

République Algérienne Démocratique et Populaire
University of Abdelhamid Ibn Badis
Faculty of of Natural and Life Sciences
Department of Food Sciences.
Mostaganem



MASTER THESIS

Presented by:

Fellouh Soumia

For the Award of the Degree of

Master's Degree in Nutrition and Disease

Specialization: Nutrition and Pathology

Thesis Topic

**Intelligent Personalized Nutritional Assistance System Based
on Consumers' Pathologies and Their Specific Needs**

in front of the committee:

Dr. Mir	Chair of the Jury	U. Mostaganem
Dr. ALACHAHER Fatima Zohra	Supervisor	U. Mostaganem
Dr. Cherrad Hayet	Examiner	U. Mostaganem

Academic Year: 2025/2026

Acknowledgements

First and foremost, I give thanks to Allah, the Almighty and the Most Merciful, for granting me the strength, patience, and perseverance necessary to accomplish this work. Without His will, none of this would have been possible.

I would also like to express my sincere gratitude to my supervisor Dr. ALCHAHER, for her valuable guidance, availability, and insightful advice throughout this work. Her constant support and intellectual rigor greatly enriched my project.

Special thanks to Dr Drissi ASMA, Faculty of Science and Technology (FST), for her collaboration to this work.

I would also like to express my heartfelt gratitude to all my professors who supported me throughout these years of study. Through their rigorous teaching and dedication, they contributed greatly to building my knowledge and awakening my scientific curiosity.

Dedication

I dedicate this modest work as a sign of respect

*To my dear parents, who have always supported, helped, and
encouraged me throughout the entirety of this work,*

To my dear sisters,

To my dear brothers,

To all my friends,

And finally, to all those who helped me accomplish this work

LIST OF ABBREVIATIONS

CGM: Continuous glucose monitors

RCT: Randomized Controlled Trial

BMR: basal metabolic rate

RNIs: Recommended Nutrient Intakes

RDAs: Recommended Daily Allowances

RI: Reference Intakes

EAR: Estimated Average Requirement

AI: Adequate Intake

UL: Upper Intake Level

TEE: total energy expenditure

WHO: World Health Organization

DASH: Dietary Approaches to Stop Hypertension

ADA: American Diabetes Association

SFD: French-Speaking Diabetes Society

BMI: Body Mass Index

LDL: Low-Density Lipoprotein

HDL: High-Density Lipoprotein

IDF: International Diabetes Federation

AHA: American Heart Association

IBS: irritable bowel syndrome

IBD: inflammatory bowel disease

RUTF: Ready-to-Use Therapeutic Food

AI: Artificial intelligence

OECD: Organisation for Economic Co-operation and Development

ESPEN: European Society for Clinical Nutrition and Metabolism

MOGA: Multi-Objective Genetic Algorithms

LLM: Large Language Model

ML: Machine learning

APC: Apports Nutritionnels Conseillés

HDS: Hébergement de Données de Santé

PNSS: Programme National Nutrition Santé

GDPR: General Data Protection Regulation

WHO: World Health Organization

ANOR: Institut Algérien de Normalisation

CRUD : (Create, Read, Update, Delete)

EGW : Environmental Working Group

OCR : Optical Character Recognition

UHT : Ultra High Temperature

LIST OF FIGURES

Figure 1. Intelligent systems for personalized nutrition support.....	29
Figure 2. DZsain Secure Login Interface — Expert Biologist Space.	38
Figure 3. DZsain Main Interface — Health Profile, Analysis Area, and Scan History.....	39
Figure 4. Detail of the "Health Profile" Panel — Selection of Medical Conditions and Food Allergies.....	40
Figure 5. Scan Module — GS1 Barcode Entry and Analysis Initiation.	42
Figure 6. Analysis Result for a Reference Processed Cheese — EWG Score 76/100, Nutritional Profile, and Health Compatibility.	43
Figure 7. Health Compatibility Alert for Arterial Hypertension and Multiple Scan History. .	45
Figure 8. Expert Biologist Interface — Management of the "Milk Products" Category in the DZsain Database.....	46

LIST OF TABLES

Table 1. Factors influencing nutritional needs	4
Table 2. Macronutrients and Micronutrients.....	6
Table 3. Nutritional Deficiencies.....	19
Table 4. Development Tools and Versions	34

