Daily Meal Planner Expert System for Diabetics Type-2

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Abstract

A successful intelligent control of patient food for treatment purpose must combines patient interesting food list and doctors' efficient treatment food list. Actually, many rural communities in Sudan have extremely limited access to diabetic diet centers. People travel long distances to clinics or medical facilities, and there is a shortage of medical experts in most of these facilities. This results in slow service, and patients end up waiting long hours without receiving any attention. Hence diabetic diet expert systems can play a significant role in such cases where medical experts are not readily available. This paper presents the design and implementation of an intelligent medical expert system for diabetes diet that intended to be used in Sudan. The development of the proposed expert system went through a number of stages such problem and need identification, requirements analysis, knowledge acquisition, formalization, design and implementation. Visual prolog was used for designing the graphical user interface and the implementation of the system.

Keywords:systems, diet, type 2 diabetes, meal plan, knowledge-base, rule base.

1 Introduction

Diabetes is a serious, life-threatening and chronic disease. It is estimated that this figure will reach 366 million by 2030 [1], with 81% of these diabetics being in developing countries, where medical care remains severely limited. Actually, recent estimates place the diabetes population in Sudan at around one million – around 95% of whom have type 2 diabetes and patients with diabetes make up around 10% of all hospital admissions in Sudan [2]. The types of food eaten in Sudan vary according to climate, although the Sudanese diet has plenty of carbohydrate-rich items some patients believe sugar is the only source of energy, therefore on hot days people consume large amount of sugary carbonated drinks [3]. Fortunately, diabetes can be managed very effectively through healthy lifestyle choices, primarily diet and exercise. Mostly, Type 2 diabetes is strongly connected with obesity, age, and physical inactivity [1]. Most medical resources reported that 90 to 95% of diabetic is diagnosed as type-2. Simply, in these cases the pancreas is not able to produce enough insulin to keep the blood sugar level within normal ranges. In addition, the majority of this type diabetics do not know they are suffering from it. Over 80-90% of Type 2 diabetes is overweight. Therefore, reducing daily carbohydrates and fats intake and the commitment to a healthy diet with a simple waling keepsyour glucose within normal ranges and help dropping those extra pounds [4].

On the other hand, the development of computer technology and tools has provided a valuable assistance for Medicare [5].

An expert system is a computer program that provides expert advice as if a real person had been consulted where this advice can be decisions, recommendations or solutions [6]. The intention of our research is to provide self-monitor for patient of type 2 diabetes to get proper amount of daily calories with list of proper diet satisfy the amount of the calories. This paper focuses on achieving ideal meal planner and the effort done towards. The paper go through the problem and need identification, requirements analysis, knowledge acquisition, formalization, design and implementation. Visual prolog was used for designing the graphical user interface and the implementation of the system. The rest of paper is organized as follows. Section 2 presents literature review and related work. Meal planner is in section 3. Section 4 describes the Results and discussions. Conclusion and future work are given in section 5.

2 Literature Review and Related Work

M. Beulah et. al (2007) [8] introduced the ability to access diabetic expert system from any part of the world. They collect, organize, and distribute relevant knowledge and service information to the individuals. The project was designed and programmed via the dot net framework using rule based. The system allows the availability to detect and give early diagnosis of three types of diabetes namely type 1, 2, gestational diabetes for both adult and children.

S. Kumar and B. Bhimrao (2012) [9] developed a natural therapy system for healing diabetic, they aim integrate all the natural treatment information of diabetes in one place using ESTA (Expert System Shell for Text Animation) as knowledge based system. Their system begins with Consultation asking the users to select the disease (Diabetes) for which they want different type of natural treatment solution then describes the diabetes diseases and their symptoms. After that describes the Natural Care (Herbal /Proper Nutrition) treatment solution of diabetes disease.

Joan Albert et. al (2013)[10] Develop expert system for the treatment of patients with several chronic diseases using evidence-based medical knowledge of hypertension, diabetes mellitus and heart failure, and represented it by means of combination rules. A rule execution system has been developed which is able to combine treatments of different diseases into a unique comorbid treatment avoiding undesired drug interactions.

