assessed the FoodWorks data and dietary recalls for added quality assurance. A series of graphs were created to assess the association between the nutrient composition and HISS categories, while adjusting for calories per serving.

A thematic analysis of the participants' feedback from the questionnaire was carried out to explore the main and sub-themes identified in the qualitative data, guiding the adjustments to improve the final HISS classification table.

Statistical Analysis

To identify the agreement and consistency of using the HISS, an intraclass correlation (ICC) was used to determine the inter-rater reliability between all the scores that were collected during the food classification activity. A two-way mixed effect model, single rater type, was used to define the consistency across the serving scores.

To investigate the aim of the HISS feasibility, the food records servings descriptive data were used to explore the association between the participant's serving results in each of the four HISS categories and the nutrient composition. A repeated measures Pearson's correlation coefficient (r) was performed using the rmcorr R package to determine the strength of the association between participants' servings in each of the HISS categories and the nutrient composition of each of the five food records. All ICC and descriptive statistics were computed in SPSS statistics software version 28. The rmcorr R package was accessed via the rmcorrShiny web interface.

Results

The HISS Food Classification Activity Results

Thirteen participants (11 females, 2 males) completed the food classification activity and Table 3 below shows an overview of the participants' percentage of servings in each of the HISS categories for all the food records together, and the deviation from the primary researchers' results. It is apparent from this table the participants had similar results when classifying the food and drink servings into the four HISS categories. What stands out in this table is participant 8 had the largest deviations out of all the participants, more specifically in the unprocessed category (18% deviation) and processed II category (-14% deviation). From the data in Table 3, it is apparent there were more deviations in the processed II and ultra-processed HISS categories.

Table 3

Percentage of Servings in Each HISS Category and the Deviation from the Primary Researchers Serving Percentage.

	% of Overall Servings in Unprocessed Category	% of Deviation	% of Overall Servings in Processed I Category	% of Deviation	% of Overall Servings in Processed II Category	% of Deviation	% of Overall Servings in Ultra-processed Category	% of Deviation	Total Servings	% of Deviation
Researcher	36%		16%		1%		47%		94.5	
Participant 1	36%	0%	13%	3%	0%	1%	51%	-4%	83.0	**11.5**
Participant 2	37%	-1%	20%	-4%	6%	-5%	38%	9%	90.2	4.3
Participant 3	33%	3%	21%	-5%	0%	1%	46%	1%	87.0	7.5
Participant 4	34%	2%	14%	2%	5%	-4%	47%	0%	100.5	-6.0
Participant 5	39%	-3%	8%	8%	2%	-1%	51%	-4%	106.0	**-11.5**
Participant 6	32%	3%	9%	7%	10%	-9%	49%	-2%	89.3	5.3
Participant 7	34%	2%	10%	5%	5%	-4%	50%	-3%	106.0	**-11.5**
Participant 8	18%	**18%**	20%	-4%	15%	**-14%**	48%	-1%	88.0	6.5
Participant 9	31%	5%	12%	4%	4%	-3%	53%	-6%	101.7	-7.2
Participant 10	33%	3%	10%	6%	9%	-8%	47%	0%	99.0	-4.5
Participant 11	30%	6%	14%	2%	18%	**-17%**	38%	9%	103.0	-8.5
Participant 12	33%	3%	11%	4%	5%	-4%	51%	-3%	92.0	2.5
Participant 13	37%	-1%	20%	-4%	6%	-5%	37%	**10%**	99.8	-5.3
Average	33%*	4%*	13%*	2%*	7%*	-6%*	47%*	0%*	95.8 (±7.81)	-2.0 (±7.82)

Note. * Standard deviations for averages were ± 0.05

To determine the reliability of the HISS, a two-way mixed effect model, single rater ICC calculation was conducted using SPSS. Table 4 below shows the consistency and agreement of the HISS when used by nutrition professionals to identify the food and drinks degree of processing. A high degree of reliability was found between the use of unprocessed and ultra-processed HISS categories. The single measure ICC for the unprocessed HISS category was .778 with a 95% confidence interval from .522 to .865, $p < .001$. For the ultra-processed HISS category, the single measure ICC was .826 with a 95% confidence level from .601 to .976, $p = .000$. Both the unprocessed and ultra-processed category's reliability was statistically significant. There was a low degree of reliability for the middle two HISS categories.

Table 4

Results of ICC Calculation Using SPSS Two-way Mixed Effect Model, Single Rater

		95% Confidence Interval		
Single Measures	Intraclass Correlation	Lower Bound	Upper Bound	Sig
Unprocessed	.778	.522	.968	<.001
Processed I	.226	.042	.751	.002
Processed II	.066	-.030	.537	.123
Ultra-processed	.827	.601	.976	.000

HISS Food Records

Table 5 shows an overview of the five food records and the food and drink servings placed in each of the HISS categories by participants. The total servings mean, and standard deviations are also presented.

Table 5

Summary Analysis of Food Records Servings in Each HISS Category

Food Records	Unprocessed		Processed I		Processed II		Ultra-processed		Total Servings	
	Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)
1	4.31	(1.36)	4.19	(2.24)	2.15	(1.52)	8.27	(2.98)	18.61	(3.19)
2	5.17	(2.14)	1.92	(1.50)	1.27	(2.54)	14.88	(2.84)	23.25	(3.69)
3	5.71	(2.95)	2.19	(1.11)	0.46	(0.88)	4.04	(1.11)	12.40	(3.91)
4	2.29	(1.41)	2.69	(1.18)	0.87	(1.69)	13.95	(3.22)	19.80	(2.78)
5	14.17	(3.68)	2.21	(1.49)	1.62	(2.18)	3.42	(1.91)	21.42	(2.99)

As shown in Table 5, there was some variation across all participants when classifying the food records food and drink items in servings. The most variation was in the Ultra-processed category, with food record 1, 2, and 4 showing a wider spread in the mean servings. The Unprocessed category also had variation in the mean servings, with food record 3 and 5 showing a larger spread amongst the participants. In the Processed II category, there was also a larger spread in food record 2, compared to the other food records.

The mean percentage of food items in servings for each of the HISS categories is displayed in Table 6. As demonstrated, food record 5 was the least processed food record (66% in Unprocessed; 10% in Processed I) followed closely by food record 3 (46% in Unprocessed; 18% in Processed I). Both food records had the lowest percentage of food items servings in the Ultra-processed category. Food record 2, and 4 had the highest number of mean servings in the Ultra-processed category, showing these eating patterns mainly consisted of processed foods, and had less unprocessed foods. Food record 1 had more spread across all four HISS categories with the highest percentage in the two middle categories (23% in Processed I; 12% in Processed II), however, this food record had the highest value in the Ultra-processed category with 44%. These eating patterns and results are visually displayed in Figure 2.

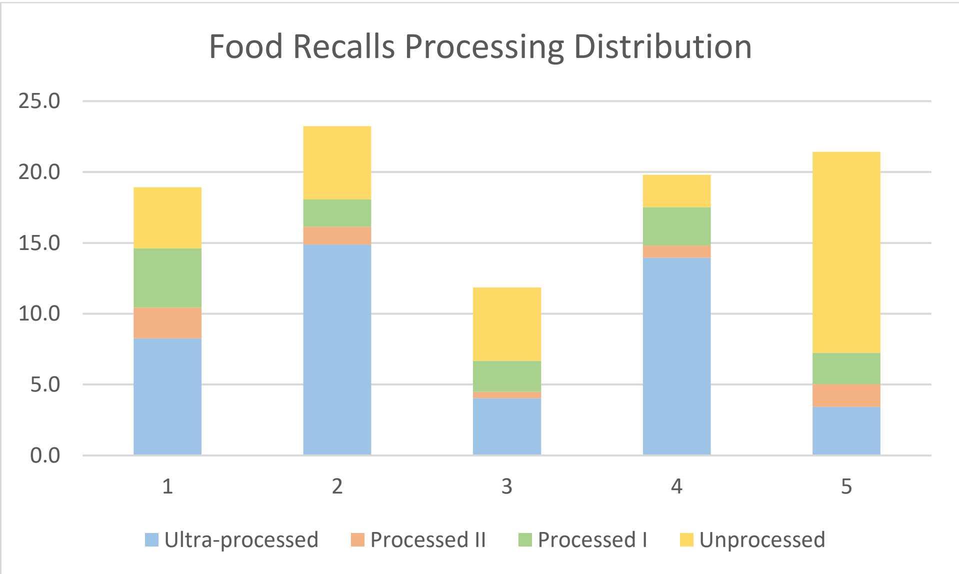
Table 6

Mean Percentage of Food Servings Placed in Each HISS Category

Food Records	Unprocessed	Processed I	Processed II	Ultra-processed	Total Servings (SD)
1	23%	23%	12%	44%	18.6 (3.2)
2	22%	8%	5%	64%	23.2 (3.7)
3	46%	18%	4%	33%	12.4 (3.9)
4	12%	14%	4%	70%	19.8 (2.8)
5	66%	10%	8%	16%	21.4 (3.0)

Figure 2

Dietary Patterns and Level of Processing in the Five Food Records



Note. Average serving distribution in the HISS categories for each food recall. Displaying the different eating patterns and food quality of the dietary records.

FoodWorks Analysis

To identify if the HISS accurately reflected food quality, the nutrient composition (total energy, total sugar, dietary fibre) of each food record was analysed. These are displayed below in Table 7 and show the Total Energy of food presented in each food record in kilocalories (Kcal) and the total sugar, dietary fibre, and total CHO presented in grams.

