

NutriSonic web expert system for meal management and nutrition counseling with nutrient time-series analysis, e-food exchange and easy data transition

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Abstract

This study was conducted to develop the NutriSonic Web Expert System for Meal Management and Nutrition Counseling with Analysis of User's Nutritive Changes of selected days and food exchange information with easy data transition. This program manipulates a food, menu and meal and search database that has been developed. Also, the system provides a function to check the user's nutritive change of selected days. Users can select a recommended general and therapeutic menu using this system. NutriSonic can analyze nutrients and e-food exchange ("e" means the food exchange data base calculated by a computer program) in menus and meals. The expert can insert and store a meal database and generate the synthetic information of age, sex and therapeutic purpose of disease. With investigation and analysis of the user's needs, the meal planning program on the internet has been continuously developed. Users are able to follow up their nutritive changes with nutrient information and ratio of 3 major energy nutrients. Also, users can download another data format like Excel files (.xls) for analysis and verify their nutrient time-series analysis. The results of analysis are presented quickly and accurately. Therefore it can be used by not only usual people, but also by dietitians and nutritionists who take charge of making a menu and experts in the field of food and nutrition. It is expected that the NutriSonic Web Expert System can be useful for nutrition education, nutrition counseling and expert meal management.

Key Words: NutriSonic, web expert system, nutrient time-series analysis, e-food exchange

Introduction

The prevalence of diabetes mellitus is increasing in the world. Diet therapy for diabetes mellitus is very important for controlling blood sugar. Food exchange is used widely for meal planning and nutrition education of diabetes mellitus. Hong *et al.* (2003) and Hong *et al.* (2004) develops calculating program for food exchange amounts of food groups. But it is very difficult to find a web-based meal planning program using food exchange.

So the program is required to be able to make meal planning by using food exchange to manage diabetes mellitus, obesity and other diseases for diet therapy.

Some off-line programs on menu planning, nutrition analysis and nutrition education counseling have been developed and used (Han, 1997a; Han, 1997b; Han & Rhee, 1993b; Hong, 1989; Hong, 1996; Kang *et al.*, 1998; Kang *et al.*, 1999; Kolasa & Miller, 1996; Peter *et al.*, 1998). Similar programs on the internet are insufficient (Choi, 2000). Therefore the system based on the internet that has a friendly user interface and accepts the needs of users is required as soon as possible (Hong & Hwang, 2001).

Nutrition related programs based on the internet were

developed such as the analysis of food intake (Han, 2000), nutritional counseling and diet management of diabetes mellitus (Han & Jeong, 2004; Hong & Kim, 2004), food exchange database construction and search system (Hong *et al.*, 2003; Hong *et al.*, 2004), menu planning and searching system: MenuGen, National Rural Living Institute (Hong *et al.*, 2004) and meal planning and evaluation system: NutriEval (Hong, 2007). But the developed programs are insufficient in meal planning using food exchange for diabetes and obesity. Users have trouble to input food or meals and can not have nutrient and e-food exchange analysis, storing and modifying the data.

In the case of the USA, as a program based on internet, the food composition table from the USDA is commonly used. Cyberdiet services food nutrition information and menu and some web sites have meal analysis functions, but those are insufficient (Lee & Nieman, 2003). The Food Surveys Research Group of the United States Department of Agriculture has developed automated methods for collecting and processing food intake data. These methods are part of the Dietary Intake Data System designed to efficiently collect and process high quality food intake data. The foundation of the system is the Automated

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Multiple Pass Method (AMPM) Blaise instrument, which is used to collect 24-hour dietary recalls (McDowell, 2003; Raper *et al.*, 2004).

In this study, we developed the internet-based food, menu and meal management expert system for nutrition management and nutrition counseling with e-food exchange, nutrient time-series analysis and data transformation. This system considers the sex, age and disease conditions and creates general meal and therapeutic meal for disease. We expect that NutriSonic will contribute to health and nutrition improvement.

Materials and Methods

The implementation of the system

Table 1 shows the development environments of server and users. The operating system for servers is Linux. The user operating system is the Microsoft Windows series. The web server is Apache. Development languages are PHP, Javascript and HTML. The database is MySQL. Users can access NutriSonic using internet browsers.