Cindy Marling et. Al (2014)[11]Presented systems are for CARE-PARTNER, which supports the long-term follow-up care of stem-cell transplantation patients; diabetes Support System, which aids in managing patients with type 1 diabetes on insulin pump therapy; renal disease; diagnosis and treatment of stress-related disorders using case-based reasoning.

N. Nnamoko et.al (2013) [12] proposes a fuzzy expert system framework that combines case-based and rule-based reasoning effectively to produce a usable tool for Type 2 Diabetes Mellitus (T2DM) management, to produce crisp outputs to patients in the form of low-risk advice. The extended framework features a combined reasoning approach for simplified output in the form of decision support for clinicians. With seven operational input variables and two additional pre-set variables for testing, the results of the proposed work will be compared with other methods using similarity to expert's decision as metrics.

D.Forbes and J. Singh (2012)[13] introduces a novel approach using new technology to improve understanding between the patient and healthcare practitioner they developed a framework that links medical information with different language and cultural information to provide ease of understanding and communication between the patient from a minority group with a healthcare practitioner from a different cultural group. The key component of this framework is the Type-2 Diabetes Management Patient-Practitioner Assistive Communication Ontology,The tool used in the implementation process is protégé 4.2. table 1 describe the comparison between various expert systems.

Table 1: Expert systems for diabetes

Authors	System purpose	Data representation	Inference Engine technique
Cindy Marling et. al(2014)[11]	CARE-PARTNER diabetes renal, stress-related disorders	Case-based	NA
Joan Albert et. al (2013)[10]	Treatment of hypertension, diabetes mellitus and heart failure	Rule based	NA
N. Nnamoko et.al (2013)[12]	Type 2 Diabetes Mellitus (T2DM) management	Case-based and Rule based	NA
S.Kumar & B. Bhimrao(2012)[9]	Natural treatment information of diabetes in one place	Rule based	Backward chaining
D.Forbes and J. Singh (2012)[13]	Understanding between the Type-2 Diabetes Patient and healthcare practitioner	Ontology. Based	NA
P. M. Beulah et.al (2007)[8]	Detect and give early diagnosis of three types of diabetes	Rule based	Backward chaining

3 The Proposed Architecture of Expert System

Figure 1 shows the major components of our expert system. The system composed of; knowledge base, working storage, inference engine, monitoring module and user interface .The general design of an expert system comprises the user-oriented parts of user interface and the working memory that stores specific information for a current problem as facts. The knowledge base contains knowledge on a particular domain in the form of logic rules or other representation technologies. The inference engine performs the reasoning by using the knowledge to perform an evaluation similar to the way a human reasons with available information. Inference engine and knowledge base are handled by a knowledge engineering module for defining rules and controlling the inference mechanism [7] Fig 1.

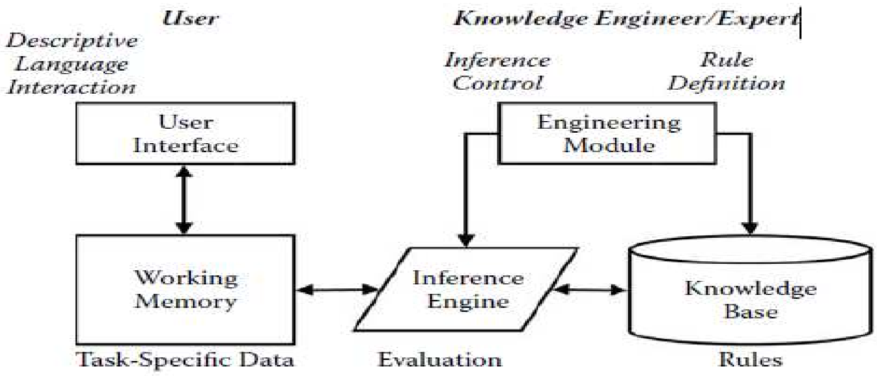

Figure1 Components of expert system

4Meal Planner

The study was carried out using hybrid of qualitative research methodology at the military hospital in Khartoum. The main objective of the study was to develop a medical expert system for the treatment of diabetes type 2. Actually, the specific phases used in developing the meal planner expert system included: (1) Problem and need identification; (2) Knowledge acquisition; (3) Knowledge formalization or modelling ;(4) Design or conceptualization; (5) Implementation; (6) Testing and maintenance.

