Diets in Dutch Hospitals: setting the scene for healthy, protein adequate, and sustainable menus

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List of abbreviations

Abbreviation	*Meaning*
AAA	Aromatic amino acids
AAS	Amino acid score
EAA	Essential amino acids
EWUU	Alliance of TU/e, WUR, UU, and UMCU
GHGE	Greenhouse gas emissions
IZA	Integral Care Agreement (Integraal Zorgakkoord)
LEDA	Dutch branded food database (Levensmiddelen Database)
MPQS	Meal protein quality score
NEVO	Dutch food composition table (Nederlandse Voedingsmiddelen tabel)
NPA	National Prevention Agreement
NVD	Dutch association of dietitians (Nederlandse Vereniging van Diëtisten)
PDCAAS	Protein digestibility-corrected amino acid score
RDA	Recommended Dietary Allowance
RIVM	National Institute for Public Health and Environment (Rijksinstituut voor Volksgezondheid en Milieu)
SAA	Sulfur-containing amino acids
UU	Utrecht University
wPD	Weighted protein digestibility
WUR	Wageningen University and Research

Summary (EN)

Background: there is an increasing awareness of the importance of nutritious food for patients resulting in hospitals putting more effort into offering healthy meals adapted to the patients nutritional needs. Additionally, hospitals are focusing on sustainability and therefore aiming to transition towards offering more healthy and plant-based meals as a strategy to reduce the environmental impact. However, adequate protein intake is crucial for patient recovery. The question arises whether increased protein intake requirements in patients at risk for malnutrition can still be met while transitioning to more plant-based meals, which have a lower protein quality than animal-based meals.

Objectives: To assess the protein quantity and quality and environmental impact of meals, the dinner meals in three Dutch hospitals offered to patients following a regular healthy diet or a protein and energy rich diet during the spring/summer season of 2023 were analyzed. Furthermore, scenario analyses were applied to a selection of these meals to study which relatively small changes can improve their protein quality. In addition, a stakeholder analysis was performed for two of the hospitals to create an overview of the food delivery system and to identify the challenges and opportunities in creating a circular and environmentally sustainable food system.

Methods: Recipe data of the dinner meals from all three hospitals was gathered and foods were linked to the Dutch Food Composition Table 2016 (NEVO). Protein quality was assessed through the protein digestibility-corrected amino acid score (PDCAAS), available protein (protein content corrected for digestibility), and utilizable protein (protein content corrected for digestibility and amino acid profile). Protein quality calculations were performed with the amino acid composition database extension of the NEVO 2016 food composition database from WUR. Protein content of the dinner meals were set against the current protein intake criterion used by the hospitals of 20 g of protein per meal, the minimum amount advised for optimal body protein synthesis. Environmental impact, including GHG emissions, land use, blue water use, acidification, and fresh and marine water eutrophication, was assessed using the Environmental Impact of Foods database from the National Institute for Public Health and Environment (RIVM). For meals scoring low in protein quality, scenario analyses were performed with the Alpha tool. Based on algorithms, this tool suggests adding or changing ingredients in order to achieve a high protein quality meal. The stakeholder analysis and identification of barriers and opportunities for a more circular and sustainable food system involved interviews with relevant stakeholders of two hospitals.

Results: Results showed that meals containing animal-based protein had a higher protein content and quality compared to vegetarian options. A total of 85% of the animal protein-based meals met the criterion of 20 g of protein per meal before correcting for protein quality, and 68% after correcting for protein quality. A total of 60% of the vegetarian meals had more than 20 g of protein per meal in total, but only 20% met this criterion after correcting for protein quality. Most animal protein- based meals (77%) had a complete amino acid profile (PDCAAS 0.82). Many vegetarian meals (60%) had incomplete amino acid profiles (PDCAAS 0.73), with lysine and leucine being the most common limiting amino acids. Protein quality was largely influenced by digestibility. Environmental impact analysis revealed on average around 50% lower GHGE in vegetarian compared to animal protein-based meals. The protein

component was the main contributor to the GHGE in animal protein-based meals. Scenario analyses suggested improving low protein quality-scoring meals by adding plant-based protein-rich ingredients such as soya flour or dried nori seaweed, resulting in complete amino acid profile and higher protein quality. Stakeholder interviews identified challenges in the protein transition, including communication towards patients and staff, financial constraints, and knowledge gaps on protein quality. Facilitators included having a clear plan and vision, effective communication towards employees, and collaboration with healthcare facilities and knowledge institutes.

Discussion: For most meals the amino acid profile was not the main determinant of utilizable protein. Therefore, it should be ensured that meals meet the 20 g protein criterion when taking digestibility into account. Adjusting portion sizes, increasing meal amounts, or modifying ingredients are suggested solutions. As shown with the scenario analyses, targeted additions to a meal can improve the protein quality of the meal without needing to increase portion sizes unrealistically. Environmental impact analysis showed that meals with meat had the highest greenhouse gas emissions (GHGE), with beef contributing significantly. Animal protein-based meals also had higher land use, acidification, and fresh and marine water eutrophication compared to vegetarian meals. Blue water use did not consistently follow the same trend across meals.

Conclusions:

- Animal protein-based dinner meals generally had a higher protein content and quality than vegetarian dinner meals (21 g vs 16 g of protein on average after correction for protein quality, respectively). Vegetarian dishes often (80%) dropped below the hospital criterion of 20 g protein per meal.
- Vegetarian dinner meals often (60%) had incomplete amino acid profiles. Limiting amino acids were lysine, leucine, and sulfur-containing amino acids (methionine and cysteine).
- Digestibility was more determining for protein quality than amino acid profile in the dinner meals. When designing vegetarian meals, the digestibility factors for each food group should be applied in order to ensure an adequate protein content.
- Targeted ingredient additions to a meal based on amino acid profile can increase the protein quality.
- Meals with animal-based protein generally had a higher protein content than vegetarian meals, yet they had a greater environmental impact, indicated by higher GHGE and increased land use.
- Challenges for the protein transition in the hospitals are communication towards patients and staff, financial constraints, and knowledge on protein quality aspects of plant-based foods.
- Facilitators for the protein transition in the hospitals are having a clear plan and vision, effective communication towards employees, and collaborating and sharing information and knowledge with other institutions such as health care facilities and universities.

Samenvatting (NL)

Achtergrond: Er is een groeiend bewustzijn van het belang van goede voeding voor patiënten, wat ertoe leidt dat ziekenhuizen meer moeite doen om gezondere maaltijden aan te bieden. Daarnaast richten ziekenhuizen zich op duurzaamheid en streven ze ernaar om over te stappen op het aanbieden van meer gezonde en plantaardige maaltijden als strategie om de milieubelasting te verminderen. Echter, eiwitinname is cruciaal voor het herstel van de patiënt. De vraag bestaat of de eiwitbehoefte van patiënten met een risico op ondervoeding nog steeds kan worden vervuld bij de overgang naar meer plantaardige maaltijden, die een lagere eiwitkwaliteit hebben dan dierlijke maaltijden.

Doelstellingen: Het doel was om de eiwitkwantiteit en -kwaliteit en de milieubelasting van de avondmaaltijden in drie Nederlandse ziekenhuizen te analyseren. De avondmaaltijden aangeboden tijdens het voorjaar/zomerseizoen van 2023 aan patiënten met een regulier gezond dieet of een eiwit- en energierijk dieet werden beoordelen. Bovendien werden scenarioanalyses toegepast op een selectie van deze maaltijden om te onderzoeken welke relatief kleine veranderingen hun eiwitkwaliteit kunnen verbeteren. Daarnaast werd een stakeholderanalyse uitgevoerd voor twee van de ziekenhuizen om een overzicht te creëren van het voedselleveringssysteem en om de uitdagingen en kansen te identificeren bij het creëren van een circulair en milieuvriendelijk voedselsysteem.

Methoden: Receptgegevens van de avondmaaltijden van alle drie de ziekenhuizen werden verzameld. Voedingsmiddelen werden gekoppeld aan de Nederlandse Voedingsmiddelentabel 2016 (NEVO). Eiwitkwaliteit werd beoordeeld aan de hand van de protein digestibility-corrected amino acid score (PDCAAS), beschikbaar eiwit (eiwitgehalte gecorrigeerd voor verteerbaarheid) en bruikbaar eiwit (eiwitgehalte gecorrigeerd voor verteerbaarheid en aminozuurprofiel). Eiwitkwaliteitsberekeningen werden uitgevoerd met de aminozuursamenstelling database-extensie van de NEVO 2016 database van WUR. Het eiwitgehalte van de avondmaaltijden werd vergeleken met de huidige eiwitcriterium van de ziekenhuizen van 20 g eiwit per maaltijd. Milieubelasting, inclusief broeikasgasemissies, landgebruik, watergebruik, verzuring, en eutrofiëring van zoet en zout water, werd beoordeeld met behulp van de Milieu-impact van voedingsmiddelen-database van het Rijksinstituut voor Volksgezondheid en Milieu (RIVM). Voor maaltijden met een lage eiwitkwaliteit werden scenarioanalyses uitgevoerd met de Alpha-tool. Op basis van algoritmen suggereert deze tool toevoegingen of wijzigingen in ingrediënten om een maaltijd met hoge eiwitkwaliteit te bereiken. De stakeholderanalyse en identificatie van barrières en kansen voor een meer circulair en duurzaam voedselsysteem omvatten interviews met relevante belanghebbenden van twee ziekenhuizen.

Resultaten: Resultaten toonden aan dat maaltijden met dierlijke eiwitten een hoger eiwitgehalte en kwaliteit hadden in vergelijking met vegetarische opties. In totaal voldeed 85% van de maaltijden op basis van dierlijke eiwitten aan het criterium van 20 g eiwit per maaltijd vóór correctie voor eiwitkwaliteit, en 68% na correctie voor eiwitkwaliteit. Van de vegetarische maaltijden had in totaal 60% meer dan 20 g eiwit per maaltijd, maar slechts 20% voldeed aan dit criterium na correctie voor eiwitkwaliteit. De meeste maaltijden op basis van dierlijke eiwitten (77%) hadden een volledig aminozuurprofiel (PDCAAS 0,82). Vaak hadden vegetarische maaltijden (60%) een onvolledig aminozuurprofiel (PDCAAS

0,73), waarbij lysine en leucine de meest voorkomende limiterende aminozuren waren. Eiwitkwaliteit werd grotendeels beïnvloed door verteerbaarheid. De milieu-impactanalyse toonde gemiddeld ongeveer 50% lagere broeikasgasemissies aan bij vegetarische maaltijden in vergelijking met maaltijden op basis van dierlijke eiwitten. De eiwitcomponent was de belangrijkste bijdrager aan de broeikasgasemissies bij maaltijden op basis van dierlijke eiwitten. Scenarioanalyses suggereerden dat het verbeteren van maaltijden met een lage score voor eiwitkwaliteit door toevoeging van plantaardige eiwitrijke ingrediënten zoals sojameel of gedroogd nori-zeewier resulteerde in een compleet aminozuurprofiel en een hogere eiwitkwaliteit. Stakeholderinterviews identificeerden uitdagingen in de eiwittransitie, waaronder communicatie naar patiënten en personeel, financiële beperkingen en kennislacunes over eiwitkwaliteit. Facilitators omvatten het hebben van een duidelijk plan en visie, effectieve communicatie naar werknemers, en samenwerking met zorginstellingen en kennisinstituten.

Discussie: Eiwitkwaliteit werd grotendeels beïnvloed door verteerbaarheid. Om die reden is het belangrijk dat maaltijden voldoen aan het criterium van 20 g eiwit wanneer rekening wordt gehouden met verteerbaarheid. Aanpassingen van portiegroottes, verhoging van maaltijdhoeveelheden of wijziging van ingrediënten worden voorgesteld als oplossingen. Zoals getoond met de scenarioanalyses, kunnen gerichte toevoegingen aan een maaltijd de eiwitkwaliteit van de maaltijd verbeteren zonder de portiegroottes onrealistisch te vergroten. Milieubelastinganalyse toonde aan dat maaltijden met vlees de hoogste broeikasgasemissies hadden, waarbij rundvlees aanzienlijk bijdroeg. Maaltijden met dierlijk eiwit hadden ook hoger landgebruik, verzuring en eutrofiëring van zoet en zout water in vergelijking met vegetarische maaltijden. Blauw watergebruik volgde niet consistent dezelfde trend over maaltijden heen.

Conclusies:

- Avondmaaltijden met dierlijk eiwit hadden over het algemeen een hoger eiwitgehalte en -kwaliteit dan vegetarische avondmaaltijden (21 g versus 16 g aan eiwit gemiddeld na correctie voor eiwitkwaliteit, respectievelijk). Vegetarische gerechten zakten vaak (80%) onder het ziekenhuiscriterium van 20 g eiwit per maaltijd.
- Vegetarische avondmaaltijden hadden vaak (60%) onvolledige aminozuurprofielen. Limiterende aminozuren waren lysine, leucine en zwavelhoudende aminozuren (methionine en cysteïne).
- In de context van ziekenhuisavondmaaltijden en hun eiwitkwaliteit is verteerbaarheid belangrijker om rekening mee te houden dan het aminozuurprofiel. Bij het ontwerpen van vegetarische maaltijden moeten de verteerbaarheidsfactoren voor elke voedselgroep worden toegepast om een adequaat eiwitgehalte te waarborgen.
- Gerichte toevoegingen van ingrediënten aan een maaltijd op basis van het aminozuurprofiel kan de eiwitkwaliteit van de maaltijd verhogen.
- Maaltijden met dierlijk eiwit hadden over het algemeen een hoger eiwitgehalte dan vegetarische maaltijden, maar hadden een grotere milieubelasting, aangegeven door hogere GHGE en verhoogd landgebruik.

- Uitdagingen voor de eiwittransitie in ziekenhuizen zijn communicatie naar patiënten en personeel, financiële beperkingen en kennis over eiwitkwaliteitsaspecten van plantaardig voedsel.
- Facilitators voor de eiwittransitie in ziekenhuizen zijn het hebben van een duidelijk plan en visie, effectieve communicatie naar medewerkers en samenwerking en het delen van informatie en kennis met andere instellingen zoals gezondheidszorginstellingen en universiteiten.

1. Background and project description

With increasing knowledge on the importance of a good nutritional status before, during, and after hospitalization, hospitals have been putting more effort into offering more healthy, nutritious and palatable meals to their patients[1]. These efforts and transitions are integrated at a national level within agreements and frameworks. For example, in the Netherlands, the 'National Prevention Agreement' (NPA) sets the goal of reaching a healthy food environment in all Dutch hospitals by 2030 [2]. Examples of improvements and efforts by hospitals are the introduction of varying menus in accordance with the Dutch Dietary Guidelines, high-protein snacks, and a-la-carte options to increase healthy food consumption, food quality, and liking.

Besides improving the health and palatability of their menus, hospitals have recently been focusing on sustainability and circular practices. The healthcare system is responsible for around 7.3% of the greenhouse gas emissions (GHGE) in the Netherlands[3]. Sustainability has therefore been integrated in agreements such as the 'Integral Care Agreement' (Integraal Zorgakkoord, IZA) and the 'Green Deal Duurzame Zorg', and addressed in the recent report of the Health Council of the Netherlands 'Verduurzaming van hulpmiddelen in de zorg' [4-6]. Nutrition in hospitals for patients, visitors, and staff, is one of the contributors to the environmental impact of the healthcare system. The diet-related environmental impact is mostly attributable to the consumption of animal-based foods[7, 8], with current plant/animal-based protein ratio consumption in the Netherlands being 40/60. For this reason, hospitals are transitioning towards offering more plant-based foods and less animal-based foods, the so-called protein transition[9]. Plant-based diets are a promising option to not only address sustainability, but also health, as inverse associations with mortality and non-communicable disease incidence (preventive health) have been shown[10]. However, less is known about the consequences of a transition to plant-based diets on recovery and health outcomes of patients admitted to hospitals. This is reflected in the 'Green Deal Duurzame Zorg', which aims at reaching a 60/40 ratio of plant/animal-based proteins by 2030 for food offered to staff and visitors, but advises healthcare providers to do what is possible from a medically responsible perspective for food offered to patients[5].

Dietary protein content and quality is key for better health outcomes for patients. For the average healthy adult, the current recommended dietary allowance (RDA) for protein is set at 0.83 g per kg of bodyweight per day. However, a significant amount of admitted patients (20-40%) are at increased risk of malnutrition[11]. Therefore, protein requirements for these patients are established at 1.2-1.5 gram/kg body weight. Since patients often have less appetite but need to eat more to reach the required protein intake, high-quality and protein-rich food products are provided. Even then most patients admitted to the hospital do not meet the protein requirements[12, 13]. Animal-based foods, which are of higher protein quality compared to plant-based foods, due to a higher digestibility and more complete amino acid profiles, conversely contribute more to environmental impact[7, 8, 14].

As much as the protein transition is crucial and relevant to tackle both health and sustainability aspects within hospitals, the question arises whether patients are able to meet protein requirements with a transition towards more plant-based protein, especially when taking protein quality into account. Performing research and monitoring the implications of the protein transition on health and sustainability aspects in hospitals is crucial to guarantee the health and recovery of the patient. For this reason, the alliance between Eindhoven University of Technology, Wageningen University & Research, Utrecht University, and University Medical Centre Utrecht (EWUU alliance) financed the seed-project described in this report, called 'Diets in Dutch Hospitals: setting the scene for healthy, planet-proof, affordable, and sustainable diets' (March 2023- March 2024). Three member hospitals (A, B, and C) of the national program 'A Taste of Excellent Healthcare' (Goede Zorg Proef Je), executed by the 'Nutrition & Healthcare Alliance' (Alliantie Voeding in de Zorg) participated in this project.

This project aimed at addressing the abovementioned question by setting the following aims:

1. to determine the nutritional (protein quantity and quality) and environmental impact of the current meals and foods offered in hospitals as a baseline for future research.
2. to bring together different stakeholders to discuss opportunities and challenges in creating a circular and environmentally sustainable food system in hospitals.

In order to achieve these aims, the following objectives were set:

<u>Objective 1:</u>

To gain more insight in the protein quantity and quality, as well as in the environmental impact of foods and meals are offered to the patients at hospitals A, B, and C. Furthermore, objective 1 was to study which relatively small changes to the current hospital menus can improve the protein quality.

<u>Objective 2:</u>

Besides providing healthy and nutritious foods with low environmental impact, a circular food system should additionally safeguard our natural resources, limit food loss and waste, use resources primarily for human consumption, and reuse food waste. Objective 2 was to create an overview of the stakeholders, their agency and interest in the food delivery system of the hospitals. Additionally, relevant aspects of circular food systems in hospitals were documented. These aspects include procurement strategies, prevention strategies for reducing food waste, and options for collecting and reusing food waste in the food system circular practices.

The team of this project included three EWUU Alliance partners and a wide expertise range, i.e. nutrition, disease, and health in a clinical setting (UMC Utrecht and Meander Medical Centre), expert center in nutrition & healthcare and network of healthcare professionals (Nutrition & Healthcare Alliance/Alliantie Voeding in de Zorg)[15], stakeholder analysis and food system integration (UU/Copernicus), and healthy and sustainable diets (WUR). This clinical setting project served as an ideal opportunity to start a collaboration between the different partners and synergize their expertise on sustainable diets and food system research. It bridges these different contexts and provides a unique opportunity where the results can be implemented into the daily practice of hospitals to improve health, sustainability, and circularity of the food delivery system.

After this project, there is a better understanding of the current protein quality and environmental impact of the hospital foods and meals, as well of which potential changes might have a significant improvement in protein quality of the meals. Secondly, we aim at understanding the opportunities and caveats for circular food systems in Dutch hospitals.

2. Methods

2.1. Current protein content and quality, and environmental impact

In order to address objective 1, the menus offered at hospitals A, B, and C to patients on a regular healthy diet (based on the Dutch Dietary Guidelines applicable to the general population) or patients following a protein and energy rich diet were analyzed. These two groups of patients were chosen since they cover around 70% of the patient population in hospitals. Hospitals change their menus on a regular basis, offering meals for each season of the year. In this project, the menus offered around the spring/summer period of 2023 were analyzed. This was the period in which the data collection and analysis took place.

<u>Data collection:</u>

Recipe data from all three hospitals were obtained. This included the recipes (ingredients and amounts) of all food products and meals available for the different menus offered. Other recipe specifications were obtained as well, such as portion sizes, product retail details and nutritional content information when needed, as well as preparation methods. Each hospital has different data sources/software systems and stores different types of information about the menus and diets. Therefore, the data had to be harmonized. Obtaining the data was performed with help from the dietitians and data managers of each hospital.

<u>Data harmonization:</u>

A separate database in Excel was created for each hospital in which all food products and meals offered at that hospital were included and categorized (by menu, meal moment, and product group), along with their recipe information such as portion size, ingredients (within a meal), and amount of each ingredient (g/mL within a meal portion). Recipe information usually provided the amounts of the ingredients within a meal needed to prepare 10 portions. Therefore, all ingredient amounts were recalculated to the amounts needed for 1 portion. In some cases, the sum of ingredient amounts within a meal (as provided by the hospital recipe information), did not coincide with the total portion size of that meal served to a patient (usually the sum was higher). This is due to the fact that amounts of individual ingredients refer to the (raw) products as bought from the retailers. While cooking, there is product loss, mostly water content loss. The original amounts of the ingredients bought by hospitals and needed for cooking a meal were used to calculate health and environmental impact later on in the analyses, as this truly reflects the environmental impact of that meal.

<u>Link to NEVO codes:</u>

Each individual ingredient or food product was linked to a corresponding Dutch Food Composition Table (NEVO) product and NEVO code. The NEVO 2016 was used for this [16]. This NEVO food composition table version was used, instead of other newer versions, since both the databases to calculate protein quality and environmental impact in this project are based on this version of the NEVO table. When a specific ingredient or food product did not have an exact corresponding NEVO product, the most comparable NEVO product in terms of nutritional content (with special attention to protein content) was chosen. Moreover, when choosing NEVO products within a cooked meal, the cooked/prepared version of a NEVO product was chosen instead of the raw version, when possible (note: all meat products were only present in the NEVO database in its raw form). This takes into account the potential production losses that take place when cooking and the fact that the original amounts of the ingredients (before cooking) were taken for analysis. We do not expect this to have an impact on health and nutritional content results, since production loss that occurs while cooking mostly accounts for water content loss and not nutrient loss.

Protein quantity and quality assessment:

The protein quantity and quality of the daily menu dinner meals in all three hospitals was calculated. These 'proposed' meals are typically composed of multiple components, such as a vegetable, a starch, and a protein component. These specific dinner meals (and not other meals or products offered) were calculated for the following reasons: 1) because these are, of all meals offered throughout the day, the meals that contribute the most to energy and protein intake, and 2) because these are the meals that are usually chosen the most by patients. Patients often choose a 'proposed' meal over ordering individual meal components to make their own dinner. Calculating protein quality for the proposed dinner meals lies closest to what patients choose and consume the most.

Protein quantity of dinner meals was calculated based on protein content. Portion sizes and energy (kcal) of dinner meals were calculated as well. For this, the NEVO food composition table 2016 was used. The menu and recipe database made for each hospital was linked to the NEVO 2016. The NEVO 2016 is based on data from the Dutch National Food Consumption Survey (DNFCS) 2012-2016, and contains nutritional content information of food products and ingredients per 100 g. The nutritional content of the food products and ingredients offered for the dinner meals in each hospital was calculated per portion of each dinner meal (in g).

To assess the protein quality of the dinner meals offered in each hospital, the amino acid composition database from WUR was used. This database is an extension of the NEVO table 2012-2016 and contains information on amino acid composition and digestibility (Appendix A) of products consumed in the DNFCS 2012-2016. Amino acid data is based on the Danish (Frida), American (USDA), English (Mccance and Widdowson), and Japanese food composition tables, since the NEVO does not have amino acid composition data [17].

Protein quality definition and calculations:

Protein quality

Protein quality is defined by international advisory bodies as the amount of essential amino acids (EAA) that are available for our body (after digestion) in relation to the requirement of these amino acids at a protein intake level corresponding to the protein intake recommendation[9].

Protein intake requirements (g/kg bodyweight) often are established on a daily level. However, protein quality should be calculated on a meal level since the amino acids from an ingested meal are only available for protein synthesis for a limited amount of time[18]. That is, protein quality cannot be estimated on a daily basis since it is not possible to add up all amino acids consumed over a day, as these will not be available throughout the whole day for protein synthesis. It is thus important to ensure that on a meal level the protein quality is high. Protein quality depends on two factors, namely digestibility, and amino acid composition[19]. Plant-proteins have a lower digestibility than animal proteins[20]. Amino acid composition is also usually more incomplete in plant-proteins compared to animal proteins[17, 21]. An important concept when talking about the amino acid composition which is crucial for the protein quality of a product or meal, is the limiting amino acid**.** The limiting amino acid is the essential amino acid which is present in the lowest amount (in relation to its requirement) in 1 g of protein of the product/meal. The limiting amino acid determines the amount of all the other amino acids present that can be used for protein synthesis. Therefore, it is important that a meal meets the requirements of all essential amino acids so that they can all be used by our body. Plant-proteins have a more incomplete amino acid profile (and therefore usually have limiting amino acids) compared to animal-proteins. To ensure that all amino acids meet their requirements, an option would be to increase the amount of protein in the meal in order to reach the requirements. Another option is to combine products that complement each other's amino acid profile, so that there is no limiting amino acid, and all amino acids can be used for protein synthesis. The latter option avoids increasing the amount of protein, and therefore the amount of energy and portion size of the meal.

