ToxiScan: A Smart Harmful Ingredient Detection Mobile Application Sources and Assessments

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Projek ini merupakan salah satu keperluan untuk Ijazah Sarjana Muda Sains Komputer dengan Kepujian
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DECLARATION

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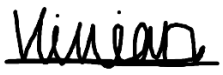

Vivian Michelle Anak Jelma Date: 23/06/2025

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ABSTRACT

As the personal care industry develops quickly, public concern related to harmful chemicals in skincare and baby products, including mercury, parabens, and phthalates, has increased due to their connection to endocrine disruption and long-term health hazards. Despite increased awareness, consumers frequently find it challenging to comprehend complex ingredient lists, requiring an increase of accessible approaches. This project presents ToxiScan, an user-friendly smartphone application intended to identify and evaluate hazardous components in skincare, body p and baby care products. The system, developed using the Waterfall Model, integrates data from regulatory entities such as the EU Cosmetic Directive and PubChem to provide real-time toxicity assessments via ingredient scanning. The application emphasizes accessibility and simplicity, especially for people with health concerns and parents. User preferences and interface design were guided by survey data, ensuring relevance and effectiveness. Usability testing showed favorable results: Functionality (90% pass rate), Efficiency (86.7%), Usability (83.3%), and Reliability (80%), proving that ToxiScan effectively addresses user requirements and promotes safer product selections through reliable and clear ingredient analysis.

ABSTRAK

Apabila industri penjagaan diri berkembang dengan pantas, kebimbangan orang ramai yang berkaitan dengan bahan kimia berbahaya dalam penjagaan kulit dan produk bayi, termasuk merkuri, paraben dan phthalates, telah meningkat disebabkan kaitannya dengan gangguan endokrin dan bahaya kesihatan jangka panjang. Walaupun peningkatan kesedaran, pengguna sering mendapati sukar untuk memahami senarai ramuan yang kompleks, yang memerlukan peningkatan pendekatan yang boleh diakses. Projek ini mempersembahkan ToxiScan, aplikasi telefon pintar mesra pengguna yang bertujuan untuk mengenal pasti dan menilai komponen berbahaya dalam penjagaan kulit, badan p dan produk penjagaan bayi. Sistem yang dibangunkan menggunakan Model Air Terjun, menyepadukan data daripada entiti kawal selia seperti Arahan Kosmetik EU dan PubChem untuk menyediakan penilaian ketoksikan masa nyata melalui pengimbasan ramuan. Aplikasi ini menekankan kebolehcapaian dan kesederhanaan, terutamanya untuk orang yang mempunyai kebimbangan kesihatan dan ibu bapa. Pilihan pengguna dan reka bentuk antara muka dipandu oleh data tinjauan, memastikan perkaitan dan keberkesanan. Ujian kebolehgunaan menunjukkan hasil yang menggalakkan: Kefungsian (90% kadar lulus), Kecekapan (86.7%), Kebolehgunaan (83.3%) dan Kebolehpercayaan (80%), membuktikan bahawa ToxiScan berkesan menangani keperluan pengguna dan menggalakkan pemilihan produk yang lebih selamat melalui analisis ramuan yang boleh dipercayai dan jelas.

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LIST OF ABBREVIATION

Abbreviation	Meaning
CPU	Central Processing Unit
CSS	Cascading Style Sheets
DBP	Dibutyl Phthalate
DEP	Diethyl Phthalate
ERD	Entity Relationship Diagram
ERD	Entity Relationship Diagram
EWG	Environmental Working Group
FDA	Food and Drug Administration
GB	Gigabyte
IOS	iPhone Operating System
NMFs	Natural Moisturizing Factors
PHP	Hypertext Preprocessor
RAM	Random Access Memory
SDLC	Software Development Life Cycle
SRS	Software Requirement Specification
UNIMAS	Universiti Malaysia Sarawak

CHAPTER 1 INTRODUCTION

1.1 Background of Study

People have become much more aware of the possible health risks of using everyday skin care, body care, and baby care goods in the past few years. More and more people are worried about harmful chemicals like parabens, phthalates, sulfates, and artificial scents. These chemicals are found in a lot of personal care products. They have been linked to a lot of bad things, like skin irritation, hormonal changes, and other long-term health problems. People who are already fragile, like babies, are especially at risk because they are more sensitive and need goods with stricter safety standards. Because of this, more people are becoming aware of the possible risks hidden in what they use daily.

Even though people are more aware of this issue, a lot of them still find it hard to read the long lists of ingredients on product labels. The common person will have trouble understanding a lot of scientific language in these lists. Also, users rarely get clear warnings or information about the possible dangers of certain ingredients, so they can't make fully informed choices. There are many databases and resources available to teach people about the safety of ingredients. Still, they are often hard to use because they require a certain amount of technical knowledge. This hole shows how badly we need an answer that is more useful and easier to use.

To solve this problem, ToxiScan suggests combining cutting-edge mobile technology with in-depth toxicological knowledge. The goal is to close the knowledge gap by giving people an easy-to-use tool for evaluating ingredients and real-time feedback on a product's safety. ToxiScan gives people the power to make healthy and safer choices for themselves and their families by giving them access to clear and accurate information.

For the ToxiScan database to work, the information it contains has to come from very reliable sources. There will be a lot of data coming from reliable regulatory bodies like the EU Cosmetic Directive and the FDA, as well as public databases like PubChem and the EWG Skin Deep. These ensure that the database stays correct, up-to-date, and reliable so users can make smart decisions that align with industry norms. This dedication to precision and dependability shows that ToxiScan is serious about changing how people think about and pick up personal care goods

1.2 Problem Statement

Many consumers are ignorant of the potentially dangerous compounds included in regular skincare, body care, and infant goods. Ingredients like parabens, phthalates, and synthetic scents are widely present in these cosmetics despite being related to major health hazards, including skin irritation, endocrine disruption, and long-term problems like reproductive issues and cancer. Vulnerable groups, such as babies, young children, and persons with allergies or sensitivities, are particularly in danger due to their heightened susceptibility to these harmful compounds. However, a key problem customers encounter is the complexity of component lists on product labels, which sometimes contain scientific jargon that makes it difficult for the average person to understand potential concerns. While regulatory authorities like the EU Cosmetic Directive and FDA publish ingredient safety standards, the information is sometimes too technical or difficult for common users to access. As a result, many consumers struggle to make informed decisions regarding the products they use every day. This underscores the essential need for a simple, accessible, and user-friendly tool that enables customers to quickly identify dangerous ingredients and make safer, more educated choices regarding their personal care products.

1.3 Aim and Objective

To create a mobile application that uses toxicology data to find dangerous ingredients in skin, body care, and baby products and let users know about them by manually scanning the ingredient list text or input ingredients. This will help users choose safer products and find harmful ingredients more efficiently.

The main objectives of this project are to:

1. To design predefined rules and an integrated database of known harmful, potentially harmful, and safe ingredients to provide toxicity analysis of cosmetic and personal care products.
2. To develop the mobile application interface with user data interactivity, such as user input for toxic ingredient screening.
3. To evaluate and test the integration of the interface with the database to ensure functionality, accuracy, and user effectiveness in identifying toxic ingredients.

1.4 Scope

The ToxiScan project aims to produce a mobile application that lets consumers discover dangerous substances in skincare, body care, and newborn care products. The software will allow users to scan or manually input component lists, giving real-time toxicity analysis based on a predefined database. This database will classify substances as dangerous, potentially harmful, or safe, referencing authoritative sources such as the EU Cosmetic Directive, PubChem, and FDA rules.

The program targets health-conscious shoppers, parents, and persons with sensitive skin who typically struggle to comprehend complex ingredient labels. By giving a user-friendly interface, ToxiScan will simplify ingredient screening, provide risk evaluations, and deliver clear feedback on any health dangers. The system will emphasize accessibility and ease of use, ensuring that people can make educated decisions about the safety of the products they use daily.

To assure reliability, the project will entail extensive testing and evaluation of the app's correctness, usability, and efficacy. This will comprise functionality tests, user input collection, and validation of ingredient classifications against trustworthy regulatory data. Ultimately, ToxiScan wants to raise consumer knowledge and allow people to choose safer personal care products with confidence.

1.5 Significance of Project

ToxiScan is crucial for empowering consumers as it facilitates the accessibility of information regarding potentially dangerous substances in skincare, body care, and newborn care products, thereby helping individuals make informed, health-conscious choices. ToxiScan promotes public health and empowers individuals to select safer products by educating users about the hazards of chemicals such as parabens and sulfates. The application employs a rule-based approach to accurately identify chemicals based on their toxicity levels, offering users clear feedback in accordance with established safety standards.

In addition, the rule-based approach, machine learning algorithms are utilized to improve the application's capacity to analyze product ingredient lists. Upon scanning or entering a component list, the system uses OCR to interpret complex chemical names and correlate them with entries in an extensive toxicological database, using information from reputable sources like the EU Cosmetic Directive and PubChem. The approach assesses every ingredient for potential hazards, like endocrine disruption or dermal irritation, and assigns a

toxicity rating. Additionally, a risk assessment methodology is employed to analyze the interactions among various components, pinpointing combinations that may increase health hazards. The application utilizes machine learning to provide users with precise, real-time data regarding ingredient safety and associated risks.

This strategy enables consumers and motivates manufacturers to use improved labelling and safer formulations, promoting enhanced transparency within the beauty sector. ToxiScan is particularly advantageous for health-conscious individuals, including parents, those with sensitive skin, and ecologically aware consumers, assisting them in selecting safer, more sustainable products. ToxiScan is a user-friendly mobile interface that facilitates quick and precise ingredient analysis, thereby making important health information available to a wider audience.

1.6 Project Timeline

Project schedule is shown with Gantt Chart as attached in Appendix A.

The Gantt chart is a useful tool for project managers because it visually represents the project's schedule, tasks, and phases. This makes it easy to see when things are due, how interdependent they are, and how far along the project is. From the fourth October of 2024 until the June of 2025, the given Gantt chart divides the project's activities into distinct timeframes, allowing for easy tracking and timely completion of phases including planning, analysis, design, implementation, testing, and post-implementation.

CHAPTER 2 LITERATURE REVIEW

2.1 Introduction

This literature review chapter will investigate and assess existing mobile applications and websites with comparable features. The main aim of this chapter is to assess the strengths and shortcomings of each system and then compare them to guide the creation of the proposed system. Furthermore, we will evaluate each module of the current system for its functionality and features. Acquiring significant insights from these existing systems will improve the proposed solution.

2.2 Existing System

This section highlights three existing systems for skincare and baby product ingredients that are quite useful nowadays, which are SkinSort, Little Bean, and INCIDecoder. Using these technologies, consumers can evaluate the components' safety, benefits, and possible irritants by conducting thorough analyses of product mixtures. So that people can make educated decisions about the items they use, each platform provides distinct characteristics including component breakdowns, irritation levels, and compatibility with various skin types. There is a rising desire for ingredient transparency in personal care and baby skincare products, and these technologies assist people choose the best products for their requirements by providing that information.

2.2.1 SkinSort

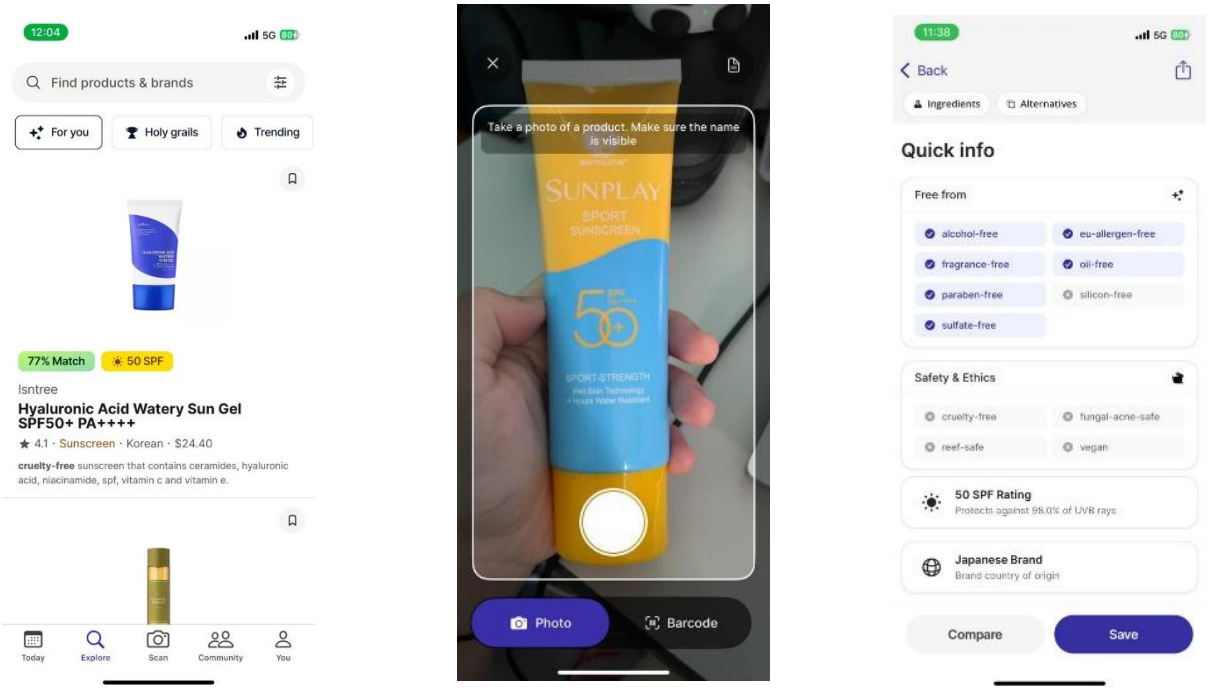


Figure 2.1 SkinSort Mobile Application

The SkinSort application is an effective tool intended to assist users in making more educated choices regarding their skincare products. The software analyzes ingredient lists from skincare products to offer comprehensive insights into the formulation, emphasizing active chemicals like retinol and salicylic acid. These studies assist customers in comprehending the function of particular components and their appropriateness for various skin types and issues, facilitating the selection of solutions that correspond with their individual requirements.

One of the application's best features is its personalized suggestions. As soon as SkinSort finds important skin problems like acne, dryness, or sensitivity, it suggests custom ways to fix them. It also informs users about ingredients that might be harmful or irritating, which makes product decisions safer and more reliable. Cautious people can avoid products that might make them react badly, which is especially helpful for people with sensitive or problematic skin.

A notable feature of SkinSort is its routine builder. This function assists customers in developing a personalized skincare regimen by suggesting goods with advantageous components and circumventing ingredient conflicts. The application guarantees that customers can synergistically combine items to optimize advantages and prevent prevalent problems, such as the layering of incompatible formulations. SkinSort enables consumers to create a

personalized skincare regimen that addresses their specific needs, promoting healthier and more brighten skin over time.

In conclusion, SkinSort is a great resource for people who want to improve their skincare routine. It gives users the information and confidence to choose the right products and improve their skin health by analysing all the ingredients in a product, making personalized suggestions, and creating a routine.

2.2.2 Little Bean

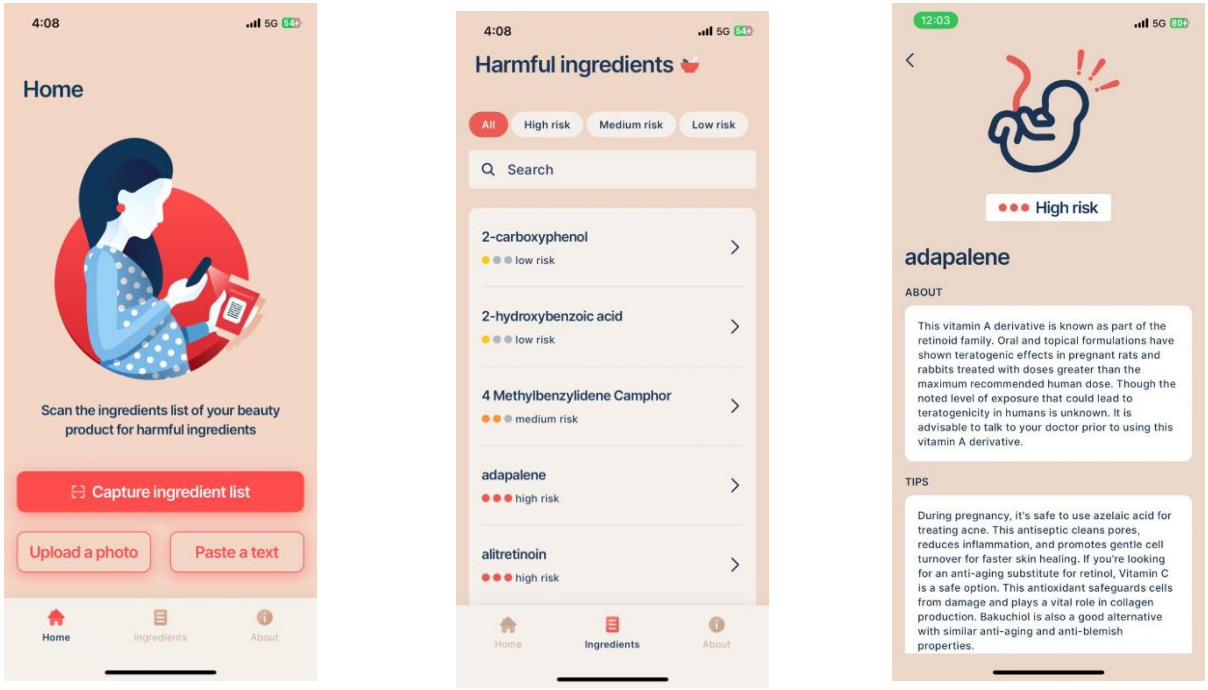


Figure 2.2 Little Bean Mobile Application

Women started an innovative health-tech startup called Little Bean with the express purpose of helping pregnant women understand and use all the many kinds of personal care products and cosmetics. Pregnant women and their unborn children are more susceptible to the harmful effects of some chemicals. Thus, the app's developers set out to fill a need by compiling accurate information on the cosmetic compounds' safety ratings. Because of this, pregnant women are better able to make choices that are good for their health and the health of their unborn child.