4.1 Problem and Need Identification

The main objective of this phase was to identify, characterize, and define the problems the system will be expected to solve. The main problems identified include: Shortage of specialist; the other medical staff in the Division needed expert knowledge and guidance, from the specialist, on treatment of diabetes; no commercially or free expert system is available in the area of diabetes; all systems available in medical fields are in English, German, or French, there isn't a single expert system available in Arabic and finally medical expert systems are rarely available in mass-distribution format.

4.2 Knowledge Acquisition

To acquire our meal knowledge for type 2 diabetes we have gathered knowledge from medical books, and experts. We have contacted the military hospital and Federal Ministry of Health for medical resources and managed to schedule some interviews with Dr. Iqbal and Dr. Nazik, we have designed the interview to express their opinions about diabetes diet and the problems between them and diabetes patients. During the interviews, we collected the data according to the pre-designed questions and also from discussions. The knowledge acquisitionmethods used in this study also include analysis of documents, the analysis from the interviewees and observation help us to find the missing information and help to design a more suitable system .during this stage, the doctors were asked to answer the following: What is diabetes; how many types of diabetes; what are the diagnosis and the treatment process; what about diabetic foods? What to eat and how much; what about sugar? What medical rules or protocols guiding to proper diet; how are these medical rules or protocols used. The step of knowledge acquisition was not only time consuming but also it was the greatest bottleneck in the development process. The step requires knowledge engineers to extract data, information and knowledge from experts.

4.3 Formalization

The information and knowledge collected were modelled in two forms to facilitate understanding of how the system will operate and how it arrives at its conclusion: 1) for calculating food servants and calculating number of calories, a rule based representation is used. Fig 2 shows how the system determines the number of services to each patient. Eq.1 shows the calculation of the Body Mass Index (BMI) [14]. 2) Frame based representation is used to connect food types and subcategories of each class according to diabetics healthy food pyramid, where we find that slots provide us with more information about each Sudanese food category and subcategory and more description means better reflection of the knowledge. Fig 3 shows a sample of this frame based representation [15].the system starts asking user to enter his personal information showing the patient dialogue. Based on this information the number of servings is calculated and hence appears in the next food-groups dialogue in which patient is giving permission to select the interested food list from system food recommendations.