PDCAAS and limiting amino acid calculation

The protein digestibility-corrected amino acid score (PDCAAS) of the dinner meals was calculated, and the limiting amino acid (if present) of the dinner meals was identified.[1]

The PDCAAS reflects the score (from 0 to 1) of 1 g of protein of the meal, and was calculated with the following formula:

$$PDCAAS = \min(AAS) * wPD$$

Where the amino acid score (AAS) reflects the amount of amino acid against its requirement (per 1 g of protein)[2], and wPD reflects the weighted protein digestibility of the meal.

Available and utilizable protein calculation

Besides establishing the PDCAAS and the limiting amino acid of the dinner meals, protein quality was assessed by calculating how much protein is available after correcting for digestibility (available protein), and then after taking into account the amino acid profile of the meal and potential limiting amino acids (utilizable protein). The amount of available protein tells you how much of the protein is digestible (stomach to blood absorption), whereas the amount of utilizable protein tells you how much of the protein can be taken up by the cells from the blood, and therefore 'utilized' by the body for protein synthesis.

Available protein was calculated by multiplying the amount of protein of a product within the meal by the digestibility factor corresponding to its food group, and afterwards summing up the amounts of available protein of each product within the meal. The digestibility factors that were used can be found in Appendix A.

Utilizable protein was calculated by multiplying the PDCAAS by the total amount of protein present in the meal.

Note: there are nine essential amino acids that our body cannot synthesize and thus must be obtained from our diet. These are: isoleucine, leucine, lysine, methionine, threonine, tryptophan, phenylalanine, valine, and histidine. Methionine and cysteine together are called the sulfur-containing amino acids (SAA), and tryptophan and phenylalanine together are the aromatic amino acids (AAA)[22].

<u>Protein intake criteria and guidelines in hospitals:</u>

The hospitals A, B, and C all use the Dutch Dietary Guidelines and the Wheel of Five as the basis to build the menus for patients who follow a regular healthy diet and for patients who follow a protein and energy rich diet[23]. Besides this, the protein intake recommendations for undernourished patients and for patients at risk of undernourishment are set at 1.2 to 1.5 g/kg bodyweight. Hospitals A, B, and C all design the assortment and menus for patients who need more protein and energy ensuring this recommendation is met throughout the day. Alongside meeting this recommendation, the hospitals also have criteria for the nutritional content of specific meals. For the dinner meals, all three hospitals aim to reach at least 20 g of protein per portion/meal[24, 25]. This criterion is based on national guidelines set for patients by for example the Dutch Association of Dietitians (Nederlandse Vereniging van Diëtisten, NVD) that state that at least 0.3 g of protein/kg bodyweight should be met per meal[11, 24]. This is to ensure adequate protein synthesis which is crucial for recovery.

<u>Environmental impact assessment:</u>

For the environmental impact, the different food products and ingredients were linked to the Environmental Impact of Foods database from the National Institute for Public Health and Environment (Rijksinstituut voor Volksgezondheid en Milieu, RIVM)[26, 27]. In this database greenhouse gas emission (GHGE), land use, blue water use, eutrophication of both salt and fresh water, and acidification potential are documented. This data is based on the life cycle of the product.

The Environmental Impact of Foods database does not contain information on all the NEVO products present in the NEVO food composition 2012-2016. For this reason, certain products and ingredients present in the hospital's menu were excluded. These were mostly herbs and spices. As these are usually present in very low quantities within the hospitals recipes and do not contribute substantially in terms of nutritional content, we do not expect that excluding these ingredients from the analysis has an major impact on the interpretation of the results.

The Environmental Impact of Foods database contains data on the different environmental impact indicators expressed per kg of food product. These amounts were recalculated to the amount of food product per portion. The environmental impact for dinner meals was calculated by adding the environmental impact of products within a meal for each indicator separately.

Calculations were performed using SAS 9.4 and R, and database preparation and visual output generation was performed with Excel.

2.1. Scenario analyses for improved protein quantity and quality

The second part of objective 1 included further analyzing the current menus of the hospitals to study which changes in the meals can result in a higher protein quality.

All dinner meals that fell below the criterion of 20 g per meal after correction for protein quality were analyzed with the Alpha-tool. The design of the Alpha tool was led by Wageningen University within the EU Project Alpha (Alternative Proteins for Healthy Ageing)[28]. This tool calculates the nutritional content and the protein quality of a meal, and based on smart algorithms will suggest alternatives to improve the protein quality of a meal. It will suggest adding additional plant-based ingredients to the recipe or changing ingredients in order to achieve a high protein quality. The tool suggests plant-based ingredients in order to take sustainability into account but does have the option of suggesting animal-based meals if wanted. The two dinner meals with the lowest score (based on the tool) from each hospital were selected to calculate alternatives and changes.

The Alpha-tool works with the same databases as the ones used in this project, namely the NEVO database 2016, and the amino acid composition extension database from WUR. It calculates a meal protein quality score (MPQS), that takes into account the digestibility and the amino acid profile of the meal and compares that against the required EAA intake on a meal level. Required EAA intake for a meal is calculated from a combination of the requirement of 0.3 g of protein per kg bodyweight, and WHO-established reference patterns for EAAs[22]. For the calculation of MPQS of recipes, an average of 70 kg bodyweight is taken, which translates into a requirement of 21 g of protein per meal. The MPQS score will thus not only reflect the protein quality of the meal but also the protein quantity.

2.2. Stakeholder analysis

Objective 2 was to create an overview of the stakeholders, their agency and interest in the food delivery system of the hospitals. Additionally, relevant aspects of circular food systems in hospitals were documented.

Firstly, an overview of the menus and the food system in each hospital was created. This was done by gathering information from the hospitals through interviews with stakeholders involved in the project from each hospital, and by visiting the hospitals. The visits to the hospitals included a tour of the kitchens and food delivery system, and it was possible to ask questions to those giving the tour (kitchen leader, manager, etc.). Information gathered through these tours and interviews was used to describe each hospital's food delivery system and available menus (see results section hospital description). This gives a better idea of all the steps taking place from food procurement and logistics, decision-making related to the menus and the food products offered, food ordering system for patients, and food delivery system to the patient. Furthermore, information was collected on food waste management and measures of circularity in each hospital.

Secondly, two hospitals (hospitals A, and B) were selected for further analysis (see results section stakeholder analysis). Interviews were conducted with all relevant stakeholders that have a role in the food delivery system of the hospital. This included structured interviews in both hospitals with the following actors: food suppliers, manager nutrition/food system team, kitchen leader and chef, kitchen administration member, leader of nutrition assistants and dietitians. Also, expert interviews were conducted with personnel of each hospital involved in the ‘Goede Zorg Proef Je’ project of the Nutrition & Healthcare Alliance, to understand the role and vision of the project in the transition towards more healthy and sustainable food in the hospitals[29]. The information gathered from the interviews was used to give an overview of the steps in the food delivery system (value chain map) and the actors involved. Furthermore, barriers and facilitators for the transition towards more healthy and sustainable foods were identified.

3. Results

3.1. Description of the hospitals and its menus

In the paragraphs below the different hospitals' food ordering system and menus are described. In Appendix B an overview of each hospital is provided, in which more detailed information is given on the type of menus each hospital has, how patients can order food, how long it takes for food to be served, etc.

3.1.1. Hospital A

<u>Menus and food ordering/delivery system for patients:</u>

Hospital A offers three different types of menu to their patients, namely the main menu, the seasonal daily menu (this was the spring menu during the period of data collection), and the protein rich snack menu. The first two are for patients who follow either a regular healthy diet or a protein and energy rich diet. The protein rich snacks menu is only available for those who need extra energy and protein as recommended by a physician.

- **Main menu:** this menu consists of individual food products that can be chosen by the patient throughout the whole day (from 7:00 to 18:15) to compose their own meal (e.g. breakfast or lunch). Furthermore, it contains meals and food products that can be ordered between 11:30 and 18:15, such as soups, sandwiches, salads, meat and vegetarian options, and vegetables. Patients can mix and match these products and meals to assemble their own meal. Products that are high in protein are indicated on the menu with a green thumb.
- **Seasonal (spring) daily menu:** this menu consists of a 'proposed' daily meal consisting of different meal components, namely a soup, an entrée salad, a main meal and either fruit or dairy dessert. The main meal consists of a protein component (with either an animal-based meat or fish option, or a vegetarian option), a starch component, a vegetable component, and a sauce/garnish. The daily menu can be ordered between 11:30 and 18:15 and changes every day from Monday to Sunday. In total there are seven daily meals during the spring season (return on a weekly basis). Besides the daily meals, the seasonal menu offers a week meal the patient can choose from instead of daily meal. Every week the week meal is different (returns on a monthly basis).
- **Protein rich snack menu:** these are protein and energy rich products. Some of them are enriched protein products. Patients who need more energy and protein are advised to take at least 3 of these snacks throughout the day.

Patients order their meals through the nutrition assistant or by calling the food call center. The food options offered to the patient are adjusted to the diet the patient follows. That is, a patient with a regular healthy diet will not be offered protein rich snacks for instance. Moreover, the food call center can see which dietary needs a patient has and can advise or nudge the patient into choosing meals and snacks that fit their needs. For instance, they can monitor how much protein the patient has consumed and nudge them to choose an extra protein rich snack if needed. After the kitchen closes (after 19:00), patients can always get a snack from the pantry if they are hungry.

Food procurement and logistics:

Hospital A works mainly with one big food supplier. In the hospital's main kitchen, the meals are prepared and cooked with raw products obtained from the suppliers. Vegetables and fruit are seasonal. Moreover, in hospital A pasta and rice are whole wheat products. Meals are cooked and served to the patient within 45 minutes. The meal service assistants bringing the food to the patients also help them with eating if required.

Food waste management and monitoring:

In May and June 2022 the food waste from the patients was assessed by measuring what patients did not eat and came back to the kitchens. This was done by taking pictures of the returned plates. Therefore, only indirect data is available, since returned meals were not weighed. Furthermore, food waste coming from cooking in the kitchen has been monitored in the past with Orbisk. The learnings obtained from this have been applied in practice. The data obtained from this device is used to estimate how much product has to be bought and prepared. Waste is disposed accordingly when plates come back from each division to the kitchen. Certain food products are re-used for meals that are cooked for the next days (e.g. leftover bread is used to make croutons).

3.1.2. Hospital B

Menus and food ordering/delivery system for patients:

In hospital B, patients can choose breakfast, a morning snack, lunch, and an afternoon snack directly from a food cart that comes by their room. Dinner has to be ordered via a tablet in the morning and is brought to the patient between 17:00 and 18:00. The meals and products offered for breakfast, lunch, morning and afternoon snacks are all suited for patients following a regular healthy diet and for patients following a protein and energy rich diet. For dinner, the menus differ slightly for patients following a healthy regular diet and for patients with a protein and energy rich diet. For patients with a protein and energy rich diet, there is an extra round of protein rich snacks and (warm) meals in the afternoon.

- **Food cart:** the nutrition assistant visits the patient several times a day with the food cart. In the morning for breakfast (with individual components that patients choose from to make their own breakfast), around 11:00 with soup options, and for lunch again (patients assemble their own lunch with products from the cart). Each patient has a personal tablet showing available food products which fit their personal diet prescription for each round. For the soup round at 11:00, patients are offered the soup of the day; for patients on an energy and protein enriched diet, the soup is enriched. In the morning between breakfast and lunch the food cart comes for a coffee and snack round, and in the afternoon it comes for a tea and snack round.

- **Dinner (spring) menu**: this menu consists of two 'proposed' dinner meals that contain a protein component, a starch component, and a vegetable component. One of the meal options always contains a vegetarian protein component, whereas the other meal varies from twice a week meat, twice a week chicken, once a week fish, and twice a week vegetarian for the protein component. The menu returns on a weekly basis (Monday to Sunday). Besides the proposed meals, patients can also make their own dinner by choosing individual products on the menu. At dinner the patient can choose one extra product to eat later that night (e.g. bag of nuts, protein bar, smoothie).

- **Protein rich (warm) meals and snacks**: patients with a protein and energy rich diet can order extra protein rich meals and snacks through the tablet in the afternoon. These meals are brought to them around 14:30. These meals and snacks include products such as a smoothie, a salad, or a wrap.

Patients order dinner and protein rich (warm) meals and snacks through a tablet. The food options a patient sees on their tablet are adjusted to the diet the patient follows. That is, a patient with a regular healthy diet will not see protein-rich snacks for instance.

Food procurement and logistics:

Hospital B works with three main food suppliers, from which they obtain raw materials to cook the meals with. Hospital B mostly works with seasonal vegetables and fruits. Moreover, hospital B cooks with whole wheat products (pasta and rice). Meals are cooked in the hospital's main kitchen a day before serving, cooled down, and warmed up the next day before serving to the patients.

Food waste management and monitoring:

Three times a year during a whole week the following waste is measured: the soup that comes back from each hospital unit (by weighing the amounts of soup returned), the disposables that are returned untouched, and the amounts of dinner meals that have not been eaten by the patient (by weighing the amounts of product returned). Furthermore, the food waste coming from cooking in the kitchen is monitored with Orbisk. The data obtained from this is used to estimate how much product has to be bought and prepared. Food waste from patient meals is disposed accordingly when plates come back from each division to the kitchen. Certain food products are re-used for employee restaurant meals that are served the next day (e.g. vegetables to make soup, or bread for croutons).

3.1.3. Hospital C

Menus and food ordering/delivery system for patients:

Hospital C works with two different food concepts, namely the 'a la carte' menu, and the 'tasting' menu. Both are suited for patients who follow a protein and energy rich diet and offer mostly the same meals. The two concepts differ in the number of meal moments. The 'a la carte' menu offers three meal moments (breakfast, lunch, and dinner), whereas the 'tasting' menu offers six meal moments (breakfast, a morning snack, lunch, an afternoon snack, dinner, and an evening snack). Whether a patient can order from the 'a la carte' menu or from the 'tasting' menu is decided on a hospital unit level. Each hospital unit will work with either the 'a la carte' or the 'tasting' food concept depending on the characteristics of the patients admitted to the hospital unit.

- **'A la carte' menu:** this menu offers proposed breakfast, lunch, and dinner options. Every day the menu offers different meal recipes that come back after 6 days (6-day cycle). Every day, there are three breakfast meals and three lunch meals to choose from. Moreover, the menu contains extra individual components that can be ordered on the side at breakfast and lunch (e.g. bread, spreads, dairy components, and fruit). Breakfast must be ordered the day before and is served between 7:30 and 9:00, and lunch must be ordered before 11:00, and is served between 12:00 and 13:00. For dinner, patients can choose between six different proposed meals. These proposed dinner meals always consist of three main components: a protein component (80 g), a starch component (150 g), and a vegetable component (150 g). Sometimes there is also a sauce/garnish component (30 g). Within the six proposed dinner meals, there is always one fish, one meat, one chicken, and two vegetarian options to choose from for the protein component. The menu also offers four desserts patients can choose from for dinner. Dinner must be ordered before 16:30 and is served between 17:00 and 19:00. Patients order breakfast, lunch, and dinner through the food assistants, who transfer the orders of the entire unit to the kitchen. Besides breakfast, lunch, and dinner, patients who need extra protein intake can choose some mid-day protein rich snacks from the 'tapas' menu.
- **'Tasting' menu:** this menu also offers proposed breakfast, lunch, and dinner options. Every day the menu offers different meal recipes that come back after 6 days (6-day cycle). The difference with the a la carte menu is that the portions for breakfast, lunch, and dinner are smaller, and that patients also get a mid-morning snack, an afternoon snack, and an evening snack (6 meal moments in total). There are five dinner meals to choose from, all containing three main components: the protein component (80 g), the starch component (90 g), and the vegetable component (90 g). Sometimes there is also a sauce/garnish component (30 g). For the protein component, there is always a fish option, a meat option, a chicken option, and two vegetarian options to choose from. Instead of ordering the meals beforehand as with the a la carte menu, for the tasting menu patients choose a meal in the moment directly from a cart brought to their room with all the little dishes.

<u>Food procurement and logistics:</u>

Hospital C works with one main food supplier. Products are prepared by the supplier and meals are constructed in the hospital's main kitchen. From there, meals are warmed up and brought to the different hospital units and its patients. Hospital C cooks with whole wheat products (pasta and rice).

<u>Food waste management and monitoring:</u>

Every last week of the month, all products that come back from the patients are noted down. Based on this data, the kitchen can make an estimation of how often certain meals are ordered and can order and prepare products accordingly in the future. Waste is disposed accordingly when plates come back from each division to the kitchen.

3.2. Current protein content and quality, and environmental impact

3.2.1. Hospital A

In this section the nutritional quality, including protein content and quality, and environmental impact of the main meals offered at hospital A are described. The main meals are part of the menus offered in the daily (spring) menu and can be ordered throughout the whole day. However, these are mostly chosen for dinner. Every day of the week the menu is different (from Monday to Sunday) and returns on a weekly basis. The main meal consists of a protein component, a starch component, and a vegetable component. A patient can choose for either a meat/fish protein component (animal protein-based meal), or for a vegetarian protein component (vegetarian meal). The other components (starch and vegetable) are the same for the animal protein-based meal and the vegetarian meal.

<u>Protein content and quality dinner meals hospital A:</u>

Monday

On Monday the animal protein-based dinner offered pork as the protein component, and the vegetarian dinner offered a vegetarian meatball. Additionally, the meal was composed of endive with bechamel as the vegetable component, cooked potatoes as the starch component, and gravy on top.

Monday

Animal protein-based
Pork steak
Gravy
Endive with bechamel sauce
Cooked potatoes

Vegetarian
Vegetarian meatball
Gravy
Endive with bechamel sauce
Cooked potatoes

Both the animal protein-based dinner and the vegetarian dinner weighed 400 g, containing around 437 kcal (Table 1). The animal protein-based meal contained 30 g of protein in total, of which 24 g were animal-based, and 6 g were plant-based. After correction for digestibility, available protein was 26 g. There were no limiting amino acids in the animal protein-based meal and the PDCAAS was 0.88. Utilizable protein was equal to available protein, namely 26 g. The vegetarian meal had 26 g of protein in total, of which 5 g were animal-based, and 21 g were plant-based. After correction for digestibility, available protein was 23 g. The vegetarian meal did not have limiting amino acids, and the PDCAAS was 0.87. Utilizable protein was equal to available protein, namely 23 g. Both the animal protein-based meal and the vegetarian meal met the criterion of 20 g protein per meal, before and after correcting for digestibility (Figure 1).

Table 1: Nutritional content and protein quality information of dinner meals offered at Hospital A on Monday

	Portion size (g)	*Energy (kcal)*	*Total protein (g)*	*Animal protein (g)*	*Plant protein (g)*	*Available protein (g)*	*Utilizable protein (g)*	*PDCAAS*	*Limiting amino acids*
Animal protein-based	400	437	29.6	23.5	6.1	26.2	26.2	0.88	None
Vegetarian	400	436	26.0	5.3	20.7	22.6	22.6	0.87	None

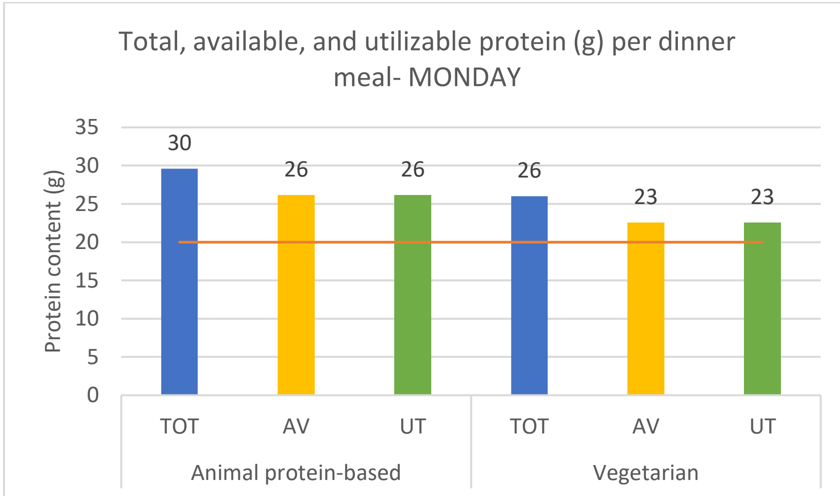

Figure 1: Protein content (g) of each dinner meal offered at Hospital A on Monday, uncorrected (total protein TOT), corrected for digestibility (available AV), and corrected for digestibility and amino acid profile (utilizable UT). The orange line indicates the threshold of the criterion of 20 g protein per meal.

Tuesday

On Tuesday the animal protein-based dinner offered mackerel fish as the protein component, and the vegetarian dinner offered a vegetable quiche as the protein component. Additionally, the meal was composed of a bean trio as the vegetable component, risotto as the starch component, and dill sauce on top.

The animal protein-based meal weighed 480 g and contained 726 kcal (Table 2). It contained 32 g of protein in total, of which 22 g were animal-based, and 10 g were plant-based. After correction for digestibility, available protein was 27 g. There were no limiting amino acids in the animal protein-based meal and the PDCAAS was 0.84. Utilizable protein was equal to available protein, namely 27 g. The vegetarian meal weighed 525 g and had 773 kcal. It contained 27 g of protein in total, of which 12 g were animal-based, and 15 g were plant-based. After correction for digestibility, available protein was 21.50 g. The vegetarian meal did not have limiting amino acids, and the PDCAAS was 0.81. Utilizable protein was equal to available protein, namely 21.50 g. Both the animal protein-based meal and the vegetarian meal met the criterion of 20 g protein per meal, before and after correcting for digestibility (Figure 2).

Tuesday

Animal protein-based
Mackerel fish
Dill sauce
Bean trio
Risotto

Vegetarian
Quiche
Dill sauce
Bean trio
Risotto

Table 2: Nutritional content and protein quality information of dinner meals offered at Hospital A on Tuesday

	Portion size (g)	*Energy (kcal)*	*Total protein (g)*	*Animal protein (g)*	*Plant protein (g)*	*Available protein (g)*	*Utilizable protein (g)*	*PDCAAS*	*Limiting amino acids*
Animal protein-based	480	726	31.9	22.0	9.8	26.6	26.6	0.84	None
Vegetarian	525	773	26.7	11.4	15.3	21.5	21.5	0.81	None

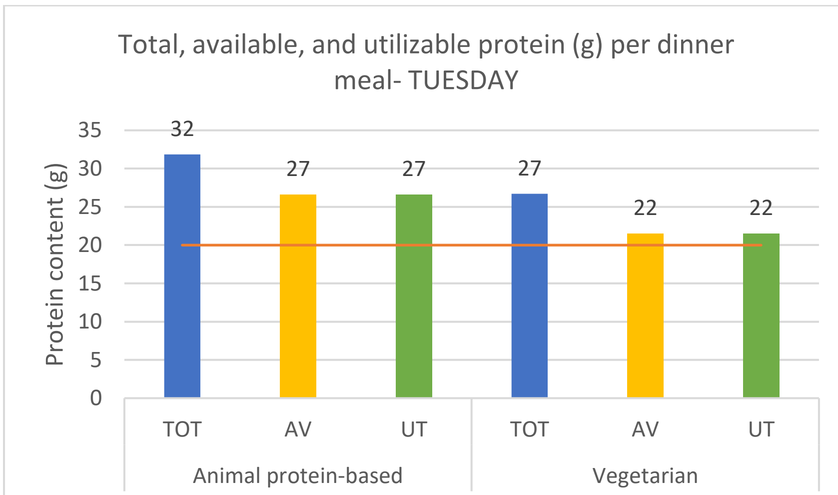

Figure 2: Protein content (g) of each dinner meal offered at Hospital A on Tuesday, uncorrected (total protein TOT), corrected for digestibility (available AV), and corrected for digestibility and amino acid profile (utilizable UT). The orange line indicates the threshold of the criterion of 20 g protein per meal.

Wednesday

On Wednesday the animal protein-based dinner offered beef goulash as the protein component, and the vegetarian dinner offered filled bell pepper (with vegetables) as the protein component. Additionally, the meal was composed of peas as the vegetable component, and mashed potato as the starch component.

The animal protein-based meal weighed 450 g and contained 435 kcal (Table 3). It contained 35 g of protein in total, of which 23 g were animal-based, and 12 g were plant-based. After correction for digestibility, available protein was 29 g. There were no limiting amino acids in the animal protein-based meal and the PDCAAS was 0.83. Utilizable protein was equal to available protein, namely 29 g. The animal protein-based meal met the criterion of 20 g protein per meal, both before and after

Wednesday

Animal protein-based
Goulash
Peas
Mashed potato

Vegetarian
Filled paprika
Peas
Mashed potato

correcting for digestibility (Figure 3). The vegetarian meal was a portion of 400 g and provided 431 kcal (Table 3). It contained 24 g of protein in total, of which 8 g were animal-based, and 16 g were plant-based. The total (crude) amount of protein in the vegetarian meal reached the criterion of 20 g of protein per meal (Figure 3). After correction for digestibility, available protein was 17 g, which was lower than the criterion of 20 g per meal. The vegetarian meal had limiting amino acids, which were the sulfur-containing amino acids (methionine and cysteine combined) (Table 3). The PDCAAS of the meal was 0.54. Utilizable protein was 13 g, which was lower than available protein, and fell below the criterion of 20 g of protein per meal (Figure 3).