TABLE OF CONTENTS

Introduction	iii
Bibliographic Review	2
I. Concepts and Foundations of Personalized Nutrition	3
I.1. Definition of Personalized Nutrition	3
I.2. Factors influencing nutritional needs (Age, sex, lifestyle).....	4
I.2.1. AGE	4
I.2.2. SEX.....	4
I.3. Specific Nutritional Needs	5
I.3.1. Macronutrients and Micronutrients	5
I.4. Recommended Nutrient Intakes	7
I.5. Adjusting Intake According to Physiological State.....	8
I.6. Role of nutrition in the prevention and management of diseases	9
I.6.1. Diet and chronic diseases	9
I.7. Importance of Individualized Nutritional Monitoring	10
II. DIET-RELATED PATHOLOGIES & NUTRITIONA RECOMMENDATION	10
II.1. Metabolic Pathologies and Nutrition	10
II.1.1. Diabetes	10
I.1.2. Obesity and Overweight	11
I.1.3. Metabolic syndrome	12
II.2. Cardiovascular Diseases and Diet	13
II.2.1. Hypertension	13
II.2.2. Dyslipidemias	14
II.3. Adapted Nutritional Principles	15
II.4. Other Specific Pathologies and Conditions	16
II.4.1. Digestive Disorders	16

II.4.2. Food Intolerances and Allergies	17
II.5. Nutritional Deficiencies and Malnutrition	18
III. INTELLEGEANT SYSTEMS FOR PERSONALIZED NUTRITIONAL SUPPORT	20
III.1. Introduction to Artificial Intelligence in Healthcare	20
III.1.1. Definition of Artificial Intelligence	20
III.1.2. Contributions of AI in the Medical and Nutritional Fields	21
III.1.3. Nutritional Decision Support Systems	22
III.1.3.2. Recommendation Algorithms.....	23
III.1.4. Smart Nutrition and e-Health	25
III.1.4.1. Mobile Nutrition Apps	25
III.1.5. Advantages and limitations of existing systems	27
Materials & Methods.....	31
I. Implementation of a Personalized Nutritional System based on Consumer Pathologies	32
I.2. Definition of the DZsain Web Application	32
I.3. Web Application Description: Subscriber and Expert.....	33
I.3.1 The Subscriber Interface	33
I.3.2 The Expert (Biologist) Interface	33
I.4. Development Tools and Versions.....	34
I.5. Web Application Interfaces.....	35
Results & Discussion	36
I. Presentation of DZsain Interfaces	37
I.1 Login Interface	37
I.2 Main Interface: Health Profile and Dashboard.....	39
I.3 Health Profile Detail: Medical Conditions and Allergies	40
I.4 Scan Feature: Barcode Entry and Analysis	41
I.5 Analysis Results: EWG Score and Nutritional Data	42

I.6 Clinical Alert Display and Scan History.....	44
I.7 Expert Interface: Milk Database Management	46
III. Nutritional Diseases: Epidemiological Context and Relevance to the NutriVa Application.....	50
III.1. Definition and Classification of Nutritional Diseases	50
III.3.2. Food Allergies: An Indispensable Preventive Dimension	52
Conclusion	53
References	53

Abstract

Algeria has witnessed a notable increase in nutrition-related chronic diseases in recent years, including diabetes, hypertension, and dyslipidemia, in a context characterized by changing dietary habits and the growing consumption of processed foods. In response to these public health challenges, improving the quality of nutritional information available to consumers has become a necessity. Within this framework, DZsain was developed as an innovative mobile application designed to help Algerian consumers assess the nutritional quality of local food products through GS1-13 barcode scanning or automatic recognition of nutritional labeling data. The application is based on the EWG Food Scores methodology, which evaluates products according to three main dimensions: nutritional quality, degree of food processing, and risks associated with ingredients and additives, thereby providing an overall assessment of their impact on health. DZsain also incorporates the concept of personalized nutrition by taking into account the user's health profile, including diabetes, hypertension, dyslipidemia, kidney disease, inflammatory bowel diseases, and food allergies, in order to deliver tailored recommendations and targeted preventive alerts. Furthermore, its database was developed in accordance with Algerian food labeling regulations, ensuring the reliability of the information provided. Consequently, DZsain serves as a digital decision-support tool that promotes nutritional awareness and contributes to the prevention of chronic diseases in Algeria.

Mots-clés : nutrition, maladies nutritionnelles, N, EWG Food Scores, nutrition personnalisée, maladies chroniques, qualité alimentaire.

