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Report

Korean Rural Development Administration's web based food and nutrient database management and validation system (NutriManager) – A report

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ABSTRACT

Food composition databases (FCDBs) are important to studies, industries, polices, and modeling related to diet and food. A FCDB has been provided by each country's government organizations. In Korea, the FCDB has been produced and provided by the Rural Development Administration (RDA) and the national food analysis system (NFAS), a network between qualified laboratories by the nation. In this study, a new web based system, NutriManager, was designed to support integrated database management and collaboration between RDA and NFAS. The main goal of this system is to provide an efficient tool to support a series of workflow from sample enrollment to validation results. NutriManager has many features related to food and nutrient database management and validation; the computerized laboratory notebook, the stepwise processes of algorithms for validity assessment and determination of the representative value, and creation of a Korean National Food Composition Table (KNFCT). Therefore, NutriManager contributes to production of food composition data with high reliability and also can be used as a more efficient tool to link with other public programs using FCDB as a key database in Korea.

1. Introduction

Since the late 1950s, computer technologies have enabled the developers and users to handle larger amounts of data more efficiently and been used to conduct many surveys of nutrients, food composition, etc. (Hoover, 1983). Researchers have included many items in software using nutrient data, and emerging nutrient values have been added to the databases for recent trend analysis (Stumbo, 2003).

Food composition databases (FCDBs) are important to studies, industries, polices, and modeling related to diet and food. A FCDB has been provided by each country's government organizations. For example, in the United States, national institutes such as the USDA (United States Department of Agriculture) has provided food composition data. The USDA also manages the NDBS (Nutrient Data Bank System) (USDA, 2016) for internal system to handle food composition data and SR (Standard Reference) (USDA, 2017) for the public provision of constructive nutrient composition data. The SR includes over 9000 food items and 150 food composition and nutrition values (Haytowitz and Pehrsson, 2016).

In Korea, the FCDB has been produced by the national food analysis system (NFAS), which is a network of analysis laboratories. The NFAS consists of the Rural Development Administration in Korea (RDA) and nine organizations, including universities, laboratories, and industries. The RDA managed the overall process and organization of the NFAS and was also designated as a contact institute to manage food and nutrition data in Korea by the United Nations Food and Agriculture Organization (FAO)/International Network of Food Data System (INFOODS), which published the guidelines for checking food composition data prior to the publication of a user table/database. In the NFAS, analytical laboratories collect food composition data, manage data quality, and develop databases. Moreover, the RDA produces standard samples for analysis, sends samples to analytical laboratories in NFAS, and publishes KNFCT (RDA, 2016). Because food composition data is analyzed and collected from distributed organizations, it is important to develop the computerized process to assess the validity of food composition data produced in NFAS and construct an automated

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production process to determine the representative values of food composition data.

This report was conducted to describe the RDA's web based food and nutrient database management and validation system (NutriManager), highlighting detailed algorithms used to evaluate the validity.

2. Methods

2.1. Software requirement elicitation and analysis

Analytical samples and their preprocessing record, laboratory notebooks by nutrient, and KNFCT (1st–8th release), and documents related to USDA SR and EuroFIR's food description files for requirement elicitation were collected and reviewed. The interdisciplinary collaboration is conducted between computer scientists and nutritional experts, including specialists in food science, chemical analysis, and policy making in the food and nutrition domain. All relevant information, such as sample profile, relationship between sample and analytical result, food/nutrient description concept and laboratory notebook for the system development were provided by experts, after which the service system was reviewed with respect to the particular scientific domains.

Through use-case analysis with the requirement modeling technique (Jacobson et al., 1999), user groups as actors of the system are identified as data producers responsible for analysis of food composition data and compilers responsible for collection and compilation of data and publication of KNFCT. RDA produces data and publishes KNFCT simultaneously. The use-case scenario was written in terms of two actors. Data compilers register sample information when the sample are acquired and before they are sent to the laboratory for analysis. And data producers select the sample registered and input raw data in the laboratory notebook form designed by nutrient, and the system calculates the nutrient values of replicates from raw data automatically. After that, the system assesses the validity through the repeatability precision test. Finally, data compilers compare mean values of all results by nutrient of all samples mapped to certain food items with those of the existing KNFCT and FCDB of other countries and determine if the value would be used as a representative value in the KNFCT.

2.2. Database design

To prepare for connectivity with FCDBs of other countries (e.g., the EU) in the future, we analyzed the thesaurus system of the international framework for food description (LanguaL) (LanguaL, 2017) and food description contents of the existing off-line KNFCT. The data model consisted of the following key entities:

- Project (project number, start date, end date, KNFCT release number, authority level)
- Food description (food code, food name, food group shown in Table 2, food classification (3 depth), food state (e.g., raw, dry, etc.), cooking method, description and the LanguaL code (N6) for harmonization of the international FCDBs).
- Nutrient description (nutrient code, name and group shown in Table 3, abbreviation, unit code, default precision, description and flag to be published in the KFNCT).
- Sample (sample information, see Table 1)
- Result (all raw data of laboratory notebook for replicates by sample, nutrient)
- Equation of laboratory notebook (target nutrient, equation, equation description)
- Repeatability lookup table (target nutrient, upper and lower limit of mean of replicates, upper relative standard deviation)
- Data source (reference)
- KNFCT (release number, food code, nutrient code, creation date, value, replacement flag)
- FCDB (FCDB contents of the countries)

2.3. Architectural design

The system architecture consisted of seven modules (workflow control, sample enrollment, encoding, investigation, output, searches, and Korean National Food Composition Table (KNFCT)) creation module), a barcode printer, four databases (sample, analytical result, existing FCDB, and investigation database), and an internal algorithm for evaluating the validity and reliability (Fig. 1). The input parameters of internal algorithms for evaluating the validity use the output of sample enrollment and encoding steps. The sub-steps of the algorithm include calculation of statistics related to validation of repeatability and analysis of the reliability.

