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**Intelligent System for Nutritional Analysis and Food Label
Compliance Based on an Enriched Food Database**

in front of the committee:

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Dedication

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LIST OF ABBREVIATIONS

ANSES : National Agency for Food, Environmental and Occupational Health & Safety

CE : European Commission

CXS : Codex Standard

DGCCRF : Directorate-General for Competition, Consumer Affairs and Fraud Prevention

FAO : Food and Agriculture Organization

FDA : Food and Drug Administration

IANOR : Algerian Standards Institute

INFOODS : nternational Network of Food Data Systems

ISO : International Organization for Standardization

OMS : nternational Organization for Standardization

ONSSA : National Office for Food Safety

UE : Union Européenne

WHO : World Health Organization

OGM : Genetically Modified Organism

QR : Quick Response

NFC : Near Field Communication

kcal : Kilocalorie

% AR : Percentage of Reference Intakes

Nutri-Score : Simplified nutritional labelling system

CIN : Computers, Informatics, Nursing

CTCPA : Technical Centre for the Preservation of Agricultural Products

INRAE : French National Institute for Agricultural Research, Food and the Environment

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Résumé

Dans un contexte marqué par l'augmentation des maladies chroniques liées à l'alimentation en Algérie, l'amélioration de la qualité de l'information nutritionnelle représente un levier essentiel pour promouvoir une alimentation saine et renforcer l'assurance qualité des produits alimentaires. DZSain est une application mobile innovante développée pour accompagner les consommateurs dans l'évaluation de la qualité nutritionnelle des aliments commercialisés sur le marché algérien. L'application permet d'analyser les produits alimentaires par lecture du code-barres GS1-13 ou par reconnaissance des informations figurant sur l'étiquette. Son système d'évaluation repose sur la méthodologie EWG Food Scores, qui combine la qualité nutritionnelle, le degré de transformation industrielle et la présence d'ingrédients ou d'additifs potentiellement préoccupants afin d'attribuer un score global de qualité. La base de données de DZsain a été constituée à partir de produits disponibles sur le marché algérien et vérifiée conformément aux exigences de la réglementation nationale relative à l'étiquetage alimentaire. Dans une approche intégrant les principes de l'assurance qualité et de la nutrition personnalisée, les résultats obtenus sont croisés avec le profil sanitaire de l'utilisateur (diabète, hypertension artérielle, dyslipidémie, insuffisance rénale, maladies inflammatoires chroniques de l'intestin et allergies alimentaires) afin de fournir des recommandations adaptées et des alertes ciblées. Cette approche contribue à améliorer la fiabilité de l'information nutritionnelle, la gestion des risques alimentaires et l'aide à la décision du consommateur. Ainsi, DZSain constitue un outil numérique prometteur pour renforcer la prévention des maladies chroniques et soutenir les stratégies de qualité et de sécurité alimentaire en Algérie.

Mots-clés : étiquetage nutritionnel, application mobile, EWG Food Scores, conformité réglementaire, profil de santé, Algérie.

Abstract

Against a backdrop of rising rates of diet-related chronic diseases in Algeria, improving the quality of nutritional information is a key strategy for promoting healthy eating and strengthening food quality assurance. DZSain is an innovative mobile app designed to help consumers assess the nutritional quality of foods available on the Algerian market. The app allows users to analyze food products by scanning the GS1-13 barcode or by recognizing the information on the label. Its evaluation system is based on the EWG Food Scores methodology, which combines nutritional quality, the degree of industrial processing, and the presence of potentially concerning ingredients or additives to assign an overall quality score. The DZSain database was compiled from products available on the Algerian market and verified in accordance with the requirements of national regulations regarding food labeling. Using an approach that integrates the principles of quality assurance and personalized nutrition, the results are cross-referenced with the user's health profile (diabetes, high blood pressure, dyslipidemia, kidney failure, chronic inflammatory bowel diseases, and food allergies) to provide tailored recommendations and targeted alerts. This approach helps improve the reliability of nutritional information, food risk management, and consumer decision-making. Thus, DZSain is a promising digital tool for strengthening the prevention of chronic diseases and supporting food quality and safety strategies in Algeria.

Keywords: nutritional labeling, mobile app, EWG Food Scores, regulatory compliance, health profile, Algeria.

ملخص

في سياق يتسم بارتفاع معدلات الإصابة بالأمراض المزمنة المرتبطة بالتغذية في الجزائر، يمثل تحسين جودة المعلومات الغذائية أداة أساسية لتعزيز التغذية الصحية وتقوية ضمان جودة المنتجات الغذائية DZSain. هو تطبيق جوال مبتكر تم تطويره لمساعدة المستهلكين في تقييم الجودة الغذائية للأطعمة المتوفرة في السوق الجزائرية. يتيح التطبيق تحليل المنتجات الغذائية من خلال قراءة الرمز الشريطي GS1-13 أو التعرف على المعلومات الواردة على الملصق. ويستند نظام التقييم الخاص به إلى منهجية EWG Food Scores، التي تجمع بين الجودة الغذائية ودرجة المعالجة الصناعية ووجود مكونات أو إضافات قد تكون مقلقة، وذلك من أجل تحديد درجة جودة شاملة. تم إنشاء قاعدة بيانات DZsain من المنتجات المتوفرة في السوق الجزائرية وتم التحقق منها وفقاً لمتطلبات اللوائح الوطنية المتعلقة بوضع العلامات على الأغذية. وفي إطار نهج يدمج مبادئ ضمان الجودة والتغذية المخصصة، يتم ربط النتائج التي تم الحصول عليها بالملف الصحي للمستخدم (السكري، وارتفاع ضغط الدم، واضطراب شحوم الدم، والفشل الكلوي، وأمراض الأمعاء الالتهابية المزمنة، والحساسية الغذائية) من أجل تقديم توصيات ملائمة وتنبيهات محددة. يساهم هذا النهج في تحسين موثوقية المعلومات الغذائية وإدارة المخاطر الغذائية ومساعدة المستهلك في اتخاذ القرار. وبالتالي، تشكل DZSain أداة رقمية واعدة لتعزيز الوقاية من الأمراض المزمنة ودعم استراتيجيات الجودة والسلامة الغذائية في الجزائر.

الكلمات المفتاحية: التوسيم الغذائي، تطبيق الهاتف المحمول، EWG Food Scores، الامتثال التنظيمي، الملف الصحي، الجزائر.

Introduction

The continuous growth and diversification of the global food market have profoundly transformed consumer habits, placing consumers before an increasingly complex product offering that is difficult to evaluate. In this context, Quality Assurance (QA) has become a central issue, not only for manufacturers and regulatory bodies, but above all for consumers themselves, who seek reliable, transparent, and comparable nutritional information to guide their everyday food choices. According to the FAO (2023), empowering consumers through an enhanced information system, such as food labels, can enable individuals to make better-informed choices when selecting food products and promote healthy and sustainable dietary practices. ScienceDirect

Nutritional labeling constitutes one of the primary channels of communication between manufacturers and consumers. Front-of-Pack Nutritional Labels (FOPLs) have been one of the main interventions to provide consumers with timely and clear information about the nutritional value of their food choices, representing an important and practical tool to assist consumers when making informed and healthier decisions (**Donini et al., 2023; Priya & Alur, 2023**). However, the effectiveness of these labels depends entirely on their accuracy and compliance with applicable standards. Accurate label information helps consumers make informed purchasing decisions by choosing healthier and more nutritious foods, whereas inaccurate or misleading information can lead to consumer misunderstanding, potentially triggering unhealthy dietary behaviors. ScienceDirect In Algeria, the regulatory framework for food quality rests on a combination of national laws and international standards. Quality assurance in Algeria is essentially based on legislation framed by the law on fraud repression and consumer protection, together with health law, phytosanitary law and veterinary law, in accordance with international standards such as the Codex Alimentarius, ISO standards, and international legislation including the Basic General Food Law (EC 178/2002) and the HACCP requirements. Regarding nutritional labeling specifically, an Interdepartmental Decree of October 19, 2017 fixes the applicable food nutrition value labeling rules, pursuant to the provisions of Article 14 of Executive Decree No. 13-378 of November 9, 2013. Despite this regulatory framework, field observations conducted in Algerian markets revealed significant non-conformities in product labeling, hindering consumers' ability to make informed quality-based choices (**Merabti & Tefiani, 2023; Bensdira & Bouhroud, 2023**). This phenomenon is not unique to Algeria: in a survey conducted in Bangladesh, 76% of the products examined were not properly labeled or did not carry required certification markings, and almost 86% did

not provide an expiration date — an essential piece of information for consumers. DOAJ + 2In response to these information gaps, digital and mobile technologies now offer innovative solutions. Food Barcode Scanner Apps (FBSAs) are increasingly being used to verify food quality; by scanning a product's barcode, they can provide a range of information including nutritional quality or data on the toxicity of food components (**Hanras et al., 2024**). The scale of this phenomenon is illustrated by the Yuka application: launched in 2017, it recorded 2.7 billion product scans in 2024 alone — 85 scans per second worldwide — confirming the rapidly growing consumer interest in such tools. Furthermore, smart labels can serve as a direct line of communication between consumers and producers, providing information that may not be conveyed by on-package labels due to physical impediments (**Barone & Aschemann-Witzel, 2022**). Wiley Online Library + 2

To assess the quality of scanned products in a scientifically rigorous manner, validated nutritional scoring methods are essential. Among these, the EWG Food Scores method stands out for its multidimensional approach. Its algorithm evaluates foods on a scale of 1 to 10 — with the best foods scoring 1 and the worst scoring 10 — by combining three components: nutritional value (including calories, saturated fat, trans fat, sugar, sodium, protein, fiber, and fruit, vegetable and nut content), ingredient concerns (focusing on the likely presence of contaminants, pesticides, hormones, antibiotics, and food additives), and the degree of processing. This holistic approach provides a comprehensive picture of a product's quality that goes well beyond a simple reading of its nutritional label. EWG It is within this context that the DZsain project was conceived — an innovative mobile application designed to meet the specific needs of Algerian consumers. DZsain aims to bridge the existing information gap by offering a rapid evaluation of food product quality through the scanning of GS1-13 barcodes, combining the EWG Food Scores nutritional scoring system with verification of compliance with Algerian labeling standards (**Hanras et al., 2024**). The primary objective of this project is therefore to implement DZsain as a consumer-oriented Quality Assurance tool that assists Algerian consumers in their food product choices, based on nutritional quality and regulatory labeling compliance.

BIBLIOGRAPHIC PART

Chapter 1. Nutrition Labeling and Compliance for

1. Food Products

1.1. Food Quality and Consumer Information

1.1.1. The Concept of Food Quality

Food quality is a multidimensional concept that refers to the extent to which a food product meets consumers’ needs, expectations, and uses (Poulain, 2002). This concept has evolved considerably over time: traditional requirements for safety and taste have gradually been joined by expectations regarding transparency, the origin of ingredients, and production methods (Birlouez, 2019). In the field of food science, quality is now understood through three complementary and inseparable dimensions: nutritional quality, health quality, and regulatory quality.

Tableau 1. The Three Dimensions of Food Quality

Dimension	Définition	Référence
Nutritional quality	Aligning nutrient composition with consumer needs; preventing chronic diseases (obesity, diabetes, cardiovascular disease)	ANSES, 2022 ; Santé Publique France, 2023
Sanitary quality	Safety assurance: absence of biological, chemical, and physical hazards. Governed by ISO 22000 and the HACCP plan	ANSES, 2022 ; Vie-publique.fr, 2024
Regulatory quality	Compliance with national, European, and international laws and regulations (INCO Regulation, Codex Alimentarius))	Règlement UE n°1169/2011 ; Codex Alimentarius, 2024

Nutritional quality refers to a food’s ability to positively contribute to consumer health through its composition of macronutrients and micronutrients. In particular, it aims to reduce the risk of chronic conditions such as obesity or type 2 diabetes (ANSES, 2022). Sanitary quality guarantees the safety of the product, meaning the absence of any biological, chemical, or physical hazards. It is based on rigorous standards such as ISO 22000 and the HACCP plan, and has been monitored in France by the General Directorate for Food (DGAL) since January 2024 (Vie-publique.fr, 2024). Finally, regulatory quality refers to the product’s compliance with applicable laws, notably the INCO Regulation (EU) No. 1169/2011 at the European level and the Codex Alimentarius at the international level (Codex Alimentarius, FAO/WHO, 2024). These three dimensions are closely intertwined: a quality product must be healthy, safe, and compliant.

