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E-Nutrition Label: Design and Architecture of a Web-Based Front-of-Pack Nutrition Labeling System

Yulita Sirinti Pongtambing[1,*], Arni Raihanah Rahman[2], Eliyah Acantha Manapa Sampetoding[3]

[1]Health Administration, Faculty of Sport Science and Health, Universitas Negeri Makassar, Makassar
Jl. A. P. Pettarani, Tidung, Kec. Rappocini, Kota Makassar, Sulawesi Selatan, Indonesia
[2]Information System, Faculty of Mathematics and Natural Sciences, Hasanuddin University, Makassar
Jl. Perintis Kemerdekaan No.10, Tamalanrea Indah, Kec. Tamalanrea, Kota Makassar, Sulawesi Selatan, Indonesia
Email: [1,*]yulita.sirinti@unm.ac.id, [2]arniraihanah8@gmail.com, [3]eliyahacantha@unhas.ac.id
Correspondence Author Email: yulita.sirinti@unm.ac.id
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Abstract−FOPNLs (Front of Pack Nutrition Labels) are nutritional labeling systems placed on the front of packaging to present nutritional information more simply. FOPNLs can help consumers quickly determine foods with better nutritional content and lower levels of salt, sugar, and fat. Nutrition labels influence consumer behavior and decision-making in determining healthy foods. However, the nutritional labeling system in Indonesia is not yet fully informative, and policies mandating that the food industry implement such labeling are not yet fully enforced. This study aims to develop an application model that automatically calculates FOPNLs for food products. The study resulted in a website prototype and limited testing, using the Design Science Research Method. DSRM can effectively bridge the theoretical foundations with practical requirements in the development of information system artifacts, particularly within the context of digital transformation in the healthcare sector. The result shows prototype functions well and can automatically calculate RDA and generate FOPNLs based on the nutritional label and serving size entered into the system. Functional evaluation using Black-Box Testing demonstrated a 100% success rate across all test scenarios, while the qualitative TAM-based assessment indicated that the proposed artifact was positively accepted, particularly regarding its perceived usefulness and ease of use. This prototype can be easily used by MSMEs that produce processed foods. Future research can be conducted through limited trials at the District or City UMKM Office.

Keywords: FOPNLs; E-Nutrition; Nutrition Literacy; Health Literacy; Digital Health

1. INTRODUCTION

The inclusion of Nutrient Adequacy Levels (AKG) on processed foods in Indonesia is regulated by BPOM Regulation Number 26 of 2021[1], which requires business actors who produce and/or distribute processed foods to provide nutrition labels. However, the current regulation still primarily presents nutritional information in table format, with the provision that AKG must be listed in a part of the label that is easily seen and read, without mandating placement on the front of the packaging [2]. On the other hand, the regulation also recognises additional voluntary formats, such as monochrome daily nutrient intake guides and the "Healthier Choice" logo [3]. This situation indicates that the nutrition labelling system in Indonesia still focuses on providing informative content but has not fully optimised consumers' understanding of product nutritional quality at the time of purchase[4].

In this context, Front-of-Pack Nutrition Labels (FOPNLs) are becoming an increasingly relevant approach. FOPNLs are a nutrition labelling system placed on the front of packaging to present nutrition information in a simpler, more concise, and easily understandable way, whether in the form of symbols, graphics, text, or a combination of these [5]. The World Health Organisation (WHO), through the Codex Alimentarius Commission, emphasises that front-of-pack nutrition labelling aims to help consumers understand the nutritional characteristics of food more quickly [6]. WHO explains that nutrition labelling policies, including front-of-pack labelling, are designed to enhance consumer understanding and support healthier food choices [7]. Evidence from international policies also shows that FOPNLs not only help identify healthier products but can also encourage the food industry to reformulate products [8]. In line with this direction, Indonesia is also beginning to move towards a front-of-package labelling system based on nutritional risk categories, such as Nutri-Grade/Nutri-Level, designed to make it easier for the public to recognise the sugar, salt, and fat content in packaged food products [9].

