Development of a Food Composition Table for Bangladesh

The study conducted by:

Institute of Nutrition and Food Science (INFS),
Centre for Advanced Research in Science (CARS)
University of Dhaka, Dhaka-1000, Bangladesh

Principal Investigator: **Nazma Shaheen, PhD**
Professor, Institute of Nutrition and Food Science (INFS)
University of Dhaka, Bangladesh

Co-Investigator(s): **Abu Torab MA Rahim, PhD**
Professor, Institute of Nutrition and Food Science (INFS)
University of Dhaka, Bangladesh

Md. Mohiduzzaman, MSc
Professor, Institute of Nutrition and Food Science (INFS)
University of Dhaka, Bangladesh

Md. Latiful Bari, PhD
Senior Scientist, Center for Advanced Research in Science
University of Dhaka, Bangladesh

SM Mizanur Rahman
Professor, Department of Chemistry, University of Dhaka

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Contents

Abbreviations

AAA	Amino Acid Auto-analyzer
AAS	Atomic Absorption Spectroscopy
AEZ	Agro-Ecological Zone
AOAC	Association of Official Analytical Chemists
ASEAN	Association of Southeast Asian Nations
BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agricultural Research Institute
BAU	Bangladesh Agricultural University
BCSIR	Bangladesh Council of Scientific and Industrial Research
BDFOODS	Bangladesh Food Data System
BIRDEM	Bangladesh Institute of Research and Rehabilitation for Diabetes, Endocrine and Metabolic Disorders
BLRI	Bangladesh Livestock Research Institute
BRRI	Bangladesh Rice Research Institute
CARS	Centre for Advanced Research in Science
CV	Coefficient of Variation
DB	Database
DKP	Deshio Khaddyodrobbeyer Pushtiman
DPPH	Diphenylpicrylhydrazyl
DPPHRSA	Diphenylpicrylhydrazyl Radical Scavenging Assay
DV	Daily Value
EDTA	Ethylene Diamine Tetra Acetic acid
ELISA	Enzyme-Linked Immuno-Sorbent Assay
ES	External Standard
EO	Expected Outputs
EU	European Union
FA	Fatty Acid

FAO	Food and Agriculture Organization of the United Nations
FCA	Food Composition Activities
FCDB	Food Composition Database for Bangladesh
FCBMS	Food Composition Database Management System
FCT	Food Composition Table
FCTB	Foods Composition Table for Bangladesh
FDA	Food and Drug Administration
FI	Food Item
FPMU	Food Planning and Monitoring Unit
GAE	Gallic Acid Equivalent
GM	Genetically Modified
GoB	Government of Bangladesh
HIES	Household Income and Expenditure Survey
HKI	Helen Keller International
HPLC	High Performance Liquid Chromatography
HYV	High Yielding Variety
ICMR	Indian Council for Medical Research
ICPMS	Inductively Coupled Plasma Mass Spectrometry
IHRM	In-House Reference Material
INFOODS	International Network of Food Data Systems
INFS	Institute of Nutrition and Food Science
IPHN	Institute of Public Health Nutrition
IUPAC	International Union of Pure and Applied Chemistry
KFs	Key Foods
LOD	Limits Of Detection
LOQ	Limits of Quantification
MRV	Maximum Recommended Value
NE	Niacin Equivalent
NFE	Nitrogen Free Extract

NFPCSP	National Food Policy Capacity Strengthening Programme
NGO	Non Government Organization
NIN	National Institute of Nutrition
NVIF	Nutritive Values of Indian Foods
NV	Nutritive Value
ORAC	Oxygen Radical Absorbance Capacity
PUFA	Polyunsaturated Fatty Acids
QAP	Quality Assurance Program
RAE	Retinol Activity Equivalent
RE	Retinol Equivalent
RDV	Reference Daily Value
RO	Research Objectives
RQ	Research Questions
SD	Standard Deviation
SOP	Standard Operating Procedure
TDF	Total Dietary Fiber
TE	Trolox Equivalent
TEAC	Trolox Equivalent Antioxidant capacity
TFC	Tables of Food Composition
TFS	Total Free Sugar
ToR	Terms of Reference
TS	Total Sugar
UNU	United Nations University
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
WFP	World Food Program
WHO	World Health Organization
YF	Yield Factor

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Executive summary

Food composition table is considered as an essential tool in the agriculture, food, nutrition and health sectors. Specifically, food composition data are required for determining the gross population requirement for foods, evaluating food consumption surveys and, above all, maintaining the proper health and nutritional status of population. However, the food composition table currently used in Bangladesh has obvious limitations of outdated analytical methods, carrying over of same data set for the nutrients over the period of time and lack of harmonization with standard food composition tables. Besides, there is a wide range of missing nutrient values and lack of analytical data and precise description of foods and data documentation. This Food Composition Table for Bangladesh (FCTB) has been designed to expand the quantity as well as to improve the quality of data in food compositional databases.

The accomplishment of Food Composition Table for Bangladesh (FCTB) has been done by searching secondary data and analyzing nationally representative samples of key foods. It is based on a systematic process of generating and collecting data followed by their compilation using FAO/INFOODS Compilation Tool version 1.2.1 according to INFOODS Guidelines. Food composition data from various research institutes, universities, national and international NGOs in Bangladesh have been collected and compiled. In addition, 40 local foods including 20 key foods have been analyzed. Values for cooked foods and recipes have been calculated by using yield factors from the available literature. Food composition data from relevant sources have been imputed to replace missing values. Values for total dietary fibre (determined by Prosky method) and protein (calculated using food-specific conversion factors instead of a general factor of 6.25) have been included. Also included are the reliable and quantitative values for amino acids, fatty acids, minerals, vitamins B_1, B_2, niacin, B_6, folic acid, C and A, beta-carotene, polyphenols, phytate and oxalate.

Now, the FCTB includes updated analytical data for nutrients of those 20 key foods that are major contributors of nutrients of public health significance to the Bangladeshi diet. Beyond the key foods, it includes analytical compositional data of a number of plant food items that are of nutritional significance. The current FCTB also includes secondary compositional data of 308 food items. Besides, nutrient composition has been provided for 37 single ingredient and 11 multi-ingredient recipes.

The present computerized database and printed tables are expected to be a remarkable addition to national and regional food compositional activities. This database can serve as a compositional information package and, due to harmonization with other database, can be exchanged with other countries. It is also the first national database which, in one single publication, includes data on amino acids, fatty acids, trace elements, certain B-vitamins, dietary fiber, heavy metals, total phenol content and antioxidant activity in addition to proximate composition. It also provides information on the inedible portion of numerous indigenous foods increasing its usefulness in evaluating the food consumption of Bangladeshi population.

Introduction

Reliable data on the nutrient composition of foods for human consumption are critical for many areas of endeavor including health assessment, formulation of appropriate institutional and therapeutic diets, nutrition education, food and nutrition training, epidemiological research on the relationship between diet and diseases, plant breeding, nutrition labeling, food policy and regulation, consumer protection, as well as for a variety of application in agriculture, trade, research, development and assistance. To date, this information, particularly in relation to energy-yielding substrates and essential nutrients, has been obtained largely from food composition tables.

Food composition activities (FCA) include data generation in an analytical laboratory, data compilation in a database management system, data dissemination through print and electronic media, and data use by various professional and lay users. Despite the FCA from different data generators of Bangladesh since 1950s, reliable and comprehensive data on the nutrient composition of foods are insufficient and backdated for the development of a national food composition table for Bangladesh (FCTB).

New high yielding foods and non-indigenous foods are constantly being introduced in the food chain of Bangladesh. Chemical analysis of every food item is not possible due to high cost of analysis, including high quality chemicals and latest methods and equipments. Priorities for analyzing foods and nutrients, therefore, must be made. In order to do so, firstly, an investigation on the key foods (KF) of the country is essential. This will generate a list of KFs. Selected key foods need to be chemically analyzed while food composition data of other KF and non-KF need to be collected from secondary sources. The resultant datasets were the major source for a comprehensive food composition database *(*FCDB) for Bangladesh.

The currently available food composition tables in Bangladesh require updating with new nutrient data, particularly with regard to the relatively newer foods like high-yielding varieties of rice, vegetables, fruits, etc. consumed by the people of Bangladesh. Moreover, food composition data also needs revision in the light of newer and more sensitive methods of analysis. Accordingly, the existing food data of the mainstream food regime of the population of Bangladesh was improved by including newer nutrient values as well as by

compiling existing food composition data from all over Bangladesh to develop a national food composition database (FCDB).

Data compilation requires a regional database management system and adherence to international food composition and data compilation standards where they exist. INFOODS guidelines and FAO/INFOODS Compilation Tool 1.2.1 is such a system that used to arrange and sequence the datasets produced by the above procedures. Though the primary objective of a FCDB is to provide data on the nutritional value of foods, it was also an integrated approach to the generation, acquisition, aggregation, processing, dissemination and use of food composition data.

Objectives, key research questions and expected outputs

Research Objectives

As per the ToR, four major issues for FCTB have been identified which were addressed to achieve the objectives and outputs set in the ToR. These are given in the Box 1.

Box 1. Research objectives (RO) of the study

01. To report ≥ Nutrient composition data of 500 food items including Key Foods (KF) consumed in Bangladesh for the inclusion in the proposed FCTB – (***food list for FCTB***)

02. To analyse ≥ 20 selected KF that have missing nutrient values – (***food compositional analysis, FCA)***

03. To review, adapt, estimate, borrow, and compile existing and newly generated nutrient data to prepare a database –(***food composition database, FCDB*)**

04. To format and produce virtual (web-based) and physical (print) versions of the FCDB – (***the FCTB***)

Research Questions

A number of research questions (RQ) emerged while setting the research objectives. These questions were resolved to get quality outputs expected from the study. The way to answer these questions was to relate them with the findings of the study. These RQ are elaborated in Box 2.

Box 2. Key research questions (KRQ) of the study

01. What is a key food (KF)? What is the need for KF in FCT? Does Bangladesh have a KF list on *food-nutrient* supply basis?

02. Is chemical analysis data of KF (if available) complete and robust? If not, what to do?

03. Why do secondary food composition data need to be compiled? How to do so?

04. What to do with the compiled food datasets? How to archive them?

05. What to do with the missing nutrient values in FCDB?

06. Can end-users' access to FCDB always be user friendly? How?

Expected Outputs

The expected outputs (EOs) given in Box 3 were based on analysis and compilation of data from a KFs list along with other non-KFs.

Box 3. Expected outputs (EO) of the study

01. A computerized food composition database (FCDB) of Bangladeshi foods containing nutrients, bioactive non-nutrients, and anti-nutrients on FAO data compilation tool 1.2.1.

02. A data entry format in the FCDB for incorporating newer data from the data generators, compilers, estimators, and researchers.

03. A user-friendly data output format for the end-users for customized uses.

04. A printable FCT and a web version of FCT including scientific documentation and local names of the foods with no or minimum missing values.

Literature review

Numerous varieties of foods and dishes are described in medieval Bengali literature as being served on the occasions of socio-religious ceremonies and festivals. A glimpse into the history and culture of the foods and dishes of Bangladesh has been noted (Rahim, 2011). But review and detailing of the nutrient composition of local foods are recent FCAs.

The first report on nutritive value of foods in Bangladesh was published in 1973 by the Institute of Nutrition (Institute of Nutrition and Food Science) in English language. This report contained tables for proximate and other nutrient values of 108 raw food items. All nutrient values of these 108 food items were analyzed values. But unfortunately methodological descriptions were not reported in that report. The researchers involved in this project described that they followed the methods of 'Hyderabad Manual' (NIN/ICMR 1971) (personal communication). This report later on was revised, compiled with new and borrowed data, and published in 1977 by INFS as a booklet known as *'Deshiyo Khaddodrobbeyer Pushtiman (DKP)'* (Nutritive Values of Local Foodstuffs) which contained 14 food group. This report was published in Bangla. The later editions of this booklet were published in 1980, 1986 and 1992. This Bangla food composition table (FCT) contained content of 13 nutrients of 338 food items, all on raw weight basis. Based on values of all nutrients except vitamin A presented in DKP by INFS, Helen Keller International (HKI) in collaboration with World Food Programme (WFP) published the first English version of FCT for Bangladesh in 1988 named as "*Tables of Nutrient Composition of Bangladeshi Foods***"** (HKI 1988). Several other GoB organizations (e.g. IPHN) and non-GoB organizations (e.g. BIRDEM) also published Tables of Food Composition (TFC) in their own format but it appears that most of their data originated from DKP which reflects food composition data that was analyzed nearly 35 years ago and is in need of updates.

The food composition activities in Bangladesh have never identified KFs for prioritizing analysis of food items. The Key Foods selection process uses food composition and food consumption data to identify and prioritize foods and nutrients for analysis (Haytowitz, et al., 2000; Haytowitz, et al., 2002). A recent report (Islam et.al. 2010) has provided newer nutrient data of selected key foods but they defined and priorities KFs incorrectly though they mention the method of Haytowitz et.al. (1996, 2000, 2002). This necessitated the fact that foods should be analyzed on a KFs list basis.

Early food composition data existed only on paper and their documentation, if available, was as stored as paper archives which were not always readily accessible to successive compilers. When computers became more common, about 20 - 30 years ago, compilers expressed their need for a food composition database management system (FCDBMS) which would assist them to store, document and manage food composition data electronically in a standardized manner, and from which they could extract data for publication of user databases or tables. It was recognized that an internationally available FCDBMS incorporating international standards would assist countries to compile and document data in a harmonized manner (Southgate and Greenfield, 1988). Over the last 20 years, several FCDBMS have been developed by national compilers such as USDA (2010), most European countries (Euro FIR, 2010) and New Zealand (Burlingame et al., 1992).