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1.1.2. The Role of Labeling in Quality Assurance

Food labeling plays a central role in the quality assurance of agri-food products. Long viewed as a mere marketing tool, it is now considered an essential means of ensuring transparency and traceability between the manufacturer and the consumer (**Eurofins Food Assurance, 2024**). A product’s final label is merely the visible part of a rigorous upstream process, during which the manufacturer must verify the reliability and origin of every piece of information printed on the packaging. In this sense, labeling represents the tangible culmination of the entire quality assurance process implemented throughout the production chain.

Tableau 2. The Role of Labeling in Quality Assurance

Fonction	Description	Legal basis
Information	Provide information on the product's nutritional information, ingredients, and allergens	EU Regulation No. 1169/2011
Traceability	Enable product tracking throughout the food supply chain (batch number, dates)	DGCCRF, 2024
Transparency	Disclose the origin of the ingredients, the production method, and the manufacturer’s quality commitments	Ministry of Agriculture, 2024; Eurofins, 2024

Regulation (EU) No. 1169/2011, known as INCO, formalized and strengthened the role of labeling by making nutrition labeling mandatory on prepackaged foods, in order to enable consumers to make informed choices (**Regulation (EU) No. 1169/2011**). The European Court of Auditors emphasizes that the evolution of the regulatory framework on labeling directly responds to growing consumer concerns regarding health, sustainability, and transparency (**European Court of Auditors, 2024**). Thus, labeling is a direct reflection of the level of quality that a manufacturer commits to guaranteeing its consumers (**Ministry of Agriculture, 2024**).

1.1.3. The Impact of Labeling on Consumer Confidence

Food labeling plays a crucial role in building consumer trust in products and brands. Against a backdrop of increasing food scandals, consumers have become increasingly demanding when it comes to the transparency and clarity of information on packaging (**Storee Retail, 2024**). This growing demand is prompting manufacturers to rethink labeling as a key driver of trust and loyalty, based on four fundamental dimensions: authenticity, commitment, consistency, and concrete evidence (**Storee Retail, 2024**).

Tableau 3. Factors Influencing Consumer Confidence in Labeling

Influencing factor	Key facts	Source
Perceived reliability	44% of French people consider food information to be unreliable	CB News / IFOP, 2019
Decision time	An average of 75 seconds for a grocery purchase; attention limited to 2–3 items	French Senate, 2022
Trust in labels	7 out of 10 French people trust product labels and best-by dates	CB News / IFOP, 2019
Nutri-Score Effect	Enhanced brand image and increased customer loyalty for brands that adopt it	Easiware, 2024
New expectations	Growing demand for environmental and ethical information on product labels	INRAE / GAEL-CLCV, 2020

Simplified labeling tools such as Nutri-Score have emerged to boost consumer confidence by making nutritional information more accessible and understandable. Studies show that consumers perceive this system as a sign of responsibility and transparency toward public health, thereby fostering customer loyalty (**Easiware, 2024**). Furthermore, research by the GAEL laboratory in collaboration with the CLCV confirms that consumer demand now extends beyond nutrition alone to include environmental and ethical information (**INRAE / GAEL-CLCV, 2020**). Ultimately, clear, honest, and comprehensive labeling builds a lasting relationship of trust between the manufacturer, the product, and the consumer.

1.2. Regulatory Framework for Nutrition Labeling

1.2.1. General Principles of Food Labeling Regulations

The regulatory framework for food labeling is based on a set of fundamental principles designed to ensure that consumers receive accurate, clear, and non-misleading information. This framework is structured around three complementary levels: international (Codex Alimentarius), European (INCO Regulation), and national (French legislation). Each level clarifies and reinforces the requirements of the previous one, forming a coherent legal framework designed to protect consumers and ensure the free movement of food products (**EU Regulation No. 1169/2011**).

Chapter 1. Nutrition Labeling and Compliance for

Tableau 4. Comparison of the main food labeling regulations

Level	Text / Standard	Year	Key Requirements
International	Codex Alimentarius CXS 1-1985 (FAO/WHO)	Revised 2024	Required disclosures, legibility, prohibition of misleading statements
European	Regulation (EU) No. 1169/2011, known as INCO	2011 (effective 2016)	Mandatory nutrition facts label, 12 items, table per 100g/100ml, allergens in bold
European	Nutri-Score (voluntary recommendation)	2017, revised 2023	Color-coded A–E logo, nutritional algorithm, adopted by 7 EU countries
National (France)	DGCCRF / Implementing Decree	2024	Requirement to display the origin of meat in restaurants, Origin'Info logo

and the introduction of the Origin'Info logo for processed products (**Ministry of Agriculture, 2024**).

1.2.2. Mandatory nutritional information

The nutrition facts panel is one of the major changes introduced by the INCO Regulation. Mandatory since December 13, 2016, it requires that seven elements be included in a nutrition table per 100g or 100ml: energy (kJ and kcal), fat (including saturated fatty acids), carbohydrates (including sugars), protein, and salt (**EU Regulation No. 1169/2011**). In addition, the regulation mandates twelve mandatory labeling statements, including the product name, the list of ingredients, allergens, net quantity, best-before date, and the manufacturer's name (**DGCCRF, 2024**).

In addition to these requirements, Nutri-Score has been recommended since 2017 as a simplified labeling tool. This color-coded logo, ranging from A to E and registered by Santé Publique France, is determined by an algorithm that takes into account the food's nutritional composition and the recommendations of the National Nutrition and Health Program (**Santé Publique France, 2023**). Its algorithm was revised in 2023 by a European scientific committee to better align the logo with the latest dietary recommendations (**Santé Publique France, 2023**).

1.2.3. The Concepts of Conformity, Nonconformity, and Traceability

Food product compliance refers to adherence to all regulatory requirements applicable to its composition, presentation, and labeling. The responsibility for providing the required information lies with the manufacturer who markets the food products under its own name; if the manufacturer is based outside the European Union, this responsibility falls on the importer (**EU Regulation No. 1169/2011**). In the event of non-compliance, products may be subject to

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administrative penalties or market withdrawals depending on the severity of the non-compliance found. La non-conformité peut prendre des formes variées : informations manquantes, données nutritionnelles inexactes, allergènes non déclarés, ou mentions misleading information regarding the product's origin. The European Court of Auditors highlights in its 2024 report that gaps persist in the harmonization of controls among Member States (**European Court of Auditors, 2024**). Traceability, for its part, is an integral and inseparable pillar of compliance: labeling must include the manufacturing batch number and specific storage conditions, enabling authorities to quickly trace a product's path in the event of a health issue and allowing manufacturers to carry out targeted and effective recalls (**DGCCRF, 2024**).

1.3. Regulatory Framework for Nutrition Labeling

Regulations governing nutrition labeling are a cornerstone of global food policy. They aim to ensure transparency regarding the composition of food products, protect consumers from misleading practices, and promote informed dietary choices. In Algeria, this regulatory framework has gradually taken shape, drawing on the international standards of the Codex Alimentarius and European experience, while adapting the requirements to the national context.

1.3.1. General Principles of Food Labeling Regulations

Food labeling adheres to a set of internationally recognized fundamental principles. These principles form the common foundation upon which all national and regional consumer information laws are based.

➤ *Internationally recognized fundamental principles*

The Codex Alimentarius, established jointly by the FAO and the WHO in 1963, sets forth the basic standards for food labeling in its General Standard for the Labeling of Prepackaged Foods (**CODEX STAN 1-1985, Rev. 2018**). This standard is based on four cardinal principles:

- Truthfulness: all information on the label must be accurate, not misleading, and verifiable.
- Clarity: the information must be legible, understandable, and accessible to the average consumer.
- Completeness: the label must include all the information necessary for an informed choice.

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- Traceability: the label must allow for the identification of the product's origin and production chain.

Tableau 5. Key regulatory texts governing food labeling

Organization / Text	Scope	Key labeling requirements
Codex Alimentarius (CODEX STAN 1-1985)	International	Product name, list of ingredients, allergens, net weight, shelf life, usage instructions
EU Regulation No. 1169/2011 (INCO)	European Union	Mentions obligatoires en arabe et français, valeur nutritive, allergènes, conditions de conservation
Executive Decree No. 13-378 (Algeria, 2013)	National (DZ)	Mandatory information in Arabic and French, nutritional information, allergens, storage instructions
Law No. 09-03 (Algeria, 2009))	National (DZ)	Consumer protection, combating misleading labeling
FDA 21 CFR Part 101 (United States)	USA	Mandatory Nutrition Facts Panel, standardized serving size, % Daily Value

➤ **Algeria's regulatory framework**

In Algeria, food labeling is governed by several laws and regulations. Law No. 09-03 of February 25, 2009, on consumer protection and the prevention of fraud, serves as the foundational legislation. It is supplemented by Executive Decree No. 13-378 of November 9, 2013, establishing the conditions and procedures for food labeling. This decree requires, in particular:

- Mandatory bilingual labeling (Arabic and French) for all information.
- Nutritional information for products intended for special nutritional purposes.
- Mandatory indication of major allergens recognized by the Codex.
- Identification of the manufacturer, importer, and distributor.
- The use-by date (DLC) or best-before date (DDM).

Algeria has also adopted standard NA 715 on the labeling of prepackaged foodstuffs, aligned with Codex STAN 1-1985. Enforcement of these regulations is jointly carried out by the Directorate of Quality and Consumer Protection (DQPC) of the Ministry of Commerce and the Laboratories for Quality Control and Fraud Prevention (LNQCRF).

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1.3.2. Mandatory nutritional information

The nutrition facts panel is the core of nutrition labeling. It informs consumers about the macro- and micronutrient content of a food product per serving. The international harmonization of these panels is a key priority for facilitating trade and ensuring consistent information.

➤ *Mandatory and optional nutrients*

Tableau 6. Mandatory and optional nutrients according to major regulations. *
Required for products with nutrition claims or intended for specific groups.

Nutrient	Required (EU/Codex)	Required (Algeria)	Unité	Base de calcul
Calories (kcal / kJ)	Yes	Yes*	kcal & kJ	Per 100 g or 100 ml
Total Fat	Yes	Yes*	g	Per 100 g or 100 ml
Saturated Fat	Yes	Not required	g	Per 100 g or 100 ml
Trans Fat	No (EU) / Yes (US)	No	g	Per 100 g or 100 ml
Total Carbohydrates	Yes	Yes*	g	Per 100 g or 100 ml
Sugars	Yes	Not required	g	Per 100 g or 100 ml
Dietary Fiber	Optional	Optional	g	Per 100 g or 100 ml
Protein	Yes	Yes*	g	Per 100 g or 100 ml
Salt (sodium x 2.5)	Yes	Optional	g	Per 100 g or 100 ml
Vitamins & Minerals	Optional (if $\geq$ 15% NRV)	Optional	mg / μ g	% of the reference value

➤ *Methods for determining nutritional values*

The nutritional values listed on labels can be determined using three methods, as defined by EU Regulation No. 1169/2011 (Annex V) and recommended by the Codex Alimentarius:

- Laboratory analysis: the reference method providing the most accurate values (AOAC, ISO, official AFNOR/JORA methods).
- Calculation based on known values: use of composition tables (CIQUAL, FAO/INFOODS, USDA database) weighted by ingredient proportions.
- Calculation based on average values: a combination of the two previous approaches, accepted for composite products.
- The analytical tolerances permitted by European regulations vary depending on the nutrient: $\pm 20\%$ for energy and macronutrients, $\pm 35\%$ for vitamins and minerals.
- These margins account for the natural variability of raw materials and analytical uncertainties.

Tableau 7. Formats for presenting nutrition information

Format	Description	Advantages	Limitations
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Nutrition facts panel (standard format)	Nutrition facts table on the back or side of the package	Comprehensive, detailed, standardized	Hard to see, difficult to read
Nutri-Score (France, Belgium, etc.)	Rating from A (green) to E (red) on the front	Quick to understand, easy to compare	Not mandatory, not adopted in Algeria
Traffic light labeling (United Kingdom)	Green/orange/red color-coding by nutrient	Intuitive for the general public	Not harmonized at the EU level
GDA / VDR (% of reference value)	% of the Daily Value	Educational, tailored to nutritional needs	Requires an understanding of user needs
Nutrition QR code	Link to detailed information online	Interactive, enriched	Requires a smartphone and an internet connection

1.3.3. The concepts of compliance, non-compliance, and traceability

The accuracy of nutrition labeling is assessed against current regulatory requirements and analytically determined values. Effective traceability is integral to this process, as it allows any identified non-compliance to be traced back to its source.