The software uses a straightforward method to classify cosmetic components into three danger categories: high-risk, medium-risk, and low-risk, allowing users to easily assess the product's safety. Considerations including toxicity, allergenicity, and hormonal interference inform these categorizations of drugs according to their possible effects during pregnancy. By

streamlining what would be a daunting process, our risk assessment approach helps consumers swiftly recognize and stay away from items that contain substances that could cause harm.

Furthermore, one of the application's most user-friendly features is quickly acquiring a product's safety profile by capturing its ingredient list or uploading the ingredient photo. Because of this, users would not have to waste time reading labels or looking up ingredients. Also, the application provides in-depth information on the possible impacts of individual substances or goods on pregnant women when they search for them. Helping users comprehend the reasoning behind each categorization and its consequences for maternal and foetal health, the application provides clear, practical guidance.

To sum up, the Little Bean mobile application empowers pregnant women to confidently select cosmetics that meet their specific safety requirements by integrating cutting-edge ingredient analysis with user-friendly capabilities. The software does more than help pregnant women make better decisions. It also promotes a culture of mindfulness by increasing knowledge about the safety of ingredients. Consequently, the Little Bean app is essential for pregnant women, connecting their health concerns with their everyday self-care practices.

2.2.3 INCIDecoder

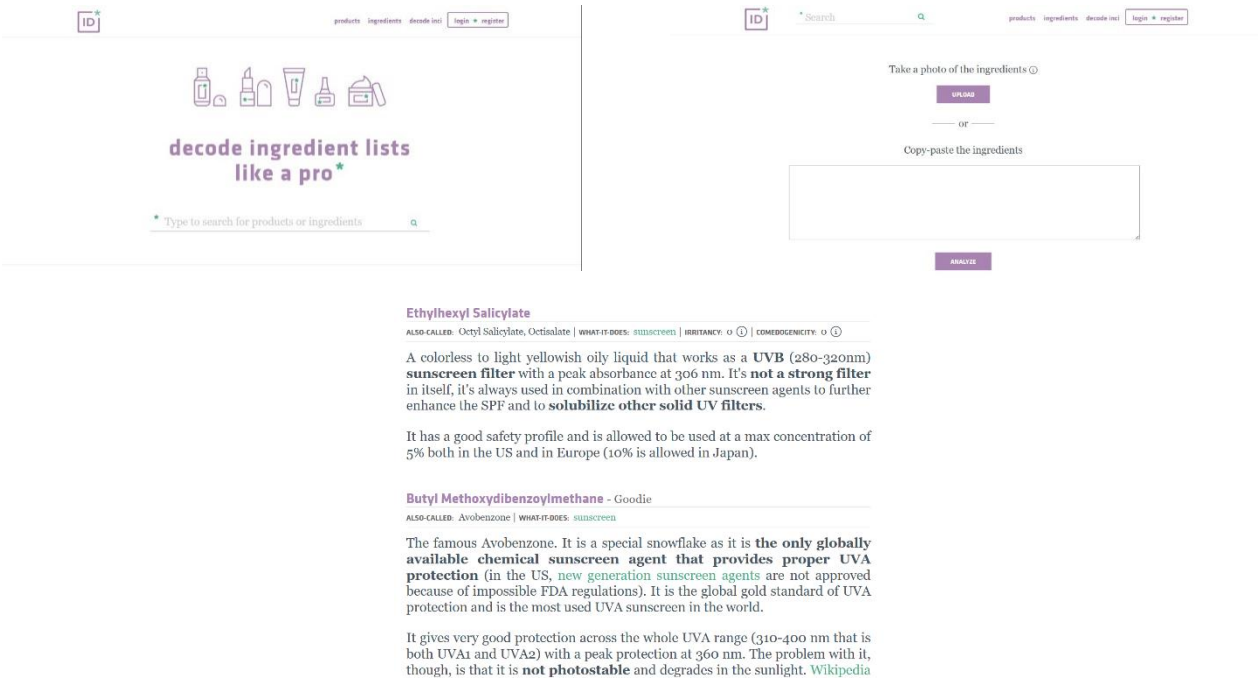


Figure 2.3 INCIDecoder Website

INCIDecoder is an easy-to-navigate website that aims to educate users about the components used in personal care items. This platform thoroughly studies each component,

allowing consumers to understand exactly what goes into their skincare products and how they could impact their skin. It aligns with the growing trend of ingredient transparency in the beauty industry. Entering a product's name or list of ingredients onto the website facilitates quick evaluation of the ingredients' functions, safety, and possible advantages. People who want to know what skincare products work best for their skin type will find this feature useful.

INCIDecoder's primary feature is its capacity to analyse ingredient lists, whether users upload a photograph or manually enter the ingredient. The website uses complex algorithms to find and rate each ingredient, giving full details on what it does, possible benefits, and how well it works with different skin kinds. This saves users time and effort because they don't have to do much study on each item separately. Instead, they can find all the information they need in one place.

Furthermore, INCIDecoder identifies substances that can harm the skin or cause irritation. Every ingredient has an "irritation level," which gives consumers a better idea of how likely their skin may be sensitive or react negatively to the product. People with sensitive skin or other skin issues find this function very helpful because it tells them which substances to avoid depending on their skin type and unique sensitivities. Users are empowered to make safer choices when selecting skincare products using INCIDecoder, which identifies potentially dangerous or irritating substances.

In Addition, the website provides an opportunity to examine skincare compounds comprehensively, enabling users to evaluate their safety and suitability for different skin conditions. INCIDecoder helps people determine which ingredients are good for them and which might worsen their skin problems, like acne, redness, or ageing because it focuses on skin safety and compatibility. INCIDecoder is an important tool for anyone who wants to improve their skincare routines by choosing the right items for their skin. Ultimately, INCIDecoder pushes for more openness in the skin care industry so that people can make better decisions and get healthier, healthier skin.

In conclusion, INCIDecoder is a useful tool for people who want to know more about the ingredients in the skincare product they buy. The website helps users make choices based on their skin type and sensitivities by breaking down each part and giving detailed information about how it works, how safe it is, and what benefits it offers. Finding ingredients that might be irritating or harmful is something that only INCIDecoder can do. This lets users choose goods that are right for their skin. Overall, this platform encourages safer skin care practices

and provides a wealth of information for those wanting to improve their skin care habits and attain healthier, more balanced skin.

2.3 Comparison Between Existing Systems and Proposed Works

Table 2.1 Comparison Between Existing Systems and Works

Feature/Aspect	SkinSort	Little Bean	INCIDecoder	Proposed work
Primary Focus	Skincare ingredient analysis	Pregnancy-safe cosmetics	Skincare Ingredient analysis	Skincare ingredient, body product and baby product analysis
Target Audience	Skincare users	Pregnant women	Skincare users	Skincare users, parents and caregivers
Personalised Recommendations	Yes (routine builder)	No (focuses on safety)	No (focuses on ingredients analysis)	No (focuses on ingredients analysis)
Ingredient Risk Rating	Yes (skin compatibility)	Yes (risk levels for pregnancy)	Yes (irritation level)	Yes (Toxic level)
Scan functionality	Yes (product name and barcode)	Yes (ingredient list)	No (manual input or photo upload)	Yes (Ingredient list and scan ingredient text)
Platform	Mobile app and website	Mobile app	Website	Mobile app

The proposed ToxiScan program is compared to current ingredient analysis methods in Table 2.3. Other existing systems only target skincare consumers or pregnant women, while ToxiScan covers both skincare and baby items, which is a major difference. In contrast to INCIDecoder, which requires user input, ToxiScan, like Little Bean, allows users to scan ingredient lists. It also gives toxicity risk ratings like other apps, but it focuses on the amounts of dangerous ingredients instead of the possibility of irritation. Overall, ToxiScan differentiates itself by

including key elements of competing systems and broadening its appeal to a wider range of users, such as parents and caregivers.

2.4 Harmful Skincare and Baby Product Ingredients

Consumers and researchers alike are becoming increasingly concerned about the potentially destructive effects that dangerous components in infant and cosmetic products could have on their health. The popularity of these goods has led to the continued usage of ingredients such as parabens, phthalates, fragrances, toluene, and mercury. This is the case despite the fact that there is evidence linking these ingredients to a variety of threats to health and adverse effects.

2.4.1 Parabens

A group of preservatives called parabens is used in many cosmetics and personal care items. There are significant worries about how they might hurt the skin. According to research, parabens can cause several lousy skin effects, especially in people with damaged or weak skin. For example, research has shown that parabens can get deeper into the skin when put on skin that is already broken or irritated. This can cause more allergic responses and skin sensitization (Al-Halaseh et al., 2022). Parabens have been associated with allergic contact dermatitis, with data indicating their potential as sensitizers, especially in those with a history of skin allergies (Arafune et al., 2021). Parabens are recognized for their mild estrogenic action, raising concerns regarding their potential involvement in endocrine disruption. This has been associated with numerous health complications, including dermatological conditions and hypersensitivity reactions (Liu et al., 2023). Furthermore, according to some research, parabens may also cause allergic contact dermatitis and can make people more sensitive, especially those who already have a history of skin reactions (Cordeiro et al., 2022). Both consumers and manufacturers should consider these risks when paraben-containing items are used or made.

2.4.2 Phthalates

Phthalates are often used to make fragrances last longer and be more flexible in makeup. However, they have also been linked to several health problems. According to research, phthalates can mess up the endocrine system, which could cause problems with reproduction and growth (Fan et al., 2022). Moreover, phthalates can cause skin problems like itching and allergic reactions when absorbed through the skin, especially when found in personal care products like sunscreens, perfumes, and lotions (Mostafa & Shaaban, 2023). For example, the chemicals dibutyl phthalate (DBP) and diethyl phthalate (DEP) have been found in many cosmetics, which has raised concerns about how common their use is (Fan et al., 2022). As

people learn more about phthalates, more and more people and companies are switching to safer, phthalate-free alternatives in skincare items to prioritize health and safety.

2.4.3 Perfume

There are many compounds in perfumes, some of which might cause skin problems. Some skin sensitivities from these reactions include allergic and irritant contact dermatitis. Based on research, perfumes can cause skin reactions because of the chemicals they contain. For example, perfumes contain allergens that can cause allergic contact dermatitis, which is when the skin becomes red and itchy after exposure to these substances (Kumar et al., 2020). There have also been reports of cases of bullous impetigo-like irritant contact dermatitis, which shows how bad reactions can be after using perfume (Zhong et al., 2022). Furthermore, synthetic fragrance components such as polycyclic musks might interact with skin enzymes, which could disrupt hormones and cause additional skin concerns (Drejslarová et al., 2024). In conclusion, perfumes make products more appealing by giving them nice smells, but they can also irritate the skin, cause allergic reactions, and expose people to harmful chemicals. This shows how important it is for people to make smart buyer choices and be careful when using skincare products.

2.4.4 Toluene

A volatile organic substance called toluene is often used as a solvent in many industrial settings. However, it is very bad for your skin if people encounter it. The fact that toluene is part of the "Toxic Trio" in cosmetics, along with dibutyl phthalate and formaldehyde, makes its harmful effects on skin health even worse. These toxins are linked to several health problems, such as cancer and harm to reproduction (L & F, 2023). In particular, exposure to toluene has been linked to skin irritation and possibly becoming more sensitive, which can worsen skin problems (Goyal & Jerold, 2021). In conclusion, toluene's ability to damage the skin barrier, cause oxidative stress, and irritate the skin makes it important to be careful when using it at work or in cosmetics.

2.4.5 Mercury

Mercury is frequently used in skin-lightening lotions because of its propensity to prevent melanin production by interfering with the enzyme tyrosinase, which is required for melanin synthesis (Yawei et al., 2020). However, even small amounts of mercury can be terrible for your health. Concerning skin-lightening products, studies have shown that even small amounts of mercury (0.319 μg/g) can cause changes in important systems like the brain, liver, and

kidneys in animal models (Bamidele et al., 2023). Moreover, the body can also become sick from long-term exposure to mercury through skin treatments. This can cause nephrotic syndrome and nerve damage in the periphery (Yawei et al., 2020). In conclusion, the presence of mercury in skincare products poses serious health hazards, underlining the importance of strict laws, public awareness, and vigorous enforcement to protect consumers from its hazardous consequences.

2.5 Impact of Skincare and Baby Product Ingredient Analysis Scanner Applications

An ingredient scanner app or website for skin care and baby care products can make a huge difference by giving people easy access to accurate information. These tools make it easier to look at ingredients, which helps parents and consumers find substances that might be harmful and make wise choices. They can raise knowledge about how safe a product is, cut down on misleading advertising, and build trust by being open and honest. These tools support safer choices, boost customer confidence, and push companies to use cleaner, more ethical formulas to meet rising accountability demands. They do this by appealing to a wide range of people, even those who know little about technology.

One of these applications' primary goals is to teach people about the ingredients in skin care products. More and more research shows that people are learning about the effects of different ingredients, like ceramides and natural moisturizing factors (NMFs), which are known to help dry skin and improve the skin barrier (Yan et al., 2022). Using scanner apps makes it easier to find these helpful ingredients, so users can choose goods that help them reach their skincare goals. Furthermore, adding advanced delivery systems like dissolving microneedles has improved the transdermal release of active compounds. This shows how important ingredient selection is for getting the desired skin results (Sim et al., 2022).

In addition, the popularity of these scanner apps fits with a more significant trend in cosmetics to use natural and eco-friendly chemicals. Consumers are increasingly choosing goods containing marine-derived compounds and other natural ingredients known to have health benefits (Alves et al., 2020). For example, bioactive chemicals found in marine environments have anti-inflammatory and antioxidant capabilities, making them a good fit for skincare products (Alves et al., 2020). Consumers are more likely to buy products with these beneficial elements because scanner applications make it easy for them to identify such products.

According to studies, parents' trust in brands is a significant factor when choosing newborn care goods. Relying on trusted brands, which frequently offer more transparent ingredient information, can help reduce the high functional risk associated with these items (Pakkala & Bhat, 2023). Scanner apps can help parents trust brands more by providing in-depth evaluations of ingredients to make decisions based on safety and effectiveness instead of just how the brand is perceived. This supports the idea that being transparent about where ingredients come from can greatly impact customer behaviour, which is in line with research showing that parents like items they perceive as safe and of good quality (Pakkala & Bhat, 2023).

In conclusion, ingredient scanner apps or websites greatly benefit users by making it simple to get reliable information on cosmetics, personal care items, and infant care items. These tools are great for discovering what elements are suitable for users and what is bad for users, and they also help with transparency and making wise decisions. They help build trust in companies by holding them accountable and providing thorough reviews of ingredients, which aligns with the current trend toward natural and environmentally friendly formulas. In addition to promoting healthier options, these platforms help fill in information gaps and resolve safety concerns, encouraging producers to focus on cleaner, more ethically sourced, and more effective formulas to suit changing customer demands.

2.6 Challenges in Checking Skincare Ingredients

Users face several challenges when checking the chemicals in skincare products. These challenges include worries over the safety, effectiveness, and comfort of the substances, as well as the combination of natural and bioactive components. Therefore, it is vital to have trustworthy ingredient checkers since consumers want more knowledge about the components that are contained in the skincare products they purchase.

The difficulty of ensuring ingredients are safe and effective is a big problem. Many users do not know how to read ingredient lists, which can cause them to get the wrong idea about what some ingredients might do. For example, the review by Adu et al. talks about the benefits of biosurfactants in skin care products, pointing out that they are safer and better for your skin than regular chemical surfactants (Adu et al., 2020). On the other hand, the conversion to the use of biosurfactants presents difficulties in obtaining regulatory permission and educating consumers about the advantages and dangers associated with their use. Furthermore, introducing natural compounds, as highlighted by Dini and Laneri, raises

problems regarding the standardization and quality control of these components in cosmetic formulas (Dini & Laneri, 2021). The inconsistent performance of natural products can result from the unpredictability in the procurement of natural products, which makes the role of ingredient checkers more difficult. Ingredient checkers are tasked with providing reliable evaluations.

The effectiveness of skincare ingredient checkers is also heavily influenced by the user experience they provide. Existing solutions may not provide users with personalized information, which can lead to frustration among users. Specifically, Nguyen et al. highlight the need to comprehend the views of users and the requirement for dermatologists to provide patients with guidance about incorporating bioactive components into their skincare routines (Nguyen et al., 2020). This demonstrates that the currently available ingredient checkers are deficient, as they frequently offer general information rather than individualized recommendations. Furthermore, the usability of these tools is of the utmost importance; as Holmes et al. have pointed out, traditional usability testing techniques might not be able to effectively evaluate the one-of-a-kind issues presented by conversational user interfaces in healthcare applications, such as skincare.

In addition, the capabilities of ingredient checkers for skincare products could be enhanced by utilizing cutting-edge technologies such as artificial intelligence and machine learning. According to Wiedermann's research findings, symptom checkers have the potential to be enhanced in terms of their accuracy and dependability with the incorporation of constructive criticism from users and thorough research. (Wiedermann et al., 2023). This strategy might be used for skincare ingredient checks, which would enable real-time updates and individualized suggestions based on the user's input and preferences.

In conclusion, the skincare business is at a crossroads, confronting various issues that include the safety of the ingredients, the sustainability of the environment, the stability of the formulation, and compliance with the regulations. Researchers, formulators, and regulatory agencies must collaborate to address these difficulties. This is necessary in order to guarantee that skincare products are not only effective but also safe and responsible to the environment. As the level of consumer knowledge and the desire for transparency continues to climb, the industry must remain flexible to meet these expectations while simultaneously encouraging innovation in the formulation of products and the development of ingredients.