Table 7

Nutrient Composition of Food Records: Descriptive Statistics

Food Records	Total Energy (Kcal)	Total Sugar (g)	Dietary Fibre (g)	CHO (g)
1	2924	73	39	424
2	2659	259	4	357
3	1202	31	11	98
4	3041	196	30	470
5	2534	110	49	179

Note. Total sugars computed from FoodWorks include glucose, fructose, sucrose, lactose, and maltose.

Food record 5 was the least processed food record with a percentage of 66% and had the highest dietary fibre (48.6g). The two food records that had the highest percentage of servings in the Ultra-processed category (food records 2 and 4) had the highest amount of total sugar (258.9g, 195.9). Food record 4 had the highest ultra-processed percentage of 70% and had the highest total energy intake (3041.2kcal).

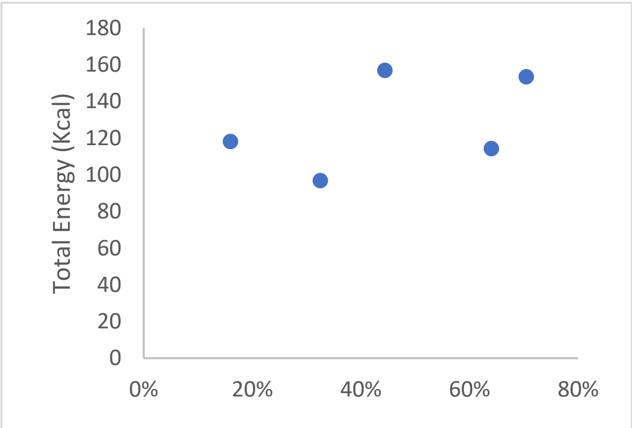
Correlation with HISS Categories and Nutritional Composition

The consumption of UPFs as a percentage in the ultra-processed HISS category was moderately positively correlated with total energy (Kcal), r_{rm} (51) = .55, $p < .001$, positively correlated with total sugar (g), r_{rm} (51) = .79, $p < .001$ with a strong association, and positively correlated with carbohydrates, r_{rm} (51) = .74, $p < .001$, with another strong association with the ultra-processed HISS category. By contrast, these nutrient components were negatively correlated with the unprocessed HISS category. There was a weak negative correlation between the unprocessed HISS category and total energy (kcal), r_{rm} (51) = -.14, $p = .309$, and total sugar (g), r_{rm} (51) = -.21, p = .135, however these were not statistically significant. A moderate negative correlation was found between unprocessed HISS category and carbohydrates (g), r_{rm} (51) = -.56, $p < .001$. For dietary fibre, the HISS ultra-processed category was negatively correlated, r_{rm} (51), = -.39, $p = .004$, in contrast to dietary fibre having a moderately positive correlation with the unprocessed HISS category, r_{rm} (51) = .44, $p < .001$ and these both were statistically significant. The ultra-processed HISS category positively correlated with total energy, total sugar, and carbohydrates and negatively correlated with dietary fibre. The unprocessed HISS category negatively correlated with total energy, total sugar, and carbohydrates and positively correlated with dietary fibre.

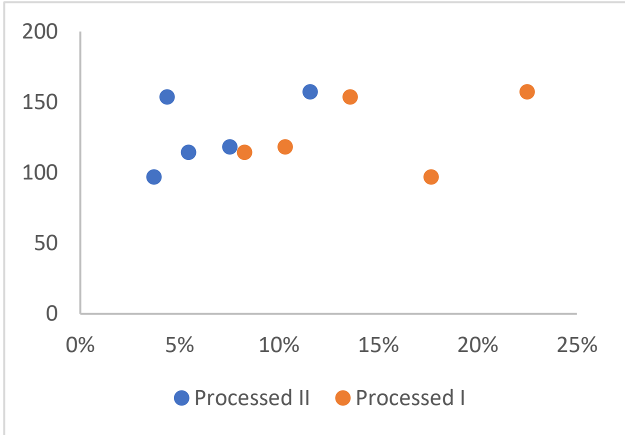
Figure 3 below presents the correlation analysis of the HISS categories and nutrient analysis with adjusting for servings and the food recalls energy intake. The standard deviation and the proportion of the variance accounted for (R^2) is presented below the figures. The overall trend from Figure 3 visually shows the percentage of processing in the five food recalls and the correlation with total energy (Kcal), total sugar (g), dietary fibre (g) and carbohydrates (g) confirming the correlations above, while adjusting for the number of servings in each food recall.

Figure 3

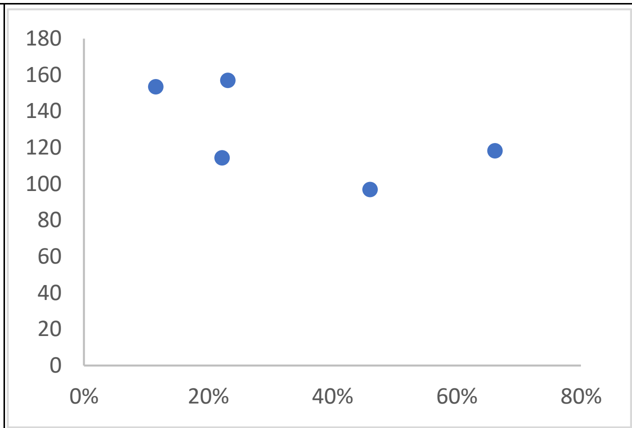
HISS Categories and Nutrient Composition per Serving Association



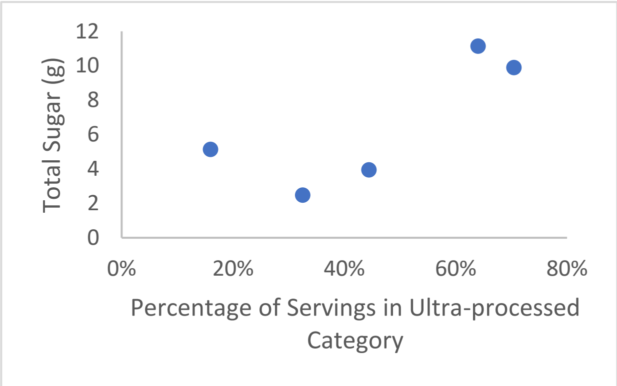
Note. UPF: *p* = .44, R^2 = 4827.6



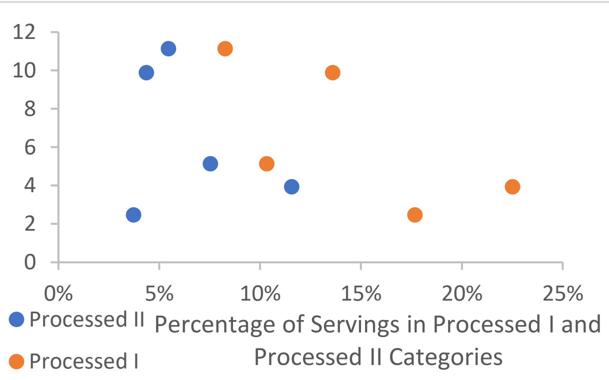
Note. Pro I: *p* = .39, R^2 = 0.59. Pro II: *p* = .55, R^2 = .45



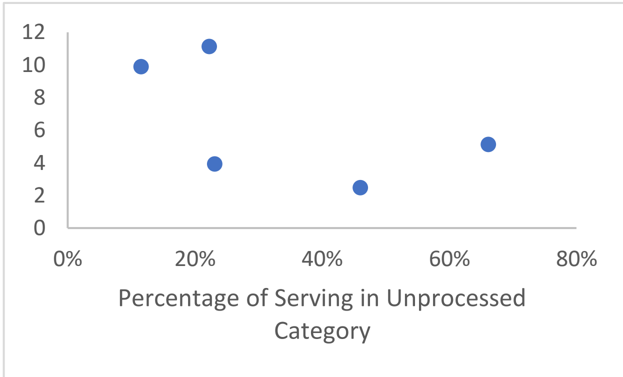
Note. UNP: *p* = -.61, R^2 = 4835.8



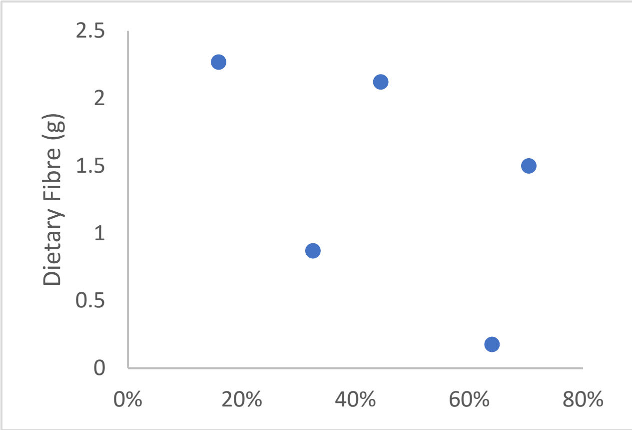
Note. UPF: *p* = .78, R^2 = 16.6



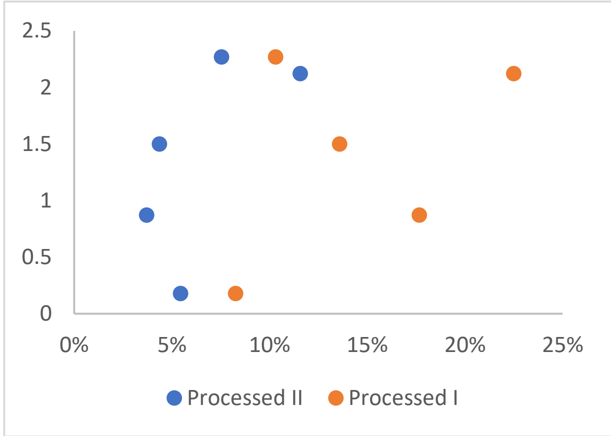
Note. Pro I: *p* = -.68, R^2 = -.14. Pro II: *p* = -.31, R^2 = .03