As shown in Fig. 2, the user interface of NutriManager is configured in the form of a web page and can be accessed through web browsers such as Internet Explorer or Chrome, and the interface operates across devices such as smartphones and tablets. As every program function and database can only be updated and upgraded on the original server, there is no need to install special program on users' personal computers. The system also provides hot keys for frequently used functions to improve accessibility. The programming language, relational database management system and methodology used Java, Oracle and object-oriented programming techniques respectively.

3. Results

3.1. Overall database management features of NutriManager

The overall database management features of NutriManager implemented by the architectural design shown in Fig. 1 are as follow:

In the sample enrollment module, the data compiler inputs general and detail information related to a logged sample profile as shown in Table 1 and the data producer inputs analytical results by sample and nutrient allocated from the data compiler, after which a registered sample profile is saved in the database.

The database is tightly connected by sample and food description codes and consists of four categories, sample, analytical result, existing FCDB, and investigation database. The sample database saves food information including geographical sources and images by sample, the analytical results database saves repeated measurements of the sample, the existing FCDB saves food composition data and related information from existing KNFCT and FCDBs of other countries, and the investigation database saves results related to the validity assessment.

The encoding module assigns identification (ID) code to the sample. The barcode printer in the system then prints a barcode label based on the ID code of the sample. The printed barcode label is attached to the sample and used to tract it throughout the overall process.

The investigation module assesses the validity of the replicates and determines the representative value by comparison between newly analysis results with existing FCDBs. The output module provides the visualized screen with a sample profile, analytical results, and validation history of the investigation module.

All users can search all information saved in the database through the search module. NutriManager also includes a KNFCT creation module, which manages and checks the aggregated nutrient values by food item historically. Every module in NutriManager is operated by the workflow control module, which controls normal functions of each module.

3.2. Validation assessment algorithm and features of NutriManager

A representative value means a final food composition value for a specific nutrient just before publishing in the KNFCT. It is determined by checking the most frequent results when analyzing the individual food samples of same kind of food items repeatedly. In other words, the representative value represents characteristic and trend of the statistical data. Until now, the representative values of the food composition have

Table 1
Sample entity for sample enrollment module.

Group	Detailed attributes
Basic Information	Food (description) code of the KNFCT, LanguaL code(N6) for harmonization, Sample name(Korean, English, Scientific, Synonym)
Part	Used portion code, Refused portion code, [Peel, Skin, Shell(Y/N)]
Sampling date and place	Cultivation area code, sampling place, Date, References
Sample state	Current, Maturity
Addition information in case of processed food	Nutrition fortification flag, Raw materials(additives) description, Nutritional Facts(Salt, Carbohydrate, Sugars, Fat, Trans fat, Saturated fat, Cholesterol, Protein, Packing agent)
Supplemental Image	Part(All, Edible, Refuse), Package, Label(Raw materials, Nutrition)
Cooking	Cooking method
Homogenization	Method, Time, Number of times, Speed
Inventory	Storage location No., Remained amount, Usage history(including manager and date), Storage place and temperature
Weight(/100 g)[a]	Before/After cooking, One process before/after cooking
Grade(g)[a]	Premium, Upper, Intermediate, Low(g)
Intake(g)[a]	Serving, Portion(g)
Weighing unit[a]	Cup, 1TS, 1ts, slice, Bulk weight(g)
Dimension of original sample [a]	Width(cm) x Height(cm) x Depth(cm)
Dimension of sample after cutting[a]	Width(cm) x Height(cm) x Depth(cm)

[a] Enrolled in form of result set and its statistical parameters (mean, standard deviation etc.).

Table 2
Food groups in the Korean food composition database within the NutriManager.

Food group	Raw materials	Cooked or Manufactured products	Total
Cereals and cereal products	132	202	334
Potatoes and starches	53	30	83
Sugars	0	62	62
Pulses	30	30	60
Nuts and seeds	56	62	118
Vegetables	408	162	570
Mushrooms	55	16	71
Fruits	175	89	264
Meat	173	153	326
Eggs	14	12	26
Fish	559	292	851
Seaweeds	53	20	73
Milk and milk products	0	60	60
Oils	0	30	30
Teas	15	46	61
Beverages	0	26	26
Alcohols	0	40	40
Seasonings	8	89	97
Manufactured dishes	0	156	156
Others	12	22	34
Total	1743	1599	3342

been determined by each repeatability precision rule of each qualified laboratories (the government or university or food company), therefore, the standardized system for producing the representative values from replicates is required. To solve this problem, the algorithm and features to assess the validity from laboratory notebook was implemented in NutriManager. Actually implemented features with the algorithms are shown in a stepwise manner in Fig. 3.

