DEVELOPMENT OF FOOD INFORMATICS SOFTWARE: A MINERAL DEFICIENCY DISEASE - FOOD GUIDE SYSTEM

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ABSTRACT

MDD-FG System is an informatics software developed to enlighten the public about the use of food in the management of mineral deficiency diseases. The mineral content of Malaysian foods are correlated with standard dietary benchmarks. It is constructed based on knowledge database and rule-based data mining principle of simple expert system. Software framework of the system is built with Microsoft Windows 8.1 environment and Visual Studio 2013. The minimum hardware installation requirements include: IntelR CoreTM processor, 0.5 – 1.0 GHz processor speed, RAM of 1 Gigabyte, and 500 Megabyte HDD Space. The database was designed in Microsoft SQL server. The data are sourced primarily from ICPMS elemental analysis of food contents. The secondary data of minerals and diseases were obtained from the literature and dietary allowances from Malaysian and WHO dietary benchmarks. The system user interface launches home page that displays the MDD-FG in text and graphic illustration. The title-bar displays 'welcome' on the home page window. The three accessible commands in the menu bar are "File", "View", and "About". The "View" contains three paths. These are "Food Dishes", "Mineral Elements", and "Deficiency Diseases". The six "View" sub-path interfaces are Foods/Diseases, Foods/Elements, Diseases/Foods, Diseases/Elements, Elements/Foods, and Elements/Diseases. The internal features and system units indicated normal behavior upon white and black box testing. End user response survey was conducted. The software was adjudged user friendly, acceptable, and efficient.

Keywords: MDD-FG, Informatics, Mineral Deficiency Diseases, Food Dishes, Mineral Elements.

INTRODUCTION

The informatics device is a tool aimed at bringing about an interactive relationship between human user and information system built as interfaces into computer. Technically, it is a harmony of natural and artificial intelligence based on algorithm, workable configuration, processing, storage, retrieval, accessibility, and information communication (Unit of Assessment, 2006). It was asserted by (Smith, Buerck, McDurmont, & Bagsby, 2009) multidisciplinary nature of Informatics makes it highly supportive to wide academic and professional fields to disseminate knowledge and decisions. Informatics is an essential concept to be embraced for efficient and effective information management (Wachhaus, 2011; Gasteiger, 2006; Frank, Hall, Trigg, Holmes, & Witten, 2004).

Human health is a priority issue that requires continuous flow of information. One of the recent innovations in food and health informatics is computer-tailored nutrition education. This is an innovative computer based tool that is meant to give individual specific feedback about dietary change in health. It has proved very efficient for individuals who have used it in terms of motivating them to make changes in diet than what general information about nutrition can provide. Great success has been recorded with the use of computer tailored nutrition education, especially in dietary fat reduction (Brug, Oenema, & Campbell, 2003).

The NutriSonic web is an innovative informatics tool found useful by nutritionists and dietitians. This inputted the stored meal database that generates information about sex, age, and healing purpose of a disease. Similarly, expert

system has also been applied for nutrition diagnosis (Chen, Hsu, Liu, & Yang, 2012). The expert system technique for the nutrition diagnosis was web based aimed at assisting the dietitians in making assessment, deduce inference, and make nutrition diagnosis. This innovative informatics software has advantage of speed and accuracy over diagnosis by human dietitians.

Integrated electronic tracing system made for Italian cheese (Papetti et al., 2012), was on preparation from the milk of Buffalo. This infotracing web-based system aimed at acquiring and linking information ready for final consumer by making use of RFID code in identifying the specific and single cheese product.

The Mineral Deficiency Diseases-Food Guide (MDD-FG) is an interactive informatics software constructed on the simple database and data mining principle. It is aimed at encouraging the administration of normally eaten foods among Malaysians to confront the reports on challenges of diseases which are of mineral malnutrition origin in terms of remedy, prevention, and health maintenance.

Mineral malnutrition is estimated to be 11 per cent of the global burden of disease. It is the number one risk to health worldwide (Black et al., 2008). It is also implicated in about 40 per cent of the 11 million deaths of children under age of 5 years in developing countries (Malnutrition in Children - UNICEF DATA, 2010). Countries may lose an estimated 2-3 percent of their Gross Domestic Product (GDP) as a result of iron, iodine, and zinc deficiencies (Horton, 2008).

