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Web-Based Informatics on Biochemical and Nutritional Composition of Food Fish in India

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Abstract

Fish, an important food commodity rich in nutrients and minerals, plays a vital role in combating hunger and malnutrition, especially in vulnerable populations where other sources of animal protein are scarce or expensive. To effectively harness its nutritional diversity, it is essential to understand the biochemical and nutritional composition of food fish. This paper presents the design, development, and integration of a web-based information system compiling biochemical and nutritional profiles of food fish in India, covering species from freshwater, brackish water, marine, and deep-sea habitats. The system was developed using HTML and CSS within the Bootstrap framework for the front-end, and PHP for server-side scripting. Nutritional composition data were stored in Microsoft Excel files and accessed through PhpSpreadsheet, a PHP library enabling read/write operations in spreadsheets. The developed system provides summarized information on bio-chemical composition of food fish including proximate composition, amino acids, minerals, and fatty acids. These information can provide insights to the researchers, academicians, and policymakers for formulating dietary guideline refinement, food policy and nutritional research for improved dietary adequacy and food security.

Keywords: Information System, biochemical & nutritional composition, food fish, HTML, PHP

Introduction

Fish is widely recognized as a nutrient-dense superfood, providing a rich source of high-quality proteins, polyunsaturated fatty acids, and essential micronutrients. Globally, it contributes at least 20% of the animal protein intake for over 3.1 billion people (Béné et al., 2015; FAO, 2016; Thilsted et al., 2016). According to Quaas, Hoffmann, Kamin, Kleemann, and Schacht (2016), a 150 g serving of fish can meet 50–60% of an adult's daily protein requirement, while also supplying essential omega-3 fatty acids, particularly eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), which are critical for brain and body functions (Aneesh et al., 2012; Mohanty et al., 2016a). Fish is also a valuable source of minerals (calcium, iodine, zinc, iron, selenium), vitamins (D, A, B), and essential amino acids that cannot be synthesized endogenously (Balami, Sharma, & Karn, 2019; Mohanty et al., 2019). Regular consumption has been linked to the prevention and management of metabolic disorders such as obesity, diabetes, and cardiovascular diseases, as well as improved maternal and child health outcomes, including enhanced fetal brain development and reduced risk of low birth weight. Lipids from fish also offer protective effects against asthma, attention deficit disorder, coronary diseases, hypertension, rheumatoid arthritis, dementia, and Alzheimer's disease (Mozaffarian & Wu, 2011; Swanson, Block, & Mousa, 2012). Owing to its broad-spectrum health benefits, fish consumption is particularly recommended for pregnant and lactating women and should be promoted as part of a balanced diet (Mohanty et al., 2012; Mohanty et al., 2014; Mohanty et al., 2016b).

Roos, Islam, and Thilsted (2003) reported that the inclusion of small indigenous species in the diet can help alleviate micronutrient deficiencies prevalent in developing countries. Micronutrient-dense fish should therefore be promoted in diets to prevent deficiencies and associated diseases (Kawarazuka & Béné, 2011; Mohanty et al., 2014; Mohanty et al., 2016b). Compared with other dietary animal proteins, fish is generally more affordable and acces-

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sible, making it a sustainable choice for improving nutrition. However, it remains undervalued and under-consumed, often due to limited public awareness. Existing food composition databases cover only a small number of species (Rittenschober, Nowak, & Charrondiere, 2013; Mohanty et al., 2015), highlighting the need for a comprehensive, accessible, and regularly updated database on the nutritional composition of fish which can improve the level of public knowledge on the nutritional benefits of fish consumption.