2.7 Challenges in Checking Baby Product Ingredients

Parents and caregivers have a hard time checking the ingredients in baby care products for many reasons, some of which are that the lists of ingredients are hard to understand, there is not a lot of information available, and caring for babies is emotionally taxing. To fully understand these problems, we need to look at the whole world of caregiving, especially considering the growing number of baby care goods on the market and the health effects that come with them.

One of the biggest problems caregivers face is that there is so much knowledge about product ingredients. Many baby care items have complicated formulas with fragrances, preservatives, and other chemicals that can be hard for caregivers to understand. For example, some ingredients in creams used for kids' health can significantly affect how well the skin's protection works, which could cause irritations or allergic reactions in babies (Kovács et al., 2020). There are worries about these products' safety because they have occlusives and stabilizers, especially for people with sensitive skin (Kovács et al., 2020).

Marketing is another important factor that businesses use to influence how their customers think and act. Brands that boast about how healthy their products are for kids' bodies might mislead concerned parents (Ji et al., 2023). According to a study, people often think that certain ingredients mean that something is professional and safe, which makes them miss possibly harmful additives (Ji et al., 2023). In the baby care industry, this trend is especially noticeable since parents are looking for safe and effective goods. However, they typically trust marketing promises and word of mouth more than scientific data (Pakkala & Bhat, 2023).

Additionally, the difficulty is complicated by socio-economic considerations that play a role in the decision-making process about purchases, as an analysis was carried out by Pakkala and Bhat (Pakkala & Bhat, 2023). shows that consumer behaviour about baby care products is greatly affected by many things, such as access to knowledge and socioeconomic status. Parents from lower-income families may not have easy access to resources that give them knowledge about safe product choices. This makes it even harder to figure out how to stay safe when it comes to ingredients.

In conclusion, due to the presence of complicated substances, a lack of knowledge, and marketing that is deceptive, parents and other caregivers confront major hurdles when evaluating newborn care products. A further barrier to making informed decisions is the existence of socioeconomic differences. Increased openness, education of caregivers, and more

stringent restrictions are all necessary components to guarantee the product's dependability and safety.

CHAPTER 3 METHODOLOGY

3.1 Introduction

This chapter discusses the methods employed to effectively finish the final year project. An appropriate and structured technique is crucial for designing an effective and functional system. The chapter digs into the Software Development Life Cycle (SDLC) and elaborates on the specific processes involved in this project's SDLC. It further includes the system and user requirements, proposed design elements such as the flowchart, context diagram, Entity Relationship Diagram (ERD), and interface design to ensure user-friendliness and functionality. Data was also collected through surveys to understand user needs and expectations for the system. Additionally, the chapter includes a Gantt chart to explain the project timeframe.

3.2 Software Development Life Cycle (SDLC)

The Software Development Life Cycle (SDLC) is a process that generates high-quality software at minimal cost and in the shortest time frame. The SDLC was chosen due to its flexibility and iterative nature, ensuring continuous refinement throughout the project. SDLC encompasses a structured framework for the development, modification, maintenance, and replacement of a software system. This project will employ a waterfall model methodology,

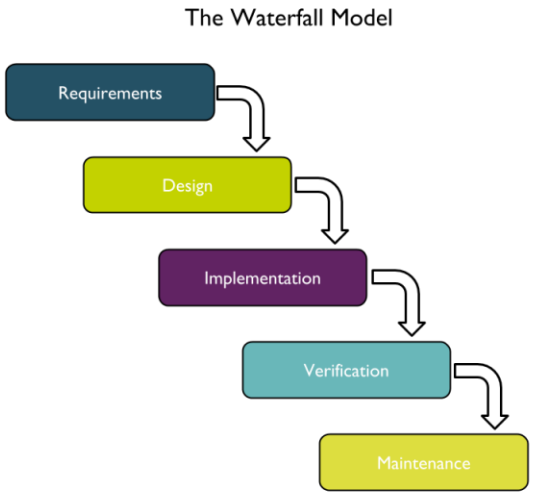


Figure 3.1 Phases in Waterfall Model

which consists of five phases which are requirements, design, implementation, testing, and maintenance.

3.2.1 Requirement Analysis

The Requirement Analysis phase concentrated on comprehending the needs of the target customers, including parents, those with sensitive skin, and health-conscious consumers. Surveys were administered to obtain insights into their difficulties in recognizing detrimental elements. Regulatory and toxicological databases, such as PubChem and EWG Skin Deep, were examined to create a systematic collection of hazardous compounds. The results were recorded as functional and non-functional needs, establishing the basis for later phases.

3.2.2 Design

System Design was the process of developing a comprehensive blueprint for the application. The operational flow was visualized by developing a flowchart, which emphasizes processes such as ingredient scanning, database querying, and the presentation of safety feedback. The database was structured using an Entity Relationship Diagram (ERD), which outlines ingredients, risk levels, and user profiles and their relationships. A context diagram was also generated to illustrate the interactions between users, the application, and external toxicological databases.

3.2.3 Implementation

During the implementation phase, the design will be turned into a functional app. The front end will be built with relevant technologies such as React Native or Flutter, while the database will be created using Firebase. Core capabilities such as component scanning, toxicity analysis, and risk level classification will be implemented to ensure the program achieves its goals. This project will be evaluated and reviewed numerous times to ensure all requirements are met.

In order to improve ingredient analysis, the system will also use machine learning techniques that are connected with a rich toxicology library. Users can input or scan a component list by the help OCR. Health hazards, such as endocrine disruption or skin irritation, will be considered for each ingredient and their toxicity level will be determined. Additionally, the system's risk assessment model will look at other component combinations to see if any interactions could enhance the danger. So, consumers can be certain that they are getting up-to-date information about the security of the product.

3.2.4 Verification

The verification phase guarantees that each project stage is under the Software Requirements Specification (SRS) and efficiently serves the users' needs. This comprises checking requirements for accuracy and practicality, validating the design with peer reviews of system architecture and wireframes, and confirming implementation with code reviews and functional tests. Verification guarantees that all requirements are entirely reviewed and bugs are fixed.

3.2.5 Maintenance

Finally, the maintenance phase will keep the application working and up to date by providing ongoing help. The toxicological database will be regularly updated with new ingredient entries, and user feedback will be constantly looked at to find ways to make things better. As part of maintenance, new versions of mobile operating systems will be tested to ensure they work with the app, and user ideas for new features will be added. This organized and step-by-step method ensures that the ToxiScan app is built quickly, meets user needs, and helps make personal care choices safer.

3.3 System Requirement

3.3.1 Hardware

Hardware Specifications are mentioned below, and the hardware involved is a laptop and mobile device. The laptop is used to code the system, while final testing will be run on the mobile device.

Table 3.1 Specifications of Laptop

Description	Specifications
Model	Acer Swift SF314-511
Processor	Intel Core i7-1165G7
Operating System	Windows 11
Graphic	Intel® Iris® Xe
Memory	16GB RAM
Storage	512GB

Table 3.2 Specifications of Mobile Device

Description	Specifications
Model	Vivo Y28s
Processor	2.4 GHz Dimensity 6300 Octa-core
Operating System	Android Version 14
Memory	8 + 8 GB RAM
Storage	256 GB

3.3.2 Software

The software used in methodology refers to the various tools and platforms that are utilized in the process of designing, developing, and managing a project in order to guarantee effectiveness and precision in the accomplishment of goals.

Development Tool

- Android Studio
- Flutter SDK
- Dart SDK

Database Management

- Firebase Realtime Database or Cloud Firestore

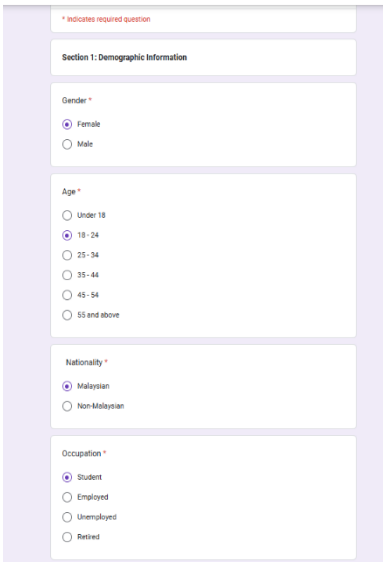
Design and Prototyping

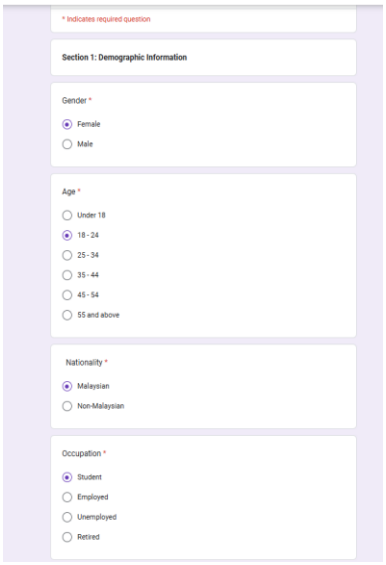
- Figma
- Draw.io

3.4 Data Collection

The ToxiScan project includes data collection using questionnaires to obtain insights into user needs and expectations. These surveys were conducted with two primary groups: Unimas students and the general public. The surveys focused on prospective users, encompassing parents, caregivers, and others concerned with ingredient safety. The emphasis was on determining favoured application attributes, obstacles encountered in comprehending product components, and anticipations for an intuitive interface. The survey findings informed the system design, ensuring the application effectively addressed customer pain areas and fulfilled their expectations.

Survey Form





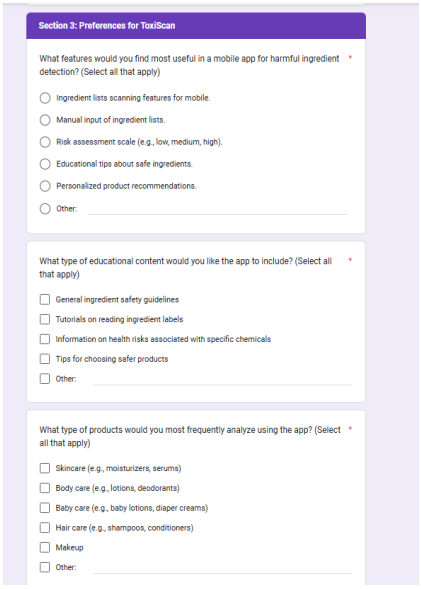


Figure 3.2 Google Form

The ToxiScan project's survey form is made to gather user preferences and demographic information so that the mobile app may be developed to identify potentially dangerous substances in personal care items. Information about the intended users, including their gender, age, country of origin, and profession, is collected by the form. In addition, it compiles data on the app's most popular features, including ingredient scanning, risk assessment, and individualized product suggestions. It explores the kinds of instructional information users would want and the product categories, such as skincare, baby care, and cosmetics, that consumers scrutinize the most. The information gathered will be vital in determining its layout and features for the app to successfully cater to its users' wants and requirements.

Requirement Analysis Chart

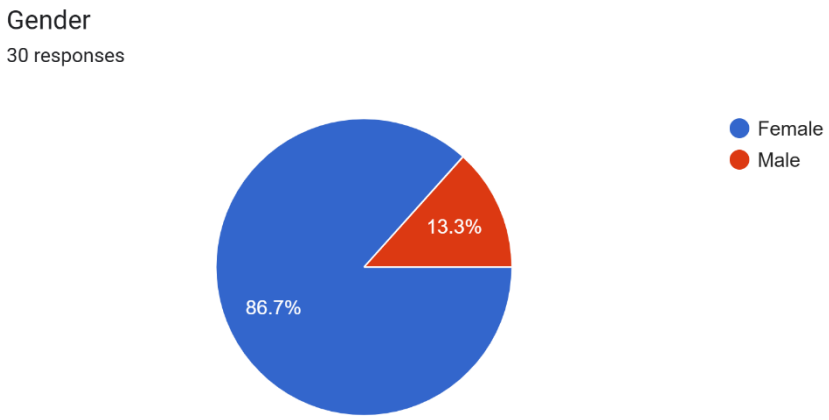


Figure 3.3 Pie Chart of The Gender

The graphic illustrates the gender distribution of 30 survey participants, indicating that 86.7% are female, depicted by the blue segment, whilst 13.3% are male, indicated by the red segment. This signifies that a substantial majority of female respondents were in the study. According to the data received from both Unimas student and public respondents, the study appears to have a mostly female user base, which could indicate that the target audience is primarily female.

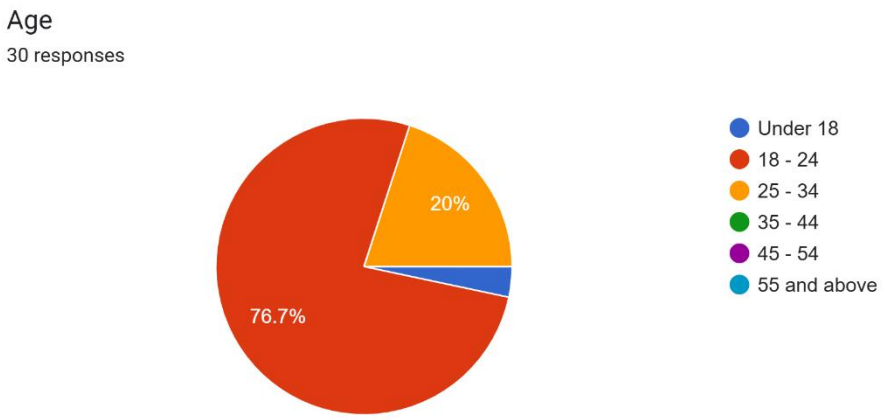


Figure 3.4 Pie Chart of the Respondent Age

The ToxiScan application's pie chart reveals that a predominant 76.7% of the target audience is aged 18–24, indicating that young adults constitute the primary user demographic of the app. Twenty percent originates from the 25–34 age demographic, which continues to provide a substantial user base for your program. This age-specific analysis underscores the necessity of customizing the app's functionalities, aesthetics, and educational materials to cater to the requirements and inclinations of younger users, who are typically more health-aware and technologically adept.

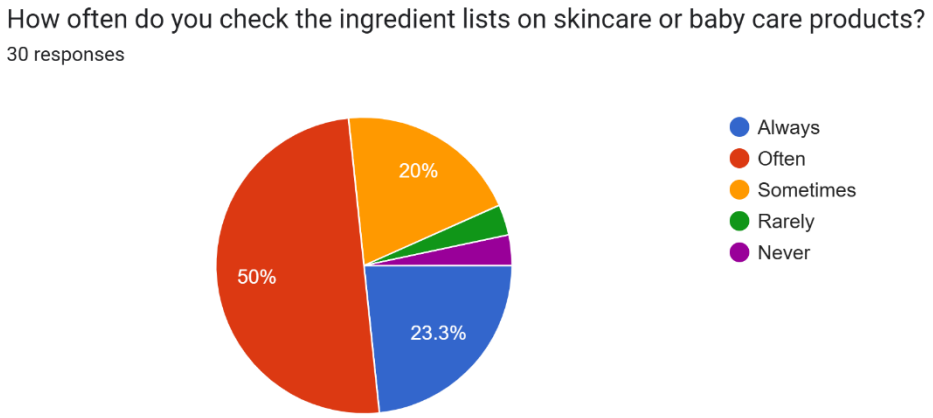


Figure 3.5 Pie Chart of Respondents Check the Ingredient Lists

The graphic illustrates the regularity with which individuals examine ingredient labels on skincare or baby care goods. The majority of participants, including students and the general public, indicate that they routinely examine ingredient lists. This indicates a widespread interest in comprehending product contents, rendering a tool for ingredient identification advantageous.

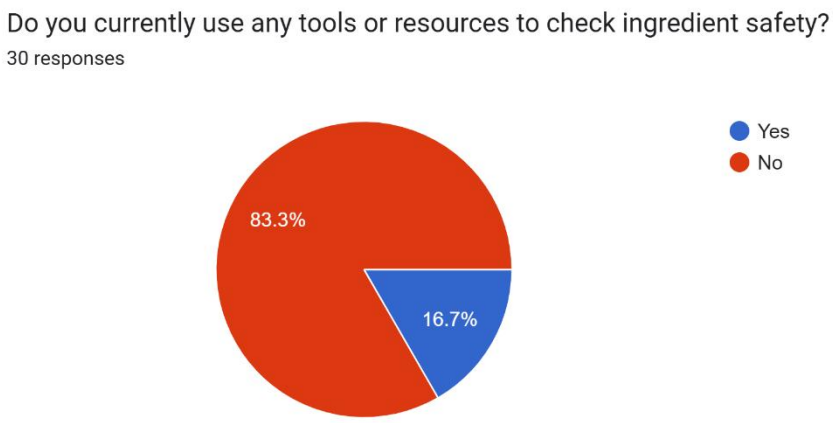


Figure 3.6 Pie Chart of Number of Respondent Use Tools

This pie chart illustrates the necessity of a technology such as ToxiScan. It reveals that there is a lack of knowledge or availability of resources for ingredient safety checks since the majority of people do not use any at the moment. ToxicScan could fill this need by offering a user-friendly solution that gives people more control over what they put into their bodies.