3.2.1. Laboratory notebook (Step 1)

An analytical result may be determined as measurement value as itself or calculated value derived by applying a unique equation specified by a nutrient to sub-measurement values (raw data). One sample may be measured N-times repeatedly. Therefore, one sample by a nutrient (e.g., ash and water) is analyzed repeatedly and has N-time replicates and one replicate measurement is determined by the above rule. Generally, these records for derivation process of analytical result are written as form of off-line laboratory notebook, namely, paper-based laboratory notebook as shown in Fig. 4. However, we developed it as online system, namely, electronic laboratory notebook (ELN). It means that not only a final nutrient value of a replicate but also all raw data used to derivation of a replicate is maintained as database. To accomplish this, a total of 85 equations by nutrient used in the NFAS laboratories were collected and implemented in the form of database. Once a data producer selects the sample and nutrient, NutriManager creates the input box by loading the input parameters and formula corresponding to the selected nutrient from the equation database. Unlike other systems, NutriManager has equation's design and database management features. A user can input the formula and its independent variables by nutrient as a textstyle in the input form and save them into database. This features enable the user to enter into a database, and load and use the various equations from a database by nutrient used in the laboratory notebook without creating newly and modifying source code for calculations by software developer whenever new equations are required. In cases of water and ash, equation 1 and 2 are used to calculate the replicate values, respectively.

After checking the sample amount, the investigation module analyzes the mean concentration of food composition in more than one sample through algorithms, such as Eqs. (1) and (2) below, which follow the official methods of the Association of Official Chemists (AOAC) International (AOAC, 2016). Eq. (1) calculates the water content (%) in the sample and Eq. (2) is an example of an algorithm calculating the ash content (%).

$$\mathrm{Ci(Water)} = \frac{((\mathrm{A}_i + B_i)\#\mathrm{XPS}\#\mathrm{ndash};\ \mathrm{C}_i)}{((\mathrm{A}_i + B_i) - \mathrm{A}_i)} = \frac{(\mathrm{A}_i + B_i)\#\mathrm{XPS}\#\mathrm{ndash};\ \mathrm{C}_i\langle\mathrm{xps{:}spanclass} = \text{"ceCheck"}\rangle)\langle/\mathrm{xps{:}span}\rangle}{B_i} \quad (1)$$

$$\mathrm{Ci(Ash)} = \frac{(\mathrm{C}_i - B_i)}{B_i} \quad (2)$$

In Eqs. (1) and (2), A is the container weight, B is the sample amount, and C is the dry weight or the weight after burning (ash), i is i^{th} replicate, and Ci (Water) and Ci (Ash) are water and ash ratio, respectively. .In this manner, the system calculates the replicates three times. For oriental melon (whole, first) example, implemented result for on-line laboratory notebook is shown in Fig. 5. Also, the Ci (Water) of oriental melon (whole, second) sample is calculated in this manner.

3.2.2. Assessing the validity (Step 2)

After calculation of replicate results, the validity of replicate values are assessed by testing the repeatability precision. At first, the mean, standard deviation (SD), and relative standard deviation (RSD) values of replicates are calculated by equation. In the case of RSD values, Eq. (3) is used.

Table 3
Components in the Korean food composition database within the NutriManager.

Proximate compositions (A)[a]	Minerals (B)[a]	Vitamins (C)[a]
Energy[b]	Calcium[b]	Vitamin A Retinol activity Equivalent
Water[b]	Iron[b]	Vitamin A Retinol Equivalent[b]
Protein[b]	Magnesium	Retinol[b]
Fat[b]	Phosphorus[b]	β-Carotene[b]
Ash[b]	Potassium[b]	α-Carotene
Carbohydrate[b]	Sodium[b]	β-cryptoxanthin
Available carbohydrates	Zinc	Vitamin D
Total sugars	Copper	(Ergocalciferol + Cholecalciferol)
Sucrose	Manganese	Ergocalciferol
Glucose	Selenium	Cholecalciferol
Fructose	Molybdenum	Total Vitamin E
Lactose	Iodine	Tocopherol (α-, β-, γ-, δ-)
Maltose	Mercury	Tocotrienol(α-, β-, γ-, δ-)
Galactose		Phylloquinone
Raffinose		Thiamin*
Total Dietary Fiber[b]		Total Riboflavin*
Water Soluble Dietary Fiber[b]		Flavin Mononucleotide
Water Insoluble Dietary Fiber[b]		Flavin Adenine Dinucleotide
alcohol		Total Niacin[b]
		Niacin equivalents
		Nicotinic acid
		Nicotinamide
		Pantothenic acid
		Pyridoxine
		Biotin
		Dietary Folate Equivalent
		Food Folate
		Folic acid
		Cyanocobalamin
		Total Ascorbic Acid
Amino acids (D)†	Cholesterol & Fatty acids (E)†	Etc. (Z)†
Sum of 19 amino acids	Cholesterol	Sodium Chloride Equivalent[b]
Total essential amino acid	Total fatty acid	Crude fiber[b]
Isoleucine	total essential fatty acid	Refuse
Leucine	Saturated Fatty acid	
Lysine	Butyric	
Methionine	Caproic	
Phenylalanine	Caprylic	
Threonine	Capric	
Tryptophan	Lauric	
Valine	Tridecanoic	
Histidine	Mysistic	
Arginine	Pentadecanoic	
Total non-essential amino acid	Palmitic	
Tyrosine	Heptadecanoic	
Cystine	Stearic	
Alanine	Arachidic	
Aspartic acid	Henicosanoic	
Glutamic acid	Begenic	
Glycine	Tricosanoic	
Proline	Lignoceric	
Serine	Monounsaturated fatty acid	
Taurine	Decenoic	
	Myristoleic	
	Palmitoleic	
	Heptadecenoic	
	Oleic	
	Vaccenic	
	Gadoleic	
	Erucic	
	Nervonic	
	Polyunsaturated fatty acid	
	Linoleic	
	Linolenic (a-, γ-)	
	Stearidonic	
	Eicosadienoic	
	Icosatrienoic	
	Eicosatrienoic	
	Arachidonic	
	Eicosatetraenoic	
	Timnodonic/ Eicosapentaenoic(EPA)	
	Docosadienoic	
	Clupanodonic/ Docosapentaenoic (DPA)	
	Docosahexaenoic (DHA)	
	Docosapentaenoic	
	Total *n*-3 polyunsaturated Fatty acid	
	Total *n*-6 polyunsaturated Fatty acid	
	Trans fatty acid	
	Trans oleic	
	Trans linolenic (18:2t)	
	Trans linolenic (18:3t)	