When FAO recently assisted countries (e.g. Lesotho and Armenia) in developing their national food composition database, the lack of a FCDBMS became so important that the authors started to build a simple Excel file to compile a national database. Overtime, this file became more sophisticated with more possibilities of documentation (Box 7). And finally the need of a freely accessible tool led to the development of the current Compilation Tool version 1.2.1, (a comparison is given in Box 7). Recently, Charrondiere and Burlingame (2011) summarized the usability of this Compilation Tool 1.2.1 for developing countries.

Box 4. International standards and guidelines and their use in the Compilation Tool

	Food	Component nomenclature	Database Nomenclature	Interchange management	Data presentation	
INFOODS	Mappable	Yes	Yes	Yes	N/A	
EuroFIR	Mappable	Mappable	N/A	Mappable	N/A	
ISO date)	N/A	N/A	N/A	N/A	Yes	(e.g.
Codex Alimentarius	Mappable	N/A	N/A	N/A	N/A	
IUPAC	N/A	Yes, when available		N/A	N/A	N/A
AgMes	N/A	N/A	N/A	N/A	Yes (bibliographic data)	
Taxonomic standards	Yes	N/A	N/A	Yes	Yes	

Source: Charrondiere and Burlingame (2011)

Methodology

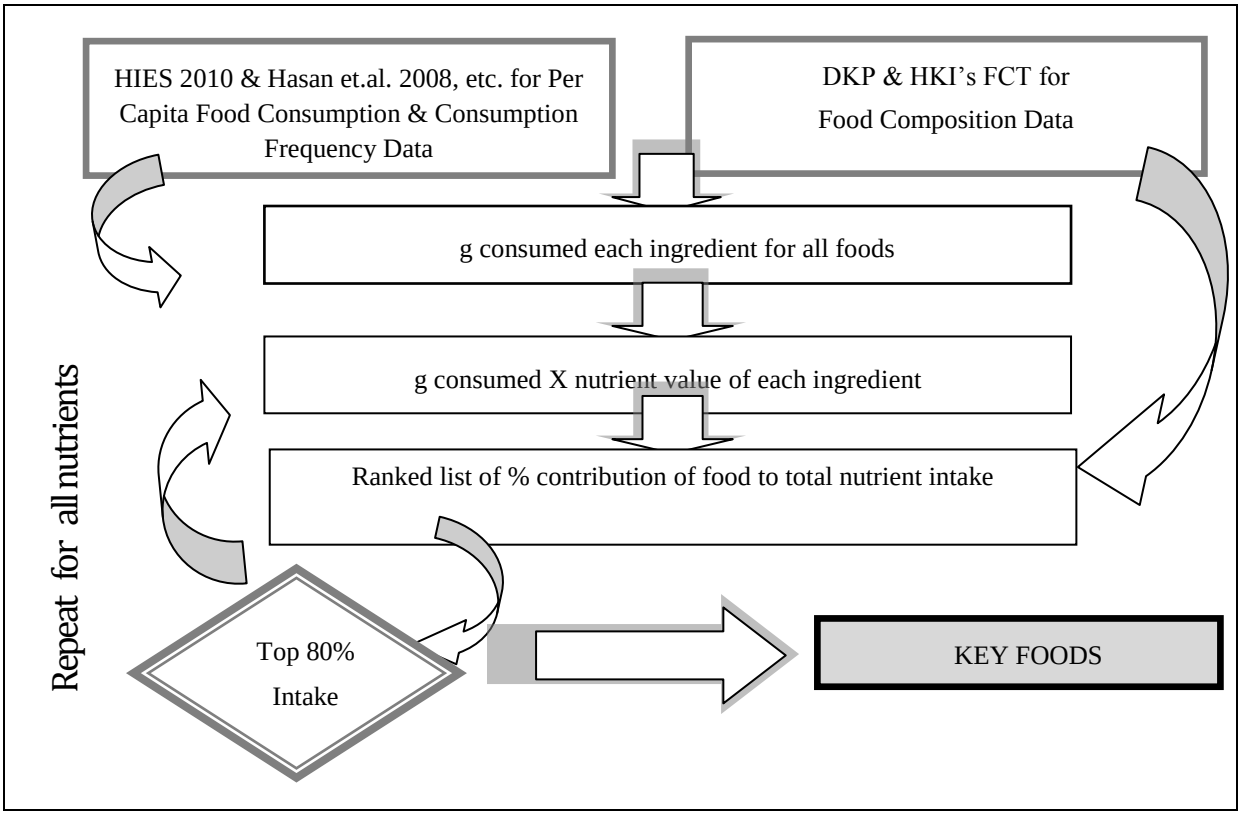
The present study has proposed four key KROs (Box 1) to be achieved which need multiple methods, e.g., Key Food (KF) identification survey (KRO-1), analysis of existing datasets (KRO-3), stakeholders consultations, laboratory analysis (KRO-2), development of data store and using formats (KRO-4), etc. The following sections elaborate design features of each methodology.

4.1 KF identification survey

Key Foods are those foods, which in aggregate contribute 75-80% of the nutrient intake for selected nutrients of public health importance from the diet (Haytowitz et. al, 2008). Since Bangladesh is facing a double burden of malnutrition, the nutrients of public health importance may not be identical with the developed countries. The nutrients in Box 5 have been judged as key nutrients for Bangladesh from the public health nutrition point of view along with nutrients listed by FAO and US Food and Drug Administration (FDA).

The KF survey had been conducted according to the method of Haytowitz et.al, (1996 and 2002) as outlined in Figure 1.

Figure 1: The Key Food Identification Approach



Per capita per day intake of major food items (HIES 2010) and intakes of individual food items (Hasan et.al.2008) were used to find out the consumption level of nutrients of public health importance (Box 5) using the food composition table of INFS (HKI/INFS 1998). To rank the KFs identified on the basis of consumption-composition ratio, the consumption frequency of each food item from various sources (HIES 2010; Islam et.al. 2010; Hasan et.al. 2008; INFS 1997) was used because no single consumption survey is currently available that describes food item wise consumption frequencies of all food items consumed by the respondent households. Therefore, the final KFs list was on the basis of consumption-composition-consumption frequency of each food items.

Box 5 Nutrients of public health importance as listed by FAO and FDA

Nutrient	RDV (FAO)	RDV (FDA)	MRV (FDA)
Protein	40–50 g	50 g	—
Vitamin A	700–1000 μg RE	5000 IU	—
Vitamin C	50–60 mg	60 mg	—
Calcium	500–800 mg	1,000 mg	—
Iron	7–40 mg	18 mg	—
Zinc	12–20 mg	—	—
Folate	300–400 μg	—	—
Thiamine	1.0–1.6 mg	—	—
Riboflavin	1.2–1.8 mg	—	—
Vitamin B-12	1.0–2.0 μg	—	—
Vitamin D	5.0–10.0 μg	—	—
Vitamin E	7.0–10.0 mg	20 mg	—
Niacin	12–20 mg	—	—
Vitamin K	40–80 μg	—	—
Vitamin B-6	1.2–2.0 mg	—	—
Fiber	16–40 g	25 g	—
Potassium	—	3.5 g	—
Saturated fat (g)	—	—	20 g
Added sugar (g)	—	—	50 g
Sodium (mg)	—	—	2400 mg
Nutrients of public health importance for Bangladesh in addition to above list			
Carbohydrate	—	—	300 g
Total fat	—	—	20 g
Jaggery/Sugar	—	—	50 g

Source:

1. FAO/WHO. Preparation and use of food based dietary guidelines. Report of a joint FAO/WHO consultation, Nicosia, Cyprus. 1996.
2. US Food and Drug Administration. Code of Federal Regulations. Sec101.9, Nutrition labeling of food, 2007.

4.2 Laboratory analysis of selected KF

The analysis of nutrients and nutritionally important food components preceded by appropriate food sampling process and careful food collection and transportation procedures. These are briefly outlined below:

4.2.1 Sample size determination

A total of 20 KF had been selected purposively for laboratory analysis from the list of KF that was result from KF survey.

4.2.2 Food sampling protocol

The sampling frame is a listing of the actual sampling units for a particular product population that provides a complete, accurate, and up-to-date coverage of the sampling units in the population. A national food sampling plan is designed to provide a geographically dispersed, proportionally representative set of samples for a given food item to provide the best estimates of the nutrient profile or the nutrient means for the population of each food in the food supply and accurately represent what is currently being consumed by the population. For this purpose the National Population Census was used to draw sample collection units proportional to the population density pattern. In addition to that, the agro-ecological zones (AEZ) concept was also considered because AEZ include models for the calculation of length of growing period, irrigation requirements, crop biomass, land suitability, and land productivity. There are 30 AEZ in Bangladesh (Figure 3) categorized mainly in view of crop production. It has been suggested to be logical that AEZ-wise collection of food samples for laboratory analysis was rational and scientific. Interestingly, each administrative division of Bangladesh has been found to be situated in more than 2 distinct AEZ (Fig. 3) with overlaps of few big AEZ. Therefore, superimposing the population distribution map and AEZ map revealed that collection of food samples from 2-3 sites of each division would automatically cover all major AEZ.

Hence, considering the area size and overlap of AEZ across all 7 divisions, selection of 14 *Haats* (village markets) was sufficient to cover the maximum crop production regions of the country as well as density-wise population areas. Seventy percent of the selected KF were collected from these 14 *Haats* (considering 70% of rural population); while the rest 30% of the selected KF were collected from wholesale/retail markets of city corporation areas (considering 30% of urban population).

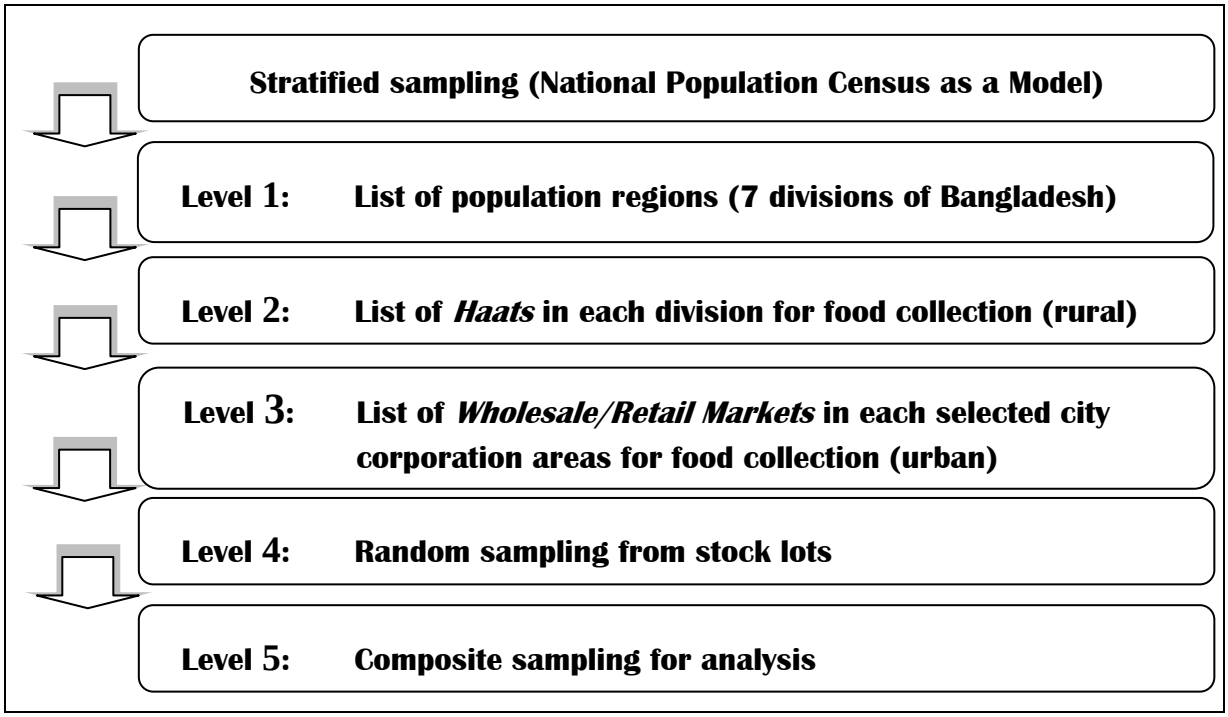
4.2.3 Sample collection protocol

Regardless of the sampling method chosen, the actual collection of the samples was random. Random sampling is an objective process, which is used to select the units that are included

in the sample. It was possible to eliminate or at least reduce bias by avoiding practices such as drawing units from the same position in crates, pallets, stacks, or piles.

Similarly, a sampler did not select units from one production line or sorting belt in lieu of others. Avoiding such sampling practices, the selected sample was, for practical purposes, approximate a random sample and was more representative of the population than a sample collected in a non-random manner. In bulk sampling situations in which the units have been thoroughly mixed, sorted, or arranged, a sample drawn anywhere from the bulk units may be considered random for practical purposes.