➤ Definition of Regulatory Compliance

A food product is considered compliant when its nutrition labeling meets three requirements simultaneously:

- Formal compliance: inclusion of all required information, adherence to specified fonts, font sizes, and languages.
- Analytical compliance: the declared values correspond, within regulatory tolerances, to the actual composition of the product.
- Semantic compliance: the nutritional and health claims made comply with the conditions of use defined by regulations (Regulation (EC) No. 1924/2006 in Europe)

➤ Types of non-conformities

Tableau 8. Categories of labeling non-compliance and reference texts

Type of Non-Conformity	Specific examples	Severity	Relevant Regulations
Formal non-conformity	Missing mandatory information, language requirements not met, font size too small	Minor to moderate	Decree No. 13-378 (DZ) / Art. 9 of Regulation 1169/2011
Analytical non-conformity	Declared sugar content more than 20% lower than actual content, energy value underestimated	Moderate to major	Annex I of EU Delegated Regulation No. 1363/2013
Claim non-conformity	“Light” claim without meeting thresholds,	Major	EC Regulation No. 1924/2006

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	“source of fiber” < 3 g/100 g		
Allergen non-conformity	Undeclared allergen or incomplete declaration	Critical (security)	Art. 21 Reg. 1169/2011 / Decree No. 13-378
Traceability non-conformity	Batch code missing, best-before date illegible or incorrect	Major	Art. 18 Reg. 178/2002 / Law 09-03 (DZ)

➤ Traceability and labeling

Traceability, defined by Regulation (EC) No. 178/2002 as the ability to trace a food product or a substance intended for incorporation into food products through all stages of production, processing, and distribution, relies largely on labeling. The batch number (batch code) is the central element of this traceability; it allows for the identification of all products manufactured under identical conditions and enables a targeted recall in the event of non-compliance.

In the food industry, traceability is ensured by integrated information systems (ERP, QHSE software) that link supplier data (raw materials), production parameters, and distributor data. Digital labeling (QR codes, RFID) is an increasingly important tool for improving real-time traceability.

1.4. Nutritional Compliance

Nutritional compliance testing is a systematic process designed to verify that the nutritional values declared on the label match the actual composition of the food product. In the field of Food Quality and Safety (QPSA), this testing is part of a comprehensive quality management approach and is critical to consumer protection and the reputation of food companies.

1.4.1. Verification methods used in the food industry

Nutritional compliance verification involves a range of complementary analytical and documentary methods. The choice of method depends on the type of product, the nutrient being analyzed, the available resources, and the required level of accuracy.

➤ Méthodes analytiques de référence

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Tableau 9. Official analytical methods for nutritional verification

Nutrient	Official method	Organization	Principle	Accuracy
Energy	Calculation (Atwater factors)	Codex / EU	Weighted sum of macronutrients	±5%
Protein	Kjeldahl (ISO 8968) / Dumas (ISO 16634)	ISO / AOAC	Total nitrogen determination × factor	±2–3%
Fat	Soxhlet (ISO 659) / Rose-Gottlieb	ISO / AOAC	Organic solvent extraction	±2%
Carbohydrates	Differential or HPLC	Codex / AOAC	100 - (water + protein + lipids + ash + fiber)	±5%
Dietary fiber	Enzymatic-gravimetric (AOAC 985.29)	AOAC	Enzymatic hydrolysis + weighing	±5%
Free sugars	Refractometric HPLC (ISO 11292)	ISO	Chromatographic separation	±3%
Salt / Sodium	Atomic absorption (ISO 11885)	ISO / AOAC	Measurement of Na ⁺ ions	±5%
Vitamins (Vit. C)	HPLC-UV (ISO 6557)	ISO	UV separation and quantification	±5–10%

➤ **Documentary and computational methods**

In addition to laboratory analyses, manufacturers use documentary methods to estimate or verify nutritional values:

- **Formulation calculation:** Based on suppliers' raw material data sheets and the quantities used in the recipe, formulation software calculates the theoretical nutritional value of the finished product.
- **Use of databases:** public databases (ANSES's CIQUAL, USDA FoodData Central, FAO/INFOODS) or proprietary databases built by the company.
- **Cross-checking:** comparison between calculated values (formulation) and analytical values to establish a variability profile and alert limits.

➤ **Analytical control plans**

An analytical control plan defines the frequency, parameters, and acceptance criteria for nutritional analyses. It is generally structured in three levels

Tableau 10. Structure of a nutritional analytical control plan

Level	Frequency	Analyzed parameters	Objective
Incoming inspection (raw materials)	Every critical/routine batch	Nutrients affecting the declared value (fat, water, protein)	Verify supplier compliance
In-process inspection	Per production batch	Critical parameters defined by HACCP (salt, sugar, moisture)	Process control
Finished product inspection	Statistical sampling plan (ISO 2859)	Complete nutritional profile + allergens	Verify label compliance
Surveillance inspection (market)	Annually or whenever the formula changes	Complete nutritional profile	Update the label

1.4.2. Limitations of manual checks

Despite their rigor, traditional control methods have significant limitations that undermine the effectiveness and efficiency of the nutritional monitoring system in the food industry.

➤ Analytical and economic limits

Tableau 11. Limitations of manual checks and their impact on nutritional compliance

Limitations	Description	Impact on Compliance
High cost of testing	Comprehensive nutritional profile analysis: €150–600 per sample, depending on the parameters	Reduces the frequency of inspections, increasing the risk of undetected non-compliance
Test turnaround time	Results in 5–15 business days for a complete profile from an accredited laboratory	Products placed on the market before test results are received
Variability in results	Analytical CV of 2–15%, depending on the nutrient and method	Difficulty distinguishing between natural variability and actual non-compliance
Sample representativeness	The analyzed sample may not be representative of the entire batch	Risk of sampling error (ISO 5725)
Manual data entry errors	Transfer of analytical results to labeling sheets	Errors in declared values due to data entry mistakes or incorrect rounding
Document management	Multiple paper documents (lab logs, product sheets, labels)	Difficulty in synchronized updates, risk of using outdated values

➤ Organizational constraints

Beyond technical limitations, manual checks are hampered by significant organizational constraints:

- Information silos: Nutritional data is scattered across the laboratory, R&D, marketing, and production departments, with no centralized management system.

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- Lack of digital traceability: it is difficult to trace compliance decisions (who validated which value, based on which analytical method?).
- Insufficient training: nutritional regulations evolve rapidly, and quality teams are not always trained in real time.
- Limited responsiveness: during an alert (recall), manually gathering traceability data can take several days, exacerbating health risks.

➤ Comparison of manual control vs. digital control

Tableau 12. Comparison of Manual and Computerized Nutritional Compliance Checks

Criterion	Manual Control	Digital Control (QPSA software)
Processing speed	Slow (days to weeks)	Fast (minutes to hours)
Risk of human error	High (multiple entries)	Low (automated calculation)
Decision traceability	Difficult to reconstruct	Automatic and time-stamped
Regulatory updates	Manual, risk of delays	Automatic if database is connected
Long-term cost	High (man-hours)	Initial investment followed by savings
Scalability	Limited by the volume of activity	Scalable to any volume
ERP/LIMS integration	Almost impossible	Possible and recommended

1.4.3. Need for digital tools to support quality control

The combination of shortcomings in manual checks and increasing nutritional regulatory requirements creates an urgent need for dedicated digital tools. These solutions are part of the digital transformation of the food industry (Industry 4.0) and aim to automate, improve the reliability of, and accelerate nutritional compliance verification processes

➤ Overview of available digital tools

Tableau 13. Overview of digital tools to support nutritional quality control

Tool Category	Examples	Key Features	Limitations
Nutritional Formulation Software	Nutrifox, Genesis R&D, Nutrilog, FoodComp	Automatic calculation of nutritional profiles, database connectivity, label generation	High cost, requires database updates
QHSE / QMS Software	IFS Food, BRC, PolyXpert, Qualio	Non-compliance management, action plans, document traceability	Not specialized in nutrition
Food Industry ERP	SAP S/4HANA, Infor FoodVision, Sage X3	Batch management integration, end-to-end traceability, recipe management	Complexity of implementation
Regulatory Compliance Tools	Mintel GNPD, Eureka (CIAA)	Regulatory monitoring, claim verification, labeling compliance	Subscription cost
Food Databases	CIQUAL (ANSES), USDA FoodData, FAO/INFOODS	Reference nutritional values, conversion factors	Do not cover all local products

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AI / ML Tools	R&D Applications (under development)	Compliance prediction, anomaly detection, label OCR	Emerging technology, not yet fully validated
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➤ Characteristics of an optimal tool for nutritional monitoring in QPSA

An ideal digital tool for nutritional compliance monitoring in a QPSA context should include the following features:

- Integrated food database: covering both local and imported products, enriched with company-specific analytical data.
- Regulatory calculation engine: automatic calculation of nutritional values with regulatory rounding and tolerance verification.
- Claim verification: automatic verification of the conditions for using nutritional claims.
- Generation of compliant labels: production of label mockups that meet format and content requirements.
- Traçabilité complète : historique des versions d'étiquettes, des analyses associées et des décisions de conformité.
- Regulatory alerts: automatic notification when a regulatory change affects a product in the portfolio.
- Interoperability: integration with LIMS, ERP, and production management systems.

➤ Challenges in the Algerian context

Tableau 14. Barriers to the adoption of digital quality control tools in Algeria and potential solutions

Challenge	Description	Possible solutions
Cost of commercial software	Market-leading solutions are unaffordable for Algerian agri-food SMEs (over €10,000/year)	Development of open-source tools tailored to the local context
Lack of a national database	Limited nutritional data is available for traditional Algerian products (couscous, merguez, chtitha, etc.)	Creation of a national food composition database (partnership between ONSSA and universities)
Human resources	Lack of specialists in IT applied to food quality	Specialized training programs in digital food safety
IT infrastructure	Limited connectivity in certain industrial areas	Hybrid solutions (cloud + offline mode)
Digital regulatory framework	Absence of regulations governing the validity of software-generated labels	Adaptation of the regulatory framework to digital practices

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This research project is set against this backdrop and aims to propose a digital solution tailored to the realities of Algeria to assist with nutritional compliance monitoring, drawing on an enriched food database and automated regulatory verification algorithm

Chapter 2. Enriched Food Databases at the Service of Quality and Safety

Food quality and safety depend on accurate and up-to-date knowledge of their nutritional composition. In this perspective, food databases are an essential tool, both for researchers and quality control actors. Initially, this chapter outlines the basics of nutritional data and their role in assessing food quality. It then presents the concept of enriched food databases and the advantages they offer for regulatory compliance monitoring. Finally, it examines the contribution of these digital tools to quality control and food risk prevention.

2.1. Nutritional Data and Food Quality

2.1.1. Nutritional Composition of Foods

The nutritional composition of a food corresponds to all the constituents that define it chemically and biologically: macronutrients (carbohydrates, lipids, proteins), micronutrients (vitamins, minerals), water, dietary fiber, and bioactive substances (Greenfield & Southgate, 2003). These constituents determine both the energy value of the food, its nutritional interest for the body, and its technological properties during processing.

In human nutrition, knowing the composition of foods is essential for evaluating the nutritional intake of individuals, proposing adapted dietary recommendations, and defining public health policies. For industry and quality control, it is the basis of any regulatory compliance process, particularly for nutritional declarations on the labels of prepackaged products.

The main families of nutrients to be declared, according to the requirements of the Codex Alimentarius (CODEX STAN 1-1985) and Algerian regulations (Executive Decree No. 13-378), are presented in the table below:

Tableau 15. Main categories of nutrients and their nutritional importance (after Codex Alimentarius, 2024; ANSES, 2020)

Nutrient Category	Examples	Main Nutritional Role	Unit of Measurement
Energy Macronutrients	Carbohydrates, lipids, proteins	Source of energy and cellular structure	g / 100 g or 100 ml
Sugars (simple)	Glucose, fructose, sucrose	Quick energy; high glycemic impact	g / 100 g
Saturated Fatty Acids (SFA)	Palmitic acid, stearic acid	Cardiovascular risk if in excess	g / 100 g
Salt / Sodium	NaCl, monosodium glutamate	Water regulation; hypertensive risk if in excess	g / 100 g
Dietary Fiber	Cellulose, pectins, inulin	Intestinal transit, satiating effect, prebiotic	g / 100 g
Micronutrients	Vitamins A, C, D, iron, calcium, zinc	Metabolic regulation, immunity, ossification	mg or µg / 100 g

2.1.2. Data Variability and Analytical Reliability

What is found in food in terms of nutrients is not a fixed value. It changes naturally depending on where the raw materials come from, how plants are grown or animals are raised, the processing methods used, storage conditions, and even how the analyses are performed (**Charrondière et al., 2011**). Consequently, it is complicated to create reliable databases and verify if what is written on labels truly corresponds to reality.

