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Plan my Meals - Automatic meal planning and nutrition monitoring

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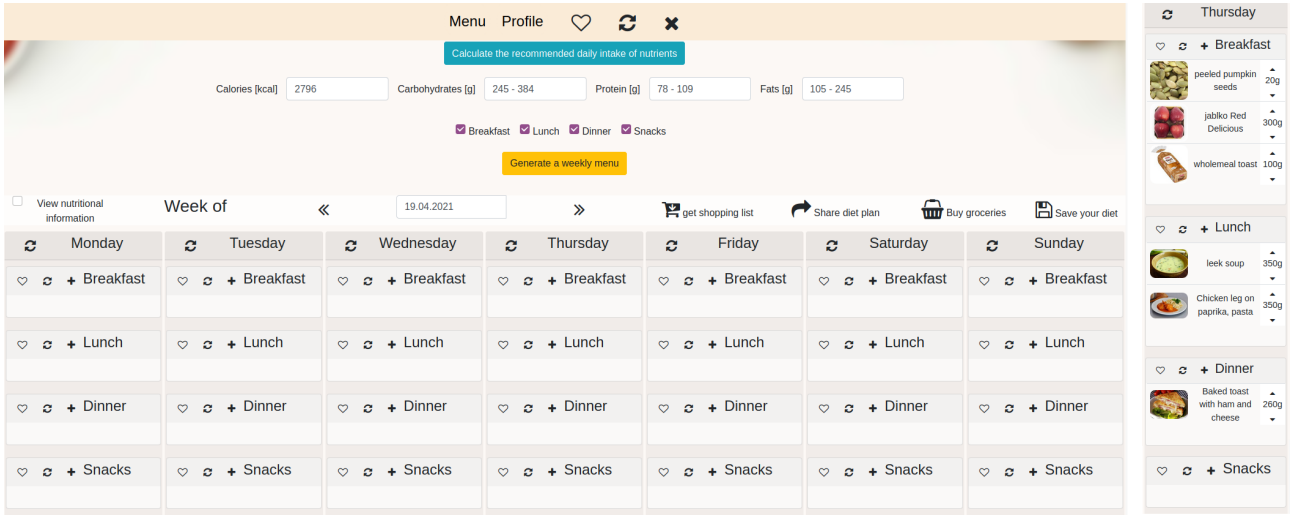

Abstract

The aim of this work is design and implementation of a web-based application that helps its users to improve their eating habits and potentially contributes to the reduction of food waste. The app allows users to easily plan their meals, monitor nutrition in their diet and automatically generate personalized meal plans according to their body predispositions, goals, and lifestyle. Most attention was given to the design and testing of a user interface that would allow users to effectively manage their meal plans.

Keywords: Meal planner — Meal plan generator — Nutrition monitoring — Web application — Django — User interface

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1. Introduction

The problematic of a proper diet is increasingly more important for the public [1] and it is possible to find a lot of information about this topic on the internet. There are many examples of diet plans and recommendations of "the ideal diet" [1]. But for one to really change his eating habits could be very difficult. One of the reasons I think is that people who want to stick to their diet need to put some extra effort into planning what and when they should eat. What will they cook and what food they need to buy. In other words, they have to spend more time planning and thinking about food choices and after some time it can become annoying. The lack of planning related to eating is in my opinion also one of the main causes of unnecessary consumer food waste. I think that better planning of eating could thus additionally help to reduce the amount of food waste among consumers.

[1] https://www.similarweb.com/top-websites/category/health/nutrition-diets-and-fitness/

The primary goal of this work is to design and implement a web application that would help its users to improve their eating habits. The main focus is on an intuitive user interface that allows users to easily plan meals and monitor their nutrition intake. The process of planning must be simple and efficient. Apart from that, it should bring users some other useful functions, like show recipes for selected meals, export a shopping list, or automatically prepare an order of groceries in an online grocery store (e.g. rohlik.cz[2]). It should lead to the building of a positive relationship with the user, which would later allow collecting data about users eating habits. This data could afterward be used to make more personalized recommendations of meals and whole personalized diet plans. The final application should allow users to plan their meals for the whole week in a fast and efficient way and users should feel motivated to eat according to their plan. It would be a great success if users of the application ate more properly and wasted less food than before using the application.

