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# A Diet Recommendation System for Persons with Special Dietary Requirements

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**Abstract:** A food recommender system assists consumers in selecting daily diets based on specific dietary guidelines. This study outlines the unique nutritional requirements of foods and the purposes of a diet recommender system to assist the person who is the victim of various diseases due to deficiency or abundance of Nutrition. The recommender system utilizes two inputs, the nutrition-based food dataset, and the the person's health profile. In this research, knowledge from the physiology field describes reasons for diseases that grow up due to inadequate or excessive intake of Nutrition in food. The diet recommendation system uses the K-means clustering algorithm, the food inference algorithm, and the patient nutrition calculation algorithm to prescribe the best food per individual patient's nutrition requirement. The food inference algorithm is based on two parameters: The K means clustered food dataset and the patient nutrition calculation value. Our study utilizes the confusion matrix to evaluate the system's performance to obtain Precision, Recall, and F measure. The result of our research is a diet recommender system that recommends the food dish(s) having an appropriate quantity of Nutrition, taking into account the gender, age, and current nutrition status of the person. This system's significant advantage is reducing the excessive usage of medicine and preventing side effects. The diet recommender system can also help a person to pre-cure from disease and get rid of appointments with a physician for medication and food prescriptions.

**Keywords:** Nutrition, Diet Recommendation, K-means Clustering, Unsupervised Learning, and Inference Algorithm.

## 1. Introduction

Recommenders are a typical example of machine learning approaches. However, these approaches have not yet been extensively used in health information systems and medical applications [1]. The recommender system offers a list of related things based on an individual's health characteristics [2]. These systems strive to rate items in terms of user preferences to recommend suitable food products to the user. Recommender systems are an information-based method that uses particular domain expertise to determine the recommendations, which is a fundamental approach in designing recommender systems [3]. Recommender systems give a stage to suggest such an item that is significant and adequate for individuals. Such a framework depends on the highlights of the thing, quiet inclinations, and brand data. This sifting-based framework gathers much data progressively from the patient's advantages, appraisals, decisions, or the thing's conduct; at that point, it channels this data to give increasingly imperative data [4].

Currently, there are several recommender systems available and broadly used, for example, Amazon, Facebook, Flicker, and Netflix. These frameworks give customized proposals to clients. Recommender

frameworks take care of data over-burden and help clients browse the alternatives in their everyday life [5]. Recommender frameworks gather the previous inclinations of clients and produce a suitable suggestions for things to fulfill the clients. The client inclination data can be gained by express appraisals or verifiable evaluations. Numerous customary recommender frameworks have focused uniquely on single-client models [6]. A recommender framework can foresee whether an individual would buy an item, founded on the patient's inclinations. This framework can be actualized depending on a patient's or thing's profile [7]. In a universe loaded with data and an assortment of decisions, it gets hard for individuals to pick the best out of the bests, which coordinates their inclinations. This is where the recommender framework becomes possibly the most critical factor; it assists individuals with discovering the best for them [8].