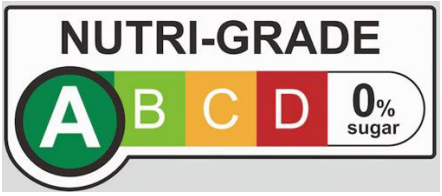

Figure 1. Nutri-Grade Level [10]

The urgency to develop the E-Nutrition Label has grown as various studies indicate that nutrition labels influence consumer behaviour and decision-making [11][12]. Findings by Gassler et al. show that the addition of Nutri-Score enhances the positive effect of healthier food composition on consumers' purchase intentions [13]. In Indonesia, studies indicate that nutrition labels influence purchasing decisions [14], while other research shows that the presence of labels on packaged products also affects consumer decisions compared to products without

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labels [15]. Thus, the transformation from conventional tabular nutrition labels to digital E-Nutrition Labels oriented toward FOPNLs is important to improve the interpretability and effectiveness of labels in supporting healthier food choices in the digital era [16].

E-Nutrition is a form of nutrition labelling that integrates information systems into digital platforms, enabling the public to access, read, and understand nutrition information more easily. The integration of these information systems utilises Information and Communication Technology (ICT) as part of modern health service transformation known as digital health [17]. Through a digital approach, the delivery of nutrition information is no longer limited to conventional packaging labels. However, it can be developed into a more interactive, informative, and user-friendly system. Thus, the implementation of E-Nutrition is expected to support the progressive transformation of public health, particularly by improving nutrition literacy, increasing access to information, and enabling the use of technology to support healthier consumption decisions [18].

Given these issues, this study focuses on developing an E-Nutrition Label based on Front-of-Pack Nutrition Labels (FOPNLs) suitable for implementation in Indonesia. This research aims to examine how digital health approaches, particularly through the implementation of FOPNLs, can be effectively applied in supporting the delivery of nutritional information that is easier for the public to understand. This research designs a website that can be used to generate digital-based FOPNLs. This website represents an initial form of research that will then proceed to stakeholder validation before being used and promoted as an application. In this context, information systems play an important role in integrating user needs, regulations, and digital technology. This study adopts a Design Science Research (DSR) approach to produce an artefact in the form of a model or design of the E-Nutrition Label, which is expected to provide both theoretical and practical contributions to the development of information systems in the field of digital health [19].

2. RESEARCH METHODOLOGY

2.1 Research Stages

This E-Nutrition Label research utilises the Design Science Research (DSR) method with the model developed by Peffers et al. (2007) [20]. This approach was chosen because it can bridge the theoretical foundation with practical needs in the development of information system artefacts[21], particularly in the context of digital transformation in the health sector. DSR is not only oriented toward solving real-world problems through solution design but also emphasises the scientific contribution of the resulting artefacts [22]. Therefore, this method is relevant to support the development of the E-Nutrition Label as part of information system innovation within the digital health framework.