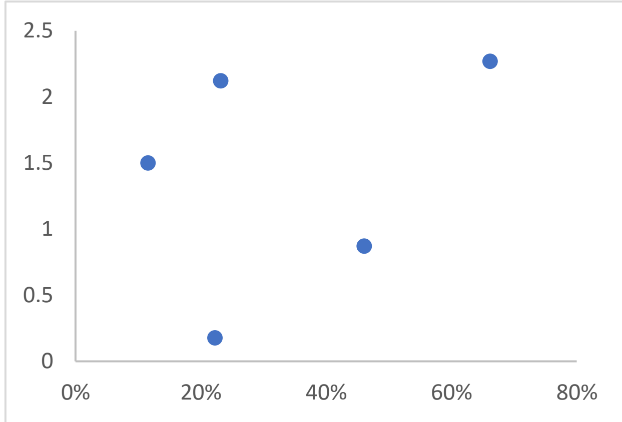
Note. UNP: *p* = -.51, R^2 = 17



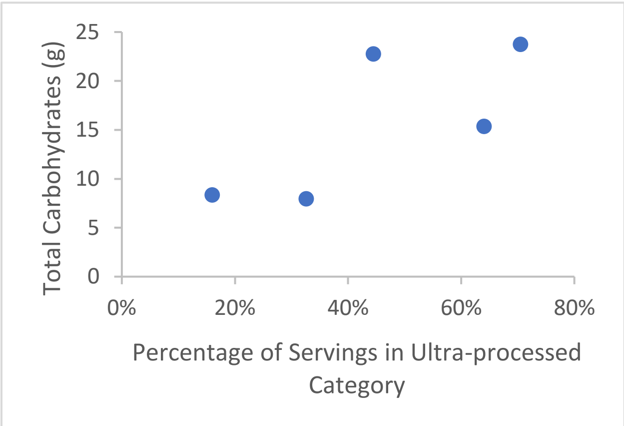
Note. UPF: p = -.50, R^2 = .60



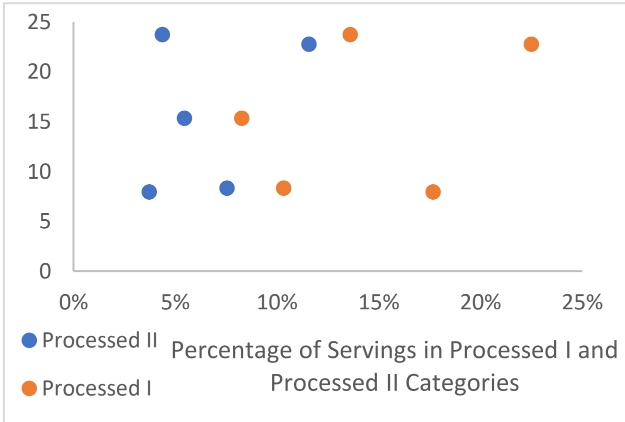
Note. Pro I: p = .39, R^2 = .02. Pro II: p = .64, R^2 = .01



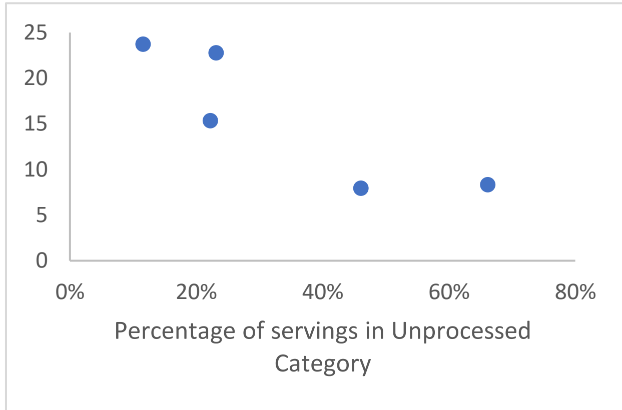
Note. UNP: p = .33, R^2 = .66



Note. UPF: p = .74, R^2 = 89.4



Note. Pro I: p = .33, R^2 = .14. Pro II: p = .34, R^2 = .08



Note. UNP: p = -.87, R^2 = 90.3

Note. in the table above the p value is the statistical significance and the R^2 value is the proportion of the variance. UNP is the unprocessed HISS category, Pro I is the processed I HISS category, Pro II is the processed II HISS category, UPF is the ultra-processed HISS category.

Questionnaire Results

The feedback received from the questionnaire had three main identified themes gathered from the thematic analysis. The set of questions aimed to examine the usability of the HISS and identify what improvements can be made to the food classification system from expert feedback. The common themes identified from the thematic analysis were recommendations to adjust the HISS, positive comments, and limitations. The recommendations to adjust the HISS were split up into sub-themes of serving sizes, distinction that serving sizes are not related to category columns, clear category distinction of food processing, and more detailed scoring and data collection.

Recommendations to Adjust HISS

The responses to the questionnaire revealed there were certainly many areas in need of improvement, in this newly developed HISS food classification system. Most of the feedback from participants suggested adjusting the digital HISS table and supporting serving sizes that were given in this study to use alongside completing the food classification activity.

Serving Sizes

A common sub-theme expressed by participants was the challenge of using the serving sizes when some food items shown in the food records were not listed in the serving size examples. There was a sense of difficulty expressed in the questionnaire when participants needed to calculate the servings for food items that had smaller or more complicated serving sizes. Participants found the serving sizes for some portions awkward to guess and suggested having serving size guides in household measures and in grams. Comments included:

> *It was occasionally hard to figure out the serving tally based on the different measurements of the foods with the guidance given. For example, 28grams of chorizo, how much of a serving is that to tally?*

Along with identifying the serving sizes for food items, reading the serving size examples also caused confusion due to the placement next to the HISS categories.

Distinction that serving sizes are not related to category columns

The placement of the serving size examples that were originally in the column next to the food group definitions and food examples also caused confusion (see Appendix B). This is because participants' thought the serving size examples were split into traditional food categories belonging to the same row and were relevant to the definitions and examples of the food processing categories. Participants recommended changing the design of the table or putting in a line between the columns to show the serving size column does not belong to the corresponding categories. Comments included:

> *On the Classification sheet, perhaps place the Serving Size column in a separate box, or underneath the classification, to make it easier to read the document. Right at the start, when looking for an item's classification, I spotted the same item on the serving size column and automatically looked for the category in that row, but then realised they were two sections apart, 1. Classification + Examples; and 2. Serving Sizes.*

Participants commented on the serving sizes and expressed their confusion of the examples next to the food processing categories, and these comments were the most common responses from the participants. Another recurrent sub-theme in the questionnaire responses was the participants needed clarity around the level of food processing with example items in the four HISS categories.

Clear Category Distinction of Food Processing

When asked about what they found difficult to use, most participants listed down certain food items that they could not classify, or food items that were listed in multiple categories. Five participants suggested certain items that should be placed in one category also suggesting where certain food items would fit best, relative to their subjective experience. Breakfast cereals and bread were common food items that were commented on in the questionnaire responses. One participant commented:

> *My main issue was categorising the food items in their correct classification, as I got a little confused. For example, you have "artisan breads" on Processed 1 but also "homemade bread" on Processed 2. For me, these two items would be categorised the same.*

Many participants gave great feedback on how they interpreted the categories in relation to food processing. For example, another participant said:

> *If the desired outcome is a tool for 'quality' some of the categories may be incongruous. For example, brought pasta sauces should (according to my reading of your list) be ultra-processed but if these include minimal added ingredients (esp. sugar) they would be considered a highly nutrient-dense food and one associated with improved outcomes.*

Another participant highlighted how looking at the photos and descriptions without access to the ingredients list was an issue they encountered because they could not identify the type and extent of processing the food has gone through. Comments included:

> *For example, spread (such as peanut butter and jams, or even salad dressing and hummus) could easily fall in different categories, depending on how they are made. For example, shop-brought jams usually contain only fruit and sugar, plus some preservatives as pectin, which according to NOVA is not an ultra-processed type of additive. Some nut butters are 100% nuts and maybe salt, whereas more processed ones will contain emulsifiers, which is a type of additive that only appears in ultra-processed foods according to NOVA.*

The comments above show how important it is to have succinct food processing group definitions, in order for the food items to be classified in the appropriate category. These comments on having a clear category distinction of food processing also support the recommendations of how to get more detailed scoring and classifications of food to determine quality.

More detailed scoring and data collection

A variety of perspectives were expressed in the suggestions for improvement with two participants recommending ways to improve the data collection. It was suggested that more detailed data collection could be helpful to understand how users are utilising the system.

> *You could note what items what people put where/serving size per items to check exactly how people are using the system.*

If moving forward the food scoring was completed manually, these suggestions would be beneficial to allow for corrections. However, this could be automatically and digitally completed through the use of an app if the HISS classification system is created digitally. Although, including ingredients lists where possible, as suggested with the inclusion of photographs would be one way to identify the type and extent of processing. This would better identify if there are additives and emulsifiers present should the food recalls not include brand names of food items. Including a pie chart once the food has been classified into the categories, to visually display the quality of the client's diet was another suggestion from one of the participants, and this could be a great tool to include in future work.