2. Existing solutions

There are many existing solutions related to this problem, but they usually focus either on meal planning or nutrition monitoring or meal recommendations.

I have found only one foreign app that well combines all mentioned functionality and it is called EatThisMuch [3]. It is a very sophisticated solution and it provides almost all desired functionality highlighted in the previous chapter. It allows users to plan individual meals in a day, add ingredients to these meals, monitor nutrition values, generate recommended meals and meal plans according to users' preferences. The app is very well-designed, it is user-friendly, and offers useful functionality. As one of the main disadvantages of the application, I see the fact that a lot of basic functions like the option to plan more days in the future or getting a grocery list are available only in a prepaid version. The app in general is more focused on single days than a whole week, at least in the free version. Also as it is mainly focused on the US market, the food found in the app is often not very common in the Czech Republic and typical Czech foods are impossible to find there. There is an existing option to create your own meals but creating each meal from scratch doesn't seem very practical when someone wants to quickly plan their meals for a week. Overall, if we dismiss the facts about limited free functionality and unavailability of local food, this solution would be almost perfect based on requirements for our solution. The unavailability of local food is a common problem for all similar foreign apps.

In the Czech Republic, there is no existing alternative, which would provide the same functionality on the same quality level. One of the most used local apps is "kaloricketabulky.cz" [4]. This app mainly focuses on monitoring of nutrition intake, and it could be used for planning meals. The advantage is a huge database of local food with detailed nutrition information and the option to easily add food to the meal plan for one day. Unfortunately, there is no option to fill meal plans automatically or to show some personalized recommendations. Also, the lack of a weekly view makes planning for more days less effective than it could be.

In my implementation, I tried to overcome mentioned weaknesses and created an application that brings desired functionality into one place.

3. Design of UI

Users need a tool that would let them easily plan their meals for a whole week and they need to have a good overview of this weekly meal plan. It should be easy and effective to build and adjust the meal plan. The whole process of planning needs to have an option to be more or less automatized and users should be provided with personalized recommendations of food, meals, and full plans. As a bonus, users get a good overview of nutrition in meals and their diet. Later, they would have the option to export a shopping list or an option of a direct groceries order.

3.1 Weekly meal plan overview

Proper visualization of the full week meal plan is the most important factor in the UI design of this application. All the main functionality is linked to the meal plan overview and users would interact with this component most of the time while using the application.

In the final version, the layout is divided into seven columns. Columns represent days in a week and each column consist of several meals based on user preference on the number of meals in a day. This layout allows users to effectively work with the full plan for a whole week. It allows to easily manipulate foods between meals and days and to select and to adjust multiple choices at once. It offers a clear overview of the weekly meal plan with nutritional information and provides easy access to all desired functions.