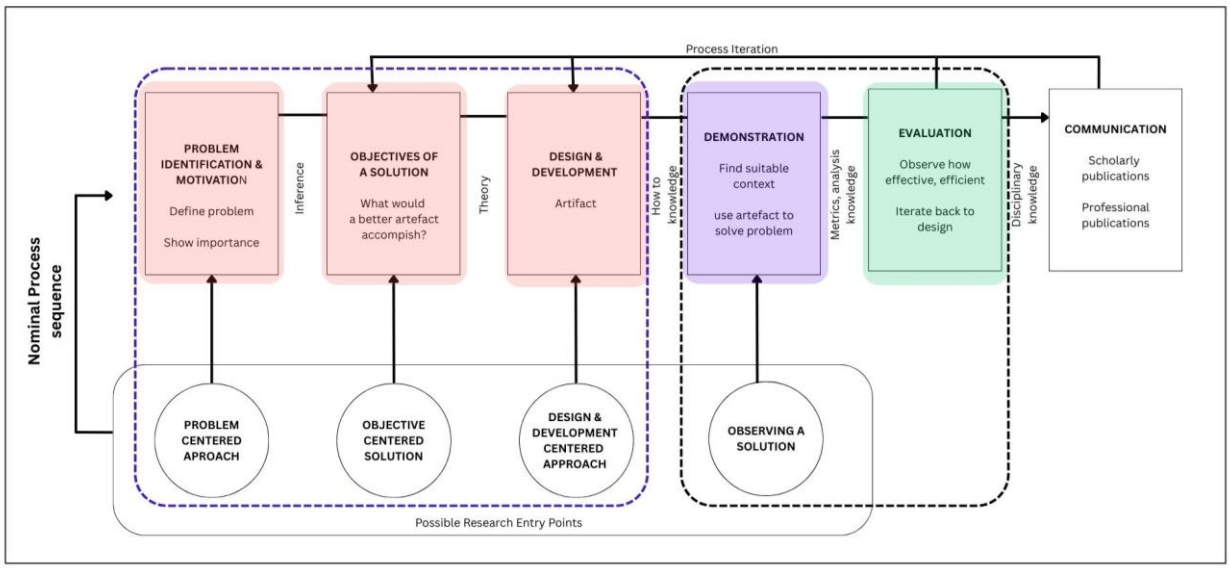

Figure 2. Adoption from DSRM Concept from Peffers et al (2007) [20]

Based on Peffers' framework, this research was conducted through five main stages. The first stage is problem identification and motivation, which identifies the research problem and assesses the urgency of its resolution. The second stage is to define the objectives for the solution, specifying the goals the solution or artefact must achieve. The third stage is design and development, which includes preparing functional requirements and designing the artefact. The fourth stage is demonstration, which shows how the developed artefact can be used to address or solve the formulated problem. The fifth stage is evaluation, which assesses the effectiveness and efficiency of the artefact and serves as a basis for making improvements or returning to the design stage if

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necessary. Furthermore, the research results are communicated through scientific publications so that the resulting contributions can be utilised.

Through these stages, this research is expected to produce an E-Nutrition Label artefact that not only meets the needs of users and stakeholders but also serves as a reference for preparing requirements and guidelines, and for developing information systems that support the implementation of digital health in Indonesia.

a. **Phase 1 Problem Identification & Motivation**
   The first phase of this research is Problem Identification and Motivation. This stage identifies the research problem and examines why solving it is important. In this phase, the researcher conducts a literature review to establish a conceptual and theoretical foundation, and field observations to understand the empirical conditions on the ground. Observations were conducted at relevant district-level agencies using a qualitative approach, given that digital FOPNLs have never been implemented in Indonesia. Therefore, this approach is deemed appropriate for a deep exploration of stakeholders' needs, perceptions, and readiness for the system's implementation.
b. **Phase 2 Objective of A Solution**
   The second phase in this research is the Objectives of a Solution. Following the interview process conducted in the previous phase, this stage focuses on formulating the objectives that the solution or artefact to be developed must achieve. In this stage, the researchers analyse with relevant stakeholders to identify needs, key issues, and levels of understanding regarding Front-of-Pack Nutrition Labels (FOPNLs), particularly within the agencies that serve as the research sites. The results of this analysis are then used to determine the objectives for developing artefacts that are relevant, contextual, and aligned with the needs of implementing the E-Nutrition Label in Indonesia.
c. **Phase 3 Design & Development**
   The third phase of this research is Design and Development, the stage of designing and developing the E-Nutrition Label artefact based on Front-of-Pack Nutrition Labels (FOPNLs). In this stage, the researcher translates the results of problem identification and solution objectives into an artefact design that aligns with user needs and the implementation context in Indonesia. This process includes formulating functional requirements, designing information structure, selecting visual elements that support label readability, and integrating digital health concepts into the system being developed. Subsequently, the design is realised as a prototype or initial model of the E-Nutrition Label, serving as a representation of the solution to the formulated problem. Thus, this phase becomes the core of the DSR process, as it produces an artefact that is not only theory-based but also practically relevant for the development of digital health information systems.
d. **Phase 4 Demonstration**
   The Demonstration Phase is a stage for implementing and showing the use of artefacts in an environment relevant to the research problem. In this study, the E-Nutrition Label artefact is realised as a website to support the needs of the Maros Regency MSME Office. This website serves as a digital platform to display product nutrition information in a simpler, clearer, and more accessible way for users. Through this demonstration, the researcher shows that the developed artefact can serve as an initial solution for implementing digital FOPNLs in Indonesia, particularly for managing nutrition information for MSME products. Thus, the demonstration stage not only presents the results of artefact development but also demonstrates its relevance and potential for supporting digital health and strengthening regional information systems.
e. **f. Phase 5 Evaluation**
   The Evaluation phase is a stage for assessing the effectiveness, efficiency, and level of acceptance of the developed artefacts. In this study, the evaluation of the E-Nutrition Label website design was conducted using Black-Box Testing to assess the system's functionality [23], and the Technology Acceptance Model (TAM) to assess user acceptance of the artefact [24]. Black Box testing focused on the conformity of the website's functions with user needs and the formulated system specifications. Meanwhile, TAM-based evaluation aimed to measure users' perceptions of the system's ease of use and benefits. The assessment was carried out by three experts who had the capacity to review both the technical aspects and usability of the system. Throughout this stage, researchers obtain critical feedback to ensure that the developed artefact not only functions technically but is also acceptable and can be optimally utilised by users in the context of digital health implementation.