Positive comments

Additional to the comments of recommendations, there were also positive comments on the HISS system and the food classification activity process. Many participants commented on how they found the photographs included in the food records visually helpful to verify and estimate servings of the food. The video explaining the food classification activity and resources provided also got mentioned, with participants finding it useful to watch before “tackling the task at hand,” helping to put one participant’s mind at ease. The comment below illustrates how looking beyond traditional dietary reporting and focusing on the quality of food, as presented in this study, is a good approach. One participant said:

> *It uses a nutrient-density focus rather than energy intake approach which resonates well with me.*

Participants responded, “the whole process was somewhat easy” and “was all pretty straightforward” when answering the first question of -what they found easy to use. With a participant positively commenting on the scoring protocol used in this research:

> *Useful to see it laid out in the end and what meal components added up to for a days’ worth of food.*

One participant found the processed food items easier to record. Commenting:

> *Processed foods are easier to record because they generally come as set servings and require less deliberation. If that’s the point of the tool, then it is fit for its purpose.*

The use of digital photography in this food classification activity and how it helped to verify the food was a common response. Comments included:

> *The photographs give a really easy way to identify what’s eaten in a day and how processed the food item is.*

With other participants also commenting on the use of photographs in the food records:

> *I found it easy to have the picture and text to verify what the food was. For example, I could see who clearly had half a chicken for lunch and could visually estimate how many servings of chicken that might be. With text only, chickens vary in size.*

There was lots of positive feedback on the HISS system, and the protocols used with participants commenting on how they found “the food classification system” and the “defined HISS groups” easy to use.

Limitations

There were some comments that highlighted areas of where the HISS system was lacking. One participant found the HISS list of food was too long and took some interpretation, with two others also commenting on how there are too many categories to refer to. Some negative, but constructive comments were also received in the questionnaire responses. Comments included:

> *I did not find it easy to use, and to me it seems a bit arbitrary. "Like beer processed 1, but health wise I'd put it in ultra-processed".*

Similarly, another participant found some of the distinction to be contradictory, with some categories incongruous; with this participant identifying some conflict between "the degree of processing and health outcomes for some categories and not for other." Overall, the participants have thoroughly helped inform the updated version of the HISS by identifying the areas needing adjustments and improvements. All comments and suggestions have been considered and used to adjust the HISS food classification, the categories, and the food examples for future use.

The feedback received from the questionnaire was immensely helpful to test the usability of the HISS and identify what aspects needed improvement for easy use and quantification of food processing. The serving sizes and the HISS categories displayed in the first HISS table have been updated following the feedback from nutrition professionals. All positive feedback has confirmed the usability of the HISS and the aspects that were limited have been acknowledged. All responses from the qualitative analysis have helped guide the adjustments made to the final HISS table to be used with digital photography.

Discussion

This study aimed to test the feasibility of a modified food classification system that identifies food processing with the use of a scoring system and digital photography food recalls. The aim was to demonstrate the usability of the HISS to assess food quality through quantification of the quality of food consumed by an individual over a day. The findings indicate the HISS system is a useful tool to quantify food quality and trained nutritional professionals were able to assess food records using digital photography images. The HISS was applicable to quantify food quality and dietary patterns from images, with differentiation between low-quality and high-quality foods achieved. The agreement and consistency of scoring using the HISS were assessed and had a high degree of agreement using inter-rater reliability measures in the two imperative outer HISS categories: unprocessed and ultra-processed. The HISS demonstrates the relationship between food processing with associations of nutrient composition evident. Evaluating the feasibility of the HISS was achievable through the use of quantitative measures, including inter-rater reliability analysis, and nutrient analysis to identify if the processing categories could predict food quality, as previously done by Bleiweiss-Sande, et al., (2019).

To assess the feasibility of the HISS, a primary objective of this study was to determine the inter-rater reliability between nutrition professionals when quantifying food servings and identifying the level of processing of foods into the HISS categories. We hypothesised that HISS would have high inter-rater reliability among participants. There was a high degree of agreement between the use of unprocessed and ultra-processed HISS categories. The middle two categories processed I and processed II showed a lower degree of agreement. The present results are important in two major respects. Firstly, identifying unprocessed food serving sizes and quantities is important because these are not displayed on packaging like ultra-processed food items are. Being able to identify both whole foods that are essential for good health and UPFs that are associated with poor health was achieved. These categories and the listed food items were important to distinguish to determine the overall quality of the diets and what foods were mainly consumed. Previous validation studies of the NOVA classification only found a moderate agreement between the raters (Lorenzoni et al., 2021). A comparison of the findings with those of other studies confirms the feasibility of the HISS and the agreement for processing categories are in accordance with other classification systems with similar inter-rater reliability results (Bleiweiss-Sande et al., 2019). The importance of having high-inter rater reliability results is essential to ensure consistency and validate the use of this tool in research.

Results from the Pearson's correlation analysis support the HISS can be used as a classification system to quantify the quality of foods with the ability to categorise ultra-processed foods, moderately processed foods, and unprocessed foods by associating with the nutrient composition of foods shown in images. As hypothesised, these results show moderate to strong associations between the HISS score and the various aspects of usual nutrient measures. These results also show that the HISS score may act as a reasonable proxy for other standard nutrient measures without the potential errors implicit in trying to capture these using more standard methods like dietary records. The HISS acts as a good proxy in demonstrating nutrients and presenting the lack of nutrients and low-quality foods that are in the ultra-processed categories which are associated with poor health. Higher energy intake, total sugar, and carbohydrates were significant predictors of foods in the ultra-processed category compared to non-processed and minimally processed foods. The results and correlations with nutrient composition in the ultra-processed category is not surprising as processed foods are enriched with sugar and refined carbohydrates and these are energy dense. Another important finding was the association of dietary fibre and the HISS categories. These results indicate higher consumption of unprocessed foods have a higher fibre intake, in comparison to ultra-processed foods. These findings corroborate the work of other studies in this area linking sugar and carbohydrates with ultra-processed foods (Martínez Steele et al., 2017). These results confirm the association and seem to be consistent with other research which found increased UPFs correlated with an increase in sugars and a decrease in fibre (Martini et al., 2021). This shows the HISS can be used to distinguish non-processed foods from highly processed foods with the nutrient concentration aligning with processing classifications.

The advantage of this approach in identifying the level of processing in foods over traditional dietary intake instruments is the overall diet is considered, and food groups are not singled out. Traditional dietary intake instruments combine all macronutrients into a singular category, overlooking the metabolic effects and the quality of macronutrients. Additionally, the quality of carbohydrates and GI of foods are also not considered. The HISS utilises evidence of the food matrix and nutrient composition by noting the effects low GI and high GI foods have on metabolism and overall health, and this is often overlooked when the focus is on traditional food grouping. Analysing food by the degree of processing takes into consideration all physical, chemical, and biological methods during the production of food and is a better way to look at dietary patterns and associated health outcomes, instead of just focusing on the nutrient composition of the diet (Chen et al., 2020). The HISS and food classification systems have a spectrum ranging from whole foods to highly processed foods consider the quality of food and the additional sugar, oils, additives, and preservatives included during processing. The main principles identified by Comerford et al., (2021) for CHO food quality assessments included nutrient profiling that is category specific, identification of enrichment and fortification, being an easy tool to use, and promotion of better food choices for improved diet quality and health. These principles align with what the HISS can achieve and was considered during the developmental phase. The HISS can be used to identify higher quality food by considering multiple food factors into an easy-to-use tool for both researchers and consumers. It is encouraging to compare with other recently published nutrient profiling systems such as the Food Compass by Mozaffarian et al., (2021) that assess the healthfulness of foods by incorporating a range of characteristics as the HISS does. Food processing, additives, food ingredients, and total fibre are health-related domains HISS incorporates to determine the quality of food with a scoring system included to help with quantification. There are a lot of nutritional attributes that need to be considered in food classification systems and nutrient profiling systems to assess the diet-health relationship. In addition to these attributes, food classification systems need to be easy to use and not limited to cultural and traditional diets as some classification systems are.

To assist in testing the feasibility of the HISS to achieve the overarching aim, nutritional professionals gave useful feedback through the questionnaire and comments were used to guide the adjustments to the HISS. From completing the thematic analysis there were multiple areas needing improvement or clarification, with both positive and negative comments received. Respondents found the defined HISS categories and the food classification easy to use, showing the positive response and easy use of the HISS food classification system. The detailed food recalls could have caused confusion as discussed in the thematic analysis. However, improvements have been made by creating standard measurements with a food database to use for identifying serving sizes, and this will be integrated in the further development and use of HISS. Another important response from the qualitative thematic analysis highlighted how a nutrient-density focus rather than an energy intake approach resonated well, showing experts in this field agreeing this paradigm shift is needed. The negative comments made on the HISS and HISS table may be explained by the fact items such as bread were placed in multiple categories causing confusion in classifying bread items in the food classification activity. Some participants were also experts in using NOVA, meaning they had a great depth of knowledge with regard to the additives and preservatives that are incorporated into foods. This explained the comment to revise the HISS by checking underpinnings of NOVA concepts. However, the functionality of NOVA has been assessed and providing detailed ingredient information did not improve consistency across raters or affect their confidence levels (Braesco et al., 2022) raising the complexity issues of NOVA. The NOVA classification system is complex and multidimensional making it complicated for raters and consumers to use. This raises questions about NOVA's ability to guide public health policies. Using HISS in a public setting with nutrition professionals assessing client's dietary intakes with this tool, can be practically used to provide advice, leading towards recommendations around the less processed, nutrient-dense foods. Advice around the levels of food processing, and promotion of consuming more whole foods is a way to give advice to the general population to gain better compliance around dietary change that can be understood.