Database structures

Table 2 shows the database composition. NutriSonic expert system database is composed of food, menus and meals. The food composition table is provided from the National Rural Living Science Institution in Rural Development Administration (National Rural Living Science Institution, 2001). And we used e-food exchange database (Hong *et al.*, 2003). The menu database is based on the results of the diet assessment system (National Rural Living Science Institute, 2000) and CAN-Pro program ver

2.0 (The Korean Nutrition Information Center, 2002). And in modifying the results, it has 24 categories from rice to others. Menu codes are divided into three: grand, middle-range, and specific classification. The meal database uses the recommended meals which are the results of the studies on developing the web-based Korean style dietary management system: MenuGen (Hong *et al.*, 2004). These are composed of meals according to the user's characteristics and therapeutic meals.

System architecture of nutrisonic web expert system

Fig. 1 shows the system architecture of the web expert system. The database is composed of user's information such as user's meal database, user's menu database and user's information and also web expert database such as recommended meal database, recommend menu database, food nutrient database and e-food exchange database (ver 1.0 and ver 2.0). With these databases, meal nutrient time-series analysis, e-food exchange and data transition can be calculated.

The scenario of meal planning and nutrition counseling

The NutriSonic web expert system is based on rules and cases. The recommended meal is based on pre-constructed cases. Meal properties are adjusted as user preferences. The web expert system verifies that the assessment of nutrients and calories is relevant to the properties of users. These results can be used for nutrition counseling, especially for diet therapy of diabetes mellitus patients. The dietitian or physical doctor teaches the food exchange system and meal planning using food exchange. But the dietitian, physical doctor and patient can not calculate the exact amount of food exchange because the present food exchange list is not complete. The e-food exchange can help the dietitian, physical doctor, diabetes patient, and their helpers to

Table 1. The development environment of server and users

Server		Users	
OS	Linux	OS	Windows(95, 98, 2000, XP, etc.)
Web Server	Apache	User's Environment	above Internet Explorer 5.0
Development Languages	PHP, Javascript, HTML	User's Environment	above Internet Explorer 5.0
Database	MySQL	Client's Environment	above Internet Explorer 5.0

Table 2. Web expert system database construction

Food	(1) The food composition table from the National Rural Living Science Institution in Rural Development Administration (The Sixth Revision, 2001) (2) e-food exchange (ver 1.0 and ver 2.0)
Menu	(1) Menu categorization (2) Menu Constituents and Nutrient Quantity Database construction (3) Recommended menus with picture and user menu database construction
Meal	(1) Characteristic recommended meals (2) Recommended meal database construction (3) Therapeutic meal database construction