In this work, a web-based information system on the biochemical and nutritional composition of food fish in India was designed and developed using XAMPP (Apache Server, MariaDB, Perl, and PHP) as the platform, with the front-end designed in Bootstrap (HTML, CSS) and the back-end implemented in PHP and PhpSpreadsheet. The Bootstrap framework was used to ensure responsiveness across devices, including desktops, smartphones, and tablets. In this study, the open-source PHP library PhpSpreadsheet was employed to manage data operations, enabling code reuse through predefined classes and functions (Balliauw, 2010). There are some information systems in fisheries (Joshy, Shyla, Ninan, Kumar, & Ravishankar, 2020; Joshy et al., 2021) that have been developed using the above-mentioned techniques. However, the literature search reveals that limited work exists on platforms dedicated to the biochemical composition of fish, except for Mohanty et al. (2015), which covered only a few species. Therefore, the developed information system covers a comprehensive biochemical and nutritional data for 304 food fish species from freshwater, brackish water, marine, and deep-sea habitats. It also covers proximate composition (moisture, protein, fat, ash), amino acid profiles (e.g., glutamic acid, aspartic acid, alanine), minerals (e.g., calcium, iron, sodium), and fatty acid classes (saturated, monounsaturated, polyunsaturated). The information contained in the system can be used in clinical and nutritional research, dietary quality assessment, dietary counseling, policy formulation, food labeling, and prioritization of aquaculture species based on nutritional value (Elmadfa & Meyer, 2010).

Materials and Methods

The information system integrates primary and secondary data on the proximate composition, amino acid content, mineral profile, and fatty acid levels of 304 food fish species, including 35 freshwater species, 7 brackish water species, 186 marine species, 31 deep-sea species, and 45 shellfish species (Gopakumar, 1997). Primary data on the biochemical composition of myctophids was also incorporated into the database. The detailed structure of the data elements is provided in Table 1.

The design of the system follows a hierarchical data model, where data are organized in a tree structure with a root node and multiple child nodes (Rai & Singh, 2015). In this structure, a table for species is defined as root node, while the biochemical constituents are defined as child nodes. The database input is stored in Excel files and accessed via PHP, with each fish species represented as a unique entity. The corresponding biochemical composition for each species is defined at a lower hierarchy level. The hierarchical representation of the input data in the information system is illustrated in Fig. 1.

Input data were organized in Microsoft Excel tables, with each row representing a single unit of information. For example, in the proximate composition table, each row contained the common name, scientific name, moisture, protein, fat, and ash content of a particular fish species. Separate tables were created to store data on proximate composition, amino acid composition, mineral content,

Table 1. Biochemical constituents of fish

Biochemical Composition	Constituents
Proximate Composition	Moisture, Protein, Fat, Ash
Amino Acids	Aspartic acid, Threonine, Serine, Glutamic acid, Proline, Glycine, Alanine, Valine, Cystine, Methionine, Isoleucine, Leucine, Tyrosine, Phenyl alanine, Histidine, Lysine, Arginine, Tryptophan
Minerals	Sodium, Potassium, Calcium, Iron, Phosphorus
Fatty Acids	Saturated fatty acids, Monounsaturated fatty acids and Polyunsaturated fatty acids