Regarding analyses, recognized reference techniques exist to measure nutrients. They are established by international organizations such as AOAC, ISO, or Codex Alimentarius. These methods allow for reproducible and comparable results from one laboratory to another.

Data reliability also depends on the frequency with which databases are updated. Because industrial recipes evolve, new additives appear, or products are voluntarily enriched with vitamins and minerals. All of this can significantly change the composition of a food between two versions of the same database.

2.1.3. Role of Data in Nutritional Quality Assessment

- Nutritional data are essential for assessing food quality. They serve to compare products and help consumers and health professionals make informed choices.
- In this study, we rely on the nutritional information on product labels to calculate three key indicators:

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- The Nutri-Score, which evaluates products from A (best quality) to E (lower quality) based on a nutritional score calculated for 100 g or 100 ml of product.
- The NOVA classification, which examines the level of industrial processing of foods, regardless of their nutritional composition.
- The EWG Food Scores, which take into account nutritional aspects, ingredient quality, and the level of processing to assign an overall rating from 1 to 10.

The following table presents the Guideline Daily Amounts (GDA) used as a basis for comparison for the nutritional evaluation of the products in the study:

Tableau 16. Guideline Daily Amounts (GDA) used in the study (after Codex Alimentarius, 2024; EU Regulation No. 1169/2011; WHO, 2023) — TEI: Total Energy Intake

Nutrient	Reference Value (GDA)	Recommendation (% TEI or target value)
Energy	2000 kcal / 8400 kJ	—
Total Lipids	≤ 70 g	< 35 % TEI
Saturated Fatty Acids	≤ 20 g	< 10 % TEI
Total Carbohydrates	260 g	50–55 % TEI
Sugars (simple)	≤ 90 g	< 10 % TEI (WHO)
Proteins	50 g	10–15 % TEI
Salt (NaCl)	≤ 6 g	< 5 g NaCl recommended (WHO)
Dietary Fiber	25 g	—
Vitamin C	80 mg	—
Calcium	800 mg	—
Iron	14 mg	—

2.2. Enriched Food Databases

2.2.1. Concept and Interest of Enriched Databases

A food database is a system that organizes and stores information on the nutritional composition of food products. This allows for efficient searching and querying of this data.

Two types of food databases can be distinguished: generic databases and enriched databases. Generic databases contain information on raw and minimally processed foods. Enriched databases, on the other hand, include additional data such as regulatory information, compliance thresholds, authorized food additives, nutritional scores, and traceability data.

Enriched databases are particularly useful because they allow for the cross-referencing of nutritional information with regulatory and normative frameworks. This makes automated verification of product compliance possible.

Chapter 2. Enriched Food Databases at the Service of Quality and Safety

Among the best-known international food databases are those developed by government agencies or international organizations. These databases are valuable tools for food professionals, researchers, and policymakers. They contribute to improving food security, nutrition, and public health.

Tableau 17. Main food databases used internationally (after FAO/INFOODS, 2022; ANSES, 2020; USDA, 2023)

Database	Responsible Organization	Coverage	Main Characteristics
USDA FoodData Central	U.S. Department of Agriculture (USDA)	Over 600,000 foods	Detailed analytical data, regular updates, open access
CIQUAL	ANSES (France)	Over 3,000 foods	French/European data, AOAC/ISO methods, online access
McCance & Widdowson	Public Health England (UK)	Over 3,000 foods	British reference, long publication history
EuroFIR	European Food Information Resource	Pan-European	Harmonization of methods, multi-country data, laboratory network
Open Food Facts	Global Community (open source)	Over 3 million products	Data from commercial labels, Nutri-Score, NOVA integrated
FAO/INFOODS	FAO — United Nations	Global	International network of databases, harmonization of methods

In the Algerian context, there is not yet an official and exhaustive national food database. Recent harmonization work carried out within the FAO/INFOODS network for North Africa nevertheless constitutes a significant step towards the creation of an Algerian composition table adapted to local eating habits (FAO, 2019). For the purposes of this study, nutritional data were directly extracted from the labels of the analyzed products, in accordance with the approach adopted in labeling compliance verification studies.

2.2.2. Integration of Regulatory Thresholds and Nutritional Standards

Enriching a food database consists of integrating composition data and the thresholds and criteria defined by regulatory texts and applicable nutritional standards. This allows for more than just consulting nutritional values. Enriching a food database leads to an automated assessment of compliance with nutritional standards and regulatory texts. Enriching a food database is therefore very useful for evaluating the compliance of a food product.

In the context of this study, data enrichment is carried out at two complementary levels:

Tableau 18. Levels of food data enrichment in the context of the study

Enrichment Level	Type of Integrated Data	Associated Frameworks
Regulatory Level	Verification of the presence of mandatory mentions (name, list of ingredients, allergens, shelf life, net weight, manufacturer details, etc.)	Decree 13-378, Law 09-03, NA 715 (IANOR), CODEX STAN 1-1985
Nutritional Level	Comparison of declared values to reference GDAs; detection of inconsistencies in the nutritional table	Codex Alimentarius 2024, EU Regulation 1169/2011, WHO 2023
Qualitative Level	Analysis of the list of ingredients (additives, flavorings, preservatives); identification of NOVA classes and EWG scoring	NOVA (Monteiro et al., 2019); EWG Food Scores (EWG, 2023)
Traceability Level	Verification of GS1 barcodes (country prefix, EAN-13/8 structure)	GS1 International Standard, GS1 Algeria

The integration of these different levels of information into a structured evaluation grid allows for a complete compliance audit for each analyzed product, ranging from formal label verification to the assessment of the product's intrinsic nutritional quality.

2.2.3. Data Structuring for Compliance Verification

Data structuring is a key step in building an enriched database. To be operational, such a base must be organized to allow for rapid and reliable querying, easy updating, and exporting of results in usable formats (comparative tables, graphs, compliance reports).

2.3. Contribution of Databases to Quality Control and Food Safety

2.3.1. Detection of Nutritional Gaps and Inconsistencies

Enriched databases are very useful in the field of quality control. They can automatically detect errors and inconsistencies between the information indicated on labels and regulatory or scientific references. These errors can be of different types:

Internal inconsistency of the nutritional table: the sum of the energy values calculated from the declared macronutrients does not correspond to the total energy value announced (error greater than $\pm 5\%$);

Abnormally high or low nutritional value compared to reference data for the product category (e.g., salt content greater than 3 g/100 g for canned tuna);

Absence of a mandatory nutrient in the table (e.g., saturated fatty acids not declared for a meat product);

Non-concordance between declared ingredients and nutritional values (e.g., sugar in first position in the list of ingredients but carbohydrates/sugars very low in the nutritional table).

Chapter 2. Enriched Food Databases at the Service of Quality and Safety

In the present study, the detection of these inconsistencies is carried out systematically for each analyzed product, using the nutritional evaluation grid and the verification calculation by Atwater factors. The results are presented in the form of compliance indicators by product and by food group.

2.3.2. Decision Support in Quality Control

Enriched databases help quality control professionals make informed decisions. They allow for determining which products or categories have the most quality problems, comparing local and imported products, and targeting recommendations towards critical points for the consumer.

The scoring systems integrated into these databases make the results easier for everyone to understand, including consumers and policymakers. They transform complex technical data into clear and visual indicators. This is the goal of the Nutri-Score and the EWG score, whose principles are presented below:

Tableau 19. EWG Food Scores interpretation grid used in the study (after EWG, 2023)

EWG Score	Quality	Interpretation	Color Code
1 – 2	Excellent	Highly recommended product	#1B5E20 (dark green)
3 – 4	Good	Acceptable product	#388E3C (green)
5 – 6	Concerning	Moderate consumption recommended	#F57F17 (orange)
7 – 8	Poor	Product not recommended	#E64A19 (red-orange)
9 – 10	Very poor	Product strongly discouraged	#B71C1C (dark red)

The NOVA classification is very useful. It helps us assess the level of processing of a product. This is possible even if we do not know its exact nutritional composition. A product can have acceptable nutritional values but be classified as NOVA 4. This means it is ultra-processed due to the presence of many additives in its formulation. The NOVA classification therefore gives us important information about the products we consume.

Tableau 20. NOVA classification of foods according to their degree of transformation (after Monteiro *et al.*, 2019; FAO, 2019)

Group	Definition	Examples
NOVA 1	Unprocessed or minimally processed foods	Fresh vegetables, fresh meats, pasteurized milk, eggs, white rice, flour
NOVA 2	Processed culinary ingredients	Oils, butter, sugar, salt, flour, starch
NOVA 3	Processed foods	Canned vegetables and legumes, cheeses, canned fish, salted meats
NOVA 4	Ultra-processed foods	Sodas, chips, nuggets, industrial sausages, sugary cereals, industrial biscuits

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2.3.3. Contribution to Food Risk Prevention

Food safety is not limited to the question of whether foods are safe to consume from a microbiological or chemical point of view. It also includes protecting consumers against false or incomplete information on labels. Databases that contain a lot of information play a very important role in avoiding problems. They allow for identifying products that could present risks to public health even before they are put on sale or during checks in stores.

The main risks associated with incorrect labeling, according to scientific studies and current rules, are as follows:

Tableau 21. Main risks associated with faulty food labeling (after Decree 13-378; Law 09-03; EFSA, 2022; Codex Alimentarius, 2024)

Risk Type	Description	Concrete Example	Potential Consequence
Allergenic Risk	Absence or insufficiency of the declaration of major allergens	Milk, gluten, peanuts not highlighted in bold on the label	Severe allergic reaction, anaphylactic shock
Nutritional Risk	Erroneous or inconsistent nutritional values leading to intake calculation errors	Energy underestimated by 30% in an industrial biscuit	Nutritional imbalance, risk of obesity or deficiency
Risk of Deception	Non-compliant or misleading nutritional claims	"No added sugars" mention on a product containing glucose syrup	Incorrect food choice by the consumer
Traceability Risk	Absence of batch number or illegible shelf life	Batch not identifiable during a product recall	Impossibility of rapid market withdrawal in case of contamination
Regulatory Risk	Non-compliance with mandatory bilingualism (Arabic/French)	Label only in a foreign language	Administrative sanction, market withdrawal

The creation of comprehensive databases, associated with systematic verification methods, is therefore an important tool for improving food safety in Algeria, in addition to official controls carried out by competent authorities such as the Directorate of Commerce, approved analysis laboratories, and ONSSA.

There is an importance of information on nutritional composition and comprehensive databases for controlling food quality and safety. By combining Algerian and international rules, recognized nutritional scoring systems such as Nutri-Score, NOVA, and EWG, and by carefully organizing the data, we can perform complete and reliable verifications. We will use these tools systematically in the following chapter, which will present the results for all the food groups studied.

Chapter 3. Intelligent Mobile Applications as a Tool

The evolution of Information and Communication Technologies (ICT) has profoundly transformed quality control methods in the food sector. The integration of intelligent mobile applications into nutritional monitoring systems represents a considerable advance for quality professionals, regulatory authorities, and consumers. In this chapter, we first examine the role of ICT in the digitalization of food quality control, then present the principles of intelligent analysis of nutritional compliance, drawing on recent scientific tools and references.

3.1. ICT and Digitalization of Food Quality Control

3.1.1. Role of ICT in Quality Systems

Information and Communication Technologies (ICT) refer to the set of technical devices and systems that enable the collection, processing, storage, transmission, and dissemination of information in digital form (UNESCO, 2023). In the field of food quality and safety, ICT can considerably improve product traceability, automate compliance controls, and accelerate decision-making within agri-food supply chains.

A systematic review published in the Journal of Medical Internet Research by Zheng et al. (2024) identified more than 400 digital applications designed to measure food and nutritional intakes, demonstrating the rapid rise of artificial intelligence and image recognition tools in the nutrition field. Similarly, the EFSA (2022) report on the digital transformation of food safety identifies ICT as a strategic lever to strengthen food risk surveillance systems at European and international level.

In the Algerian context, the digitalization of food quality control remains at an early stage, but the strategic directions of the digital development plan (e-Algeria 2025) open promising prospects for integrating digital tools into control procedures carried out by commerce directorates and accredited analysis laboratories.