BMI= ((Weight (kg))/⟦Height (M) ⟧^2) ,

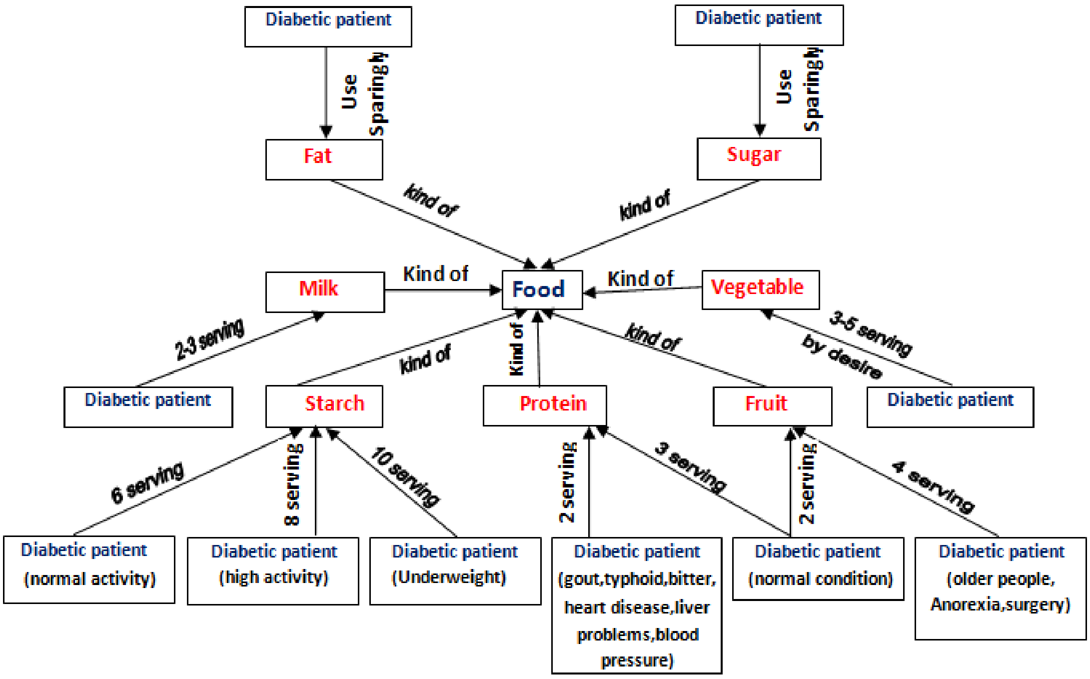

Figure2 Diabetics numbers of allowed servings

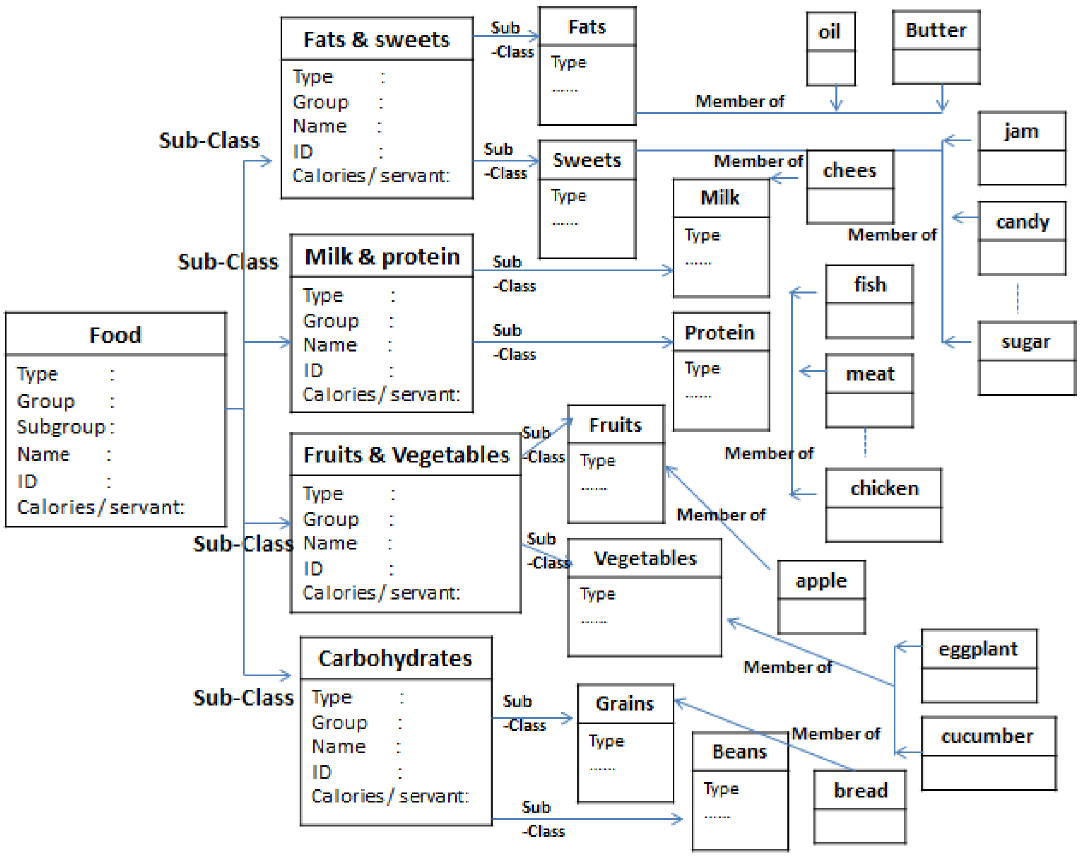

Figure 3Sample of diabetics' food frame representation

4.4 Design

The systems developed so far have used a command driven, dialog type user interface. Increasingly windows and menus, are being used to make interfaces easier to understand and work with. In the context of the meal plan, age, gender, body mass index (BMI), blood Glucose levels (BGL), physical activity and the related diseases with the diabetic are the main risk factors to consider. The outcome of each of these factors directly or indirectly depends on one or more of the other(s) and, the overall reaction determine the plan outcomes. The system consists of two main graphical user interface components. The first component is the Patient dialog which consist of name, gender, age, weight, height, activity type, BGL, favorite-meals and additional diseases .second is the Food groups dialog which consist of items names and items list Fig.4 ,Fig.5 and Fig.6 gives sample screen shots of the user interface.