This research focuses on the first iteration of the E-Nutrition Label artefact, conducted at the Office of Cooperatives and Small and Medium Enterprises of Maros Regency, South Sulawesi. In this iteration, the analysis was carried out gradually, starting from Phase 1 (Problem Identification and Motivation), Phase 2 (Objectives of a Solution), and Phase 3 (Design and Development), which were compiled descriptively and qualitatively based on previous research findings as well as the results of the study in this research (red text). These stages were continued in Phase 4 (Demonstration) in blue text and Phase 5 (Evaluation) in green text to demonstrate the developed artefact and assess its functionality and acceptance. This research report includes a justification for the results of the website design produced as a form of artefact development, while also presenting scientific contributions in the field of digital health as a basis for the development of digital-based E-Nutrition Label or FOPNLs applications in the future.

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2.2 Related Works

At this stage, the Related Works section presents the results of the research team's previous studies, serving as a foundation for the development of the E-Nutrition Label prototype. The results in Stage 1, Stage 2, and Stage 3 were obtained from three interrelated previous studies: the socialisation of nutrition label literacy, the design of a digital Front-of-Pack Nutrition Labels (FOPNLs) model, and the exploration of stakeholder perceptions regarding the implementation of digital FOPNLs on MSME products. These three studies serve as the conceptual and empirical basis for designing the artefact in this research, which is subsequently realised as a website prototype and evaluated in Stages 4 and 5.

The first study focused on socialization activities on micronutrient content and nutritional labels on packaged food products for the staff of the Maros Regency Office of MSMEs and Cooperatives [25]. This study is based on the increasing prevalence of non-communicable diseases (NCDs), which are closely related to unhealthy food consumption patterns, especially packaged foods high in sugar, salt, and fat. During the activities, participants were provided with an understanding of how to read nutrition labels and interpret serving sizes through the stages of preparation, development of the Nutrition Value Survey (NVS) instruments, use of packaged food examples, socialization, and evaluation. The results of the activities indicated that, prior to the socialization, the majority of participants did not yet understand how to read nutrition labels or accurately estimate serving sizes. However, after socialization, participants' understanding of the nutritional information on the packaging increased. This finding indicates that nutrition literacy remains a major challenge, but it can also be improved through targeted education. The results of this study provide an important basis for developing digital nutrition label systems that consider readability, ease of understanding, and users' educational needs.

The second study discusses a narrative description and analysis regarding the development of a digital-based FOPNLs model. This study stems from the fact that the increasing prevalence of overweight and obesity is a major risk factor for non-communicable diseases in various countries, which is influenced by excessive consumption patterns of sugar, salt, and fat. In this context, FOPNLs are positioned as a nutritional labelling tool that helps consumers choose and control their consumption of packaged foods and beverages, including products produced by MSMEs. This study employs the Design Science Research Methodology (DSRM) approach through five stages: problem identification, requirement definition, artefact design and development, model demonstration, and artefact evaluation. The results of this study led to the development of a digital-based FOPNLs model that emphasises the importance of integrating digital nutrition labelling on MSME product packaging. This integration can help the public understand nutritional information while also providing added value to MSMEs by enabling them to produce healthier, more competitive products. Thus, the second study provides a strong methodological framework for developing digital artefacts.