The following table summarizes the main applications of ICT in food quality systems:

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Tableau 22. ICT Applications in Food Quality Systems (EFSA, 2022 ; Zheng et al., 2024; Safety Culture, 2025)

Application Domain	Technology Used	Contribution to Quality Control	Tool Examples
Product Traceability	RFID, QR codes, blockchain	Real-time tracking from production to distribution	GS1, IBM Food Trust
Label Control	OCR (Optical Character Recognition), barcode scanning	Automated reading of nutritional and regulatory information	Open Food Facts, Yuka, FoodVisor
Cold Chain Monitoring	IoT sensors, mobile applications	Detection of temperature breaks; real-time alerts	SafetyCulture, Eezytrace
HACCP Compliance Audit	Mobile applications, cloud computing	Dematerialization of controls, automatic archiving, report generation	SafetyCulture iAuditor, Eezytrace HACCP
Nutritional Assessment	AI, machine learning, computer vision	Automatic calculation of nutritional scores, detection of inconsistencies	MyFitnessPal, NutriflyAI, FoodRec
Consumer Information	Mobile applications, web interfaces	Providing nutritional scores and allergen alerts	Yuka, ScanUp, QuelProduit

3.1.2. Digitalization of Food Product Control

The digitalization of food product control corresponds to the transfer of paper-based verification procedures to integrated digital systems, which facilitate the automated collection, processing, and archiving of control data (FAO, 2022). This transition offers several advantages described in the scientific and technical literature:

- Reduction of human data entry errors, through automation of data flows;
- Considerable time savings during audits and inspections: establishments adopting mobile solutions, according to SafetyCulture (2025), reduce their control time by an average of 30 to 50%;
- Improved traceability and responsiveness in the event of a product recall;
- Standardization of control procedures, making it easier to compare production sites or batches;
- Secure archiving and automatic time-stamping of results, essential for regulatory audits.

In methodological terms, the digitalization of nutritional labeling control relies on two complementary technologies: automated barcode reading (EAN-13/EAN-8, QR code) and optical character recognition (OCR). These technologies enable real-time retrieval of information on a product label and its automatic comparison against a reference database incorporating applicable regulatory requirements. A system combining AI and OCR, described

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in the International Journal of Engineering Technology (Reddy *et al.*, 2026), achieves over 95% accuracy for the extraction and verification of data on food labels.

3.1.3. Mobile Applications in Food Safety

Mobile applications dedicated to food safety and quality are today one of the most accessible and widespread forms of control digitalization. They are distinguished by their ergonomics, their availability anywhere, and their capacity to offer an immediate response to the user, whether a consumer, quality professional, or official inspector.

In their narrative review published in the journal *Dietetics* (2024), Arana-Alvarez *et al.* identify more than one hundred studies evaluating mobile nutrition and food control applications, highlighting their effectiveness in improving dietary behaviors and strengthening users' nutritional awareness. Among the best-known applications internationally:

Tableau 23. Main Mobile Applications Used in Quality Control and Nutrition (Li *et al.*, 2024; Safety Culture, 2025)

Application	Developer	Main Functionality	Database Coverage	Score / Indicator
Open Food Facts	Open Food Facts Association (France)	Collaborative open database; barcode scanning	Over 3 million products (worldwide)	Nutri-Score, NOVA, Eco-Score
Yuka	Yuca Company (France)	Evaluation of food and cosmetic products	Proprietary data + Open Food Facts	Score /100 (nutrition 60%, additives 30%, organic 10%)
MyFitnessPal	Under Armour (USA)	Personal nutritional tracking, calorie calculation	Over 14 million foods	Macronutrients, RDA
FoodVisor	FoodVisor SAS (France)	Food recognition by photo + AI	Proprietary + CIQUAL	Nutritional values calculated by AI
SafetyCulture (iAuditor)	SafetyCulture (Australia)	Mobile quality and HACCP audit for professionals	Customizable checklists	Compliance rate, PDF reports
NutrifyAI	Research team (2024)	Food detection by computer vision (YOLO)	Public nutritional databases (USDA, CIQUAL)	Nutritional composition estimated by AI

The study conducted by Li *et al.* (2024), published in the journal *Nutrients*, evaluates 18 mobile nutrition applications using MARS (app quality) and ABACUS (behavioral change potential) grids. Results show that applications integrating artificial intelligence for visual food recognition achieve better functional performance, with recognition accuracy of up to 97% for MyFitnessPal and 92% for Fastai. This study nevertheless highlights the need to improve the

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cultural diversity of databases, particularly for non-Western foods, which is especially relevant in the Algerian context.

3.2. Intelligent Analysis of Nutritional Compliance

3.2.1. Principles of Intelligent Analysis Applied to Quality Control

Intelligent analysis of nutritional compliance encompasses all automated processes that verify, from the information on a food product label, the consistency and accuracy of declared nutritional data and their compliance with applicable regulatory requirements. It relies on the combination of several technologies: optical character recognition (OCR), barcode reading, artificial intelligence (AI), and nutritional scoring algorithms (Reddy et al., 2026; Zheng et al., 2024).

A study recently published in the Journal of Medical Internet Research (Zheng et al., 2024) shows that AI systems applied to nutrition are now capable of automatically identifying foods, estimating their nutritional composition, and detecting inconsistencies in manufacturers' declarations, with accuracy equivalent to reference analytical methods for the main macronutrients. These systems rely on machine learning algorithms trained on large databases, such as the USDA FoodData Central or Open Food Facts.

The key steps of the intelligent analysis process for nutritional compliance are:

Data acquisition: EAN-13 barcode reading or visual label recognition by OCR;

- Information extraction: automatic retrieval of the ingredient list, nutritional table, and mandatory statements;
- Regulatory comparison: verification of the presence of all mandatory statements according to the applicable regulatory framework (Decree 13-378, NS 715, Codex STAN 1-1985);
- Score calculation: Nutri-Score, NOVA classification, EWG Food Scores;
- Inconsistency detection: verification of the internal consistency of the nutritional table using Atwater factors;
- Report generation: synthesis of results, identification of non-conformities, and formulation of recommendations.

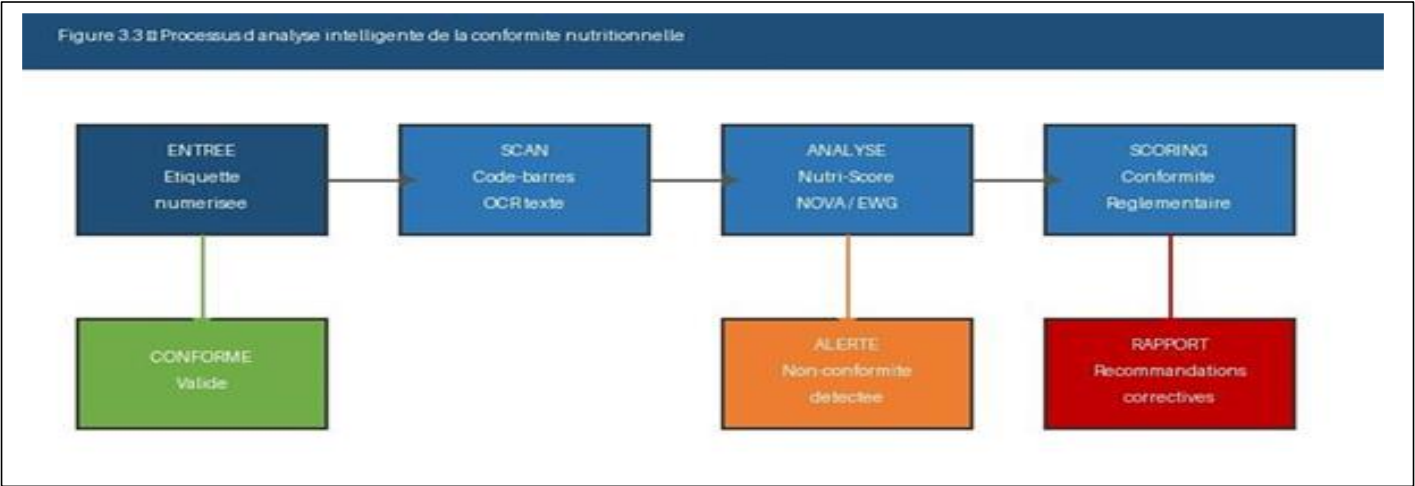


Figure 1.. Intelligent analysis process for nutritional compliance of a food product

3.2.2. Automated Verification of Nutritional Labels

Automated verification of nutritional labels is undoubtedly one of the most concrete applications of intelligent analysis in food quality control. Its objective: to reduce the time and resources devoted to manual inspections while gaining in rigor and reproducibility. A study published in the International Journal of Engineering Technology (Reddy et al., 2026) shows that systems combining OCR and barcode reading are more flexible and reliable than those relying on a single technology. Under varying lighting or print quality conditions, they achieve a correct data capture rate exceeding 95%.

In the context of nutritional labeling verification, automated control enables.

Tableau 24. Types of Automated Verifications Applied to Nutritional Labels (Reddy & al., 2026; Codex Alimentarius, 2024)

Verification Type	Description	Associated Technology	Main Advantage
Presence Verification	Checking for each mandatory item (name, expiry date, ingredient list, etc.)	OCR + regulatory database	Completeness and speed of control
Consistency Verification	Internal consistency check of the nutritional table (Atwater factors)	Energy calculation algorithm	Detection of declaration errors
Nutritional Compliance Verification	Comparison of declared values against regulatory thresholds and RDAs	NutriScore / EWG scoring	Objective nutritional quality ranking
Allergen Verification	Detection of allergens in ingredient list and control of their highlighting (bold, italic, color)	NLP (natural language processing) + OCR	Protection of allergic consumers
Traceability Verification	GS1 barcode check, batch number, and expiry/best-before date	EAN-13/EAN-8 scan + GS1 database	Rapid identification and easier product recall

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Yuka is a fine example of what automated verification can bring to the general public. A survey commissioned by the application from Ifop, published in November 2025, reveals that 78% of food industry professionals acknowledge that the Yuka score influences the composition of their products. Even more significantly, 41% say they systematically integrate it into their formulation processes. These figures clearly show that these digital nutritional analysis tools do more than help consumers: they concretely transform industrial practices as well.

For its part, Open Food Facts, which lists over 3 million products worldwide, is the largest collaborative and freely accessible food database. It brings together the Nutri-Score, NOVA classification, and Eco-Score, and serves as the primary source for many mobile apps, including Yuka in its early days (**Open Food Facts, 2024**).

3.2.3. Decision Support for FSQA Stakeholders

Intelligent mobile applications and digital nutritional analysis systems offer considerable potential as decision support tools for the various stakeholders in the food safety and quality assurance (FSQA) sector: manufacturers, official controllers, and consumers, beyond their use by consumers alone.

Tableau 25. Contribution of Digital Tools for FSQA Stakeholders (based on Li & *al.*, 2024; National Consumer Council, 2024; SafetyCulture, 2025)

FSQA Stakeholder	Information Needs	Contribution of Digital Tools	Identified Limitations
Manufacturers & Producers	Pre-market compliance verification; formulation optimization	Automated label audit, real-time nutritional scoring, competitor comparison	Implementation costs; need for staff training
Official Controllers & Inspectors	Rapid verification of mandatory labels in the field; inspection report generation	Mobile audit applications (SafetyCulture iAuditor, Eezytrace); fast scan in distribution	Reliability of local databases; absence of Algerian national database
Consumers	Clear and accessible information on the nutritional quality of products at the point of purchase	Yuka, Open Food Facts, ScanUp: immediate information by barcode scan	Potential algorithm bias; per-100g rating not always representative (National Consumer Council, 2024)
FSQA Researchers & Educators	Updated nutritional composition data; scoring tools for comparative studies	USDA FoodData Central, CIQUAL, Open Food Facts for research and education	Data variability by version and region

Methods

This chapter presents the full implementation of the DZsain web application. It covers the architecture, the technologies chosen, the roles of the two main user profiles — subscriber and expert — and a detailed walkthrough of every interface that constitutes the system. The goal is to give the reader a precise and complete understanding of how the application was built and how each component contributes to its overall function.

DZsain was designed to respond to a concrete need in Algeria: helping consumers understand the nutritional content of everyday food products in a way that is personalized to their medical profile. The implementation choices reflect a balance between simplicity of deployment, scientific rigour of the nutritional scoring, and ease of use for people who may have no prior technical background.