Figure 2: Sample Frame and Sampling Protocol



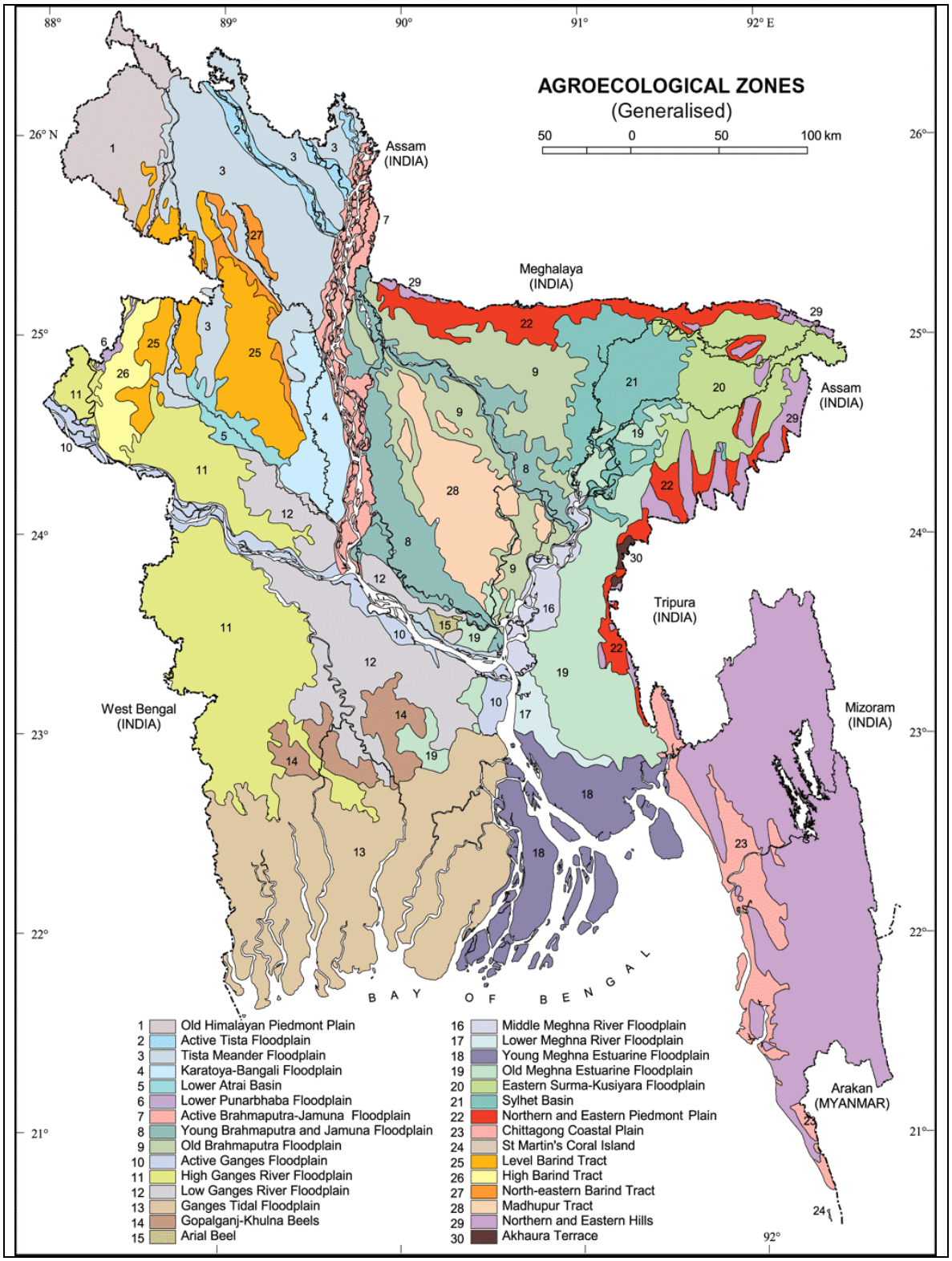
4.2.4 Logging the laboratory samples

Packing, storage, and transportation are factors that may affect levels of specific nutrients in certain commodities. Deteriorative processes may affect the analytical estimates determined by the laboratory in such a way that the laboratory estimates may not adequately represent the nutrient levels in the population. So logging the laboratory samples was the same as the producers/wholesalers/ retailers pack, store, and transport their food commodity to the consumers.

The sampler who is responsible for collecting the samples marked or tagged them and maintained a log to record pertinent details about their history. This information accompanied the sample and the analytical results through the chain of custody. Details, as mentioned in

the forgoing, was included if appropriate for the product as a minimum. A scheme of sample collection and transportation protocol is presented in Figure 4.

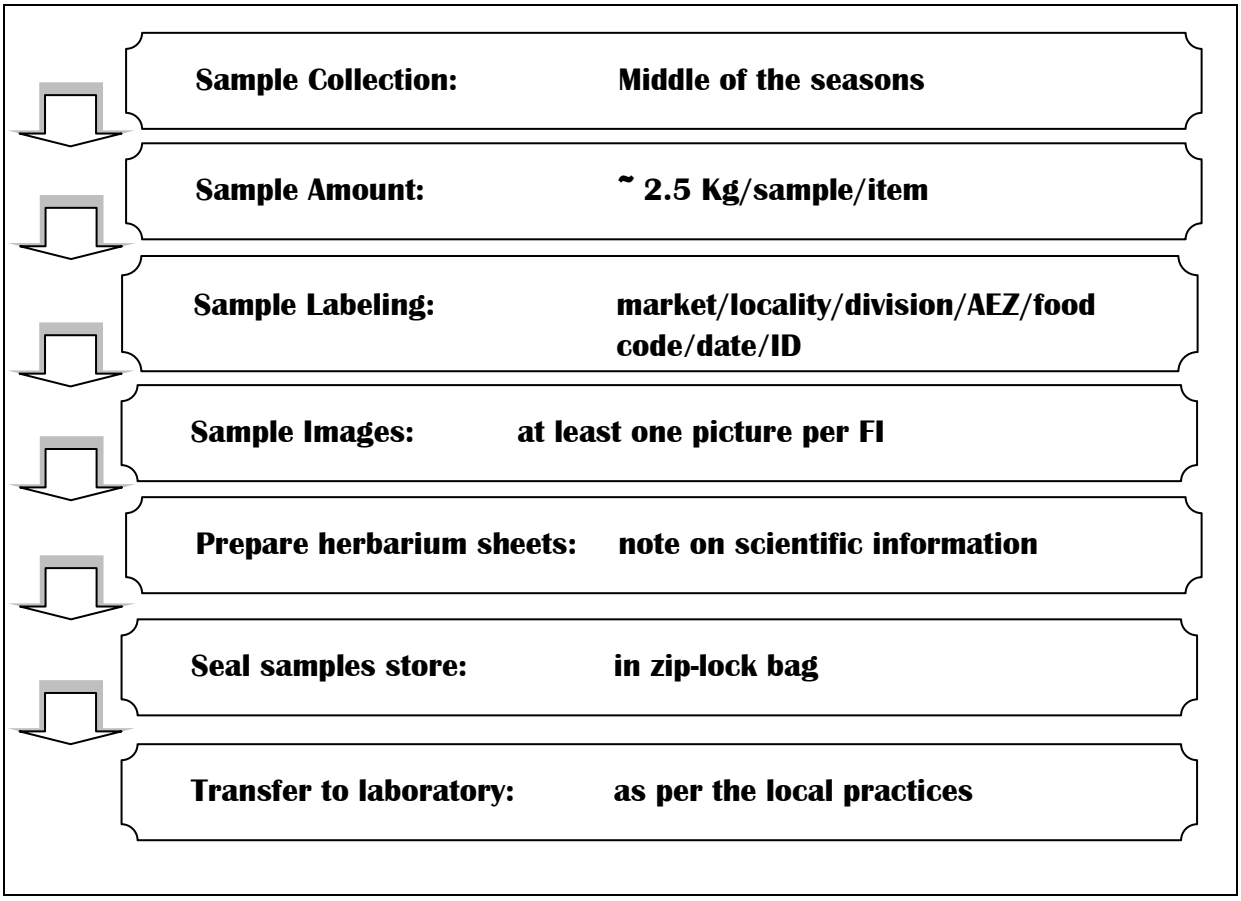
Figure 3: The Agro-ecological Zones of Bangladesh



In planning the sample collection activities, it was necessary to consider the following:

1. identification number (assigned by sampler)
2. name of the product
3. product variety
4. size or amount of product collected (referred to as the "increment")
5. place and date of collection
6. lot number or code
7. name and address of the grower, processor, distributor, shipper, supplier, retailer, etc.
8. description of the dispatch information (packing, shipping, and handling) sent to the analytical laboratory
9. any auxiliary information that was needed in the statistical evaluation (e.g., stratum size, cluster size, etc.).

Figure 4: Sample Frame and Sampling Protocol



4.2.3 Laboratory analysis protocol

Laboratories performing nutrient analyses were able to demonstrate that they operate under a documented Quality Assurance program that provides assurance that samples were

adequately logged, stored, sampled, analyzed, and archived (if needed); that the integrity of the data collected was maintained; that analysts were appropriately trained; that equipment was calibrated; that analyses were conducted by appropriate calibrated methods and according to standard operating procedures; and that data were checked for errors and for reasonableness of results. Each selected method was standardized in the laboratory and validated according to the AOAC/IUPAC validation protocol and SOP for each method was documented. For quality control and assurance programme Standard Reference Materials, spiked samples, or other validation materials were used.

Each food item was analyzed in duplicates/triplicate and mean was calculated for each nutrient. Analysis of foodstuffs collected was done at CARS, INFS, and other two collaborating organizations as detailed below.

4.2.3.1 Composite Test Samples

An analytical laboratory generally performs single and replicate determinations on single composite and commingled composite test samples. A single composite sample is a homogeneous mix of units of the same type (e.g., same variety, growing region, season, brand, lot). A commingled composite sample is a homogeneous mix of units of different types (e.g., different varieties, growing regions, seasons, brands, lots). Compositing, as it relates to nutrient analysis, is a process of physically averaging the concentrations of the nutrients in the units of the test sample. For the purpose of the present study, a single composite sample of a homogeneous mix of units of the same type and variety of food items were ideal to follow.

4.2.3.2 How Many Composite Samples is Necessary?

There are a number of factors to consider in determining a sample size, that is, the minimum number of composites to analyze. Historical nutrient data that are available in the scientific literature or are collected through a pilot study were used to estimate a sample size that fulfills predetermined criteria. Two formulas that were used to estimate such sample sizes are described below Box 6.

Cost considerations are an important factor, particularly if data bases for several products are contemplated. There are several questions that should be asked at this point:

1. Are there any nutrients that are known to be absent from the product or that are present at insignificant levels?
2. What is the time frame for the data base development?
3. How much risk of values being out of compliance is acceptable?

Therefore, considering a 90% confidence interval and a relative error of 15%, the estimates will change.

Box 6 . Formulas for determining minimum number of composite sample

Formula I: This formula infers that the true mean (nutrient value) of the population is within a given confidence interval of a specified width, for a simple random sample:

$n = z^2 \sigma^2 / \epsilon^2$, where

n = the sample size you wish to calculate
z^2 = the square of a value from a table of the normal distribution for a risk α
[For a 95% confidence level, use 1.96 and square it.]
σ^2 = the square of the population standard deviation, which is the variance
ε^2 = the square of the margin of error desired for the sample estimate
[$\varepsilon = P\,\mu$; P is the relative error, e.g., 5% or 15%; μ is the mean]
The formula may be simplified to: $n = (1.96)^2 \sigma^2 / (P\,\mu)^2$

Formula II: This formula may be used when there is only an estimate of relative variation of the population (i.e., the population coefficient of variation, which is the population standard deviation divided by the population mean).

$\mathbf{n = z^2 (CV)^2 / P^2}$, where

n = the sample size you wish to calculate
z^2 = the square of a value from a table of the normal distribution for a risk
[For a 95% confidence level, use 1.96 and square it.]
CV^2 = the square of the coefficient of variation $(\sigma / \mu)^2$
P^2 = the square of the relative error desired for the sample estimate, e.g., 5%
The formula may be simplified to: $\mathbf{n = (1.96)^2 (CV)^2 / P^2}$

However, FDA analyzes single composite samples based on 12 units each. Therefore, it is a good rule of thumb in developing a data base to include 12 units in each single composite sample that is tested. Regardless of the type of composite used, however, it is designed to be good to prepare the composite to contain the product in proportion to the sampled fraction for the item that is being composited.

4.2.3.3 Selecting the Analytical Methodology

For FAO compliance purposes, uses of appropriate methods as given in the most recent edition of Official Methods of Analysis of AOAC International or if no AOAC method is available or appropriate, by other reliable and appropriate analytical procedures were planned. Whenever possible, uses of AOAC Official Methods were desired because such methods have undergone collaborative evaluations with respect to the following aspects.
Accuracy: a measure of the closeness of agreement between the measured value and a value that is accepted as a "true" value or an accepted reference value;

Precision: a measure of the repeatability of the method under conditions of usual operation;
Specificity: the ability of the method to measure accurately and specifically the analyte of interest in the presence of other components that are expected to be present in the sample matrix;
Sensitivity: the limits of detection (LOD) and of quantification (LOQ);
Linearity (and range): the ability of the method to give results those are proportional to the analyte concentration within a specified range of concentrations.

It is well recognized that modifications of AOAC Official Methods may be needed because the Official Methods are not currently available for all nutrients of interest in all food matrices. In such case the ASEAN Manual of Nutrient Analysis (ASEANFOODS 2011) was useful for a list of methods that was adopted after method validation as per AOAC/IUPAC protocol in order to analyze the composite sample are listed in Box 7.