In the past decade, a lot of reported cases of mineral deficiency disease emergencies have been reported. It was reported (Norhaizan & Ain, 2009) that there were nearly about one million cases of anaemia due to deficiency of iron. In the same study, the osteoporosis due to calcium, magnesium, and phosphorus balance deficiencies was reported to be up to 2.5 million cases as in 2009.

Osteoporosis was prevalent among the elderly in Malaysia (Lai, Chua, Chan, & Low, 2008). This disease was characterized by weak and easily fractured bones of the spine, hip, wrists, and arms, especially in the aged population. It is projected (Mafauzy, 2000) that about 3.3 million Malaysians by year 2020 will attain the age of above 65 years. This requires proper nutritional plan to avert such ugly incidence. Similarly, by year 2050, Asia will account for over 70% of the 6.26 million hip fractures (Kannus et al., 1996). In Malaysia, hip fractures as a result of osteoporosis affected 218 women and 88 men per 100,000 (Lau et al., 2001).

Mineral Deficiency Diseases are currently being tackled by administration of various supplementary mineral formulations. Information about the administration of the normally eaten Malaysian foods is yet to be comprehensively reported in either on prints or online databases. The MDD-FG software was developed to bridge this information gap for the Malaysians. MDD-FG system is built because of the need to pass information on foods as a veritable alternative to the conventional supplementation.

The use of this software is highly necessary. It responds with information by the click and scroll of buttons within few seconds. The software is also developed to solve problems of ignorance of Mineral worth of the Malaysian foods and lack of awareness of various Mineral Deficiency Diseases.

1. Materials and Method

1.1 Hardware and Software

The MDD-FG system is constructed based on knowledge database and rule based data mining principle of expert system. Like all computer system, the functional unit of the MDD-FG is a combination of hardware and software.

1.1.1 Software

The software consists of two segments. The first being Microsoft Windows 8.1 environment was used, which provided easy start up, supported diverse Apps, blended with many devices, encouraged multi-tasking, allowed customizations, and supported multi-media. The second segment is Microsoft Visual Studio 2013 with the following features: Visual Studio Languages, .NET Framework 4.5.1, Debugging and Diagonistic features, Visual Studio IDE feature, MS SQL Server, and LightSwitch feature.

The software features are put together as software requirement to develop the MDD-FG system. The C# was the programming language used. Data was stored in Microsoft SQL server and queried using .Net framework 4.5.

Entity Relationship Model (ERM) is achieved by use of Data modeler tool to unify the data view. This is to achieve a design of data management of relational entity.

The built database and the set rules are set and the user can obtain an automatically configured response. In addition, the Integrated Development Environment (IDE) housed the program. This makes it easy to run, create, and debug the Visual Basic C# program.

1.1.2 Hardware

Hardware for the system was composed with the consideration for cost, storage capacity, and processor speed. Minimum hardware requirement for the MDD-FG installation and their unique features are: Processor of minimum of IntelR CoreTM processor with built-in security and longer battery life, Processor Speed of minimum of 0.5 – 1.0 GHz using Microsoft windows 7 or 8.1, Random Access Memory (RAM) of minimum of 1 Gigabyte and Hard Disk Drive (HDD) Space of minimum of 500 Megabytes.

1.2 Knowledge Database

Database for the MDD-FG software was designed in Microsoft SQL server. Data tables are drawn, stored, computed, managed, standardized, and designed to suite researcher's objectives and specifications.

The MDD-FG database consists of:

- Mineral Content of foods
- Food lists (text and figures)
- Dish size list
- Mineral Elements list
- Mineral Deficiency Diseases (MDD) list, and
- The Recommended Dietary Allowance (RDA) table

The Mineral Content of food is the primary data source from results of ICPMS elemental analysis. The elements, MDD and RDA are the secondary information sources obtained from the literature.