2 Definition of the DZsain Web Application

DZsain is a web-based food safety and nutritional analysis platform developed specifically for the Algerian market. It enables users to scan or manually enter product barcode and receive a comprehensive nutritional assessment adapted to their declared health conditions and allergies.

At its core, DZSain computes an EWG-inspired score (Environmental Working Group methodology) for each product. This score, ranging from 0 to 100, reflects both the intrinsic nutritional quality of the product — based on sugars, saturated fats, sodium, fibre, and protein content — and a degree of food processing, measured by the detection of food additives, artificial flavorings, and other industrial markers in the ingredient list.

The application maintains two complementary databases. The first is the Algerian food database (Algerian Food Database), which stores detailed nutritional profiles of products commonly found in Algerian supermarkets, organised into seven categories: mineral waters, dairy products, cheeses, canned goods, cereals, fats, and confectionery. The second is a local SQLite database that tracks user scan history and authenticates expert accounts.

DZSain is not a generic food tracking tool. It is purpose-built to help individuals living with chronic conditions — such as diabetes, hypertension, coeliac disease, or irritable bowel syndrome — make safer daily food choices by flagging products that conflict with their specific health profile.

3 Web Application Description: Subscriber and Expert

3.1 The Subscriber Interface

The subscriber is the primary end user of DZSain. No account creation is required: the application is intentionally open so that any person — patient, caregiver, or curious consumer — can use it immediately without a registration barrier. The subscriber interacts with the system through a single, unified page that combines profile configuration, product scanning, and result display.

The subscriber workflow unfolds in three stages:

- **Profile configuration:** the user selects from a predefined list of pathologies (Type 1 and Type 2 diabetes, haemorrhagic rectocolitis, gastric ulcer, coeliac disease, irritable bowel syndrome, and arterial hypertension) and a list of allergens (eggs, tree nuts, seafood, preservatives, food dyes, and seeds). These selections are stored locally in the browser session and transmitted with every analysis request.
- **Product identification:** the user can either type a barcode directly into the search field or upload a photograph of the product label. In the image mode, the OCR engine reads the label and extracts the relevant nutritional information automatically.
- **Result consultation:** once analysis is complete, the system displays the product name, its EWG score on a visual gauge, a colour-coded classification (green / yellow / orange / red), a nutrient grid showing sugars, saturated fats, sodium, fibre, protein, and energy, and a personalised health profile tab that lists any conflicts detected between the product's composition and the user's declared conditions or allergies.

3.2 The Expert (Biologist) Interface

The expert interface is reserved for validated biologist accounts and is accessed through a dedicated login page. Experts are identified by their email address and password, which are stored in the local SQLite database. A default demonstration account is pre-created at application startup (**expert@DZSain.dz / expert123**).

Once authenticated, the expert accesses a dashboard that is structurally different from the subscriber view. It is built around a persistent left sidebar with navigation items, giving access to the following modules:

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- Statistics overview key figures including the total number of products per category in the Algerian database and the cumulative number of scans recorded in the history table.
- Product management: a full CRUD (Create, Read, Update, Delete) interface allowing the expert to browse products by category, search by name, add new products with all their nutritional fields, modify existing records, and delete obsolete entries. The system dynamically adapts the input form to match the exact column structure of the selected category table.
- Scan history: a read-only view of all analyses performed by subscribers, including product name, barcode, EWG score, classification, and timestamp.
- Account management: the expert can view their session information and log out securely.

4. Development Tools and Versions:

DZSain was built using an entirely open-source stack. The table (Table1) below summarizes the main technologies, frameworks, and libraries used, along with their respective versions.

Tool	Version	Role
Backend		
Python	3.10+	Main programming language for the backend
Flask	2.x	Lightweight web framework (routing, controllers)
Flask-SQLAlchemy	3.x	ORM layer for database models and queries
Flask-Login	0.6.x	Session management and expert authentication
SQLite	3.x (built-in)	Local relational database (users, scan history)
Werkzeug	2.x	WSGI utilities and request routing
Frontend		
HTML5	Standard	Standard markup language for all interfaces
CSS3 (Custom Properties)	Standard	Responsive layout and theming
JavaScript (ES2020)	ES2020	Dynamic UI and fetch API calls

Methods

Data and Analysis		
AlgerianFoodDatabase	Custom	SQLite-backed nutritional database
NutritionAnalyzer	Internal	EWG-inspired scoring engine
OCREngine	Internal	Label image reading (optical character recognition)
Deployment and Tooling		
Visual Studio Code	Latest	Primary code editor
Postman	Latest	API endpoint testing

Tableau 26. Development Tools and Versions

The architecture follows a classic Model-View-Controller pattern: Flask routes act as controllers, and SQLAlchemy models alongside the custom database modules form the data layer. All database interactions use parameterised queries to prevent SQL injection. The application runs on port 5050 and can be exposed publicly via a ngrok tunnel for demonstration or remote access.

5. Web Application Interfaces :

This section describes each interface that makes up the DZsain application. For each screen, the purpose, the main visual components, and the interactions available to the user are explained. The interfaces are divided into two groups: those accessible to subscribers and those reserved for authenticated exp

Results & discussion

DZSain is website that helps users make informed decisions about their diet, specifically designed for Algeria. It uses two methods to identify products: scanning the GS1 barcode and analyzing the image of the nutrition label. The website features an Algerian food database, calculates the EWG score for each product, and provides a personalized analysis based on the user's health profile, including medical conditions and food allergies. A key feature of DZSain is that its database was entirely created, structured, and populated by its developers. The DZSain database was built using manual field surveys. Nutritional information was collected directly from the labels of food products available on the Algerian market. Each entry was rigorously verified to ensure compliance with current regulatory requirements. This approach ensures that the database is relevant, reliable, and tailored to the Algerian context. In this section, we present the results of tests conducted using the application on a specific cheese product from the Algerian market. We discuss each functional interface using annotated figures, then compare these results with those of digital tools available internationally.

1. Overview of DZSain's Interfaces :

1.1 Login Interface :

The DZSain login interface (Figure 1) is reserved for nutrition experts authorized to view and manage the Algerian food database integrated into the website. It takes the form of a simple, centered form, with a field for an institutional email address (**format expert@DZSain.dz**) and a password field, followed by a "Log In" button. A link back to the general public interface is also provided, facilitating navigation between the two areas of the application.

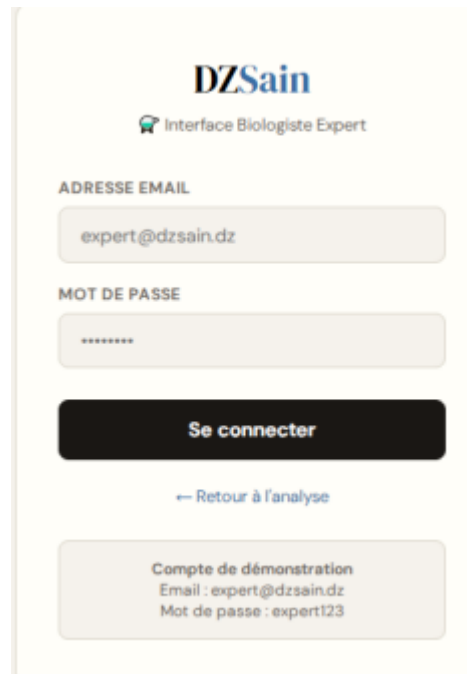


Figure 2. DZSain Secure Login Interface — Expert Nutritionist Area

This segmentation of access levels is a key architectural feature: it clearly separates the user-patient area—which is open and focused on consultations—from the expert area, which is dedicated to entering, validating, and updating product data. This two-tier access control model (user/expert) is recommended in the field of health information systems, particularly to ensure the integrity and reliability of nutritional databases (Vos et al., 2023).

From an ergonomics perspective, the interface adheres to the principles of visual simplicity and readability, with high contrast between text and background, and clearly delineated input fields. The provision of a demo account in a separate panel reflects an educational approach designed to facilitate new expert users' adoption of the tool.

1.2 Main Interface: Health Profile and Dashboard

Figure 2 shows the main interface of DZSain, organized into two distinct functional panels. The left panel, titled “Health Profile,” allows the user to select their medical conditions (type 1 and 2 diabetes, ulcerative colitis, gastric ulcer, celiac disease, high blood pressure, etc.) and food allergies (eggs, tree nuts, fish and shellfish, canned foods, food colorings, sesame seeds, etc.) using checkboxes organized into drop-down lists. The right panel displays the central analysis area—initially empty, with the message “No analysis in progress”—as well as a history of recent scans with their EWG scores and timestamps (Figure 2).

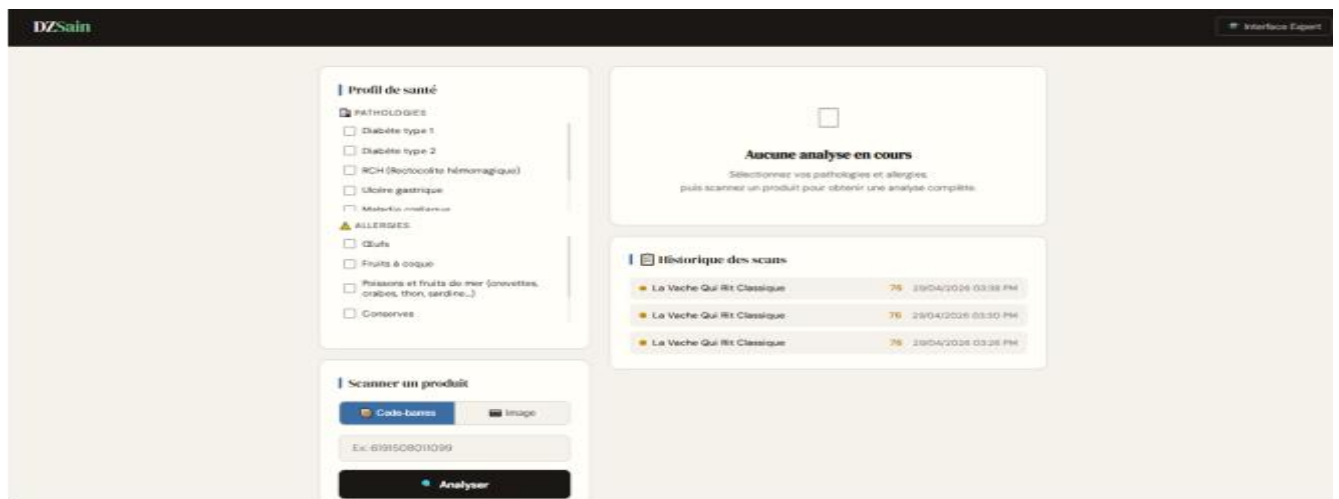


Figure 2. Main Analysis Page

Figure 3 .DZSain’s main interface — Health profile, analysis area, and scan history

This interface layout reflects a user-centered approach focused on initial personalization: the user begins by defining their health profile before scanning a product, which allows the algorithm to tailor the analysis to individual needs. This approach aligns with current recommendations for the design of mobile health (mHealth) applications, which emphasize the need to integrate the user’s clinical context into nutritional decision-support systems (Hou *et al.*, 2020; Lieffers *et al.*, 2018).

The scan history, displayed at the bottom of the right panel along with the product name, EWG score, and date/time, introduces a longitudinal dimension to dietary tracking. This traceability feature, though preliminary in the current version, paves the way for trend analysis and personalized nutritional guidance over time.

1.3 Health Profile Details: Medical Conditions and Allergies

Figure 3 provides a close-up view of the “Health Profile” panel, revealing the scope and level of detail of the clinical parameters available. The conditions covered include type 1 and type 2 diabetes, ulcerative colitis (UC), gastric ulcer, celiac disease, irritable bowel syndrome (IBS), and hypertension. The listed allergens include eggs, tree nuts, fish and seafood (shrimp, crab, tuna, sardines), canned foods, food colorings, and sesame seeds.