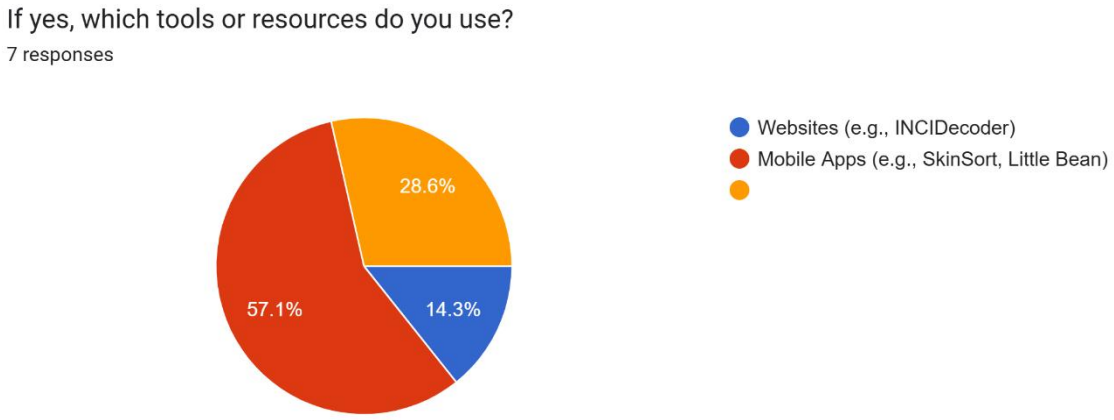


Figure 3.7 Type of Tools Use Pie Chart

This pie chart shows the distribution of resources or instruments used by individuals to check the safety of ingredients. While some respondents utilize both mobile apps and websites, the majority choose the former. This trend emphasizes the increasing dependence on mobile applications for convenience and accessibility. It suggests that a tool like ToxiScan, which is intended as a mobile app, would successfully serve user preferences and demands.

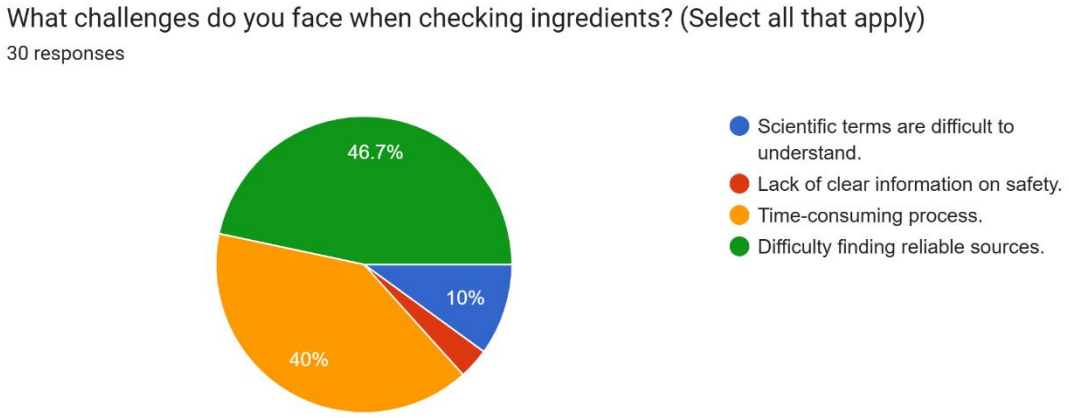


Figure 3.8 Challenges When Checking analyzs Pie Chart

This pie chart shows the most common problems individuals have when trying to verify the contents of a product. The most prevalent complaint is the difficulty locating trustworthy sources; subsequent complaints include the lengthy procedure and unclear safety instructions. A smaller percentage of people say they have trouble understanding scientific jargon. These findings highlight the importance of a tool such as ToxiScan, which may streamline ingredient testing by giving accurate, comprehensible, and user-friendly information.

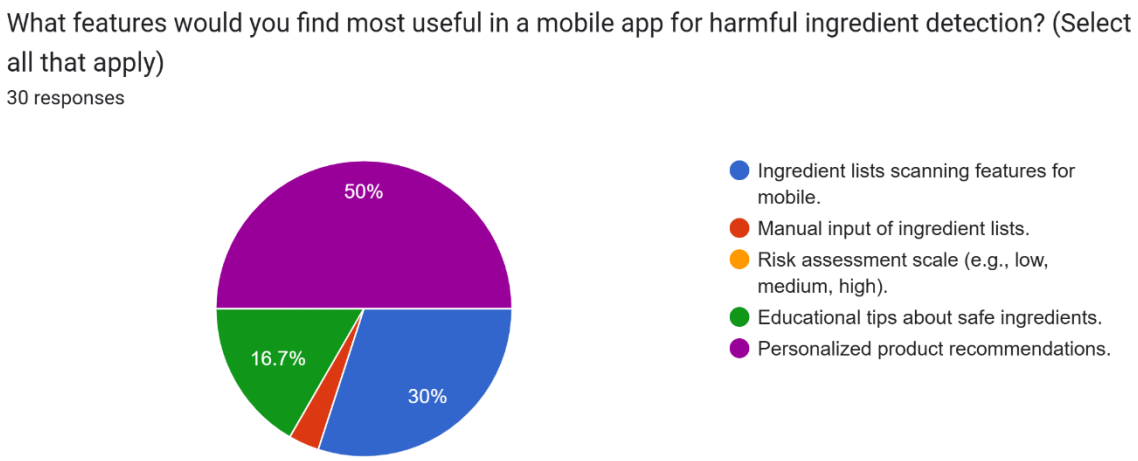


Figure 3.9 Most Useful Features Pie Chart

This pie chart illustrates the elements that users want in a mobile app that can detect dangerous ingredients. These features align with ToxiScan's goals. Given the significant preference for both features, ToxiScan's design should prioritize personalized product recommendations and ingredient list scanning. Incorporating capabilities to categorize ingredient safety levels aligns with the interest in risk assessment scales. ToxiScan will be a convenient, informative, and user-centric tool that satisfies user needs.

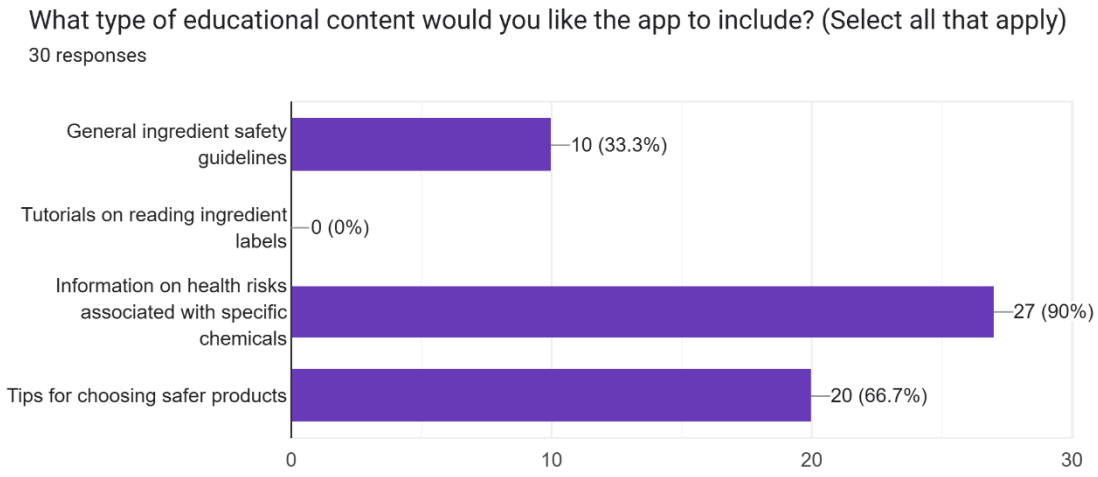


Figure 3.10 Respondent preferences Bar Chart

This bar chart highlights user preferences for ingredient safety educational content in a mobile app. After receiving advice on selecting safer products, most users indicated an excellent desire for details regarding the health hazards connected with individual chemicals. There was moderate interest in general ingredient safety standards, but no one attended lessons on how to read ingredient labels. Based on these findings, ToxiScan should focus on producing content that offers straightforward health information and practical guidance to increase its educational value.

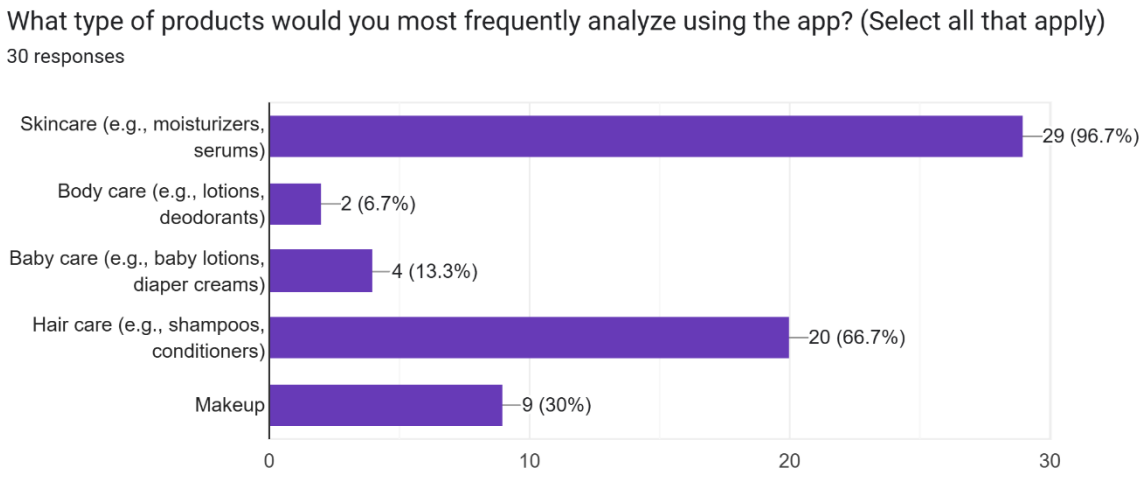


Figure 3.11 Bar Chart of Type of Product Most Frequently Analyze

This chart illustrates the categories of products that Unimas student and public are mostly inclined to evaluate using a mobile application such as ToxiScan. Skincare products, including moisturizers and serums, are the most commonly chosen category, succeeded by hair care items and cosmetics. There is relatively diminished interest in evaluating body care and baby care goods. The findings indicate that ToxiScan should prioritize skincare and hair care analysis while offering alternatives in other areas to meet varied customer requirements.

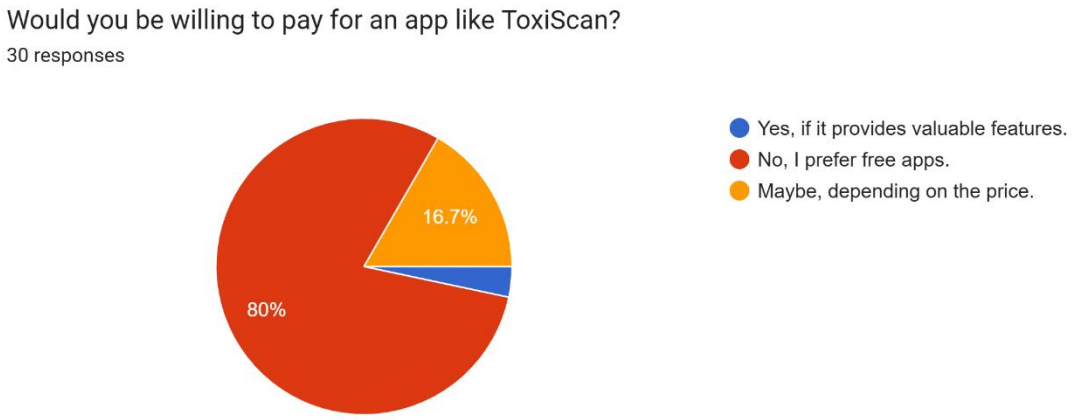


Figure 3.12 Pie Chart of Respondent Willing to Pay

The majority of participants want free applications, although a minority may contemplate payment contingent upon the cost. A limited cohort is willing to pay if the application offers valuable functionalities. These data indicate that although the majority of users prefer free access, providing premium features at a modest price may attract individuals inclined to purchase superior functionalities.

In conclusion, the survey offers significant insights into Unimas student and general public preferences, knowledge levels, and prospective areas for enhancement. The data will be crucial in enhancing the ToxiScan application, ensuring it addresses varied interests, attracts the audience successfully, and corresponds to the preferred characteristics of the respondents.

3.5 Proposed Design

ToxiScan's design guarantees a user-friendly, efficient system that provides precise ingredient safety analysis. It integrates multiple design components, such as a flowchart, context diagram, and entity-relationship diagram (ERD), to offer a clear visualization of the system's architecture and workflow. These components collectively inform the development and functionality of the mobile application.

3.5.1 Flowchart

Flowcharts are visual representations of processes, workflows, or systems that use arrows and symbols to show the order of operations and choices. It makes the system easier to comprehend and analyze by offering a clear and logical framework, which helps simplify complex procedures. Specifically, for ToxiScan, the flowchart shows the steps a user takes to scan ingredients, get product details, and manage their profiles, all with the goal of optimizing the system's workflow.

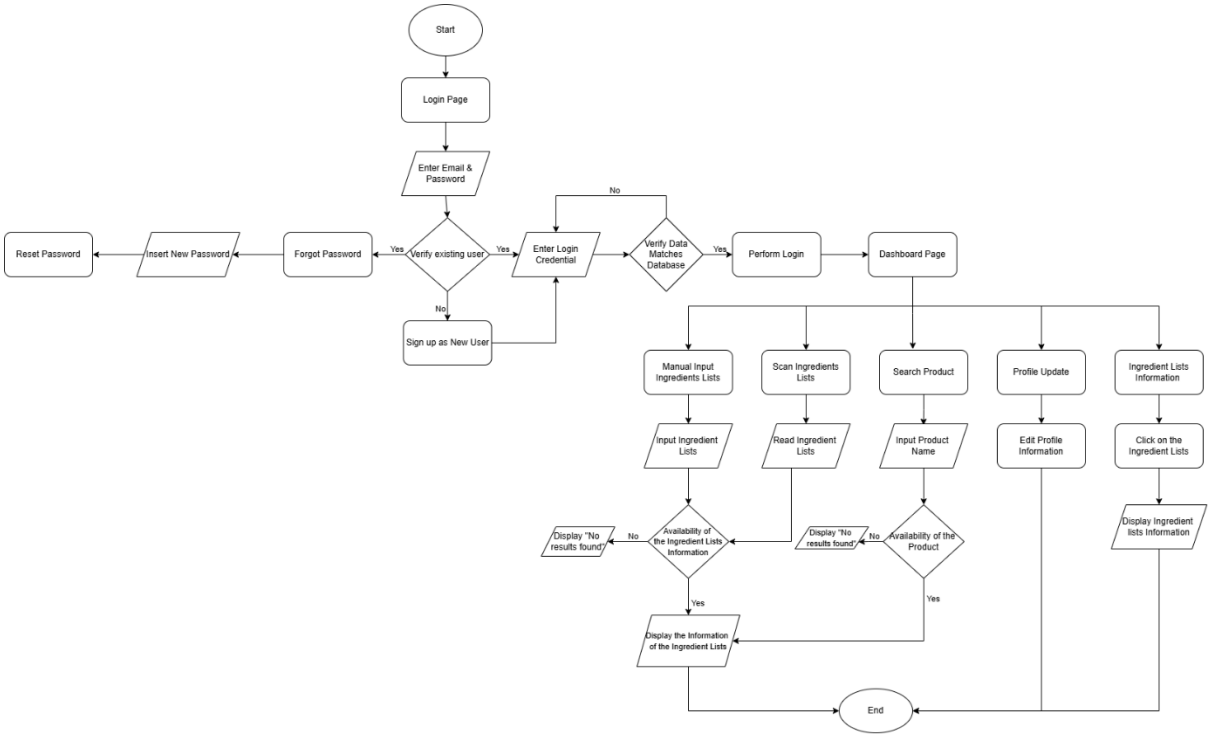


Figure 3.13 Flowchart of the System

3.5.2 Context Diagram

A context diagram shows the overall relationship between a system and its users, administrators, and databases, as well as the data that flows into and out of the system from these outside sources. Users interact with ToxiScan through login, ingredient scanning, and analysis results; administrators engage with ToxiScan through user comments, bug patches, and feature deployments; and regulatory databases communicate with ToxiScan through communication with ingredient data updates.

The database used in ToxiScan was not populated with real-world product ingredient data but was instead built based on considerable research and compilation of known compounds and their associated dangers. The data was acquired from publicly available regulatory sources such as PubChem and the EU Cosmetic Directive, guaranteeing that the rebuilt dataset appropriately represents real-world toxicity knowledge. This technique was important due to constraints in accessing comprehensive industry databases, providing for a regulated and structured data collection that corresponds with the system's objectives.

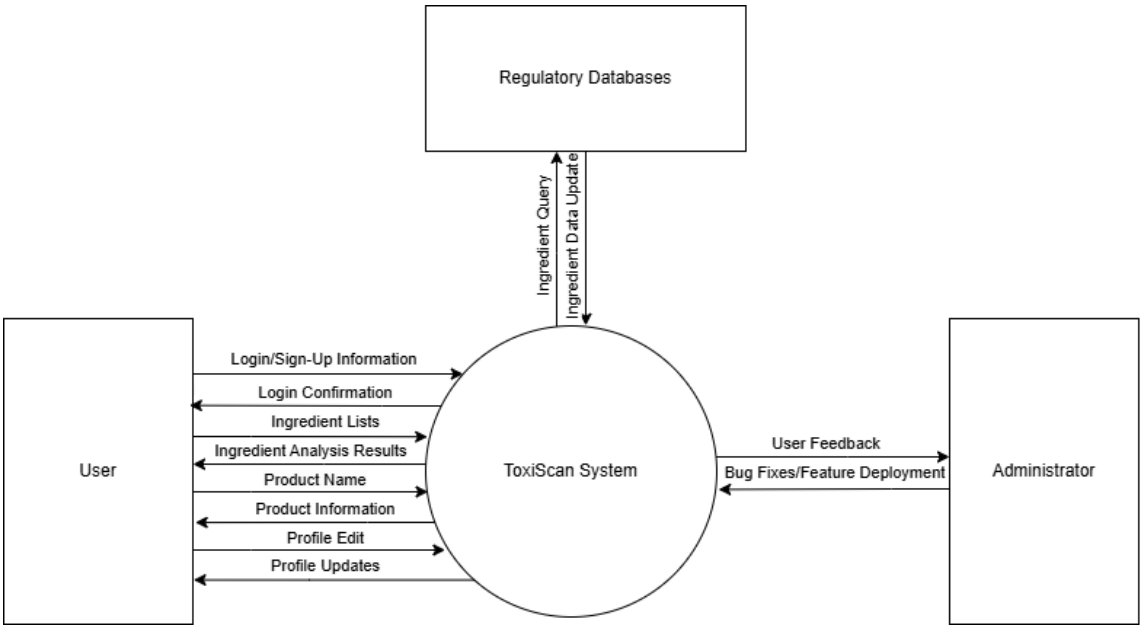


Figure 3.14 Context Diagram

3.5.3 Entity Relationship Diagram

An Entity-Relationship Diagram, also known as an ERD, is a graphical representation of the data structure in a system. It displays entities (such as User, Product, Ingredient, and Scan), their attributes, and the relationships between them in order to ensure that data management is both organized and efficient. In this diagram, the ToxiScan system links users, their scans, and product ingredient details in order to provide safety analysis and results.