1.3 Chemical and Dietary Basis of MDD-FG Datas

Foods were sampled from reputable and well patronized restaurants in Johor Bahru, Malaysia. Triplicates of 41 commonly eaten food types were selected for this study. The samples were dried and wet ashed with the mixture of Nitric acid and Hydrogen peroxide (Salau, 2012a, 2012b, 2015; Salau & Hasan, 2014; Salau, Deba, & Yusuf, 2012; Salau & Usman, 2012; Aremu, Olonisakin, Opaluwa, Mohammed, & Salau, 2007). The analytical instrument used in quantifying the element contents of food was the Inductively Coupled Plasma-Mass Spectrometry (ICP-MS). The 14 elements quantified are: Chromium, Cobalt, Molybdenum, Nickel, Selenium, Iron, Copper, Manganese, Zinc, Potassium, Sodium, Magnesium, Phosphorus, and Calcium.

Qualitative and quantitative validation parameters were observed to ensure that integrity of results are not compromised (Salau, 2015; Salau & Hasan, 2014). Validation of the accuracy was performed by the use of SRM 1570a: a certified reference material of trace elements in spinach leaves. The Limit of Detection and Quantitation (LOD and LOQ) indicated good performance of methods. The calibration plots and regression parameters are of good sensitivity with least R^2 of 0.996. There is a significant precision criterion at 95% confident level. Both ashing and instrumental procedure were optimized (Salau, 2015; Salau & Hasan, 2014).

The Recommended Dietary Allowance (RDA) values are computed from standards in the literature. The standard dietary values derived from (National Coordinating Committee on Food and Nutrition (NCCFN), 2010; Dietary Guidelines for Americans, 2005; Acu-Cell-Nutrition, n.d; CAC, 2006; Malaysian Food Act 281, 1983 and Food Regulations, 1985). Seventy (70) types of Mineral Deficiency Diseases are captured in the database. The element contents of the foods are presented as percentage fractions of the RDA. The MDD-FG system uses the percentage in computing the dishes that are able to meet 100%, 50%, and 30%. The fractions 100% and above are respectively referred to as high content value. The moderate content value foods are those with RDA percentage fractions from 50% to less than 100%. The fraction between 30% and less than 50% are low content values. In terms of the application of the foods, only twice repeated meals or two - dish meal would be required in moderate content values. Similarly, only thrice repeated meals or three-dish meal would be required for low content value foods.

1.4 Limitation, Assumption and Disclaimer

The daily Recommended Dietary Allowance (RDA) values are provided by health regulatory authority and defined as the intake level that could describe a healthy individual (Otten, Hellwig, & Meyers, 2006). In practice, the RDA values are usually lower than therapeutic doses (Acu-Cell-Nutrition. (n.d)). Therefore is limitation of the MDD-FG software to its application to curative purpose. This is because the RDA values, which are health maintenance and disease preventive data, are imputed rather than therapeutic dose values. The MDD-FG system is a guide on food choices based on results of the current research (Salau, 2015). The information therein is not to substitute absolute drug or medicine. Mineral deficiencies are most times co-factors with vitamins and other food classes as causes of diseases.

1.5 End User Acceptance and System Testing

White box and black box testing methods were employed by the software engineer on the system. White box testing was done to test the internal features of the system. The black box testing was also done by examining how the unit functions with its behaviour relative to inputs and the corresponding output.

User acceptance survey was conducted to evaluate the degree of acceptability of the software as well as about how well the user expectations are met. This testing is done with questionnaire instrument. The nine–item questionnaire was focused on criteria of accessibility, acceptability, and effectiveness. 40 respondents that are resident in Skudai were selected. 15 of the respondents are foreigners while 25 are Malaysians who are either working or students. The attributes of participating respondents are: willingness to take part, knowledge of computer software, and ability to provide response. The ranking scale of 1 (low) -5 (high) was used to grade the response.