Box 7. Selection of analytical methods for nutrient analysis

I. Methods	**AOAC and other standard methods of food analysis.**
II. Parameters	i. Proximate analysis: Protein, Fat, CHO, Water, Ash (by Micro-level digestion-distillation system) ii. Macro-minerals: Na, K, Ca, Mg iii. Heavy metals: Hg, As, Se Cd, Pb (by ICPMS) iv. Trace Metals : Cu, Zn, Fe v. Amino acid (AAA) vi. Total Phenol (by Spectrophotometer) vii. Antioxidant activity: DPPH & ORAC (by ELISA with microtiter plate) viii. Antinutrients: Phytate & Oxalate (by Spectrophotometry & Colorimetry) ix. Fatty acid profile (by Gas liquid chromatography) x. Total dietary fiber (TDF) (by Enzymatic-gravimetric method) xi. Total sugar (TS) (by Titemetric method) xii. Total free sugar (TFS) (by Titemetric method) xiii. Retinol xiv. β-Carotene (by HPLC) xv. Vitamin C, B_1, B_2, B_6
III. Quality Assurance Program (QAP)	i. Method Standardization ii. Method Validation: Internal standard (IS), External standard (ES), percentage of recovery iii. Data Quality: Precision (CV), Accuracy (In-house reference material - IHRM and well documented food) iv. Meticulous Documentation

Each analytical procedure was accompanied with a quality assurance program to ensure the quality of the data. Extensive documentation of every single step for laboratory analysis had been carried out. These documentations are kept for data management, identification of missing steps and values, as well as recall points for repeats of analysis.

4.2.3.1 Analytical methods for nutrient analysis

a) Proximate content

The proximate analyses for 20 key foods were done according to the Association of Official Analytical Chemists (AOAC) Methods. These methods were established at the Institute of Nutrition and Food Science laboratory of University of Dhaka and had been used for the last 15 years. Analyses were performed with homogenate sample in a repeated manner. Repeated analyses from the same homogenate (from extraction to analysis) validate the homogeneity of the sample and repeated analyses of the same extract validate the instrument precision.

Proximate Composition of each sample of each item was determined in duplicate estimations and the mean value was recorded.

Moisture: Moisture content is one of the most variable components, particularly in the plant origin foods. Variability in moisture content of particular food affects the food composition as a whole. Therefore, the moisture value remains as an essential component for nutrient composition, as well as, food composition database.
Moisture content was determined by weight loss on drying of the sample in an oven at 105°C for 6 h (AOAC 2000). The moisture-free samples were charred and heated to 600°C until a constant weight was achieved, the residue being quantified as ash (AOAC 2000).

Protein: The protein content was determined by Kjeldahl method No 984.13 (AOAC 2000) modified in our laboratory at a micro scale. After acid digestion in BUCHI DIGEST SYSTEMK-437 equipped with a BUCHI SCRUBBER, B-414, samples were distilled in BUCHI DISTILLATION UNIT, K-350. Released nitrogen was trapped in 0.1N sulfuric acid and back titrated with 0.1N sodium hydroxide to estimate the total nitrogen which was converted to protein by multiplying with appropriate factor for that specific food.

Total Fat: The most appropriate and frequently used method for total lipid estimation is the continuous extraction of fat with petroleum ether or diethyl ether. Since the study sample contained more than 10% water, they were dried to constant weight at 60-70^{O} C for 16-18

hours (overnight) and stocked for fat estimation. The "Soxhlet" method is recognized by AOAC as the standard method for crude fat analysis. The crude fat from the dried sample was estimated by the semi-continuous solvent extraction procedure (Soxhlet method), described in method no. 991.36 of AOAC (2000). The fat was extracted from the dried sample (5g) using petroleum ether (40-60 boiling range) as a solvent.

Ash content: For ash estimation, dried samples were ignited at 600˚C to burn out all organic materials. A residue inorganic material which is remained in this temperature is the content of ash. In present study, ash content of 20 key food samples were estimated by heating the dried raw sample in a Muffle furnace at 600˚C for 3-5 hours till to constant weight (AOAC, 1998d). Ash content was calculated from weight difference between initial and final weight of the food samples.

Dietary Fiber: Dietary fiber has been determined by AOAC method (2000) using total dietary fiber assay kit. This method is a combination of enzymatic-gravimetric method – Prosky (985.29). Dried fat free sample was gelatinized with heat stable α-amylase, then enzymatically digested with protease and amyl glycosidase to remove protein and starch present in food sample. The residue was filtered and washed with ethanol and acetone. After drying, half of the residue was analyzed for protein and half for ash. Total dietary fiber was the weight of the residue minus the weight of the protein and ash.

Calculation of Carbohydrate and Energy: The content of available carbohydrate in the food sample was determined by difference. Carbohydrate was calculated by subtracting the sum percentage of moisture, protein, fat, ash, crude and dietary fiber (FAO,1998) The nitrogen free extract (NFE) was obtained by subtracting the sum of the values for moisture, protein, fat and ash from 100 (Ferris et.al., 1995). This value was considered as "total carbohydrate" and was calculated by following equation.

Carbohydrate (NFE g %) = 100 − (Protein+ lipid + moisture +ash + TDF) g/100 g

b) Water soluble Vitamins

Analysis of vitamin C: The method detects vitamin C (L-ascorbic acid) of natural origin using HPLC method. The fresh food samples (vegetables and fruits) were homogenized in 3% metaphosphoric acid. The sample extract, obtained after filtering the homogenate, was

chromatographed on an RP C18 column by means of HPLC. Evaluation has been carried out by comparing the peak area against an ascorbic acid standard (Lakshanasomya N, 1998).

Analysis of vitamin B_1: Vitamin B_1 (Thiamin) has been determined by HPLC method (AOAC, 2000). The vitamin B_1 was extracted from the food by acid hydrolysis followed by enzymatic hydrolysis. The aqueous extract was injected onto a reverse phase HPLC column and thiamin was determined after post column derivatisation with alkaline potassium ferricyanide that converted the thiamin to thiochrome which fluorescenced in ultraviolet light (942.23).

Analysis of vitamin B_2: Vitamin B_2 (Riboflavin) in foods has been determined by HPLC method (AOAC, 2000). The vitamin B_2 was extracted from the food by acid hydrolysis followed by enzymatic hydrolysis. The aqueous extract was injected onto a reverse phase HPLC column and the fluorescence of riboflavin has been measured (970.65).

Analysis of vitamin B_6: Vitamin B_6 (Pyridoxine) in foods has been determined by microbiological method (AOAC, 2000). Heating raw samples with diluted mineral acid under autoclaving conditions liberates the B_6 vitamin from their protein complex and also hydrolyses phosphorylated forms to the free vitamin. The process must be protected from light. This heat-treatment was necessary for the determination of total B_6 in foods because of the assay organism, *Saccharomyces carlsbergensis*, utilizes only the non-phosphorylated form of vitamin.

c) Fat-soluble vitamins

Retinol and β-carotene

Retinol and β-carotene of the sample extract was estimated by HPLC according to the method of ASEAN Manual of Nutrient Analysis (2011).

After homogenization and saponification of the sample in a solution of ethanolic potassium hydroxide the retinol and β-carotene released was totally extracted with organic solvents. Separation of the retinol content was done with part of the extract by reversed phase HPLC. Quantification was carried out against vitamin A and β-carotene standard respectively.

d) Mineral profile

i. Calcium and Magnesium have been determined by Atomic Absorption Spectrophotometer (AAS) (AOAC, 2000).

Triplicate of each sample (1.0 g) was accurately weighed into clean, dry microwave Teflon vessels of Microwave digester -Closed Vessel Acid Digestion (CEM MARS Express System). Then, 10.0 ml HNO_3 was added to the 1.0 g samples. A seal-forming tool was used to expand the lip-seals on the lids that were placed in each vessel. The vessels were placed in a bomb jacket with screwed caps. The vessels were placed in the microwave system and the optimized digestion program (200ºC for 10 minutes) was employed for the sample being analyzed. Upon completion of the microwave step, the vessels were removed from the microwave system. Under a fume hood, the screw caps and lids of each vessel were slowly unscrewed, allowing the nitrogen oxides to escape slowly. Then the samples were quantitatively transferred into 25-ml volumetric flasks and diluted with deionized water. The solutions needed no filtration as there were no particles that could disrupt the nebulizer flow. The clear solutions were then transferred quantitatively in to falcon tube for atomic absorption spectrophotometric analysis. Blank was made by similar procedure without addition of sample.

ii. Sodium and potassium content of sample have been determined by flame photometry (Flame Photometer, Model: PFP7).

Flame photometry relies upon the fact that the compounds of the alkali and alkaline earth metals can be thermally dissociated in a flame and that some of the atoms produced will be further excited to a higher energy level. When these atoms return to the ground state they emit radiation which lies mainly in the visible region of the spectrum. Each element emits radiation at a wavelength specific for that element. Sodium and potassium were measured by atomic flame emissions in terms of the emission wavelength at 589 and 766 nm, respectively and produced yellow and violet colors, respectively.

Amount of sodium and potassium present in the samples determined by extrapolation. The calibration curve was prepared by measuring the intensity of emission for a series of solutions of different concentrations (0 ppm, 1 ppm, 2 ppm, 3 ppm, 4 ppm and 5 ppm) prepared by using a standard solution of Na and K, and plotting a graph between emission intensity versus concentration of the ionic species of the element. The concentration of the element in the unknown sample was found out from the standard plot by using the formula $y = mx + c$. Where y is reading of unknown concentration, m and c are slope and intercept of calibration curve, respectively; x is unknown concentration to be determined. Further, it is very important to measure the emission from the standard and unknown solutions under conditions that are as nearly identical as possible.

iii. Vanadium, Chromium, Manganese, Iron, Nickel, Copper, Zinc, Silver, Arsenic, Selenium, Molybdenum, Cadmium, Antimony, Barium and Lead have been determined by ICP-MS (Agilent7700) (JAOAC 73,404,1990).

Freeze dried samples (0.3 g) were accurately weighed into clean, dry microwave Teflon vessels of Microwave digester. Then, 5.0 ml HNO_3 and 2.0 ml hydrogen peroxide were added to the 0.3g samples and kept for 20 minutes for pre-digestion. The samples were digested for 30 minutes in Berghof (MWS-2) microwave digestion unit. After digestion, the final volume was made to 25ml by milli-Q water. After filtration through 0.2 µm syringe filter the samples were analyzed by using ICP-MS (Agilent 7700).

e) Phytate and Oxalate

Phytate

Phytate, a naturally occurring organic compound found in plant seeds, roots and tubers, was determined using a modified ion exchange method of Ellis and Morris (1983, 1986).

Phytate was extracted from triplicate samples of dried food (60°C) using diluted HCL. Extractants were mixed with EDTA/ NaOH solution and placed in an ion exchange column. Phytate was diluted with 0.7 M NaCl solution and digested with concentrated mixture of HNO_3 / H_2SO_4, to release P, which was measured colorimetrically. Amount of phytate in original sample was calculated as hexaphosphate equivalent.

Oxalate

In foods, oxalates are present in soluble and insoluble form. Soluble oxalates are extracted using water and insoluble oxalates are extracted using 2M HCl, which converts the insoluble form to soluble forms of oxalate.

About 2 g of dried sample was taken, 50 ml of Milli-Q water was added for soluble oxalates and 50 ml of HCl for total oxalate. The sample mixture was then vigorously mixed for 2 minutes in vortex and then kept in water bath at 80^0 Q water (soluble oxalate) and 2M HCl (total oxalate). Then 10 ml diluted sample was centrifuged and vacuum filtered through 0.2 µm filter. The filtrate was collected in glass tube and transferred into 1.5 ml auto sampler vial for HPLC analysis.

*f) **Total phenol***

Total phenol content of the selected sample extracts was estimated colorimetrically according to the Folin-Ciocalteau method (Singlleton & Rossi, 1965). For each sample, 10μl of extracts were put into 3 test tubes. Then, 60μl of water was added to each of the test tubes. Next, 15μl of two times diluted Folin-Ciocalteu reagent (by water) was added and allowed to stand for 5 minutes at room temperature. This was followed by the addition of 75 μl of 2% (w/v) sodium carbonate solution to the mixture which was allowed to stand for 15 min at room temperature. The absorbance was measured at 75 nm with Schimadzu UV-VIS spectrophotometer. A control sample was prepared containing the same volume of reference gallic acid. A gallic

acid standard curve of varying concentrations was constructed by plotting gallic acid concentrations on abscissa and absorbance on ordinates for quantification of total polyphenol. The total polyphenol content was expressed as gallic acid equivalent per fresh weight (mgGAE/g FW).

g) Antioxidant capacity (DPPHRSA)

Estimation of the antioxidant capacity of the samples was performed by DPPH radical scavenging assay of Brand-Williams, Cuvelier & Berset (1995). Sample extracts were mixed with the same volume of 30% acetone. Amounts of 200, 400 and 800 μL of the samples were put into test tubes and added with 800, 600 & 200 μL of 50% acetone respectively. The next step was the addition of 500 μL of 200 mM MES buffer to all of the tubes. Then, 500 μL of 400 μM DPPH solution in EtOH was added to all these tubes (one by one at a similar interval rate). After 20 min (room temperature) absorbance was measured at 520 nm. For the sample blank, three tubes with 200, 400 and 800 μL each were added with 50 % acetone in similar volumes as the samples - 800, 600 and 200 μL. Then, 500 μL of 200 mM MES buffer was added to all the tubes. Instead of DPPH solution, 500 μL of ethanol was added to all the blanks and absorbance was measured to substract the sample colour. A standard curve was constructed by plotting varying Trolox concentrations on abscissa and absorbance on ordinates. The antioxidant capacity of the assayed samples was calculated from the standard curve, in terms of Trolox Equivalent Antioxidant Capacity (TEAC) and was expressed as μmol TE/g FW.

h) Fatty acid

Total lipid was extracted from the samples according to the modified method of Folch et al. After extracting the sample were air dried. For the determination of individual fatty acids the air dried samples were dried by nitrogen. Heptadecanoic acid as internal standard was added and then saponified with 12.5 ml alcoholic potassium hydroxide by refluxing at 60^0 C for one hour. After saponification the non saponifiable fractions were extracted by using n-hexane. The residue containing the potassium salt of fatty acid was acidified with 6N HCl. The free fatty acids were extracted similarly as the non-saponifiable matters. The fatty acids were methylated according to the method of Morrison and Smith, and finally a portion was injected into a gas liquid chromatography (Pye Unicam GC 304, glass column, 1500mm X 4mm) of 10% DEGS on 100-120 mesh Diatonite CAW was used. Nitrogen was used as carrier gas at flows of 32ml/min. The standards were carried out through the same procedure.

i) Amino acid

Percent composition of amino acid of samples were estimated by the modified method of Moore et al. The sample was taken in such a way so that each contains 100mg of protein and was dissolved in deionized water. In a digestion tube the aliquots were taken and concentrated HCl was added in an amount so that the final concentration becomes 6N. The digestion tube was partially sealed at the middle and kept under acetone containing dry ice. The tube was completely sealed after it was almost chilled, and was placed in an oven at 110° C for 24 hours. The tube was cut at the middle of the neck and kept in a desiccator containing

Po5 until HCl was completely dried. The sample was then dissolved in HCl: H_2O solution at pH 2.2. Sample was centrifuged and supernatant was collected in a vial. The amino acid composition was determined in a fully automated liquid chromatography (JLC-300 TEOL LTD, TOKYO)

4.2.4 Statistically analyzing the data and interpreting the results

4.2.4.1 Exploring the Data

The first step in working with any data set is to make sure that the data are clean, that is, virtually error free. Once the data was found error free, screening for outliers was the next step. Outlier testing allows the identification of influential observations that might actually be transcription or analytical errors in the data.