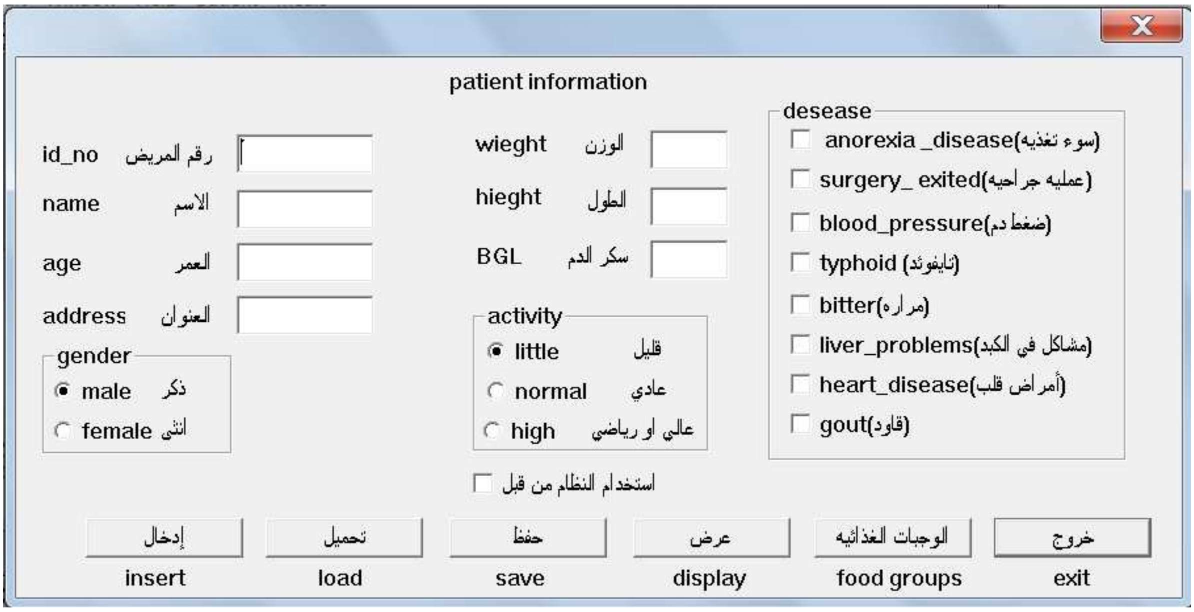

Figure 4 Patient dialog

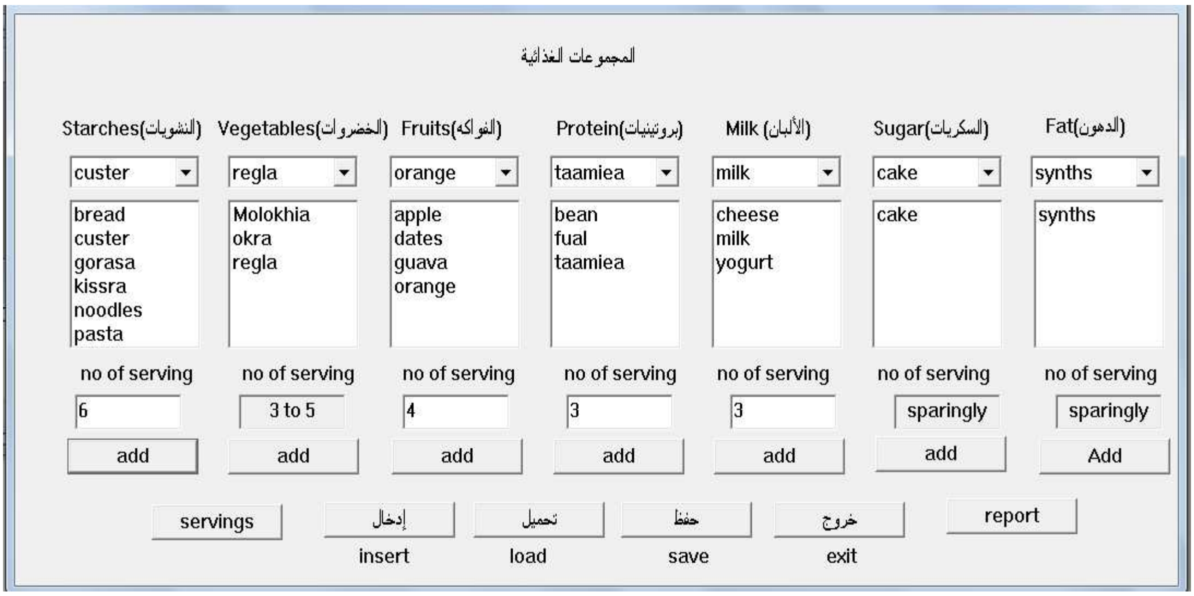

Figure 5 Food groups servings dialog

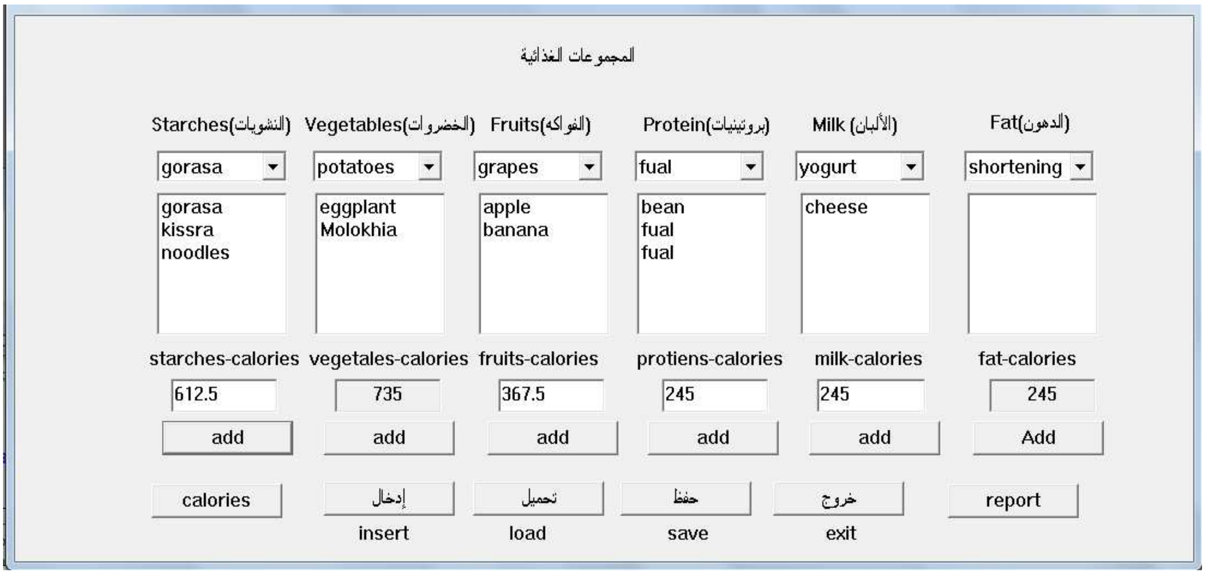

Figure 6 Food groups calories-dialogue

4.5 Implementation

This phase involves the actual coding of the system (writing of the Prolog commands that run the system). The codes were developed and customized in Visual Prolog. The implementation of the prototype is both compact and readable due to the following features of Prolog:

• Each rule is represented as a single Prolog term (a relatively complex structure).

• The factors of the rule structure are defined as operators to allow the easy-to-read syntax of the rule.

• Prolog's built-in backtracking search makes rule selection easy.

The inference engine: As for the inference Engine, the user provides information about the problem to be solved and the system then attempts to provide insights derived or inferred from the knowledge base by examining the facts in the knowledge base. The backward-chaining is goal-driven, Our Expert System use backward chaining as its inference engine guided by the goal to the data. From table [2] a very common inference engine is based on representing knowledge in a rule based, the prototype is performed by a process of backward chaining through rules recursively, the rule-based approach is the most straightforward for this prototype.