[a] Food composition group code.
[b] Twenty-two components published in KNFCT (e.g., Calcium*).

$$\text{RSD (i, n)} = {}^{SD}/_{mean} \quad (3)$$

The mean value of replicates is compared with the concentration ranges through look-up table shown in Table 4 and the range and the corresponding upper RSD limit (%) is determined. If the RSD value of replicates is less than the upper RSD limit, the result (the mean value of replicates) is assessed as “valid”. When the result is not “valid”, the result screen outputs the “Yes” message to reanalyze, at which point the data producer is requested to input the new analysis result by NutriManager. The implemented result for validity assessment of two samples for oriental melon is shown in Fig. 6. All history of reanalyzed results is designed to be recorded and tracked.

3.2.3. Determining the representative value (Step 3)

After assessing the validity, the representative value of the food composition for specific food item is determined by comparing the newly analyzed results with food composition data in existing FCDBs.

If there are already specific food item in the KNFCT or external FCDB for references, for the same kind of food item, all mean values of the newly analyzed results by nutrient are compared with mean values of corresponding food composition data by nutrient found in the KNFCT or FCDBs of other countries to determine if the values are in the range of 80–120% or not. If the values were within this range, the old values were also included into a new mean. The range of 80–120% is based on the standard guideline for concentrations of functional or market components used in health functional food in Korea (Ministry of Food and Drug Safety, 2014). Implemented result for this process of oriental melon example is shown in Fig. 7. Finally, the results including the representative values determined by repeated analysis are saved in the investigation database.

4. Discussion

This study focused on improvement of the national FCDB management system to produce nutritional data about domestic products. Similarly, many countries have developed domestic and global FCDB and incorporated databases between countries to provide more diverse and exact data regarding food composition. In the United States, the USDA determines representative values for food by analyzing products

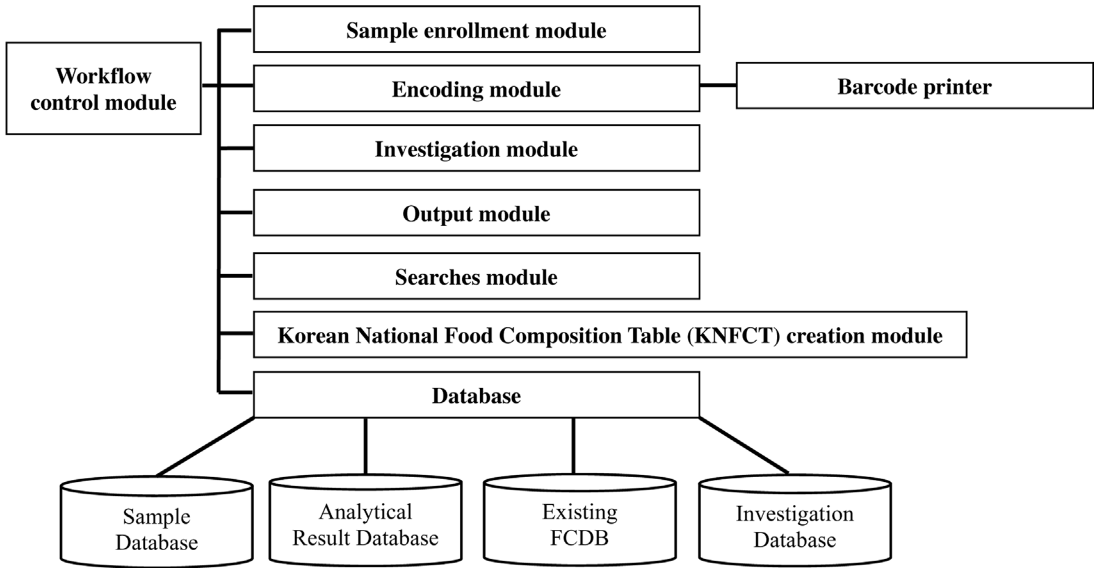


Fig. 1. The architectural design of NutriManager.