Table 3: Nutritional content and protein quality information of dinner meals offered at Hospital A on Wednesday

	Portion size (g)	*Energy (kcal)*	*Total protein (g)*	*Animal protein (g)*	*Plant protein (g)*	*Available protein (g)*	*Utilizable protein (g)*	*PDCAAS*	*Limiting amino acids*
Animal protein-based	450	435	35.3	23.0	12.3	29.4	29.4	0.83	None
Vegetarian	400	431	23.6	7.9	15.7	17.0	12.8	0.54	SAA

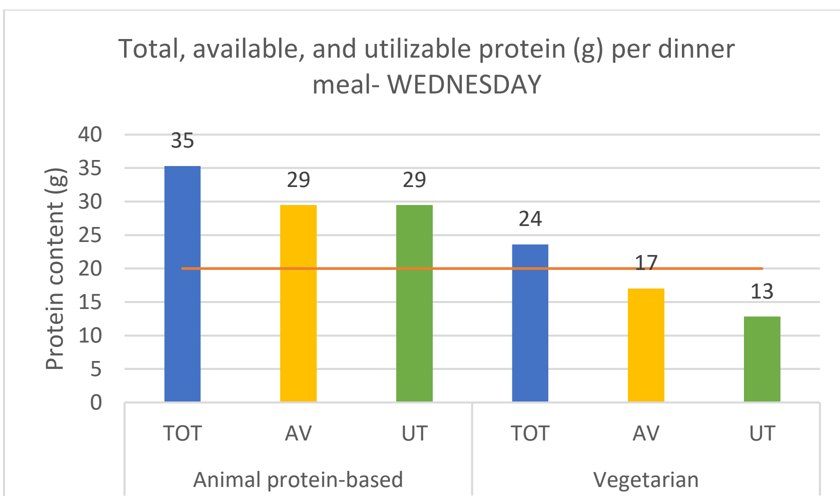

Figure 3: Protein content (g) of each dinner meal offered at Hospital A on Wednesday, uncorrected (total protein TOT), corrected for digestibility (available AV), and corrected for digestibility and amino acid profile (utilizable UT). The orange line indicates the threshold of the criterion of 20 g protein per meal.

Thursday

> **Thursday**
>
> **Animal protein-based**
> Asian stew
>
> **Vegetarian**
> Asian stew vegetarian

On Thursday the animal protein-based dinner offered Asian beef stew, and the vegetarian dinner offered an Asian vegetable stew.

Both the animal protein-based meal and the vegetarian meal weighed 350 g, but the animal protein-based meal provided 366 kcal, while the vegetarian meal provided 425 kcal (Table 4). The animal protein-based meal contained 25 g of protein in total, of which 19 g were animal-based, and 6 g were plant-based. After correction for digestibility, available protein was 22 g. There were no limiting amino acids in the animal protein-based meal and the PDCAAS was 0.88. Utilizable protein was equal to available protein, namely 22 g. The animal protein-based meal met the criterion of 20 g protein per meal, both before and after correcting for digestibility (Figure 4). The vegetarian meal contained 22 g of protein in total, of which 2 g were animal-based, and 20 g were plant-based (Table 4). After correction for digestibility, available protein was 19 g. The vegetarian meal had no limiting amino acids and had a PDCAAS of the meal was 0.97. Utilizable protein was therefore equal to available protein (19 g). The vegetarian meal contained more than 20 g in total but fell below the criterion of 20 g per meal when correcting for digestibility (Figure 4).

Table 4: Nutritional content and protein quality information of dinner meals offered at Hospital A on Thursday

	Portion size (g)	*Energy (kcal)*	*Total protein (g)*	*Animal protein (g)*	*Plant protein (g)*	*Available protein (g)*	*Utilizable protein (g)*	*PDCAAS*	*Limiting amino acids*
Animal protein-based	350	366	24.5	18.8	5.7	21.7	21.7	0.88	None
Vegetarian	350	425	21.8	1.53	20.3	18.9	18.9	0.87	None

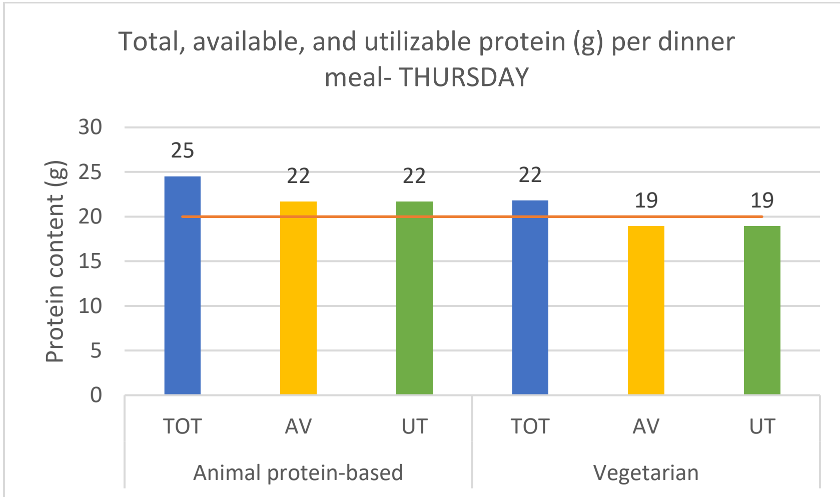

Figure 4: Protein content (g) of each dinner meal offered at Hospital A on Thursday, uncorrected (total protein TOT), corrected for digestibility (available AV), and corrected for digestibility and amino acid profile (utilizable UT). The orange line indicates the threshold of the criterion of 20 g protein per meal.

Friday

On Friday the animal protein-based dinner offered redfish as the protein component, and the vegetarian dinner offered a cheese omelet as the protein component. Additionally, the meal was composed of carrots with snow peas as the vegetable component, fried potatoes as the starch component, and lemon sauce on top.

Friday

Animal protein-based
Redfish fillet
Lemon sauce
Carrots with snow peas
Fried potatoes

Vegetarian
Cheese omelet
Lemon sauce
Carrots with snow peas
Fried potatoes

The animal protein-based meal weighed 395 g, and provided 394 kcal (Table 5). It contained 29 g of protein in total, of which 25 g were animal-based, and 4 g were plant-based. After correction for digestibility, available protein was 24 g. There were no limiting amino acids in the animal protein-based meal and the PDCAAS was 0.84. Utilizable protein was equal to available protein, namely 24 g. The animal protein-based meal met the criterion of 20 g protein per meal, both before and after correcting for digestibility (Figure 5). The vegetarian meal was a portion of 435 g and provided 441 kcal. It contained 20 g of protein in total, of which 16 g were animal-based, and 4 g were plant-based (Table 5). After correction for digestibility, available protein was 18g. The vegetarian meal had no limiting amino acids and had a PDCAAS of the meal was 0.87. Utilizable protein was therefore also 18 g. The vegetarian meal contained more than 20 g in total, but fell below the criterion of 20 g per meal when correcting for digestibility (Figure 5).

Table 5: Nutritional content and protein quality information of dinner meals offered at Hospital A on Friday

	Portion size (g)	Energy (kcal)	Total protein (g)	Animal protein (g)	Plant protein (g)	Available protein (g)	Utilizable protein (g)	PDCAAS	Limiting amino acids
Animal protein-based	395	394	28.9	24.6	4.3	24.3	24.3	0.84	None
Vegetarian	435	441	20.6	16.4	4.2	18.0	18.0	0.87	None

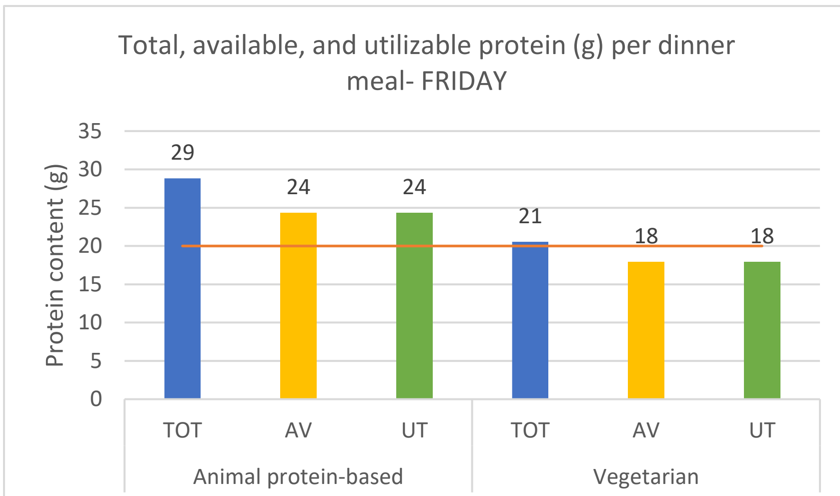

Figure 5: Protein content (g) of each dinner meal offered at Hospital A on Friday, uncorrected (total protein TOT), corrected for digestibility (available AV), and corrected for digestibility and amino acid profile (utilizable UT). The orange line indicates the threshold of the criterion of 20 g protein per meal.

Saturday

On Saturday the animal protein-based dinner offered beef as the protein component, and the vegetarian dinner offered chickpea sausage as the protein component. Additionally, the meal was composed of beetroot with onion as the vegetable component, mashed potato as the starch component, and gravy on top.

The animal protein-based meal weighed 400 g, and contained 347 kcal (Table 6). It contained 26 g of protein in total, of which 22 g were animal-based, and 4 g were plant-based. After correction for digestibility, available protein was 23 g. There were no limiting amino acids in the animal protein-based meal and the PDCAAS was 0.90. Utilizable protein was equal to available protein, namely 23 g. The animal protein-based meal met the criterion of 20 g protein per meal, both before and after correcting for digestibility (Figure 6). The vegetarian meal

Saturday

Animal protein-based
Beef steak
Gravy
Beetroot with onion
Mashed potato

Vegetarian
Chickpea sausage
Gravy
Beetroot with onion
Mashed potato

weighed 450 g and provided 454 kcal (Table 6). It contained 12 g of protein in total, of which 3 g were animal-based, and 9 g were plant-based. After correction for digestibility, available protein was 9 g. The vegetarian meal had limiting amino acids, which was lysine. The PDCAAS of the meal was 0.57. Utilizable protein was 7 g. The vegetarian meal fell below the criterion of 20 g per meal both before and after correcting for digestibility and amino acid profile (Figure 6).

Table 6: Nutritional content and protein quality information of dinner meals offered at Hospital A on Saturday

	Portion size (g)	*Energy (kcal)*	*Total protein (g)*	*Animal protein (g)*	*Plant protein (g)*	*Available protein (g)*	*Utilizable protein (g)*	*PDCAAS*	*Limiting amino acids*
Animal protein-based	400	347	25.9	22.2	3.7	23.2	23.2	0.90	None
Vegetarian	450	454	12.2	3.1	9.1	9.0	7.0	0.57	Lysine

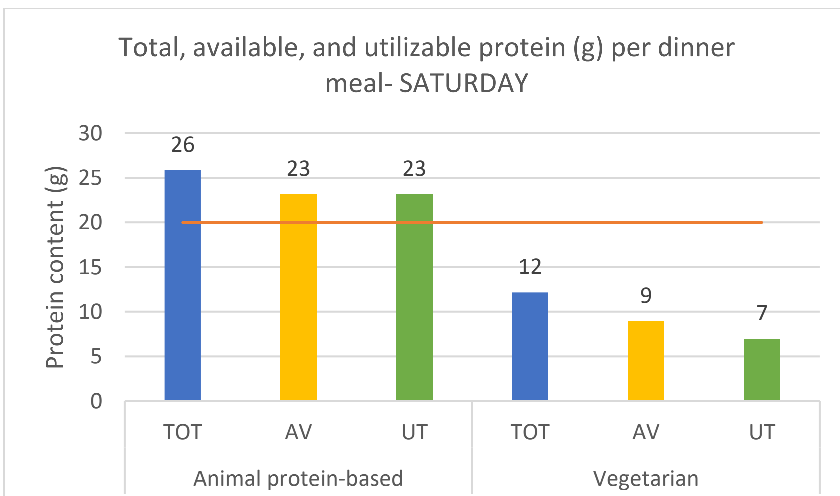

Figure 6: Protein content (g) of each dinner meal offered at Hospital A on Saturday, uncorrected (total protein TOT), corrected for digestibility (available AV), and corrected for digestibility and amino acid profile (utilizable UT). The orange line indicates the threshold of the criterion of 20 g protein per meal.

Sunday

On Sunday the animal protein-based dinner offered chicken as the protein component, and the vegetarian dinner offered mushroom ragout as the protein component. Additionally, the meal was composed of a bean mix as the vegetable component, fried potatoes as the starch component, and gravy on top.

Sunday

Animal protein-based
Chicken cordon bleu
Gravy
Bean mix
Fried potatoes

Vegetarian
Mushroom ragout
Gravy
Bean mix
Fried potatoes

The animal protein-based meal weighed 410 g, and contained 380 kcal (Table 7). It contained 28 g of protein in total, of which 21 g were animal-based, and 7 g were plant-based. After correction for digestibility, available protein was 25 g. There were no limiting amino acids in the animal protein-based meal and the PDCAAS was 0.88. Utilizable protein was equal to available protein, namely 25 g. The animal protein-based meal met the criterion of 20 g protein per meal, both before and after correcting for digestibility (Figure 7). The vegetarian meal weighed 450 g and provided 506 kcal (Table 7). It contained 17 g of protein in total, of which 3 g were animal-based, and 14 g were plant-based. After correction for digestibility, available protein was 14 g. There were no limiting amino acids and the PDCAAS was 0.81. Utilizable protein was equal to available protein, namely 14 g. The vegetarian meal fell below the criterion of 20 g per meal both before and after correcting for digestibility (Figure 7).

Table 7: Nutritional content and protein quality information of dinner meals offered at Hospital A on Sunday

	Portion size (g)	*Energy (kcal)*	*Total protein (g)*	*Animal protein (g)*	*Plant protein (g)*	*Available protein (g)*	*Utilizable protein (g)*	*PDCAAS*	*Limiting amino acids*
Animal protein-based	410	380	27.9	21.3	6.6	24.7	24.7	0.88	None
Vegetarian	450	506	17.2	3.1	14.1	13.9	13.9	0.81	None

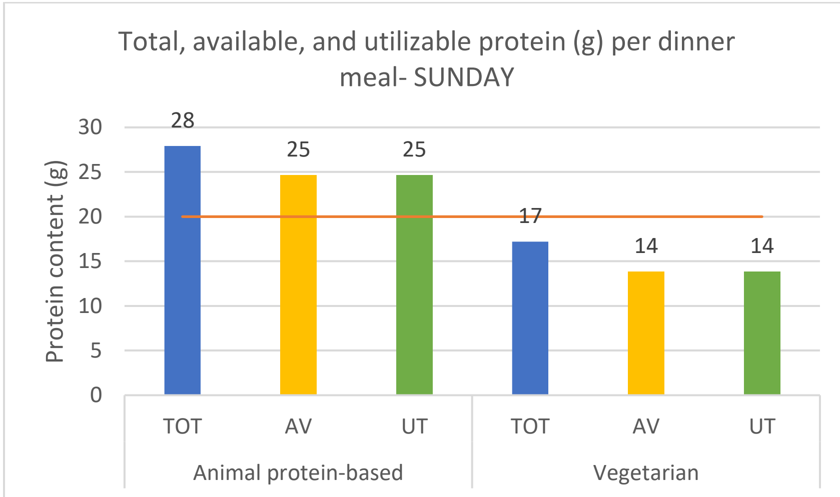

Figure 7: Protein content (g) of each dinner meal offered at Hospital A on Sunday, uncorrected (total protein TOT), corrected for digestibility (available AV), and corrected for digestibility and amino acid profile (utilizable UT). The orange line indicates the threshold of the criterion of 20 g protein per meal.

<u>Environmental impact dinner meals hospital A:</u>

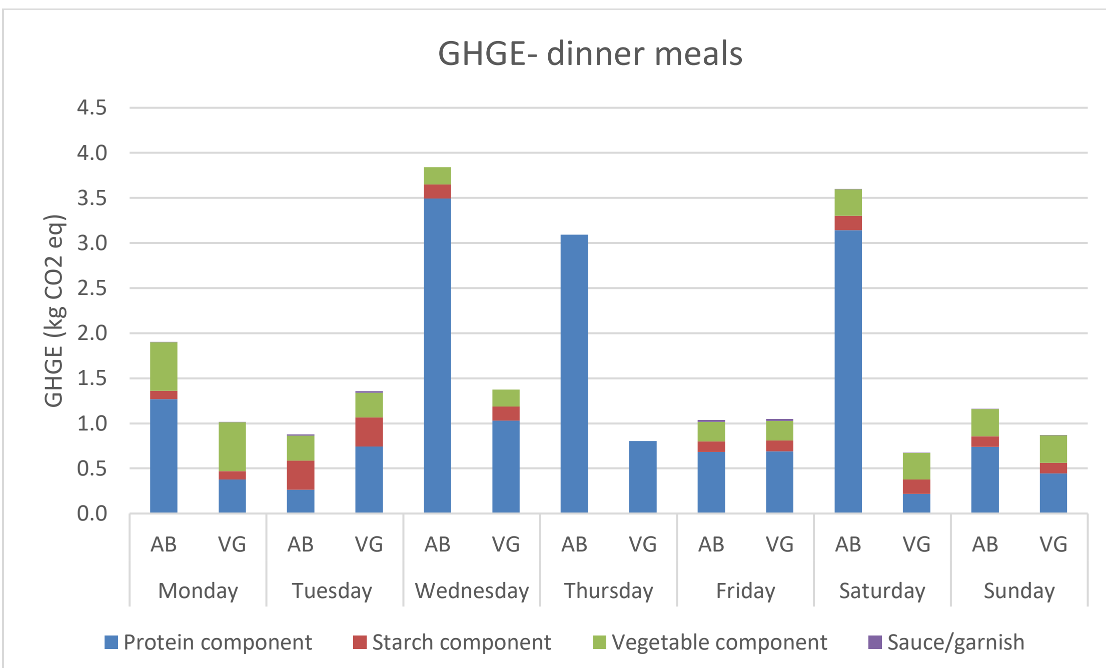

Figure 8: GHG emissions (kg CO2 eq) per dinner meal (animal protein-based AB or vegetarian VG) offered at Hospital A

Figure 8 shows the GHGE of all the animal protein-based and vegetarian dinner meals offered at hospital A from Monday to Sunday, and the breakdown of GHGE per component within a meal (protein, starch, vegetable, or sauce component).

On all days except on Tuesday and Friday, the animal protein-based meal had a higher GHGE than the vegetarian meal. These were all days where the animal protein-based meal offered meat as a protein component, whereas on Tuesday and Friday the protein component was fish. On Tuesday the GHGE of the animal protein-based meal was lower than the GHGE of the vegetarian option (where the protein component is vegetable quiche), whereas on Friday the GHGE of the animal protein-based meal was similar to the GHGE of the vegetarian meal (where the protein component is cheese omelet). In general, it can be observed that the component contributing the most to GHGE in both the animal protein-based and the vegetarian meals was the protein component, followed by the vegetable component, and then by the starch component. The highest GHGE was observed for the animal protein-based meals on Wednesday (3.8 kg CO2 eq), Thursday (3.1 kg CO2 eq), and on Saturday (3.6 kg CO2 eq) (Table 8). GHGE was mostly attributable to the protein component, which in all three cases was composed of beef.

In Table 8 the environmental impact of GHGE, land use, acidification, fresh water eutrophication, marine water eutrophication, and blue water use of the animal protein-based and vegetarian meals offered from Monday and Sunday are shown. All environmental indicators, except blue water use, were higher for the meals where meat was the protein component compared to the vegetarian meals. The meals that had fish as the protein component (on Tuesday and Friday) showed a lower GHGE, land use, acidification, and fresh and marine water eutrophication compared to the vegetarian meals. Blue water use was higher for the animal protein-based meals compared to the vegetarian meals, except on Tuesday, Friday, and Saturday, when it was lower. The animal protein-based meal on Tuesday and Friday offered fish as the protein component, and on Saturday beef, whereas the vegetarian meal on Tuesday offered quiche, on Friday cheese omelet, and on Saturday chickpea sausage. The higher blue water use in the vegetarian meal on Saturday was mostly due to the chickpea sausage.

Table 8: Environmental impact (GHG emissions, land use, blue water use, acidification potential, and fresh and marine water eutrophication) of each dinner meal offered at Hospital A

Day	*Dinner meal option*	*GHGE (kg CO2 eq)*	*Land use (m2a)*	*Blue water use (L)*	*Acidification (kg SO2)*	*Fresh water eutrophication (kg P eq)*	*Marine water eutrophication (kg N eq)*
Monday	Animal protein-based (meat)	1.90	1.42	25.7	1.77e-2	1.79e-4	2.68e-3
	Vegetarian	1.02	0.56	17.6	5.34e-3	8.36e-5	1.17e-3
Tuesday	Animal protein-based (fish)	0.88	0.59	70.7	5.40e-3	9.44e-5	1.16e-3
	Vegetarian	1.36	1.05	90.3	1.16e-2	1.46e-4	1.90e-3
Wednesday	Animal protein-	3.84	1.85	45.0	5.72e-2	1.78e-4	9.54e-3

	based (meat)						
	Vegetarian	1.38	0.59	27.8	8.68e-3	1.11e-4	1.46e-3
Thursday	Animal protein-based (meat)	3.09	1.57	35.7	4.86e-2	1.51e-4	8.38e-3
	Vegetarian	0.81	0.54	22.5	3.68e-3	6.57e-5	8.25e-4
Friday	Animal protein-based (fish)	1.04	0.31	14.2	3.67e-3	5.30e-5	5.83e-4
	Vegetarian	1.05	0.75	20.8	1.12e-2	8.87e-5	1.51e-3
Saturday	Animal protein-based (meat)	3.60	1.72	40.3	5.65e-2	1.52e-4	9.47e-3
	Vegetarian	0.67	0.48	105.7	4.45e-3	6.17e-5	1.04e-3
Sunday	Animal protein-based (meat)	1.16	0.95	26.1	7.63e-3	1.14e-4	1.22e-3
	Vegetarian	0.87	0.55	20.2	4.21e-3	7.62e-5	9.13e-4

3.2.2. Hospital B

In this section the nutritional quality, including protein content and quality, and environmental impact of the dinner meals offered to patients following a protein and energy rich diet at hospital B are described. Every day of the week the menu is different (from Monday to Sunday), and returns on a weekly basis. A patient can normally choose for either a dinner option with meat or fish as the protein component (animal protein-based meal) or a vegetarian dinner meal. However, on Monday and Saturday the two dinner options offered were both vegetarian. All dinner meals are excluding dessert, which can be chosen separately. Besides the protein component, dinner meals include a starch component, and a vegetable component. The dinner meals offered to patients following a protein and energy rich diet were chosen to be described in the results sections as these do not differ substantially from those offered to patients on a regular diet. Only on Tuesday and Sunday the animal protein-based meal has an extra ingredient for those following a protein and energy rich diet. The difference in the animal protein-based meals with these ingredients (for patients with a protein and energy rich diet) or without (for patients with a regular healthy diet) is minimal in terms of protein and energy content.

Protein content and quality dinner meals hospital B:

Monday

On Monday the both dinner options offered were vegetarian. The first one offered shakshuka with fried egg, and the second offered a vegetarian sausage.

Monday

Vegetarian (1)
Shakshuka, fried egg, nut rice, and tzatziki

Vegetarian (2)
Vegetarian sausage, rucola tomato mash, lentil salad, and gravy

The shakshuka vegetarian dinner weighed 335 g and contained 485 kcal (Table 9). It contained 21 g of protein in total, of which 7 g were animal-based, and 14 g were plant-based. The total amount of protein in the meal fell above the criterion of 20 g protein per meal (Figure 9). After correction for digestibility however, available protein was 16 g, falling below the criterion of 20 g protein per meal. The meal had a limiting amino acid (lysine) and the PDCAAS was 0.77. Utilizable protein was therefore lower than available protein, namely 14 g. The vegetarian sausage dinner weighed 555 g with 821 kcal (Table 9). It had 19 g of protein in total, of which 1 g was animal-based, and 18 g were plant-based. After correction for digestibility, available protein was 15 g. The meal had a limiting amino acid (lysine) and the PDCAAS was 0.67. Utilizable protein was 14 g. The vegetarian meal fell below the criterion of 20 g per meal both before and after correcting for digestibility (Figure 9).

Table 9: Nutritional content and protein quality information of dinner meals offered at Hospital B on Monday

Meal option	*Portion size (g)*	*Energy (kcal)*	*Total protein (g)*	*Animal protein (g)*	*Plant protein (g)*	*Available protein (g)*	*Utilizable protein (g)*	*PDCAAS*	*Limiting amino acids*
Vegetarian (1)	335	485	20.9	7.0	13.9	15.8	14.0	0.77	Lysine
Vegetarian (2)	555	821	19.2	1.2	17.9	14.8	13.8	0.67	Lysine

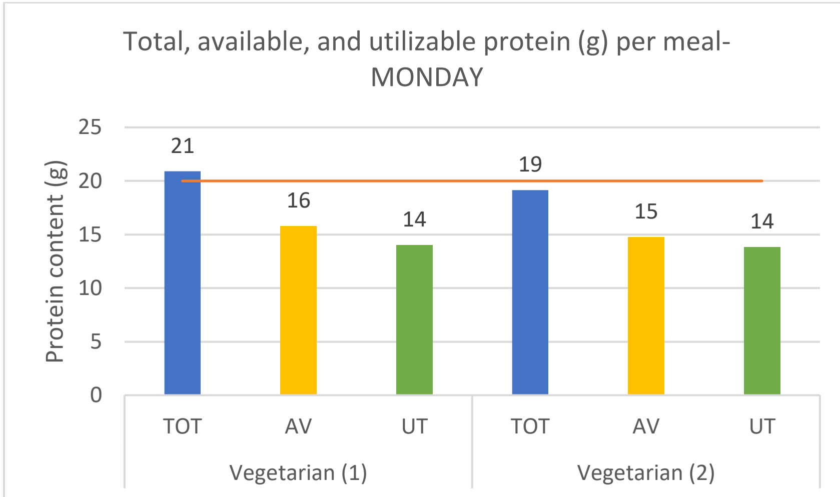

Figure 9: Protein content (g) of each dinner meal offered at Hospital B on Monday, uncorrected (total protein TOT), corrected for digestibility (available AV), and corrected for digestibility and amino acid profile (utilizable UT). The orange line indicates the threshold of the criterion of 20 g protein per meal.