5 Results

The result of the integration of the various parts of the system modeled in Figures 2 to 3 gave rise to the complete architecture as shown in Figure 1. The core of the architecture consists of the patient database, rules base, inference engine and user interface. The patient database contains facts that are the smallest piece of information supported by the inference engine. The rule base contains rules in the form of if-then statements, which represent the knowledge provided by Figure 2. Finally the system connect all gathered information and performs inferences through its knowledge engine process to output a recommended five meals for every patient per day, breakfast, lunch, snack1, dinner and snack2, this prototype will be able to perform correct meal planning and suggest appropriate diet using calories base or serving base, Fig 7 report using serving base depend on the knowledge of Fig 5 and Fig 8 report using calorie base depend on the knowledge of Fig 6.

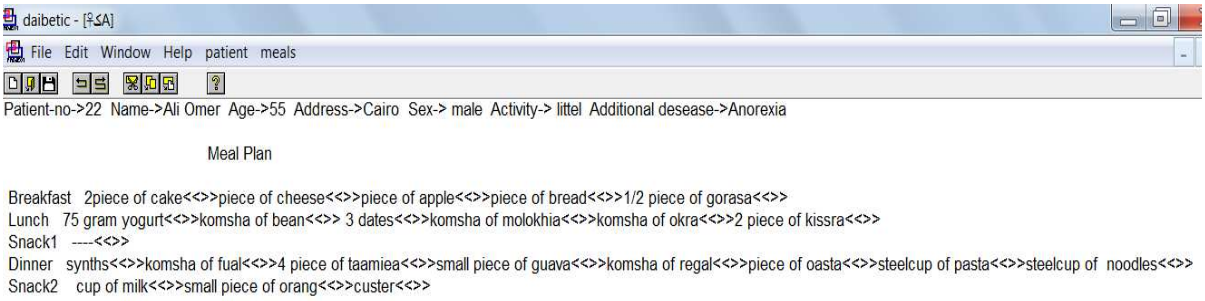

Figure 7 Meal plan report using servings

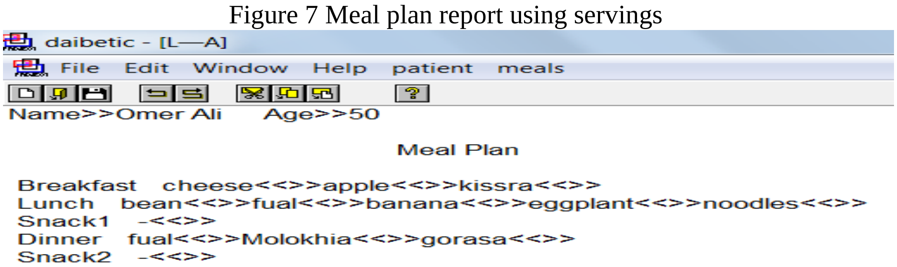

Figure 8 Meal plan report using calories

6 Conclusion

This paper described the design and implementation of a medical expert system for diabetes diet that intended to be used in Sudan. The expert system provides the patients with medical advices and basic knowledge on diabetes diet. Actually, the development of the proposed expert system went through a number of stages such problem and need identification, requirements analysis, knowledge acquisition, formalization, design and implementation. Visual prolog was used for designing the graphical user interface and the implementation of the system components. The incremental development of expert systems within a rapid prototyping framework is a viable approach in the domain of diabetic assistance. It has also been important to bear in mind from the beginning of a diabetic type-2 expert system development effort that the system will eventually be used by people who are with no complex background of computer systems. Hence the graphical user interface must be a simplified as possible. In addition, the food culture of sudation must be of main attention in allowance and prevention by the recommended diet of the system. Many difficulties faced us during the requirement of various skills needed for the development of a successful diabetic expert system. These were include that more information and guidance on medication are incomplete ,thus data acquisition is expensive ,I travelled twice form Egypt to Sudan and spent 6 months collecting required information , beside the specialist is not available all the time, in addition to lack of resources no commercially or free expert system is available in the area of diabetes. The proposed expert system is a promising helpful tool that reduces the workload for physicians and provides a more comfort for diabetic patients.

In future work, the test and maintenance will investigate. Additional analysis and evaluation of the system will certainly further define the strengths and weaknesses of its approach.

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