ملخص

تشهد الجزائر في السنوات الأخيرة تصاعداً ملحوظاً في معدلات الأمراض المزمنة المرتبطة بالتغذية، كالسكري وارتفاع ضغط الدم واضطرابات الدهون، في سياق تحولات عميقة في الأنماط الغذائية وتزايد الاعتماد على الأغذية المصنّعة، ويُشكل تحسين جودة المعلومات التغذوية المتاحة للمستهلك ركيزة أساسية في مواجهة هذه التحديات الصحية. واستجابةً لهذا الواقع، طُوّر تطبيق DZsain ، وهو تطبيق ذكي مبتكر يُمكن المستهلك الجزائري من تقييم الجودة التغذوية للمنتجات الغذائية المحلية عبر مسح الباركود GS1-13 أو التعرف التلقائي على بيانات الملصق الغذائي، حيث يعتمد منهجية EWG Food Scores التي تُقيّم المنتج وفق ثلاثة محاور رئيسية هي: الجودة التغذوية، ودرجة التصنيع الغذائي، ومخاطر المكونات والإضافات، لينتهي إلى تقييم شامل يعكس الأثر الحقيقي للمنتج على صحة المستهلك. كما يتميز التطبيق بتبنيّه مبدأ التغذية الشخصية من خلال ربط نتائج التحليل التغذوي بالملف الصحي للمستخدم الذي يشمل حالات السكري، وارتفاع ضغط الدم، واضطرابات الدهون، والقصور الكلوي، والأمراض الالتهابية للأمعاء، والحساسيات الغذائية، مما يتيح تقديم توصيات مخصصة وتنبيهات وقائية دقيقة تُقلّص المخاطر الغذائية المرتبطة بكل حالة مرضية. وإضافةً إلى ذلك، بُنيت قاعدة بيانات التطبيق وفق التشريع الجزائري الخاص بالوسم الغذائي، بما يعزز موثوقية المعلومات وجودة التقييمات المقدمة، ليصبح DZsain بذلك أكثر من مجرد أداة إعلامية، بل منظومة رقمية متكاملة لدعم القرار الغذائي، تساهم في رفع مستوى الوعي التغذوي لدى المستهلك وتعزيز الوقاية من الأمراض المزمنة ودعم الأمن الغذائي في الجزائر.

الكلمات المفتاحية: التغذية، الأمراض الغذائية، EWG Food Scores، التغذية الشخصية، الأمراض المزمنة، جودة الغذاء.

Résumé

L'Algérie connaît ces dernières années une augmentation notable des maladies chroniques liées à l'alimentation, telles que le diabète, l'hypertension artérielle et les dyslipidémies, dans un contexte marqué par l'évolution des habitudes alimentaires et la consommation croissante d'aliments transformés. Face à ces enjeux de santé publique, l'amélioration de l'information nutritionnelle destinée au consommateur apparaît comme une nécessité. C'est dans cette perspective que l'application DZsain a été développée afin d'aider le consommateur algérien à évaluer la qualité nutritionnelle des produits alimentaires locaux grâce à la lecture du code-barres GS1-13 ou à la reconnaissance automatique des données de l'étiquetage nutritionnel. L'application repose sur la méthodologie EWG Food Scores, qui analyse les produits selon trois dimensions principales : la qualité nutritionnelle, le degré de transformation industrielle et les risques associés aux ingrédients et additifs, permettant ainsi d'obtenir une évaluation globale de leur impact sur la santé. DZsain intègre également le concept de nutrition personnalisée en tenant compte du profil de santé de l'utilisateur, notamment le diabète, l'hypertension artérielle, les dyslipidémies, l'insuffisance rénale, les maladies inflammatoires de l'intestin et les allergies alimentaires, afin de fournir des recommandations adaptées et des alertes préventives ciblées. De plus, sa base de données a été conçue conformément à la réglementation algérienne relative à l'étiquetage alimentaire, garantissant la fiabilité des informations fournies. Ainsi, DZsain constitue un outil numérique d'aide à la décision alimentaire contribuant à la sensibilisation nutritionnelle et à la prévention des maladies chroniques en Algérie.

Mots-clés : nutrition, maladies nutritionnelles, EWG Food Scores, nutrition personnalisée, maladies chroniques, qualité alimentaire.

Introduction

INTRODUCTION

The global burden of chronic diet-related diseases represents one of the most pressing public health challenges of the twenty-first century. According to the World Health Organization, dietary risk factors account for approximately 11 million deaths annually worldwide, with non-communicable diseases such as type 2 diabetes, arterial hypertension, dyslipidemia, obesity, and cardiovascular diseases sharing a common etiological root: a chronic mismatch between dietary intake and individual nutritional requirements, further aggravated by the growing consumption of ultra-processed food products rich in added sugars, saturated fats, sodium, and synthetic additives (**Monteiro *et al.*, 2019**).

In Algeria, a rapid nutritional transition has deepened these challenges, with diabetes affecting approximately 12.3% of adults over 35 and arterial hypertension reaching nearly one-third of this population group (MSPRH, 2019), underscoring the urgent need for evidence-based tools to support informed dietary decision-making. While mobile health applications offer promising avenues for personalized nutritional monitoring, existing platforms such as Open Food Facts, Yuka, and MyFitnessPal remain limited to generalized assessments that fail to account for individual pathological profiles or the specificities of locally marketed food products (**Branca *et al.*, 2020**).