Tuesday

On Tuesday the animal protein-based dinner offered beef as the protein component, and the vegetarian dinner offered beans as the protein component. The vegetable and starch components were different for the animal protein-based dinner and the vegetarian dinner.

> **Tuesday**
>
> **Animal protein-based**
> Beef stew with broccoli, mashed potato, and gravy
>
> **Vegetarian**
> Beans, vegetables, mushrooms, and rice

The animal protein-based dinner weighed 380 g and had 390 kcal (Table 10). It contained 25 g of protein in total, of which 17 g were animal-based, and 8 g were plant-based. After correction for digestibility, available protein was 21 g. The meal had no limiting amino acid and the PDCAAS was 0.83. Utilizable protein was 21 g. The animal protein-based meal fell above the criterion of 20 g of protein per meal, both before and after correcting for digestibility (Figure 10). The vegetarian dinner was a portion of 425 g with 567 kcal (Table 10). It had 22 g of protein in total, all of which were plant-based. This fell above the criterion of 20 g of protein per meal (Figure 10). However, after correction for digestibility, available protein was 15 g. The meal had a limiting amino acid, namely the sulfur-containing amino acids (methionine and cysteine combined) and the

PDCAAS was 0.58. Utilizable protein was therefore lower than available protein, namely 12.5 g. This fell below the criterion of 20 g per meal after correcting for digestibility (Figure 10).

Table 10: Nutritional content and protein quality information of dinner meals offered at Hospital B on Tuesday

Meal option	Portion size (g)	Energy (kcal)	Total protein (g)	Animal protein (g)	Plant protein (g)	Available protein (g)	Utilizable protein (g)	PDCAAS	Limiting amino acids
Animal protein-based	380	389	25.6	17.3	8.3	21.2	21.2	0.83	None
Vegetarian	425	567	21.6	0.09	21.5	15.1	12.5	0.58	SAA

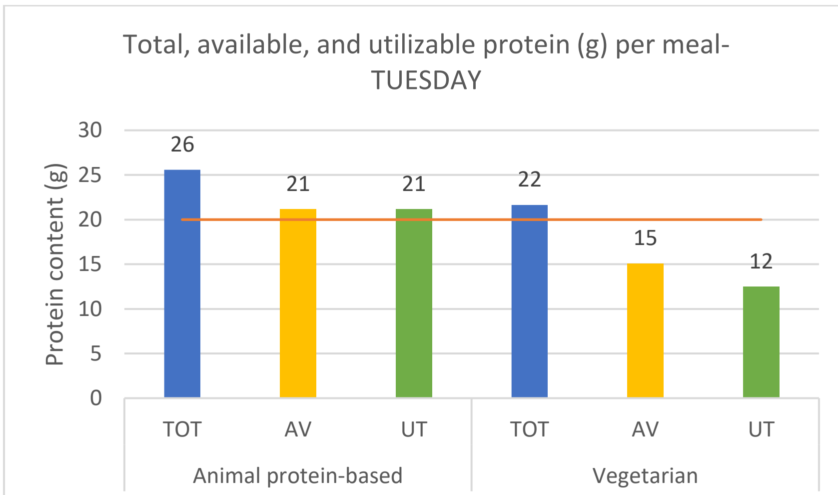

Figure 10: Protein content (g) of each dinner meal offered at Hospital B on Tuesday, uncorrected (total protein TOT), corrected for digestibility (available AV), and corrected for digestibility and amino acid profile (utilizable UT). The orange line indicates the threshold of the criterion of 20 g protein per meal.

Wednesday

On Wednesday the animal protein-based dinner offered chicken as the protein component, and the vegetarian dinner offered bolognese pasta with plant-based mincemeat as the protein component. The vegetable and starch components were different for the animal protein-based and the vegetarian dinners.

Both the animal protein-based dinner and the vegetarian dinner were portions of 500 g. The animal protein-based dinner provided 542 kcal, and the vegetarian dinner 481 kcal (Table 11). The animal protein-based dinner had 28 g of protein in total, of which 22 g were animal-based, and 6 g were plant-based. After correction for digestibility, available protein

Wednesday

Animal protein-based
Chicken & vegetable balls, endive mash, and gravy

Vegetarian
Pasta bolognese with grated cheese, and cucumber paprika salad

was 24 g. The meal had no limiting amino acid and the PDCAAS was 0.85. Utilizable protein was therefore 24 g. The vegetarian dinner had 26 g of protein in total, of which 5 g were animal-based, and 21 g were plant-based. After correction for digestibility, available protein was 20.5 g. The meal had a limiting amino acid (lysine) and the PDCAAS was 0.75. Utilizable protein was 20 g. Both the animal protein-based dinner and the vegetarian dinner had more than the 20 g of protein set as the minimum criterion per meal before and after correcting for digestibility (Figure 11).

Table 11: Nutritional content and protein quality information of dinner meals offered at Hospital B on Wednesday

Meal option	*Portion size (g)*	*Energy (kcal)*	*Total protein (g)*	*Animal protein (g)*	*Plant protein (g)*	*Available protein (g)*	*Utilizable protein (g)*	*PDCAAS*	*Limiting amino acids*
Animal protein-based	500	542	28.0	21.6	6.4	23.7	23.7	0.85	None
Vegetarian	500	481	26.3	5.4	20.9	20.5	19.7	0.75	Lysine

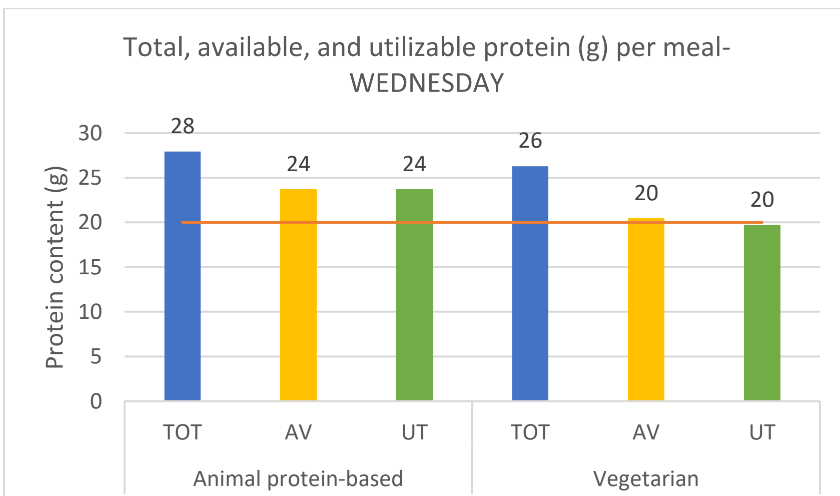

Figure 11: Protein content (g) of each dinner meal offered at Hospital B on Wednesday, uncorrected (total protein TOT), corrected for digestibility (available AV), and corrected for digestibility and amino acid profile (utilizable UT). The orange line indicates the threshold of the criterion of 20 g protein per meal.

Thursday

> **Thursday**
>
> **Animal protein-based**
> Nasi goreng with chicken, atjar, kroepoek, and peanut sauce
>
> **Vegetarian**
> Chili without carne, rice, and cucumber tomato salad

On Thursday the animal protein-based dinner offered chicken as the protein component, and the vegetarian dinner offered chili without carne (with plant-based mincemeat) as the protein component. The vegetable and starch components were different for the animal protein-based dinner and the vegetarian dinner.

The animal protein-based dinner was a portion of 480 g that provided 767 kcal (Table 12). The animal protein-based dinner had 38 g of protein in total, of which 21 g were animal-based, and 17 g were plant-based. After correction for digestibility, available protein was 33 g. The meal had no limiting amino acid and the PDCAAS was 0.86. Utilizable protein was 33 g. The animal protein-based dinner had more than the criterion of 20 g of protein per meal, before and after correcting for digestibility (Figure 12). The vegetarian dinner was a portion of 500 g and had 409 kcal (Table 12). It contained 22 g of protein in total, of which 1 g was animal-based, and 21 g were plant-based. This fell above the criterion of 20 g of protein per meal (Figure 12). After correction for digestibility, available protein was 17 g. The meal had a limiting amino acid (leucine) and the PDCAAS was 0.77. Utilizable protein was 17 g. This was below the criterion of 20 g per meal (Figure 12).

Table 12: Nutritional content and protein quality information of dinner meals offered at Hospital B on Thursday

Meal option	*Portion size (g)*	*Energy (kcal)*	*Total protein (g)*	*Animal protein (g)*	*Plant protein (g)*	*Available protein (g)*	*Utilizable protein (g)*	*PDCAAS*	*Limiting amino acids*
Animal protein-based	480	767	37.8	20.6	17.2	32.5	32.5	0.86	None
Vegetarian	500	409	22.3	1.0	21.3	17.2	17.1	0.77	Leucine

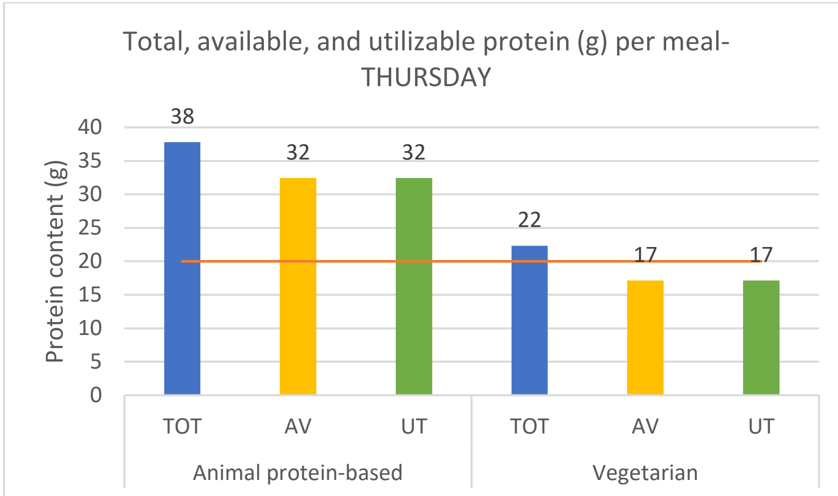

Figure 12: Protein content (g) of each dinner meal offered at Hospital B on Thursday, uncorrected (total protein TOT), corrected for digestibility (available AV), and corrected for digestibility and amino acid profile (utilizable UT). The orange line indicates the threshold of the criterion of 20 g protein per meal.

Friday

On Friday the animal protein-based dinner offered beef as the protein component, and the vegetarian dinner offered nasi goreng with atjar and peanut sauce.

> **Friday**
>
> **Animal protein-based**
> Beef stew, couscous, and green beans
>
> **Vegetarian**
> Nasi goreng with atjar, and peanut sauce

The animal protein-based dinner was a portion of 380 g that provided 345 kcal (Table 13). The animal protein-based dinner contained 28 g of protein in total, of which 19 g were animal-based, and 9 g were plant-based. After correction for digestibility, available protein was 24 g. The meal had no limiting amino acid and the PDCAAS was 0.85. Utilizable protein was 24 g. The animal protein-based dinner fell above the criterion of 20 g of protein, both before and after correcting for digestibility (Figure 13). The vegetarian dinner was a portion of 400 g and 527 kcal (Table 13). It contained 20 g of protein in total, of which 3 g were animal-based, and 17 g were plant-based. After correction for digestibility, available protein was 16 g. The meal had a limiting amino acid (leucine) and the PDCAAS was 0.76. Utilizable protein was 16 g. The vegetarian meal had more than 20 g of protein in total, but fell below the criterion of 20 g per meal after correcting for digestibility (Figure 13).

Table 13: Nutritional content and protein quality information of dinner meals offered at Hospital B on Friday

Meal option	*Portion size (g)*	*Energy (kcal)*	*Total protein (g)*	*Animal protein (g)*	*Plant protein (g)*	*Available protein (g)*	*Utilizable protein (g)*	*PDCAAS*	*Limiting amino acids*
Animal protein-based	380	345	27.8	18.6	9.2	23.6	23.6	0.85	None
Vegetarian	400	527	20.5	3.3	17.2	16.1	15.7	0.76	Leucine

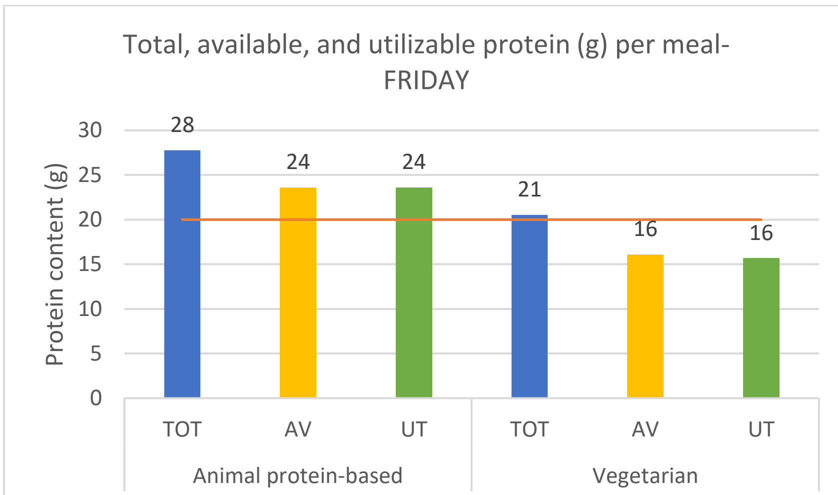

Figure 13: Protein content (g) of each dinner meal offered at Hospital B on Friday, uncorrected (total protein TOT), corrected for digestibility (available AV), and corrected for digestibility and amino acid profile (utilizable UT). The orange line indicates the threshold of the criterion of 20 g protein per meal.

Saturday

On Saturday both options for dinner were vegetarian. The first dinner option was a pasta bolognese with plant-based mincemeat, and the second dinner option was shakshuka with fried egg. The vegetable and starch components were different for the two vegetarian dinners.

Saturday

Vegetarian (1)
Pasta bolognese with grated cheese, vegetarian balls, and cucumber tomato salad

Vegetarian (2)
Shakshuka, fried egg, nut rice, chickpea salad, and tzatziki

The vegetarian pasta Bolognese was a portion of 600 g and 471 kcal (Table 14). It contained 36 g of protein in total, of which 8 g were animal-based, and 28 g were plant-based. After correction for digestibility, available protein was 31 g. The meal had no limiting amino acid and the PDCAAS was 0.87. Utilizable protein was 31 g. The vegetarian pasta bolognese fell above the criterion of 20 g of protein per meal, both before and after correcting for digestibility (Figure 14). The shakshuka dinner was a portion of 410 g with 604 kcal (Table 14). It had 24 g of protein in total, of which 7 g were animal-based, and 17 g were plant-based. After correction for digestibility, available protein was 18 g. The meal had a limiting amino acid (lysine) and the PDCAAS was 0.67. Utilizable protein was 16 g. The shakshuka dinner meal contained more than 20 g of protein in total but this fell below the criterion of 20 g per meal after correcting for digestibility (Figure 14).

Table 14: Nutritional content and protein quality information of dinner meals offered at Hospital B on Saturday

Meal option	*Portion size (g)*	*Energy (kcal)*	*Total protein (g)*	*Animal protein (g)*	*Plant protein (g)*	*Available protein (g)*	*Utilizable protein (g)*	*PDCAAS*	*Limiting amino acids*
Vegetarian (1)	600	471	35.8	8.0	27.8	31.2	31.2	0.87	None
Vegetarian (2)	410	604	24.2	7.0	17.1	18.0	16.3	0.67	Lysine

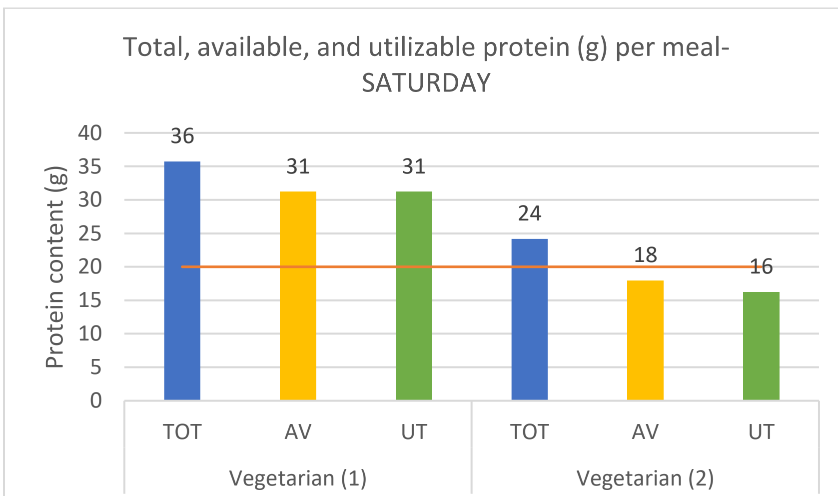

Figure 14: Protein content (g) of each dinner meal offered at Hospital B on Saturday, uncorrected (total protein TOT), corrected for digestibility (available AV), and corrected for digestibility and amino acid profile (utilizable UT). The orange line indicates the threshold of the criterion of 20 g protein per meal.

Sunday

On Sunday the animal protein-based dinner offered salmon as the protein component, and the vegetarian dinner offered nuts as the protein component. The vegetable and starch components were different for the animal protein-based and the vegetarian dinners.

The animal protein-based dinner was a portion of 420 g and 613 kcal (Table 15). It contained 27 g of protein in total, of which 24 g were animal-based, and 3 g were plant-based. After correction for digestibility, available protein was 23 g. The meal had no

Sunday

Animal protein-based
Salmon filet, potato tart, carrots, and herbs sauce

Vegetarian
Vegetable mix with nuts, quinoa salad, and

limiting amino acid and the PDCAAS was 0.84. Utilizable protein was 23 g. The animal protein-based dinner fell above the criterion of 20 g of protein per meal, both before and after correcting for digestibility (Figure 15). The vegetarian dinner was a portion of 425 g with 815 kcal (Table 15). It contained 24 g of protein in total, of which 1 g was animal-based, and 23 g were plant-based. The total amount of protein in the meal fell above the criterion of 20 g of protein per meal (Figure 15). However, after correction for digestibility, available protein was 16 g. The meal had a limiting amino acid (lysine) and the PDCAAS was 0.45. Utilizable protein was 11 g.

Table 15: Nutritional content and protein quality information of dinner meals offered at Hospital B on Sunday

Meal option	*Portion size (g)*	*Energy (kcal)*	*Total protein (g)*	*Animal protein (g)*	*Plant protein (g)*	*Available protein (g)*	*Utilizable protein (g)*	*PDCAAS*	*Limiting amino acids*
Animal protein-based	420	613	27.4	23.8	3.6	23.0	23.0	0.84	None
Vegetarian	425	815	23.8	1.0	22.8	15.9	10.7	0.45	Lysine

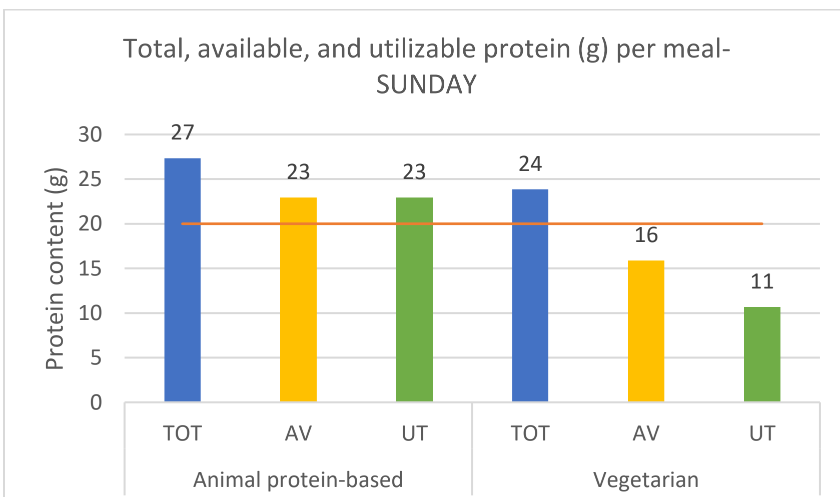

Figure 15: Protein content (g) of each dinner meal offered at Hospital B on Sunday, uncorrected (total protein TOT), corrected for digestibility (available AV), and corrected for digestibility and amino acid profile (utilizable UT). The orange line indicates the threshold of the criterion of 20 g protein per meal.

Environmental impact dinner meals hospital B:

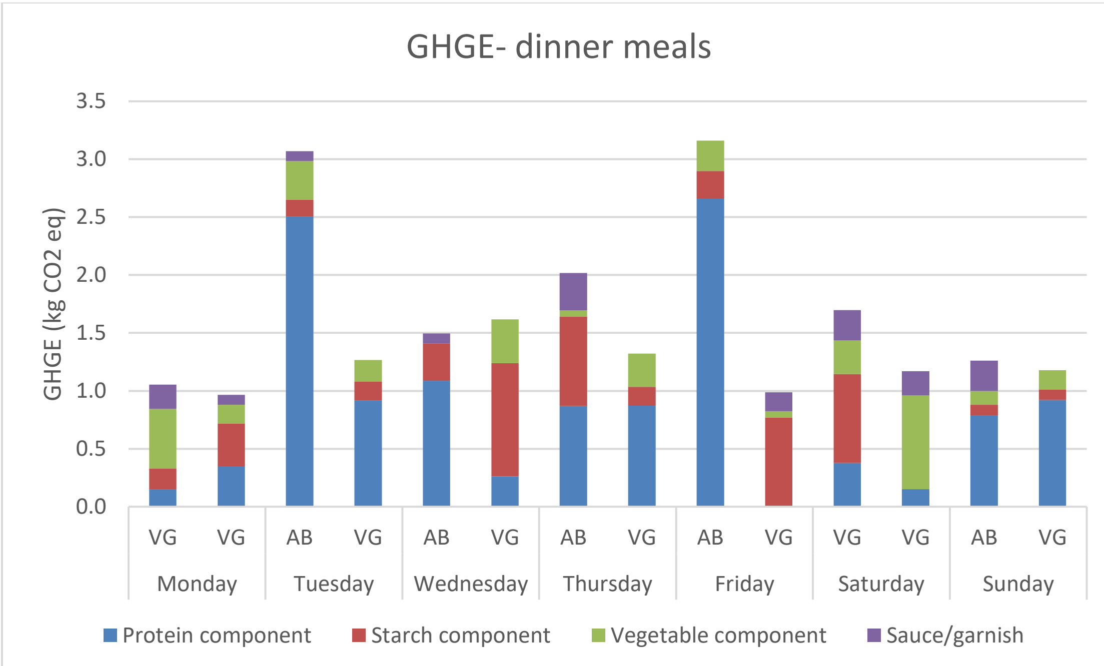

Figure 16: GHG emissions (kg CO2 eq) per dinner meal (animal protein-based AB or vegetarian VG) offered at Hospital B

Figure 16 shows the GHGE of all the animal protein-based and vegetarian meals offered at hospital B from Monday to Sunday, and the breakdown of GHGE per component within a meal (protein, starch, vegetable, or sauce component).

On most days, the animal protein-based meal had a higher GHGE than the vegetarian meal. The highest GHGE can be observed on Tuesday (3.1 kg C02 eq) and on Friday (3.2 kg C02 eq) for the animal protein-based dinner option, with the protein component being the biggest contributor. In both these dinner options the protein component was beef. In the vegetarian meals the protein component contributed less to the total GHGE of the meal compared to the animal protein-based meals.

In Table 16 the environmental impact of GHGE, land use, blue water use, acidification, fresh water eutrophication, and marine water eutrophication of the animal protein-based and vegetarian dinners offered from Monday and Sunday are shown. In general, animal protein-based meals had higher GHGE, land use, acidification, and fresh and marine water eutrophication compared to vegetarian meals. Blue water use was generally higher for all vegetarian dinners compared to the animal protein-based dinners.

Table 16: Environmental impact (GHG emissions, land use, blue water use, acidification potential, and fresh and marine water eutrophication) of each dinner meal offered at Hospital B

Day	*Meal option*	*GHGE (kg CO2 eq)*	*Land use (m2a)*	*Blue water use (L)*	*Acidification (kg SO2)*	*Fresh water eutrophication (kg P eq)*	*Marine water eutrophication (kg N eq)*
Monday	Vegetarian (1)	1.05	0.77	75.2	5.92e-3	8.66e-5	1.04e-3
	Vegetarian (2)	0.97	0.76	83.2	3.56e-3	9.29e-5	9.38e-4
Tuesday	Animal protein-based (meat)	3.07	1.81	43.3	1.98e-4	1.98e-4	8.75e-3
	Vegetarian	1.27	1.06	117.1	1.94e-4	1.94e-4	1.55e-3
Wednesday	Animal protein-based (meat)	1.50	1.01	21.5	1.38e-4	1.38e-4	1.38-3
	Vegetarian	1.62	0.50	51.8	5.60e-5	5.61e-5	1.04e-3
Thursday	Animal protein-based (meat)	2.02	1.31	52.4	1.25e-2	1.78e-4	1.69e-3
	Vegetarian	1.32	0.59	62.5	3.82e-3	8.01e-5	5.94e-4
Friday	Animal protein-based (meat)	3.16	1.56	41.3	4.64e-2	1.52e-4	7.90e-3
	Vegetarian	0.99	0.65	38.6	4.55e-3	6.90e-5	8.87e-4
Saturday	Vegetarian (1)	1.70	0.59	48.4	6.24e-3	6.08e-5	9.53e-4
	Vegetarian (2)	1.35	1.16	107.1	6.61e-	1.14e-4	1.29e-3
Sunday	Animal protein-based (fish)	1.26	0.65	11.3	5.10e-3	9.67e-5	1.16e-3
	Vegetarian	1.18	1.44	221.3	8.60e-3	1.64e-4	1.90e-3

3.2.3. Hospital C

In this section the nutritional quality, including protein content and quality, and environmental impact of the dinner meals offered at hospital C are described. Six dinner options are offered every day (day to day 6). There are always five warm meals to choose from, and one salad. All warm meals are composed of a protein component (80 g), a vegetable component (150 g), and a starch component (150 g). For the protein component there are always several meat and vegetarian options, and sometimes a fish option is offered.