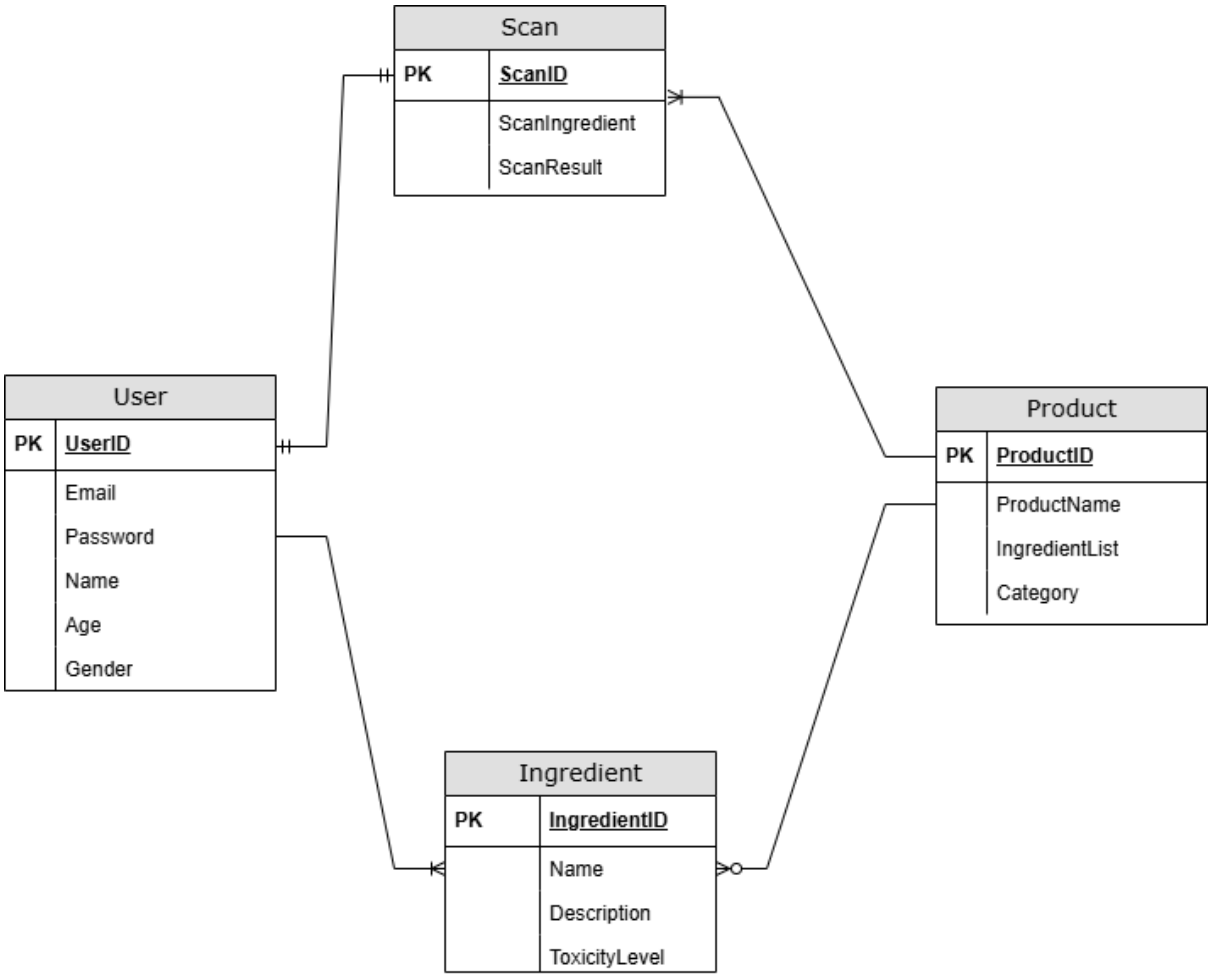


Figure 3.15 Entity Relationship Diagram

3.6 Interface Design

Interface design entails ensuring that a system's visual arrangement and interactive components are user-friendly and comprehensible. The interface design of ToxiScan emphasizes a clean and user-friendly layout. It encompasses functionalities such as login/signup interfaces, ingredient scanning, search capabilities, and user profile management to ensure users can efficiently use the application and accomplish their tasks.

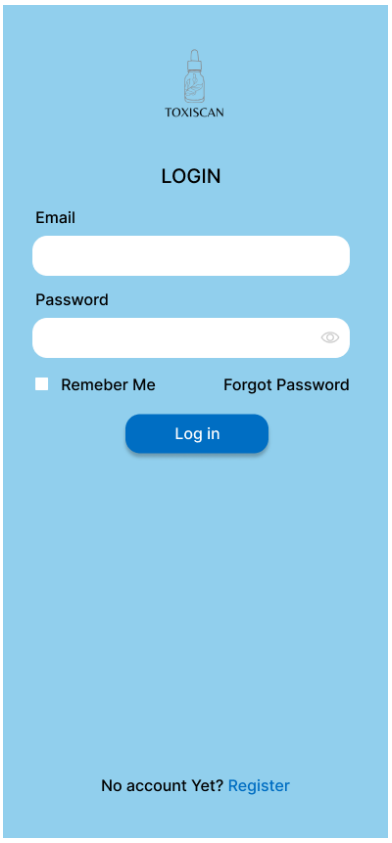


Figure 3.16 Login Page

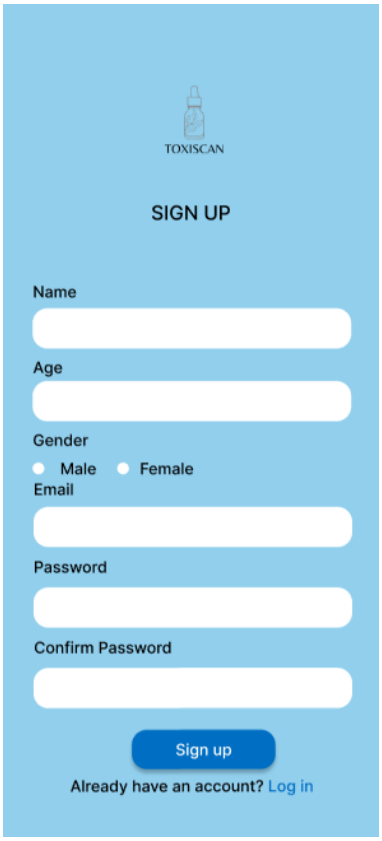


Figure 3.17 Signup Page

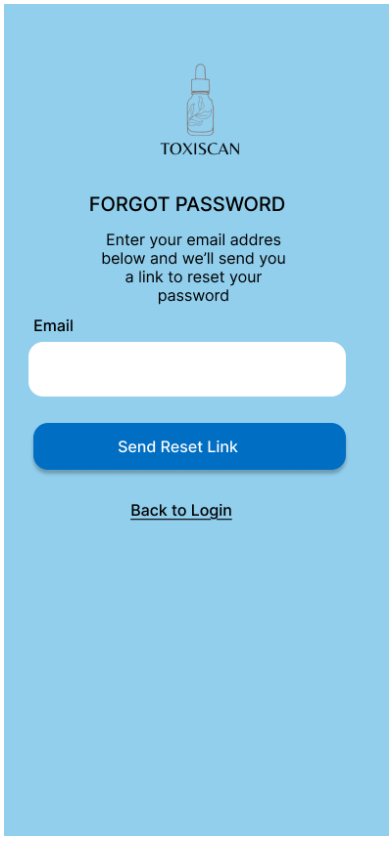


Figure 3.18 Forgot Password Page

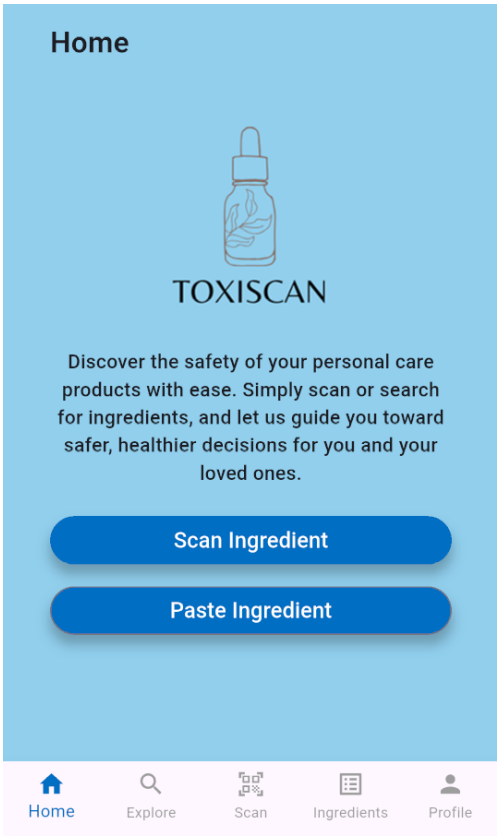


Figure 3.19 Forgot Password

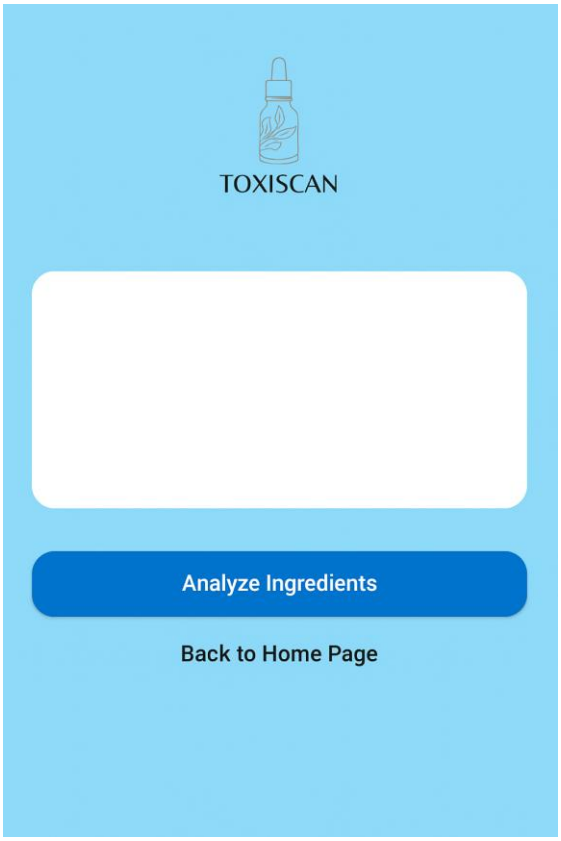


Figure 3.21 Paste Ingredient Page

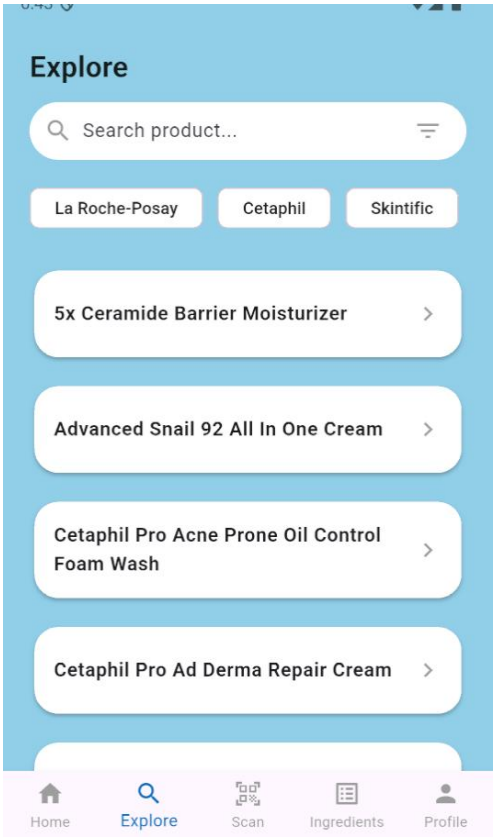


Figure 3.20 Explore Page

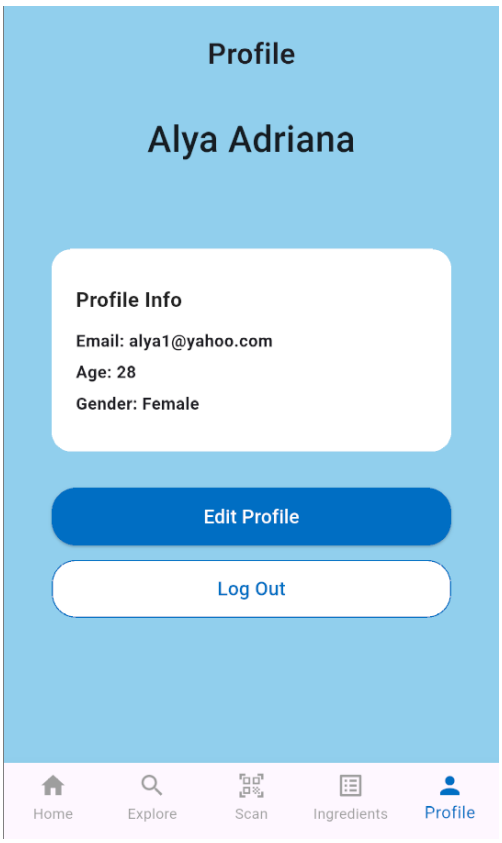


Figure 3.25 Profile Page

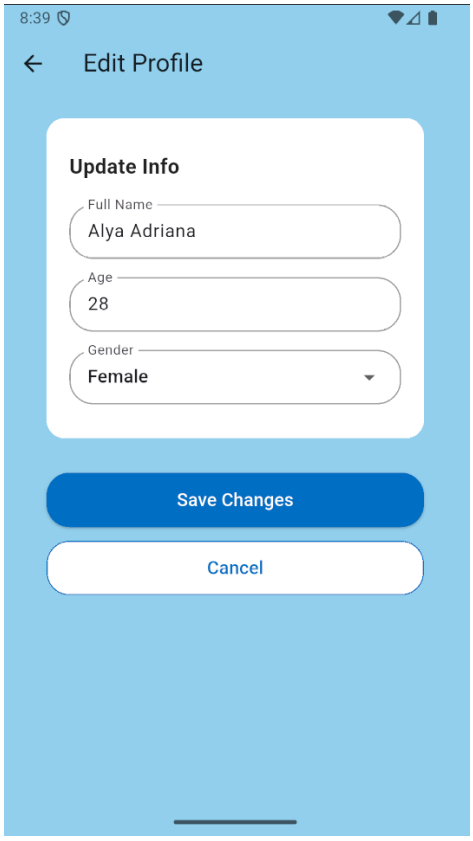


Figure 3.22 Edit Profile Page

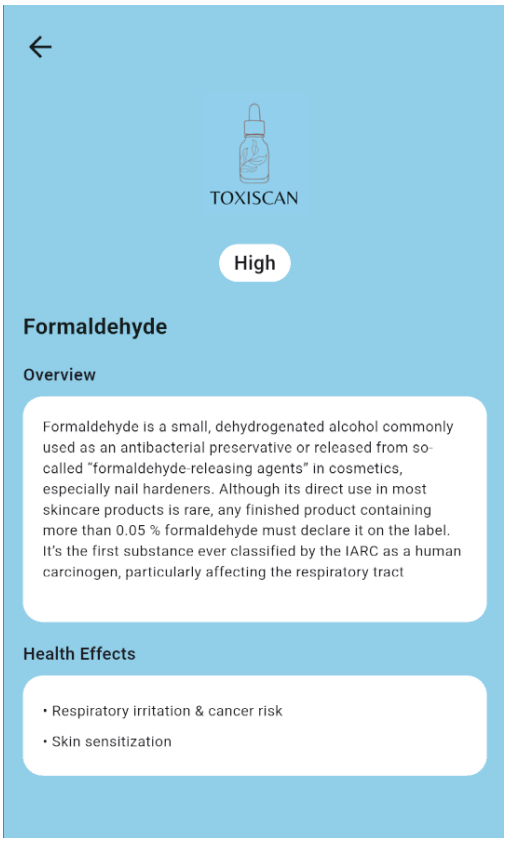


Figure 3.24 Ingredient Info Page

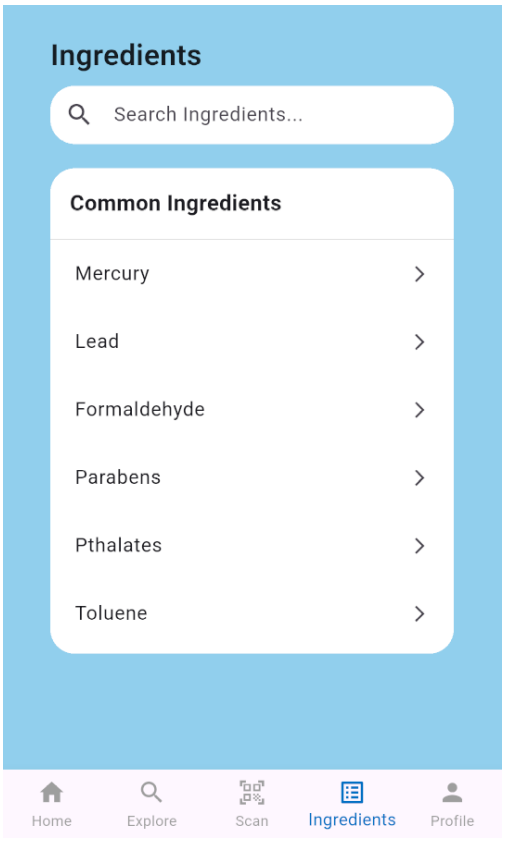


Figure 3.23 Ingredient Page

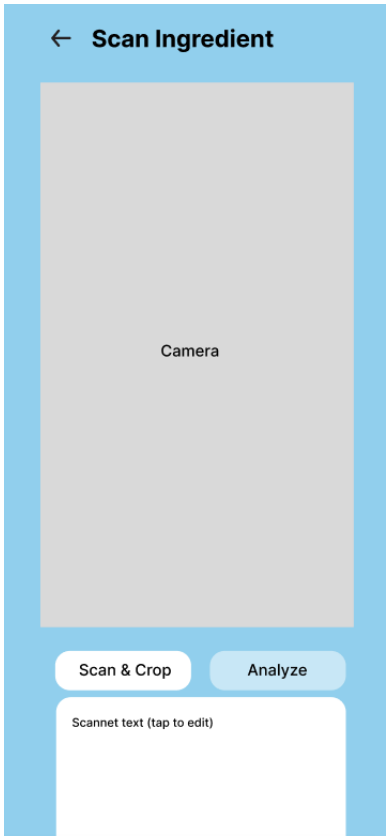


Figure 3.26 Scan Page

CHAPTER 4 IMPLEMENTATION

4.1 Introduction

This chapter goes into more detail about how the ToxiScan project, which is called "ToxiScan: A Smart Harmful Ingredient Detection Mobile Application," was put into action. It outlines the methodology and planning steps that were discussed in Chapter 3. This chapter talks about both the system's physical and logical implementation. It goes into detail about how the system was built, how the database was added, and how the main features, like scanning ingredients and figuring out risks, were coded. The chapter also talks about the technologies, programming languages, frameworks, and software tools that were used during creation. Each step in this phase is based on the proposed design and aims to turn the theoretical design into a mobile app that works perfectly.