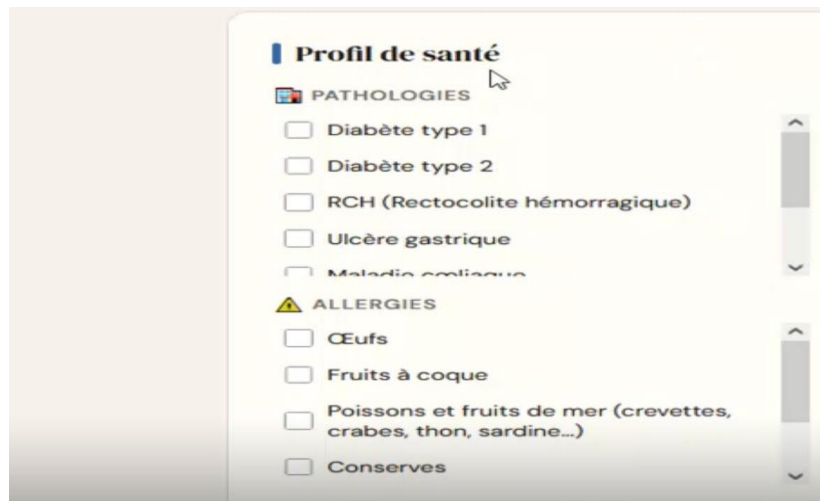


Figure 4 Detail of the “Health Profile” panel — Selection of medical conditions and food allergies

The selection of medical conditions included is not arbitrary: it corresponds to the most prevalent chronic conditions in Algeria for which specific dietary recommendations exist. According to the 2019 National Health Survey (MSPRH, 2019), diabetes affects approximately 12.3% of Algerian adults over the age of 35, while hypertension affects nearly 30% of this same population. These two conditions therefore represent priority targets for personalized nutritional intervention.

For allergies, the list covers the major allergens defined by the Codex Alimentarius (CAC/GL 23-1997, revised) and included in European Regulation 1169/2011 (EU, 2011), to which Algerian regulations partially refer (Executive Decree 05-484, amended in 2013). The inclusion of food colorants as a category of allergens is particularly relevant in the context of industrial sweets and confectionery, which constitute a significant portion of the products analyzed in this study.

1.4 Fonctionnalité de scan : saisie du code-barres et analyse

Figure 4 shows the product scan module, located at the bottom of the left panel of the interface. Two identification methods are available: entering a barcode (GS1-13) and importing an image of the nutrition facts panel. The input field displays a sample format (e.g., 61915p8011099), and a black “Analyze” button allows you to start the analysis. In the background, you can also see that the condition “High blood pressure” has been checked in the health profile, thereby configuring the upcoming analysis.

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The screenshot displays the 'Scan Module' of the DZSain application. It features a sidebar on the left with a list of health conditions and allergies: 'Intestin irritable (SII)', 'Hypertension artérielle' (checked), 'ALLERGIES', 'Poissons et fruits de mer (crevettes, crabes, thon, sardine...)', 'Conserves', 'Colorants alimentaires', and 'Graines (sésame...)'. The main area contains a 'Scanner un produit' section with buttons for 'Code-barres' and 'Image', a text input field with the example 'Ex: 6191508011099', and an 'Analyser' button. To the right, there is a section titled 'Historique des scans' showing two entries for 'La Vache Qui Rit Classique' with a score of 76 and timestamps from 29/04/2026.

Figure 5 Scan Module — GS1 Barcode Entry and Analysis Trigger

The use of the GS1-13 barcode as the primary identifier is a technically sound choice: this international standard is used on virtually all food products sold in Algeria, in accordance with the country's membership in GS1 Algeria. Each barcode is unique to the product-brand-format combination, enabling unambiguous identification. However, the effectiveness of this feature depends directly on the completeness of the internal database, which must link each barcode to its associated nutritional characteristics.

The alternative image-based analysis method represents a significant advance for local or artisanal products that do not yet have a barcode registered in the database. It involves the use of optical character recognition (OCR) techniques or machine learning-based image analysis, the reliability of which directly determines the quality of the generated scores. Comparable applications such as Open Food Facts use similar approaches, although their robustness has been documented as varying depending on the quality of the image provided (**Brugailières et al., 2021**). 1.5 Résultats d'analyse : score EWG et données nutritionnelles

Figure 5 represents the core functionality of DZSain : it displays the complete results of the nutritional analysis for a pasteurized processed cheese sold on the Algerian market, obtained by scanning the barcode. The calculated EWG score is 76.0/100, categorized as “Moderate” (orange badge). The displayed nutritional profile indicates: sugars 0.0 g/100g, saturated fat 12.3 g/100g, sodium 1200.0 mg/100g, fiber 0.0 g/100g, protein 10.0 g/100g, energy 0.0 kcal. The “Health Profile Compatibility” section highlights the following alert for the previously selected condition “High Blood Pressure”: “High sodium (1200 mg/100g) — blood pressure risk.”

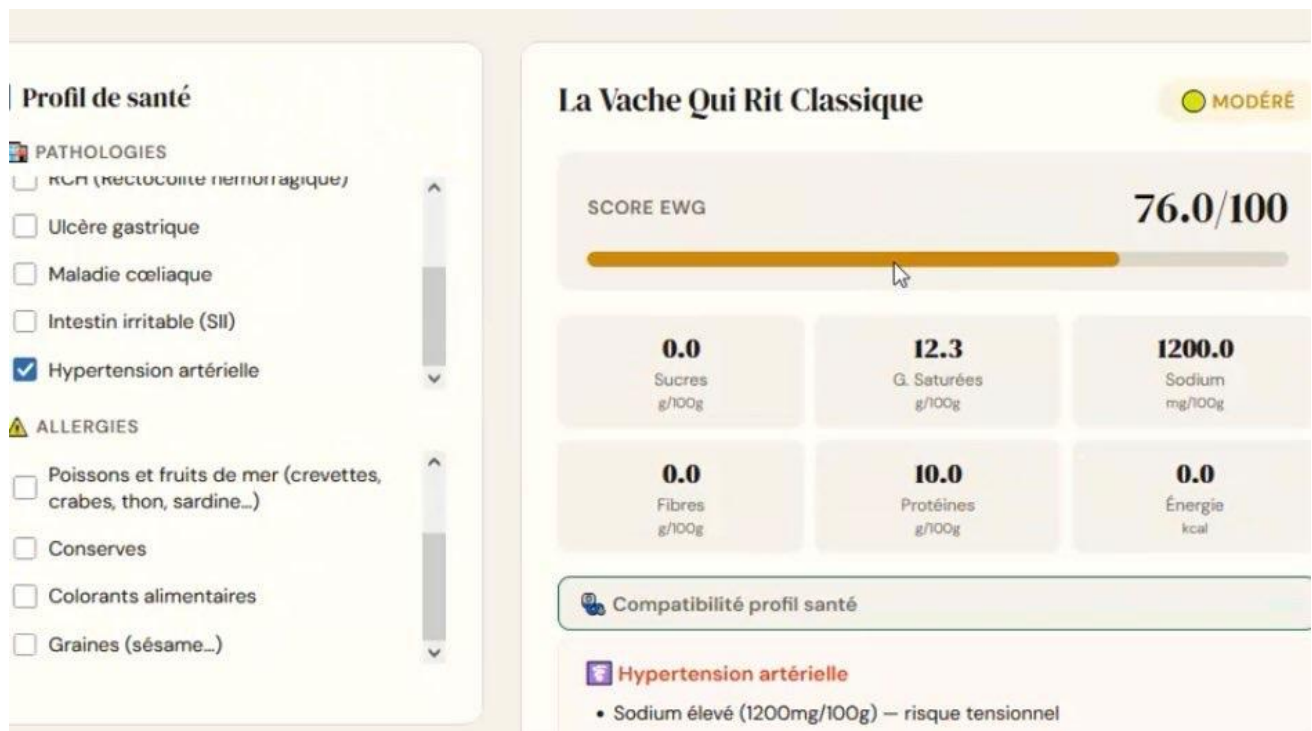


Figure 6 Analysis results for a reference processed cheese — EWG Score 76/100, nutritional profile, and health compatibility

The EWG score of 76/100 places this processed cheese in the “Moderate” category, indicating acceptable nutritional quality but with identified areas of concern. The EWG Food Scores methodology, developed by the Environmental Working Group (EWG, 2012), combines three components: nutritional concerns (sugars, saturated fats, sodium, etc.), the level of processing (processing score), and ingredient-related concerns (additives, allergens). A score of 76/100 indicates that the product has an overall satisfactory profile, although the sodium and saturated fat content warrants special attention.

The sodium content of 1,200 mg/100g is indeed very high for a processed cheese. By way of comparison, the World Health Organization (WHO) recommends a total daily sodium intake of less than 2,000 mg (WHO, 2023), meaning that 100g of this product already accounts for 60% of the recommended daily sodium intake. The alert generated by DZSain for people with hypertension is therefore clinically relevant and consistent with established dietary recommendations for this condition (Sacks *et al.*, 2019).

With regard to saturated fat (12.3 g/100 g), this value exceeds the 10 g/100 g threshold generally considered high in the Nutri-Score system (Herberg *et al.*, 2019), which would have resulted in an unfavorable classification under this reference system. The consistency between the EWG

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score and other nutritional assessment systems validates the relevance of the method used in DZSain .

1.6 Display of Clinical Alerts and Scan History

Figure 6 complements the analysis in Figure 5 by presenting the “Health Profile Compatibility” section with the high blood pressure alert displayed in two overlapping formats: a bulleted list detailing the alert (“High sodium (1200 mg/100g) — blood pressure risk”) and a consolidated version in a text banner. The scan history is also visible, showing three analyses of the same product at different times (3:38 PM, 3:30 PM, 3:26 PM), all with an EWG score of 76.