4.2.4.2 Calculating Report Values

The following steps were followed in calculating a reportable value based on laboratory data:

1. To calculate the mean (average) nutrient content value from the analyzed nutrient values;
2. To calculate the standard deviation where applicable;
3. To convert the mean and standard deviation from a "per 100 g" basis to the label serving size
   required for the food;
4. To construct a one-sided 95% prediction interval;
5. To select the mean or predicted value for the nutrition label;
6. To calculate the percent daily value (DV) for appropriate nutrients; and
7. To round the values according to FAO or FDA rounding rules.

4.3 Development of food composition database

4.3.1 Background

The reasons for the development of a food composition database for each country have been extensively discussed by Greenfield and Southgate (2003a). Off the many data compilation tools prepared by different organizations (see literature review in the following section), the FAO data compilation tool 1.2.1 has been recommended for faster data exchange among developing countries and hence has been considered for the development of a FCDB for Bangladesh.

4.3.2 Compilation methodology

The Compilation Tool 1.2.1 is structured basically according to Greenfield and Southgate (2003) and separates the database into different stages:

I. Archival database : to compile original data into the archival database
II. Reference database : to manage data in the reference database while completing missing data through borrowing, calculating or estimating
III. User databases : to select a subset of the reference database to be published in the user database

4.3.3 Sources of data

Before outlining criteria for data scrutiny, the primary sources of the data are illustrated below.

Box 8 Sources of compositional data

Source	***Description***
Primary publications	Articles in the scientific literature containing compositional data for foods
Secondary publications	Reviews or published compilations including compositional data
Unpublished reports	Reports ranging from analytical records to reports prepared for internal use within an organization, but not published in a formal sense
Analytical reports	
specific	Analyses carried out specifically within a database programme
non-specific	Analytical work carried out for other purposes

4.3.4 Data scrutiny criteria

The bases for data scrutiny criteria were in accordance with the guidelines of INFOODS. The food samples must be representative. Thus, scrutiny includes evaluation of the sampling plan used to obtain the food in terms of number/weight of items collected, date and time of collection, geographic location, mode of combination of items, etc. These have been described in section 4.2 of this report.

Box 9 Criteria for scrutiny of data	
Parameter	***Criteria***
Identity	Unequivocal identification of food sampled
Sampling protocol	Collection of representative sample
Preparation of food sample	Cooking method Precautions taken Material rejected as inedible, etc.
Laboratory and analytical sample preparation	Nature of material analysed Methods used for sample preparation
Analytical procedures	Choice of method Compatibility Quality assurance procedures
Mode of expression	Compatibility with that used in the database

4.3.5 Assembling data sources

A rigorous search of the literature was conducted. Recent papers were sought by regular consultation of abstracting literature and databases. Journals not covered by an abstracting service were referred to directly. Contact with sources of unpublished data will be developed and these were: university, government and private laboratories; research institutes; commodity boards and food manufacturers.

4.3.6 Archival stage

All the relevant information obtained were recorded systematically using one of the many computerized database management systems available. It was robust and comprehensive and represented the archive or store of all values reported for the composition of foods. Historic data was also in the collection because these provide information that helps in the assessment of whether the composition of a food is changing over time or whether it has a stable composition.

4.3.7 Reference stage

The archival stage provides the basis for preparing the reference database. In this, all the acceptable data for each food from different archival records are combined and presented in a common compatible format with links to the archival records and their metadata. To do this, review of all the available data for each food was done (Box 12).

Most data sources usually do not provide coverage of all the constituents required for the database as a whole and typically cover a limited range of components. So care was taken to consider whether the different samples of foods were compatible. This requires comparing water and fat contents and considering whether the adjustment of values to a constant base justified.

Box 10 Criteria for acceptance of compositional values into a database

Criterion	***Clearly acceptable***	***Progressively decreasing acceptability***	***Usually unacceptable***[1]
Sampling criteria			
Identity of food	Unambiguous	Identity becomes less clear	Any ambiguity
Representativeness	Indigenous to the database population	Less representative of the foods consumed	Not stated
Number of samples	Protocol designed to achieve defined confidence limits	Sample numbers chosen arbitrarily	Selective samples, or very limited in number
Nature of material analysed	Clearly defined	Definitions becoming less clear	Not stated or unclear
Analytical sample preparation	Described in detail and known to conserve nutrients	Described briefly, but still known to conserve nutrients	Not stated, or no evidence of need to protect nutrients in sample
Analytical criteria			
Choice of analytical method	Well established and internationally compatible	Less well described, or unpublished modifications	Not stated
Performance of method	Established, validated in collaborative trials	Established, but not validated in-house	Not stated, or not known to be adequate. Possibly superseded by better method
Quality assurance	Described, or referenced. Use of proper standards and standard reference materials	No record of quality assurance, replicate analyses only.	Not stated
Mode of expression	Units and methods of calculation clearly stated	Progressively less-clearly described	Units and factors not given

Note: [1] Where the values are the only ones available it may be useful to archive the data.

4.3.8 Preparation of the user databases

Several different user databases and tables can be prepared from a single, well-constructed reference database. The preparation of user databases requires examination of the food records in the reference database and their combinations (where necessary) and final checks for internal consistency. In many cases, the database for all the foods is provided in the "reference database" for the country or region. In this report we see the "user databases" as those that contain one set of data for each food item, and in which the nutrients and other constituents are given one value per food item. It may be necessary to provide two or more entries for a single food, for example where seasonal differences in composition are sufficient to justify two separate food records. All data to be used in preparing the user databases should have been entered during the archival and/or reference stages.

The preparation of a user database for Bangladesh was prepared after review of similar kind of FCT like that of West Africa, Thailand, India, Pakistan and Mozambique. It contained food composition data in 15 food groups like that of DKP/HKI FCT. Nutrients in the main table included proximate, dietary fiber, Iron, Calcium, Sodium, Potassium, Zinc, Magnesium, Copper, Vitamin C, B1, B2, B6, Folate, Niacin eq., Vitamin A, RE, Retinol eq., ß-Carotene, Vitamin D and Vitamin E. Other nutrients and bioactive compounds viz., Fatty acid, SFA, MUFA, PUFA, Cholesterol, Amino Acid, antinutrient factors (phytate, oxalate), bioactive compounds (e.g., total phenol content, antioxidant capacity) and total sugar are presented in the annexes.

Recipes with existing analytical data were included in the FCDB. Missing values were calculated by mixed recipes calculation method and EUROFIR nutrient retention factor at food groups level and yield factors at recipe level (determined by nutrient).

For a comprehensive FCTB, it must not contain missing values. So data for missing values was borrowed and imputed from FCTs of USDA 2012, NVIF 1989, ASEANFOODS, Thai FCT, Danish FCT, UK FCT, Pakistani FCT etc.

4.3.9. Summary of the compilation process

An overview of the compilation process is given in Box 11. Each stage of preparation demanded detailed scrutiny of the preceding stages, and frequently required a return to the data source level.

Box 11	Summary of compilation process		
Stage	***Summary of operations***	***Type of scrutiny applied***	***Format***
Data source	Collection of sources containing compositional data	Analogous to reviewing a scientific paper; check on consistency of data; preliminary assessment of data quality	In form published: paper or electronic record
Archival record	Compilation of information from data sources	Scrutiny of data source against formal criteria; refining assessments of data quality	Database format, plus records of sampling protocols; analytical methods; common modes of expression adopted
Reference database	Compilation of data from archival records for each food	Comparison of values from different sources; re-scrutiny of archival and data sources to assess inconsistencies; calculation of statistical measures	In database format, with array of all acceptable values for each food item; records of statistical analyses; formal assessments of data quality
User database	Selection and compilation of series of values for each food item in database	Combination of values to give one value for each nutrient per food item; mean, or median, plus suitable measures of variability	In format required by database users

Results and discussion

5.1. Results of 20 key foods analyzed

Composite sample of 20 KFs were analyzed for 31 nutrients, amino acid and fatty acid profile, antinutrients, bioactive compounds and antioxidant capacity. The results are presented in tubular form according to different group of nutrients.

5.1.1. Proximate

The proximate composition of 20 KFs are presented in Table 5.1.1. Rice (BR-28) contains 6.5g of protein and 3.78g of total dietary fiber (TDF) and wheat flour contains 10.6g protein and 4.4 g of TDF. Protein content of three analyzed fish ranges from 15.9g to 20.8g. The fat content of the key foods varies widely (11.0g to 3.0g). However, the highest protein content has been found in lentil and fat in pangas fish. Dietary fiber is highest in lentil (13.2g) and lowest in mango (1.6g).

Table 5.1.1: Percentage of proximate nutrients (g/100 g EP) on fresh weight basis

	Food name	Water (g)	Protein (g)	Fat (g)	TDF (g)	Ash (g)	CHO (NFE)* (g)
Cerelas	Rice, BR-28, parboiled, milled, raw	12.4	6.5	0.4	3.8	0.5	76.4
	Wheat, flour, white	12.2	10.6	1.6	4.4	0.8	70.3
Pulses	Lentil, dried, raw	12.2	27.7	0.8	13.2	2.9	43.2
Vegetables	Bean, seeds and pods, raw	90.0	2.4	0.1	4.3	0.6	2.5
	Brinjal, purple, long, raw	91.4	1.9	0.1	4.1	0.7	2.0
	Carrot, raw	89.7	0.9	0.3	2.6	0.6	6.0
	Green chili, with seeds, raw	85.5	2.8	0.1	8.4	1.0	2.1
	Onion, raw	83.7	1.4	0.1	1.9	0.7	12.2
	Tomato, ripe, red, raw	95.0	1.1	0.2	1.7	0.5	1.4
Starchy roots	Potato, Diamond, raw	81.7	1.2	0.2	2.1	0.9	14.0
Fruits	Banana, Sagar, ripe, raw	75.2	1.3	0.838	2.6	0.8	19.2
	Jackfruit, ripe, raw	77	1.2	0.2	7.2	1.1	13.3
	Mango, Langra, yellow flesh, ripe, raw	78.4	0.8	0.4	1.6	0.8	18
Fish	Pangas, without bones, raw	70.8	15.9	11	0	1	0
	Rohu, without bones, raw	76.3	20.6	2.6	0	0.9	0
	Tilapia, without bones, raw	76.2	20.8	3	0	1.1	0
Meat	Chicken breast, without skin, raw	72.9	22.3	1.8	0	1.1	0
	Chicken leg, without skin, raw	71.9	19.2	5.7	0	1	0
Egg	Eggs, chicken, farmed, raw	72.3	14.5	9.0	0	0.8	Tr
Milk	Milk, cow, whole fat (pasteurised, UTH)	88.3	3.1	3.7	0	0.6	4.3

5.1.2. Water soluble vitamins

Thiamin content in analysed samples ranges from 0.028 to 2.066 mg per 100 gm of edible portion (brinjal and jackfruit respectively). Among the analysed KFs, the rich sources of thiamin are fish, fruits and pulses. Riboflavin content of 20 KFs shows that highest amount is present in Milk and lowest in Tomato. In case of vitamin B_6, highest source is chicken leg whereas lowest amount is present in Tomato. L-Ascorbic acid content of the vegetables and fruits reveals that green chili and mango (Langra variety) contain highest amount (102 mg) whereas banana contain the lowest (1.033 mg).