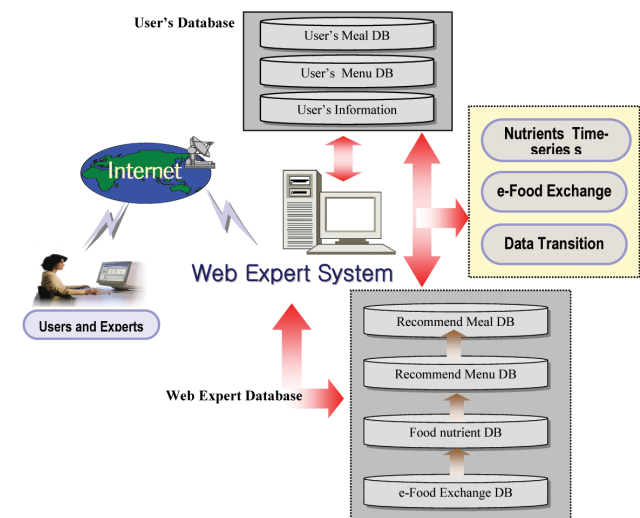


Fig. 1. The System Architecture of NutriSonic Web Expert System

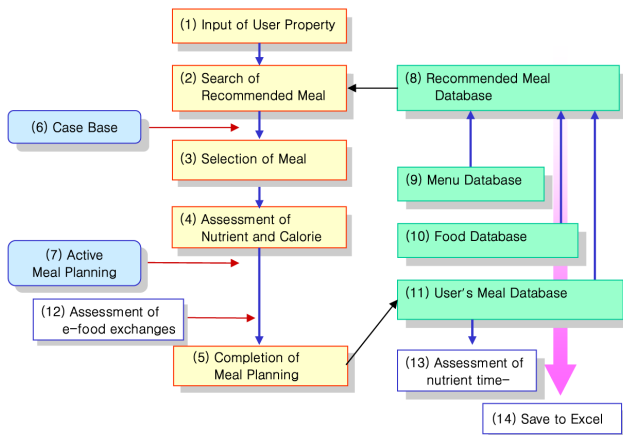


Fig. 2. Scenario of meal planning by NutriSonic Web Expert System

calculate the exact amount of food exchange of their diets to meet recommend food exchange amount. Fig. 2 shows the process of meal planning.

Fig. 2, (1) is a step to input the user's sex and age. (2) is a step to search the meal which is relevant to the user's properties from the recommended meals (8). (3) is a step to select a meal among the recommended meals. (4) assesses the nutrients and calories of the meals, the menus and foods. This step verifies that the planned meal is relevant to the user's properties. (5) completes the meal planning. By composing the menu (9) using the food database (10), a recommended meal database is made. The stored meal in (11) is included in the user's meal database. Anyone can use it. Case Base (6) is used when a user searches the recommended meal and selects the meal. (12) is a step to verify and assess e-food exchange information of a current menu or meal. In (13), users can trace his or her nutrients time-series analysis. The expert system provides users with data transition function to Excel (14).

Results

Menus of nutrisonic web expert system

Table 3 shows the meals of the NutriSonic Web Expert System. The main menu are (1) Meal Management, (2) Menu Management, (3) Food Management, (4) Nutrient and e-food exchange Analysis. Each main menu has its sub menu. And the sub meals have some node menus. As shown in Table 3, some functions are shared in each function for common purposes. For example, nutrient and e-food exchange analysis is a shared function to Meal Management and Menu Management, etc. NutriSonic web expert system provides a dynamic view, informative results and data transition function.

Table 3. The menus of NutriSonic Web Expert System

Expert Menus		
Main contents	Sub contents	Specific contents
Meal Management	Meal Planning	(1) User Meal (2) User Menu (3) Recommended Meal
	(1) Meal Search (2) Nutrient Analysis (3) Nutrient Time-series Analysis (4) e-food exchange Analysis	(1) User Meal Search, Nutrient Time-series analysis (2) Recommended Meal Search (3) Search for Meal (4) Nutrient Analysis for Meal (5) Nutrient Analysis for Food (6) Nutrient Analysis for Food (7) Nutrient Time-series Analysis for Meal (8) e-Food Exchange of Food and Meal
Meal Management	Comparing a daily recommended nutrition quantity	(1) Comparing a daily recommended nutrition quantity (2) View of nutrient analysis
Menu Management	Menu Input and Search	(1) Menu input, delete, modify (2) Menu search
Dish Management	Nutrient Analysis of Menu	(1) Nutrient analysis (2) Photo of a portion (3) e-Food Exchange of Menu
Food Management	Food Input and Search	(1) Food input, delete, modify (2) Food search (3) Conditional search of food
Nutrient Analysis	(1) Nutrient Analysis (2) Foodstuffs Analysis (3) Comparing with RDA	(1) Nutrient Analysis for Meal (2) Nutrient Analysis for Menu (3) Nutrient Analysis for Food (4) Comparing a daily recommended nutrition quantity (5) e-Food Exchange of Food and Meal (6) Data Transition to Excel

Introduction of home page

Fig. 3 is the main screen of NutriSonic web expert system (<http://nutrition.ulsan.ac.kr/nutrisonic/>). This screen is for users. The nutrient and e-food exchange database in food, menu and meal that a user can use is made by experts. The main functions of the system are meal management, menu management, food management, search, and nutrient and e-food exchange analysis. The recommended meals and menus are made by experts. The NutriSonic web expert system aims to make use of an expert's meals and menus, and to provide relevant meal



Fig. 3. Main screen of NutriSonic Web Expert System

planning and nutrition counseling. The system is concentrated on the informative functions.