To address this gap, the present study introduces **DZsain**, an intelligent personalized nutritional assistance system combining GS1-13 barcode scanning, automated nutritional label data extraction, EWG Food Scores-based product evaluation and a clinical compatibility module that cross-references results with the user's health profile, covering diabetes, hypertension, dyslipidemia, chronic kidney disease, inflammatory bowel diseases, and food allergies. (**EWG, 2012**)

This work aims to review the scientific foundations of personalized nutrition, examine existing digital solutions and their limitations, develop a locally adapted nutritional assessment platform, and evaluate DZsain against leading international tools contributing to chronic disease prevention and consumer empowerment in Algeria.

Bibliographic Review

Bibliographic Review

In the context of rising chronic diseases and growing health awareness, traditional dietary guidelines have shown clear limitations in meeting the diverse needs of individuals with specific pathologies such as diabetes, cardiovascular disease, or obesity. This gap highlights the urgent need for more intelligent and personalized approaches to nutrition.

This chapter establishes the theoretical foundation for an Intelligent Personalized Nutritional Assistance System by exploring the core principles of personalized nutrition, the biological and behavioral factors influencing nutritional needs, the roles of macronutrients and micronutrients, internationally recognized nutrient intake references, and the adjustment of dietary needs across different physiological states. It further examines the relationship between diet and chronic disease prevention, ultimately providing the scientific rationale for designing a system capable of delivering tailored nutritional recommendations based on each consumer's unique health profile and specific needs.

I. Concepts and Foundations of Personalized Nutrition

I.1. Definition of Personalized Nutrition

Personalized nutrition is a modern dietary approach that adapts food recommendations to the unique needs of each individual, integrating personal factors such as general health, lifestyle, athletic goals, and specific metabolism to optimize intake and maximize health benefits. **(Singar, et al, 2024)**

It is based on an individualized strategy that considers genetics, eating habits, metabolic responses, and physiological predispositions, going beyond general advice for greater effectiveness in preventing nutritional deficiencies or excesses. **(Bailey,R et al, 2023)**

Personalized, or precision, nutrition analyzes genetic makeup, biochemical markers, the gut microbiota, physical activity, and body composition to adjust diets, aiming to prevent chronic diseases prevalent in industrialized countries while correcting specific nutritional imbalances. **(Olivier & Diane, 2023)**

This scientific method studies the interactions between nutrients and DNA to develop personalized diets that positively influence metabolism, digestion, and overall health, unlike standard plans that ignore inter-individual genetic variations. **(Pérez-Beltrán et al, 2022)**

I.2. Factors influencing nutritional needs (Age, sex, lifestyle)

I.2.1. AGE

Age modifies nutritional needs due to physiological changes: in children and adolescents (9-18 years), high energy intake (2200-3200 kcal/day) supports rapid growth and bone accumulation; in adults (19-50 years), it stabilizes around 2000-2600 kcal; while in seniors (>70 years), it decreases by 10-20% (1800-2200 kcal) due to sarcopenia and a slowed metabolism, with increased needs for protein (1.2 g/kg/day), vitamin D (20 µg/day) and calcium (1200 mg/day) to counteract osteoporosis and frailty. **(Cacciarella, 2024)**

I.2.2. SEX

Sex leads to hormonal and morphological differences: men, with greater lean mass, have higher energy requirements (2400-3000 kcal/day for 19-30 year olds, sedentary/active) and less iron (8 mg/day); women, influenced by menstrual cycles, pregnancy or menopause, require more iron (18 mg/day pre-menopause, 8 mg post), folic acid (400-600 µg/day during pregnancy) and calcium (1000-1200 mg/day after age 50) to compensate for losses and osteoporotic risks. **(Luci, 2023)**

I.2.3. Life style

Lifestyle directly impacts energy expenditure and macronutrients: a sedentary adult needs 1800-2200 kcal/day, a moderately active adult 2000-2600 kcal (+20%), and a very active adult (elite athletes) up to 4000-5000 kcal (+50-100%) with 6-10 g/kg of carbohydrates, 1.6-2.2 g/kg of protein, and increased hydration (35-50 ml/kg); smokers or those under stress require more antioxidants (vitamin C +35%). **(accesnutation, 2026)**

Table 1. Factors influencing nutritional needs **(Trumbo *et al.*, 2002)**

Dimension	Age	Sex	Lifestyle
Energy needs	High in infancy & adolescence (rapid growth); decline gradually in adulthood; lower in elderly due to reduced basal metabolic rate (BMR)	Males generally have higher total energy expenditure due to greater lean muscle mass and higher BMR; needs increase in females during pregnancy & lactation	Physical activity level is the primary modulator; sedentary individuals need significantly fewer calories than athletes or manual laborers
Protein	Critical in infancy, childhood, and adolescence for tissue synthesis; requirements remain elevated in older	Males typically require more total protein; pregnant and breastfeeding females	Athletes require 1.2–2.0 g/kg/day; vegetarian/vegan diets demand careful planning for essential amino acids;