Table 5.1.2: Content of water soluble vitamins (mg/100 g EP) on fresh weight basis

Name	Thiamin*	Riboflavin*	Vitamin B_6	Vitamin C* (L-Ascorbic acid)
Banana	0.939 ± 0.020	0.080 ± 0.030	0.1048	1.033 ± 0.15
Bean	0.083 ± 0.001	0.087 ± 0.002	0.063	9.633 ± 0.55
Brinjal	0.028 ± 0.001	0.070 ± 0.001	0.079	1.287 ± 0.46
Carrot	0.044 ± 0.001	0.085 ± 0.003	0.133	1.437 ± 0.16
Chicken breast	0.122 ± 0.010	0.073 ± 0.030	0.315	NA
Chicken leg	0.090 ± 0.030	0.118 ± 0.040	0.350	NA
Egg	0.184 ± 0.040	0.187 ± 0.001	0.150	NA
Green Chili	0.034 ± 0.001	0.050 ± 0.001	0.230	102.267 ± 3.30
Jackfruit	2.066 ± 0.060	0.045 ± 0.003	0.313	3.433 ± 4.30
. Lentil	0.767 ± 0.010	0.13±0.01	0.336	NA
. Mango	0.925 ± 0.010	0.144 ± 0.001	0.162	102.977 ± 3.96
. Milk	0.062 ± 0.004	0.276 ± 0.010	0.053	NA
. Onion	0.045 ± 0.002	0.136 ± 0.010	0.168	4.500 ± 1.13
. Pangas fish	0.151 ± 0.010	0.056 ± 0.030	0.107	NA
. Potato	0.081 ± 0.005	0.093 ± 0.010	0.277	19.067 ± 5.70
. Rice	1.126 ± 0.010	0.014±0.001	0.168	NA
. Rohu fish	0.611 ± 0.050	0.102 ± 0.040	0.112	NA
. Tilapia fish	0.970 ± 0.040	0.088 ± 0.030	0.111	NA
. Tomato	0.038 ± 0.001	0.043 ± 0.010	0.049	12.287 ± 2.80
. Wheat flour	0.129±0.03	0.05±0.01	0.099	NA

*Results are expressed as Mean ± SD, NA= Not applicable

5.1.3. Minerals

Table 5.1.3 presents the contents of Ca, Mg, Na, K, Fe, Cu, Zn, Se of 20 key foods. For calcium, milk is the rich source. Magnesium is in lowest concentration in tomato and in highest in lentil. Sodium content is lowest in mango and highest in banana. Potassium is present in lowest amount in egg and in highest amount in lentil. Copper has been found in lowest concentration in milk and in highest concentration in jackfruit. Lowest concentration of zinc is present in carrot and highest in chicken leg. Selenium content is lowest in rice highest in tilapia.

Table 5.1.3: Minerals content (mg/100g) of 20 key foods

Name	Ca	Mg	Na	K	Fe	Cu	Zn	Se
Banana	11.341	22.957	9.869	410.681	0.286± 0.003	0.094± 0.004	0.235 ±0.003	0.03± 0.001
Bean	70.010± 8.1	50.883± 15.2	10.026 ±1.1	170.485± 05.1	0.91±0. 33	0.6±0.0 4	4.75±0. 12	0.01±0. 001
Brinjal	21.112± 1.6	23.764± 1.9	7.636± 1.3	177.69±1 .48	0.364± 0.03	0.682± 0.01	0.567± 0.03	0.006± 0.0
Carrot	25.858	16.081± 0.6	54.050 ±4.3	145.236± 15.1	0.363± 0.07	0.225± 0.01	0.074± 0.02	0.003± 0.001
Chicken breast	14.784± 2.0	31.905± 0.8	36.894 ± 0.09	315.27± 15.3	0.48± 0.03	0.106± 0.003	2.663± 0.2	0.079± 0.01
Chicken leg	17.893± 3.0	29.252± 0.3	55.069 ± 0.2	299.059± 28.4	1.04± 0.1	0.22± 0.01	7.222± 0.2	0.072± 0.01
Egg	29.295	20.88	115.95 6	110.427	0.53± 0.05	0.301± 0.01	5.3010. ± 0.3	0.106± 0.01
Green Chili	22.041± 1.0	43.346± 2.0	11.994 ±1.9	281.736± 18.4	1.645± 0.02	0.872± 0.07	1.967± 0.08	0.004± 0.002
Jackfruit	8.584	42.423	0.662± 0.1	267.984± 23.9	0.32± 0.01	1.18 ±0.04	1.19± 0.01	0.044± 0.003
Lentil	12.59	71.533	37	635	5.1	0.794± 0.12	3.886± 0.82	0.007± 0.002
Mango	12.608	14.69	0.422± 0.1	180.890± 37.9	0.237± 0.002	0.789± 0.03	0.604± 0.01	0.043± o.oo4
Milk	103.0±7 .0	22.425± 7.8	51.155 ±6.2	131.164± 11.1	0.089± 0.01	0.054± 0.0	3.735± 0.17	0.042± 0.02
Onion	23.969	24.121± 1.96	11.119 ±0.0	209.749± 29.3	0.942± 0.02	0.363± 0.03	3.449± 0.13	0.008± 0.002
Pangas fish	14.372	28.932	45.856	18.612	0.148± 0.0	0.066 ± 0.01	1.85± 0.2	0.088 ± 0.01
Potato	11.463± 0.6	20.556± 1.4	16.893 ±2.2	286.28± 1.9	0.507± o.1	0.43± 0.1	3.019± 3.0	0.004± 0.001
Rice	8.687±0 .6	15.476± 1.7	1.967± 0.0	145.601± 00.0	0.65±0. 0	0.2±0.0 5	1.32±0. 21	0.002± 0.0
Rohu fish	29.587± 2.1	36.794 ±1.8	38.481 ± 2.4	309.207 ± 12.1	0.425 ± 0.02	0.346 ± 0.04	3.2 ± 0.3	0.104 ± 0.01
Tilapia fish	19.3	35.879	55.065	340.51	0.494 ± 0.1	0.114 ± 0.003	3.157 ± 0.2	0.118 ± 0.01
Tomato	12.952	7.418	6.797± 1.3	156.310± 28.1	0.197± 0.01	0.972± 0.1	2.0±0.2	0.006± 0.001
Wheat flour	12.793± 0.07	57.886± 1.04	9.831± 0.07	210.271± 20.18	3.81± 0.31	0.19± 0.1	1.547± 0.12	0.024± 0.02

*Results are expressed as Mean ± SD

5.1.4. Heavy metals

Among the KFs three have been found to contain heavy metals beyond the safe limits recommended by FAO/WHO: Tilapia fish (As: 148.61 μg), milk (Pb: 5.92 μg) and mango

(Pb: 95.70 µg). They are unsafe considering the safe limit of 1ppm for As in fish, and 0.02 and 0.1 ppm of Pb in milk and fruit respectively.

Table 5.1.4: Content of heavy metals (µg/100 g EP) on fresh weight basis*

Name	V	Cr	Mn	Ni	As	Mo	Ag	Cd	Sb	Ba	Pb
Banana	0.75±0.1	31.74±1.22	1074.66±35.99	3.74±0.11	0.05±0.02	3.64±0.11	0.02±0.02	0.03±0.0	0.22±0.0	75.36±1.2	0.47±0.01
Bean	37.85±7.16	111.03±5.42	2835.26±195.99	204.7±1.2	1.84±0.66	61.95±10.81	0.25±0.11	0.81±0.09	0.40±0.07	321.21±20.0	8.05±1.01
Brinjal	10.36±2.06	49.74±2.89	1375.22±235.43	94.89±7.39	0.58±0.1	13.65±3.14	0.31±0.05	4.09±3.17	0.5±0.06	54.85±3.44	1.07±1.09
Carrot	7.09±1.3	29.60±2.11	698.63±65.59	10.34±0.68	0.63±0.05	5.59±0.62	0.17±0.20	2.30±0.32	0.75±0.21	872.19±79.67	2.86±2.49
Chicken breast	1.94±0.5	123.17±18.29	58.48±1.23	0.84±0.13	4.15±0.10	9.73±0.34	0.02±0.02	0.03±0.0	0.11±0.02	5.95±1.68	0.35±0.49
Chicken leg	1.93±0.1	123.34±15.22	93.82±1.3	2.37±0.23	4.26±0.13	9.54±0.28	0.01±0.0	0.09±0.0	0.19±0.01	8.06±1.62	1.14±0.02
Egg	3.63±0.85	122.17±13.90	136.69±3.04	9.65±0.44	1.20±0.67	35.86±1.03	0.03±0.01	0.18±0.0	0.07±0.0	809.76±24.89	6.64±0.08
Green Chili	12.58±2.18	64.97±3.93	1695.0±124.74	225.91±13.36	0.38±0.15	8.02±1.32	0.06±0.01	2.33±1.11	0.72±0.14	61.34±16.07	0.56±0.49
Jackfruit	2.62±0.34	86.33±7.96	2475.98±101.04	88.22±1.23	0.69±0.08	6.44±0.12	0.32±0.01	3.66±0.05	0.42±0.01	743.96±16.77	2.52±0.04
Lentil	6.2±1.4	28.3±7.3	927.08±182.2	82.2±7.5	0.3±0.1	85.2±20.5	0.1±0.0	0.1±0.0	0.2±0.2	15.2±2.8	0.0±0.0
Mango	1.57±0.36	89.27±14.89	605.94±31.49	29.28±0.39	1.29±0.03	2.46±0.04	0.05±0.01	0.5±0.01	0.68±0.03	122.89±1.87	95.70±1.19
Milk	2.89±0.45	161.89±4.47	253.96±9.35	20.32±0.83	4.89±0.38	25.61±0.92	0.03±0.0	0.18±0.01	0.08±0.0	204.93±10.48	5.92±0.16
Onion	6.34±1.48	54.19±13.10	17.66±1.48	54.81±5.01	0.77±0.16	5.58±1.31	0.05±001	2.27±1.66	0.29±0.05	153.65±32.56	2.65±2.33
Pangas fish	1.73±0.62	134.89±32.31	31.08±4.59	0.803±1.27	7.71±0.88	0.63±0.06	0.04±0.04	0.04±0.0	0.17±0.03	4.31±1.9	1.68±0.23
Potato	14.5±1.25	52.83±5.07	692.82±125.37	64.33±2.79	0.63±0.06	5.83±2.57	0.3±0.1	1.34±0.67	0.85±0.15	61.16±2.16	0.73±0.63
Rice	8.04±2.09	18.30±6.35	465.38±58.2	21.33±15.4	2.16±3.19	10.18±7.49	0.07±0.01	0.88±0.18	0.33±0.2	14.33±3.03	1.34±1.35
Rohu fish	7.6±1.12	105.41±10.41	63.57±7.74	1.22±0.23	10.76±1.37	1.7±0.21	0.12±0.01	0.06±0.01	0.806±0.09	24.62±3.997	1.97±0.25
Tilapia fish	15.1±0.2	127.38±14.34	251.24±15.7	59.6±2.65	148.61±4.0	2.37±0.04	0.01±0.0	0.32±0.0	0.3±0.0	76.26±0.96	9.04±0.13
Tomato	32.01±10.69	79.52±5.94	1631.95±84.89	68.97±3.10	0.59±0.17	8.11±1.3	0.23±0.13	5.62±0.4	0.24±0.21	50.26±6.82	0.54±0.3
Wheat flour	2.94±0.64	35.16±13.04	2207.71±502.57	14.44±1.57	0.5±0.1	20.89±0.56	0.13±0.02	1.04±0.8	0.12±0.04	371.3±20.95	2.45±0.03

*Results are expressed as Mean ± SD

5.1.5. Total phenol content and antioxidant capacity

Bean and banana, respectively, have the highest and lowest TPC and AA among the analysed samples respectively. The TPC ranged from 0.005 to 1.495 mg GAE/g fresh weight, whereas it is 0.76 to 20.106 µmol TE/g fresh weight for antioxidant capacity. Descending order of TPC and antioxidant capacity of the samples are Bean> Green chili> Brinjal> Tomato> Onion> Potato> Mango> Jackfruit> Banana and Bean> Tomato> Onion> Greenchili> Potato> Mango> Jackfruit> Brinjal> Banana (Table 5.1.5)

Table 5.1.5: Content of total phenol and DPPH

Name	TPC (mg GAE/ g FW)	DPPH (µmol TE/ g FW)
Banana	0.005 ± 0.002	0.76 ± 0.06
Bean	1.495 ± 0.04	20.106 ± 1.34
Brinjal	0.585 ± 0.05	0.895 ± 0.14
Green chili	0.88 ± 0.02	1.938 ± 0.42
Jack fruit	0.03 ± 0.4	0.934 ± 0.0
Mango	0.117 ± 0.01	1.078 ± 0.11
Onion	0.182 ± 0.02	1.992 ± 0.28
Potato	0.137 ± 0.01	1.296 ± 0.17
Tomato	0.328 ± 0.004	2.771 ± 0.10

5.1.6. Fat soluble vitamins

Retinol and beta-carotene were analyzed for 20 key foods (when applicable). Retinol content is highest in egg and lowest in tilapia. Beta-carotene is highest in carrot and lowest in banana.

Table 5.1.6: Content of retinol and β-carotene (µg/100 g EP) on fresh weight basis

Name	Retinol	β-carotene
01. Rice	NA	NA
02. Wheat flour	NA	NA
03. Lentil	NA	33.984
04. Potato	NA	27.15
05. Onion	NA	22.776
06. Carrot	NA	3945.956
07. Bean	NA	202.592
08. Brinjal	NA	45.438
09. Green Chili	NA	114.828
10. Banana	NA	21.442
11. Jackfruit	NA	28.178
12. Mango	NA	299.543
13. Tomato	NA	103.853
14. Pangas fish	5.143	NA
15. Rohu fish	3.193	NA
16. Tilapia fish	2.033	NA
17. Chicken breast	25.152 ± 1.5	NA
18. Chicken leg	22.802 ± 1.4	NA
19. Egg	165.246 ± 1.1	NA
20. Milk	30.177 ± 0.2	NA

NA: Not available

5.1.7. Fatty acid profile

Rohu contains more PUFA as compared to pangas and tilapia. According to the content of n-3 FA, rohu is better source than tilapia and pangas. Alpha-linoleic acid content is highest in rohu. Chicken contains higher PUFA compared to egg.