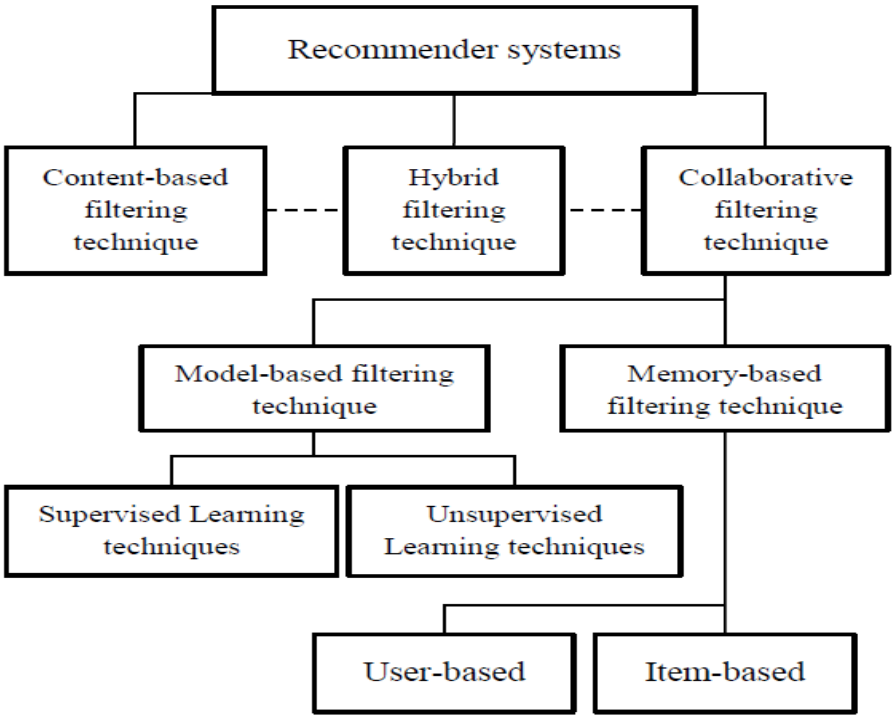


**Figure 1.** Framework of Recommender System [9]

**2. Problem Statement**

Food is a basic need of every living body. There are different authors from a variety of the knowledge domain who are working on food, and they are also working on the impact of food on living bodies; they are working on the quality of food. So, to live, the body needs food to grow up [10]. Furthermore, the feed also contains such kinds of chemical elements named ingredients. Making ingredients are being utilized for the making of food. In the database of the Food and Drug Administration (FDA) [11], there is a list of over three thousand ingredients. In this research, machine learning plays a vital role in pressure, preventing and prescribing food according to the patient's health and diseases [12]. In this research, the researcher proposed a Diet Recommender System that recommends food to patients rather than medicine. After normalizing this dataset is used a machine-learning algorithm on this dataset, and then an algorithm is proposed that infers data from trained data. Furthermore, hence food is prescribed rather than medicine to the patient.

**3. Related Work**

Despite the facts mentioned above and figures, maintaining a healthy intake of food is of paramount importance. However, keeping track of personal food needs due to the wide variety of dietary components

and products is very difficult for an average individual. A framework of a standardized food recommendation program is required to prescribe the correct food given the person's disease [13]. The critical challenge in developing such a program is the handling of larger quantities of data in terms of ingredients, amount, medical information, expectations of people, and at the same time, taking into account the pathological reports of an individual. A patient, for the most part, presents with a grievance or an issue. Making the correct determination is a critical advance in beginning the proper treatment [14]. Making an accurate determination depends on coordinating numerous snippets of data. Furthermore, therefore recommendations based on the health situation of the patient would be highly beneficial and helpful in this regard [15]. Around 1 out of each disease from coronary illness, stroke, and Type 2 diabetes are connected to a terrible eating routine. That is around 1,000 deaths daily, in an advanced nation like the US [14, 16, 17]. There are loads of spots to lay the fault. Calories are modest, and cheap nourishments brimming with salt, sugar, and fat are, for the most part, within our reach all day [16]. All in all, how best to turn this around? The food prescription framework for sick individuals is a progressive step in that it will prescribe a healthy eating routine to individuals dependent on their present well-being condition, as demonstrated by their blood test report [17].

Therefore, in this research, it is introduced that a recommender system takes patient health data, and according to patient health, our recommender system prescribes the food that suits patient health, and patients can be recovered from any disease. In the food recommender systems, there is a need to look after the conditions like iron deficiency [18], kidney diseases, diabetes, and hypertension [19]. The food prescription system gets the patient's health report and its analysis of the patient's health state based on different parameters of human body composition [20]. These parameters are Potassium [21], Fat [22], Calcium [23], Protein [20], Fiber [24], and Iron [25]. These parameters play a significant role in stainable health for humans. If one of the parameter values shouts or lower from the decided range patient can face any disease [26]. Food and medication suggestions shift, starting with one diabetic patient and then onto the following depending on their present well-being [7, 32]. Conventional philosophy uses Type-1 fuzzy rationale and is, in this way, incapable to effectively deal with vulnerability issues. Information advancement is helpful for information examination, yet it is, at present, not utilized in existing frameworks. It may be hard to store, recover, and examine much patient information. The proposed framework uses cloud administrations to deal with the data. This article presents a fuzzy ontology that utilizations Type-2 unclear rationale to computerize the procedure of food and medication proposals for an IoT-based medicinal services framework [28]. Quiet records are advanced by connecting them with linked open data. Linked available data utilizes an asset depiction outline work (Resource Description Framework), diagram information, and model. In IoT, the well-being condition expectation process for patients requires vital information. A dynamic information base was made with the assistance of doctors, patients, and web-based social networking where patients with a similar ailment have posted their side effects [26]. A connected information administration is required on the grounds that this data starts from various web sources in differing designs. Information is then changed over into an organized single organization that makes it simpler for patients and doctors to share and reuse in crisis circumstances [29].