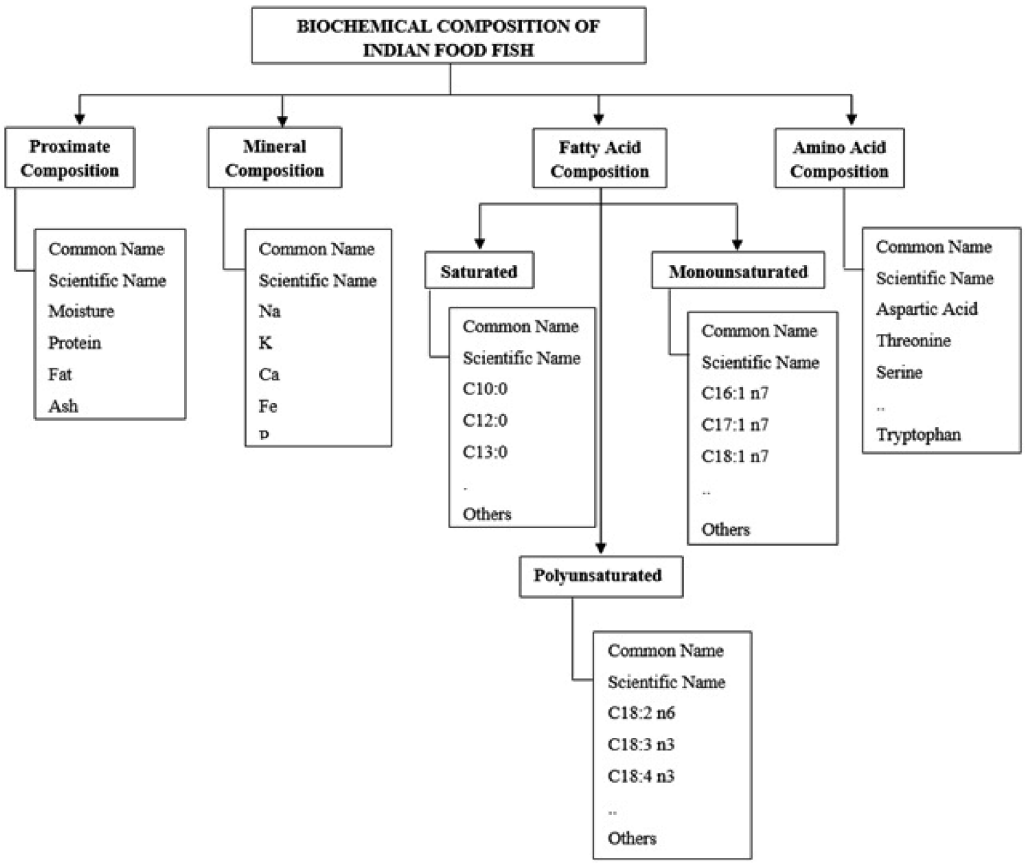

Fig. 1. Hierarchical model representation of the information system

saturated fatty acids, monounsaturated fatty acids, and polyunsaturated fatty acids. Additionally, a dedicated table was designed to store the common and scientific names of each fish species, where these names served as a primary key to uniquely identify each row across the database tables. This structure ensured accurate mapping of data for all 304 species, covering freshwater, brackish water, marine, deep-sea fish, and shellfish. Microsoft Excel was chosen as the input format for its ease of adaptation, data management, and updating capabilities. An example of a unique identification input table for the proximate composition of freshwater fish is shown in Fig. 2 and the schematic representation of the data mapping structure is given in Fig. 3.

The information system was built on a client–server architecture that works on a request–response model. The user interface was designed as a simple, browser-based web page, enabling users to access the system and retrieve data from the web server without requiring any specialized software. The system consisted of two primary modules, viz., a User Interface Module, which handles user interactions, allowing searches and retrieval of biochemical composition data for selected fish species, and a Data Management Module, which processes user requests, queries the database, and delivers the requested information to the user interface (Balliauw, 2010). These modules communicate seamlessly to process requests and render data efficiently. The overall architecture of the web application is illustrated in Fig. 4.

A visual site map representing the structural layout of the web-based information system is shown in Fig. 5. The home page served as the index page, providing navigation links to the main sections such as types of fish and the contact form. It also included brief descriptive text about the information system, along with hyperlinked images representing different fish categories, viz., freshwater fish, brackish water fish, shellfish, marine fish, deep-sea fish, and

Common Name	Scientific Name	Moisture	Protein	Fat	Ash
Calbasu	*Labeo calbasu*				
Carp	*Cyprinus carpio*				
Carp	*Cirrhinus reba*				
Carp	*Labeo potail*				
Catfish	*Clarius batrachus*				
Catla	*Catla catla*				
Dwarf catfish	*Mytus vittatus*				
Freshwater shark	*Wallago attu*				
Lesser spiny eel	*Macrognathus aculeatum*				
Mrigal	*Cirrhinus mrigala*				
Mullet	*Mugil kelaartil*				
Murrel	*Channa marullus*				
Murrel	*Channa striatus*				
Murrel	*Channa punctatus*				
Mussullah mahseer	*Tor mussullah*				
Olive carp	*Puntius sarana*				
Glassy Perchlet	*Ambassis*				
Rohu	*Labeo rohita*				
Sleeper	*Eleotris fusca*				
Stigma barb	*Barbus*				
Stinging catfish	*Saccobranchus*				
Tilapia	*Tilapia mossambica*				