4.2 Implementation

This chapter discusses the implementation of the ToxiScan mobile application based on the methods outlined in Chapter 3. ToxiScan is created to assist users, especially health-conscious adults and parents, in identifying dangerous substances in cosmetics, body and baby care products. The system is meant to evaluate component lists and deliver real-time toxicity ratings, boosting product transparency and enabling safer customer choices.

The implementation phase transforms the suggested system design into a working application. The development approach includes front-end and back-end integration, database setup, an ingredient analysis module, and user interface functionality. It displays a user interface perspective.

4.3 Component Installation and Configuration

The system's UI is built using Android Studio's Dart and Flutter frameworks, offering a sleek, responsive design that makes navigating the app and accomplishing tasks a breeze. In order to control the local server environment and the database, Firebase are set up on the backend.

4.4 Public View

4.4.1 Sign Up Page

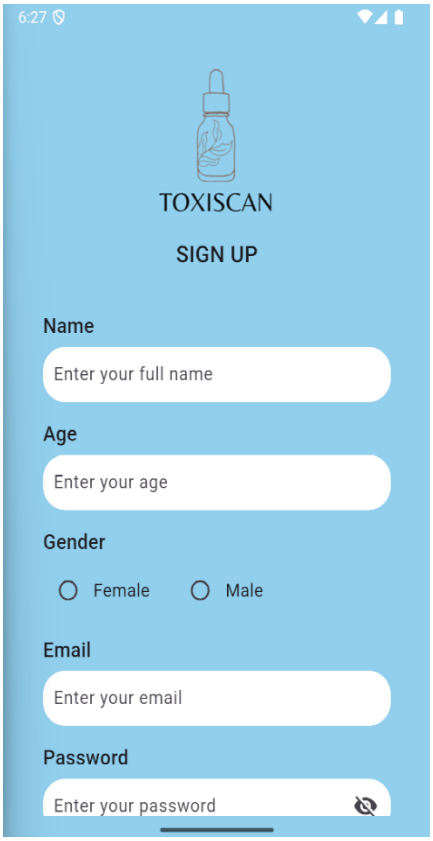


Figure 4.1 Signup Page

Figure 4.1 displays the Sign Up page of the ToxiScan mobile application, where new users are asked to input their email, password, name, age, and select their gender to create an account. This page guarantees that user-specific information is collected for a personalised experience and helps the system manage individual preferences and safety issues more effectively.

4.4.2 Log In Page

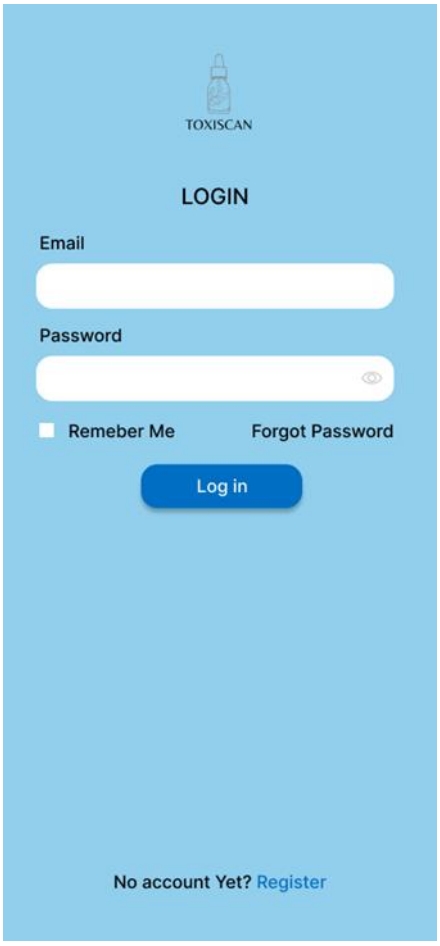


Figure 4.2 Login Page

After registration, the ToxiScan application's Log In page, shown in Figure 4.2, allows registered users to access their accounts by entering their email and password. The page offers features that make it easier and more accessible for users, such as remembering their login session and recovering forgotten passwords.

4.4.3 Forgot Password Page

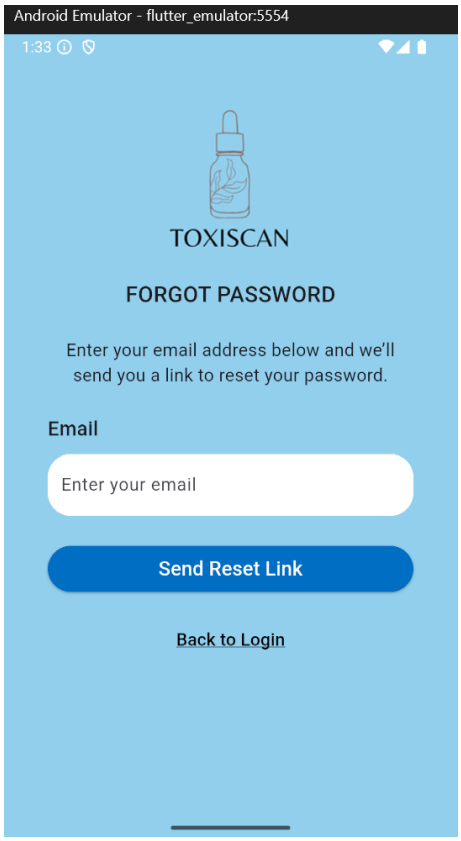


Figure 4.3 Forgot Password Page

If a user forgets their login information, they can typically retrieve access to their account using the "Forgot Password" option. Password reset links are sent to users' registered email addresses once an automated mechanism verifies their identification. By eliminating the need for complicated identification checks or direct support interaction, this flow strikes a good balance between security and ease when resetting passwords. Finally, it makes accounts accessible even if credentials are forgotten or lost, streamlines user self-service, and decreases help-desk burden.

4.4.4 Home Page

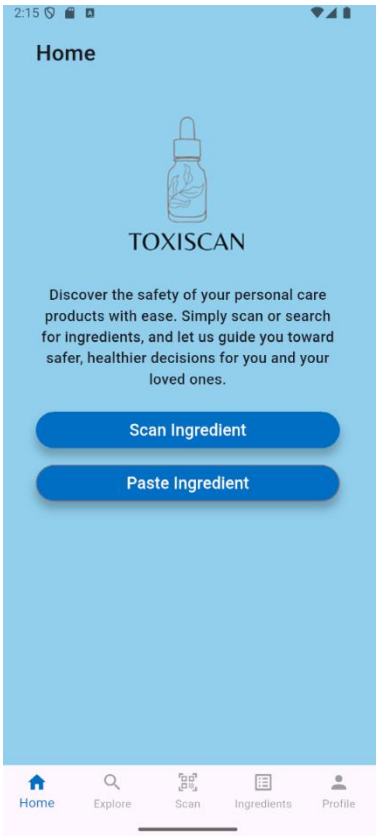


Figure 4.4 Home Page

After logging into the ToxiScan mobile app, the primary user interface appears on the Home Page, as shown in Figure 4.3. Using the two main choices, "Scan Ingredient" and "Paste Ingredient," Tap Scan Ingredient button and it will navigate to the Scan page. With a navigation bar for easy access to other important features and a brief description of the app's purpose to assist users in discovering dangerous substances and making safer personal care choices the website is well-designed.

4.4.5 Paste Ingredient Page

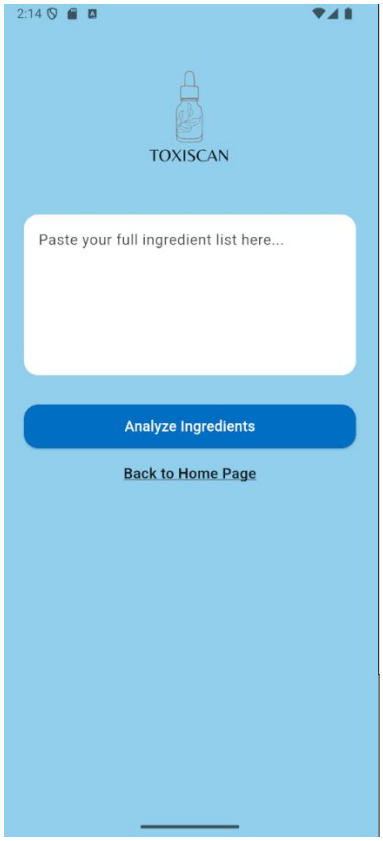


Figure 4.5 Paste Ingredient Page

In Figure 4.5 simply copy and paste all of your product's ingredients into the large text box on the Paste Ingredient page. Then, tap the Analyze Ingredients button to view the toxicity report for each ingredient and this will direct to Analyze Ingredient Page at figure 4.6. If the user decides not to continue, the user may go back to the home page by tapping the Back button. If the user simply has a text version of the product's ingredients, this is a fast way to verify if it is safe to use.

4.4.6 Analyze Ingredient Page

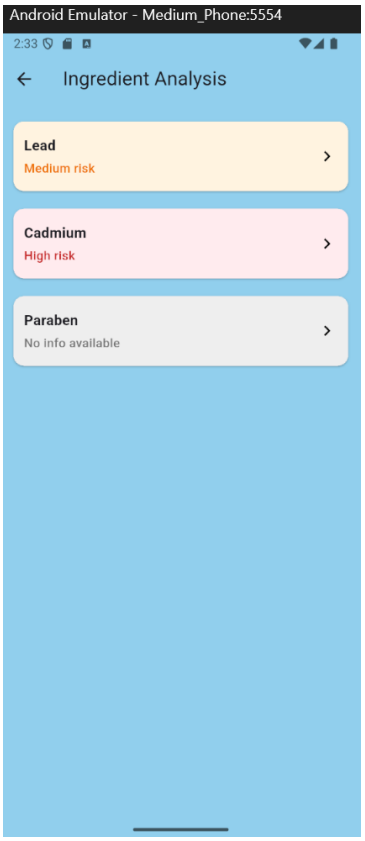


Figure 4.6 Analyze Ingredient Page

The Analyze Ingredient Page displays the toxicity risk levels of each ingredient that a user has either scanned or pasted into the application. Once the user taps the "Analyze" button, the app processes the ingredient list and classifies each item into risk categories such as High Risk, Medium Risk, or Low Risk, which are visually represented using colour-coded cards. Each card includes the ingredient name and its risk level, and users can tap any item for more detailed safety information which is it will navigate to the Ingredient Info Page. This page provides a clear and quick overview of potential health concerns, helping users make informed decisions about the safety of personal care products.

4.4.7 Explore Page

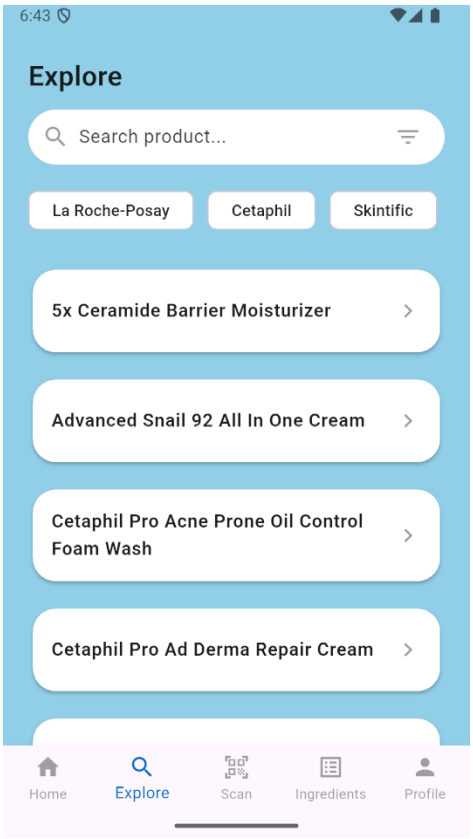


Figure 4.7 Explore Page

The figure shows the ToxiScan app's Explore Page, where users can look for the items. Users may easily check their ingredient analyses by browsing the product catalog and selecting items with an image placeholder and name. Users are able to more easily find particular products of interest thanks to the search bar at the top, which improves usability by allowing keyword-based searches.

4.4.8 Ingredients Detail Page

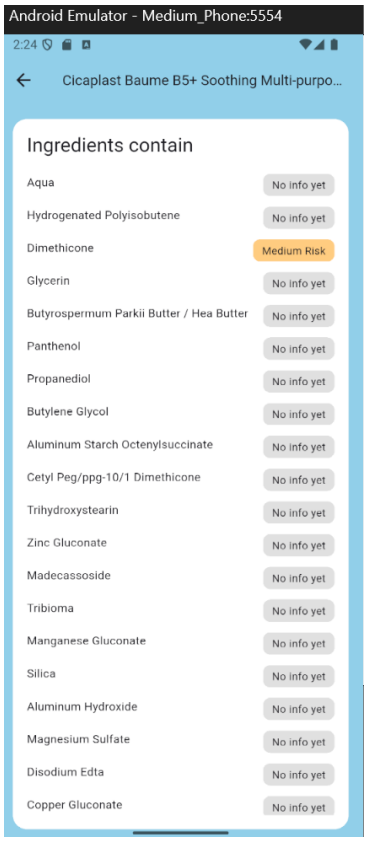


Figure 4.8 Ingredients Detail Page

The Ingredients Detail Page displays a comprehensive list of all ingredients contained in a selected product, as shown after tapping the product name from the Explore Page (Figure 4.7). Each ingredient is listed alongside its corresponding risk label such as High Risk,Medium Risk, Low Risk or No Info Yet, allowing users to assess the safety of individual components. This page provides a clear, scrollable view for users to examine ingredient transparency, especially helpful for identifying potentially harmful substances in complex formulations. It serves as a critical step in empowering users with detailed safety data before using or purchasing the product.

4.4.9 Scan Page

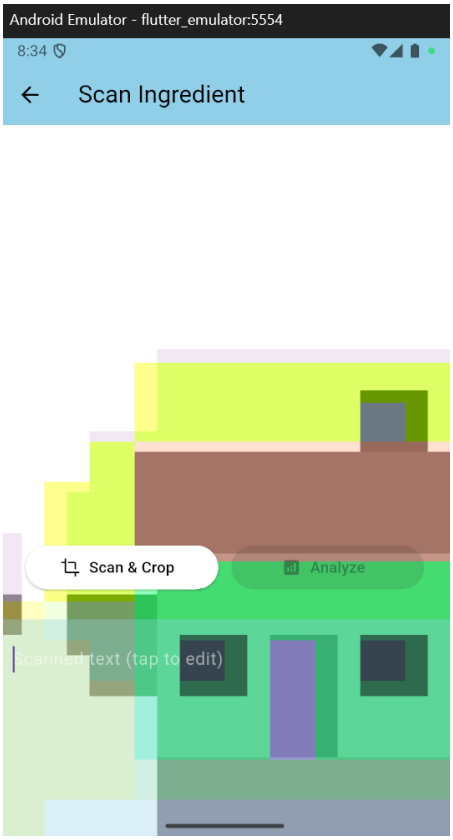


Figure 4.9 Scan Page

The Scan Page in the ToxiScan mobile application allows users to identify potentially dangerous ingredients in products for personal care by capturing and analyzing text from labels of products. The application employs Optical Character Recognition (OCR) technology via a "Scan & Crop" button, enabling users to photograph an ingredient list, crop the relevant section, and automatically extract information. The extracted text is shown in an editable box, enabling users to manually modify or correct any OCR inaccuracies just before selecting the "Analyze" button. Upon analysis, the application connects every component with a predefined toxicology database to categorize them by risk level, delivering real-time feedback. This function is particularly beneficial for health-conscious individuals and parents seeking a swift, accessible method for checking ingredient safety directly from the packaging.