A group recommendation system is used in different domains. In a different environment, the system works differently according to the preference and types of the domain [30]. Group recommender systems for movies, before watching any movie and spending 3 hours on the movie, the user must get recommendations about the movie, whether it is according to the person trust or not. Group recommender systems for music, before listening to the music, the system helps to recommend the songs according to users' tastes. Group recommender systems for travel if someone wants to move from one place to another

no matter within the city or out of the country [31]. This system helps to choose the airlines or bus system. Group recommender systems for TV programs, if someone wants to watch any TV production, the previous user's preference helps to choose among various shows [32]. Recommender Systems are valuable tools as they assist a user in making decisions and choosing among a broad set of items. Recommender systems use the preferences and features of a user while generating a suggestion for himself [14, 38]. The study [33] focuses on only one disease, and it uses Naïve Bayes [34], SVM [35], and RM algorithm to recommend food to the patient. The drawback of the study is that it focuses on just one disease, but it is using three different algorithms to recommend suitable food. The presented research focuses on the twelve other diseases, and complete food is recommended just based on the adequate nutrient level. The study suggests the required food compared to the simple food recommendation system [36].

**Table 1**. Literature Analysis

| Reference | Recommendation | Findings/ Novelty | Algorithm Used | Methodology |
|---|---|---|---|---|
| [6] | AI Nutrition Recommendation System | Survey | SVM<br>CNN | Research direction for a nutrition-based food recommendation |
| [38] | Food Recommendation to Diabetic Patients | Diabetic Food Recommendation system | K-means<br>SOM | Diet recommendation only for Diabetic patients |
| [32] | Food Recommendation to Diabetic Patients | D-Care System | Amazon SagaMaker service | Diet recommendation only for Diabetic patients |
| [37] | Food Recommendation System | Algorithm applying techniques analysis | CF (model-based & memory based) | Food recommendation according to user's interest and taste. |
| [5] | Food Recommendation | Diet-Right (innovative food recommendation) | ACO | Optimal Food recommendation based on cellulated nutrition value |
| [2] | Food Recommendation | Associated food recommender algorithm | Collaborative and content-based filtering | Food recommendation according to tousers' interest |
| [33] | Food Recommendation for Kidney Patients | Algorithm analysis | SVM<br>Random Forest<br>Naïve Bayes | Food recommendation for only kidney patients |

In [37], compared the two different algorithms called the collaborative filtering model and the memory-based filtering model. The author claimed that the collaborative-based algorithm is more suitable and can recommend the best food. In the presented study, different algorithms are presented, and the food is recommended based on required adequate nutrients. The algorithm used in this study is based on the nature of the dataset and in [38] presented the framework based on the ontology of the food datasets. The author also stated that the diet recommendation to diabetic patients. The study is based on the K mean and

SOM algorithms. On the other hand, our study is based on twelve diseases, not just diabetic disease, to recommend the needed food item to the patient.

## 4. Materials and Methods

In this study methodology for the problem statement is defined in such a way that initially, we elaborate user and systems interaction diagram and the processes that the system will execute and finally recommend the food. Moreover, this study explains how the diet recommender system works according to a persons input, and lastly, Methodology this study demonstrates the algorithm that works for recommendation.