[2] https://www.rohlik.cz/

[3] https://www.eatthismuch.com/

[4] https://www.kaloricketabulky.cz/

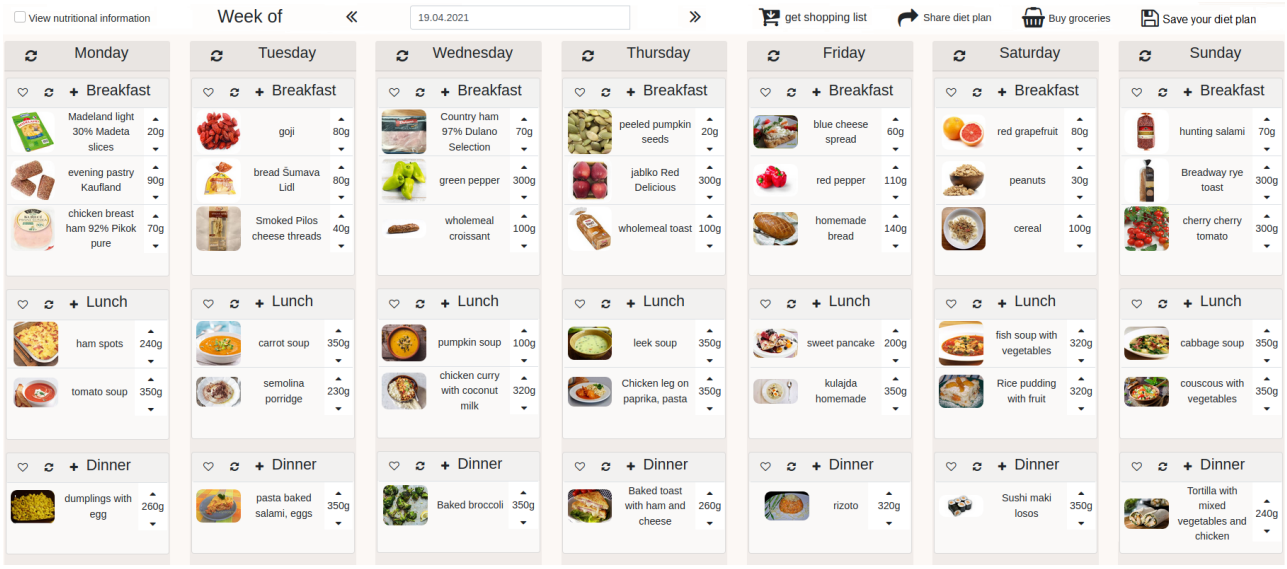

Figure 1. Weekly meal plan overview with generated meals

3.2 Nutrition monitoring

Nutrition intake monitoring is a required feature because it will enable a better understanding of users' eating habits and users could be provided with better feedback. It will make it possible to create and display statistics about their diet over time. It will also be crucial for recommending suitable foods and whole diet plans tailored to the specific user.

For users to have a better insight into their diet, nutrition statistics are shown for every day and also for individual meals in a day. For every food in the database, there is available information about the basic nutrients per 100 grams. That includes kilo-calories, carbs, sugars, proteins, and fat. It could furthermore help users to prepare more balanced meal plans that correspond to their recommended nutrition intake, which could also be calculated in the application.

3.3 Meal search and adding to plan

Adding food and whole meals to the weekly meal plan will be one of the most frequent tasks of the user during manual food planning. It must therefore be easily accessible, simple, and fast. Added food and meals, may be more often included in the recommended diet, same as foods similar to those or foods added by similar users. I also think that the activity of recording the consumed food can be psychologically beneficial for users while following a certain diet. With each recorded food, users create some visible evidence that they ate as they should. This can bring them a good feeling about themselves, increase their motivation for further continuation in a diet and reduce the likelihood of cheating on a diet.

To achieve that easily, users can either directly select a food from the list of recommended foods, from the list of their favorite foods, or they can start searching for a specific food in the database. If the searched food is not in a database, users have an option to create new foods. It is of course possible to remove added food from the plan or adjust the amount. To simplify and speed up work with the weekly meal plan, it is possible to select several meals and add selected foods to all of them at once, so that it is not necessary to search for and add the same foods repeatedly. It is also possible to select several foods and remove them all at once. Selected foods in the plan can also be added to other meals on any day without the need to search again.