Previous food classification systems used in research are complex and do not quantify the food being classified. The use of the scoring system and incorporated serving sizes facilitates the assessments of food quality to identify the level of processing and overall healthiness of foods. It is recommended that classification systems use quantitative measures to robustly assess the healthiness of food environments (Crino et al., 2017). Responses from the questionnaire identified having distinct serving sizes helped the classification process. These features contrast with existing food classification systems that define industrial, traditional, and artisanal-domestic processing but do not quantify food quality with any quantitative measures in their food classification systems. Epidemiology research using NOVA, for instance, used diet quality indices such as the Healthy Eating Index to measure diet quality. The HISS was developed with a scoring system based on the serving size amounts to be classified across the four HISS categories. Results show food items displayed in the digital images can be analysed to identify serving sizes while also identifying the degree of processing. In addition, by calculating the percentage of serves in each HISS category based on the participants' food items scores, digital photography can be used to associate nutrient composition and food quality with having no recall bias. Digital photography can be used for food processing analysis with the use of the HISS and outlined serving sizes. Therefore, digital photography as a tool can be used to assess diets and is an easy way to capture food intake (Carolina Archundia Herrera & Chan, 2018). As opposed to filling out food recalls and questionnaires that are prone to misreporting limitations. Using HISS in the free-living situation would require every meal, snack, and drink item to be photographed, which requires a device on hand at all times and could bring compliance issues. However, photographs of meals and food intake is easy to capture, and less time consuming than completing a diet diary where each single ingredient needs recording. Using the HISS and capturing meals and food and drink items through photography will bring consumers more awareness of what they are eating. With the ubiquitous availability and use of smartphones, this would make this method more convenient, however, regular compliance would be needed from the user. This is a substantial step forward with combining digital food photography with a measure of food quality and is an original contribution to the field of nutritional epidemiology. The HISS could differentiate higher quality food items and lower quality food by using digital images with the nutrient composition data associated with the degree of processing. In a practical sense, this would provide consumers the education around accessing and purchasing the higher quality foods through the use of the food items displayed in HISS food classification table. Digital dietary assessment can reduce misreporting that is seen in problematic self-reporting methods, by capturing the quality of food to be used alongside the HISS. In nutritional epidemiology, there has been constant disagreements on healthy food, and unifying public health messages, and these have not made progress in reducing the disease burden. There needs to be an urgent change in policy to improve diet quality and establish nutrition as central in public health.

Limitations

It is important to acknowledge this study had limitations. This is especially important in the confines of this Master's degree dissertation project so far, as time and resources were concerned. Firstly, the digital food records used for the food classification activity were only hypothetical and there was a limited number used to capture different diets. If more food records were used and they captured more variability of diets from the general population, different results may have been obtained. Secondly, there were limited raters used for this study, only reaching the exact number of raters needed to conduct the ICC analysis, based on the sample size calculation. Thirdly, the scoring system used with the HISS was basic and did not include algorithms that could have generated a better output. Finally, with some additions added to the MOH serving sizes, there was a lack of specificity with some of the items in the HISS and this caused confusion for participants in the scoring.

This study also has several notable strengths. Including qualitative methods allowed professionals to give their input and make suggestions to improve the HISS. This is the first food classification system that has aimed to quantify food quality with combining digital photography. The HISS is a food classification that can assess food quality and compare the healthiness of foods seen in dietary patterns. This instrument has the potential to influence the field of nutritional epidemiology with a nuanced approach to assess diets to help researchers conduct research, and guide consumers. Approaching the assessment of food intake with identifying the degree of processing offers the possibility of moving beyond nutrient based guidelines and into a food matrix guideline as a means to unify public health messages.

Future Directions

Future work is required to establish the viability of the HISS tool and further develop the instrument to be used in epidemiology and nutrition practice. Further research should be undertaken to apply practice and epidemiology research to understand what the population is actually eating, what proportion of the population in New Zealand has a UPFs dietary pattern, and how UPFs relate to health. Focusing on the degree of food processing offers the possibility of moving beyond nutrient-based guidelines and more into a food matrix and food processing policy guidelines. To develop a full picture of the use of the HISS instrument in practice, it will depend on the HISS being usable, not only by nutrition professionals but also by the general public. Firstly, this has implications for promoting more education and health promotion around food processing and an individual's diet. It could be used to help individuals learn about what their dietary patterns are, if they are consuming mainly processed foods, or sufficient whole foods. With a focus on food quality and not singular nutrients and overall calories that other dietary tools present, HISS has the ability to guide consumers towards unprocessed and minimally processed foods. The HISS is an instrument that could help individuals improve their awareness of dietary habits, with a health professional guiding them to what food items should be reduced or increased and promoting them towards quality whole foods and home-cooked meals instead of processed foods. HISS could be used in health promotion and epidemiology concurrently as it is an easy tool to understand, that is not too complicated to use. With the HISS tool being straightforward in its applicability it has more of a chance to be effective and utilised in health promotion initiatives and could reach more people in the community. Secondly, it would help understand the efficacy of interventions in dietary change if this is progressed into an online aspect using electronic versions connected to a food database. With a clear framework and category definitions, the opportunity to create a digital application in the near future, offers a new dietary tool with a different focus of food quality and the degree of food processing. There is abundant room for further progress in developing this instrument using online delivery and coding for consumers and professionals to use. It can be used to provide more education around the abundance of UPFs in society and promote policy change around dietary recommendations. Having an educative aspect is a missing element in existing dietary tools and digital applications and offering more guidance and a new perspective on processed foods in an easily understood way can bring more awareness around the diet-related health outcomes. With the range of health promotional aspects this instrument can bring, it also has the opportunity to improve the eco-nutrition (environmental factors and humans health) aspect which could be powerful by improving individual health and positively impacting the environment by reducing single-use plastic consumption that comes with processed foods. By promoting whole food diets and shifting the paradigm to one with less intake of processed foods, this can reduce the rubbish and single-use plastic wastage that are coming from processed packaged foods, produced by Big Food companies. The combination of improving and influencing health promotion aspects with encouraging whole foods, less processed foods, and reducing rubbish, will positively impact both the general health of the population and environmental aspects. If these educational and health promotion aspects can be achieved by using the HISS in practice, this tool could potentially rapidly advance nutritional epidemiology to reduce the burden of diseases caused by dietary factors.

Conclusion

Ultra-processed food consumption is negatively affecting humans' health and the nutritional quality of diets. Having novel food classification systems that can be used by researchers, nutrition professionals and consumers to accurately quantify and promote quality food is essential to understand the effects of food choices on health and create behavioural change. Bringing more awareness around UPFs to improve consumers understanding of the impacts of their food choices, could encourage a beneficial behaviour change resulting in better health outcomes. This can be reinforced through encouraging a better relationship with healthy, unprocessed food through an increased understanding and awareness of the physiological and metabolic responses to ultra-processed food choices. A paradigm shift towards food processing in conjunction with a reduced focus on traditional food grouping will better reflect the food matrix and quality of macronutrients consumed. Food classification systems such as the HISS that incorporate measures of diet quality are easy to use and will place more attention on helping consumers understand food processing and create beneficial and lasting change. The results of this study demonstrate the HISS is a reliable and feasible tool to use in reporting digital photography food recalls and quantifying food quality. Results confirmed the association UPFs have with nutrient measures, correlating UPFs with higher energy intake, increased sugar and carbohydrates, and decreased fibre. The HISS is an instrument with the potential to develop nutritional epidemiology by clearly identifying the degree of food processing and accurately reflecting the quality of dietary patterns. HISS can be applied in combination with digital photography methods to capture diet quality and provide more education around minimally processed foods, promoting the user towards more whole foods. Further research is needed in this area on a larger scale to confirm these findings and better understand what the population is eating, and the effects UPFs are having on humans' health.

References

Baker, P., Machado, P., Santos, T., Sievert, K., Backholer, K., Hadjikakou, M., Russell, C., Huse, O., Bell, C., Scrinis, G., Worsley, A., Friel, S., & Lawrence, M. (2020). Ultra-processed foods and the nutrition transition: Global, regional and national trends, food systems transformations and political economy drivers. *OBESITY REVIEWS, 21*(12). https://doi.org/10.1111/obr.13126

Bleiweiss-Sande, R., Chui, K., Evans, E. W., Goldberg, J., Amin, S., & Sacheck, J. (2019). Robustness of Food Processing Classification Systems. *Nutrients, 11*(6). https://doi.org/10.3390/nu11061344

Bodnaruc, A. M., Prud'homme, D., Blanchet, R., & Giroux, I. (2016). Nutritional modulation of endogenous glucagon-like peptide-1 secretion: a review. *Nutrition & Metabolism, 13*(1), 92. https://doi.org/10.1186/s12986-016-0153-3

Bonaccio, M., Costanzo, S., Di Castelnuovo, A., Persichillo, M., Magnacca, S., De Curtis, A., Cerletti, C., Donati, M. B., de Gaetano, G., & Iacoviello, L. (2022). Ultra-processed food intake and all-cause and cause-specific mortality in individuals with cardiovascular disease: the Moli-sani Study. *Eur Heart J, 43*(3), 213-224. https://doi.org/10.1093/eurheartj/ehab783

Braesco, V., Souchon, I., Sauvant, P., Haurogné, T., Maillot, M., Féart, C., & Darmon, N. (2022). Ultra-processed foods: how functional is the NOVA system? *European Journal of Clinical Nutrition*. https://doi.org/10.1038/s41430-022-01099-1