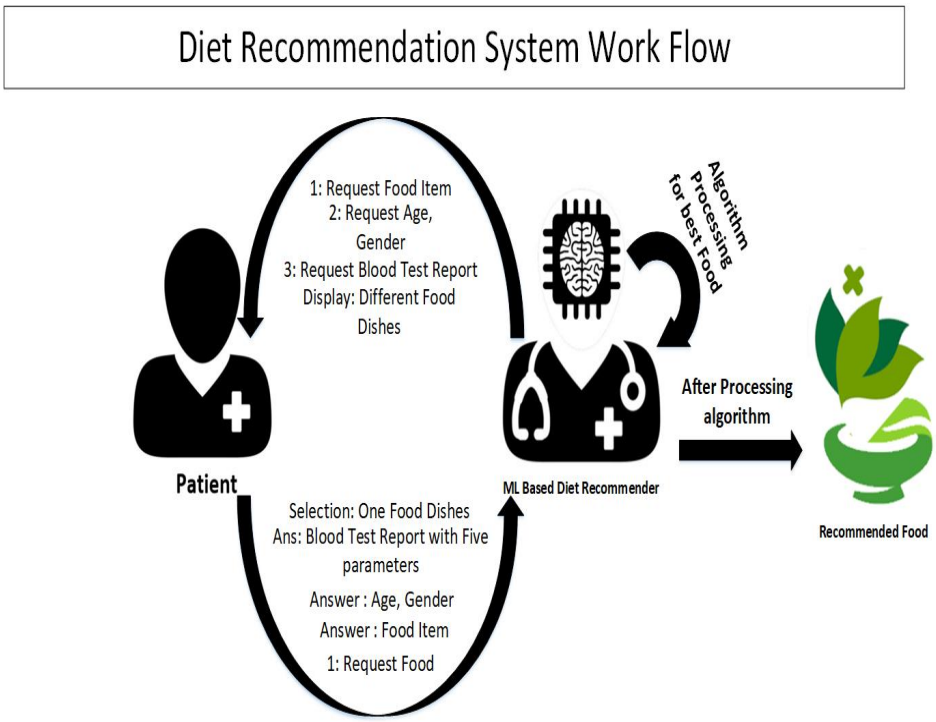


**Figure 2.** Machine Learning-based Diet Recommendation Work Flow

Fig. 2 shows that first of all, users or patients will generate a request for food. This request is then sent to Machine Learning based diet recommender. Based on this request system will ask us for the desired food item, and the user will select one of the items from the list. After that system will generate a request for the age and gender of the user so that system can recommend a dish based on his age. The user will then provide his age and gender. Then the system will ask for the users patient's blood test report so that the system recommend a dish after analyzing the level of different parameters like potassium protein fats, e.g., inpatients' blood. So, after analyzing the patient's age , theblood report system will t The algorithm will then start processing, and it will use K-means clustering [4] to provide the best food to the patients based on calorie count, nutritional value [27], age, and blood sample reports so that patients can enjoy their food without harming his health [39].