Bibliographic Review

	adults (≥ 65) to prevent sarcopenia	have substantially increased requirements	stress and illness increase needs
Calcium & bone health	Peak bone mass built during adolescence (1300 mg/day); needs intensify again in older adults to prevent osteoporosis	Post-menopausal females face accelerated bone loss due to estrogen decline, requiring higher calcium (1200 mg/day) and vitamin D intake	Sedentary behavior reduces bone density; weight-bearing exercise increases it; excessive alcohol and smoking impair calcium absorption
Iron	Critical in infancy, toddlerhood, and adolescence; requirements drop after menopause in females; elderly may be at risk of deficiency due to poor absorption	Females of reproductive age need nearly double the iron of males (18 mg vs 8 mg/day) due to menstrual losses; needs increase in pregnancy	Vegetarian/vegan diets carry higher risk of iron deficiency (non-heme iron); endurance athletes may experience iron losses through hemolysis
Vitamins	Vitamin D & K critical for bone development in children; folate essential in reproductive-age females; B12 absorption declines with age due to reduced gastric acid	Folate needs surge in pregnancy (600 $\mu\text{g/day}$) to prevent neural tube defects; vitamin A needs increase during lactation	Sun exposure determines vitamin D synthesis; smoking increases vitamin C needs; alcohol excess depletes B vitamins and folate
Hydration	Infants and elderly are most vulnerable to dehydration; thirst perception diminishes with age, requiring proactive fluid intake in older adults	Males generally require more fluid (3.7 L/day) vs females (2.7 L/day); needs increase sharply during pregnancy and breastfeeding	Heat, humidity, and high physical activity drastically increase fluid and electrolyte requirements; caffeine and alcohol impair hydration
Fat & fatty acids	DHA essential for infant brain development; omega-3s increasingly important in aging adults to reduce inflammation and cognitive decline	Female hormonal cycles influence fat metabolism; omega-3 needs rise during pregnancy and lactation for fetal neural development	High-fat, low-carb diets (e.g., ketogenic) alter fat utilization; dietary pattern (Mediterranean vs Western) shapes cardiovascular risk
Fiber & gut health	Crucial throughout life; elderly often consume insufficient fiber, contributing to constipation and increased cardiometabolic risk	Females tend to have slower gut transit time; fiber intake can modulate estrogen levels via gut microbiome modulation	Highly processed diets are fiber-deficient; plant-based and whole-food diets generally exceed fiber recommendations (25–38 g/day)

I.3. Specific Nutritional Needs

I.3.1. Macronutrients and Micronutrients

Macronutrients are the nutrients that the body needs in large quantities (grams per day) to provide energy, build tissues, and regulate physiological processes; They include carbohydrates

Bibliographic Review

(45-65% of total energy intake, or 3-5 g/kg/day for a sedentary adult), proteins (10-20%, or 0.8-1.2 g/kg/day for muscle and enzyme synthesis), and lipids (20-35%, or 1-1.5 g/kg/day for hormone production and the absorption of fat-soluble vitamins). Water is sometimes considered a fourth essential macronutrient, although it is not an energy source. **(Gonzalez-Arias, 2023)**

Micronutrients, needed in small amounts (milligrams or micrograms per day), do not provide energy but act as enzymatic cofactors, antioxidants and metabolic regulators; they include vitamins (A, C, D, E, K and B group, such as 90 mg/day of vitamin C for immunity or 15 µg/day of vitamin D for calcium absorption) and minerals (calcium 1000 mg/day for bone, iron 8-18 mg/day for oxygen transport, zinc 11 mg/day for immune function), essential for energy production, nerve function and cell protection. **(Marchand, 2024)**

The fundamental difference lies in their complementary roles: macronutrients provide calories and basic structure (e.g., 1 g of carbohydrates = 4 kcal, 1 g of lipids = 9 kcal), while micronutrients catalyze their metabolism and optimize their functions; a deficiency in either leads to imbalances (fatigue, deficiencies, chronic diseases). **(Selimi, 2025)**

Table 2. Macronutrients and Micronutrients **(Mahan & Raymond, 2017)**

Nutrient	Type / Classification	Primary function	Daily requirement (adult)
Macronutrients — needed in large amounts (grams)			
Carbohydrates	Simple (sugars) & complex (starch, fiber)	Primary energy source for brain and body (4 kcal/g); fiber supports gut health and glycemic control	45–65% of total energy; ≥25–38 g/day fiber
Proteins	Essential & non-essential amino acids (20 total)	Tissue building & repair, enzyme and hormone synthesis, immune function, transport molecules	0.8 g/kg/day (adults); up to 2.0 g/kg for athletes
Fats (Lipids)	Saturated, monounsaturated, polyunsaturated (omega-3 & omega-6), trans fats	Energy storage (9 kcal/g), fat-soluble vitamin absorption (A, D, E, K), cell membrane structure, hormone production	20–35% of total energy; <10% saturated; omega-3: 1.1–1.6 g/day
Water	Essential macronutrient (0 kcal)	Temperature regulation, nutrient transport, waste elimination, metabolic reactions, joint lubrication	2.7 L/day (women) — 3.7 L/day (men)
Micronutrients — needed in small amounts (mg / µg)			