Meal planning with nutrisonic

Fig. 4 is a screen of meal planning. The top screen is divided into 4 frames. Each frame is numbered as its operation characteristic for convenient user interface.

1) Selection of menu classification

Fig. 4, [1] is a selection of menu categories. This is classified by meals like breakfast, lunch and dinner. A user can search a menu by selecting each group from the first and the second categories. Also, a user can input the menu name directly to find it. In the menu category, the grand menu classification is classified by 14 groups, such as rice and soup. Rice has middle-range classifications like a crust of lightly scorched boiled rice, lightly scorched dried rice, plain rice, rice with glutinous rice, etc. Like this system, all menus are classified into the grand, middle-ranged, and specific categories. This classification is modified based on the “diet assessment system of National Rural Living Science Institute” or “Can Pro”.

In case of a menu search, users can search the menus with the full or partial-word. Single food name searching is impossible. Retrieved food or planning menus can be added to a current meal. After meal planning and storing, the meal pattern is given automatically as a menu classification. This automatic pattern is the initiative try in internet-based meal planning. Users or experts can add the contents of recommended meals or user meals in the search meal. And they can modify and add the rate or quantity of the current meal's menus and each food.

2) Selection of menu

Fig. 4, [4] shows the results that the selected menu is added to the current meal. It is the result of searching according to the conditional input for menu selection function. In NutriSonic web expert system, experts or users can follow by adding work: (1) categorical menu selection, (2) recommended meal searching and adding, (3) meal searching and adding, (4) menu searching and adding, (5) single food searching and adding, (6) making a single food and adding it.

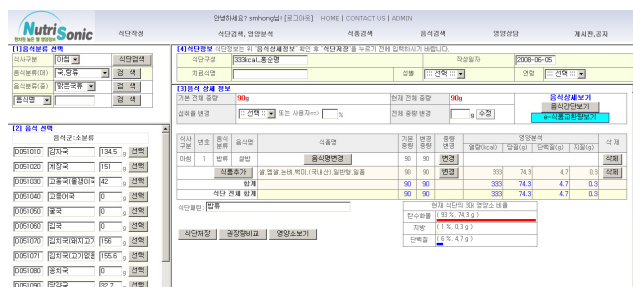


Fig. 4. The meal planning screen of NutriSonic Web Expert System

3) Detailed information of meal

Fig. 4, [3] is a detailed view of menus in a current meal. Users can change or modify the menu name, foodstuffs of a menu and quantity of foodstuffs. And a user can analyze nutrients of menus and food. In case of changing the total weight of a current meal, an expert is able to change the total weight to the weight, percentage and user's degree. Adding or deleting the menus in a current meal is possible. Also, the rates of calories, fat and proteins are presented. And the sum for a current meal, for meals and for menus is calculated. The rates and percentages of carbohydrates, proteins and fats in a whole meal are shown by a bar graph. And the amount of e-food exchange amount of a meal is calculated. In [4], the name of the current planning meal is created automatically with composition of user-name and total calories. When a menu is added to a current meal, the meal name is changed simultaneously.

4) Information of meal

Fig. 4, [4] shows the meal properties. There is a meal planning date and a meal applying date. Users or experts can select each property. Age properties have general age groups with infants. In case of women, the age groups are divided into pregnant or not and the first or second half of pregnancy. The planned meal is stored in the database. The properties of recommended meals is not sufficient to provide the meals which a user needs. For a more intellectual meal planning, we consider the following factors: user's activity, a clinical history and a propensity of meal intake.

Nutrient and e-food exchange analysis and storing of meal

The function of meal planning has a view of recommended energy, nutrient, e-food exchange. If a user does not select the meal properties, the criterion of nutrient analysis is based on the 20~29 years of age and a male. Fig. 4 shows the view of recommended energy and nutrients.