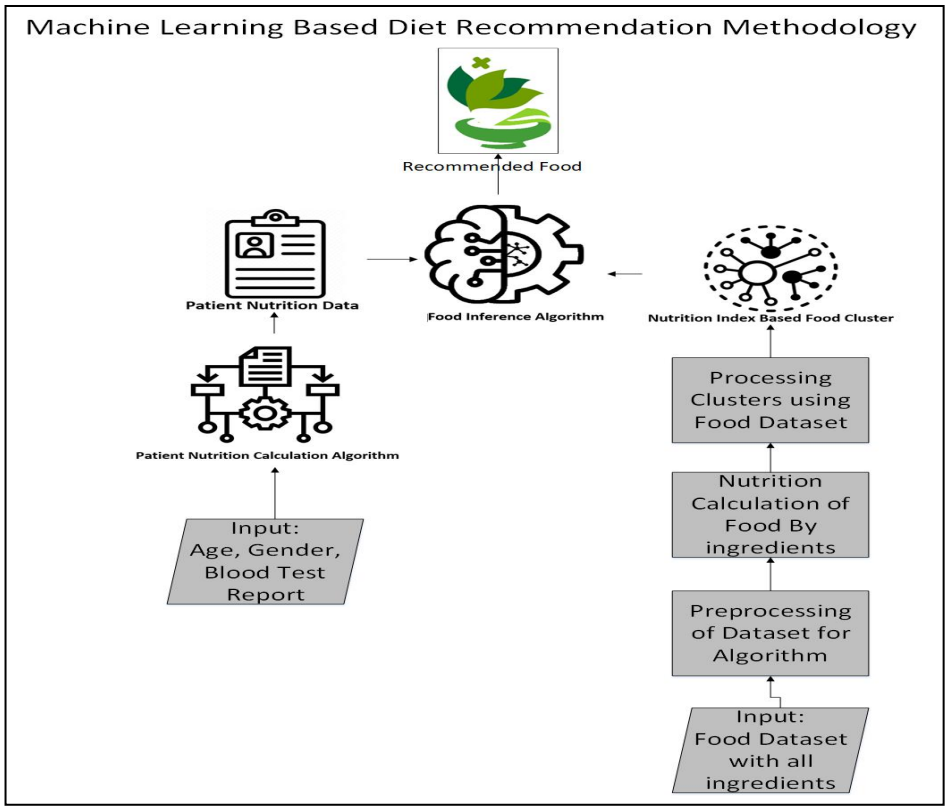


**Figure 3.** Proposed Machine Learning-based diet recommendation internal Methodology

Fig. 3 shows there are two different inputs in the form of datasets. After the data is inputted, the data is pre-processed for the algorithm. This pre-processing is done so that the algorithm can be processed before moving to the next stage, where the body nutrition is calculated. It is essential to calculate the nutrition level in the body so that the food inference algorithm can run efficiently to recommend suitable food. After the nutrition level is calculated, the data is further clustered, and the nutrition index is measured before the food is inferred using the food inference algorithm. Whereas on the other hand, the blood test report, age, and gender of the patient enter to analyze the information to recommend suitable food. The food nutrition calculation algorithm runs these inputted report data. The data is then sent to the next phase, where the inferred based data on the calculation of the Nutrition is compared and analyzed with the patient blood test reports. These two processes are conjugated after the clustering and analysis to foresee the results of the desired need of the body, and only after the proper check, the food inference algorithm will conjugate these two different inputs and recommend the healthy or suitable food for the patient.

Machine learning-based recommendation works in a way that gives its recommendations based on two activities that run in parallel. One activity is related to the patient, and the other is to food. In inpatient activity, the first step to be taken as input is to get the patient's age, gender, and blood test report. Based on these criteria, the patient nutrition calculation algorithm will recommend patient nutrient data like how much potassium patients need or how much calories or fat are feasible. And then, this data will be sent to the food inference algorithm. Whereas on the other hand side, initial input will be given in the form of food with ingredients, and then an algorithm will start its computation on this given data set, which will result in the calculation of nutrients by components. After that a, further processing will be done to form clusters on the foundations of nutrients by the elements to form index-based food cluster and based on this cluster a food will be recommended to patient, and then it will be sent to food inference algorithm.

4.1 Food Inference Algorithm

| | |
|---|---|
| **Input:** | Patient health requires Nutrition food and Nutrient Based Clustered Food Dishes. |
| **Processing:** | 1st parameter is patient health fat, which is compared with Recommended fat by FDA.<br>2nd parameter is patient health calcium, compared to Recommended calcium by FDA.<br>3rd parameter is patient health protein, which is compared to the Recommended protein by FDA.<br>4th parameter is patient health potassium, which is compared to RecommendePotassium by FDA.<br>5th parameter is patient health fiber, compared to Recommended fiber by FDA. |
| **Output:** | Recommended Diet |

If any of these values is greater or less, then it will move to the next phase accordingly, and in the next stage, the system calculates inferred Nutrition of food, based on FDA standard and suits to person. Because of these inferred nutrition values based on the individual health state and percentage of required Nutrition for the body. So, this calculated percentage for a person's required nutrition values will lead to the solution of the diseases that a person faces. Moreover, these diseases are already explained in the introduction that can be tackled by following this system-recommended food. In this algorithm, the foreground point is inferred values calculated by order of daily meals as well. For example, if a person is facing the disease hypocalcemia and he has 40 percent less calcium in his body according to FDA requirements, then this algorithm follows the meal plan and recommends the meal accordingly.

**5. Results and Discussion**

In this research, Precision, Recall, and F-1 Score measure are used to evaluate the accuracy of the recommendation system. These metrics assess a recommender system's accuracy based on the products it recommends to the user. The precision is the fraction of the products in the test set scored by the users and recommended by the recommender method. The precision metric is the ratio of the recommended items to the total number of things the program recommends. The precision metric represents the ratio of the recommended things to the total number of articles recommended by the system and is given by Eq (1). The recall represents the ratio of the recommended things to all items in the test set rated by the users and is specified by Eq (2). The F-measure metric is the precision and recall weighted mean and is given by Eq (3). So, the F-measure is a combined accuracy and Recall metric. The below Table illustrates the confusion matrix of the recommendation and its relationship to these metrics.

$$Precision = \frac{TP}{TP+FP} \quad (1)$$

$$Recall = \frac{TP}{TP+FN} \quad (2)$$

$$F1 = 2 * \frac{Precision*Recall}{Precision+Recall} \quad (3)$$

**Table 2.** Confusion Matrix

| | **Person daily intake required Nutrition by FDA** | **Person daily information not required Nutrition by FDA** |
|---|---|---|
| **Food Nutrition Recommendation** | TP | FP |
| **Food Nutrition not Recommendation** | FN | TN |

The terms in the Table. 2 are defined as follows:

TP, true positive: number of Food Dishes Recommended to the person according to FDA preferred daily nutrition intake.