2. Results and Discussion

2.1 System Launch and User Interface

The MDD-FG system is run by user as shown in the flow chart in Figure 1. This figure describes the operational path of the system. Starting from VIEW to SUB-VIEW and the eventual display of the paired relationship of food, disease, and

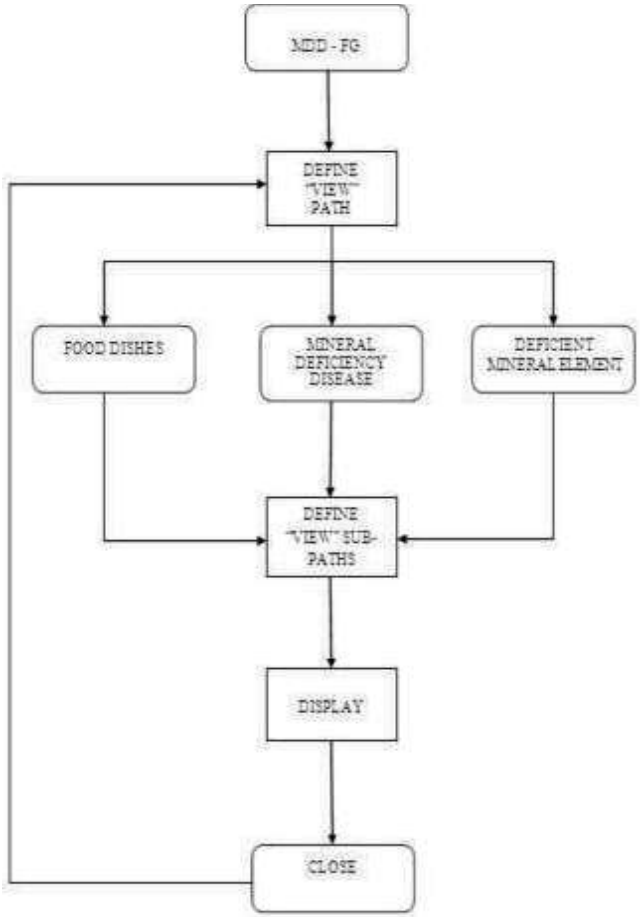

Figure 1. Flowchart for MDD–FG System Operation

mineral elements. The home page is launched with welcome page displaying the MDD-FG in text and images as shown in Figure 2. The welcome page symbolizes what the system stands for : Food-disease-Mineral guide.

The title-bar displays 'welcome' on the home page

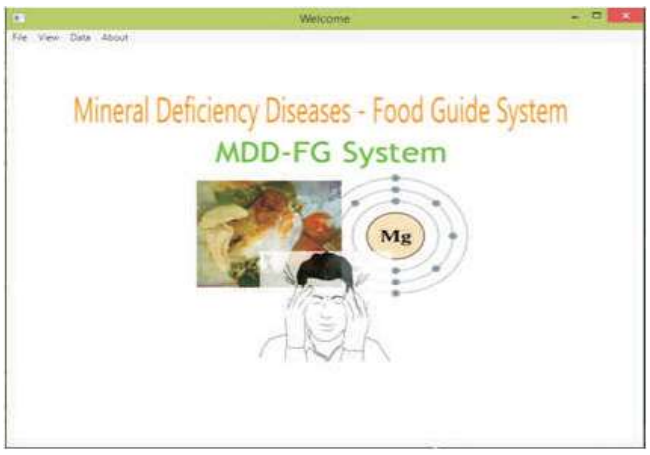

Figure 2. Home Page of the MDD–FG System

window. The three accessible commands in the menu bar are "File", "View", and "About". The "File" contains "exit" to close the home page window. The "About" in the menu bar displays a brief introduction to the MDD-FG as well as the Disclaimer. The "View" contains three paths. These are "Food", "Elements", and Diseases". The summary of the "View" paths and sub-paths is displayed in Figure 3. The three paths also lead to six sub-paths. The interface of one of the six sub-menus (Mineral Deficiency Disease (Alopecia) / Food dishes interface) is shown in Figure 4. The Figure 4 displays Nasi Berlauk, Nasi Beriani, and Mamak Rojak as containing adequate minerals that can manage the Alopecia (hair loss) disease.

2.2 System Testing

Testing of software is a necessary process in software development aimed at scrutinizing and evaluating the units of software to see if the system is functional and if the required condition for a system is met (Bucchiarone, Melgratti, & Severoni, 2007). The internal features of the system were tested using white box method. In this process, each component of the software was checked and tested individually. The test result shows normal functionality of the system. The system unit functions with its behavior relative to inputs and the corresponding output was done using black box method. The test result shows normal behavior and good data traffic.