1) Nutrients analysis and storing meal

This is comparing and analyzing a daily nutrient recommended quantity of planning or of a planned meal. For a user's age and sex, the web expert system calculates the sum of each meal such as breakfast, lunch and dinner. Then, the web expert system compares the total energy with a daily nutrient recommended quantity. There is a nutrient analysis of foodstuffs in each meal. Also, it provides information of foodstuffs in a current meal. If needed, it is possible to modify and delete the current meals, menus, and foodstuffs. When the meal planning is completed, the web expert system stores the meal as meal properties. Stored meals can be used in meal searching, meal modification and new meal planning.

2) Analysis of nutrient changes

After making a meal for users, or recommending nutritionists

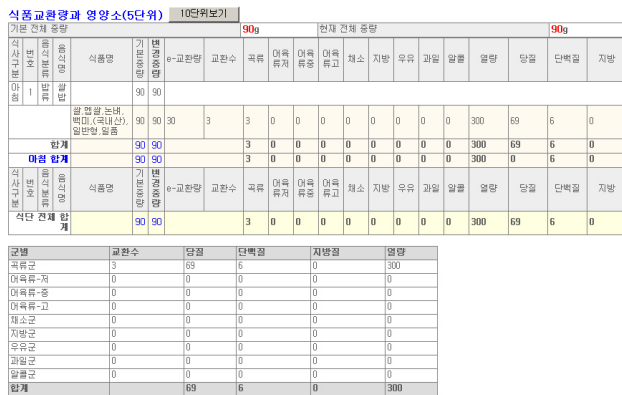


Fig. 5. e-Food exchange of sample meal by NutriSonic



Fig. 6. Selecting data to nutrient time-series analysis of sample meal

or users can review the nutrient changes and check the status. The system provides the changes of meal nutrients, which a user selects among registered meals. Stored meals can be used in meal analysis or changes analysis at any time. Fig. 5 shows the sample meal for changes analysis.

3) View of e-food exchange

In making a meal, nutritionists or users are able to review the nutrient information with food exchange. Fig. 5 shows the e-food exchange information of a current meal or selected meal.

4) Nutrient time-series analysis of user meals

Users or experts can select any meal which they want. Fig. 6. shows the selection of 3 meals data (June 5, 19, 29) for nutrient time-series analysis information among the meals which are selected by a user. Fig 7 shows nutrient time-series analysis bar grape among the 3 meals data which are selected by user. The change information consists of the comparing for each nutrient and ratio of major energy nutrient like carbohydrates, fat and protein of selected days.

Meal search

Fig. 8 is a screen of a meal search. The conditional items are menu name, meal name, sex, age, calories of meal, and the