Table 5.1.7: Fatty acid content (g/100g EP)

Food name	C 14:0	C 16:0	C 18:0	C 20:0	C 24:0	C 16:1 cis n-7	C 18:1, n-9	C 20:1, n-9	C 22:1, n-9	C 18:2, cis, n-6	C 18:3, cis, n-3	C 20:5, cis, n-3	C 22:6, cis, n-3
Pangas	0.33	2.878	0.715	0.058	0.067	0.113	3.936	0.164	0.133	1.374	0.087	-	0.036
Rohu	0.048	0.601	0.167	-	0.065	0.09	0.576	0.038	-	0.403	0.097	0.031	0.089
Tilapia	0.087	0.758	0.19	-	0.042	0.153	0.962	0.044	-	0.295	0.018	-	0.058
Chicken breast	0.009	0.375	0.115	-	0.029	0.087	0.567	0.006	-	0.259	0.014	-	0
Chicken leg	0.029	1.244	0.328	0.011	0.049	0.348	1.99	0.019	-	0.81	0.048	-	0
Chicken Eggs	0.026	1.928	0.624	-	0.149	0.221	3.293	0.02	-	1.139	0.023	-	0.048

Table 5.1.8 shows the fatty acid profile of key foods of plant origin. It reveals that wheat flour contains more PUFA as compared to rice and lentil.

Table 5.1.8: Fatty acid content (g/100g EP)

Food name	C 14:0	C 16:0	C 18:0	C 20:0	C 18:1 n-9	C 20:1 n-9	C 18:2 cis,n-6	C 18:3 cis,n-3	C 20:4 cis,n-6
Soya oil	0.085	10.283	3.78	-	21.17	-	53.854	6.425	1.104
Rice, BR-28, parboiled, milled, raw	0.009	0.082	0.005	0	0.075	-	0.167	0.006	0.004
Wheat, flour, white	0.002	0.203	0.014	0.004	0.142	0.006	0.685	0.042	0.000
Lentil, dried, raw	0.002	0.113	0.018	0.005	0.166	0.006	0.334	0.091	-

Fatty acid profile of milk is presented in table 5.1.9. It reveals that milk is a great source of myristic, palmitic, stearic and oleic acids.

Table 5.1.9: Fatty acid content of milk (g/100g EP)

Fatty acids	(g/100g sample)	Fatty acids	(g/100g sample)
C 6:0	0.016	C 20:0	0.014
C 8:0	0.021	C 14:1 cis, n-5	0.036
C 10:0	0.059	C 16:1 cis n-7	0.053
C 12:0	0.086	C 18:1, n-9	0.834
C 14:0	0.314	C 20:1, n-9	0.005
C 15:0	0.039	C 22:1, n-9	0.007
C 16:0	0.971	C 18:2, cis, n-6	0.094
C 18:0	0.418	C 18:3, cis, n-3	0.013

Protein quality of foods depends both on the presence of essential amino acids and their quantity. Total essential amino acid content per 100 g of edible portion of food is higher in lentil (10.05 g) and lowest in milk (1.25 g). But, egg ranks first with chicken breast and milk being second and third respectively when essential amino acid content per 100 g of protein are compared among the key foods.

Table 5.1.10: Amino acid content (mg/100g EP)

	Rice, BR-28, parboiled, milled, raw	Wheat, flour, white	Lentil, dried, raw	Pangas, without bones, raw	Rohu, without bones, raw	Tilapia, without bones, raw	Chicken breast, without skin, raw	Chicken leg, without skin, raw	Eggs, chicken, farmed, raw	Milk, cow, whole fat (pasteurised, UTH)*
Isoleucin	229	307	1048	622	760	762	989	809	913	131
Leucine	501	691	2017	1139	1434	1493	1665	1485	1050	267
Lysine	234	276	2118	1251	1577	1598	1612	1405	620	225
Methionine	206	220	147	563	630	676	794	643	455	69
Cysteine	140	218	216	144	125	145	203	164	382	21
Phenylalanine	345	475	1431	625	828	820	857	758	1233	136
Tyrosine	244	270	836	469	543	609	732	670	334	140
Threonine	222	300	1032	683	867	897	977	835	442	124
Tryptophan	50	124	257	234	313	296	294	233	220	33
Valine	368	450	1366	762	984	942	1164	975	912	187
Arginine	476	440	2265	990	1240	1275	1322	1184	644	105
Histidine	149	229	633	324	544	483	808	518	198	77
Alanine	568	556	1917	1632	2185	2220	2018	1771	1295	157
Aspartic acid	574	505	3228	1339	1853	1902	2058	1691	1577	211
Glutamic acid	1301	3537	5481	2581	3456	3491	3826	3408	2024	713
Glycine	287	412	1150	1137	1356	1415	1068	1017	602	62
Proline	265	1065	1075	751	986	894	905	836	505	264
Serine	321	505	1515	629	802	810	924	818	1103	161

5.1.11. Sugar

Fourteen samples among 20 KFs were analyzed for reducing sugar and total sugar the values for which are presented in table 5.1.11.

Table 5.1.11: Content of sugar per 100g of fresh material of different foods

Foods	Reducing sugar (RS)	Total sugar (TS)
Carrot	6.24	13.19
Mango	10.98	25.23
Jack Fruit	11.45	29.84
Tomato	5.39	14.30
Bean	7.80	19.13
Brinjal	12.78	28.37
Chilly	11.35	32.78
Onion	3.59	11.66
Wheat Flour	3.96	10.13
Potato	6.37	10.73
Banana	7.73	19.72
Milk	8.10	17.47
Lentils	6.33	12.61
Rice	7.08	21.97

5.1.12. Antinutrient

Among 20 KFs eight samples were analyzed for soluble, insoluble, total oxalate and two samples were analyzed for phytic acid. In percentage amount, total oxalate is highest in green chili and lowest in onion. Among three analyzed samples (rice, wheat and lentil) wheat contain highest amount of phytic acid.

Table 5.1.12: Content of oxalate and phytic acid

<table>
<tr><th>Name</th><th colspan="3">Oxalate (mg/100g EP)</th><th>Phytic acid (mg/100g EP)</th></tr>
<tr><td></td><td>Total</td><td>Soluble</td><td>Insoluble</td><td rowspan="8">Not applicable</td></tr>
<tr><td>Potato</td><td>12.05</td><td>10.91</td><td>1.14</td></tr>
<tr><td>Onion</td><td>2.66</td><td>1.83</td><td>0.83</td></tr>
<tr><td>Carrot</td><td>6.21</td><td>0.28</td><td>5.93</td></tr>
<tr><td>Bean</td><td>24.96</td><td>5.17</td><td>19.79</td></tr>
<tr><td>Green chili</td><td>28.88</td><td>19.69</td><td>9.18</td></tr>
<tr><td>Banana</td><td>2.73</td><td>1.05</td><td>1.68</td></tr>
<tr><td>Jackfruit</td><td>9.67</td><td>6.20</td><td>3.46</td></tr>
<tr><td>Mango</td><td>3.40</td><td>0.93</td><td>2.48</td></tr>
<tr><td>Rice</td><td colspan="3" rowspan="3">Not applicable</td><td>98.92</td></tr>
<tr><td>Wheat</td><td>227.03</td></tr>
<tr><td>Lentil</td><td>133.36</td></tr>
</table>

5.2. Secondary data entry

The following tables (5.2.1-3) summarize the data entered in the FAO compilation tool 1.2.1.

Table 5.2.1 Data sources for the food composition databank (archival database)

Category	Number
a. Paper	94
b. Thesis	70
c. Reports	06
d. Unpublished data	02

Table 5.2.2: Summary of food composition databank (archival database)

No. of Food Groups	No. of food	Total no. of variety &/or item	Total no. of entry
15	626	1015	2575

Table 5.2.3 Summary of food composition databank (user database)

No. of Food Groups	No. of food
15	381

In archival database, there are 2575 entries which covered 15 food groups and 1015 food items including varieties. However, 381 foods were incorporated into user database instead of 500 foods as per ToR. Due to the unavailability of regional databases to fill up missing nutrient in the main table for the development of user database without any missing value as per ToR, 381 foods were incorporated into User database.

List of recipes

1. ***Ruti (10 numbers)***

Ingredients

Ingredients	Weight (g)
Wheat flour	280
Water	159
Salt	2

Yield factor: 0.86

Procedure

Wheat flour is kneaded into medium soft dough using water and salt. The dough is kept aside for approximately ten minutes. The dough is divided into ten equal portions and shaped into small balls. Each ball is then rolled out on a flat board into even and flat, circular shapes, known as *'ruti'*. It is then roasted in a pan or griddle known as *'tawa*'.

Five servings

2. ***Sweet biscuit***

Ingredients

Ingredients	Weight (g)
Wheat flour	84
Sugar	28
Ghee, vegetable/Vanaspati	14
Baking powder	1
Water	22

Yield factor: 1.03

Procedure

Sugar is powdered and sieved along with flour and baking powder. Butter or vanaspati is added and the mixture is made into a medium to stiff dough with some milk or water. The dough is rolled out, cut into rounds or squares and put into a greased pan. This baked in a pre heated oven at 120^{0} C for about half an hour.

6 – 7 biscuits (3 servings)

3. Plain Khichuri

Ingredients

Ingredients	Weight (g)
Rice	28
Lentils	28
Bay leaf	0.5
Ghee or Vanaspati	14
Onion	7
Cumin	1
Salt	2
Water	180

Yield factor: 0.75

Procedure

Sliced onions are fried in melted ghee or vanaspati in a pan. Cumin and bay leaf are added and stirred in. Cleaned and washed rice and lentils are added into the pan and sauted for 3 minutes. Hot water is then added, stirred well and cooked on low heat for about 20 minutes until the grains are soft cooked and the water is fully absorbed.

Two servings

4. Plain pulao

Ingredients

Ingredients	Weight (g)
Atop rice	150
Onion	5
Oil (Soya bean)	10
Cardamom, Cinnamon, Bay leaf	2
Ginger and Garlic paste	1
Salt	2
Water	345

Yield factor: 0.93

Procedure

Atop rice is washed thoroughly with clean water. In a cooking pan, oil, spices and the washed atop rice are put together and sauted for about 5 minutes. Hot water is then added, after which the pan is covered. When the ingredients are cooked properly, the pan is taken off the heat. Garnish is added as desired.

Three servings

5. ***Ladies finger-tomato bhuna***

Ingredients

Ingredients	Weight (g)
Ladies finger/okra	300
Tomato	95
Onion	3
Ginger paste	4
Garlic	2.8
Turmeric powder	0.8
Green chillies	3.4
Soya bean oil	16
Salt	3

Yield factor: 0.54

Procedure

Ladies finger/okra and tomatoes are washed, cut into medium pieces and kept aside for 5 minutes. Oil is put in a nonstick frying pan and all ingredients, except ladies finger are added to the oil. The ladies fingers are mixed well and sauted. After that tomato is added and the pan is covered. The vegetables are cooked in mild heat for 15 minutes till done.

Three servings.

6. ***Bitter gourd fry***

Ingredients

Ingredients	Weight (g)
Bitter gourd	320
Onion	30
Turmeric powder	2.5
Green chillies	5
Soybean oil	20
Salt	2.5

Yield factor: 0.62

Procedure

Bitter gourds, onion, and green chilies are washed and sliced. Oil is heated in a frying pan, bitter gourd and onions are added, sauted and cooked on mild heat for 15 minutes till done.

Four servings

7. ***Potato Mash (Bhorta)***

Ingredients

Ingredients	Weight (g)
Potatoes	400
Onion	14
Green chilies	3.8
Mustard oil	2
Salt	2.6

Yield factor: 0.83

Procedure

Potatoes with skin are boiled and peels are removed. The potatoes are then mashed, finely cut green chilies and onion, salt and oil are added and mixed thouroughly. Fresh mustard oil is added and mixed well.

Four servings

*8. **Small Fish Fry***

Ingredients

Ingredients	Weight (g)
Kechki	150
Potato	96
Onion	35
Green chili	5.5
Turmeric	1.7
Soya bean oil	17
Salt	2
Water	176

Yield factor: 0.73

Procedure

Small fish (kechki), onion, potato and green chilis are washed and then sliced. All the ingredients are mixed in a frying pan and put on the burner for heating. After 3-4 minutes, water is added and the pan is covered with a lid. When the ingredients became semi dry, the pan is removed from the heat.

Two servings

*9. **Payesh***

Ingredients

Ingredients	Weight (g)
Atap rice	60
Milk	1250
Sugar	265
Cardamom	0.6

Yield factor: 0.64

Procedure

Milk is boiled in a heavy bottomed pan. After that atap rice and cardamom are added and cooked at high a temperature till it simmers. When the rice is fully cooked, sugar is added and the rice-milk mixture is further heated. When the mixture turns semi-thick and is done, it is removed from the pan and poured in a dessert bowl.

Four servings

10. Fish ball

Ingredients

Ingredients	Weight (g)
Boneless fish	300
Onion	100
Green chilli	30
Soybean oil	20
Flour	200
Egg	90
Coriander leaves	20
Ginger paste	2.5
Garlic paste	2.5
Coriander powder	10
Salt	5
Water	120

Yield factor: 0.72

Procedure

Boneless fish fillet are washed properly and boiled until it becomes soft. Onion, green chili, flour, egg, coriander leaves are added and mixed properly with the boiled fish. Small balls are made and fried in preheated oil till it turns golden brown.