2.3 User Feedback Evaluation

The measures of accessibility, ease of use, aesthetic quality, functionality, and acceptability of the software have an average score of 4, which is a very good rank on the scale. 38 respondents found the software very easy to handle, while 29 out of 40 scored the interface of the software very attractive and aesthetic. A very high rank was obtained on informative features and usefulness of the information by 75 and 80 per cent respondents, respectively. 31 out of 40 respondents scored the software very high in eagerness to have personal possession of the software in the future.

In terms of the effectiveness measure of the software, the users' feedback showed a very good ranking on the software satisfactorily meeting its purpose of development. An average of 34 out of 40 respondents agreed that the software meets up with expectation. This respondents' judgment portrays the software as effective. The general recommendation of the respondents is the need to enlarge the database on the foods and the Mineral Deficiency Diseases. The overall response obtained showed that the end user scored the system high in terms

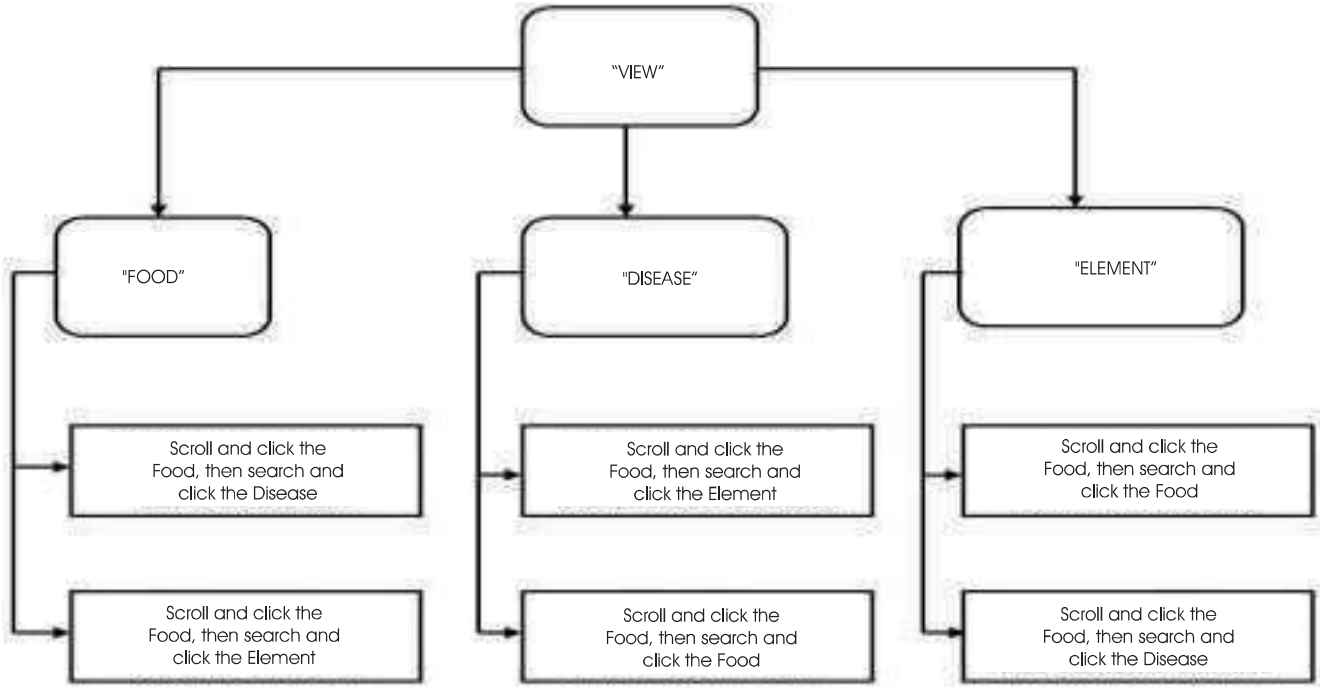

Figure 3. Flowchart for the "VIEW" Sub-menu

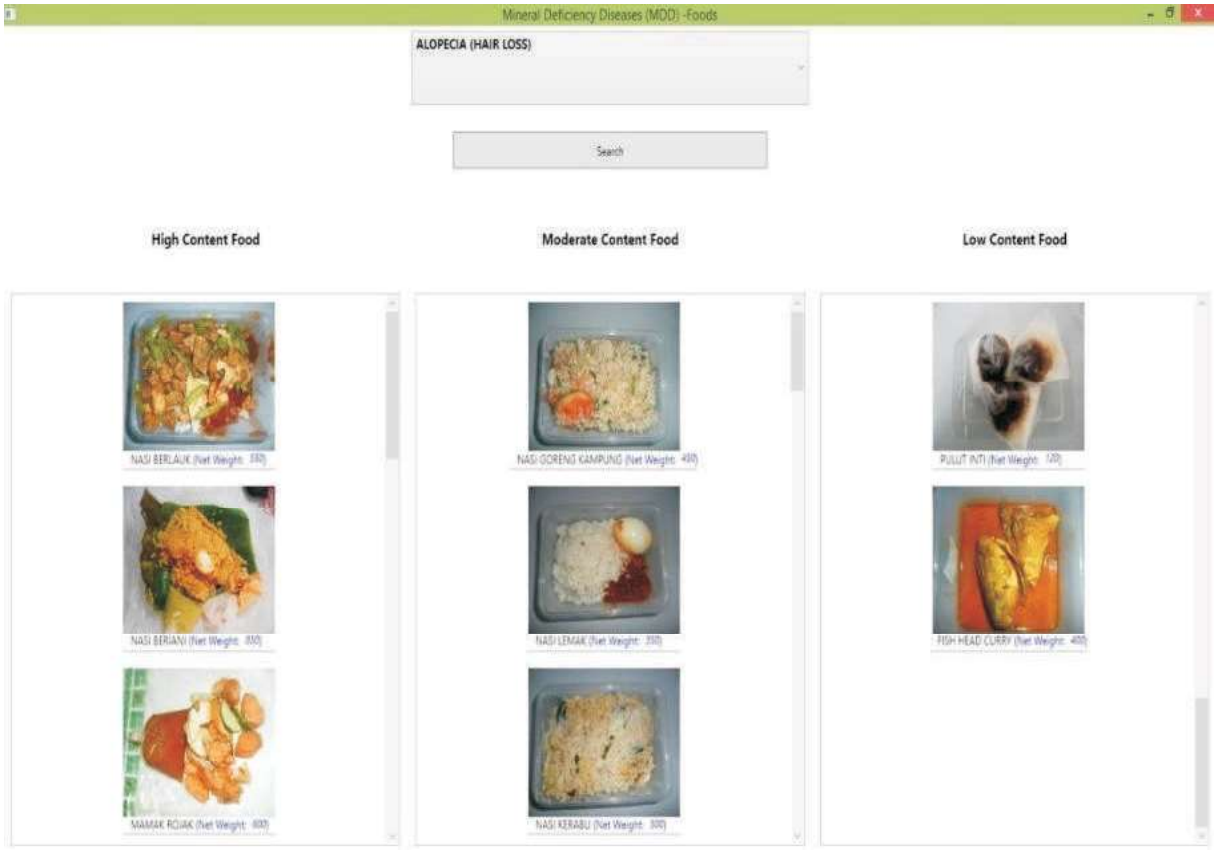

Figure 4. Mineral Deficiency Disease (Alopecia) / Food Dishes Interface

of ease of use, attractiveness, informativeness, efficiency, reliability, and effectiveness.

2.4 The MDD-FG and other Informatics Systems

The food guide system developed is a public-oriented one, which takes foods commonly eaten into consideration. It compares well with (Maillot, Vieux, Amiot, & Darmon, 2009) modeling informatics. However, the latter is meant to inform and help individual to make dietary choices and fulfill nutrient-based (Smith et al., 2009) recommendations.