Fig. 2. Input table on proximate composition of fresh water fish

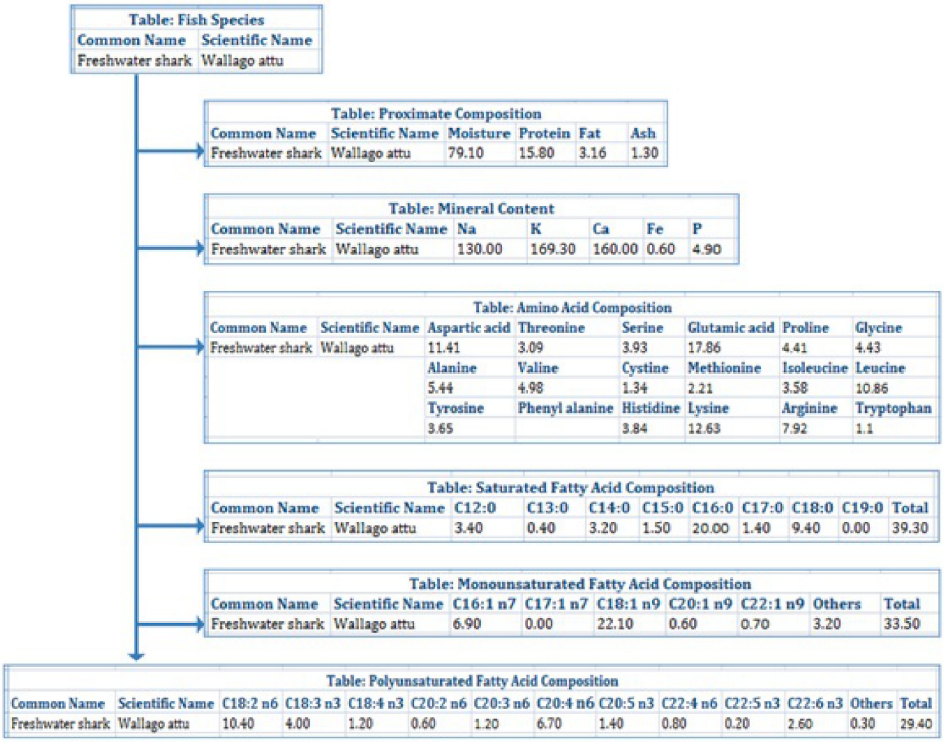

Fig. 3. Mapping of a fish species to different input tables

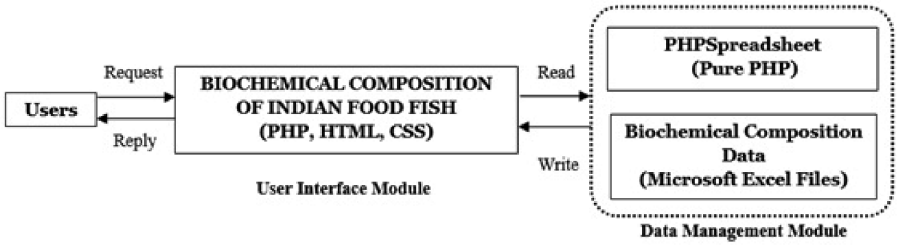

Fig. 4. The architecture of the information system

myctophids. The "Ask the Expert" contact form was integrated into the home page layout to enable user queries and feedback. The navigation hierarchy began at the home page, which linked to the types of fish section and the contact section. From the types of fish section, users could access species lists for each category, and subsequently navigate to the biochemical and nutritional composition data for a selected fish species. The PhpSpreadsheet library was integrated into the web application for reading Excel-based data. As an open-source PHP library, it was obtained from the official GitHub repository. The downloaded package was extracted locally, and necessary PHP extensions were installed via composer to enable interaction between PHP and the local database. The library was initialized using:

```
require_once "vendor/autoload.php";
```

The autoload.php file invoked Composer's autoloader:

```
<?php

require_once __DIR__ . '/composer/autoload_real.php';

return ComposerAutoloaderInit51d8a6a3bf2e26979b517620880727b2::getLoader();
```

Namespaces for the required PhpSpreadsheet classes were declared:

```
use PhpOffice\PhpSpreadsheet\Spreadsheet;

use PhpOffice\PhpSpreadsheet\Reader\Xlsx;
```