The third study explored the perceptions of the Maros Regency Office of Cooperatives, Industry, and Trade regarding the digital FOPNLs model on MSME products. This study was motivated by the development of FOPNLs as a global strategy to reduce the incidence of non-communicable diseases and to make it easier for consumers to understand nutritional information. In line with technological advancements, this study assessed that a digital approach could strengthen the implementation of FOPNLs while supporting the competitiveness of MSMEs. Using Focus Group Discussion (FGD) methods, consultative meetings, and short questionnaires with expert staff of the Cooperatives, Industry, and Trade Office, the results indicated that participants generally supported the implementation of a digital-based FOPNL model for MSME products. Nevertheless, they also emphasised the importance of extensive socialisation for MSMEs and the public, particularly concerning the ability to read nutritional labels and understand nutrient adequacy values. These findings indicate that stakeholder acceptance of the digital model is quite strong, yet its implementation still requires support in education, guidance, and institutional readiness.

Overall, these three studies form a complementary foundation for this research. The first study emphasises the importance of improving nutritional literacy as a basis for implementing digital nutrition labels. The second study provides conceptual and methodological guidance in developing a digital FOPNL model through a Design Science Research approach. Meanwhile, the third study indicates stakeholder support for implementing the digital model in MSME products, although dissemination and user capacity strengthening remain required. Therefore, the results of Phases 1, 2, and 3 of these three studies are analysed and synthesised to continue the development of the E-Nutrition Label Prototype in this research. This synthesis then serves as the basis for the implementation of Phase 4, namely the demonstration of the website prototype, and Phase 5, namely limited trials and evaluation of the developed artefact.

3. RESULT AND DISCUSSION

The Results and Discussion section of this study presents the findings from the research stages conducted using the Design Science Research approach. Stages 1, 2, and 3, which include problem identification, solution objective formulation, and artefact design and development, have been published in previous journals. Therefore, this section specifically focuses on Stage 4 and Stage 5 as a continuation of the process, namely the demonstration of the E-Nutrition Label website prototype and its evaluation. The results presented include the developed website

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prototype and the system testing outcomes. To facilitate presentation, this section is divided into two main subsections: (3.1) Results, which outlines the research findings, and (3.2) Discussion, which examines the testing results and the relevance of the artefact in the context of health digital development.

3.1 Result

In the Results section, the discussion is organized into three main parts. First, Related Works, which explains the results of Stage 1, Stage 2, and Stage 3 that were previously conducted. Second, the development of a website-based E-Nutrition Label prototype as a form of digitizing nutritional information. Third, prototype testing conducted using the Black Box Testing method quantitatively and the Technology Acceptance Model (TAM) qualitatively to assess the system's functionality and acceptance.

3.1.1 E-Nutrition Label Prototype

The E-Nutrition Label prototype developed in this study is designed as a website, a digital medium that presents nutritional information more easily, interactively, and systematically. The selection of a website platform is based on considerations of accessibility, ease of use, and flexibility in displaying Front-of-Pack Nutrition Labels (FOPNLs) to users, particularly MSME actors, local governments, regulators, and consumers. Through a website-based approach, nutritional information is presented not only in a static form, as on conventional labels. However, it can also be developed into a digital medium that supports readability, efficiency of information delivery, and integration with the needs of digital health transformation.

In Figure 3, the E-Nutrition Label Use Case Diagram shows four main actors in the system: MSME parties, local government administrators, regulators, and consumers. These four actors indicate that the system being developed not only serves as a medium for presenting nutritional information but also as a means of interaction among stakeholders to support the implementation of digital nutrition labelling.