Protein content and quality dinner meals hospital C:

Day 1

On day 1, the two meat protein components that were offered were turkey and beef, the fish was cod, the two vegetarian options were plant-based minced meat bolognese and vegetarian chicken, and the salad was a nut rice salad.

All dinner meal options were 410 g per portion, except the salad which was 420 g (Table 17). The energy of the meals ranged from 271 kcal (turkey fillet dinner) to 694 kcal (vegetarian chicken). The vegetarian chicken dinner had the most protein in total (32 g), followed by the beef option (28 g), the vegetarian bolognese (25 g), the turkey fillet (25 g), the fish (25 g), and the salad (20 g). All dinner options except for the salad had a total protein content that exceeded the 20 g criterion of protein per meal (Figure 17). The vegetarian dinner options and the salad were mostly composed of plant-based protein, while the meat and the fish dinner options contained mostly animal-based protein (Table 17). All dinner meals had a lower protein content when correcting for digestibility (available protein), but fell above the criterion of 20 g of protein per meal, except for the salad (Figure 17). All dinner options had no limiting amino acids except for the salad and the vegetarian chicken. The utilizable protein of these two meals was lower than available protein.

Day 1

Turkey fillet
With romanesco mix, noisette potatoes, and gravy

Fried cod
With vegetable paella, yellow rice, and paprika sauce

Beef meatball
With green beans, cooked potatoes, and espagnole sauce

Nut rice salad
With tuna, brown bread and margarine

Vegetarian bolognese
With mixed vegetables, whole-wheat macaroni, and grated cheese

Vegetarian chicken
With broccoli mix, mashed potatoes, and espagnole sauce

Table 17: Nutritional content and protein quality information of dinner meals offered at Hospital C on day 1

	Portion size (g)	*Energy (kcal)*	*Total protein (g)*	*Animal protein (g)*	*Plant protein (g)*	*Available protein (g)*	*Utilizable protein (g)*	*PDCAAS meal*	*Limiting amino acids*
Turkey fillet	410	271	24.5	15.8	8.7	20.4	20.4	0.83	None
Fried cod	410	363	24.5	16.2	8.3	20.2	20.2	0.82	None
Beef meatball	410	427	27.5	20.8	6.6	24.2	24.2	0.88	None
Nut rice salad	420	462	19.8	7.7	12.1	15.2	14.3	0.72	Lysine
Vegetarian bolognese	410	370	24.7	9.2	15.5	20.5	20.5	0.83	None
Vegetarian chicken	410	694	32.2	3.2	29.0	23.0	21.9	0.68	Leucine

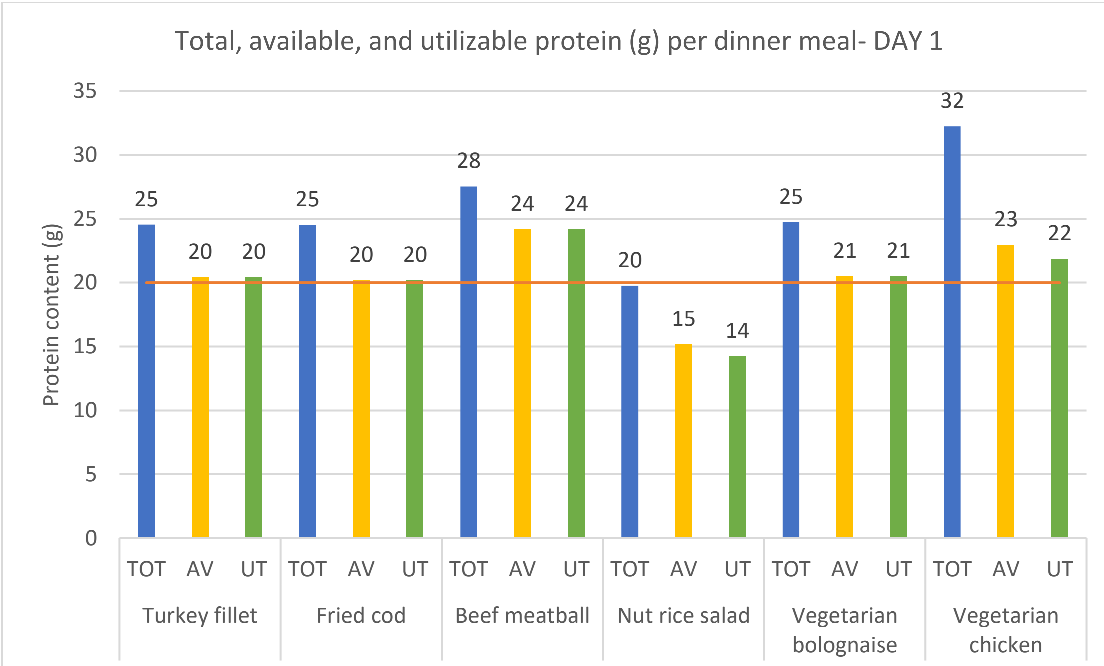

Figure 17: Protein content (g), of each dinner meal offered at Hospital C on day 1, uncorrected (total protein TOT), corrected for digestibility (available AV), and corrected for digestibility and amino acid profile (utilizable UZ). The orange line indicates the threshold of the criterion of 20 g protein per meal.

Day 2

On day 2, the two meat protein components that were offered were beef and pork, the fish was cod, the two vegetarian options were vegetarian burger and vegetarian nuggets, and the salad was a potato salad.

Day 2

Beef teriyaki
With grilled vegetables, and whole-wheat noodles

Vegetable burger
With beetroot and apple, cooked potatoes, and gravy

Pork
With chicory, mashed potatoes, and espagnole sauce

Potato salad
With tomato and mozzarella, brown bread and margarine

Codfish
With peas, carrot, quinoa, and Hollandaise sauce

Vegetarian nuggets
With green beans, cooked potatoes, and espagnole sauce

Dinner options portion sizes ranged from 380 to 425 g and had an energy content ranging from 273 kcal (beef teriyaki) to 679 kcal (pork) (Table 18). The pork dinner had the highest amount of protein in total (35 g), followed by the fish (29 g), the vegetarian options (18 g), the beef teriyaki (18 g), and the salad (17 g). Only the pork dinner meal and the fish dinner meal had a total (crude) protein content higher than the 20 g of protein per meal criterion (Figure 18). The vegetarian dinner options and the salad were mostly composed of plant-based protein, while the meat and the fish dinner options had mostly animal-based protein (Table 18). All dinner meals had a lower protein content when correcting for digestibility (available protein), an fell below the criterion of 20 g of protein per meal, except for the pork and the fish dinner meal. The beef dinner, the pork dinner, and the salad had limiting amino acids (leucine and lysine), and therefore had a utilizable protein that was lower than available protein (Figure 18).

Table 18: Nutritional content and protein quality information of dinner meals offered at Hospital C on day 2

	Portion size (g)	*Energy (kcal)*	*Total protein (g)*	*Animal protein (g)*	*Plant protein (g)*	*Available protein (g)*	*Utilizable protein (g)*	*PDCAAS meal*	*Limiting amino acids*
Beef teriyaki	380	273	17.6	6.3	11.3	13.7	13.3	0.76	Leucine
Vegetable burger	410	360	18.1	1.4	16.7	15.5	15.5	0.86	None
Pork	410	679	34.7	19.8	14.9	26.7	24.4	0.70	Leucine
Potato salad	425	411	17.1	7.2	9.9	13.4	11.6	0.68	Lysine
Codfish	410	385	28.7	18.5	10.3	23.1	23.1	0.80	None
Vegetarian nuggets	410	392	18.3	2.3	16.1	15.3	15.3	0.83	None

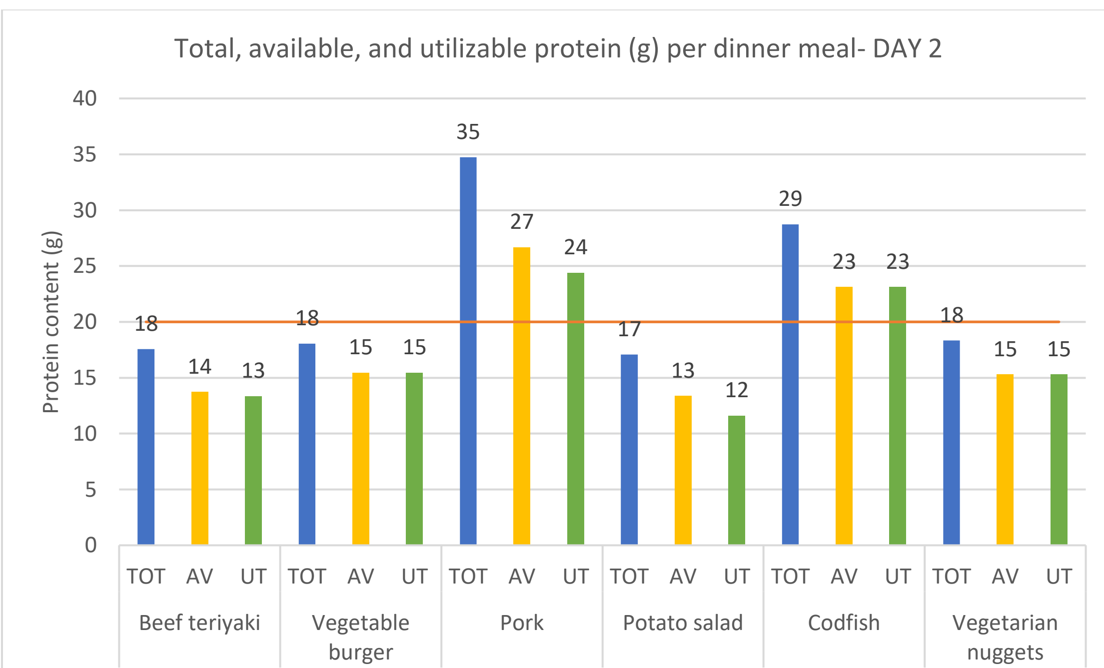

Figure 18: Protein content (g), of each dinner meal offered at Hospital C on day 2, uncorrected (total protein TOT), corrected for digestibility (available AV), and corrected for digestibility and amino acid profile (utilizable UZ). The orange line indicates the threshold of the criterion of 20 g protein per meal.

Day 3

On day 3, three meat protein components were offered, namely sausage, chicken, and beef. The two vegetarian options were nasi and vegetarian meatball, and the salad was a pasta chicken salad.

Dinner options portion sizes ranged from 380 to 425 g and had an energy content ranging from 267 kcal (beef) to 465 kcal (fried sausage) (Table 19). The vegetarian meatball had the most protein in total (28 g), followed by the beef steak (23 g), the fried sausage (22 g), the pasta chicken salad (21 g), the nasi (20 g), and the chicken tandoori (15 g). All dinner options except the chicken had a total (crude) protein content that exceeded the criterion of 20 g of protein per meal (Figure 19). The vegetarian dinner options and the salad were mostly composed of plant-based protein, while the meat and the fish dinner options had mostly animal-based protein (Table 19). All dinner meals had a lower protein content when correcting for digestibility (available protein). All options had a complete amino acid profile except for the nasi and the salad, which had lysine and leucine as limiting amino acid, respectively (Table 19). Utilizable protein of these two meals was very similar to available protein (Figure 19).

Day 3

Fried sausage
With fajita vegetable mix, smashed sweet potato, and gravy

Chicken tandoori
With mixed vegetables, and brown rice

Nasi
With tjap tjoy, foe yong hai, and seroendeng

Pasta chicken salad
With brown bread and margarine

Beef steak
With endive, cooked potatoes, and espagnole sauce

Vegetarian meatball
With spinach, boiled egg, spaghetti, and tomato sauce

Table 19: Nutritional content and protein quality information of dinner meals offered at Hospital C on day 3

	Portion size (g)	*Energy (kcal)*	*Total protein (g)*	*Animal protein (g)*	*Plant protein (g)*	*Available protein (g)*	*Utilizable protein (g)*	*PDCAAS meal*	*Limiting amino acids*
Fried sausage	410	465	21.8	13.4	8.4	18.1	18.1	0.83	None
Chicken tandoori	380	276	14.6	7.1	7.5	11.8	11.8	0.81	None
Nasi	410	448	19.7	9.8	9.8	15.2	15.2	0.77	Lysine
Pasta chicken salad	425	386	20.5	8.3	12.1	16.2	15.4	0.75	Leucine
Beef steak	410	267	22.7	17.5	5.2	19.8	19.8	0.87	None
Vegetarian meatball	410	434	27.6	9.9	17.7	23.1	23.1	0.84	None

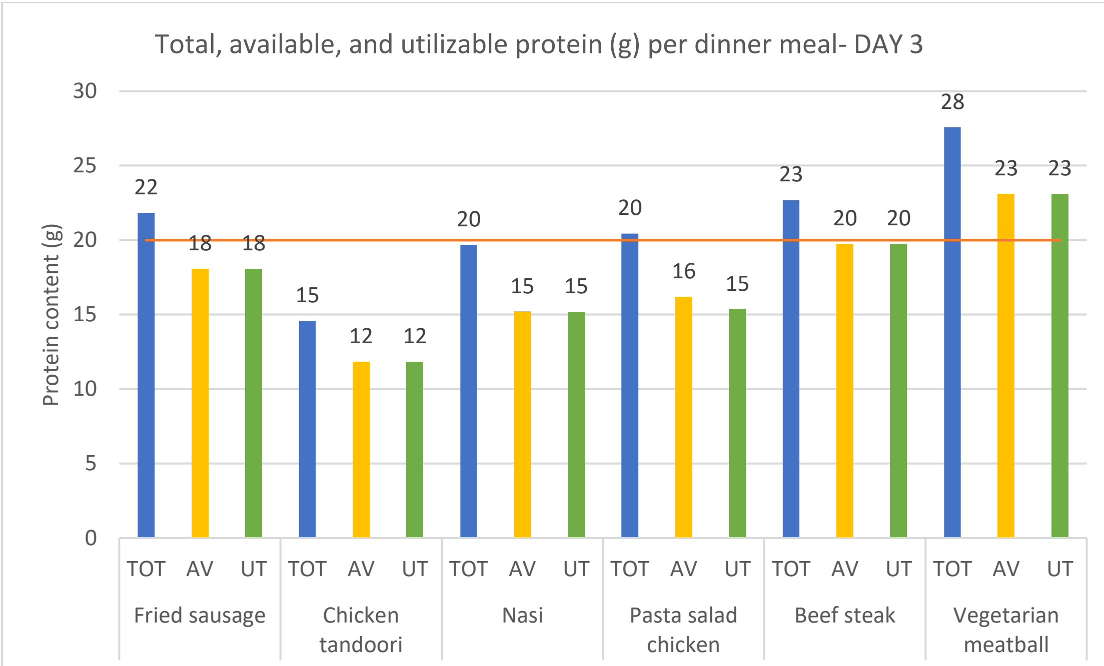

Figure 19: Protein content (g), of each dinner meal offered at Hospital C on day 3, uncorrected (total protein TOT), corrected for digestibility (available AV), and corrected for digestibility and amino acid profile (utilizable UZ). The orange line indicates the threshold of the criterion of 20 g protein per meal.

Day 4

On day 4, the two meat protein components were turkey and beef, and the fish option was hake fillet. The two vegetarian options were soja balls and vegetarian schnitzel, and the salad was a quinoa salad.

Day 4

Hake fillet
With ratatouille, tagliatelle and Normandic fish sauce

Turkey fillet
With green beans, cooked potatoes, and espagnole sauce

Beef steak
With white cabbage curry, rosti potatoes, and tomato sauce

Quinoa salad
With smoked salmon, brown bread, and margarine

Soja balls
With carrots, white rice, and espagnole sauce

Vegetarian schnitzel
With cauliflower, fried potatoes, and gravy

Dinner options portion sizes ranged from 410 to 425 g and had an energy content ranging from 278 kcal (turkey) to 416 kcal (beef steak) (Table 20). The hake fillet had the most protein in total (27 g), followed by the turkey fillet (22 g), the beef steak (21 g), the quinoa salad (19 g), the vegetarian schnitzel (18 g), and the soja balls (14 g). Only the meat or dinner options had a total (crude) protein content higher than the criterion of 20 g of protein per meal, and were composed of mostly animal-based protein. The meat and fish meals did not have limiting amino acids, and when correcting for digestibility only the protein content of the hake fillet remained above the 20 g criterion (Figure 20). The vegetarian dinner options and the salad were mostly composed of plant-based protein, and had a protein content below 20 g after correcting for digestibility. The quinoa salad and the soja balls meals had an incomplete amino acid profile, with the limiting amino acids being leucine and lysine, respectively (Table 20). Utilizable protein was slightly lower than available protein in these two meals (Figure 20).

Table 20: Nutritional content and protein quality information of dinner meals offered at Hospital C on day 4

	Portion size (g)	*Energy (kcal)*	*Total protein (g)*	*Animal protein (g)*	*Plant protein (g)*	*Available protein (g)*	*Utilizable protein (g)*	*PDCAAS meal*	*Limiting amino acids*
Hake fillet	410	342	27.1	15.6	11.6	22.0	22.0	0.81	None
Turkey fillet	410	278	22.2	16.4	5.8	19.1	19.1	0.86	None
Beef steak	410	416	21.4	16.6	4.8	17.4	17.4	0.81	None
Quinoa salad	425	402	19.2	7.8	11.4	14.8	14.0	0.72	Leucine
Soja balls	410	373	13.9	1.2	12.7	10.9	10.2	0.74	Lysine
Vegetarian schnitzel	410	356	17.7	1.8	16.0	14.8	14.8	0.83	None

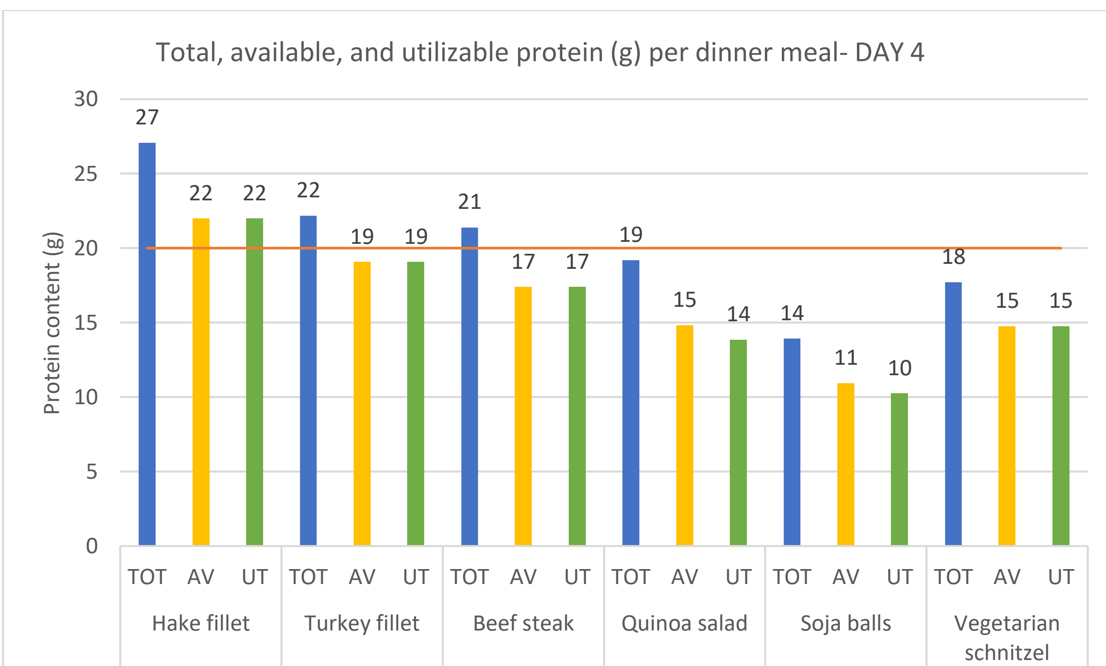

Figure 20: Protein content (g), of each dinner meal offered at Hospital C on day 4, uncorrected (total protein TOT), corrected for digestibility (available AV), and corrected for digestibility and amino acid profile (utilizable UZ). The orange line indicates the threshold of the criterion of 20 g protein per meal.

Day 5

On day 5, three meat protein components were offered, namely bami (with pork), chicken fillet, and steak tartar. The two vegetarian options were lentil curry and vegetarian stir-fry strips, and the salad was a greek salad.

Dinner options portion sizes ranged from 200 to 410 g and had an energy content ranging from 237 kcal (salad) to 502 kcal (lentil curry) (Table 21). The steak tartar had the most protein in total (31 g), followed by chicken fillet (25.5 g), and the lentil curry (25 g). The steak tartar had the highest total protein content (31 g), followed by the chicken (26 g), the red lentil curry (25 g), the bami (24 g), the vegetarian stir-fry strips (21 g), and the salad (8 g). All meals except the salad had a total (crude) protein content that exceeded the criterion of 20 g of protein per meal (Figure 21). The vegetarian dinner options and the salad were mostly composed of plant-based protein, while the meat and the fish dinner options had mostly animal-based protein (Table 21). All dinner meals had a lower protein content when correcting for digestibility (available protein). The meat containing meals had no limiting amino acids and remained above the 20 g criterion when correcting for digestibility. The vegetarian meals and the salad had an incomplete amino acid profile (with lysine and leucine being the limiting amino acids), and dropped below 20 g when correcting for protein quality. The difference in available and utilizable protein was very small, except for the salad (Figure 21).

Day 5

Bami
With babi pangang, spicy vegetables pineapple, and seroendeng

Chicken fillet
With Tuscan vegetable mix, fried potatoes, and mushroom sauce

Red lentil curry
With broccoli, couscous, and cashew nuts

Greek salad
With brown bread and margarine

Steak tartar
With spinach, egg, cooked potatoes, and gravy

Vegetarian stir-fry strips
With peas, cooked potatoes, and tomato sauce

Table 21: Nutritional content and protein quality information of dinner meals offered at Hospital C on day 5

	Portion size (g)	*Energy (kcal)*	*Total protein (g)*	*Animal protein (g)*	*Plant protein (g)*	*Available protein (g)*	*Utilizable protein (g)*	*PDCAAS meal*	*Limiting amino acids*
Bami	410	360	24.1	12.9	11.2	20.5	20.5	0.85	None
Chicken fillet	410	265	25.5	18.6	6.8	21.9	21.9	0.86	None
Red lentil curry	410	502	24.8	0.0	24.8	17.7	17.4	0.70	Lysine
Greek salad	200	237	7.8	7.7	0.1	6.1	2.3	0.30	Lysine
Steak tartar	410	365	31.1	26.1	5.0	28.0	28.0	0.90	None
Vegetarian stir-fry strips	410	338	20.5	1.1	19.4	16.0	15.5	0.76	Leucine

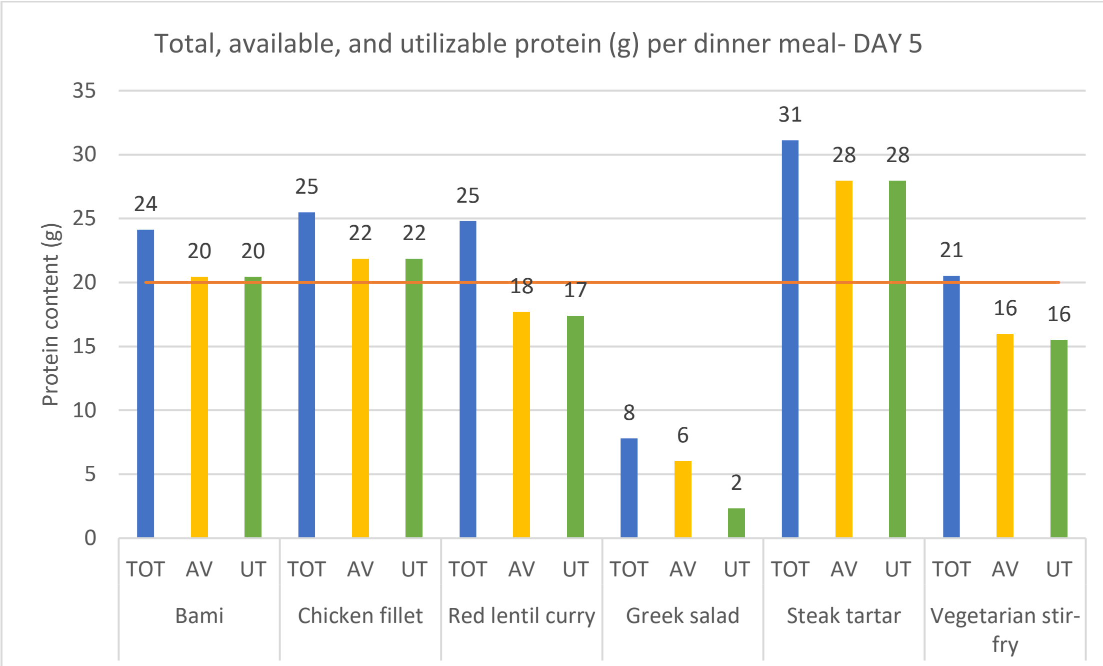

Figure 21: Protein content (g), of each dinner meal offered at Hospital C on day 5, uncorrected (total protein TOT), corrected for digestibility (available AV), and corrected for digestibility and amino acid profile (utilizable UZ). The orange line indicates the threshold of the criterion of 20 g protein per meal.

Day 6

On day 6, the two meat options were boeuf bourguignon and pork fillet, and the fish option was salmon. The two vegetarian options were falafel burger and omelet, and the salad was a pasta chicken salad.