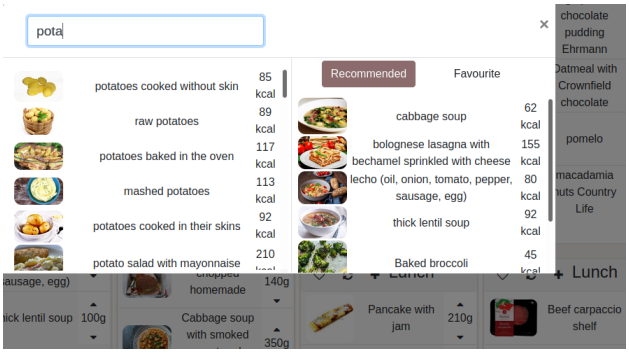

Figure 2. Modal window for food search with recommended and favourite foods

3.4 Favourite food and meals

For better personalized recommendations, a faster search of favorite foods and more friendly user experience, it is necessary to allow users to provide some feedback on an ongoing basis. One way to enable this for users is an option to add a specific food or an entire meal to their favorite foods/meals. This will make it easier for them to find food if, for example, they often add it to their meal plan. At the same time, users'

favorite foods and meals are important information for generating personalized meal plans. By adding foods and meals to favorites, users will increase the personalization level of recommended meals.

3.5 Automation tools

There is a functionality that lets users automatically generate recommended meals in a day or a meal plan for the entire week. The goal is to generate personalized and balanced meal plans or at least inspire users with individual meals or meal plans and ease the process of their meal planning. The quality of generated meal plans could be evaluated based on how its nutrition values fit the requirements, how well are individual foods combined and how are the combinations suitable for individual meals in a day.

Users have an option to set up the generator so that the generated meal plan corresponds more to their preferences. It was therefore necessary to decide which parameters users will be able to specify before generating the meal plan. Height, weight, age, gender, level of physical activity, and the user's goal were chosen as the main ones. The goal can be one of: "lose weight", "gain weight" or "maintain the current weight". These parameters are sufficient for a calculation of a recommended daily nutrient intake. The user has the option to generate a meal plan for the entire week and can also generate or regenerate a plan for individual days or only selected meals. This is the second option how can users easily set up and customize their meal plan in a more automated way. The simplified algorithm for generating meal plans could be described by the following diagram.

4. Automatic generation of meal plans

The ideal output of the meal plan generator would be a perfectly balanced weekly meal plan tailored to the users' needs and preferences. To achieve that, it is necessary to design an algorithm that could come up with such an output based on available data. To reach this ideal output, additional work has to be done. In this work, it was about getting a step closer to the ideal. It is important to state what kind of data we have and how this data could be used to generate suitable meal plans for users. Also, what properties should a suitable meal plan have.

The meal plan is planned for 7 days, and it consists of several meals for every day. Meals are divided into 4 categories: "breakfast", "snack", "lunch" and "dinner". In every meal, there could be a random amount of different foods. There is a database created for purposes of the app with roughly 10000 foods with nutrient information. The Food is divided into categories and subcategories. There are 11 main categories and 52 subcategories. Few examples of categories could be "Fruit", "Vegetable", "Meat" or "Main dish". This food data was collected with permission from the site mentioned in section 3.2. From users, we have information about their height, weight, goal, age, gender and level of physical activity. We also know what foods they manually added to meal plans recently and what foods and meals are saved as their favourite. Before planning meals, we need to calculate recommended daily nutrition intake for a user. At first, we need to calculate the resting metabolic rate (RMR). We can use the Mifflin-St. Jeor equation which is proven to be the most effective method for this purpose: [2]