The NutriSonic web which applies expert system based computer software was applied in nutrition counseling, nutrition education, and meal management (Hong, Cho, Lee, Kim, & Kim, 2008). This inputted the stored meal database that generates information about sex, age, and healing purpose for a disease. This food guide system is web-based and complicated database. It is not as simple, accessible, and offline as the developed MDD-FG system.

Conclusion

The interactive Mineral Deficiency Diseases - Food Guide (MDD-FG) Software was successfully developed. This system makes it possible to get information about Malaysian foods that can help in managing the mineral deficiency diseases.

The system also facilitates the familiarity of the users with the various mineral elements and their role against the mineral deficiency diseases. Furthermore, the system compares well with some advantages with existing Food Guide systems.

First-hand knowledge of the proportion of the mineral elements in various Malaysian food dishes can also be obtained. In the future, the software can include more foods and also be upgraded to web-based system so that extended users can be reached.

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References

[1]. Acu-Cell-Nutrition. (n.d). DRI/RDA, Negative Health/Side Effects, over Dose, Toxicity and Nutritional Requirements. The Clinical Research Resource for Cellular Nutrition and Trace Mineral Analysis. http//www.acu-cell.com (Accessed on 2 Nov., 2014).

[2]. Aremu, M. O., Olonisakin, A., Opaluwa, O. D., Mohammed, Y., & Salau, R. B. (2007). Nutritional qualities assessment of tilapia fish (Tilapia quineensis). *Indian J. Multidisciplinary Research*, 3(3), 443-465.

[3]. Black, R. E., Allen, L. H., Bhutta, Z. A., Caulfield, L. E., De Onis, M., Ezzati, M., & Maternal and Child Undernutrition Study Group. (2008). Maternal and child undernutrition: Global and regional exposures and health consequences. *The Lancet*, 371(9608), 243-260.

[4]. Brug, J., Oenema, A., & Campbell, M. (2003). Past, present, and future of computer-tailored nutrition education. *The American Journal of Clinical Nutrition*, 77(4), 1028S-1034S.

[5]. Bucchiarone, A., Melgratti, H., & Severoni, F. (2007, August). Testing service composition. In *Proceedings of the 8th Argentine Symposium on Software Engineering (ASSE'07)* (pp.1-10).

[6]. CAC. (2006). *List for Standard Contaminant Element Levels of Foods*. Retrieved from http://www.codexalimentarius.net/web/index_en.jsp

[7]. Chen, Y., Hsu, C. Y., Liu, L., & Yang, S. (2012). Constructing a nutrition diagnosis expert system. *Expert Systems with Applications*, 39(2), 2132-2156.

[8]. Dietary Guidelines for Americans. (2005). *U.S. Department of Health and Human Services*. Retrieved from https://health.gov/dietaryguidelines/dga2005/document/default.htm

[9]. Frank, E., Hall, M., Trigg, L., Holmes, G., & Witten, I. H. (2004). Data mining in bioinformatics using Weka. *Bioinformatics*, 20(15), 2479-2481.

[10]. Gasteiger, J. (2006). Chemoinformatics: A new field with a long tradition. *Analytical and Bioanalytical Chemistry*, 384(1), 57-64.

[11]. Hong, S. M., Cho, J. Y., Lee, J. H., Kim, G., & Kim, M. C. (2008). NutriSonic web expert system for meal management and nutrition counseling with nutrient time-series analysis, e-food exchange and easy data transition. *Nutrition Research and Practice*, 2(2), 121-129.

[12]. Horton, R. (2008). Maternal and child undernutrition: An urgent opportunity. *The Lancet*, 371(9608), 179-179.

[13]. Kannus, P., Parkkari, J., Sievänen, H., Heinonen, A., Vuori, I., & Järvinen, M. (1996). Epidemiology of hip fractures. *Bone*, 18(1), S57-S63.

[14]. Lai, P. S. M., Chua, S. S., Chan, S. P., & Low, W. Y. (2008). Validation of the English version of the quality of life questionnaire of the European Foundation for Osteoporosis (QUALEFFO) in Malaysia. *International Journal of Rheumatic Diseases*, 11(4), 421-429.