Bibliographic Review

Fat-soluble vitamins	Vitamin A, D, E, K	Vision (A), bone & immune health (D), antioxidant protection (E), blood clotting (K)	A: 700–900 µg RAE; D: 15–20 µg; E: 15 mg; K: 90–120 µg
Water-soluble vitamins	Vitamin C & B-complex (B1, B2, B3, B5, B6, B7, B9, B12)	Energy metabolism (B-complex), collagen synthesis & immune function (C), red blood cell formation (B9, B12), nerve function (B12)	C: 75–90 mg; B12: 2.4 µg; Folate: 400 µg; B6: 1.3–1.7 mg
Macro-minerals	Calcium, phosphorus, magnesium, sodium, potassium, chloride, sulfur	Bone & teeth structure (Ca, P), muscle contraction (Mg, Ca), fluid & electrolyte balance (Na, K), nerve transmission	Ca: 1000–1300 mg; Mg: 310–420 mg; K: 2600–3400 mg; Na: <2300 mg
Trace minerals	Iron, zinc, iodine, selenium, copper, manganese, fluoride, chromium	Oxygen transport (Fe), immune function & wound healing (Zn), thyroid hormone synthesis (I), antioxidant defense (Se)	Fe: 8–18 mg; Zn: 8–11 mg; I: 150 µg; Se: 55 µg

I.4. Recommended Nutrient Intakes

The Recommended Nutrient Intakes (RNIs), established by ANSES (French Agency for Food, Environmental and Occupational Health & Safety), represent the average intakes covering the needs of 97.5% of the healthy population for a given nutrient, serving as a reference to prevent deficiencies and optimize health; for an adult aged 20 to 40, they include 50 to 55% of Total Energy Intake (TEI) from carbohydrates, 35 to 40% from lipids (with an omega-6/omega-3 ratio close to 5) and 12 to 16% from proteins (i.e. 0.8 g/kg/day), with specific values such as 110 mg/day of vitamin C, 5 µg/day of vitamin D, 900 mg/day of calcium and 16 mg/day of iron for women. **(ANSES, 2021)**

The Reference Intakes (RIs), formerly known as Recommended Daily Allowances (RDAs) in the European Union, are standard values used for the nutritional labeling of foods and food supplements, set by European regulation at 800 µg for vitamin A, 80 mg for vitamin C, 5 µg for vitamin D, 800 mg for calcium, 14 mg for iron and 375 mg for magnesium, although they do not take into account variations according to age, sex or physiological state, unlike the more precise RDAs adapted to specific subpopulations. **(Marangoni *et al*, 2025)**

Bibliographic Review

The Reference Intakes (RIs) of Health Canada and the U.S. Institutes of Medicine include four complementary indicators: the Estimated Average Requirement (EAR) covering 50% of individual needs, the Recommended Dietary Allowance (RDA) covering 97-98% of healthy individuals, the Adequate Intake (AI) used when scientific data are insufficient to establish an RDA, and the Tolerable Upper Intake Level (UL) beyond which adverse effects may occur, with, for example, an RDA of 30 g/day for dietary fiber, 2.5 L/day of total body water for men and 2 L/day for women, and an average energy intake of 2000-2500 kcal depending on the level of physical activity and basal metabolic rate. (Murphy *et al*, 2016)

I.5. Adjusting Intake According to Physiological State

Nutritional intake must be adjusted according to physiological state, as energy and nutrient requirements vary considerably throughout life. During pregnancy, energy requirements gradually increase from 70 kcal/day in the first trimester to 260 kcal/day in the second and approximately 500 kcal/day in the third, with increased requirements for protein (1.1 g/kg/day), iron (30 mg/day to support blood volume expansion and fetal development), folic acid (600 µg/day to prevent neural tube defects), calcium (1200 mg/day), and iodine (220 µg/day), while hydration must reach 2.3 L/day to allow for the synthesis of new tissues and amniotic fluid. (Marangoni *et al*, 2016)

During breastfeeding, additional energy requirements reach 500 kcal/day to support milk production, bringing the total recommended intake to between 2000 and 2500 kcal, with increased requirements for protein (1.3 g/kg/day), calcium (1300 mg/day to maintain maternal bone density and ensure milk content), vitamin B12 (2.8 µg/day for the infant's neurological development), vitamin C (120 mg/day), and water (2.7 L/day), while strictly avoiding alcohol and limiting caffeine. (Carretero-Krug *et al*, 2024)