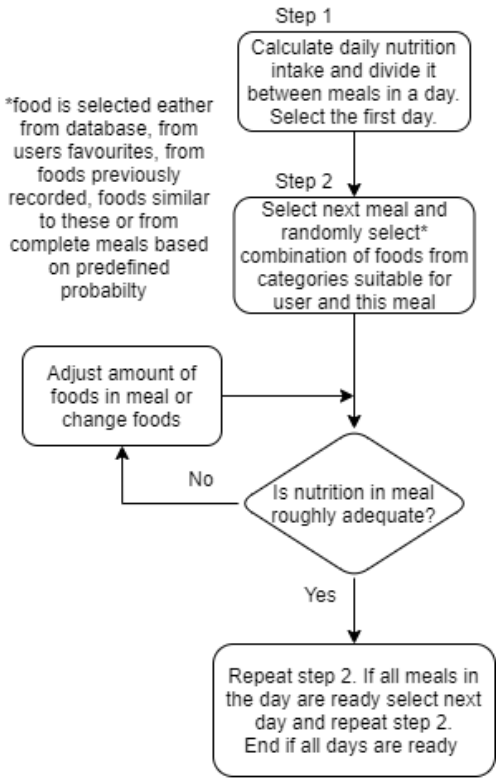

Figure 3. Simplified meal plan generator algorithm

- Men: calories/day = 10 x weight (kg) + 6.25 x height (cm) – 5 x age (y) + 5
- Women: calories/day = 10 x weight (kg) + 6.25 x height (cm) – 5 x age (y) – 161

Equation 1. Calculation of RMR for men and women

RMR is increased for 10% which roughly accounts for energy needed to digest food [3]. Than it is adjusted to users activity level using activity multiplier. This way is estimated the Total Daily Energy Expenditure (TDEE) or total calories intake per day needed for maintaining weight.[2] If the user's goal is to lose or gain weight, TDEE is decreased or increased by 10%

- Sedentary = RMR x 1.2 (little or no exercise, desk job)
- Lightly active = RMR x 1.375 (light exercise/ sports 1-3 days/week)
- Moderately active = RMR x 1.55 (moderate exercise/ sports 6-7 days/week)
- Very active = RMR x 1.725 (hard exercise every day, or exercising 2x/day)
- Extra active = RMR x 1.9 (hard exercise 2 or more times per day)

Equation 2. Adjustment of RMR by activity level

respectively. Now we know the approximate amount of calories there should be in a meal plan for every day. This amount should ideally be distributed between main macronutrients in a ratio recommended for an average person. Carbs should account for 45%-65% of energy, protein 10%-35% of energy, and fat 20%-35% of energy.[4] Recommended ratio could be manually adjusted. The level of personalization of generated meal plans would depend on the amount of data available about individual users.

5. Architecture and implementation

The solution is a web application, so it is based on client-server architecture. As the main implementation framework was used the Django framework. It supports the fast development of scalable and secure web applications built in Python. Django uses the Model-View-Template design pattern for the development of web applications.

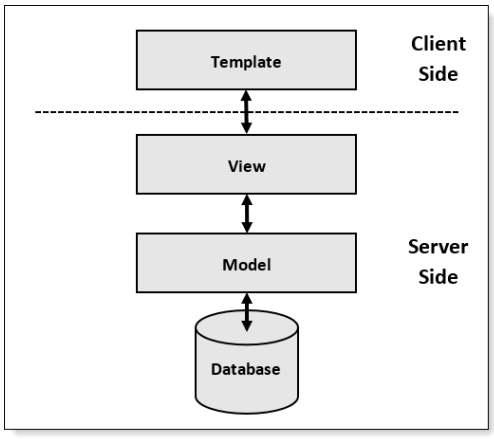

Figure 4. Model-View-Template design pattern

The model is the data access layer. It is an object that mirrors the tables that are in the database. The main models created in this application are models for food, user, meal, and meal plan

The view is the business logic layer. It has the rules to access the data through models and pass them to the appropriate templates. All data processing, responding to the users requests and propagation of changes to the database through models take place there.

The template is the presentation layer. It has all the information about how to present the data. All UI design is implemented there with the use of HTML layouts, CSS and JavaScript codes.[5]

JavaScript is used for handling some of the user's interactions with the frontend on the client's side. It is used for the implementation of asynchronous communication with the server (view). It asks for data and transforms asynchronously received data which are in JSON format. For example, JavaScript function implemented for responsive food search asynchronously gets new search results through view whenever input in search-bar is changed. JavaScript is also responsible for making dynamic changes on the page like manipulation with elements and changing their colors and other properties.