Dinner options portion sizes ranged from 380 to 425 g and had an energy content ranging from 212 kcal (boeuf bourguignon) to 690 kcal (pork fillet) (Table 22). The pork fillet had the most protein in total (36 g), followed by the salmon (26 g), the pasta chicken salad (21 g), the omelet (17 g), the falafel burger (12 g) and the boeuf bourguignon (12 g). The pork, the salmon, and the pasta chicken salad exceeded the criterion of 20 g protein per meal in terms of total protein content. The vegetarian dinner options and the salad were mostly composed of plant-based protein, while the meat and the fish dinner options had mostly animal-based protein. All dinner meals had a lower protein content when correcting for digestibility (available protein). Only the pork fillet and the salmon remained above the criterion of 20 g of protein per meal when correcting for digestibility and amino acid profile (Figure 22). Half of the

Day 6

Boeuf bourguignon
With cabbage, and cooked potatoes

Falafel burger
With green beans, cooked potatoes, and espagnole sauce

Omelet
With leak, brown rice, and mushroom sauce

Pasta chicken salad
With brown bread and margarine

Pork fillet
With cauliflower, mashed potatoes, and gravy

Salmon
With carrots, whole-wheat pasta, and chive sauce

dinner meals had limiting amino acids and therefore a utilizable protein that was lower than the available protein (falafel burger, pasta chicken salad, and pork fillet).

Table 22: Nutritional content and protein quality information of dinner meals offered at Hospital C on day 6

	Portion size (g)	*Energy (kcal)*	*Total protein (g)*	*Animal protein (g)*	*Plant protein (g)*	*Available protein (g)*	*Utilizable protein (g)*	*PDCAAS meal*	*Limiting amino acids*
Boeuf bourguignon	380	212	11.7	7.2	4.5	9.5	9.4	0.80	Leucine
Falafel burger	410	354	11.8	0.6	11.2	9.1	8.5	0.72	Leucine
Omelet	410	338	17.3	9.8	7.4	14.6	14.6	0.85	None
Pasta chicken salad	425	386	20.5	8.3	12.1	16.2	15.4	0.75	Leucine
Pork fillet	410	690	35.7	20.1	15.6	27.4	25.3	0.71	Leucine
Salmon	410	415	25.8	16.1	9.8	20.4	20.4	0.80	None

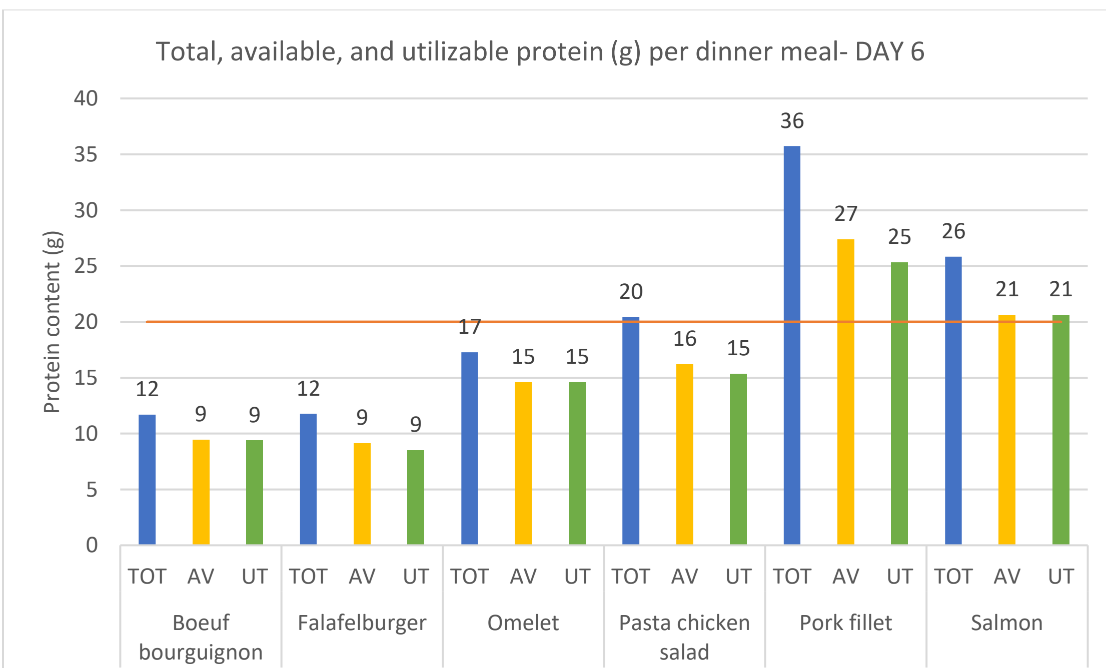

Figure 22: Protein content (g), of each dinner meal offered at Hospital C on day 6, uncorrected (total protein TOT), corrected for digestibility (available AV), and corrected for digestibility and amino acid profile (utilizable UZ). The orange line indicates the threshold of the criterion of 20 g protein per meal.

Environmental impact dinner meals hospital C:

Day 1

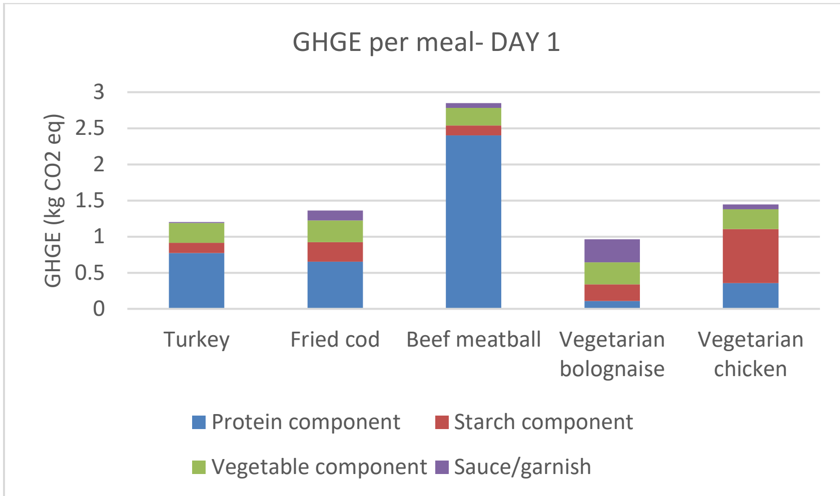

Figure 23: GHG emissions (kg CO2 eq) per dinner meal offered on day 1 at Hospital C

Figure 23 shows the GHGE of every dinner meal offered on Day 1 at hospital C. The beef meatball option had the highest GHGE compared to the other meals. In the meals where the protein component was either meat or fish, the GHGE biggest contributor was the protein component, whereas in the vegetarian options, the protein component was not the biggest contributor.

Day 2

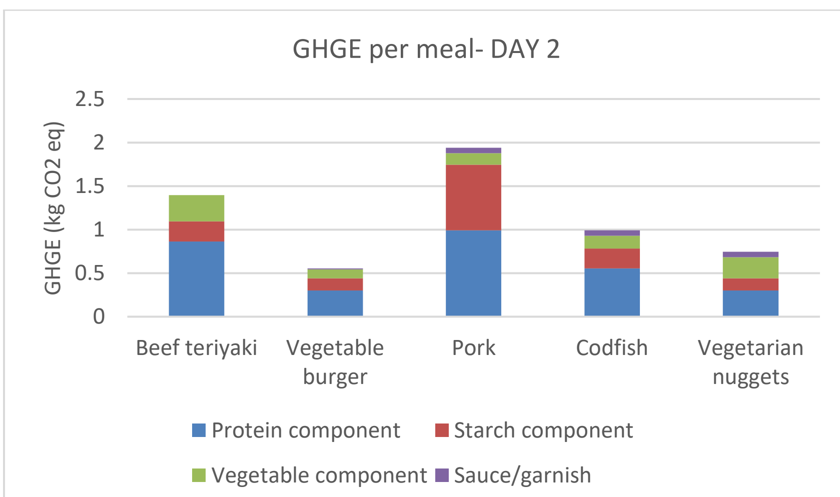

Figure 24: GHG emissions (kg CO2 eq) per dinner meal offered on day 2 at Hospital C

Figure 24 shows the GHGE of every dinner meal offered on Day 2 at hospital C. The meat options had the highest GHGE, followed by the fish option, and then the vegetarian options. In all meals the biggest contributor to total GHGE of the meal was the protein component.

Day 3

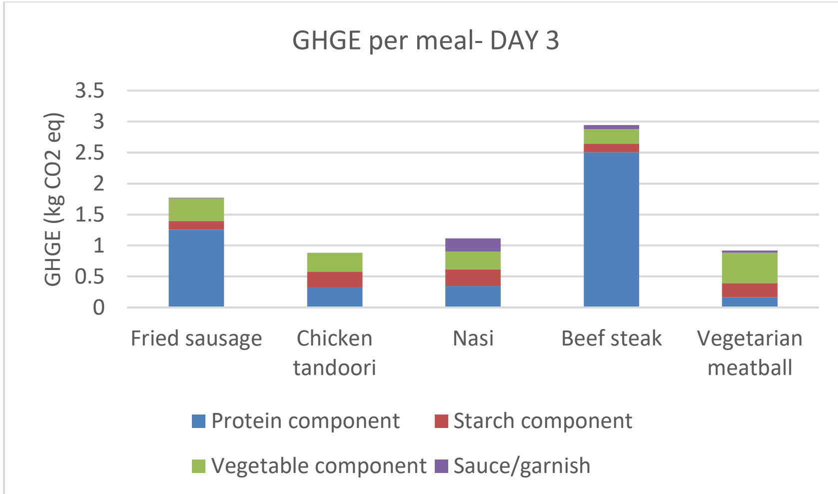

Figure 25: GHG emissions (kg CO2 eq) per dinner meal offered on day 3 at Hospital C

Figure 25 shows the GHGE of every dinner meal offered on Day 3 at hospital C. The meat options had the highest GHGE, while the vegetarian options had the lowest. In the meals where the protein component was meat or chicken, the GHGE biggest contributor was the protein component, whereas in the vegetarian options, the protein component was not the biggest contributor.

Day 4

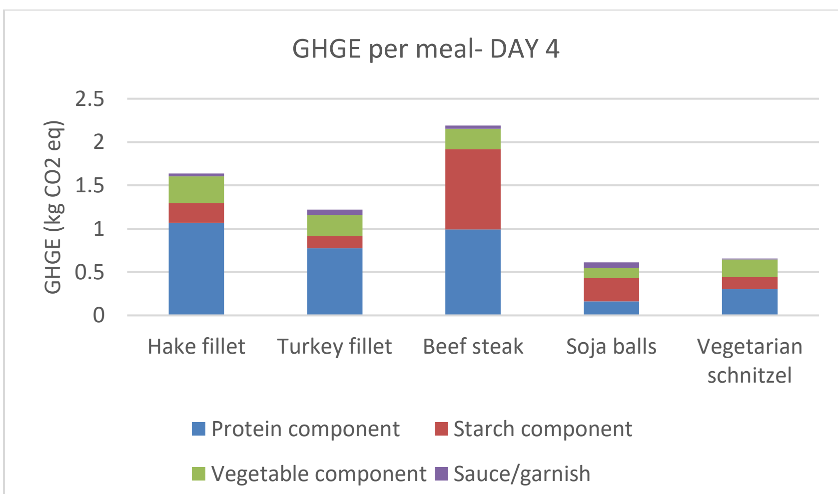

Figure 26: GHG emissions (kg CO2 eq) per dinner meal offered on day 4 at Hospital C

Figure 26 shows the GHGE of every dinner meal offered on Day 4 at hospital C. The beef steak option had the highest GHGE, followed by the fish option, and then the turkey fillet. The vegetarian options had the lowest GHGE. In the meals where the protein component was either meat or fish, the GHGE biggest contributor was the protein component, whereas in the vegetarian options, the protein component is not the biggest contributor.

Day 5

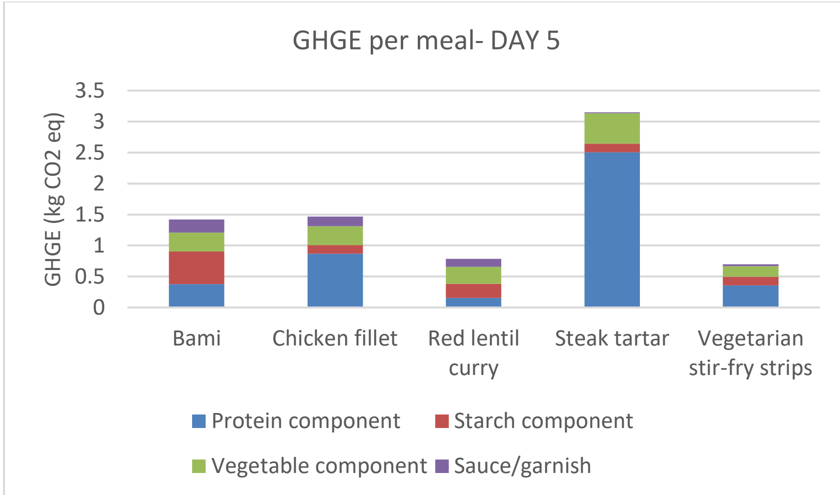

Figure 27: GHG emissions (kg CO2 eq) per dinner meal offered on day 5 at Hospital C

Figure 27 shows the GHGE of every dinner meal offered on Day 5 at hospital C. The steak tartar had the highest GHGE, followed by the chicken fillet, and the bami with pork. The vegetarian options had the lowest GHGE. In the steak tartar and the chicken fillet meals the GHGE biggest contributor was the protein component, whereas in the vegetarian options, the protein component was not the biggest contributor.

Day 6

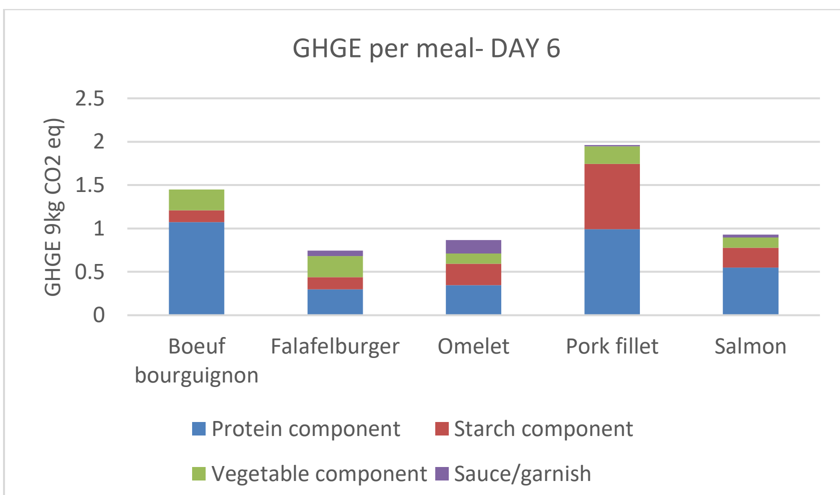

Figure 28: GHG emissions (kg CO2 eq) per dinner meal offered on day 6 at Hospital C

Figure 28 shows the GHGE of every dinner meal offered on Day 6 at hospital C. The meat options had the highest GHGE, followed by the fish option, then the omelet, and then the falafel burger. In the meals where the protein component was either meat or fish, the GHGE biggest contributor was the protein component, whereas in the vegetarian options, the protein component was not the biggest contributor.

Table 23 shows the environmental impact of GHGE, land use, blue water use, acidification, fresh water eutrophication, and marine water eutrophication of all dinner meals offered from day 1 to day 6 at hospital C. Dinner options with meat as the protein component had higher GHGE, land use, acidification, and fresh and marine water eutrophication compared to vegetarian meals. Blue water use did not show the same trend. Vegetarian meals had higher or similar blue water use than meat containing meals.

Table 23: Environmental impact (GHG emissions, land use, blue water use, acidification potential, and fresh and marine water eutrophication) of each dinner meal offered at Hospital C

Day	*Meal option*	*GHGE (kg CO2 eq)*	*Land use (m2a)*	*Blue water use (L)*	*Acidification (kg SO2)*	*Fresh water eutrophication (kg P eq)*	*Marine water eutrophication (kg N eq)*
Day 1	Turkey fillet	1.20	0.82	26.4	1.00e-2	1.43e-4	1.67e-3
	Fried cod	1.36	1.09	58.6	5.72e-3	9.58e-5	1.48e-3
	Beef meatball	2.85	1.47	29.8	4.59e-2	1.48e-4	7.77e-3
	Nut rice salad	0.95	0.30	41.4	3.93e-3	5.21e-5	6.54e-4
	Vegetarian bolognese	0.96	0.44	22.0	7.06e-3	5.99e-5	1.31e-3
	Vegetarian chicken	1.44	0.91	29.0	9.57e-3	1.42e-4	2.10e-3
Day 2	Beef teriyaki	1.40	0.65	24.0	1.71e-2	7.87e-5	3.12e-3
	Vegetable burger	0.56	0.25	10.0	1.85e-3	4.57e-5	4.36e-4
	Pork	1.94	1.29	25.4	1.67e-2	1.78e-4	2.63e-3
	Potato salad	0.76	0.39	20.9	6.27e-3	5.44e-5	1.14e-3
	Codfish	0.99	0.23	9.7	3.90e-3	3.99e-5	5.52e-4
	Vegetarian nuggets	0.75	0.39	14.2	3.40e-3	7.39e-5	7.62e-4
Day 3	Fried sausage	1.77	0.97	31.7	1.83e-2	1.23e-4	2.89e-3
	Chicken tandoori	0.88	0.43	41.8	5.42e-3	8.12e-5	8.83e-4
	Nasi	1.12	0.57	54.8	8.34e-3	1.05e-4	1.08e-3
	Pasta chicken salad	0.88	0.55	24.3	5.37e-3	7.53e-5	8.77e-4
	Beef steak	2.94	1.46	29.6	4.65e-2	1.41e-4	7.89e-3
	Vegetarian meatball	0.92	0.57	17.9	6.52e-3	7.45e-5	9.57e-4
Day 4	Hake fillet	1.64	0.50	24.2	5.47e-3	1.70e-4	9.65e-4
	Turkey fillet	1.22	0.75	21.2	9.31e-3	1.19e-4	1.21e-3
	Beef steak	2.19	1.39	34.4	1.55e-2	2.27e-4	2.79e-3
	Quinoa salad	0.69	0.33	20.2	2.58e-3	5.45e-5	6.81e-4
	Soja balls	0.61	0.23	30.2	3.21e-3	4.24e-5	5.91e-4
	Vegetarian schnitzel	0.66	0.39	15.9	3.53e-3	8.13e-5	9.84e-4
Day 5	Bami	1.42	0.88	33.3	1.06e-2	1.39e-4	1.67e-3
	Chicken fillet	1.47	0.79	28.9	1.01e-2	1.27e-4	1.24e-3

	Red lentil curry	0.79	0.94	83.4	6.50e-3	2.02e-4	1.93e-3
	Greek salad	0.26	0.19	9.8	1.19e-3	2.55e-5	3.51e-4
	Steak tartar	3.15	1.68	33.3	4.97e-2	1.60e-4	8.03e-3
	Vegetarian stir-fry strips	0.70	0.47	14.2	3.18e-3	6.70e-5	4.76e-4
Day 6	Boeuf bourguignon	1.45	0.76	20.4	2.17e-2	1.07e-4	3.98e-3
	Falafel burger	0.74	0.64	14.0	3.25e-3	7.81e-5	8.62e-4
	Omelet	0.87	0.45	37.4	7.18e-3	7.83e-	8.40e-4
	Pasta chicken salad	0.88	0.55	24.3	5.37e-3	7.53e-5	8.77e-4
	Pork fillet	1.96	1.36	27.1	1.71e-2	2.03e-4	2.96e-3
	Salmon	0.93	0.33	10.9	2.81e-3	6.40e-5	7.27e-4

3.3. Scenario analyses for improved protein quantity and quality

From each hospital, one or two dinner meals were selected to analyze further. The dinner meals that were selected were meals that did not meet the 20 g criterion after correcting for protein quality. Meals were analyzed with the Alpha-tool on protein quality first, and then suggestions were made for alternative or extra plant-based ingredients to improve the protein quality of the meal. It is important to note that there are some methodological differences between the Alpha tools calculations for protein quality and the protein quality calculations made in this project. These differences are explained in Appendix C.

3.3.1. Hospital A

For hospital A the vegetarian dinner meal offered on Sunday (Mushroom ragout, with bean mix, fried potatoes, and gravy) was chosen to analyze with the Alpha tool. This meal was a portion of 450 g and provided 506 kcal. It had a total protein content of 17 g, and after correction for digestibility the protein content was 14 g. The meal had no limiting amino acids (all EAA reached their requirement), and utilizable protein was therefore equal to available protein (14 g). Based on the Alpha tool, which sets the protein content corrected for protein quality (both digestibility and amino acid profile) against the requirements of protein per meal (21 g of protein), the MPQS score of the meal was 71%. This means that 71% of the total protein content of the meal is available for body protein synthesis (12 g). To reach a MPQS score of 100%, the Alpha-tool suggested adding either 25 g of soya flour, 31 g of wheat germ, or a combination of wheat germ (19 g) and soya beans (13 g).

3.3.2. Hospital B

For hospital B one of the vegetarian meals offered on Monday (shakshuka, with fried egg, nut rice, and tzatziki) was chosen to analyze with the Alpha tool. The meal was a portion of 335 g and provided 485 kcal. It had a total protein content of 21 g, and after correcting for digestibility the available protein content was 16 g. When also taking into account the amino acid composition of the meal (where the limiting amino acid was lysine), the utilizable protein was 14 g. Based on the Alpha tool, which sets the protein content corrected for protein quality (both digestibility and amino acid profile) against the requirements of protein per meal (21 g of protein), the MPQS was 90%. This means that 90% of the total protein content of the meal is available for body protein synthesis (19 g). To reach a MPQS of 100%, the Alpha-tool suggested adding either 5.6 g of soya flour, or 11.5 g of pistachio nuts to the meal.

3.3.3. Hospital C

For hospital C the vegetarian dinner meals offered on day 5 (vegetarian stir-fry strips with peas, cooked potatoes, and tomato sauce) and on day 6 (falafel burger with green beans, cooked potatoes, and espagnole sauce) were chosen to analyze with the Alpha tool. The vegetarian stir-fry strips meal was a portion of 410 g and provided 338 kcal. It had a total protein content of 20.5 g, and after correcting for digestibility the available protein content was 19 g. When also taking into account the amino acid composition of the meal (where the limiting amino acid was leucine), the utilizable protein was 15.5 g. Based on the Alpha tool, which sets the protein content corrected for protein quality (both digestibility and amino acid profile) against the requirements of protein per meal (21 g of protein), the MPQS was 70%. This means that 70% of the total protein content of the meal is available for body protein synthesis (14 g). To reach a MPQS of 100%, the Alpha-tool suggested adding either a combination of dried nori seaweed (9 g) and vegetarian minced meat (16 g), or a combination of vegetarian minced meat balls (12 g) and vegetarian minced meat (19 g).

The falafel burger dinner meal was a portion of 410 g and provided 354 kcal. It had a total protein content of 12 g, and after correcting for digestibility the available protein content was 9 g. When also taking into account the amino acid composition of the meal (where the limiting amino acid was leucine), the utilizable protein was 8.5 g. Based on the Alpha tool, which sets the protein content corrected for protein quality (both digestibility and amino acid profile) against the requirements of protein per meal (21 g of protein), the MPQS was 50%. This means that 50% of the total protein content of the meal is available for body protein synthesis (6 g). To reach a MPQS of 100%, the Alpha-tool suggested adding either 50 g of dried nori seaweed or 76 g of vegetarian minced meat balls.

3.4. Stakeholder analysis

Hospitals A and B were selected to conduct interviews with all relevant actors in the food system of the hospitals. Through interviews with these actors, a value chain map was created for each hospital. Information was gathered on food procurement and logistics, food product and menu design process, food preparation, and food ordering and delivering system. In addition, barriers and facilitators in transitioning towards a more healthy and sustainable food system (including the protein transition) were identified.

3.4.1. Hospital A

Value chain map:

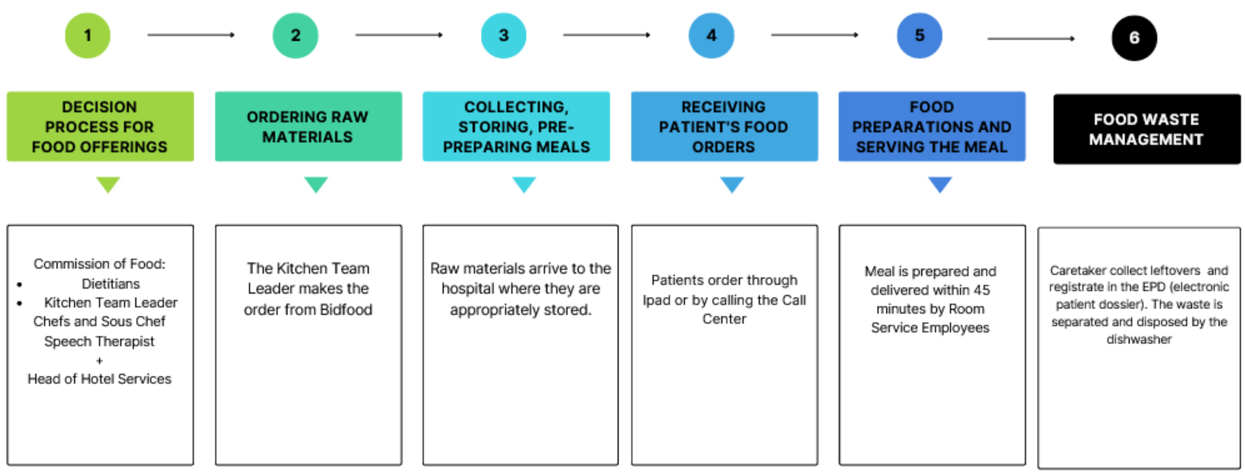

Figure 29: Value chain map Hospital A

Food product and menu deciding process:

The decisional process for the food offerings in the hospital involves collaboration with various experts in the so called 'commission of food'. Once a month the commission meets to (re)design the menus. The commission is composed of dietitians, the kitchen team leader, the chef and sous-chef, and a speech therapist.