In older people (over 65 years), energy requirements decrease by 10 to 20% due to the decline in basal metabolism and the reduction in physical activity, but protein requirements increase to 1.2-1.5 g/kg/day to prevent sarcopenia (muscle wasting), calcium (1200 mg/day) and vitamin D (20 µg/day or 800 IU) to combat osteoporosis, vitamin B12 (2.4 µg/day, with particular attention to reduced absorption), and fiber (30 g/day) to maintain intestinal transit, while ensuring sufficient hydration (30-35 ml/kg/day) as the sensation of thirst decreases with age. (Volkert *et al*, 2022)

Bibliographic Review

In children and adolescents, needs are high to support rapid growth: children (4-12 years) require 1.0-1.2 g/kg/day of protein, 800-1000 mg/day of calcium and 10-15 µg/day of vitamin D, while adolescents (13-18 years) have maximum requirements for energy (2200-3200 kcal/day depending on sex and activity), iron (11-15 mg/day, especially in girls after the first period), calcium (1200 mg/day for peak bone mass accumulation) and zinc (11 mg/day for growth and sexual maturation). **(Everett, 2025)**

In athletes, energy intake can increase by 20 to 100% depending on the intensity and duration of the effort (up to 4000-6000 kcal/day for elite athletes), with carbohydrate requirements increased to 6-10 g/kg/day to replenish glycogen stores, protein requirements to 1.6-2.2 g/kg/day for muscle repair and hypertrophy, lipid requirements to 20-35% of total energy expenditure (TEE) for endurance efforts, and adequate hydration (500-1000 ml/h of exercise) with sodium intake (500-700 mg/L) to compensate for sweat losses.

I.6. Role of nutrition in the prevention and management of diseases

I.6.1. Diet and chronic diseases

An unbalanced diet, characterized by an excess of calories, saturated fats, added sugars and salt, combined with a deficiency in fiber, fruits and vegetables, is recognized as the main modifiable risk factor for chronic non-communicable diseases, contributing to approximately 80% of cases of cardiovascular disease, stroke, type 2 diabetes and certain cancers, according to the World Health Organization (WHO). **(Linda, 2026)**

Regular consumption of ultra-processed foods, rich in additives and poor in essential nutrients, promotes chronic low-grade inflammation, oxidative stress and insulin resistance, central pathophysiological mechanisms in the development of metabolic syndrome, abdominal obesity and atherosclerosis, thus increasing premature mortality by 20 to 30% in the populations concerned **(Vitale et al, 2024)**

Conversely, Mediterranean-style or DASH (Dietary Approaches to Stop Hypertension) diets, rich in fruits, vegetables, whole grains, legumes, oily fish, and olive oil, and providing a high density of antioxidants (polyphenols, vitamins C and E), soluble fiber, and omega-3 fatty acids, significantly reduce the incidence of chronic diseases by 25 to 35%, by improving lipid profile, insulin sensitivity, blood pressure, and vascular endothelial function. **(Linda, 2026)**

I.7. Importance of Individualized Nutritional Monitoring

Individualized nutritional monitoring is essential because it allows dietary recommendations to be tailored to each patient's unique biological, metabolic, and behavioral characteristics, significantly increasing the effectiveness of interventions compared to standardized advice. A clinical study demonstrated that personalized nutrition reduced adverse clinical outcomes from 27% to 23% in hospitalized patients, while improving energy levels, functional status, and quality of life, confirming its superiority over standard hospital nutrition. (Schuetz *et al*, 2019)

This close and regular monitoring ensures not only the relevance of the dietary plan but also its flexibility, allowing for continuous adjustments based on observed results, biomarkers (blood glucose, lipid profile, blood pressure), and patient feedback. This optimizes the achievement of therapeutic goals and prevents early dropouts.

Personalized nutritional interventions have led to significant improvements in glycemic control, waist circumference, and other metabolic markers in adults with prediabetes or metabolic syndrome, with greater benefits observed during prolonged and intensive follow-up. This underscores the importance of sustained and tailored support to break the cycle of failed diets and reduce frustration associated with generic approaches. (Robertson *et al*, 2024)

Finally, a personalized nutritional assessment, conducted by a registered dietitian-nutritionist, allows for the early identification of nutritional imbalances before they become problematic, the development of a follow-up plan adapted to chronic conditions (diabetes, cardiovascular disease, digestive disorders), and the prevention of malnutrition in older adults. It also ensures that the advice is easily applicable to daily life, considering the patient's taste preferences, budget constraints, and lifestyle. (Dobrow *et al*, 2022)

II. DIET-RELATED PATHOLOGIES & NUTRITIONAL RECOMMENDATION

II.1. Metabolic Pathologies and Nutrition

II.1.1. Diabetes

Type 2 diabetes, a chronic metabolic disease characterized by hyperglycemia resulting from insulin resistance and a relative deficiency in its secretion, is closely linked to modifiable dietary factors, including excessive consumption of refined carbohydrates, added sugars, and