[15]. Lau, E. M. C., Lee, J. K., Suriwongpaisal, P., Saw, S. M., De, S. D., Khir, A., & Sambrook, P. (2001). The incidence of hip fracture in four Asian countries: The Asian Osteoporosis Study (AOS). *Osteoporosis International*, 12(3), 239-243.

[16]. Mafauzy, M. (2000). The problems and challenges of the aging population of Malaysia. *The Malaysian Journal of Medical Sciences: MJMS*, 7(1), 1-3.

[17]. Maillot, M., Vieux, F., Amiot, M. J., & Darmon, N. (2009). Individual diet modeling translates nutrient recommendations into realistic and individual-specific food choices. *The American Journal of Clinical Nutrition*, 91(2), 421-430.

[18]. Malaysian Food Act 281, 1983 and Food Regulations, 1985. *Incorporating Amendments up to January 1, 2006 Warta Kerajaan Malaysia, Laws of Malaysia* (Vol. 29).

[19]. Malnutrition in Children - UNICEF DATA. (2010). *IndexMundi: United Nation International Children Education Fund*. United Nation Statistics Division.

[20]. National Coordinating Committee on Food and Nutrition (NCCFN). (2010). *Ministry of Health Malaysia, Malaysian Dietary Guidelines*. Retrieved from http://www.moh.gov.my/images/gallery/Garispanduan/diet/introduction.pdf [Accessed Dec. 9, 2015].

[21]. Norhaizan, M. E., & Ain, A. W.N. F. (2009). Determination of phytate, iron, zinc, calcium contents and their molar ratios in commonly consumed raw and prepared food in malaysia. *Malaysian Journal of Nutrition*, 15(2), 213-222.

[22]. Otten, J. J., Hellwig, J. P., & Meyers, L. D. (Eds.). (2006). *Dietary Reference Intakes: The Essential Guide to Nutrient Requirements*. National Academies Press.

[23]. Papetti, P., Costa, C., Antonucci, F., Figorilli, S., Solaini, S., & Menesatti, P. (2012). A RFID web-based infotracing system for the artisanal Italian cheese quality traceability. *Food Control*, 27(1), 234-241.

[24]. Salau, R. B. (2012a). Comparative evaluation of analytical techniques for the quantification of potassium in fruit juices and corresponding beverages. *Journal of Science, Technology, Mathematics and Education (JOSTMED)*, 8(3), 8-13.

[25]. Salau, R. B. (2012b). Nutritional comparisons of milk from two cow specie and local preparations of soya milk drinks. *IOSR Journal of Applied Chemistry (IOSR-JAC)*, 2(6), 41-44.

[26]. Salau, R. B. (2015). *Profiling of mineral contents of typical malaysian muslim foods* (Doctoral Dissertation, Universiti Teknologi Malaysia).

[27]. Salau, R. B., & Hasan, M. N. (2014). Evaluation and analysis of dietary essential mineral micronutrients in selected Malaysian foods using FAAS and ICP-MS. *Modern Applied Science*, 8(6), 103-111. doi:10.5539/mas.v8n6p103.

[28]. Salau, R. B., & Usman, B. (2012). Level of Copper, Manganese and Zinc in common traditional foods in Minna, North-Central zone of Nigeria. *IRACST–Engineering Science and Technology: An International Journal (ESTIJ)*, 2(6), 968-971.

[29]. Salau, R. B., Deba, A. A., & Yusuf, J. (2012). Quantification of Iron, Magnesium and Phosphorus contents of selected local dishes in Minna, Nigeria. *IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)*, 1(3), 33-36.

[30]. Smith, J. K., Buerck, J. P., McDurmont Jr, L. L., & Bagsby, P. G. (2009). Multidisciplinary informatics: A primer for course development. *Journal of Computing Sciences in Colleges*, 24(5), 198-203.

[31]. Unit of Assessment. (2006). *UoA 23, Computer Science and Informatics*. 2006. Retrieved from: http://www.rae.ac.uk/pubs/2006/01/docs/f23.pdf

[32]. Wachhaus, T. A. (2011). Governance as a Framework to Support Informatics. *Innovation Journal*, 16(1), 1-14.

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