Data were read **cell-by-cell** using PhpSpreadsheet's predefined methods such as getSheet(), getCell(), and getValue(), and rendered dynamically to the user via PHP's echo statement. For example:

```
$spreadsheet->getSheet($sheetIndex)->getCell($column.$row)->getValue();
```

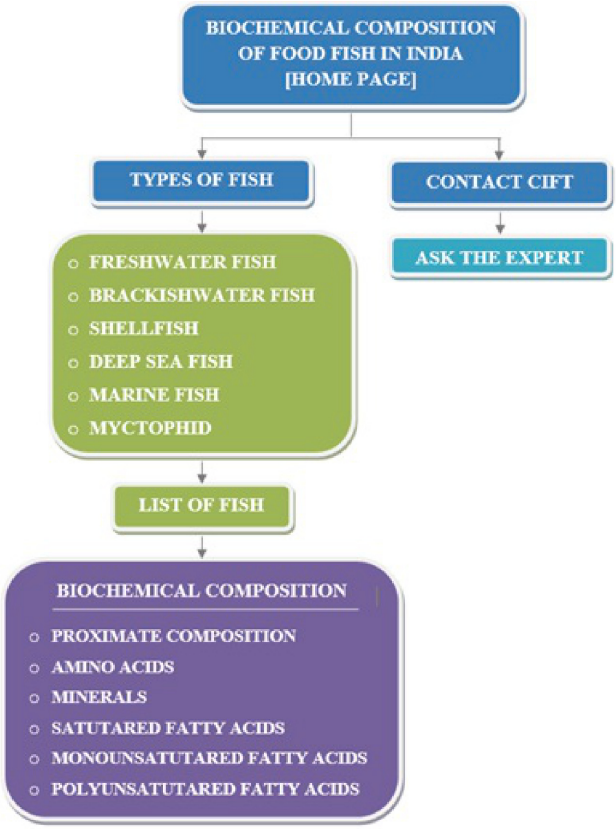

Fig. 5. Web based system design of the information system

Results and Discussion

The web-based information system initially loads with the Home Page, which provides a brief description of the system and a top navigation menu with links to Home, Types of Fish, and Contact CIFT (Fig. 6a). The home page follows a single-page website layout, enabling users to navigate between sections either by selecting menu links or by scrolling vertically. The Types of Fish section presents the available categories—freshwater fish,

brackish water fish, shellfish, deep-sea fish, marine fish, and myctophids—each linked to a corresponding List of Fish page for that category (Fig. 6b). For instance, to view the biochemical composition of Drift fish (*Areoma indicus*), the user can select the Marine Fish category, then click on the listed species name, which redirects to the Biochemical Composition page for that fish (Fig. 6c). The List of Fish page displays both the common name and scientific name for each species as hyperlinks, allowing direct access to detailed biochemical and nutritional data. Users can also download the displayed data in spreadsheet or PDF format for offline reference. Additionally, the system integrated a **Contact Form** under the *Ask the Expert @CIFT* section using PHP scripts, allowing users to submit queries or suggestions related to the information system. The form includes fields for user details and a message box, with a **Submit** button to send the request. Upon submission, the server processes the input and returns a confirmation message—either *"Mail sent successfully"* for successful delivery or *"Some error occurred. Please try again later"* in case of failure.

A comprehensive information system on the biochemical and nutritional composition of fish is vital for evaluating nutrient abundance and health benefits. Developing food composition databases from available resources and supplementing missing data has been recommended as a strategy to enhance database quality (Leclercq, Valsta, Turrini, & Aida, 2001). Traditional approaches to food composition database development, such as laboratory analysis, are costly, time-consuming, and often outdated, particularly when dealing with large numbers of species. The availability of data on the composition of food fish is limited and as Puwastien (2003) stated, development of local or regional databases is to be encouraged as these hold priority over the foreign databases. To address this, a web-