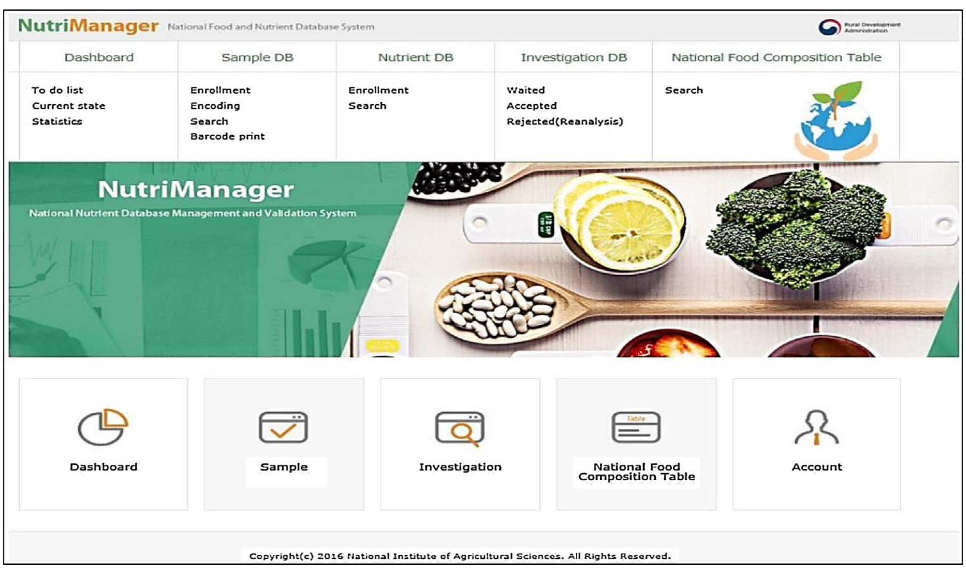


Fig. 2. Main screen of RDA's web based food and nutrient database management and validation system (NutriManager).

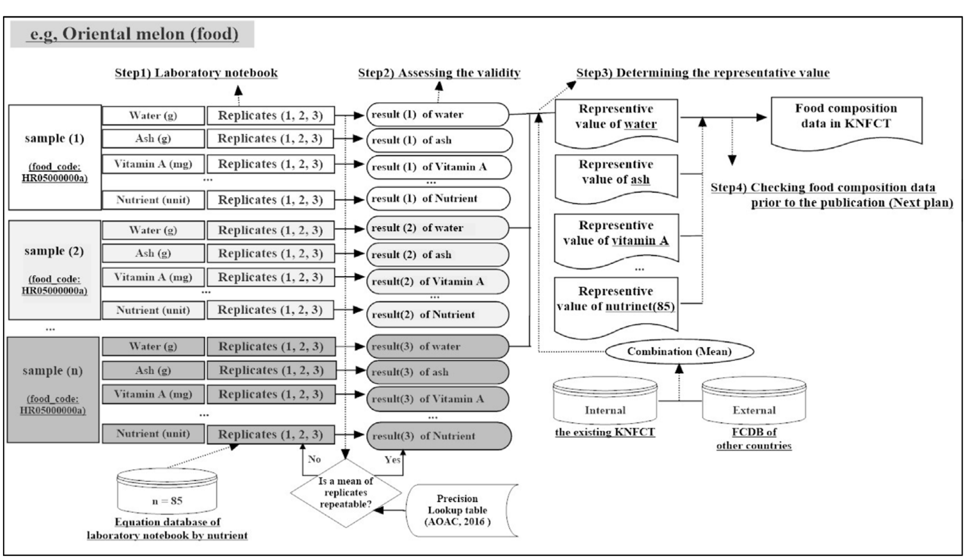
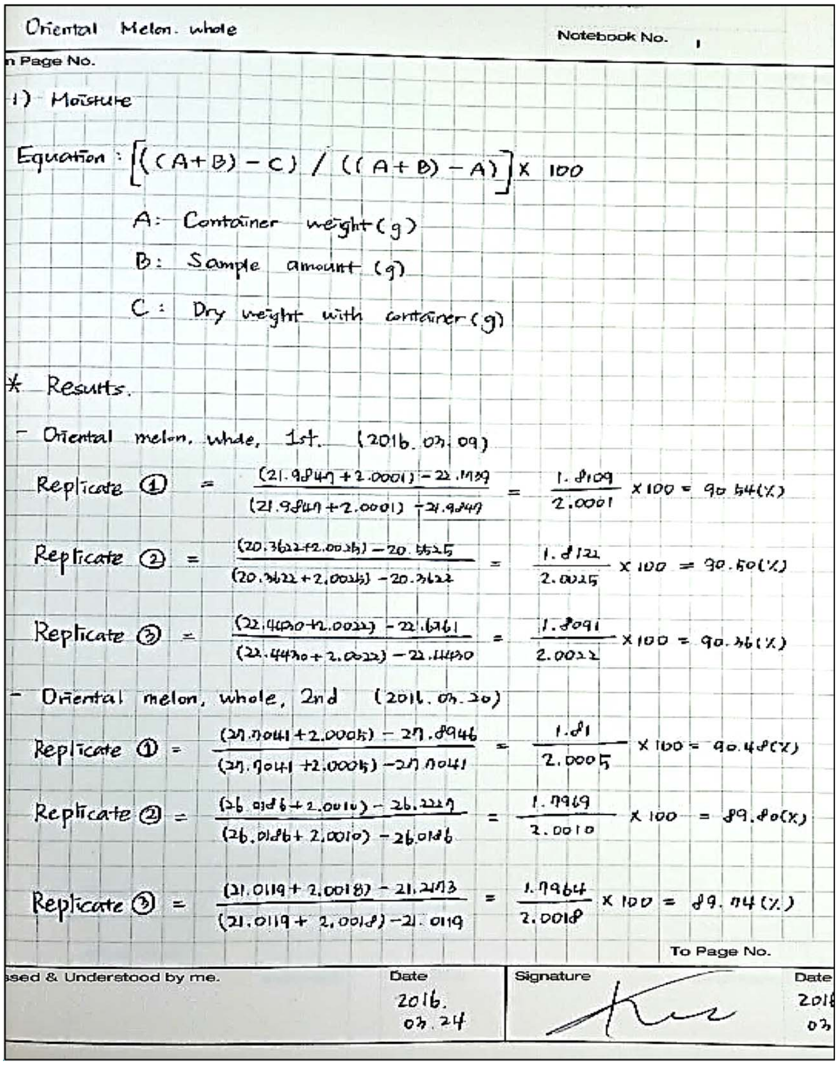