FN, false negative: number of Food dishes that are not Recommended to the person according to FDA preferred daily nutrition intake.

TN, true negative: number of Food Dishes that are not Recommended to the person and did not belong to the FDA preferred daily Nutrition intake.

FP, false positive: number of Food Dishes Recommended to the person and did not belong to FDA preferred daily intake of Nutrition.

In this study, six compositional elements of the human body are used, and the diseases based on these elements are in the foreground of this research. Food is recommended to the person concerning conditions a person faces. In this research, precision, recall, and F-Score are calculated for different food items for the illnesses to evaluate system efficiency. Precision, Recall, and F score is measured by the following additional food item selected by the user.

Chicken

Vegetable

Honey

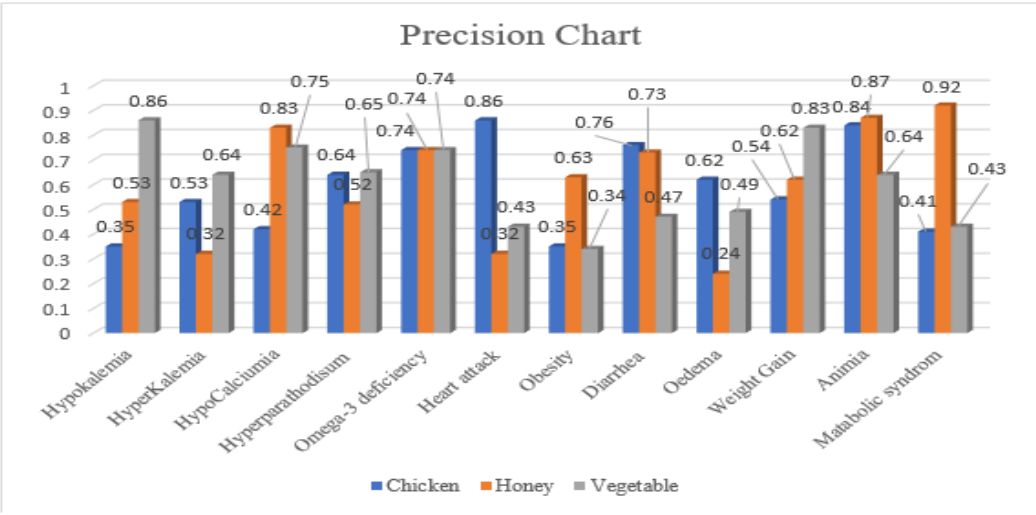


**Figure: 4.** Precision measure by food dishes recommendation to the person

In Fig. 4, a single food item is selected, and according to the food item, the system recommends food dishes to different patients listed in the chart, as mentioned above. Now in fig. 4 above, it is evaluated that the system recommended food fulfills the requirements of the FDA for daily intake of Nutrition, as well as patient requires Nutrition for a specific dish. This precision chart shows the precision values of different diseases and shows how functional our system is when food items are selected. The design shows other behavior on other food dishes.