The selection of food products and menu design is determined by several factors. Most importantly, the products and menus must cover all dietary needs of the patients. Other factors such as the number of plant-based options that are to be included in the menu is taken into account. The designed menus and selection of products must be checked for approval by the Head of Hotel Services to make sure that the food offerings are aligned with the food vision, strategy and policy of the hospital.

Food suppliers and logistics:

Food suppliers are selected with the prerequisite of sharing the hospital's strategy and vision. They are viewed as partners that will collaborate in achieving healthy and sustainable diets.

The hospital also receives inspiration and ideas from the supplier. For instance, hospital A will host a specialized cook that works for the supplier, to cook at the hospital's employee restaurant and show and teach the hospital's kitchen staff to change the prejudices around the taste of plant-based meals. Information on the environmental impact of the food offerings is also provided by the supplier.

Food preparation:

In hospital A meals are cooked from raw materials in the kitchen. Different kinds of chefs collaborate for this, such as diet cooks specialized in recipes suited for patients, and restaurant cooks specialized in hospitality. The collaboration between these chefs leads to patients being satisfied with the available products and meal options. This is known because through questionnaires, patients evaluate their experience with the hospital's food system, from ordering to room service, and food quality and liking.

Food ordering and delivery system for patients, and food waste management:

Patients order their meals through the nutrition assistant or by calling the call center. Employees in the call center have access to a platform where they can see the dietary needs of the patients (recorded by the dietitians). They can advise the patients on what to choose and nudge them to eat more if they have not eaten enough already. The food is prepared and delivered within 45 minutes with special 'under plates' that keep the food warm. Room service employees check if the patient needs help during consumption. Once the patient has finished eating, the caretaker collects the leftovers and registers how much the patient has consumed in the EPD (electronic patient dossier). Finally, the waste is separated and disposed of accordingly.

Barriers and facilitators:

The barriers identified during interviews with actors from the food system of the hospital are:

- Communication with employees: the hospital is composed of several departments and there are multiple actors involved. Ensuring that everyone is aware of the vision and strategy of the hospital together with the motivations behind them, is a challenge.
- Communication with the patients and resistance to change: patients do not like changes or traditional foods to be taken away from the menu. Most of the time it has been noticed that a vegetarian dish is appreciated when the patient does not know that it is plant-based. On the other hand, once they do know they show disinterest towards the food. The hospital finds it challenging to determine when and how much to communicate towards the patient.
- Financial constraints: it is challenging to achieve a more plant-based menu that is nutritionally appropriate while staying within the hospital's budget.
- Protein quality knowledge and data availability: currently there are no tools provisioning data regarding the protein quality of a plant-based dish which makes it difficult to construct plant-based meals and menus. Furthermore, patients have the

possibility to make their own meal from the different components listed in the menu. This makes it hard for the staff to control the protein quality of each combination. There is lack of information on which plant-based sources to use, and to implement more plant-based meals without it meaning that patients have to eat substantially more (due to a lower quality), as they already have a lower appetite.

The identified facilitators or perceived opportunities are:

- Clear vision and plan: having a clear vision and strategy for the food system transition helps to achieve set goals
- Informed employees: when the actors that are in close touch with the patients are informed about the decisions taken about the food offerings and the motivations behind them, they are also able to explain it to potentially complaining patients. On the other hand, if a frustrated patient asks for clarifications and the employee does not have an answer for it, more resistance to change rises.

3.4.2. Hospital B

Value chain map:

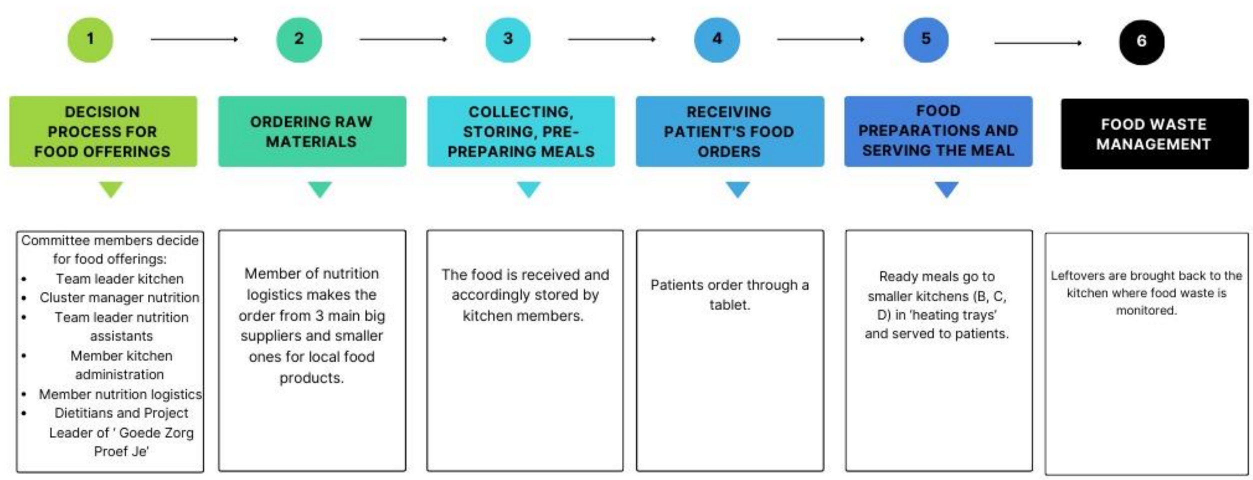

Figure 30: Value chain map Hospital B

Food product and menu deciding process:

The committee responsible for the design of the menu and choice of products is composed of the team leader of the kitchen, the manager of the nutrition team, the team leader of the nutrition assistants, a member of the kitchen administration, a member of food logistics, dietitians, and the leader of the 'Goede Zorg Proef Je' project in the hospital.

The committee ensures that the hospital fulfills its goals and ideals for its food vision. As part of the 'Goede Zorg Proef Je' project, the hospital works towards reaching a healthy food offering by 2030.

Food suppliers and logistics:

The hospital has 3 main big suppliers and several smaller suppliers for the provision of seasonal and regional fruits and vegetables. The member of nutrition logistics is in charge of ordering the food products.

Food preparation:

Two days before the meals are served, preliminary preparations are made where products are selected according to the meals that will be cooked on serving day. These products are stored in fridges, and the next day meals are cooked and cooled down again. On serving day the meals are warmed up and brought to the patients. As meals are pre-prepped two days in advance, the kitchen staff has to make an estimation of the number of meals that will be needed on serving and consumption day. When there are kitchen leftovers (what patients do not order), meals are served at a cheaper price in the restaurant for visitors and employees.

Some of the meal components are pre-cooked by the supplier.

Food ordering and delivery system for patients, and food waste management:

Patients order their meals either on the spot (breakfast and lunch) or through a tablet (dinner) where they can see pictures of the available dishes. The hospital has 1 big kitchen, and 3 smaller kitchens (one per hospital unit) where food products are distributed to all departments of that specific unit of the hospital. Cooked and cooled meals are transported in heating carts to the department and heated before distribution to the patients. Finally, food waste is centrally separated and disposed of accordingly.

Barriers and facilitators:

The barriers identified during interviews with actors from the food system of the hospital are:

- Communication: the transition towards more healthy and sustainable food requires the whole hospital to be part of it. Therefore, all actors need to be informed about the goals and the motivations behind them. There are online meetings where sometimes information about sustainability goals is shared, however many doctors or employees do not have time to participate in them. There is a need for a more effective communication method. Another communication problem is that what happens on the floor is not seen by higher staff positions, which lowers the effectiveness of designed interventions. Nutrition assistants find it difficult to communicate the hospital's sustainability goals to patients and thus explain the changing food offerings. They experience difficulties in nudging patients towards the healthier sustainable choice due to patients' resistance.

- Resistance to change: most patients do not like the idea of 'vegetarian' or 'vegan' dishes even if they would appreciate the taste eventually. This is explained by a resistance to change towards a new approach since people, especially the elders, want things to be how they used to be in the past.

- Financial constraints: the transition towards more plant-based alternatives is estimated to cost between 20% to 40% more than animal origin products without having this extra budget. For this reason, the hospital postpones certain goals or prioritizes the transition only for a certain segment of patients in order to have time to find more affordable suppliers or solutions. Since the hospital started focusing on waste management years ago, at the moment there are no additional savings coming from that aspect of a sustainable food system to be invested in new food supplies.

- According to the supplier, the producers that collaborate with the supplier have specialized for years in animal products in terms of packaging, machinery or other practices. This increases the price once they have to shift towards plant-based offerings. This is due also to the subsidies provided by the government for farmers that own animals or produce animal products. On the contrary, producers focusing on fruits or vegetables do not have financial support from the government which makes these products costly.

- The supplier also notes that hospital catering is only a small part of the market, while most food supply goes to retailers. This means that the food offerings are shaped by the expectations of retailers. The supplier notes that also in supermarkets there is a shift towards more plant-based offerings, however this goes at a slower rate.

- Protein quality knowledge and data: to achieve required amounts of proteins with plant-based alternatives requires a larger amount of consumption which is not always possible with patients which struggle in having appetite.

- Salt content: sometimes the amount of salt in plant-based meat substitutes is higher compared to meat and this challenges the achievements of healthy dishes for patients.

The facilitators or perceived opportunities are:

- Collaboration with universities: they provide knowledge and data

- Joining the Goede Zorg Proef Je project: the possibility to share experience and information between hospitals in the Netherlands helps in achieving sustainable and healthy diets.

- Investment in advanced ovens which ensure more food safety. This will allow the kitchen to reduce reliance on pre-prepared dishes in favor of cooking from scratch using raw ingredients.

4. Discussion and conclusion

Protein content and quality:

The results on protein content and quality of the dinner meals were similar for hospitals A, B, and C. In general, animal protein-based meals (meals with a protein component composed of meat or fish) had higher protein content levels than the vegetarian dinner meals, before and after correcting for protein quality. Of the animal protein-based meals offered in the hospitals, 85% had a total (crude) protein content higher than 20 g, the criterion used by the hospitals as minimal amount of protein required per meal. Most (68%) of the animal protein-based meals also had more than 20 g of protein when correcting for digestibility. Most (77%) of the animal protein-based meals had a complete amino acid profile, meaning that all amino acids were above their requirement and there was no limiting amino acid. Therefore, in these cases utilizable protein (protein corrected for digestibility and amino acid profile) was equal to available protein (protein corrected for digestibility only). This suggests that in general, the animal protein-based meals offered at the hospitals have a high protein quality in terms of amino acid profile. Both the fact that these meals are composed of a variety of ingredients (protein, starch, and vegetable products) that offer different amino acid profiles, and the fact that they contain animal-based proteins which are of high quality, explain the complete amino acid profile of the whole meal. This is also reflected in the PDCAAS score of animal protein-based meals, which was on average 0.82. In the few animal protein-based meals that had an incomplete amino acid profile (four out of thirty), the limiting amino acid was leucine.

Regarding the vegetarian dinner meals, results showed that these were generally lower in protein content than the animal protein-based meals, both before and after correcting for protein quality. Most (60%) of the vegetarian meals had a total (crude) protein content higher than 20 g. However, when correcting for protein digestibility, the protein content dropped below 20 g for most (80%) vegetarian meals. More than half (60%) of the vegetarian meals did not have a complete amino acid profile, meaning that not all essential amino acids in the meal reached their requirement. Limiting amino acids were lysine, leucine, and SAA (methionine and cysteine). Utilizable protein of these meals was therefore lower than the available protein. The lower protein quality of vegetarian meals is reflected as well in the PDCAAS, which was lower for vegetarian meals (0.73 on average), compared to the PDCAAS of animal protein-based meals (0.82 on average). Hospital C was the only hospital offering salads for dinner as one of the six meal options for dinner, instead of only warm meals. Results showed that only the salad containing meat (pasta chicken salad) had more than 20 g of protein in total, but less than 20 g when correcting for protein quality. All the vegetarian salads had an incomplete amino acid profile and did not reach the 20 g of protein (before and after correcting for protein quality), while the portion size of most salads was similar to those of pasta chicken salad and the warm meals. There were several meals offered at hospitals B and C that contained only plant-based protein. These were the vegetarian meals offered at hospital B on Tuesday (beans and vegetables), Thursday (chili without carne), and Sunday (vegetable mix with nuts), and the vegetarian meals offered at hospital C on day 2 (vegetarian burger), day 5 (red lentil curry, and vegetarian stir-fry strips), and day 6 (falafel burger). Most of these meals had more than 20 g of protein in total but had between 10 and 17 g of protein when correcting for protein quality. All but one of the plant protein-based meals (the vegetarian burger) had an incomplete amino acid profile and as limiting amino acid, mainly leucine or lysine. The plant-based meals had an average PDCAAS of 0.69, whereas vegetarian meals had an average PDCAAS of 0.75, indicating a lower protein quality of plant protein-based meals compared to vegetarian meals.

Concerning the dinner meals with an incomplete amino acid profile (mostly vegetarian) it is noticeable that the difference between the total (crude) amount of protein per meal and the utilizable protein is mostly attributable to the correction for digestibility. The difference between total and available protein was bigger than the difference between available and utilizable protein. This suggests that digestibility has a bigger impact than the amino acid profiles on the protein quality of the dinner meals offered at all three hospitals. Considering this, and the fact that the protein content of vegetarian meals tends to fall below 20 g after correcting for digestibility, especial attention should be put on making sure that the provided vegetarian meals reach the criterion of 20 g protein per meal when taking digestibility into account. The digestibility factors for each food group can be applied when designing these meals to ensure an adequate protein intake (Appendix A). Digestibility factors are available per food group and can be applied to all food products within a food group. Research is still needed to refine these digestibility factors and be able to apply them per food product.

Portion sizes of the meals and the quantities of ingredients and components in the meal are important to consider when it comes to protein quality and reaching the criterion of 20 g per meal. The results show that meals with bigger portion sizes reach the criterion of 20 g of protein in the meal more easily and have a better protein quality compared to meals that are smaller. However, it is important to consider the relation between portion size and energy (kcal), protein content, and whether a meal is animal or plant protein-based. The results show that, in general, the vegetarian meals had bigger portion sizes and higher energy (kcal) amounts than the animal protein-based meals, while having a lower protein content. There were some exceptions to this, such as the vegetarian bolognese offered on day 2 at hospital C, which had a similar portion size and energy (kcal) content compared to the meat options, while still having an adequate protein content than some of the meat containing meals.

There are several solutions to increase protein quantity and quality in meals with an incomplete amino acid profile and/or meals that do not reach the 20 g. Whether a meal does not reach the 20 g can be either because from the start the portion sizes are too small, or because due to digestibility (and amino acid profile) correction protein content falls below 20 g. A solution is to increase the amounts of current ingredients in the meal. However, the risk of increasing portion sizes is potentially having more food waste if patients do not eat the whole meal. In most hospitals the portion size is variable from half a portion up to a double portion. Patients typically do not order a bigger portion size of a meal, rather they will order something different from the menu on the side. Therefore, it is important to make sure that the meal in its standard portion size is adequate. Another option, especially for meals or products provided in hospitals with less variety of ingredients and smaller amounts (e.g. simple salads, soups, sandwiches), is offering extra products in the same meal moment that will increase protein quantity and protein quality. Offering an entrée, a (protein-rich) snack, or a dessert at the same meal moment could be an option and is already common practice in the hospitals. This can result in meals reaching the 20 g protein per meal more easily. In this study the main dinner meals excluding entrées and desserts were analyzed to investigate if the minimum intake of a patient (when only consuming the main dinner meal) reaches an adequate protein intake.

When the problem is not only the portion size of the meal or the available protein, but that the meal has an incomplete amino acid profile, the solution could be adapting the meal by adding or changing specific ingredients to make the amino acid profile complete and thus increasing the protein quality. In the results section explaining the scenario analyses, some examples are given. Depending on the amino acid composition of the meal, adding certain products that complement the limiting amino acid of the meal can lead to a complete amino acid profile. Leucine, lysine, and the sulfur-containing amino acids (methionine and cysteine) were the limiting amino acids in the vegetarian meals with incomplete amino acid profiles. To improve these meals in order to reach a high protein quality, products rich in leucine, lysine, or SAA should be added. Plant-based products rich in lysine and in leucine are legumes, soy products, and nuts and seeds, while products rich in SAA are grains for instance.

It is important to note that the nutritional content information used for this project might be different from the nutritional content information used by hospitals to design their meals. Hospitals design their meals based on dietary guidelines using nutritional content and recipe information provided by the suppliers of the food products they use. This nutritional content information can be different from the one used in this project, which is based on the corresponding NEVO products chosen for each food product. Another consideration is that within this project the offered menus were analyzed, without taking into account which meals are chosen and consumed the most by patients. Therefore, there is an idea of how far along the hospitals are in offering animal-based versus vegetarian meals, but it is unknown whether this also translates into an actual transition in the foods chosen and consumed by patients. Furthermore, this project focused on protein content and quality, but it is important to investigate what the impact of the protein transition in patients means for other nutrients.

<u>Scenario analyses for improved protein quality:</u>

Examples on improving protein quantity and quality were provided by the Alpha tool. This tool provides recommendations based on the need for meals to attain both a high protein quality and a sufficient protein intake, with a minimum of 21 g per meal. If a meal contains less than 21 g of protein in total (before even correcting for protein quality), it will suggest adding ingredients to the meal that will not only ensure a high protein quality and a complete amino acid profile, but also that the total amount of 21 g of protein is reached. This was the case in the example meals analyzed for the vegetarian meal offered at Hospital A (mushroom ragout, with a total of 17 g of protein and a MPQS score of 71%, and for the falafel burger option offered at hospital C (with a total of 12 g of protein and a MPQS score of 50%). The recommendation based on the Alpha-tool to reach a MPQS score of 100% for the vegetarian meal at hospital A was to add either 25 g of soya flour, or 31 g of wheat germ, or a combination of wheat germ (19 g) and soya beans (13 g). The recommendation for the falafel burger of hospital C was to add either 50 g of dried nori seaweed or 76 g of vegetarian minced meat balls. It can be observed that as the total protein content in the meal decreases, a higher quantity of the product is recommended to be added in order to achieve the necessary 21 g of protein per meal. Depending on the food product, this can result in having to add a smaller or bigger amount of ingredient. Results showed that utilizable protein calculated with the Alpha tool differs from utilizable protein calculated based on the formulas used in this project. This can be explained due to methodological differences (Appendix C).

Whether the suggested ingredients to add to the meals are appropriate and fit within the already existing meal is a question. In the case of the mushroom ragout with beans from hospital A, adding a combination of wheat germ and soya beans could fit the meal in terms of palatability. However, in cases such as the vegetarian stir-fry strips meal from hospital C, it is questionable whether adding dried nori seaweed is suitable. The Alpha tool is still in development and algorithms are still being improved to also take suitability and acceptability of suggested ingredients in the meal into account. It is also noticeable that certain products suggested by the Alpha tool, such as the dried nori seaweed, are products that are generally not very accepted yet in the food culture of the Netherlands and more expensive. Furthermore, adding soy or nut products is not always an option due to potential allergenic reasons. Another limitation of the suggestions made by the Alpha tool is that some suggestions might not be very realistic. For instance, the suggestion for the vegetarian stir-fry strips meal of hospital C is to add a combination of vegetarian minced meat balls and vegetarian minced meat. These are essentially both vegetarian minced meat products, added to the already present vegetarian stir-fry strips.

Environmental impact:

Results on the environmental impact of dinner meals of hospitals A, B, and C showed that meals containing meat as a protein component had the highest GHGE (on average 2.04 kg CO2 eq per dinner meal). Meals containing fish had an average GHGE of 1.08 kg CO2 eq. Vegetarian meals and plant protein-based meals had the lowest GHGE (on average 0.98 kg CO2 eq for vegetarian meals, and 0.94 kg CO2 eq for plant protein-based meals). In animal protein-based meals, the biggest contributor to the total GHGE of the meal was the protein component. This was relative to portion size. That is, the protein component was not necessarily bigger in portion size compared to the other components (starch or vegetable) of the meal (Appendix D). In vegetarian meals the protein component was not necessarily always the biggest contributor to total GHGE. This is in line with what is known about the higher environmental impact (GHGE) of meat in comparison to plant-based products. Particularly, beef showed a very high GHGE (3.13 kg CO2 eq per 100 g versus 0.38 kg CO2 eq per 100 g for a vegetable burger). Moreover, the results showed that the animal protein-based meals had higher land use, acidification, fresh and marine water eutrophication than vegetarian meals. Blue water use, used for irrigation in food production systems, did not show the same trend. In some cases, blue water use was higher for animal protein-based meals compared to vegetarian meals, in some cases equal, and in some cases lower.

Main conclusions:

- Animal protein-based dinner meals generally had a higher protein content and quality than vegetarian dinner meals (21 g vs 16 g of protein on average after correction for protein quality, respectively). Vegetarian dishes often (80%) dropped below the hospital criterion of 20 g protein per meal.
- Vegetarian dinner meals often (60%) had incomplete amino acid profiles. Limiting amino acids were lysine, leucine, and sulfur-containing amino acids (methionine and cysteine).
- Digestibility was more determining for protein quality than amino acid profile in the dinner meals. When designing vegetarian meals, the digestibility factors for each food group should be applied in order to ensure an adequate protein content.
- Targeted ingredient additions to a meal based on amino acid profile can increase the protein quality.
- Meals with animal-based protein generally had a higher protein content than vegetarian meals, yet they had a greater environmental impact, indicated by higher GHGE and increased land use.
- Challenges for the protein transition in the hospitals are communication towards patients and staff, financial constraints, and knowledge on protein quality aspects of plant-based foods.
- Facilitators for the protein transition in the hospitals are having a clear plan and vision, effective communication towards employees, and collaborating and sharing information and knowledge with other institutions such as health care facilities and universities.

Future research:

In future research projects, the following points could be investigated:

- Investigating the health impact of the menus at hospitals using nutritional content information from the Dutch branded food database (LEDA), which contains brand-specific product information, rather than the NEVO database, which uses generic average product nutrition information.
- Investigating the health and environmental impact of actual intakes of the patients, instead of the health and environmental impact of the available menus. Investigating what patients actually consume throughout their stay at the hospital reflects the real health and environmental impact of the current menus in the hospitals.
- Investigating the effect of the protein transition in hospitals on the intake of relevant nutrients, such as iron and vitamin B12.
- Investigate the patients' perspective on the protein transition: likeability, attitude, and determinants of acceptance of vegetarian and plant-based meals.
- Investigate the health professionals' and other hospital employee's perspective on the protein transition: likeability, attitude, and determinants of acceptance of vegetarian and plant-based meals.
- Develop tools for hospital staff and patients to calculate environmental impact and protein quality of meals.

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Appendix

Appendix A: Digestibility factors for each food group

Table 24: Digestibility factors of each food group (supplementary file 1 from Heerschop, S.N., et al. 2023)

NEVO product group	NEVO product group description	Digestibility factor
1	Potatoes and tubers	0.55
2	Alcoholic beverages	0.65
3	Bread	0.90
4	Miscellaneous foods (plant-based foods such as seaweed, cacao powder, yeast, etc.)	0.65
5	Eggs	0.97
6	Fruits	0.76
7	Pastry and biscuits	0.90
8	Cereals and cereal products	0.70
9	Vegetables	0.65
10	Savory bread spreads	0.90
11	Savory sauces	Animal-based: 0.90 Plant-based: 0.65
12	Savory snacks	Animal-based: 0.90 Plant-based: 0.65
13	Cheese	0.95
14	Herbs and spices	0.65
15	Milk and milk products	0.95
16	Non-alcoholic beverages	0.65
17	Nuts and seeds	0.75

18	Legumes	0.75
19	Clinical formulas (Foods for special nutritional value)	0.90
20	Mixed dishes	Animal-based: 0.90 Plant-based: 0.65 Mix of animal and plant--> take 0.90
21	Soups	Animal-based: 0.90 Plant-based: 0.65 Mix of animal and plant--> take 0.90
22	Sugar, sweets and sweet sauces	0.80
23	Fats and oils	0.65
24	Fish	0.90
25	Meat and poultry	0.95
26	Meat substitutes and dairy substitutes	0.94
27	Cold meat cuts	0.95

Appendix B: Overview food delivery system hospitals

Hospital A

Table 25: Overview food system and menus at Hospital A

Type of menu	Diet type (regular healthy diet/protein and energy rich diet)	Meal moment/ Ordering moment	Delivery time	Ordering method	Portion size options	Extra info
Main menu: contains individual items (for breakfast, snacks, lunch, and dinner), and (warm) meals	Patients following a regular healthy diet and patients following a protein and energy rich diet	• Individual items: between 7 and 18.15 • Meals: between 11.30 and 18.15 (includes the menu of the day, and other products such as sandwiches, soups, meal salads, and individual products).	Max 45 min	Through the nutrition assistant or through the phone with the food service center	Some meals/products have portion size options: 0.5, 1, 1.5, 2	• Protein- rich products are indicated with a thumb • Breakfast can be ordered the previous day
Snack menu (protein-rich snacks)	Patients following a protein and energy rich diet	Includes both warm and cold protein- rich snacks. The recommendation is to eat 3 protein- rich snacks per day (unless stated otherwise by the physician). These can be ordered between 7 and 18.15.	Max 45 min	Through the nutrition assistant or through the phone with the food service center	Some meals/products have portion size options: 0.5, 1, 1.5, 2	• Products containing less salt are indicated with an asterisk
Menu of the day (spring season)	Patients following a regular healthy diet and patients following a protein and energy rich diet	Ordering is possible between 7 and 18.15	Max 45 min	Through the nutrition assistant or through the phone with the food service center	Some meals/products have portion size options: 0.5, 1, 1.5, 2	• Menu returns on a weekly basis. Daily (from Monday to Sunday) there is a different offer (always including soup, side dish, main meal, and fruit/dessert).