Fig. 6. (a, b, c). Home page of the web-based information system

based information system was developed by compiling existing biochemical composition data for Indian food fish, including proximate composition, amino acids, minerals, and fatty acids. The system incorporates data for 304 species across freshwater, brackish water, marine, shellfish, deep-sea fish, and myctophids (Fig. 7). By consolidating and supplementing available information, it provides a reliable, user-friendly platform that delivers comprehensive nutritional profiles efficiently, offering clear advantages over traditional data storage methods (Cade, 2017). Compared to many existing databases that rely on SQL for data management, the developed system uses PHPSpreadsheet to import input data efficiently. Built with a Bootstrap framework, the system automatically adapts its interface to the user's device, enabling access across platforms via the internet. This ensures that users can explore the biochemical compositions of a wide variety of Indian food fish, thereby promoting better utilization of fishery resources. Furthermore, the system includes export functionality, allowing users to download data in multiple formats such as documents, spreadsheets, or PDFs for offline reference and reuse.

Adequate intake of proteins and essential nutrients in recommended quantities is fundamental to maintaining good health, preventing nutritional deficiencies, and reducing the risk of disease. Food composition databases and tables play a crucial role in raising consumer awareness about the nutritional content of their diets. India, endowed with a rich diversity of fish species, offers valuable sources of proteins, minerals, micronutrients, and beneficial fatty acids such as omega (ù)-3. To bridge existing knowledge gaps and promote the increased consumption of fish for improved nutrition and health

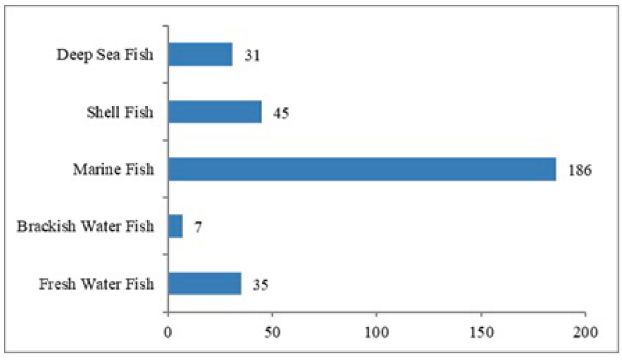

Fig. 7. Total number of species included in the information system

benefits, the development and implementation of nutritional composition databases—especially focused on food fish—must be encouraged. Such initiatives are vital for addressing malnutrition, enhancing food security, and reducing the global burden of undernutrition. Fisheries contribute significantly to the global food economy, providing sustenance to approximately 950 million people worldwide (Kiran, 2019) and directly employing over 200 million people (Gareth, 2001). In a developing country like India, where aquaculture is strongly supported, access to reliable biochemical and nutritional information on fish species can help to prioritize aquaculture efforts, thereby improving nutritional outcomes and strengthening the national food economy.

Fish, being a highly perishable food commodity, undergoes quality deterioration during storage due to enzymatic, biochemical, and microbial reactions. Reliable information on the biochemical composition of fish helps stakeholders adopt better preservation methods to maintain nutritional quality. In this context, Psomas et al. (2012) developed a food microbial growth database to assist the food industry in controlling the reliability and stability of foods throughout processing and distribution stages. Similarly, food composition data is crucial for planning and developing nutraceutical products, formulating food policies and guidelines, and contributing to nutritional food security. The developed system can further support research activities, enhance existing databases, and assist in food labelling efforts. However, information on the biochemical and nutritional composition of food fishes remains limited. The present work addresses this gap by developing a national-level information system that compiles comprehensive nutrient profiles for a wide range of food fish species consumed in India. The approach integrates complete nutrient profiles, imputing missing data where necessary. Despite the extensive data collection efforts, data availability posed a major constraint due to the limited coverage in pre-existing food tables, resulting in the exclusion of some species. Nonetheless, the system's design using PHPSpreadsheet allows easy integration of new biochemical composition data for additional fish species in the future.

Finally, a web-based information system on biochemical and nutritional composition of food fish was designed and developed to have comprehensive profiles of various food fish in different aquatic

environments using PHP, HTML, CSS, and the Bootstrap framework for responsive design. This system contained nutritional data for about 304 Indian food fish species, offering easy access via any web browser and data being managed through PhpSpreadsheet and Excel files, diverging from traditional database systems.

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