6. Evaluation of generated meal plans

By experimenting with the created module for the automatic generation of meal plans, we can now determine the properties of automatically generated meal plans and state whether the nutritional composition corresponds to the required values. For the purpose of the experiments, a model person is selected, who has a height of 178 cm, a weight of 84 kg, and an age of 42 years. These are approximately the characteristics of the average man in the Czech Republic. His goal is to maintain his weight and his physical activity is on average level. The recommended daily nutrient intake calculated in the application is as follows:

- Calories: 2971 kcal
- Carbohydrates: 260 - 409 grams
- Proteins: 83 - 126 grams
- Fats: 111 - 260 grams

The following table shows the nutritional statistics of automatically generated meal plans for our model person with a different number of generated samples.

Generated days	7	30	100
Average calories	2526	2674	2895
Average carbohydrates	285	305	328
Average proteins	101	102	109
Average fats	98	107	126

Table 1. Table of nutritional statistics per day

We can see that average nutritional values of automatically generated meal plans for a day are with growing samples converging to optimal calculated recommended nutrition intake. However, differences between individual days are significant. The deviation

between minimal and maximal nutritional values is quite high as the following table shows.

	min	max
calories	1826	3574
carbohydrates	135	540
proteins	72	165
fats	56	167

Table 2. Table of minimal and maximal nutritional values per day in 30 generated days

The automatically generated meal plans don't always fit nutritional requirements, but by regenerating the days or the individual meals that are most off in their nutrition, users can create balanced meal plans with optimal nutritional values. Meals don't repeat very much and almost every newly generated combination of foods is unique as there is a lot of foods to choose from. Every unsuitable meal could eventually be easily regenerated. Evaluation of the gastronomical quality of generated meals is left to users, and it is more discussed in the next chapter.

7. User testing

Testing was mainly focused on the user interface and user experience. Especially on clarity, usability, and usefulness factors. Questions thus were as follows.

- Is it clear to the user how to use the application?
- Is the application useful for meal planning?
- Is the process easy, comprehensible, and effective?
- Can the user easily determine recommended nutrition intake and monitor nutrition in their diet?
- What do users think about the quality of automatically generated meals and meal plans?

In other words, the goal was to determine, if users can easily achieve specified goals if the processes are effective and how does the solution satisfy specified requirements. Testing was divided into two parts and after finishing each part users were given a short survey related to the test. The application was tested on five users so far.

7.1 GUI testing

The first part of the testing was primarily focused on the overall layout of application and design of individual elements. The aim was to find out, if the functionality of elements was clear at the first sight, if users orient themselves in the app environment well and if they can predict the results of specific actions.

In this test, users have not been given any specific tasks. They were just asked to think aloud and try to use the application however they want. This type of testing has been performed through the development since the first prototypes. This allowed to continually reveal weaknesses, helped to better specify requirements for the application, and make design changes in the early stages of development. For example in the original UI design, individual days of meal plan were stacked vertically. Testing has shown that this design was kind of confusing and could be the cause of inefficiencies while using the application. Also, the look of many components and icons was changed.