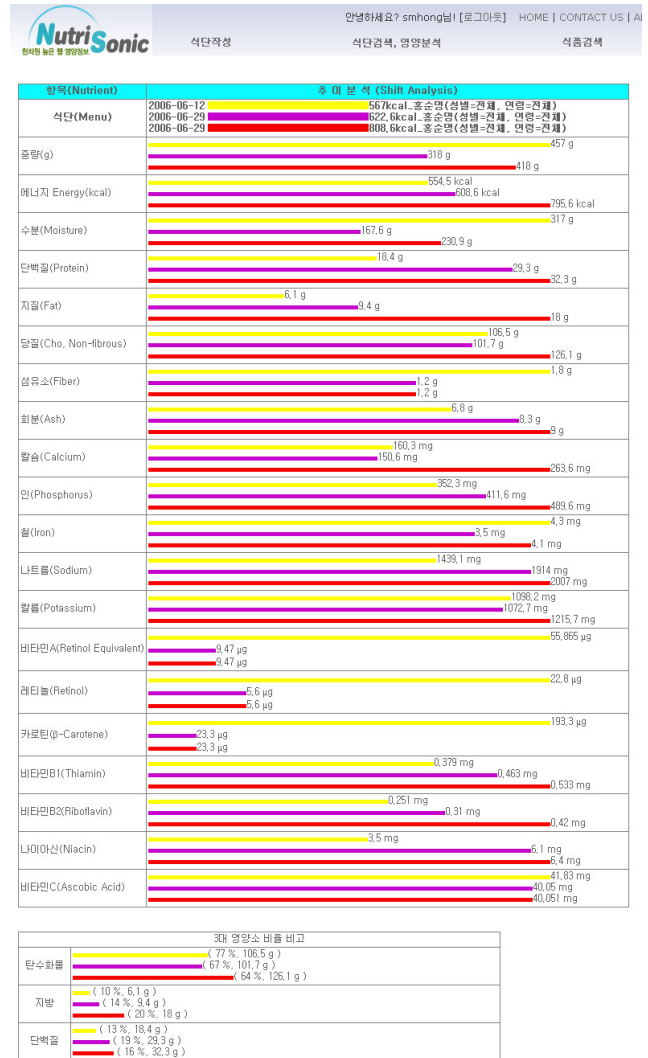


Fig. 7. Nutrient Time-series analysis for each meal's nutrient by NutriSonic

*** 권장식단 검색** *** 사용자 식단 검색** [식단검색 도움말] [1일 영양권장량]

식단구성	<input type="text"/>
작성일자	<input type="text"/> 2008-04-22 의 형식으로 입력해 주세요
음식명	<input type="text"/>
치료식명	<input type="text"/>
성별	선택 ▼
연령	선택 ▼
칼로리	<input type="text"/> ~ <input type="text"/> kcal 식단 ▼
식단패턴	<input type="text"/> <input type="button" value="패턴찾기"/>




 권장식단 검색  치료식단 검색  홍순명님 식단보기

Fig. 8. A screen of meal search

patterns of a meal. In this search process, recommended meals and user's meals are available.

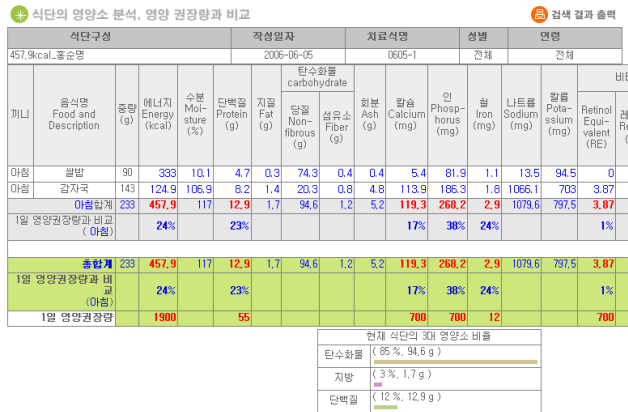


Fig. 9. Comparison of a current meal with the recommended dietary allowance

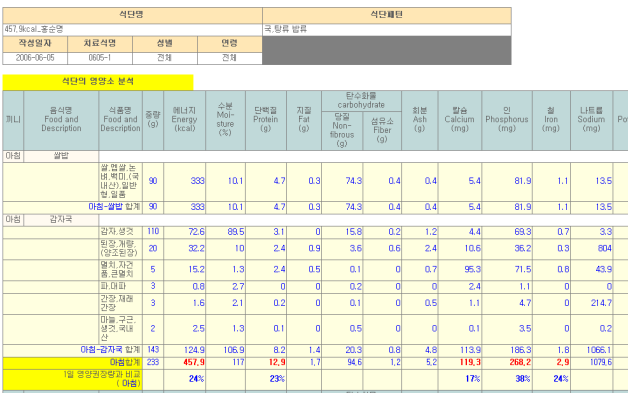


Fig. 10. Nutrient analysis of a current meal

Fig. 9 is a comparison screen of a current meal with the Korean Recommended Dietary Allowance (2000). The screen shows the menu names, quantities and nutrient analysis data. Also, it shows the sum of breakfast, lunch, dinner and the comparison of daily recommended nutrient quantity. The rate is presented as a percentage. On the bottom of the screen is the calorie rates of three main nutrients. Fig. 10 is a screen of nutrient analysis of a current meal. In a detailed view, there are menu names, food names, quantities of foods, menus and meals, calories and three main nutrients. Also, the web expert system shows the rates of the three main nutrients as a bar graph. Besides, the system provides a comparison analysis with the recommended nutrient quantity and a view of nutrient analysis.