Fig. 3. The stepwise processes of algorithms for assessing validity and determining the representative value.


Oriental Melon. whole Notebook No. 1

n Page No.

1) Moisture

Equation : [((A+B) − C) / ((A+B) − A)] X 100

A: Container weight (g)

B: Sample amount (g)

C: Dry weight with container (g)

* Results.

- Oriental melon, whole, 1st. (2016. 03. 09)

Replicate ① = (21.9847 + 2.0001) − 22.1739 / (21.9847 + 2.0001) − 21.9847 = 1.8109 / 2.0001 X 100 = 90.54(%)

Replicate ② = (20.3622 + 2.0025) − 20.5525 / (20.3622 + 2.0025) − 20.3622 = 1.8122 / 2.0025 X 100 = 90.50(%)

Replicate ③ = (22.4430 + 2.0022) − 22.6361 / (22.4430 + 2.0022) − 22.4430 = 1.8091 / 2.0022 X 100 = 90.36(%)

- Oriental melon, whole, 2nd (2016. 03. 30)

Replicate ① = (27.7041 + 2.0005) − 27.8946 / (27.7041 + 2.0005) − 27.7041 = 1.81 / 2.0005 X 100 = 90.48(%)

Replicate ② = (26.0186 + 2.0010) − 26.2227 / (26.0186 + 2.0010) − 26.0186 = 1.7969 / 2.0010 X 100 = 89.80(%)

Replicate ③ = (21.0119 + 2.0018) − 21.2173 / (21.0119 + 2.0018) − 21.0119 = 1.7964 / 2.0018 X 100 = 89.74(%)

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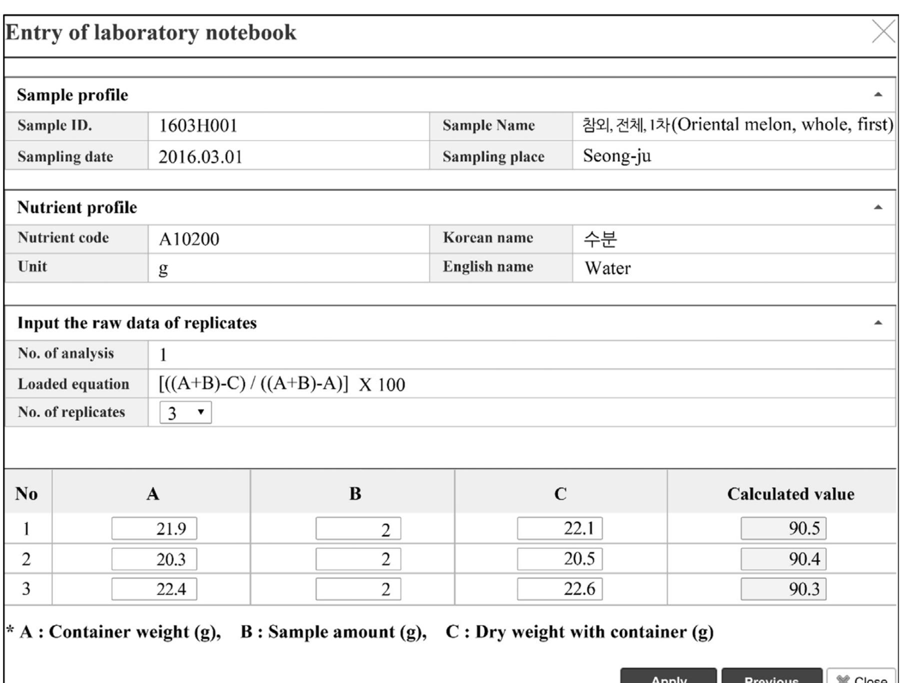
Fig. 4. Example of off-line laboratory notebook for two samples of oriental melon (Step 1).