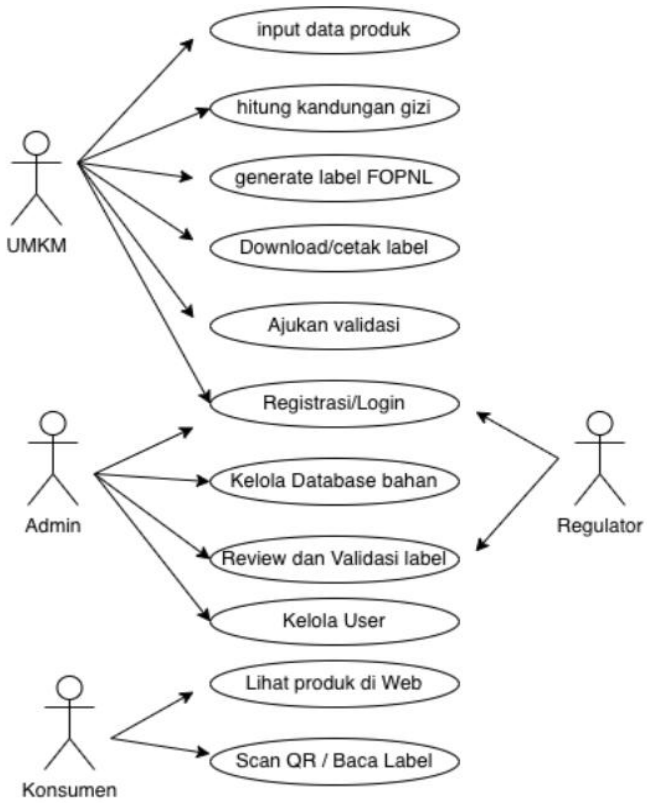

Figure 3. Usecase Diagram E-Nutrition Label

The initial stage of prototype development involved creating a mock-up of the system's visual design. The mock-up was arranged to illustrate the interface structure, information layout, page navigation, and the main elements that will be displayed on the E-Nutrition Label website. At this stage, the researchers mapped user needs into a simple yet representative visual design, providing an initial overview of the system's usage flow. The creation of the mock-up also aimed to ensure that key components, such as product identity, nutritional content information, label categories, and FOPNLs display, could be organised clearly and easily understood. In Figure 4, the mock-up design of the nutrition value calculation page contains various product names as part of the system's main features. This page was designed to assist users, particularly MSME actors or administrators, in managing and calculating product nutritional information in a more structured and systematic manner.

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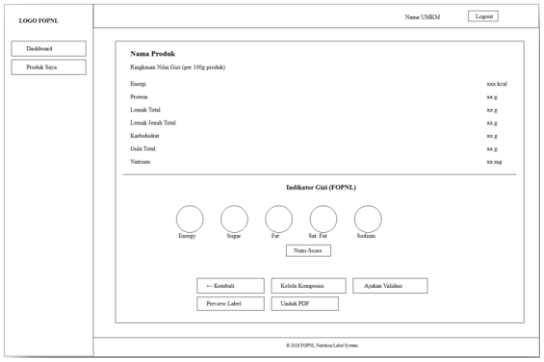

Figure 4. Mockup design of the nutrition calculation page

After the mock-up design is prepared, the next stage is creating the website as the means of realising the developed artefact. At this stage, the visual design is translated into a web-based system that can be operated and tested. The website is developed to meet the functional requirements identified in the previous stage, so that it can display product nutritional information digitally, in a structured manner and in an easily accessible format.

The development of this website focuses not only on visual aspects but also on system functionality, ease of navigation, and the user experience when accessing E-Nutrition Label information. The result of this stage is a website prototype that can serve as an initial demonstration platform for the implementation of digital-based FOPNLs on MSME products in Maros Regency.

In Figure 5, the product nutrition detail page is shown, providing more detailed information about the product's nutritional content. This page serves as the primary medium for users to view a product's complete nutritional content, thereby supporting the system's goal of enhancing the understanding, readability, and accessibility of nutritional information online. Regarding intellectual property rights, the User Guide has been registered under IP number EC002026040509 on March 16, 2026.