Menu search and management

Fig. 11 is a screen of menu search and management. It is a search result in order of cooked rice, boiled rice with assorted mixtures, fried rice and fried rice with kimchi. It is possible for a user to search menus by menu name or menu classification. So a searched menu provides food ingredients with each nutrient, menu nutrients and pictures (Fig. 12). The web expert system provides a screen print-out and view of a portion.



Fig. 11. Menu search and management of NutriSonic expert system



Fig. 12. Searched Menu with ingredients, nutrients and menu pictures by NutriSonic

Food management and search

Table 4 shows the food management and search contents. Food management and search has input food composition data and conditional search items such as food group, food code, Korean food name, English food name, calorie and nutrient. And food is divided into key foods and total foods in the database. Fig. 13 is a screen of food management. Food data modifying, deleting and saving with new food name are available on food

Table 4. Food management and search of the web expert system

Food management and search	Food Group
	All groups, cereals, potatoes and starches, sugars and sweeteners, pulses, nuts and seeds, vegetables, mushrooms, fruits, meats, eggs, fish and shellfish, seaweeds, milks, oils and fats, beverages, seasonings, prepared foods, others
	Food Code
	Food Name: Korean, English
	Calorie: range
	Nutrient
Food management and search	e-Food exchange, protein, fat, non-fibrous, fiber, ash, calcium, phosphorus, iron, sodium, potassium, retinol, β -carotene, thiamin, riboflavin, ascorbic acid, niacin
	Search with key foods in database
	Search with total foods in database

식품번호	F00001	식품명	참치, 생것				영양				
에너지(kcal)	66	수분(g)	81.4	단백질(g)	2.8	지방(g)	0.001	당질(g)	14.4	섬유소(g)	0.2
회백분(g)	1.1	칼슘(mg)	4	인(mg)	68	철(mg)	0.6	나트륨(mg)	3	칼륨(mg)	465
비타민A(%)	0	비타민B1(%)	0	비타민B2(%)	0.11	비타민B6(%)	0.06	비타민C(%)	0	비타민E(%)	1
비타민C(mg)	54	비타민D(%)	0	비타민K(%)	0.001	비타민P(%)	0.001	비타민Q(%)	0	비타민R(%)	0
수분	81.4	단백질	2.8	지방	0.001	당질	14.4	섬유소	0.2	회백분	1.1
칼슘	4	인	68	철	0.6	나트륨	3	칼륨	465	비타민A	0
비타민B1	0	비타민B2	0.11	비타민B6	0.06	비타민C	0	비타민E	1	비타민K	0.001
비타민P	0.001	비타민Q	0	비타민R	0	비타민S	0	비타민T	0	비타민U	0

부 외 사항

- * '타' 분석자료' 표시는 검출에 -를 받은 것
- * '검출' 표시는 측정값이 있을 때만 표시
- * '인산' 표시는 0.001
- * 지용성 수분은 세척과정에서 얻어 있는 1%인 '타'로 입력 (0%)는 농분량(%)으로 입력