Six balls (medium sized)

11. Beef handi kabab

Ingredients

Ingredients	Weight (g)
Boneless beef	365
Onion	250
Green chilli	2
Soybean oil	50
Red chilli powder	5
Cardamom	1
Cinnamon	1
Ginger paste	2.5
Garlic paste	2.5
Coriander powder	9
Sugar	5
Salt	5
Water	50

Yield factor: 0.82

Procedure

Boneless beef is washed properly. Onion, red chili, green chili, cardamom, cinnamon, ginger paste, garlic paste and coriander powder are fried together in oil. Then meat is added to mixed spices. Water is added and cooked until the meat becomes tender.

Eight servings

Conclusion

FCTB is the first updated national food composition database in which an attempt has been made to fill in the nutrient-gaps as much as possible during the project period. It is also the first national table which, in one single publication, includes data on amino acids, fatty acids, cholesterol, trace elements, certain B-vitamins, heavy metals, dietary fiber, phenolic compounds and anti-oxidant activity. It also provides information on the inedible portion of numerous key foods (20), increasing its usefulness in evaluating the food consumption of the people in Bangladesh.

On the basis of a comprehensive key food list determined for the first time according to food consumption-composition-frequency data.

FCTB is constructed by incorporating primary data of 20 key foods and secondary data of Bangladeshi foods generated since 1973. A total of 381 foods have been entered in Food Compilation Tool 1.2.1.

Policy implications

Reliable data on the nutrient composition of foods for human consumption are critical for many areas of endeavor including health assessment, formulation of appropriate institutional and therapeutic diets, nutrition education, food and nutrition training, epidemiological research on the relationship between diet and diseases, plant breeding, nutrition labeling, food policy and regulation, and consumer protection, as well as for a variety of application in agriculture, trade, research, development and assistance.

Bangladesh is experiencing a long-term change in food supply with the emergence of HYV newer foods as well as change in soil composition due to environmental changes, increased use of fertilizers and crop intensity resulting in possible alterations in their nutrient composition. Bearing this in mind, an updated Food Composition Table for Bangladesh has been constructed including a total of 604 foods (excluding varieties). This national database is the first to include data on amino acid profile, fatty acid profile, cholesterol, certain B-vitamins, dietary fiber, heavy metals, total phenol content and antioxidant activity.

The users of Bangladesh Food Composition Table will vary greatly: nutritionists, dietitians, food and agricultural scientists, manufacturers, food technologists, home economists, public health scientists, economists, agricultural planners, food service managers, manufacturers, teachers, epidemiologists, physicians, non-specialist consumers and journalists. Food composition data from this updated table would be essential for a variety of purposes in many fields including:

1. Formulation of national food and nutrition policy, setting goals for agricultural production and designing guidelines for consumption and particular policies such as trade, assistance, food fortification or food supplementation, increased subsidy or promotion of certain foods etc.
2. Determination of gross per capita nutrient availability to assess gross adequacy or inadequacy of the national food supply and indicate shortfalls or excesses.
3. Assessment of nutrient intakes (nutritional analysis) at individual and group levels to show gross dietary adequacy or inadequacy, or dietary imbalance in determining dietary advice, prescribing therapeutic diet and/or exploring the relationship of a diet to a variety of health indices – sickness and death patterns, growth rate, birth weight, measures of clinical nutritional status, physical performance, etc.
4. Planning of institutional diets in translating recommended nutrient intakes for large sectors of the population (e.g. hospitals, prisons, military establishments, schools, day-care centers, orphanage etc) into cost-limited foods and menus.
5. Nutritional regulation of the food supply using data on primary raw foods in this database as a reference point for desirable nutrient levels for processed and newly introduced foods. This national database can also provide a preliminary check on label information or claims.

Recommendations

Reliable nutrient compositional data of foods are required in nutritional assessment, dietary management of disease, prevention and control of nutrient deficiencies, epidemiological research on non-communicable diseases, nutrition education and nutrition labeling as well as for a variety of applications in the field of nutrition, agriculture, trade, development and assistance. Further work is necessary for which allocation of funding is required in order to generate primary analytical data for the rest of the key foods as determined in present project.

Moreover, increased funding is required for the adequate generation of food composition data that capture elements of biodiversity. Besides there is a need to strengthen collaboration and coordination in food composition study as well as capacity of the institutions (public/govt./NGO) involved in food composition research. At the same time, adequate training should be provided for the relevant personnel to generate and manage food composition data according to INFOOD guidelines.

Finally, Since the FCTB has been constructed with rigorous and meticulous analytical and compilation methodology, its dissemination in sectoral use should be undertaken. Its urgent to advocate the link between food consumption, food composition and biodiversity in the health, nutrition, agriculture, trade and environment sectors at the national level.

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Annexure

Table 1. List of Haat/ Bazar for Sample Collection

Division	District	Union	Village	Market Name
Chittagong	Noakhali	Maizdee	Maizdee	Maizdee Bazar
	Noakhali	Sonapur	Sonapur	Syampur Bazar
	Chittagong	Liazuddin	Liazuddin	Liazuddin Bazar
	Chittagong	Bottoli	Bottoli	Botttoli Bazar
Sylhet	Moulovibazar	Sadar	Sadar	Kacha Maler Aroth
	Moulovibazar	Sadar	Sadar	Bhai Bhai Store, Beripara
	Hobigonj	Sadar	Sadar	Chowdhury Bazar (old market)
	Hobigonj	Sadar	Sadar	Hobigonj Chowdhury bazar (old Market)
	Sylhet	Sadar	Sadar	Nawab Ali Market
Rangpur	Gaibandha	Gobindogonj	Gobindogonj Bazar	Gobindogonj Bazar (4)
	Dinajpur	Sundorpur	Doshmail	Doshmail hat (2)
	Dinajpur	Sadar	Bahadur Bazar	Bahadur Bazar (1)
	Dinajpur	Sundorpur	Kantonogor	Kantojeu nogor Bazar (3)
Rajshahi	Bogra	Raninagar	Mahosthangarh	Mohasthangarh Bus Stand Bazar (5)
	Rajshahi		Saheb Bazar	Saheb Bazar Boro Kachabazar
	Pabna	Atghoria Sadar	Atghoria hat	Atghoria hat
Khulna	Jessore	Jessore	Jessore Sadar	Doratona Boro Kachabazar
	Jessore	Rupdia Union	Rupdia hat	Rupdia hat
	Kushtia	Khas Mothurapur	Mothurapur Boro Bazar	Mothurapur Boro Bazar
Dhaka	Mymenshingh	Mymenshingh	Sadar	Sadar Bazar
	Dhaka	Savar	Amin Bazar	Amin Bazar
	Dhaka	Dhanmondi	New Market	New market
	Dhaka	Tejgaon	Kawranbazar	Kawranbazar
	Dhaka	Keranigonj	Rohitpur	Rohitpur
	Kishoregonj	Kishoregonj	Kishoregonj	Boro Bazar
	Kishoregonj	Jinari	Hazipur	Hazipur Hat
Barisal	Barisal	Barisal Sadar	Sadar	Municipal Bazar
	Barisal	Chorfashan	Chorfashan	Bot-tola Bazar

Table 2: List of Journals

International Journals

- Environmental Science & Technology
- Helen Keller International
- Journal of Food Science and Engineering
- Legume Research
- Malaysian Journal of Nutrition
- Qualitas plantarum, plant foods for human nutrition
- World Journal of Zoology
- Journal of Food Composition and Analysis

National Journal

- Bangladesh Horticulture
- Bangladesh Journal of Agricultural Research
- Bangladesh Journal of Biological Science
- Bangladesh Journal of Medical Science
- Bangladesh Journal of Nutrition
- Bangladesh Journal of Science
- Bangladesh Journal of Scientific Research
- Bangladesh Journal of Scientific & Industrial Research
- Bangladesh Journal of Zoology
- Dhaka University Journal of Biological Science
- Dhaka University Journal of Science
- Journal of the Bangladesh Agricultural University
- Khulna University Studies

Table 3: List of libraries & organization

- Dhaka University Science Library
- Bangladesh Council of Science & Industrial Research (BCSIR)
- Institute of Nutrition and Food Science (INFS)
- Bangladesh Agricultural Research Institute(BARI)
- Asiatic Society
- Helen Keller International
- Bangladesh Institute of Health Services
- Biochemistry Department, D.U.
- Chemistry Department, D.U.
- Fisheries Department, D.U.
- Botany Department, D.U.
- Bangladesh Agricultural University
- Jahangirnagar University
- Chittagong University
- Rajshahi University

Table 4: Dominant varieties of the nine winter vegetables, rice and lentil of the key food list were selected for the present study. The selected dominant varieties are given below.

Sample	Variety
Bean	BARI Sheem 1
Carrot	Koroda 35
Eggplant/Brinjal	BARI Begun-8/10
Green chilli	Banglalanka 1
Lentil	BARI moshur-4
Onion	BARI Onion 1 (Taherpuri)
Potato	Diamond
Rice	BR-28
Tomato	BARI Tomato 1(Ratan)/Udayan

Table 5: The Key Foods appeared in the list of foods supplying 80% of the selected nutrient

Sl. No.	Food Item*	% of Total Citation**
1	Rice (6)	7.06
2	Tomato (6)	7.06
3	Green Chili (6)	7.06
4	Egg Plant (5)	5.88
5	Banana (5)	5.88
6	Onion (5)	5.88
7	Tilapia fish (4)	4.71
8	Wheat Flour (4)	4.71
9	Potato (4)	4.71
10	Pond Pangas (4)	4.71
11	Silver carp (4)	4.71
12	Hen's egg (4)	4.71
13	Rooti (4)	4.71
14	Lentils (3)	3.53
15	Jack fruit (3)	3.53
16	Mango (3)	3.53
17	Shrimp (2)	2.35
18	Rohu (2)	2.35
19	Cooking oil (1)	1.18
20	Hilsha fish (1)	1.18
21	Amaranth stem (1)	1.18
22	Folwal (1)	1.18
23	Bitter gourd (1)	1.18
24	Bean (1)	1.18
25	Pumpkin (1)	1.18
27	Indian spinach (1)	1.18
28	lady's finger (1)	1.18
29	Salmon (1)	1.18
30	Mrigal fish (1)	1.18

*In parentheses is the citation no. of the food appeared in each nutrient that make up 80% of the total consumption; **Total Citation =85

Table 6 : 20 KFs selected for analysis

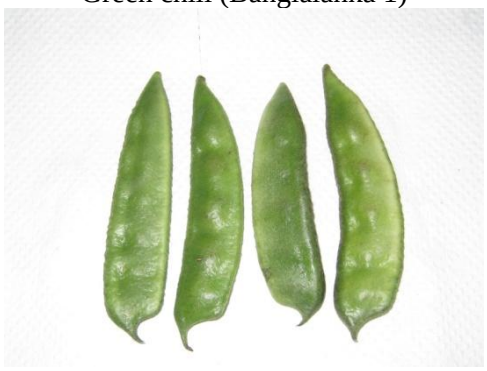
Rice	Hen’s egg
Tomato	Lentil
Green chili	Jackfruit
Brinjal	Mango
Banana	Rohu
Onion	Bean
Tilapia fish	Cooking oil
Wheat flour	Chicken
Potato	Carrot
Pangash	Milk

Images of samples processed and analyzed

Brinjal (BARI Begun-8/10)

Green chili (Banglalanka 1)

BARI Onion 1 (Taherpuri)



Bean (BARI Sheem 1)

Potato (Diamond)

Carrot (Koroda 35)

BARI Tomato 1(Ratan)

Lentil (BARI moshur-4)

Rice (BR-28)

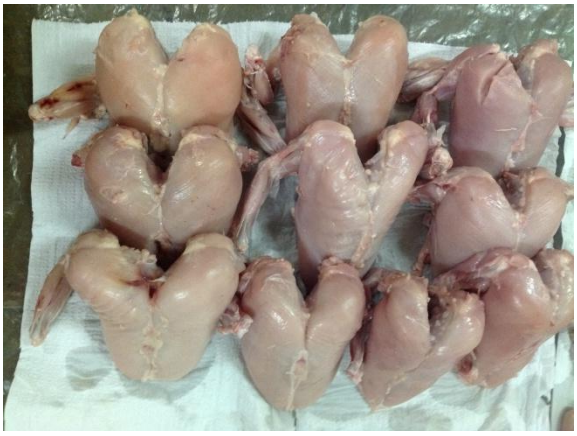
Mango

Jackfruit

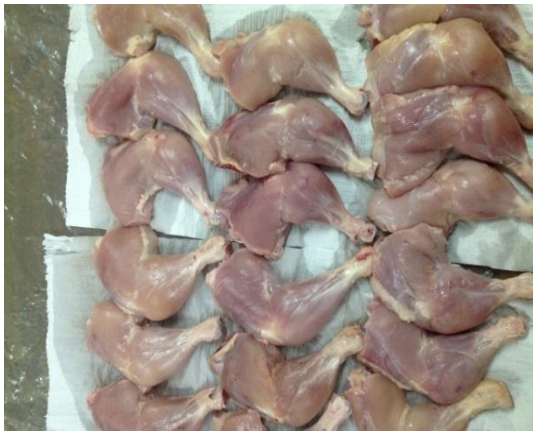
Rohu

Tilapia

Pangas



Chicken breast



Chicken leg

Wheat

Oil

Banana

Milk

Egg

Sample collected from seven divisions

Weighing

Washing

Air drying

Dressing

Composite sample

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- BARI
- BIRRI
- BAU
- BLRI

Data provider

- Institute of Nutrition and Food Science (INFS), DU
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- Asiatic Society