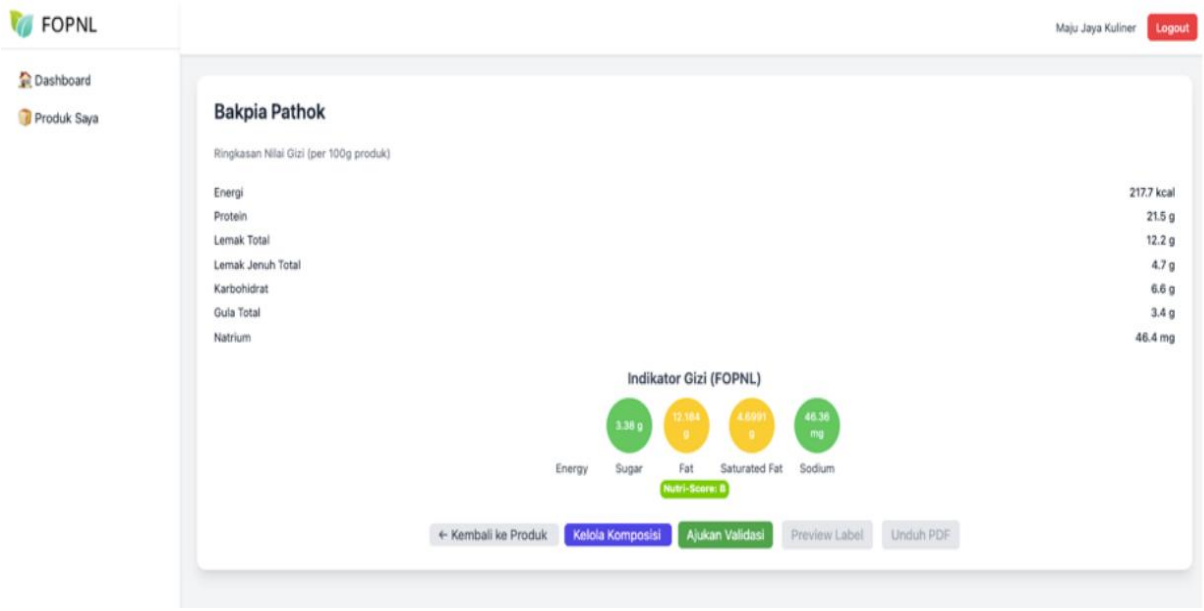

Figure 5. Sample Product Detail Page Nutrition Value

Overall, the development results of the E-Nutrition Label website prototype indicate that the designed artefact has successfully translated the needs of users and stakeholders into a more structured, informative, and easily accessible digital system. This design not only represents the concept of Front-of-Pack Nutrition Labels (FOPNLs) in a digital format but also demonstrates its potential implementation as a more effective medium for delivering nutritional information for MSME products. After the design and prototype development stages are complete, the next step is to test the built system to assess its functionality, performance, and acceptance.

3.1.3 Testing Prototype

In general, the results of Black-Box Testing conducted on the nutritional value calculation feature page indicate that all tested functions have operated as expected under the established test scenarios. Each feature, ranging from nutritional value calculation to FOPNL indicators, Nutri-Score, label preview, and PDF download, produces outputs that match the expected results. Therefore, the nutritional value calculation feature page can function properly and fulfil the system functionality aspects summarised in Table 1.

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Table 1. Feature Testing Sample for Nutrition Value Calculation

Scenario	Action	Output	Status
Hitung Gizi	Klik hitung	Nilai gizi tampil	Success
Indikator FOPNLs	Nilai tersedia	Traffict light tampil	Success
Nutri-score	Data lengkap	Grade muncul	Success
Preview label	Klik preview	Label tampil	Success
Unduh PDF	Klik unduh	File PDF terdownload	Success

The evaluation of system acceptance for the E-Nutrition Label prototype was conducted using the Technology Acceptance Model (TAM) through interviews with three experts: a health expert, an expert from the relevant governmental agency, and an information systems expert. The use of these three perspectives aims to obtain a more comprehensive assessment of the system's usefulness, ease of use, user attitudes, and intention to use. An overall summary is shown in Table 2 below.

Table 2. TAM Analysis on the E-Nutrition Application

Category	Description
Perceived Usefulness (PU)	Respondents believe that the FOPNL application developed is very beneficial for MSMEs in presenting nutritional information in a clear, standardized, and easily understandable manner, thereby enhancing consumer trust and assisting with nutritional labeling requirements and BPOM certification.
Perceived Ease of Use (PE)	Respondents assess that the FOPNLs application is easy to use, with a clear, simple, straightforward flow, making it easier for MSME actors to enter product data and nutritional values without manual calculations.
Attitude Toward Using (ATU)	Respondents stated that they feel comfortable using the FOPNLs application because the available features meet their needs and do not complicate the user experience.
Behavioral Intention to Use (BI)	Respondents show a very high willingness to continue using the FOPNLs application in the future because it is considered useful and easy to use, in line with their needs.

Thus, the results of the TAM evaluation not only reflect the technical aspects of the application but also take into account its relevance to public health needs, institutional support, and the suitability of implementation from the information system perspective.