Burrows, T. L., Ho, Y. Y., Rollo, M. E., & Collins, C. E. (2019). Validity of Dietary Assessment Methods When Compared to the Method of Doubly Labeled Water: A Systematic Review in Adults. *Front Endocrinol (Lausanne), 10*, 850. https://doi.org/10.3389/fendo.2019.00850

Cannon, G., & Leitzmann, C. (2022). Food and nutrition science: The new paradigm. *Asia Pac J Clin Nutr, 31*(1), 1-15. https://doi.org/10.6133/apjcn.202203_31(1).0001

Carolina Archundia Herrera, M., & Chan, C. B. (2018). Narrative Review of New Methods for Assessing Food and Energy Intake [article]. *Nutrients, 10*(8), 1064-1064. https://doi.org/10.3390/nu10081064

Chen, X., Zhang, Z., Yang, H., Qiu, P., Wang, H., Wang, F., Zhao, Q., Fang, J., & Nie, J. (2020). Consumption of ultra-processed foods and health outcomes: a systematic review of epidemiological studies. *Nutrition Journal, 19*(1), 86. https://doi.org/10.1186/s12937-020-00604-1

Coad, J., & Pedley, K. (2020). Nutrition in New Zealand: Can the Past Offer Lessons for the Present and Guidance for the Future? *Nutrients, 12*(11). https://doi.org/10.3390/nu12113433

Comerford, K. B., Papanikolaou, Y., Jones, J. M., Rodriguez, J., Slavin, J., Angadi, S., & Drewnowski, A. (2021). Toward an Evidence-Based Definition and Classification of Carbohydrate Food Quality: An Expert Panel Report. *Nutrients, 13*(8), 2667. https://www.mdpi.com/2072-6643/13/8/2667

Crino, M., Barakat, T., Trevena, H., & Neal, B. (2017). Systematic review and comparison of classification frameworks describing the degree of food processing. *Nutr Food Technol, 3*(1), 138.

Cuevas-Sierra, A., Milagro, F. I., Aranaz, P., Martínez, J. A., & Riezu-Boj, J. I. (2021). Gut Microbiota Differences According to Ultra-Processed Food Consumption in a Spanish Population. *Nutrients, 13*(8), 2710. https://www.mdpi.com/2072-6643/13/8/2710

Doulah, A., Mccrory, M. A., Higgins, J. A., & Sazonov, E. (2019). A Systematic Review of Technology-Driven Methodologies for Estimation of Energy Intake [article]. *IEEE Access, 7*, 49653-49668. https://doi.org/10.1109/ACCESS.2019.2910308

Efendic, S., & Portwood, N. (2004). Overview of incretin hormones. *Horm Metab Res, 36*(11-12), 742-746. https://doi.org/10.1055/s-2004-826157

Fardet, A. (2016). Minimally processed foods are more satiating and less hyperglycemic than ultra-processed foods: A preliminary study with 98 ready-to-eat foods [Article]. *Food and Function, 7*(5), 2338-2346. https://doi.org/10.1039/c6fo00107f

Fardet, A. (2018). Characterization of the Degree of Food Processing in Relation With Its Health Potential and Effects. *Adv Food Nutr Res, 85*, 79-129. https://doi.org/10.1016/bs.afnr.2018.02.002

Fardet, A., Rock, E., Bassama, J., Bohuon, P., Prabhasankar, P., Monteiro, C., Moubarac, J.-C., & Achir, N. (2015). Current Food Classifications in Epidemiological Studies Do Not Enable Solid Nutritional Recommendations for Preventing Diet-Related

Chronic Diseases: The Impact of Food Processing. *Advances in Nutrition, 6*(6), 629-638. https://doi.org/10.3945/an.115.008789

Fatehah, A. A., Poh, B. K., Shanita, S. N., & Wong, J. E. (2018). Feasibility of Reviewing Digital Food Images for Dietary Assessment among Nutrition Professionals [Article]. *Nutrients, 10*(8), 12, Article 984. https://doi.org/10.3390/nu10080984

Ferretti, F., Mariani, M., & Sarti, E. (2021). Is the development of obesogenic food environments a self-reinforcing process? Evidence from soft drink consumption. *Globalization & Health, 17*(1), 1-13. https://ezproxy.aut.ac.nz/login?url=https://search.ebscohost.com/login.aspx?direct=true&site=eds-live&db=edb&AN=152026442

Freedman, L. S., Commins, J. M., Moler, J. E., Arab, L., Baer, D. J., Kipnis, V., Midthune, D., Moshfegh, A. J., Neuhouser, M. L., Prentice, R. L., Schatzkin, A., Spiegelman, D., Subar, A. F., Tinker, L. F., & Willett, W. (2014). Pooled results from 5 validation studies of dietary self-report instruments using recovery biomarkers for energy and protein intake. *Am J Epidemiol, 180*(2), 172-188. https://doi.org/10.1093/aje/kwu116

Gearhardt, A. N., & Schulte, E. M. (2021). Is Food Addictive? A Review of the Science. *Annual Review of Nutrition, 41*, 387-410. https://ezproxy.aut.ac.nz/login?url=https://search.ebscohost.com/login.aspx?direct=true&site=eds-live&db=edb&AN=152949104

Gouel, C., & Guimbard, H. (2019). Nutrition Transition and the Structure of Global Food Demand. *American Journal of Agricultural Economics, 101*(2), 383-403. https://doi.org/https://doi.org/10.1093/ajae/aay030

Gupta, S., Hawk, T., Aggarwal, A., & Drewnowski, A. (2019). Characterizing Ultra-Processed Foods by Energy Density, Nutrient Density, and Cost [Original Research]. *Frontiers in Nutrition, 6*. https://doi.org/10.3389/fnut.2019.00070

Haile, B., Neme, K., & Belachew, T. (2017). Evolution of human diet and effect of globalization on regional diet with emphasis to the Mediterranean diet. *Nutrition & Food Science, 47*(6), 869-883. https://doi.org/10.1108/NFS-02-2017-0017

Hall, K. D., Ayuketah, A., Brychta, R., Cai, H., Cassimatis, T., Chen, K. Y., Chung, S. T., Costa, E., Courville, A., Darcey, V., Fletcher, L. A., Forde, C. G., Gharib, A. M., Guo, J., Howard, R., Joseph, P. V., McGehee, S., Ouwerkerk, R., Raisinger, K., Rozga, I., Stagliano, M., Walter, M., Walter, P. J., Yang, S., & Zhou, M. (2019).

Ultra-Processed Diets Cause Excess Calorie Intake and Weight Gain: An Inpatient Randomized Controlled Trial of Ad Libitum Food Intake. *Cell Metabolism, 30*(1), 67-77.e63. https://doi.org/10.1016/j.cmet.2019.05.008

Herrera, M. C. A., & Chan, C. B. (2018). Narrative Review of New Methods for Assessing Food and Energy Intake. *Nutrients, 10*(8). https://doi.org/10.3390/nu10081064

Hobbs, M., Mackenbach, J. D., Wiki, J., Marek, L., McLeod, G. F. H., & Boden, J. M. (2021). Investigating change in the food environment over 10 years in urban New Zealand: A longitudinal and nationwide geospatial study. *Social Science & Medicine, 269*, 113522. https://doi.org/https://doi.org/10.1016/j.socscimed.2020.113522

Hochsmann, C., & Martin, C. K. (2020). Review of the validity and feasibility of image-assisted methods for dietary assessment. *INTERNATIONAL JOURNAL OF OBESITY, 44*(12), 2358-2371. https://doi.org/10.1038/s41366-020-00693-2

Krebs-Smith, S. M., Pannucci, T. E., Subar, A. F., Kirkpatrick, S. I., Lerman, J. L., Tooze, J. A., Wilson, M. M., & Reedy, J. (2018). Update of the Healthy Eating Index: HEI-2015. *Journal of the Academy of Nutrition and Dietetics, 118*(9), 1591-1602. https://doi.org/https://doi.org/10.1016/j.jand.2018.05.021

Lane, M. M., Davis, J. A., Beattie, S., Gómez-Donoso, C., Loughman, A., O'Neil, A., Jacka, F., Berk, M., Page, R., Marx, W., & Rocks, T. (2021). Ultraprocessed food and chronic noncommunicable diseases: A systematic review and meta-analysis of 43 observational studies. *Obes Rev, 22*(3), e13146. https://doi.org/10.1111/obr.13146

Lorenzoni, G., Benedetto, R. D., Ocagli, H., Gregori, D., & Silano, M. (2021). A Validation Study of NOVA Classification for Ultra-Processed Food on the USDA Food and Nutrient Database. *Current Developments in Nutrition, 5*(Supplement_2), 594-594. https://doi.org/10.1093/cdn/nzab044_025

Ludwig, D. S., Aronne, L. J., Astrup, A., de Cabo, R., Cantley, L. C., Friedman, M. I., Heymsfield, S. B., Johnson, J. D., King, J. C., Krauss, R. M., Lieberman, D. E., Taubes, G., Volek, J. S., Westman, E. C., Willett, W. C., Yancy, W. S., & Ebbeling, C. B. (2021). carbohydrate-insulin model: a physiological perspective on the obesity pandemic. *American Journal of Clinical Nutrition, 114*(6), 1873-1885. https://ezproxy.aut.ac.nz/login?url=https://search.ebscohost.com/login.aspx?direct=true&site=eds-live&db=edb&AN=153984705