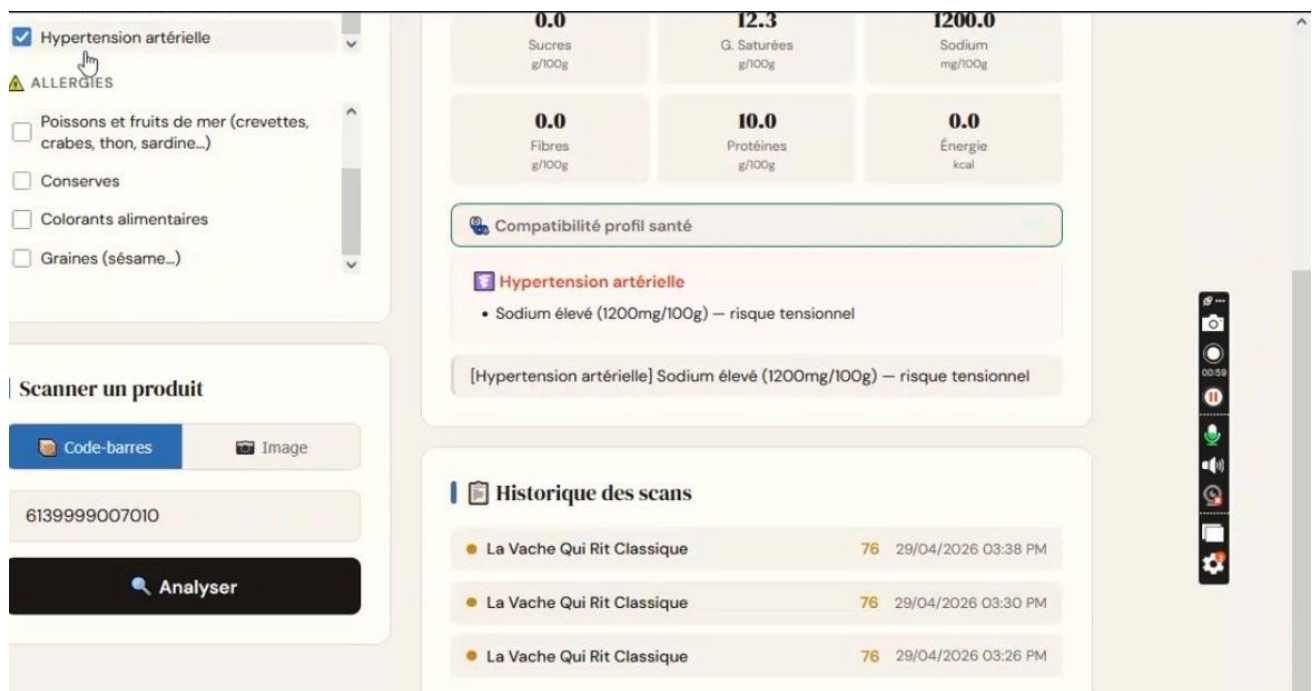


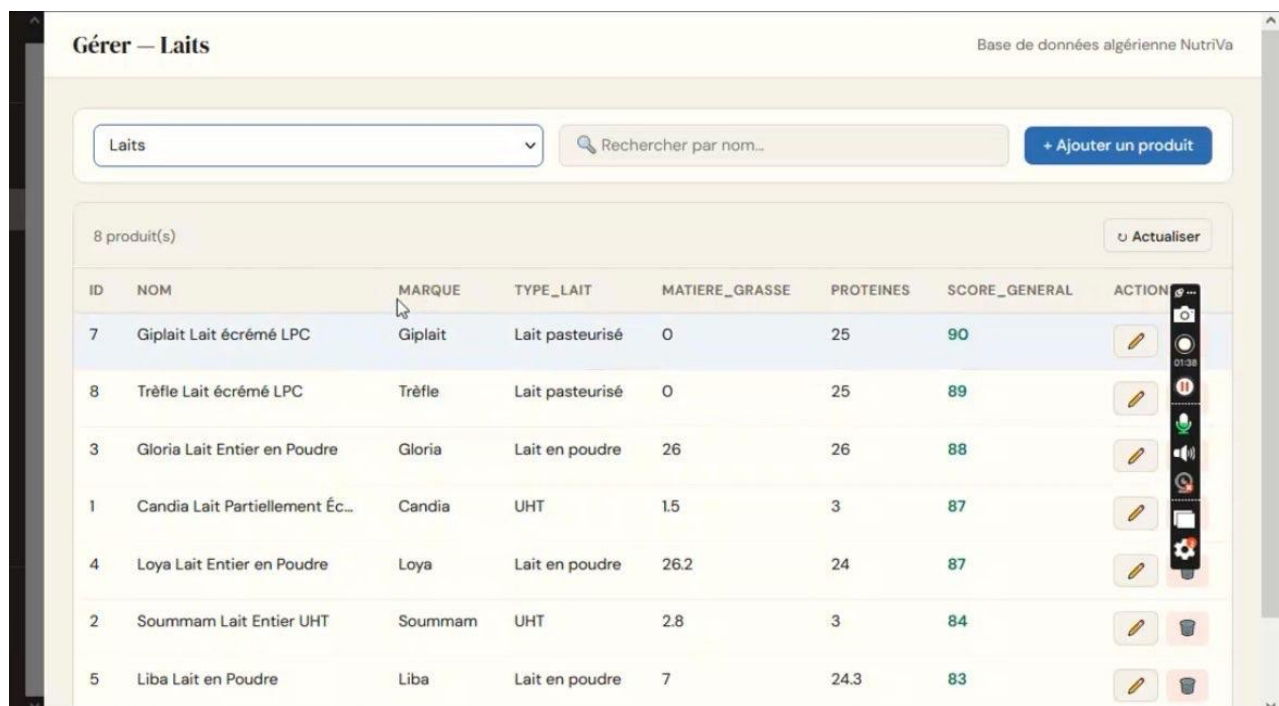
Figure 7 Health Compatibility Alert for High Blood Pressure and History of Multiple Scans

The dual presentation of the alert—in the form of a structured bullet point and a summary banner—demonstrates a focus on communicating nutritional risk. This informational redundancy aligns with the design principles of digital health alert systems, which recommend using multiple channels to present critical information to maximize its impact on user behavior (Tansil et al., 2022). The scan history, featuring three repeated analyses of the same product at short intervals, confirms the persistence of DZSain’s data. This chronological tracking, even in its early stages, provides a foundation for the future development of a food diary numérique (food diary), a feature found in established food tracking apps (Burke et al., 2019), and one that has been shown to be useful in supporting patients with diabetes and hypertension (Burke et al., 2019).

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1.7 Expert Interface: Milk Database Management

Figure 7 shows the management interface reserved for expert biologists, specifically for the “Milk” category. The table lists eight Algerian dairy products along with their attributes: brand, type of milk (pasteurized, UHT, powdered), fat content, protein content, and calculated overall score. Action buttons allow each entry to be edited or deleted, and a “+ Add a Product” button allows the database to be expanded. Sorting by descending score, from 90 to 83, provides an immediate comparison of the different types of milk available on the Algerian market.



ID	NOM	MARQUE	TYPE_LAIT	MATIERE_GRASSE	PROTEINES	SCORE_GENERAL	ACTION
7	Giplait Lait écrémé LPC	Giplait	Lait pasteurisé	0	25	90	
8	Trèfle Lait écrémé LPC	Trèfle	Lait pasteurisé	0	25	89	
3	Gloria Lait Entier en Poudre	Gloria	Lait en poudre	26	26	88	
1	Candia Lait Partiellement Éc...	Candia	UHT	1.5	3	87	
4	Loya Lait Entier en Poudre	Loya	Lait en poudre	26.2	24	87	
2	Soummam Lait Entier UHT	Soummam	UHT	2.8	3	84	
5	Liba Lait en Poudre	Liba	Lait en poudre	7	24.3	83	

Figure 8 Biologist Expert Interface — Management of the “Milk” category in the DZsain database

This expert interface represents the “back-end” component of DZSain, which is essential for the maintenance and development of the Algerian food database. The fact that the database includes local Algerian products—which are absent from major international databases—constitutes DZSain’s fundamental added value compared to existing tools. This localization of data addresses a documented gap: global nutritional databases provide very insufficient coverage of products from North African markets (Branca et al., 2020).

The scores observed for milk reveal a trend consistent with nutritional recommendations: pasteurized skim milk scores higher than whole milk UHT, due to their lower saturated fat content. This ranking aligns with WHO recommendations on reducing saturated fat intake to

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prevent cardiovascular disease (WHO, 2023). It validates the effectiveness of the scoring algorithm built into DZSain for distinguishing between products within the same category.

The presence of delete buttons (trash can icon) only for certain products and not for others suggests a logic of protecting reference data: the products that form the foundation of the database are protected against accidental deletion, while more recent or less validated entries can be deleted. This implicit distinction between reference data and provisional data should be formalized and documented in an expert user guide.

By comparing DZSain with existing international digital nutrition information tools, we can clearly identify its added value and potential areas for improvement.

Open Food Facts (OFF) is the world's largest open-source collaborative database, with over 3.4 million products listed across 165 countries (**Vos et al., 2023**). It powers numerous mobile nutrition apps around the globe. However, its coverage of Algerian products is very limited: a search by origin for "Algeria" yields only a few hundred entries, and the reliability of seasonal or manually entered data is inconsistent. DZSain stands out here with a database intentionally designed around products available on the Algerian market, featuring an expert validation process.

A very popular French mobile app, which had over 55 million users in 2024, scans barcodes and assigns scores to foods by combining nutritional quality (60% of the score based on Nutri-Score), the presence of additives (30%), and organic certification (10%) (nutrition app, 2024). In comparison, DZSain uses the EWG Food Scores methodology rather than the Nutri-Score, making it more sensitive to issues related to additives and industrial processing. Furthermore, this tool does not offer a personalized clinical compatibility module based on medical conditions, which is a clear distinguishing advantage for DZSain

A leading U.S. app, with over 200 million users worldwide, focuses on calorie tracking and weight management, featuring a database of over 14 million food products (calorie tracking app, 2023). However, it does not provide an analysis of a product's suitability for specific medical conditions or an overall quality score. DZSain therefore stands out for its more clinical approach, focused on the prevention and management of chronic diseases, rather than solely on weight loss.

Another U.S. app combines nutritional scores with consumer education. It includes alerts for certain health conditions (diabetes, high cholesterol) and suggests alternative products. Its geographic coverage is primarily North American, using USDA databases. Its educational

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approach is nonetheless a source of inspiration for the future development of DZSain particularly for enriching clinical alerts with context-specific dietary recommendations **(Abrams et al., 2015)**.

Nutrinet-Santé, France's leading online epidemiological study, includes over 170,000 participants and offers tools for collecting dietary habits **(Hercberg et al., 2010)**. Although it is not comparable to DZSain in terms of daily use, it demonstrates that it is entirely possible and useful to use digital tools to collect nutritional data on a large scale. It therefore serves as a model for integrating an epidemiological dimension into DZSain in the future.

For its part, the EWG Food Scores methodology, developed by the Environmental Working Group (EWG, 2012) in the United States, is based on three main criteria: nutritional concerns (by evaluating nutrients to limit, such as added sugars, saturated fats, sodium, and synthetic additives), the processing score (based on the level of industrial processing according to the NOVA classification), and ingredient-related concerns (allergens, potential contaminants, GMOs). The final score ranges from 0 to 100, with a higher score indicating better quality.

DZSain's adoption of this method is justified for several reasons. First, the aspect related to industrial processing is particularly relevant in Algeria, where consumption of ultra-processed foods (NOVA 4) has risen sharply since the 2000s **(Moubarek et al., 2021)**. Second, the inclusion of additives addresses a growing concern among the most informed Algerian consumers and aligns with the labeling transparency objectives advocated by the Codex Alimentarius (CAC/GL 36-1989). Finally, the nutritional dimension of the EWG score is consistent with the Nutrient Reference Values (NRVs) adopted in Algerian regulations (Executive Decree 13-378).

From a regulatory standpoint, DZSain complies with Algeria's nutritional labeling regulations. Executive Decree 05-484 of December 22, 2005, as amended by Executive Decree 13-378 of November 9, 2013, establishes labeling requirements for prepackaged food products intended for consumers. This framework specifically requires the declaration of energy, protein, carbohydrate, fat, and sodium content, while allowing for the optional inclusion of other nutrients. DZSain uses precisely these declared data to calculate its scores.

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DZSain's contribution in this context is twofold: on the one hand, it helps consumers decipher nutritional data that is often complex and poorly understood (**Grunert & Wills, 2007**); on the other hand, it can serve as a monitoring tool for food quality professionals, enabling them to identify inconsistencies or anomalies in nutritional declarations. This second aspect aligns directly with the objectives of official food product control, as provided for by Law No. 09-03 of February 25, 2009, on consumer protection and the prevention of fraud.

However, DZSain does not replace laboratory analyses for verifying regulatory compliance. The scores generated are decision-support indicators based on data reported by manufacturers, not on independent analytical measurements.

This limitation must be clearly communicated to users, particularly in the expert interface, to avoid any confusion between decision support and compliance certification. Several limitations are worth noting in the current version of DZSain. First, the database coverage remains incomplete: although it is representative for certain categories (such as milk and cheese), it does not yet cover all products available on the Algerian market. The continuous expansion of this database, through a rigorous validation protocol including reference laboratory analyses, is the most critical development priority.

Second, the image analysis functionality for the nutrition table relies on image processing algorithms whose performance has not yet been systematically evaluated across a wide range of Algerian nutrition tables, which feature varied typographies and layouts.

Finally, the lack of a clinical evaluation of DZSain's impact on users' dietary behaviors represents a significant gap. Randomized controlled trials on the effectiveness of mobile nutrition apps have shown mixed results, often linked to user retention and the quality of professional support (**Lieffers et al., 2018**). Such an evaluation would be necessary to validate the clinical relevance of DZSain. Among the identified development prospects are: the integration of a module for alternative recommendations (suggestions for equivalent products with better scores), the development of a native mobile interface (iOS/Android), connection to biometric measurement devices (glucose meter, connected blood pressure monitor) for even more personalized alerts, and the creation of a longitudinal nutritional dashboard to track dietary habits over time.

Conclusion

DZsain represents an original and context-specific contribution to the field of digital tools for nutritional decision-making in Algeria. By combining an Algerian food database built and validated by experts, a recognized scoring methodology (EWG Food Scores), and a personalized clinical compatibility module, the app offers a functional solution to a real and documented public health need.

Tests conducted on a reference pasteurized processed cheese validated the app's main features: barcode identification, EWG score calculation, display of a detailed nutritional profile, generation of relevant clinical alerts (high sodium for hypertension), and retention of scan history. The expert interface dedicated to database management, illustrated for the milk category, demonstrates the viability of a two-tier governance model (user/expert biologist) to ensure data integrity and quality.

Compared to leading digital tools available internationally, DZSain stands out for three key features: the Algerian-specific nature of its database, the integration of a clinical compatibility module for specific conditions and allergies, and the use of a scoring methodology (EWG) that takes into account nutrients, additives, and the degree of industrial processing. These features give it specific relevance in the context of Algeria's nutritional transition and the public health objectives defined by the Ministry of Health.

The identified limitations—partial database coverage, unevaluated image recognition performance, and the absence of clinical impact assessment—represent areas for improvement in future versions of the application. Addressing these issues progressively, following a rigorous scientific protocol that involves partnerships with food analysis laboratories and clinical nutrition research teams, will enable DZSain to consolidate its position as a leading tool for promoting the nutritional quality of Algerian food products.

DZSain exemplifies the convergence of information and communication technologies (ICT) and food science in the service of public health—a convergence that the international scienti

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