4.4.10 Ingredients Page

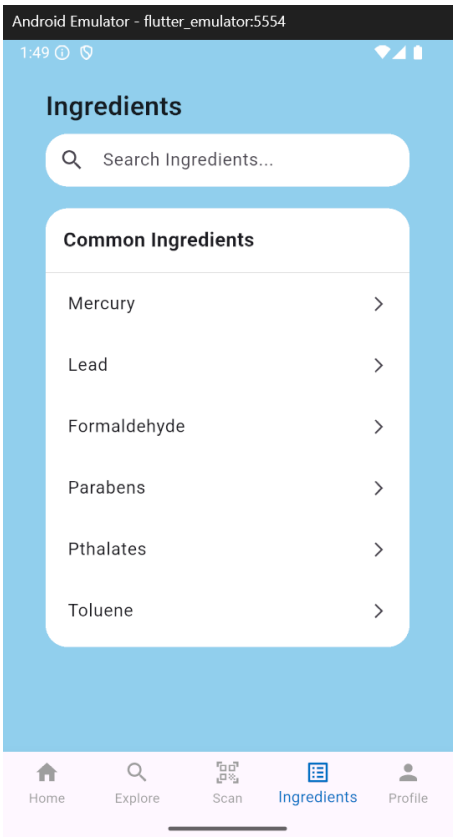


Figure 4.10 Ingredients Page

The ToxiScan app's Ingredients Page, shown in Figure 4.5, is a searchable of typical ingredients used in cosmetics and other personal care items. To identify particular ingredients, users can use the search box; alternatively, they can peruse the list to learn about potential health hazards and toxicity. Having a clearer picture of the component's safety level allows users to make more informed product selections.

4.4.11 Ingredients Info Page

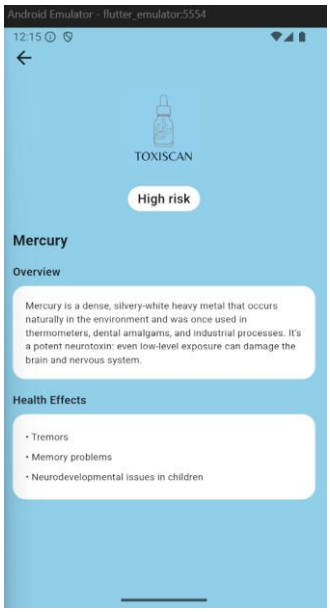


Figure 4.11 Ingredient Info Page

Figure 4.8 shows that when users tap on "Mercury" on the Ingredients Page Figure 4.7, a dedicated detail view opens. This view promptly warns users of the substance's high-risk status, provides a brief overview of its chemical properties and common uses, and lists its primary health effects. All of this is contained in one focused screen, allowing users to go from browsing to practical safety information with ease.

4.4.12 Profile Page

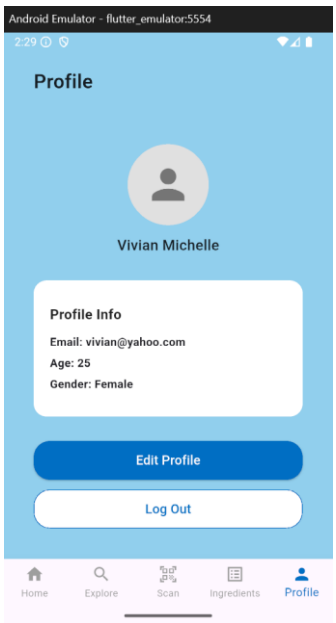


Figure 4.12 Profile Page

Users can access and update their details, such as full name, email, age, and gender, on the ToxiScan application's Profile Page (Figure 4.6). The user can make sure the data is up-to-date and secure by using the choices to modify their profile details or log out of the application on this page. To provide users more control over their account preferences, it has a minimalist design.

4.4.13 Edit Profile Page

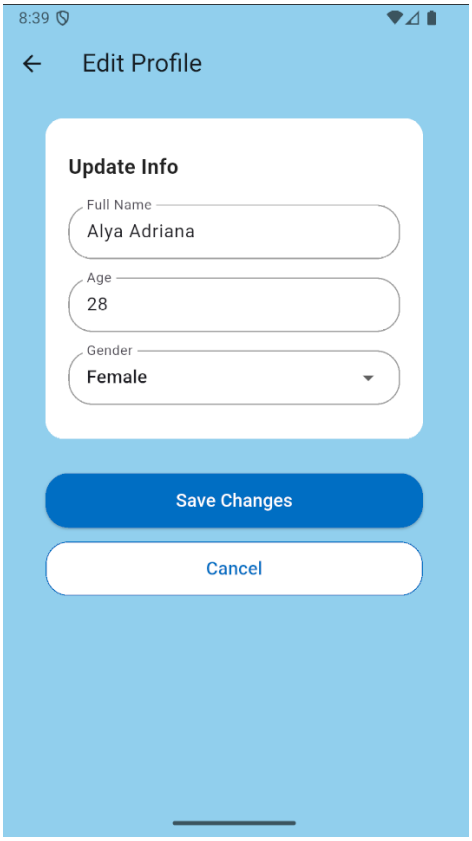


Figure 4.13 Edit Profile Page

The Edit Profile Page allows users to edit their details, including name, age, and gender, to make sure their profile remains correct and personalized. After making modifications, users can save the changed details, which are then mirrored on the main Profile Page and kept in the backend database. This feature promotes user control and guarantees that the app gives a personalized experience depending on the user's current data.

CHAPTER 5 TESTING

5.1 Introduction

The primary aim of functional testing is to verify that each element of the ToxiScan mobile application functions precisely as outlined in the Software Requirements Specification (SRS). This includes executing essential workflows user registration and authentication, text and image ingredient analysis, comprehensive ingredient lookup, and profile management to guarantee precise data management, appropriate UI feedback, and resilient error handling in both standard and edge-case scenarios. Functional testing thoroughly validates each user interaction and backend operation, establishing certainty that the application's logic, data flows, and interfaces perform reliably before its release.

Usability testing assesses ToxiScan from the end-user's perspective, emphasizing navigation ease, simplicity of on-screen instructions, and overall interface satisfaction. Representative users are seen executing essential tasks such as submitting an ingredient list for analysis or reviewing detailed component profiles to pinpoint any areas of confusion, excessive steps, or layout deficiencies. Metrics such as task-completion rates, time-on-task assessments, and qualitative feedback inform precise enhancements to button positioning, menu structure, labeling, and instructional text, guaranteeing that ToxiScan operates correctly while also providing a clear and efficient user experience.

5.2 Test Environment Setup

The testing phase was conducted using both physical and virtual environments. Devices used included a Vivo Y28s running Android 14 and Android Studio's emulator. The backend utilized Firebase Emulator Suite for testing Firestore and Authentication interactions. The application was tested under both Wi-Fi and offline scenarios to verify performance reliability.

5.3 Test Strategy

5.3.1 Functional Testing

Functional testing is a form of black-box testing that assesses the application's features for its functional requirements, neglecting its behind implementation. Functional testing thoroughly evaluates each user-facing action, including registration, login, ingredient search, and profile updates in ToxiScan, to verify that inputs provide the right and expected results. Testers build test cases based on the Software Requirements Specification, including standard,

limit, and error-handling scenarios, and later control them in an environment that closely resembles production. Functional testing verifies that all defined behaviors operate correctly under different circumstances by concentrating on the tasks the system accomplishes rather than the methods employed.

Functional testing involves several levels, including functional tests (assessing particular parts or functions), integration tests (evaluating interactions between modules, such as the OCR engine and the risk-classification service), system tests (checking thorough processes on the target device), and user acceptance tests (ensuring deliverables align with user expectations). Automated test suites efficiently execute failure scenarios to identify any unintentional negative impacts of new code, but manual investigation can reveal edge situations that scripted tests may overlook. Collectively, these layers of functional testing provide assurance that each feature operates as designed, data flows are consistent, and the application's fundamental logic withstands both normal and unforeseen usage.

5.3.2 Usability Testing

Usability testing is a method employed to assess a product by conducting tests with representative end users. In a usability test, users are instructed to do standard tasks, such as submitting a list of ingredients for evaluation or accessing a detailed view of an ingredient, while observers record any instances of confusion, errors, or delays. Usability testing prioritizes the ease and efficiency with which users achieve their objectives and their level of satisfaction, rather than assessing technical accuracy. Sessions may be held either in-person or remotely, utilizing think-aloud protocols where participants describe their thoughts during tasks and screen recordings to track navigation patterns, stops, and incorrect clicks.

Essential metrics gathered during usability testing encompass task-completion rate (the proportion of users who successfully complete a specified task), time-on-task (the duration required), error rate (the quantity and nature of errors), and subjective satisfaction scores (typically obtained through standardized tools such as the System Usability Scale). Qualitative feedback from consumers regarding confusing labels, button positioning, or visual confusion informs specific design enhancements. Through the iterative refinement of prototypes or live features informed by actual user insights, teams guarantee that the end result is not only functionally accurate but also easy to use efficient, and pleasurable for the target audience.

5.4 Test case

Table 5.1 Test Case for User Login

Module: Login Testing Objective: To verify login with valid login credentials								
Test Case ID	Test Scenario	Test Steps	Input Data	Expected Result	Actual Result	Status (Pass/Fail/Not Executed/Suspended)	Defect Severity	Notes
TC-L1	User login into the input fields with valid email and password	1. Users enter email and password on the text field 2. User click 'Login' button. 3. Verify entered email and password in the database	Email: ali@gmail.com Password: Hello123@	• The system grant access to the user to login. • The profile of the user will show at the profile page.	User logged in, profile displayed	Pass	Low	
TC-L2	User login into the system with incorrect email or password	1. User enter incorrect password and email in the input field 2. User click on the 'Login' button. 3. Verify entered email and password in the database.	Email: ali@gmail.com Password: Hello123@	• A message 'Wrong email or password' will be displayed	Error message "Wrong email or password" shown correctly	Pass	Medium	
TC-L3	Empty email and password fields	1. Open app 2. Leave email and password fields empty 3. Tap "Login" button	[Empty fields]	• A message 'Please enter your email' and 'Please enter you password' will be displayed	Warning: "Please enter your email" and "password" displayed	Pass	Medium	
TC-L4	Invalid email format	1. Open app 2. Enter malformed email (e.g., ali#mail.com) 3. Enter valid password 4. Tap "Login" button	Email: ali#mail.com Password: Hello123@	• Message: "Enter a valid email address."	Message "Enter a valid email address" shown	Pass	Low	
TC-L5	Password field visibility toggle	1. Open app 2. Enter password 3. Tap eye icon to toggle visibility	Password: Hello123@	• Password switches between masked and visible	Password visibility toggled between	Pass	Low	

					masked and plain text			
TC-L6	Remember Me session feature	1. Open app 2. Enter valid credentials 3. Tick "Remember Me" 4. Tap Login 5. Reopen app	Email: ali@gmail.com Password: Hello123@	• User remains logged in redirected to Home Page automatically	App reopened and user session persisted	Pass	Low	

Table 5.2 Test Case for Forgot Password

Module: Login Testing Objective: To verify user is able to reset password								
Test Case ID	Test Scenario	Test Steps	Input Data	Expected Result	Actual Result	Status (Pass/Fail/Not Executed/Suspended)	Defect Severity	Notes
TC-FP1	Request a password reset with registered email	1. Tap "Forgot Password" 2. Enter registered email 3. Tap "Send Reset Link"	Email: ali@gmail.com	• Reset link sent to email Confirmation message displayed.	Reset link sent to email, confirmation displayed	Pass	Low	
TC-FP2	Request a password reset with an unregistered email	1. Tap "Forgot Password" 2. Enter unregistered email 3. Tap "Send Reset Link"	Email: notfound@gmail.com	• Display "No account found for that email. • " below the email field	Error: "No account found for that email" displayed	Pass	Medium	
TC-FP3	Enter empty input field	1. Open the app 2. Tap "Forgot Password" 3. Leave email field blank 4. Tap "Send Reset Email"	[Empty field]	• Display message "Required Email"	Warning: "Required Email" displayed	Pass	Low	
TC-FP4	Enter invalid email format	1. Open the app 2. Tap "Forgot Password" 3. Enter invalid format email 4. Tap "Send Reset Email"	Email: ali#gmail	• Message: "Please enter a valid email."	Error message: "Please enter a valid email" displayed	Pass	Low	

Table 5.3 Test Case for Signup Page

Module: Signup Testing Objective: To verify that users can register successfully, and input validation works for various conditions.								
Test Case ID	Test Scenario	Test Steps	Input Data	Expected Result	Actual Result	Status (Pass/Fail/Not Executed/Suspended)	Defect Severity	Notes
TC-S1	Successful User Sign Up	4. Tap 'Register' on the login page. 5. Enter a valid email 6. Enter a strong password meeting policy (8+ chars, mixed case, number). 7. Fill in required profile fields (name, age, gender). 8. Tap Sign Up.	Email: ali@gmail.com Password: Hello123@ Name: Ali bin Abu Age: 23 Gender: Male	• The account is created. • User will be navigate to log in page and display "Registered successfully."	Account created, redirected to login	Pass	Medium	
TC-S2	Sign Up with Invalid Email	4. Tap 'Register' on the login page. 5. Enter an invalid email. 6. Enter a valid password and fill other fields. 7. Tap Sign Up.	Email: ali@gmail.com Password: Hello123@	• Inline validation shows "Please enter a valid email address."	Message: "Please enter a valid email address" shown	Pass	Low	
TC-S3	Sign Up with Weak Password	5. Tap 'Register' on the login page. 6. Enter a valid email. 7. Enter a weak password. 8. Fill other fields. 9. Tap Sign Up.	Email: ali@gmail.com Password: 123	• Inline validation shows "Password must be at least 6 characters"	Message: "Password must be at least 6 characters" shown	Pass	Low	
TC-S4	Empty mandatory fields	1. Tap "Register" 2. Leave one or more fields blank 3. Tap "Sign Up"	[Empty fields]	• Inline validation: "Please enter your name", "Please enter your age"," Please enter your email", "Password must be at least 6 characters"	Inline messages for all missing fields appeared	Pass	Low	
TC-S5	Duplicate email	1. Tap "Register"	Email: ali@gmail.com	• Message display "Email already in use"	Error: "Email already in use" shown	Pass	Medium	

	registration	2. Enter already-registered email 3. Fill all fields 4. Tap "Sign Up"						
TC-S6	Mismatched passwords	1. Tap "Register" 2. Enter password 3. Enter different confirm password 4. Enter all field 5. Tap "Sign Up"	Password: Hello123@ Confirm: Hello321@	• Inline message: "Passwords do not match."	Message: "Passwords do not match" shown	Pass	Low	

Table 5.4 Test Case for Home Page

Module: Home Page Testing Objective: To verify the correct display and functionality of UI elements, navigation, and overall layout on the Home Page.								
Test Case ID	Test Scenario	Test Steps	Input Data	Expected Result	Actual Result	Status (Pass/Fail/Not Executed/Suspended)	Defect Severity	Notes
TC-HP1	Navigation to all bottom navigation bar	1. Login app 2. On Home page, tap on every bottom navigation bar	-	• Navigate to 'Explor page', "Scan page", "Ingrdients Page", "Profile Page"	All navigation tabs load their respective pages successfully	Pass	Low	
TC-HP2	Button for "Scan Ingredient" and "Paste Ingredient"	1. Login app 2. On Home page, tap on every bottom navigation bar	-	• Able to navigate to "Scan Page" and "Paste Ingredient Page"	Buttons navigate to Scan Page and Paste Ingredient Page correctly	Pass	Low	
TC-HP3	Bottom Navigation bar visibility	1. Login app 2. View bottom navigation bar	-	Icons for Home, Explore, Scan, Ingredients, and Profile are visible and clickable	Navigation bar is fully visible and all icons are responsive	Pass	Low	
TC-HP4	Instructional text visibility and clarity	1. Login app 2. Observe every text and logo	-	• Text is clear, grammatically correct, and clearly explains the purpose	Texts and logo are visible, grammatically correct, and informative	Pass	Low	

Table 5.5 Test Case for Paste Ingredient Page

Module: Paste Ingredient Page Testing Objective: To verify that all UI elements are able to navigate and work as intended.								
Test Case ID	Test Scenario	Test Steps	Input Data	Expected Result	Actual Result	Status (Pass/Fail/Not Executed/Suspended)	Defect Severity	Notes
TC-PI1	Paste ingredient list and analyze	1. Login app 2. Navigate to Paste Ingredient page 3. Paste valid ingredient list 4. Tap “Analyze Ingredients”	“Mercury, Lead, Pthalates”	• Analysis result page is displayed showing each ingredient with correct risk classification	Analysis result screen displayed with risk levels for each ingredient	Pass	High	
TC-PI2	Leave input field blank	1. Login app 2. Navigate to Paste Ingredient page 3. Leave text box empty 4. Tap “Analyze Ingredients”	[Blank]	• Error SnackBar appears: “Please enter the ingredient list before analyzing.”	Error snackbar “Please enter the ingredient list before analyzing” appeared	Pass	High	
TC-PI3	Navigate back to Home page	1. On Paste Ingredient screen 2. Tap “Back to Home Page” link	-	• User is redirected to the Home Page	Tapping “Back to Home Page” redirects to Home Page	Pass	Low	
TC-PI4	Analyze with extra whitespace/typos	1. Paste ingredients with random spaces or typos 2. Tap “Analyze Ingredients”	“ Mercury, Paraben, ”	• Trims whitespace, ignores blanks, and returns valid results for recognized items	App trims whitespace and handles typos correctly; result returned	Pass	Medium	

Table 5.6 Test Case for Explore Page

Module: Explore Page Testing Objective: To verify that the search, filter, and navigation functions operate correctly, allowing users to efficiently find and access detailed information about products based on ingredient safety.								
Test Case ID	Test Scenario	Test Steps	Input Data	Expected Result	Actual Result	Status (Pass/Fail/Not Executed/Suspended)	Defect Severity	Notes
TC-EP1	Search by product keyword	1. Login app 2. Tap on the Explore tab in the bottom navigation bar. 3. Tap on the search bar labeled “Search product…”.	“Ceramide”	• Only products with "Ceramide" in title should be displayed	Products containing “Ceramide” are displayed in search results	Pass	Medium	