Hospital B

Table 26: Overview food system and menus at Hospital B

Type of menu	Diet type (regular healthy diet/protein and energy rich diet)	Meal moment/ Ordering moment	Delivery time	Ordering method	Portion size options	Extra info
Food cart	Patients following a regular healthy diet and patients following a protein and energy rich diet	Food cart passes a few times a day: breakfast, coffee round, soup round (at 11), and lunch	In the moment	Through nutrition assistant	Patient chooses how much he/she wants to eat in the moment (e.g. Two sandwiches)	• Soup: there is always a vegetarian soup option, a protein rich soup option, and a low sodium soup.
Protein rich (warm) meals	Patients following a protein and energy rich diet	In the afternoon	Around 14.30	Through ordering system (tablet)	1 product/portion size	• Small meal such as smoothie, salad, wrap
Dinner (spring menu)	Patients following a regular healthy diet and patients following a protein and energy rich diet	Patients have to order dinner in the morning.	Between 17.00-18.00	Through ordering system (tablet)	Through ordering system patient can choose for half or a full portion. If the patient needs a double portion, the nutrition assistant arranges that.	• Menu returns on a weekly basis. Daily (from Monday to Sunday) there is a different offer • Patient can choose from proposed animal protein-based or vegetarian meal, otherwise patient can make their own meal out of individual products. • At dinner the patient can choose an extra product (to eat later that night), one choice per day (e.g. bag of nuts, protein bar, smoothie).

Hospital C

Table 27: Overview food system and menus at Hospital C

Type of menu	Diet type (regular healthy diet/protein and energy rich diet)	Meal moment/ Ordering moment	Delivery time	Ordering method	Portion size options	Extra info
A la carte menu (summer season)	Patients following a regular healthy diet and patients following a protein and energy rich diet	3 meal moments: breakfast, lunch and dinner In between patients can choose from the **tapas menu** for extra protein rich snacks.	Max 45 min	Patient orders through nutrition assistant, and nutrition assistant lets the kitchen now what all patients at the hospital unit need	Main meals contain 150 g vegetables, 150 g starch and 80 g meat or fish	• Cycle of 6 days • For extra protein there is the tapas menu • The main meal offers 5 options (some meat-containing and some vegetarian), and a salad. The menu contains a logo for the vegetarian option.
Tasting menu (summer season)	Patients following a regular healthy diet and patients following a protein and energy rich diet	Nutrition assistant passes by 6 times a day with a food cart	Patient can choose in the moment which products to take from the truck	In the moment patient chooses from food cart.	Meals contain 90 gr vegetables/ 90 gr starch and 80 gr meat or fish The other 5 moments are protein- rich.	• Cycle of 6 days • Per meal there is choice out of 5 meals of which 2 are always vegetarian. Also one light digestible option.

Appendix C: Methodological differences between the protein quality calculations for this project the Alpha tool calculation

Table 28: Methodological differences in protein quality calculation for this project versus Alpha tool

	Project protein quality calculations	Alpha tool calculations
Amount of available and utilizable protein vs. MPQS score	Available and utilizable protein are calculated based on formulas. Available and utilizable protein per meal are shown. Criterion of required amount of protein per meal (20 g) is not taken into account in these formulas.	MPQS score calculated based on available EAAs compared to their requirements, where the requirement takes into account the criterion of protein that has to be met per meal (0.3 g protein per kg body weight, average is 70 kg, thus 0.3*70=21 g protein per meal). Score will be lower if the meal does not meet the 21 g.
Amino acids compared to the requirements	Methionine and cysteine are taken together (SAA).	Methionine and cysteine are taken separately. This means that with this method maybe methionine is limiting (and score will be lower), while with the project method it is not.
Amounts of amino acids	Since the amino acid composition data does not come from the NEVO database but from external databases, the sum of the amino acids does not coincide with total protein (according to NEVO). To correct for this, the amounts of amino acids are recalculated so that the sum of them coincides with total protein according to the NEVO.	Recalculation of amino acids is not done. This means that the sum of amino acids does not coincide with total protein (according to NEVO). Different amounts of amino acids are thus set against the requirements with this method. This can lead to differences in results (limiting amino acid, etc.).

Appendix D: Recipe and protein content information dinner meals hospitals A, B, and C

Hospital A

Table 29: Recipe information (ingredients, portion size, energy kcal) and protein content information per dinner meal offered at Hospital A

Dinner meal option (day)	Meal component	Portion size (g)	Energy (kcal)	Total protein (g)	Animal protein (g)	Plant protein (g)
Animal protein-based (Monday)	Pork steak	100	170	20.70	20.70	0.00
	Endive with bechamel	150	182	7.02	2.80	4.21
	Cooked potatoes	100	83	1.90	0.00	1.90
	Gravy	50	2.4	0.01	0.00	0.01
	Total	**400**	**437**	**29.62**	**23.50**	**6.12**
Vegetarian (Monday)	Vegetarian meatball	100	170	17.10	2.50	14.60
	Endive with bechamel	150	182	7.02	2.80	4.21
	Cooked potatoes	100	83	1.90	0.00	1.90
	Gravy	50	2.4	0.01	0.00	0.01
	Total	**400**	**436**	**26.02**	**5.30**	**20.72**
Animal protein-based (Tuesday)	Mackerel	130	372	20.39	19.50	0.89
	Bean trio	150	126	6.71	0.00	6.71
	Risotto	150	196	4.41	2.54	1.87
	Dill sauce	50	32	0.36	0.00	0.36
	Total	**480**	**726**	**31.87**	**22.04**	**9.83**
Vegetarian (Tuesday)	Quiche	175	419	15.23	8.84	6.39
	Bean trio	150	126	6.71	0.00	6.71
	Risotto	150	196	4.41	2.54	1.87
	Dill sauce	50	32	0.36	0.00	0.36
	Total	**525**	**773**	**26.71**	**11.38**	**15.33**
Animal protein-based (Wednesday)	Goulash	200	177	24.23	22.11	2.13
	Peas	150	135	8.50	0.00	8.50
	Mashed potato	100	123	2.56	0.85	1.71
	Total	**450**	**435**	**35.29**	**22.96**	**12.34**
Vegetarian (Wednesday)	Filled paprika	150	173	12.53	7.02	5.51
	Peas	150	135	8.50	0.00	8.50
	Mashed potato	100	123	2.56	0.85	1.71
	Total	**400**	**431**	**23.59**	**7.87**	**15.72**
Animal protein-based (Thursday)	Asian stew	350	365	24.53	18.79	5.74
Vegetarian (Thursday)	Asian stew vegetarian	350	425	21.81	1.53	20.28
	Redfish fillet	90	151	24.59	24.53	0.06

Animal protein-based (Friday)	Carrots with snow peas	150	89	2.16	0.00	2.16
	Fried potatoes	105	128	1.92	0.00	1.92
	Lemon sauce	50	26	0.18	0.06	0.12
	Total	**395**	**394**	**28.85**	**24.59**	**4.27**
Vegetarian (Friday)	Cheese omelet	130	198	16.29	16.29	0.00
	Carrots with snow peas	150	89	2.16	0.00	2.16
	Fried potatoes	105	128	1.92	0.00	1.92
	Lemon sauce	50	26	0.18	0.06	0.12
	Total	**435**	**441**	**20.55**	**16.35**	**4.21**
Animal protein-based (Saturday)	Beef steak	100	150	21.31	21.30	0.01
	Beetroot with onion	150	72	2.00	0.00	2.00
	Mashed potato	100	123	2.56	0.85	1.71
	Gravy	50	2	0.01	0.00	0.01
	Total	**400**	**347**	**25.88**	**22.15**	**3.73**
Vegetarian (Saturday)	Chickpea sausage	150	257	7.61	2.25	5.36
	Beetroot with onion	150	72	2.00	0.00	2.00
	Mashed potato	100	123	2.56	0.85	1.71
	Gravy	50	2	0.01	0.00	0.01
	Total	**450**	**454**	**12.18**	**3.10**	**9.08**
Animal protein-based (Sunday)	Chicken cordon bleu	100	151	22.10	21.30	0.80
	Bean mix	155	98	3.89	0.00	3.89
	Fried potatoes	105	128	1.92	0.00	1.92
	Gravy	50	2	0.01	0.00	0.01
	Total	**410**	**380**	**27.92**	**21.30**	**6.61**
Vegetarian (Sunday)	Mushroom ragout	140	277	11.40	3.13	8.27
	Bean mix	155	98	3.89	0.00	3.89
	Fried potatoes	105	128	1.92	0.00	1.92
	Gravy	50	2	0.01	0.00	0.01
	Total	**450**	**506**	**17.21**	**3.13**	**14.08**

Hospital B

Table 30: Recipe information (ingredients, portion size, energy kcal) and protein content information per dinner meal offered at Hospital B

Dinner meal option (day)	Meal component	Portion size (g)	Energy (kcal)	Total protein (g)	Animal protein (g)	Plant protein (g)
Vegetarian 1 (Monday)	Shakshuka	150	208	8.22	0.02	8.20
	Fried egg	35	45	4.31	4.31	0.00
	Nut rice	100	182	5.52	0.00	5.52
	Tzatziki	50	50	2.86	2.64	0.22
	Total	**335**	**485**	**20.91**	**6.97**	**13.94**
Vegetarian 2 (Monday)	Vegetarian sausage	80	281	10.64	9.6	1.04
	Rucola tomato mash	350	278	5.31	0.13	5.18
	Lentil salad	75	149	2.70	0.02	2.68
	Gravy	50	115	0.50	0.05	0.45
	Total	**555**	**832**	**19.15**	**9.80**	**9.35**
Animal protein-based (Tuesday)	Beef steak	80	108	17.04	17.04	0.00
	Broccoli	150	56	6.03	0.01	6.02
	Mashed potato	100	110	2.00	0.20	1.80
	Gravy	50	115	0.50	0.05	0.45
	Total	**380**	**389**	**25.57**	**17.30**	**8.27**
Vegetarian (Tuesday)	Beans, vegetables, and mushrooms	250	327	12.47	0.04	12.42
	Rice	100	131	3.10	0.00	3.10
	Kidney bean salad	75	110	4.06	0.04	4.02
	Total	**425**	**568**	**19.63**	**0.08**	**19.54**
Animal protein-based (Wednesday)	Chicken and vegetable balls	100	147	21.5.	21.5.	0.00
	Gravy	50	115	0.50	0.05	0.45
	Mashed endive	350	280	5.95	0.00	5.95
	Total	**500**	**542**	**27.95**	**21.55**	**6.40**
Vegetarian (Wednesday)	Pasta Bolognese (with plant-based mincemeat)	350	203	13.10	0.84	12.21
	Grated cheese	20	74	4.54	4.54	0.00
	Cucumber paprika salad	150	24	1.01	0.00	1.01
	Total	**520**	**301**	**18.65**	**5.38**	**13.22**
Animal protein-based (Thursday)	Nasi goreng	350	362	15.54	3.31	12.22
	Atjar	50	15	0.50	0.00	0.50

	Kroepoek	25	129	0.88	0.88	0.00
	Chicken	80	111	16.40	16.40	0.98
	Peanut sauce	50	149	4.50	0.00	4.50
	Total	**555**	**766**	**37.82**	**20.59**	**18.20**
Vegetarian (Thursday)	Chili without carne (with plant-based mincemeat)	250	253	18.18	0.93	17.25
	Rice	100	131	3.10	0.00	3.10
	Cucumber tomato salad	150	25	1.06	0.08	0.98
	Total	**500**	**409**	**16.34**	**1.01**	**21.33**
Animal protein-based (Friday)	Beef stew	130	159	19.45	17.70	1.75
	Couscous	100	139	5.24	0.86	4.38
	Green beans	150	46	3.07	0.01	3.06
	Total	**380**	**344**	**27.76**	**18.57**	**9.19**
Vegetarian (Friday)	Nasi goreng	350	362	15.54	3.31	12.22
	Atjar	50	15	0.50	0.00	0.50
	Peanut sauce	50	149	4.50	0.00	4.50
	Total	**450**	**526**	**20.54**	**3.31**	**17.22**
Vegetarian 1 (Saturday)	Pasta Bolognese	350	203	13.10	0.84	12.21
	Grated cheese	20	74	4.54	4.54	0.00
	Vegetarian balls	100	169	17.10	2.50	14.60
	Cucumber tomato salad	150	25	1.06	0.08	0.98
	Total	**620**	**471**	**35.80**	**7.96**	**27.79**
Vegetarian 2 (Saturday)	Shakshuka	150	208	8.22	0.02	8.20
	Fried egg	35	45	4.31	4.31	0.00
	Nut rice	150	182	5.52	0.00	5.52
	Chickpea salad	75	119	3.25	0.05	3.20
	Tzatziki	50	50	2.86	2.64	0.22
	Total	**460**	**604**	**24.16**	**7.02**	**17.14**
Animal protein-based (Sunday)	Salmon filet	120	251	22.64	22.01	0.63
	Potato tart	100	80	1.70	0.00	1.70
	Carrots	150	54	1.24	0.01	1.23
	Herbs sauce	50	228	1.77	1.74	0.03
	Total	**420**	**613**	**27.35**	**23.76**	**3.59**
Vegetarian (Sunday)	Vegetable mix with nuts	250	680	19.71	0.01	19.70
	Quinoa salad	75	55	2.44	1.03	1.41
	Potato tart	100	80	1.70	0.00	1.70
	Total	**325**	**815**	**23.85**	**1.04**	**22.81**

Hospital C

Table 31: Recipe information (ingredients, portion size, energy kcal) and protein content information per dinner meal offered at Hospital C

Dinner meal option (day)	Meal component	Portion size (g)	Energy (kcal)	Total protein (g)	Animal protein (g)	Plant protein (g)
Turkey fillet (day 1)	Turkey fillet	80	90	15.84	15.84	0.00
	Romanesco mix	150	41	5.84	0.00	5.84
	Noisette potatoes	150	125	2.85	0.00	2.85
	Gravy	30	16	0.00	0.00	0.00
	Total	**410**	**271**	**24.54**	**15.84**	**5.70**
Fried cod (day 1)	Fried cod	80	90	16.64	16.24	0.40
	Vegetable paella	150	47	2.85	0.00	2.85
	Yellow rice	150	219	4.80	0.00	4.80
	Paprika sauce	30	8	0.24	0.00	0.24
	Total	**410**	**363**	**24.53**	**16.24**	**8.29**
Beef meatball (day 1)	Beef meatball	80	242	21.20	20.24	0.88
	Green beans	150	35	2.70	0.00	2.70
	Cooked potatoes	150	125	2.85	0.00	2.85
	Espagnole sauce	30	26	0.78	0.57	0.21
	Total	**410**	**427**	**27.53**	**20.81**	**6.64**
Nut rice salad (day 1)	Nut rice salad	355	235	13.15	7.65	5.45
	Brown bread	60	155	6.60	0.00	6.60
	Margarine	5	36	0.00	0.00	0.00
	Total	**420**	**426**	**19.75**	**7.65**	**12.10**
Vegetarian Bolognese (day 1)	Vegetarian Bolognese	80	44	4.70	0.45	4.25
	Mixed vegetables	150	47	2.85	0.00	2.85
	Whole-weat macaroni	150	197	8.40	0.00	8.40
	Grated cheese	30	83	8.79	8.79	0.00
	Total	**410**	**370**	**24.74**	**9.24**	**15.50**
Vegetarian chicken (day 1)	Vegetarian chicken	80	91	11.20	1.12	10.08
	Broccoli mix	150	41	5.85	0.00	5.85
	Mashed potatoes	150	537	14.40	1.50	12.90
	Espagnole sauce	30	26	0.78	0.57	0.21
	Total	**410**	**694**	**32.23**	**3.19**	**29.04**
Beef teriyaki (day 2)	Beef teriyaki	80	30	6.32	6.32	0.00
	Grilled vegetables	150	47	2.85	0.00	2.85

	Whole-weat noodles	150	197	8.40	0.00	8.40
	Total	**380**	**273**	**17.57**	**6.32**	**11.25**
Vegetable burger (day 2)	Vegetable burger	80	154	14.16	1.36	12.80
	Beetroot and apple	150	67	1.05	0.00	1.05
	Cooked potatoes	150	125	2.85	0.00	2.85
	Gravy	30	16	0.00	0.00	0.00
	Total	**410**	**360**	**18.06**	**1.36**	**16.70**
Pork (day 2)	Pork	80	91	17.76	17.76	0.00
	Chicory	150	26	1.80	0.00	1.80
	Potatoes	150	537	14.40	1.50	12.90
	Espagnole sauce	30	26	0.78	0.57	0.21
	Total	**410**	**679**	**34.74**	**19.83**	**14.91**
Potato salad (day 2)	Potato, tomato and mozzarella salad	360	220	10.47	7.18	3.29
	Brown bread	60	155	6.60	0.00	6.60
	Margarine	5	36	0.00	0.00	0.00
	Total	**425**	**410**	**17.07**	**7.18**	**9.89**
Codfish (day 2)	Codfish	80	84	18.40	18.40	0.00
	Peas, carrots	150	52	3.00	0.00	3.00
	Quinoa	150	171	6.60	0.00	6.60
	Hollandaise sauce	30	54	0.21	0.06	0.18
	Total	**410**	**385**	**28.74**	**18.46**	**10.31**
Vegetarian nuggets (day 2)	Vegetarian nuggets	80	204	12.00	1.68	10.32
	Green beans	150	38	2.70	0.00	2.70
	Cooked potatoes	150	125	2.85	0.00	2.82
	Espagnole sauce	30	26	0.78	0.57	0.21
	Total	**410**	**392**	**18.33**	**2.25**	**16.08**
Fried sausage (day 3)	Fried sausage	80	181	13.44	13.44	0.00
	Fajita vegetable mix	150	128	6.75	0.00	6.75
	Smashed sweet potato	150	141	1.65	0.00	1.65
	Gravy	30	16	0.00	0.00	0.00
	Total	**410**	**465**	**21.84**	**13.44**	**8.40**
Chicken tandoori (day 3)	Chicken tandoori	80	87	18.64	18.64	0.00
	Mixed vegetables	150	47	2.85	0.00	2.85
	Brown rice	150	197	4.65	0.00	4.65
	Total	**380**	**276**	**14.58**	**7.08**	**7.50**

Nasi (day 3)	Nasi	80	219	4.80	0.00	4.80
	Tjap tjoy	150	33	1.50	0.00	1.50
	Foe yong hai	150	102	9.84	9.84	0.00
	Seroendeng	30	94	3.54	0.00	3.54
	Total	**410**	**448**	**19.68**	**9.84**	**9.84**
Pasta chicken salad (day 3)	Pasta chicken salad	360	195	13.85	8.34	5.51
	Brown bread	60	155	6.60	0.00	6.60
	Margarine	5	36	0.00	0.00	0.00
	Total	**425**	**386**	**20.45**	**8.34**	**12.11**
Beef steak (day 3)	Beef steak	80	82	16.96	16.96	0.00
	Endive	150	35	2.10	0.00	2.10
	Cooked potatoes	150	125	2.85	0.00	2.85
	Espagnole sauce	30	26	0.78	0.57	0.21
	Total	**410**	**267**	**22.69**	**17.53**	**5.16**
Vegetarian meatball (day 3)	Vegetarian meatball	80	105	7.30	0.70	6.61
	Spinach and egg	150	115	11.41	9.26	2.18
	Spaghetti	150	197	8.40	0.00	8.40
	Tomato sauce	30	18	0.48	0.00	0.48
	Total	**410**	**434**	**27.58**	**9.92**	**17.66**
Hake fillet (day 4)	Hake fillet	80	72	15.44	15.44	0.00
	Ratatouille	150	47	2..85	0.00	2.85
	Tagliatelle	150	197	8.40	0.00	8.40
	Normandic fish sauce	30	27	0.39	0.12	0.30
	Total	**410**	**342**	**27.08**	**15.56**	**11.55**
Turkey fillet (day 4)	Turkey fillet	80	90	15.84	15.84	0.00
	Green beans	150	38	2.70	0.00	2.70
	Cooked potatoes	150	125	2.85	0.00	2.85
	Espagnole sauce	30	26	0.78	0.57	0.21
	Total	**410**	**278**	**22.17**	**16.41**	**5.76**
Beef steak (day 4)	Beef steak	80	106	16.56	16.56	0.00
	White cabbage curry	150	24	1.35	0.00	1.35
	Rosti potatoes	150	267	3.00	0.00	3.00
	Tomato sauce	30	18	0.48	0.00	
	Total	**410**	**416**	**21.39**	**16.56**	**4.83**
Quinoa salad (day 4)	Quinoa salad with smoked salmon	360	212	12.60	7.81	4.79
	Brown bread	60	155	6.60	0.00	6.60
	Margarine	5	36	0.00	0.00	0.00
	Total	**425**	**402**	**19.20**	**7.81**	**11.39**
Soja balls (day 4)	Soja balls	80	105	7.30	0.70	6.60

	Carrots	150	48	1.05	0.00	1.05
	White rice	150	219	4.80	0.00	4.80
	Espagnole sauce	30	26	0.78	0.57	0.21
	Total	**410**	**397**	**13.93**	**1.27**	**1267**
Vegetarian schnitzel (day 4)	Vegetarian schnitzel	80	181	12.16	1.76	10.40
	Cauliflower	150	35	2.70	0.00	2.70
	Fried potatoes	150	125	2.85	0.00	2.85
	Gravy	30	16	0.00	0.00	0.00
	Total	**410**	**356**	**17.71**	**1.76**	**15.95**
Bami (day 5)	Bami	80	29	1.80	0.00	1.80
	Babi pangang	150	39	7.08	7.08	0.00
	Spicy vegetables pineapple	150	47	2.85	0.00	2.85
	Seroendeng	30	94	3.54	0.00	3.54
	Total	**410**	**359**	**24.12**	**12.93**	**11.19**
Chicken fillet (day 5)	Chicken fillet	80	87	18.64	18.64	0.00
	Tuscan vegetable mix	150	47	2.85	0.00	2.85
	Fried potatoes	150	125	2.85	0.00	2.85
	Mushroom sauce	30	6	1.14	0.00	1.14
	Total	**410**	**265**	**25.48**	**18.64**	**6.84**
Red lentil curry (day 5)	Red lentil curry	80	88	6.15	0.00	6.15
	Broccoli	150	41	5.85	0.00	5.85
	Couscous	150	189	6.45	0.00	6.45
	Cashew nuts	30	185	6.36	0.00	6.36
	Total	**410**	**502**	**24.80**	**0.00**	**24.80**
Greek salad (day 5)	Greek salad	135	190	1.20	0.12	1.08
	Brown bread	60	155	6.60	0.00	6.60
	Margarine	5	36	0.00	0.00	0.00
	Total	**200**	**237**	**7.80**	**0.12**	**7.68**
Steak tartar (day 5)	Steak tartar	80	110	16.88	16.88	0.00
	Spinach and egg	150	115	11.40	9.23	2.18
	Cooked potatoes	150	125	2.85	0.00	2.85
	Gravy	30	16	0.00	0.00	0.00
	Total	**410**	**365**	**31.13**	**26.11**	**5.03**
Vegetarian stir-fry strips (day 5)	Vegetarian stir-fry strips	80	91	11.20	1.12	10.08
	Peas	150	104	6.00	0.00	6.00
	Cooked potatoes	150	125	2.85	0.00	2.85
	Tomato sauce	30	18	0.48	0.00	0.48

	Total	**410**	**338**	**20.53**	**1.12**	**19.41**
Boeuf bourguignon (day 6)	Boeuf bourguignon	80	56	7.19	7.19	0.00
	Cabbage	150	32	1.65	0.00	1.65
	Cooked potatoes	150	125	2.85	0.00	2.85
	Total	**380**	**212**	**11.69**	**7.19**	**4.50**
Falafel burger (day 6)	Falafel burger	80	166	5.44	0.00	5.44
	Green beans	150	38	2.70	0.00	2.70
	Cooked potatoes	150	125	2.85	0.00	2.85
	Espagnole sauce	30	26	0.78	0.57	0.21
	Total	**410**	**354**	**11.77**	**0.57**	**11.20**
Omelet (day 6)	Omelet	80	102	9.84	9.84	0.00
	Leak	150	33	1.65	0.00	1.65
	Brown rice	150	197	4.65	0.00	4.65
	Mushroom sauce	30	6	1.14	0.00	1.14
	Total	**410**	**338**	**17.28**	**9.84**	**7.44**
Pasta chicken salad (day 6)	Pasta chicken salad	360	195	13.85	8.34	5.51
	Brown bread	60	155	6.60	0.00	6.60
	Margarine	5	36	0.00	0.00	0.00
	Total	**425**	**386**	**20.45**	**8.34**	**12.11**
Pork fillet (day 6)	Pork fillet	80	102	18.64	18.64	0.00
	Cauliflower	150	35	2.70	0.00	2.70
	Mashed potatoes	150	537	14.40	1.50	12.90
	Gravy	30	16	0.00	0.00	0.00
	Total	**410**	**690**	**35.74**	**20.14**	**15.60**
Salmon (day 6)	Salmon	80	143	16.00	16.00	0.00
	Carrots	150	48	1.05	0.00	1.05
	Whole-wheat pasta	150	197	8.40	0.00	8.40
	Chive sauce	30	27	0.39	0.12	0.30
	Total	**410**	**415**	**25.84**	**16.12**	**9.75**