Luiten, C. M., Steenhuis, I. H. M., Eyles, H., Ni Mhurchu, C., & Waterlander, W. E. (2016). Ultra-processed foods have the worst nutrient profile, yet they are the most available packaged products in a sample of New Zealand supermarkets. *PUBLIC HEALTH NUTRITION, 19*(3), 530-538. https://doi.org/10.1017/S1368980015002177

Martin, C. K., Correa, J. B., Allen, H. R., Champagne, C., Nicklas, T., & Gunturk, B. (2014). Measuring food intake with digital photography [Article]. *Journal of Human Nutrition and Dietetics, 27*(SUPPL.1), 72-81. https://doi.org/10.1111/jhn.12014

Martínez Steele, E., Popkin, B. M., Swinburn, B., & Monteiro, C. A. (2017). The share of ultra-processed foods and the overall nutritional quality of diets in the US: evidence from a nationally representative cross-sectional study. *Popul Health Metr, 15*(1), 6. https://doi.org/10.1186/s12963-017-0119-3

Martini, D., Godos, J., Bonaccio, M., Vitaglione, P., & Grosso, G. (2021). Ultra-Processed Foods and Nutritional Dietary Profile: A Meta-Analysis of Nationally Representative Samples. *Nutrients, 13*(10), 3390. https://www.mdpi.com/2072-6643/13/10/3390

Monteiro, C., Cannon, G., Lawrence, M., Louzada, M. L., & Machado, P. (2019). FAO. Ultra-processed foods, diet quality, and health using the NOVA classification system.

Monteiro, C., Cannon, G., Levy, R., Claro, R., & Moubarac, J.-C. (2012). The Food System. Processing. The big issue for disease, good health, well-being. *World Nutrition, 3*, 527-569.

Monteiro, C. A., Cannon, G., Levy, R. B., Moubarac, J. C., Louzada, M. L., Rauber, F., Khandpur, N., Cediel, G., Neri, D., Martinez-Steele, E., Baraldi, L. G., & Jaime, P. C. (2019). Ultra-processed foods: what they are and how to identify them. *Public Health Nutr, 22*(5), 936-941. https://doi.org/10.1017/s1368980018003762

Monteiro, C. A., Cannon, G., Moubarac, J. C., Levy, R. B., Louzada, M. L. C., & Jaime, P. C. (2018). The UN Decade of Nutrition, the NOVA food classification and the trouble with ultra-processing. *Public Health Nutr, 21*(1), 5-17. https://doi.org/10.1017/s1368980017000234

Monteiro, C. A., Moubarac, J. C., Cannon, G., Ng, S. W., & Popkin, B. (2013). Ultra-processed products are becoming dominant in the global food system. *Obes Rev, 14 Suppl 2*, 21-28. https://doi.org/10.1111/obr.12107

Moubarac, J. C., Parra, D. C., Cannon, G., & Monteiro, C. A. (2014). Food Classification Systems Based on Food Processing: Significance and Implications for Policies and Actions: A Systematic Literature Review and Assessment. *Curr Obes Rep, 3*(2), 256-272. https://doi.org/10.1007/s13679-014-0092-0

Mozaffarian, D., El-Abbadi, N. H., O'Hearn, M., Erndt-Marino, J., Masters, W. A., Jacques, P., Shi, P., Blumberg, J. B., & Micha, R. (2021). Food Compass is a nutrient profiling system using expanded characteristics for assessing healthfulness of foods. *Nature Food, 2*(10), 809-818. https://doi.org/10.1038/s43016-021-00381-y

Petrus, R. R., do Amaral Sobral, P. J., Tadini, C. C., & Gonçalves, C. B. (2021). The NOVA classification system: A critical perspective in food science. *Trends in Food Science & Technology, 116*, 603-608. https://doi.org/https://doi.org/10.1016/j.tifs.2021.08.010

Pfrimer, K., Vilela, M., Resende, C. M., Scagliusi, F. B., Marchini, J. S., Lima, N. K., Moriguti, J. C., & Ferriolli, E. (2015). Under-reporting of food intake and body fatness in independent older people: a doubly labelled water study. *Age Ageing, 44*(1), 103-108. https://doi.org/10.1093/ageing/afu142

Popkin, B. M., Corvalan, C., & Grummer-Strawn, L. M. (2020). Dynamics of the double burden of malnutrition and the changing nutrition reality. *Lancet, 395*(10217), 65-74. https://doi.org/10.1016/s0140-6736(19)32497-3

Popkin, B. M., & Ng, S. W. (2022). The nutrition transition to a stage of high obesity and noncommunicable disease prevalence dominated by ultra-processed foods is not inevitable. *OBESITY REVIEWS, 23*(1), e13366. https://doi.org/https://doi.org/10.1111/obr.13366

Poti, J. M., Mendez, M. A., Ng, S. W., & Popkin, B. M. (2015). Is the degree of food processing and convenience linked with the nutritional quality of foods purchased by US households? *The American Journal of Clinical Nutrition, 101*(6), 1251-1262. https://doi.org/10.3945/ajcn.114.100925

Prentice, A. M., Black, A. E., Coward, W. A., Davies, H. L., Goldberg, G. R., Murgatroyd, P. R., Ashford, J., Sawyer, M., & Whitehead, R. G. (1986). High levels of energy expenditure in obese women. *British medical journal (Clinical research ed.), 292*(6526), 983-987. https://doi.org/10.1136/bmj.292.6526.983

Ravelli, M. N., & Schoeller, D. A. (2020a). Traditional Self-Reported Dietary Instruments Are Prone to Inaccuracies and New Approaches Are Needed [Mini Review]. *Frontiers in Nutrition, 7*(90). https://doi.org/10.3389/fnut.2020.00090

Ravelli, M. N., & Schoeller, D. A. (2020b). Traditional Self-Reported Dietary Instruments Are Prone to Inaccuracies and New Approaches Are Needed. *Frontiers in Nutrition, 7*, 90-90. https://doi.org/10.3389/fnut.2020.00090

Rucklidge, J. J., Johnstone, J. M., & Kaplan, B. J. (2021). Nutrition Provides the Essential Foundation for Optimizing Mental Health [Article]. *Evidence-Based Practice in Child & Adolescent Mental Health, 6*(1), 131-154. https://doi.org/10.1080/23794925.2021.1875342

Rucklidge, J. J., Kaplan, B. J., & Mulder, R. T. (2015). What if nutrients could treat mental illness? *Australian & New Zealand Journal of Psychiatry, 49*(5), 407-408. https://doi.org/10.1177/0004867414565482

Sadler, C. R., Grassby, T., Hart, K., Raats, M., Sokolović, M., & Timotijevic, L. (2021). Processed food classification: Conceptualisation and challenges. *Trends in Food Science & Technology, 112*, 149-162. https://doi.org/https://doi.org/10.1016/j.tifs.2021.02.059

Salvatore, T., Nevola, R., Pafundi, P. C., Monaco, L., Ricozzi, C., Imbriani, S., Rinaldi, L., & Sasso, F. C. (2019). Incretin Hormones: The Link between Glycemic Index and Cardiometabolic Diseases. *Nutrients, 11*(8), 1878. https://www.mdpi.com/2072-6643/11/8/1878

Scott, J. C. (2017). *Against the grain : a deep history of the earliest states*. Yale University Press. http://ebookcentral.proquest.com/lib/AUT/detail.action?docID=6424075

Silva, C. A., Santos, I. d. S., Shivappa, N., Hebert, J. R., Crivellenti, L. C., & Sartorelli, D. S. (2019). The role of food processing in the inflammatory potential of diet during pregnancy. *Revista de saude publica, 53*, 113-113. https://doi.org/10.11606/S1518-8787.2019053001154

Spreadbury, I. (2012). Comparison with ancestral diets suggests dense acellular carbohydrates promote an inflammatory microbiota, and may be the primary dietary cause of leptin resistance and obesity. *Diabetes Metab Syndr Obes, 5*, 175-189. https://doi.org/10.2147/dmso.S33473

Stuckler, D., & Nestle, M. (2012). Big Food, Food Systems, and Global Health. *PLOS Medicine, 9*(6), e1001242. https://doi.org/10.1371/journal.pmed.1001242

Teicholz, N. (2014). *The big fat surprise : why meat, butter, and cheese belong in a healthy diet* (First Simon & Schuster hardcover editon. ed.). Simon & Schuster.