3.2 Discussion

The results of this study indicate that the development of the E-Nutrition Label does not stand alone, but is a logical continuation of a series of related works previously conducted by the research team. Initial research on the socialization of nutrition labels to employees of the Department of SMEs and Cooperatives of Maros Regency found that nutrition literacy, particularly in reading labels and understanding serving sizes, still needs improvement. Subsequent research focusing on the development of a digital-based Front-of-Pack Nutrition Labels (FOPNLs) model provided a conceptual and methodological foundation for digital nutrition labeling as a relevant strategy to help consumers understand nutritional information more easily. Furthermore, a study on stakeholders' perceptions within the Department of Trade and Industry of Maros Regency found support for the implementation of digital FOPNLs for MSME products. These three studies complement each other and strengthen the argument that the development of the E-Nutrition Label prototype is a relevant necessity from the perspectives of education, system modeling, and stakeholder acceptance.

From the perspective of artifact development, the web-based E-Nutrition Label prototype demonstrates that the concept of FOPNLs can be translated into a more practical, context-specific digital system. The choice of a website platform is important because it enables broader, more flexible, and more easily accessible nutritional information for various actors, including MSME practitioners, local government administrators, regulators, and consumers. The presence of four actors in the use case diagram shows that this system functions not only as a one-way information medium but also as a collaborative tool that connects the needs of production, regulation, supervision, and consumption. In this context, the website prototype is not merely a digital representation of a conventional nutrition label, but a transformation of the information system that supports the integration of nutrition labeling, MSME product governance, and society’s need for healthier food information.

Furthermore, the process of creating the mock-up and implementing the website demonstrates that the development of the E-Nutrition Label has considered both functional aspects and user experience. It is evident in the design of the nutritional value calculation page, the FOPNL indicator feature, the Nutri-Score display, the label preview, and the product nutritional detail page. The organization of these elements indicates that the artifact was designed to address the main issues associated with conventional nutrition labels, namely limitations in readability, ease of interpretation, and accessibility of information. Consequently, the resulting prototype not only has technical

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value but also practical value, supporting nutrition literacy and enhancing the competitiveness of MSME products. These findings align with the objectives of digital health, which emphasize the use of digital technology to expand access, improve understanding, and support better decision-making in public health.

The prototype testing results further reinforce that the developed E-Nutrition Label website has the potential for further implementation. Based on Black Box Testing, all main features on the nutritional value calculation page were successfully executed according to the testing scenarios and produced the expected outputs. It indicates that functionally, the system has performed well. Meanwhile, the evaluation using the Technology Acceptance Model (TAM) through interviews with three experts from the health, government, and information systems fields showed positive acceptance of the system. The prototype was considered useful, easy to use, provided a good user experience, and had the potential for continued use. Nevertheless, several inputs, such as the need to strengthen socialization, regulatory support, and the development of additional features, indicate that this artifact still requires refinement in the next iteration. Overall, the test results confirm that the E-Nutrition Label prototype meets the basic functionality and user acceptance requirements, making it worthy of consideration as an initial model for the development of digital nutrition labeling based on FOPNLs in Indonesia.

4. CONCLUSION

This study developed a web-based E-Nutrition Label prototype as an initial digital artifact for generating Front-of-Pack Nutrition Labels (FOPNLs) for MSME products. The prototype demonstrates a technical contribution by enabling structured nutritional data processing into automated outputs, including nutrition value calculation, FOPNL indicators, Nutri-Score generation, label preview, and PDF export. Functional testing confirmed that the main system features operated as intended, while expert-based TAM evaluation indicated positive acceptance in terms of perceived usefulness, ease of use, attitude toward use, and intention to use. These findings suggest that the artifact is feasible as a proof-of-concept for digital nutrition labeling implementation. However, this study also acknowledges important limitations. The prototype has not yet been evaluated for scalability in managing large volumes of MSME product data at a national level, where broader deployment would require more robust database design, performance optimization, and scalable system architecture. In addition, interoperability with external regulatory systems, particularly the BPOM database, has not yet been implemented. Future development should therefore focus on large-scale performance testing, API-based integration with health authority databases, and standardization of data exchange to support wider adoption. With these enhancements, the proposed system can serve as a foundation for a more scalable and interoperable digital nutrition labeling platform in Indonesia.

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