Entry of laboratory notebook

Sample profile

Sample ID.	1603H001	**Sample Name**	참외, 전체, 1차(Oriental melon, whole, first)
Sampling date	2016.03.01	**Sampling place**	Seong-ju

Nutrient profile

Nutrient code	A10200	**Korean name**	수분
Unit	g	**English name**	Water

Input the raw data of replicates

No. of analysis	1
Loaded equation	[((A+B)-C) / ((A+B)-A)] X 100
No. of replicates	3

No	A	B	C	Calculated value
1	21.9	2	22.1	90.5
2	20.3	2	20.5	90.4
3	22.4	2	22.6	90.3

*** A : Container weight (g), B : Sample amount (g), C : Dry weight with container (g)**

Apply Previous Close

Fig. 5. Implemented result for on-line laboratory notebook (Step 1).

Table 4
The lookup table for repeatability precision test (AOAC, 2016).

Concentration unit (per 100 g)					
g		mg		μg	
Concentration range	Upper RSD Limit	Concentration range	Upper RSD Limit	Concentration range	Upper RSD Limit
10 ≤ mean < 100	3	100 ≤ mean < 1000	6	100 ≤ mean < 1000	16
1 ≤ mean < 10	4	10 ≤ mean < 100	8	10 ≤ mean < 100	22
0.1 ≤ mean < 1	6	1 ≤ mean < 10	12	1 ≤ mean < 10	30
0.01 ≤ mean < 0.1	8	0.1 ≤ mean < 1	16	0.1 ≤ mean < 1	45
0.001 ≤ mean < 0.01	12	0.01 ≤ mean < 0.1	22	0.01 ≤ mean < 0.1	63
0 ≤ mean < 0.001	Pass	0.001 ≤ mean < 0.01	30	0.001 ≤ mean < 0.01	89
		0 ≤ mean < 0.001	Pass	0 ≤ mean < 0.001	Pass

produced or supplied domestically and provides food composition data on websites. Moreover, FCDB management system called DaRis (an acronym of "database management system" in Slovakia) was developed to collect existing data and provide a national FCDB that will be used internationally (Porubská et al., 2014)

Previously published studies also suggested that it was important to use FCDB in diverse fields, such as academic and industrial settings (Porubská et al., 2014). However, other systems differ from NutriManager because their starting point of FCDB management system is not the computerized laboratory notebook, and they do not conduct modeling as a computerized validation system. In contrast, NutriManager establishes an integrated management system via an on-line database through systematic modeling of analytical sample information, analytical notebook, results, and KNFCT information from the overall life-cycle of FCDB production in Korea. The system work-flow of individual and mutual groups between data producers and compliers is constructed, which decreases the error associated with repeatability method and establishes a system for integration and utilization of external data such as FCDBs from other countries.

As a data compiler, the RDA had trouble managing data when the revised KNFCT was published or newly analyzed food composition data conflicted with that of existing items. NutriManager has features to manage an updated KNFCT release in a time-series manner. Similar to folders in Microsoft Explorer, NutriManager manages all food composition data by project unit. When the final food composition data are transferred to the KNFCT, a revised edition project to publish is selected. In this part, if a certain food composition is present in the existing edition, the duplication is checked automatically. The users then determine whether they select 'replace' or not and write down the reason for replacement when the item is duplicated. Existing data is saved originally and printed out in a time-series manner. As a result, it is compatible with existing editions according to the revisions in the output module of KNFCT.

The productivity was improved by developing a computerized coding system and management program for existing and newly produced food composition data. The consideration for harmonization between FCDBs of other countries was constructed by considering the LanguaL codeset as an additional food description code. We tried to do mapping work between NutriManager and LanguaL code; however, mapping could not be completed because of the workload and differences between dietary habits or cultivation products.