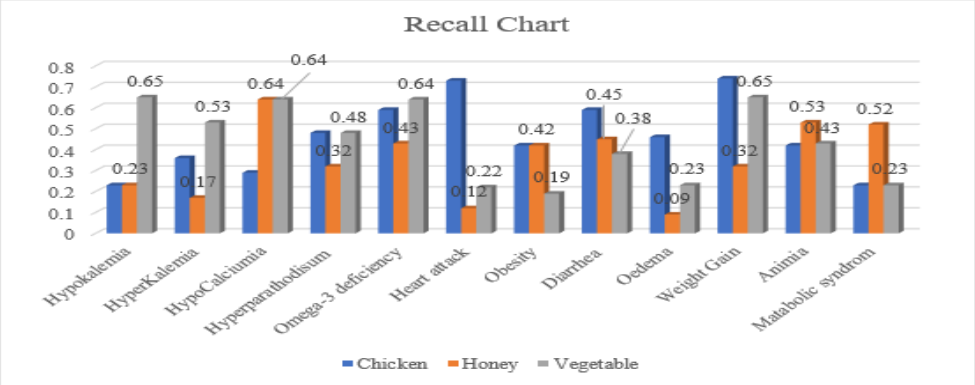


**Figure 5.** Recall measure by food dishes recommendation to the person

Fig. 5 is a metric that quantifies the number of correct optimistic predictions made out of all optimistic predictions that could have been made. Unlike precision, which only comments on the accurate optimistic predictions out of all optimistic predictions, recall indicates missed optimistic predictions. The recall is calculated for the recommended food dishes, and the results show the system accuracy concerning the food item chicken. It can recognize that there is not a striking difference between precision and recall results; hence it reflects in our scenario, the dataset demonstrates the same results, and therefore recall is another evidence of the accuracy of our results.

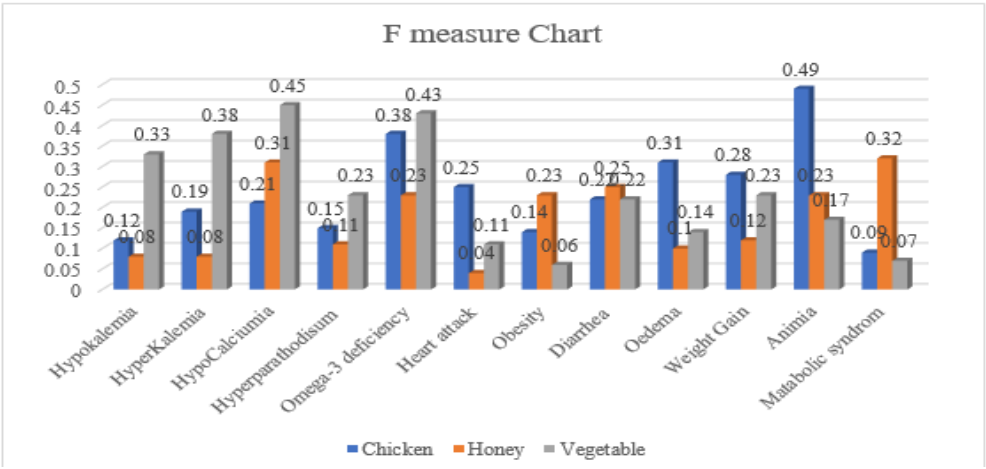


**Figure 6.** F measure of food dishes recommendation for the person

F-Measure provides a single score that balances the concerns of precision and recall in one number. So, the F measure is calculated to justify our result, and it reflects that the system is very proficient and can provide the recommendation about food to the person suffering from any disease listed in the above chart.

## 6. Conclusions

Good health depends on adequate intake of Nutrition in food. An adequate information of Nutrition in food is essential for people to live healthily. Moreover, diseased people have many limitations [40]. For different diseases, nutrition therapy is critical to control, manage and prevent people from various diseases.

moreover, nutrition therapy is the alternate solution of conditions concerning medicine. Hence, the food pyramid is another way for the patients of various conditions. Food dish(s) can be classified according to their nutritional value, and food of the same dietary value can be grouped and substituted with each other. So, in this research, the solution is provided for the problem statement in such a way that the diet recommender system recommends the best nutrition food to the user/patient by using k-means clustering algorithms and others that are proposed in this study and also prescribing the food to the patient who suffered from a disease. In this research, the highlighted area is the underlying reason for diseases, how it grows in a patient, and how a person can pre-cure and take off the conditions. The total area of this research is compositional elements of the body, and I overcame ten conditions based on these compositional elements. Our system gets the heath state of the patient-by-patient nutrition amount in the blood and identify the diseases and prescribe the food to particular disease patient.

The significant advantage of this system is to reduce the excessive usage of medicine and prevent side effects. The diet recommender system can also help a person to pre-cure from disease and get rid of appointments with a physician for medicine and food prescription. Our study introduced tMMethodologyhat the diet recommendation system uses different algorithms, a K-means clustering algorithm that converts the food dataset in other clusters by nutrition index of food, and the patient nutrition calculation algorithm is used to calculate the patient required amount of Nutrition. Moreover, the inference algorithm utilizes this information to infer the necessary amount of Nutrition for the patient who is a victim of some disease due to deficiency of abundance of Nutrition. The result of our research is a diet recommender system that recommends the food dish(s) having an appropriate quantity of Nutrition, taking into account the gender, age, and current nutrition status of the person. For the accuracy of the prescribed food, Precision, Recall, and F measure is used in this research.

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