Fig. 13. A screen of food management

식품번호	식품명	영역	에너지	e-식품	수분	단백질	지방	탄수화물	회백	칼슘	인
Item NO.	Food and Description	English Name	Energy (kcal)	Food (g)	Moisture (%)	Protein (g)	Fat (g)	Carbohydrate (g)	Ash (g)	Calcium (mg)	Phosphorus (mg)
F01007	가래, 도장국	Prosimilant, Polished grain	352	30	14	11.5	2.1	70.4	0.4	1.6	245
F01012	밀가루, 도장국(도장)	Buckwheat noodle, (Dried)	360	30	12	13.6	2.6	70.2	0.4	1.2	250
F01014	밀가루, 도장국(도장)	Naeng Myeon(Buckwheat vermicelli), Instant	341	30	12.3	10.5	1.4	73.9	0.4	1.5	116
F01015	밀가루	Buckwheat starch jelly	58	180	84.5	1.7	0.2	12.8	0.2	0.6	40
F01020	밀가루, 중력분, 국내산	Wheat flour, medium (Domestic)	378	25	0.3	11.5	1.1	86.6	0.2	0.3	31
F01025	밀가루	Bread crumbs	355	30	8.1	14.2	3.7	72.2	0.2	1.6	29
F01026	밀가루	Frying powder	329	30	11.8	7.3	1.5	76.6	0.2	2.6	214
F01029	국수, 삶은	Noodle, Boiled	125	85	70.6	4.6	0.4	24.2	0.1	0.1	12
F01030	국수, 삶은	Ra Myeon, Ra Myeon	381	25	8.2	8.6	14.1	61.4	0.5	7.2	91
F01034	국수, 삶은, 국내산	So Myeon, Dried	384	30	11	8.7	0.2	77.1	0.2	2.8	7
F01036	국수, 삶은, 삶은	So Myeon, Boiled	122	80	61.3	3.2	0.2	26.9	0.1	0.3	4
F01038	국수, 삶은, 삶은	Udang, Raw	339	70	63.5	3.8	0.4	31.8	0.2	0.3	3
F01049	국수, 삶은, 삶은	Uji Myeon, dried	339	40	36.5	6.6	0.8	56.1	0	0	37
F01052	국수	Biscuit, military type	415	25	6.6	8.7	9.4	73.5	0.3	1.5	21
F01053	국수, 삶은	Raisin bread	280	40	38	6.6	3.7	49.9	0.2	1.5	42

Fig. 14. A result of food search with food exchange

e-식품교환량과 영양소(10단위)

e-식품교환량과 영양소	
식품군	선택
곡류군	○ 3.4
야채군	□ 0.4
야채군	□ 0.3
야채군	□ 0
채소군	△ 2.7
지방군	□ 0.5
유제품	◇ 0.5
과일군	● 0.4
곡류군-알	● 0

대분류	범류	중분류	비밀번호, 품목 범류	음식코드	D014029
음식명	비밀번호			음식종류(g)	332.5

식품명	중량(g)	e-식품 교환량 (g)	e-식품 교환량 (g)	대 분 류	중 분 류	채 소	지 방	유 지	과 일	알 류	알 류	단 백 질	지 방
쌀, 찰													

the food was obtained (Raper *et al.*, 2004).

In Korea, some internet programs such as MenuGen (Hong *et al.*, 2004) and NutriEval (Hong, 2007) provide food composition tables with a searching engine. And web-based programs for nutrition were developed (Han & Jeong, 2004; Her & Lee, 2002; Hong & Kim, 2005; Hong *et al.*, 2004; Hong, 2007; Lee *et al.*, 2002), but web-based food exchange calculating programs for diet therapy partly. Nutrition related programs based on the internet were developed such as the analysis of a food intake and nutrition screening system (Han, 2000), a web-based internet program for nutritional counseling and diet management of patient with diabetes mellitus (Han & Jeong 2004), food exchange database construction and search system (ENECC/E-Food Exchange) based on the internet (Hong *et al.*, 2003), e-food exchange database construction of commonly used foods and search system (Hong *et al.*, 2004) and menu planning and recommended menu search system (MenuGen) of the National Rural Living Science Institution in Rural Development Administration (Hong *et al.*, 2004). In addition, there is the status of eating habits, analysis of eating habits, obesity, calorie expenditure and nutrient analysis of menus in the internet program of the nutrition computing (Hong & Kim, 2004). And NutriEval (KFDA, Korea Food and Drug Administration) was developed with drag and drop for meal planning and nutrient evaluation for children (Hong, 2007). But the developed programs are insufficient in meal planning and nutrient analysis. Especially on diet therapy using food exchange for diabetes and obesity, users have trouble to input food or meals and can not have nutrient and e-food exchange analysis, storing and modifying the data.

We expect that NutriSonic will contribute to meal planning using e-food exchange for meal management of diabetes and obesity and nutrition improvement. And we hope NutriSonic with e-food exchange, nutrient time-series analysis and data transition could be widely used for diet therapy and nutrition education.

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