As a next step, we will apply the guidelines of FAO/INFOODS,

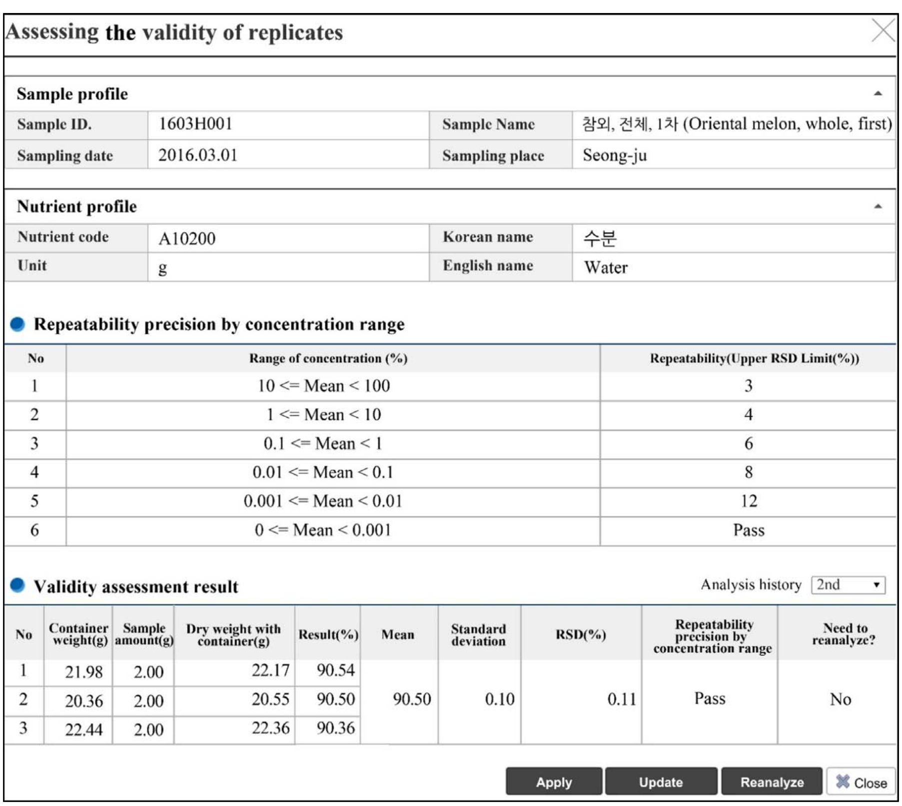


Fig. 6. Implemented result for assessing the validity of food composition (Step 2).

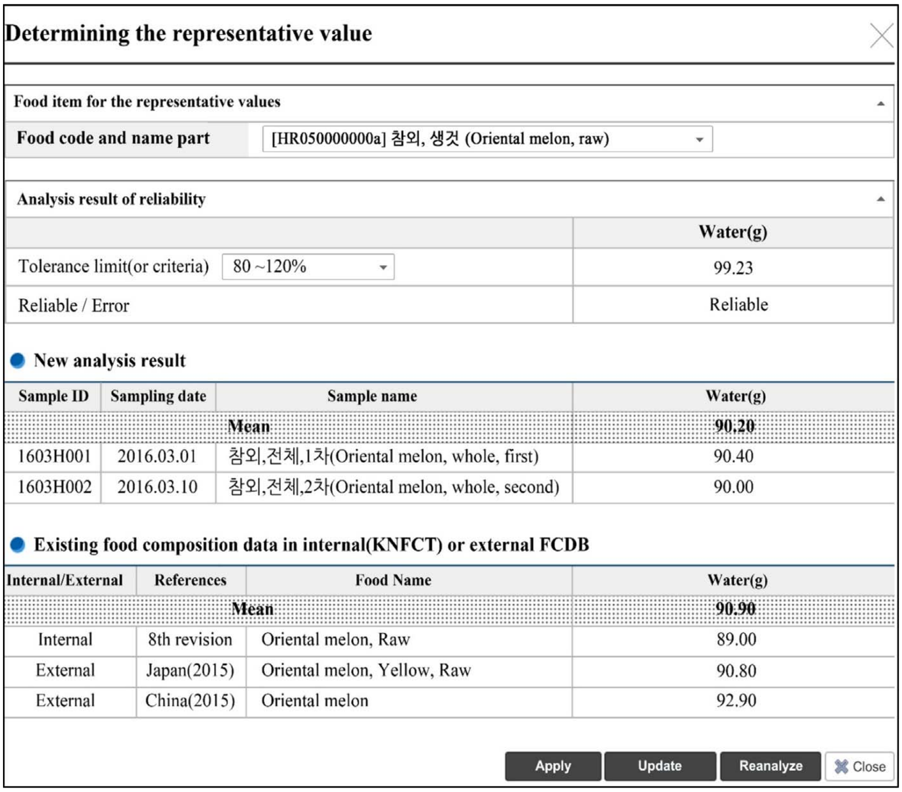


Fig. 7. Implemented result for determining the representative values of food composition (Step 3).

checking food composition data prior to the publication of a user table/database.

5. Conclusions

The RDA's NutriManager is web-based food and nutrient database management and validation system that supports a series of workflow from sample enrollment to validation results related to the construction of FCDB. NutriManager computerizes all equations by nutrient for off-line laboratory notebook, and all data for these input parameters and calculated results are saved by sample. An automated process of validity checking and determination of the representative value in the distributed environment of the laboratory network was established and implemented. NutriManager is based on the eGovernment Standard Framework (Ministry of the Interior, 2016), which is an infrastructure environment for implementing web based application SWs for the Korean government that supports mobile and various web browser environments.

In summary, after the sample enrollment signal is delivered from the enrollment module, the control module saves information in the sample database or existing FCDBs. At the same time, the control module operates the encoding module to set an ID code according to food, food composition, and sample. The workflow control delivers the results to an investigation module for evaluation by assessing the validity and determining the representative values of the food composition for certain food items. The system also provides a software interface for data exchange with other systems and can be used as a more efficient tool to link with other public programs such as the Korean Health and Nutritional Examination Survey (KHANES) using FCDB as a key database in Korea.

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