Timper, K., & Brüning, J. C. (2017, Jun 1). Hypothalamic circuits regulating appetite and energy homeostasis: pathways to obesity. *Dis Model Mech, 10*(6), 679-689. https://doi.org/10.1242/dmm.026609

Wood, B., Williams, O., Nagarajan, V., & Sacks, G. (2021). Market strategies used by processed food manufacturers to increase and consolidate their power: a systematic review and document analysis. *Globalization & Health, 17*(1), 1-23. https://ezproxy.aut.ac.nz/login?url=https://search.ebscohost.com/login.aspx?direct=true&site=eds-live&db=edb&AN=148340138

World Health Organization. (2021). *Malnutrition*. World Health Organization https://www.who.int/news-room/fact-sheets/detail/malnutrition

Zhong, G.-C., Gu, H.-T., Peng, Y., Wang, K., Wu, Y.-Q.-L., Hu, T.-Y., Jing, F.-C., & Hao, F.-B. (2021). Association of ultra-processed food consumption with cardiovascular mortality in the US population: long-term results from a large prospective multicenter study. *International Journal of Behavioral Nutrition and Physical Activity, 18*(1), 21. https://doi.org/10.1186/s12966-021-01081-3

Zinöcker, M. K., & Lindseth, I. A. (2018). The Western Diet-Microbiome-Host Interaction and Its Role in Metabolic Disease. *Nutrients, 10*(3). https://doi.org/10.3390/nu10030365

Appendices

Appendix A

Serving Sizes

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

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

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

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

Original Human Interference Scoring 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.	**3.1** Homemade breads; soups; granola and breakfast cereals; baking and biscuits.	**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
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.	**3.2** Peeled or sliced fruit in syrup; canned fish in flavouring or oil; cured meat (beef jerky); dried fruit; hummus; pesto; aioli. and	**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); cured bacon, breads and wraps; rice cakes; breakfast cereals; biscuits; fizzy 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); dressings and sauces; spreads; margarine; baby formulas; ready-to-drink alcoholic beverages; instant coffee.	**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 C

AUTEC Approval

Auckland University of Technology Ethics Committee (AUTEC)

Auckland University of Technology
D-88, Private Bag 92006, Auckland 1142, NZ
T: +64 9 921 9999 ext. 8316
E: ethics@aut.ac.nz
www.aut.ac.nz/researchethics

23 September 2021

Grant Schofield
Faculty of Health and Environmental Sciences

Dear Grant

Re Ethics Application: **21/326 Feasibility of using digital photography with a food processing classification system to improve quantification of food quality**

Thank you for providing evidence as requested, which satisfies the points raised by the Auckland University of Technology Ethics Committee (AUTEC).

Your ethics application has been approved for three years until 23 September 2024.

Non-Standard Conditions of Approval

1. Amendment of the Information Sheet as follows:
   a. In the section on privacy remove the reference to data being anonymous.
   b. State the qualification being sought.

Non-standard conditions must be completed before commencing your study. Non-standard conditions do not need to be submitted to or reviewed by AUTEC before commencing your study.

Standard Conditions of Approval

1. The research is to be undertaken in accordance with the Auckland University of Technology Code of Conduct for Research and as approved by AUTEC in this application.
2. A progress report is due annually on the anniversary of the approval date, using the EA2 form.
3. A final report is due at the expiration of the approval period, or, upon completion of project, using the EA3 form.
4. Any amendments to the project must be approved by AUTEC prior to being implemented. Amendments can be requested using the EA2 form.
5. Any serious or unexpected adverse events must be reported to AUTEC Secretariat as a matter of priority.
6. Any unforeseen events that might affect continued ethical acceptability of the project should also be reported to the AUTEC Secretariat as a matter of priority.
7. It is your responsibility to ensure that the spelling and grammar of documents being provided to participants or external organisations is of a high standard and that all the dates on the documents are updated.
8. AUTEC grants ethical approval only. You are responsible for obtaining management approval for access for your research from any institution or organisation at which your research is being conducted and you need to meet all ethical, legal, public health, and locality obligations or requirements for the jurisdictions in which the research is being undertaken.

Please quote the application number and title on all future correspondence related to this project.

For any enquiries please contact ethics@aut.ac.nz. The forms mentioned above are available online through http://www.aut.ac.nz/research/researchethics. (This is a computer-generated letter for which no signature is required)

The AUTEC Secretariat
Auckland University of Technology Ethics Committee

Appendix D

Participant Information Sheet

Participant Information Sheet

Date Information Sheet Produced:

22/09/2021

Project Title

Feasibility of using digital photography with a food processing classification system to improve quantification of food quality

Kia ora my name is Olivia Malamatenios the primary research, and you are receiving this invitation to voluntary participate in a master's research project that will contribute to a qualification in a Masters of Sport, Exercise and Health.

What is the purpose of this research?

The aim of this research is to determine if a modified food rating system is feasible to quantify food quality by looking at digital images. We are trying to find out if the instrument captures food quality and reflects different eating patterns. Involvement with you, as practicing nutrition professionals in this research will help determine the useability and reliability of the developed system and give feedback on the food classification and scoring system. The findings from this research may be used for academic publications.

How was I identified and why am I being invited to participate in this research?

The selection process has been aimed towards registered practicing nutrition health professionals, who are registered dieticians or registered with the Nutrition Society. You have received this Information Sheet because you fit the inclusion criteria and have familiarity with assessments of food intake that involves identifying and assessing food products. Your contact email used for the purpose of this research and has been obtained through Prof Grant Schofields professional networks.

How do I agree to participate in this research?

If you would like to participate in the research, please respond to this email within two weeks, by booking an appointment with us at the Human Potential Centre. A consent form will need to be signed before participating in the activity. Your participation in this research is voluntary (it is your choice) and whether or not you choose to participate will neither advantage nor disadvantage you. You are able to withdraw from the study at any time. If you choose to withdraw from the study, then you will be offered the choice between having any data that is identifiable as belonging to you removed or allowing it to continue to be used. However, once the findings have been produced, removal of your data may not be possible.

What will happen in this research?

The project will involve an hour of your time involving familiarisation with a food classification and scoring system and then take part in an activity to classify meals, that will be completed individually. The Human Interference Scoring System (HISS) will be described in detail, covering the different levels of food processing categories, the scoring system, and the serving sizes that will be used in the activity. Once familiar with the classification system and scoring protocol, a series of 24-hour food recalls from digital photographs will be presented. The digital photographs will show meals, snacks, and drinks consumed in a 24-hour period. You will be required to identify the food products and tally the different servings into the four appropriate categories. Once completed the activity with 5 food recalls, totals should be recorded and noted down on the given sheet. The research will involve providing feedback on the overall system, the usability of it, and give additional comments as you please. The feedback gathered from this project will be used to adjust the HISS system if needed and all responses will be acknowledged and appreciated.

What are the discomforts and risks?

Potential discomfort and risks might occur with ambiguity in task completion when classifying foods. To alleviate discomfort or risks, when taking part in this activity there is no right or wrong answers, and the aim of this project is to test the feasibility to see if the system can be of use. Feedback is encouraged throughout the data collection process and any questions will be discussed.

What are the benefits?

The benefits of taking part in this research is helping advance the food classification system to quantify quality of food and have the opportunity to share experiences with the activity. You will also be familiarising with new intellectual property whilst assisting to the completion of a qualification.

How will my privacy be protected?

Your privacy and confidentiality will be respected at all times. The data collected for this project will only be available for the researchers to access and your personal details will not be identified in the findings. All data will remain confidential in the findings.

What are the costs of participating in this research?

There are no costs involved with participating in this research. Your time is required, and the activity will not take any longer than an hour.

What opportunity do I have to consider this invitation?

To take part in this project, please respond within 2 weeks with an email to organise a time to complete the activity and data collection. You have the opportunity to seek further information if required. Participation is voluntary and withdrawal during the study can happen at any point without any adverse consequences.

Will I receive feedback on the results of this research?

If you wish to receive results from this project you will receive a one-to-two-page summary of the findings if requested.

What do I do if I have concerns about this research?

Any concerns regarding the nature of this project should be notified in the first instance to the Project Supervisor,

Concerns regarding the conduct of the research should be notified to the Executive Secretary of AUTEC, *ethics@aut.ac.nz* , (+649) 921 9999 ext 6038.

Whom do I contact for further information about this research?

Please keep this Information Sheet and a copy of the Consent Form for your future reference. You are also able to contact the research team as follows:

Researcher Contact Details:

Olivia Malamatenios

Olivia.malamatenios@gmail.com

Project Supervisor Contact Details:

Project Supervisor Contact Details:

Prof Grant Schofield

P: 09 921 9169 **M:** 021 481489

Grant.schofield@aut.ac.nz

Appendix E

Consent Form

Consent Form

Project title: Feasibility of using digital photography with a food processing classification system to improve quantification of food quality

Project Supervisor: Prof Grant Schofield

Researcher: Olivia Malamatenios

- ○ I have read and understood the information provided about this research project in the Information Sheet dated 22/09/2021.
- ○ I have had an opportunity to ask questions and to have them answered.
- ○ I understand that taking part in this study is voluntary (my choice) and that I may withdraw from the study at any time without being disadvantaged in any way.
- ○ I understand that if I withdraw from the study then, while it may not be possible to destroy all data collected, I will be offered the choice between having any data that is identifiable as belonging to me removed or allowing it to continue to be used. However, once the findings have been produced, removal of my data may not be possible.
- ○ I agree to take part in this research.
- ○ I wish to receive a summary of the research findings (please tick one): Yes○ No○

Participant's signature: ....

Participant's name: ....

Participant's Contact Details (if appropriate):

....

....

....

....

Date:

Approved by the Auckland University of Technology Ethics Committee on 23 September 2021 AUTEC Reference number 21/326

Note: The Participant should retain a copy of this form.

Appendix F

Scoring Sheet

TE WĀNANGA ARONUI O TĀMAKI MAKAU RAU

Food Classification Activity Scoring Sheet

Date: ______________

Name: ____

	1: Unprocessed/ Minimally processed	2: Processed I	3: Processed II	4: Ultra-processed
No. 1				
Tally of Servings				
Total Servings				
% Total				
No. 2				
Tally of Servings				
Total Servings				
% Total				
No. 3				
Tally of Servings				
Total Servings				
% Total				
No. 4				
Tally of Servings				
Total Servings				
% Total				
No. 5				
Tally of Servings				
Total Servings				
% Total				

Appendix G

Questionnaire

AUT
TE WĀNANGA ARONUI O TĀMAKI MAKAU RAU

Please provide feedback on the usability of the HISS classification and scoring system with responding to the following questions:

What did you find easy to use?

What did you find difficult to use?

What are your suggestions for improvements?