		4. Enter the keyword “Ceramide”. 5. Tap the Search button on the keyboard.						
TC-EP2	Open product detail	1. Login app 2. Navigate to Explore Page 3. Tap a product card.	-Product Card: “5X Ceramide Soothing Toner”	• Navigate to product detail page showing full ingredient analysis	Ingredient profile page opened correctly	Pass	Medium	
TC-EP3	Invalid search keyword	1. Login app 2. Navigate to Explore page 3. Enter "xyznoname123" 4. Tap Search	"xyznoname123"	• No results found message displayed	Message shown: “No product found”	Pass	Low	
TC-EP4	Filter reset behavior	1. Login app 2. Navigate to Explore Page 3. Apply filter 4. Clear filter	Filter: sort reset	• Product list returns to full unfiltered state	Clearing filters resets the product list to default view	Pass	Low	
TC-EP5	Filter product by La Roche Posay, Skintific, Cetaphil, Filter reset after deselecting brand, Filter + Search Combination	1. Login app 2. Navigate to Explore Page 3. Test each of brand by tap each button.	Tap brand button	• Show products listed in the brand tap.	Products are filtered by brand buttons; filter + search works as expected	Pass	Medium	

Table 5.7 Test Case for Scan Page

Module: Scan Ingredient Page Testing Objective: To verify search functionality, filter control, and navigation to product detail.								
Test Case ID	Test Scenario	Test Steps	Input Data	Expected Result	Actual Result	Status (Pass/Fail/Not Executed/Suspended)	Defect Severity	Notes
TC-SP1	Successful image capture and crop	1. Login the app 2. Navigate to Scan tab 3. Tap Scan & Crop 4. Capture a product ingredient label 5. Crop the image as needed 6. Verify scanned text appears in the text area	Image of label (e.g., ingredient list on lotion)	• OCR correctly extracts and displays text in editable area. • Able to crop the image.	OCR engine captured and displayed ingredient text successfully after crop	Pass	Medium	
TC-SP2	Analyze scanned ingredients	1. Login app 2. Navigate to scan tab or tap Scan Ingredient button	Scanned text: “Parabens, Phthalates, Mercury”	• Each ingredient is analyzed and labeled with a risk level	System labeled all recognized ingredients by correct toxicity level	Pass	High	
TC-SP3	Edit scanned text manually	1. Login app 2. Navigate to scan text 3. Scan and crop the image 4. Tap scanned text area 5. Modify or correct OCR results manually 6. Tap Analyze	Edited text: “Lead, Formaldehyde”	• Manual input accepted and analyzed accurately	Manual input in editable box was accepted and analyzed accurately	Pass	Medium	

Table 5.8 Test Case for Ingredient Page

Module: Ingredients Page Testing Objective: To verify that users can search, browse, and navigate to detailed safety information for common ingredients listed in the app accurately and efficiently.								
Test Case ID	Test Scenario	Test Steps	Input Data	Expected Result	Actual Result	Status (Pass/Fail/Not Executed/Suspended)	Defect Severity	Notes
TC-IP1	Search for an existing ingredient	1. Login 2. Tap on Ingredients tab 3. Tap on search bar 4. Enter "Formaldehyde"	Keyword: "Formaldehyde"	• Filtered result showing only "Formaldehyde"	"Formaldehyde" displayed correctly in search results	Pass	Low	
TC-IP2	View ingredient detail	1. Login 2. Navigate to Ingredient tab 3. Tap on the ingredient to view detail	"Pthalates"	• Navigates to Ingredient Info page	Tapping "Phthalates" opened its detailed info page	Pass	Low	
TC-IP3	Scroll through full list	1. Login app 2. Open Ingredients tab 3. Manually scroll down through entire list	-	• All ingredients load smoothly, no crash or lag	Full list scrollable without UI lag or crash	Pass	Low	

Table 5.9 Test Case for Profile Page

Module: Profile Page Testing Objective: To ensure that the Profile Page correctly displays user information, allows profile editing, and handles logout functionality securely and accurately.								
Test Case ID	Test Scenario	Test Steps	Input Data	Expected Result	Actual Result	Status (Pass/Fail/Not Executed/Suspended)	Defect Severity	Notes
TC-PP1	View user profile information	1. Launch app 2. Log in 3. Tap on Profile tab	User logged in as: alya1@yahoo.com	• Name, email, age, and gender are correctly displayed	User's name, email, age, and gender displayed correctly	Pass	Low	
TC-PP2	Edit user profile information	1. Login app 2. Navigate to Profile Page 3. Tap Edit Profile 4. Change name and age 5. Tap Save	New Name: Alya A. Age: 29	• Profile page shows updated info after saving	Profile info updated and reflected immediately on screen	Pass	Medium	
TC-PP3	Log out from the application	1. Login app 2. Navigate to Profile Page 3. Tap Log out button	-	• Redirects to login screen; user session cleared	Tap on "Log Out" redirected user to Login Page, session cleared	Pass	Low	
TC-PP4	Edit with invalid data	1. Login app 2. Navigate to Profile Page 3. Tap Edit Profile 4. Enter invalid age (e.g., -5) 5. 3. Tap Save	Age: -5	• Validation error message displayed	Validation error shown for negative age input	Pass	Medium	

5.5 System Quality Attribute

5.5.1 Functionality

Functionality indicates the degree to which the software system executes its specific duties accurately and satisfies the given requirements. ToxiScan includes essential functionalities, including ingredient scanning, toxicity level analysis, user profile management, and user input validation (e.g., empty fields or duplicate email addresses). It verifies that the application executes its intended functions smoothly and without mistakes.

5.5.2 Reliability

Usability indicates the simplicity and ease with which users interact with the application. It includes the clarity of UI elements, navigation design, and the user experience for new users. For ToxiScan, this includes the ease with which users can navigate between screens, comprehend instructions, and use capabilities such as “Scan & Crop” or “Paste Ingredient” without requiring technical knowledge.

5.5.3 Efficiency

Efficiency refers to the speed and resourcefulness with which the application executes tasks while enhancing performance. This includes application response time, memory consumption, and CPU performance. In the context of ToxiScan, efficiency was evaluated by assessing navigation speed and application responsiveness, particularly on lower-end devices.

5.5.4 Usability

Usability indicates the ease and intuitiveness with which users engage with the application. It includes the clarity of user interface elements, navigation design, and the experience for new users. For ToxiScan, this includes the ease with which users navigate between screens, understand instructions, and use features such as “Scan & Crop” or “Paste Ingredient” without demanding technical knowledge.

5.6 System Quality Attributes Test Cases

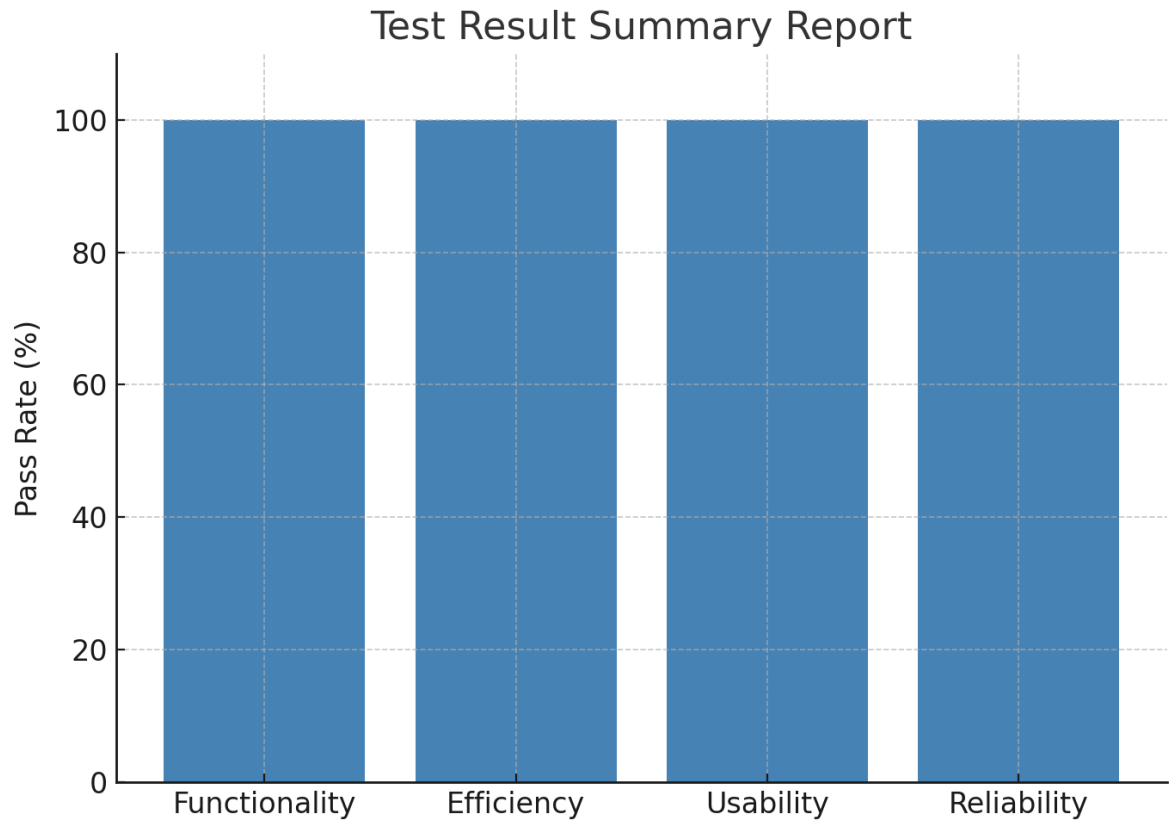
Table 5.10 System Quality Attribute Test Cases

Test Case ID	Quality Attribute	Test Scenario	Test Steps	Input Data	Expected Result	Actual Result	Status	Severity
TC-QA 1	Usability	Navigation between pages	1. Login an 2. Tap all tabs: Home, Explore, Scan, Ingredients, Profile	-	All pages load correctly	As expected	Pass	Low
TC-QA 2	Usability	UI readability	1. Visit each screen 2. Observe labels/buttons	App screens	Clear, easy-to-read text	As expected	Pass	Low
TC-QA 3	Usability	First-time user scan experience	1. Login app 2. go to Scan page	No instructions	User understands flow without guidance	Users complete task without help	Pass	Medium
TC-QA 4	Reliability	Invalid login	1. Launch app 2. Enter wrong email & password	Email: test@wrong.com	Show error message	Displays error	Pass	Medium
TC-QA 5	Reliability	Repeated scans return consistent output	1. Login page 2. Tap on Paste Ingredient Button 3. Paste same ingredients multiple times	Mercury, Paraben	Same analysis each time	Consistent result	Pass	Low

TC-QA 6	Reliability	Scan malformed input	1. Login app 2. Tap on Paste Ingredient button 3. Paste 'abcd1234@!#' and Analyze	Wrong input	Show ‘No i	Error handled gracefully	Pass	High
TC-QA 7	Reliability	Use app without internet	1. Disconnect Wi-Fi 2. perform scan	No internet	Show offline error or fallback	Handled correctly	Pass	Medium
TC-QA 8	Functionality	Analyze valid ingredients	1. Login app 2. Nabigate to Scan Page 3. Paste list 4. Tap Analyze	Mercury, Lead	Show toxicity results	Works correctly	Pass	High
TC-QA 9	Functionality	Edit and save profile	1. Login app 2. Navigate to Profile Page 3. Tap edit page 4. Change name and age	Name: Ali, Age: 23	Updates reflect correctly	Saved and shown	Pass	Medium
TC-QA 10	Functionality	Submit blank ingredient list	1. Login app 2. Tap Paste Ingredient button 3. Leave field empty 4. Tap analyze	[Blank]	Show validation error	Error shown	Pass	High
TC-QA 11	Functionality	Add duplicate	1. Launch app	Email: existing@gmail.com	Error: Email	Validation works	Pass	Medium

		email during sign-up	2. Register with existing email		already in used			
TC-QA 12	Efficiency	Test response speed for navigation	1. Login app 2. Switch tabs quickly	None	Transitions <2s	Smooth performance	Pass	Low

5.6.1 Test Result Summary Report



nl

Figure 5.1 Test Result Summary Bar Chart

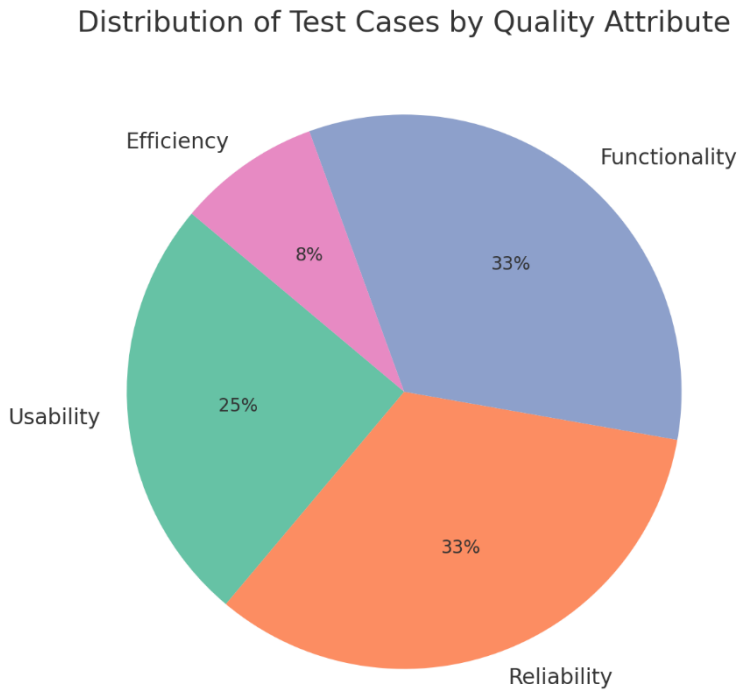


Figure 5.2 Distribution of Test Cases by Quality Attribute
Pie Chart

This distribution illustrates a balanced strategy emphasising key program functionalities and system reliability, while also validating basic performance and usability. Enhancing efficiency testing in future iterations could lead to a more accurate evaluation of system optimisation and scalability.

CHAPTER 6 CONCLUSION AND FUTURE WORKS

6.1 Introduction

This chapter provides a summary of the ToxiScan mobile application, including a discussion of how successfully the project met its goals, a discussion of the limitations that were faced, and a discussion of ideas for improvements that could be implemented in the future.

6.2 Objective and Achievement

Objectives	Achievements
To design predefined rules and an integrated database of known harmful, potentially harmful, and safe ingredients to provide toxicity analysis of cosmetic and personal care products.	Built a Cloud Firestore ingredient collection with many ingredient documents classified as high, medium, or low risk.
To develop the mobile application interface with user data interactivity, such as user input for toxic ingredient screening.	Created a Flutter front end featuring text- and image-scan input methods, user authentication via Firebase Auth, and real-time toxicity feedback. Designed intuitive UI screens for ingredient results and profile settings, all syncing live with Firestore.
To evaluate and test the integration of the interface with the database to ensure functionality, accuracy, and user effectiveness in identifying toxic ingredients.	Ran unit, integration, and end-to-end tests against the Firestore emulator no critical bugs found.

6.3 Limitation

Considering these achievements, certain limits arose. The ingredient database, although broad, does not include every unusual or newly introduced ingredient, resulting in occasional "unknown" outcomes. Our OCR engine, which uses Tesseract, encounters difficulties with unusual fonts, curved labels, and inadequate lighting, leading to misinterpretations that may result in incorrect toxicity classifications. ToxiScan presently supports only Android smartphones, so restricting accessibility for iOS users and limiting potential market reach.

6.4 Future Work

To address the problems and enhance ToxiScan's functionality, we suggest other upgrades. Automating database updates through the scheduled intake of regulatory and open-source ingredient data from agencies such as the FDA and EU Cosmetic Regulation would guarantee accurate, current coverage. Enhancing the OCR pipeline with a hybrid deep-learning model integrating the Vision API with Tesseract and implementing multi-language normalization will improve accuracy across various label formats. Transferring the application to iOS (via Flutter's cross-platform compatibility) will widen the user the population, while adding individualized risk profiling (enabling users to indicate allergies or sensitivities) will customize toxicity feedback to meet individual requirements. A cloud-based analytics dashboard for administrators will facilitate real-time monitoring of scan patterns, misinformation reports, and ingredient popularity, informing product enhancements and public health initiatives.

6.5 Conclusion

ToxiScan illustrates that a smartphone application using both rule-based systems and machine learning can effectively provide real-time toxicity evaluations for chemicals in personal care items. The project accomplished its main objectives by developing an intuitive interface, integrating regulatory-compliant databases, and implementing a dependable ingredient scanning and categorization engine. The application demonstrated its effectiveness in deciphering ingredient lists through OCR, offering users particularly parents and health-conscious consumers practical safety information.

Despite its achievements, the present version of ToxiScan displays limits. The toxicological database, while thorough, may not include all unusual or newly introduced chemicals, occasionally giving inconclusive results. The OCR module, using the software, encounters difficulties with flawed or low-resolution images, which negatively impact scanning precision. Furthermore, the application is exclusively accessible on Android devices, so it ignores a significant iOS user demographic and constrains its widespread uses. These constraints highlight opportunities for enhancement in both technical effectiveness and platform usability.

Future improvements may significantly improve ToxiScan's functionality. Automating database updates from reputable bodies such as the FDA and EU Cosmetic Directive will guarantee accurate and up-to-date ingredient coverage. Enhancing the OCR pipeline with hybrid AI models may improve text recognition precision across various label formats. Extending to iOS and facilitating user-specific risk profiling would enhance the app's

inclusivity and personalization. These enhancements position ToxiScan to develop into a comprehensive platform for ingredient safety knowledge and digital health empowerment.

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Appendix

Appendix A