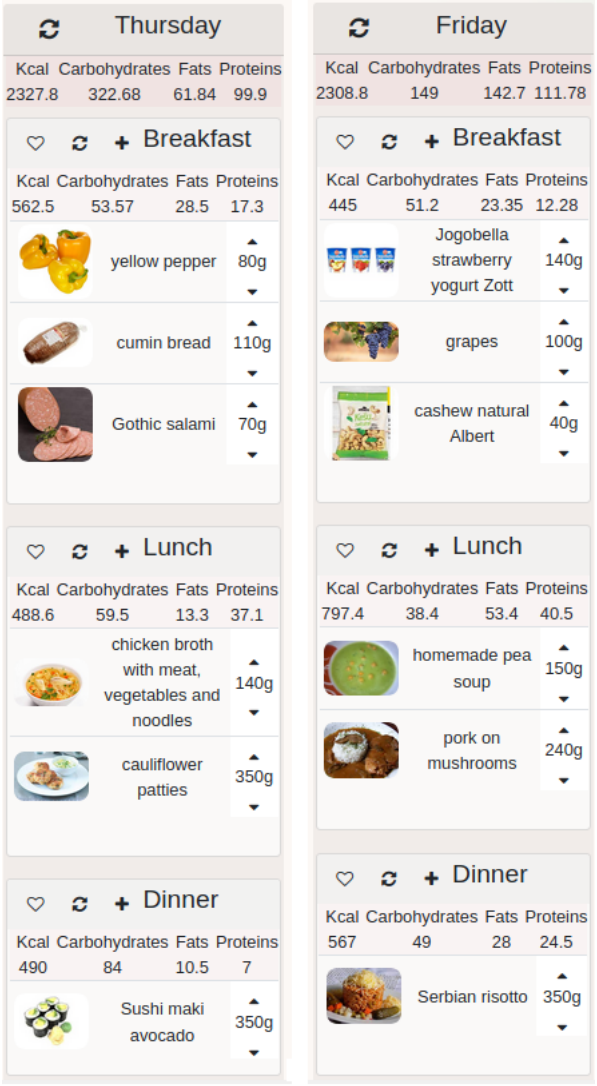

Figure 5. Example of generated meals in two days with displayed nutritional information (for clarity, snacks are not displayed)

7.2 Usability testing

intake". Afterward, users had to rank following and some more statements on a scale from one to ten in the survey, where one means totally disagree and ten means totally agree. Based on the results, corresponding improvements in food search, food selection, and generator were implemented.

Based on the answers from surveys, users quickly learned how to use the application and seemed to be overall satisfied with the application. They find it as an easy-to-use, beneficial tool for planning meals for a week. They claimed the process to be simple and efficient, and they had been inspired by automatically generated meals and meal plans. The app also allowed them to easily determine their recommended nutrition intake and monitor nutrition in their diet.

Statement	Score
I quickly learned how to use the application	8.5
I found preparation of a weekly meal plan easy and effective	7.9
I quickly found all individual foods I wanted	8.2
I used some recommended foods during preparation of the meal plan	7.1
The app allowed me easily determine my recommended nutrition intake and monitor nutrition in meals	9.3
Combinations of foods in individual automatically generated meals were suitable	7.2
I incorporated automatically generated meals, or I was inspired by them	8.6
The overall quality of automatically generated meal plans seemed good to me	6.2

Table 3. Results of testing with the five initial users

8. Conclusions

The aim of this work was design and implementation of an application that gives users a better overview over their diet, lets them easily plan or record their meals with the option to monitor the nutritional composition and eventually helps to improve users eating habits and contributes to the reduction of food waste.

It brings users a functionality to easily plan their meals for a whole week. The key part is the intuitive user interface with automation tools which can make this process fast and effective. It allows users to effectively create and manage their weakly meal plan, overview nutrients in their diet, and more. There is a function for the calculation of a recommended daily nutrition intake and also a meal plan generator that could prepare the weekly meal plan automatically according to individual user predispositions. More functions like shopping list export, automatic grocery order, or incorporation of food recipes are currently under development and there is a lot of other interesting functions I have in mind that could be implemented in the future. It is also worth noting that the application is cross-platform and, thanks to its fully responsive design, is available for a wide range of devices with different display sizes.

There is of course much to improve on the quality of automatically generated meal plans. Both at the level of nutritional quality and at the level of personalization for individual users. It could be done by using some machine learning technique as more data becomes available from users. There could be more specific generator settings, for example for users with specific allergies or diets. It could also be worthwhile to incorporate some gamification techniques that would make the process of planning more fun and that would motivate users to follow their plans.

How tests have shown so far, the application is useful for purposes stated at the beginning of this chapter. Nevertheless, more time and testing is needed for final conclusions on the impact of the application on the eating habits of long-term users and the amount of their food waste. Further software-side testing is also required before the application can be fully published. The publication is expected by the end of June 2021.

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