Bibliographic Review

saturated fats, contributing to visceral obesity and systemic inflammation. **(Nicholas *et al*, 2024)**

The new 2024-2025 recommendations from the American Diabetes Association (ADA) and the French-Speaking Diabetes Society (SFD) emphasize the quality rather than the strict quantity of carbohydrates, allowing a wide range of intake (from 30 to 50% of total energy intake) as long as other nutrients are balanced, with absolute priority given to dietary fiber (>35 g/day) from whole fruits, vegetables, legumes, and whole grains to slow carbohydrate absorption. **(Darmon *et al*, 2023)**

The Mediterranean diet, rich in monounsaturated fatty acids (olive oil), omega-3 fatty acids (oily fish, nuts), polyphenolic antioxidants, and fiber, is recommended as a first-line dietary model, having demonstrated a 30% reduction in cardiovascular risk in diabetics and a significant improvement in insulin sensitivity. **(preskri, 2026)**

Limiting high glycemic index carbohydrates (>70) and distributing carbohydrate intake evenly across the three main meals (avoiding postprandial spikes) are effective strategies for stabilizing blood glucose and reducing HbA1c by 0.5 to 1%, a key parameter for long-term diabetes control. **(preskri, 2026)**

Individualized nutritional management of diabetes also includes moderate weight loss (5-10% of body weight) in overweight patients, achieved through personalized calorie restriction (500-750 kcal/day deficit). This leads to sustained glycemic control and can induce partial or complete remission in newly diagnosed patients, highlighting the importance of regular dietary monitoring and therapeutic education focused on self-management of food intake. **(Lean *et al*, 2019)**

I.1.2. Obesity and Overweight

Obesity and overweight are defined by the World Health Organization (WHO) as an abnormal or excessive accumulation of adipose tissue that may impair health, characterized by a Body Mass Index (BMI) greater than 25 kg/m² for overweight and 30 kg/m² for obesity, resulting from a chronic energy imbalance between caloric intake and energy expenditure. **(Lin & Li, 2021)**

This complex chronic disease is multifactorial, involving not only unbalanced eating habits (excessive consumption of ultra-processed foods, high in saturated fats, added sugars, and salt)

Bibliographic Review

and increasing sedentary lifestyles, but also genetic predispositions (2 to 8 times higher risk with a family history), metabolic factors (reduced basal metabolic rate), psychological factors (chronic stress, depression, eating disorders), and environmental factors (obesogenic environments, limited access to healthy foods). **(Koliaki et al, 2025)**

Nutritional recommendations favor a personalized and sustainable approach aimed at moderate but significant weight loss (5-10% of initial body weight), achieved through an individual calorie deficit of 500-750 kcal/day, with a diet rich in fiber (25-30 g/day) from fruits, vegetables, legumes, and whole grains to promote satiety, improve intestinal transit, and reduce LDL cholesterol. **(Kim, 2021)**

The Mediterranean diet is recommended as a reference dietary model, rich in seasonal fruits and vegetables, whole grains, oily fish (omega-3), olive oil (monounsaturated fatty acids), and oilseeds, while limiting red meat, full-fat dairy products, and processed foods. It has demonstrated superior effectiveness for sustainable weight loss and reducing cardiovascular risk in obese individuals. **(Koliaki et al, 2022)**

Nutritional management should be accompanied by behavioral therapy and regular physical activity (150-300 min of moderate activity per week), with close dietary monitoring by a healthcare professional to adapt recommendations to individual constraints, prevent nutritional deficiencies, manage food cravings, and maintain long-term results, thus avoiding the yo-yo effect of unsupervised restrictive diets. **(Andrea et al, 2020)**

I.1.3. Metabolic syndrome

Metabolic syndrome, also called syndrome X or insulin resistance syndrome, is not a disease per se but a set of five risk factors which, when at least three are present, significantly increase the likelihood of developing cardiovascular disease, type 2 diabetes or a stroke. **(Dhondge et al, 2024)**

The diagnostic criteria, defined by the International Diabetes Federation (IDF) and the American Heart Association (AHA), include: excessive waist circumference (≥ 102 cm in men and ≥ 88 cm in women), elevated fasting blood glucose (≥ 100 mg/dL or 5.6 mmol/L), blood pressure $\geq 130/85$ mmHg, triglyceride level ≥ 150 mg/dL (1.7 mmol/L) and HDL cholesterol (good cholesterol) level < 40 mg/dL (1.0 mmol/L) in men and < 50 mg/dL (1.3 mmol/L) in women. **(Levy, S. M., & Nessen, M, 2025)**

Bibliographic Review

The core pathophysiology of metabolic syndrome is based on insulin resistance, a condition in which cells respond poorly to insulin, resulting in compensatory hyperinsulinemia, atherogenic dyslipidemia (high triglycerides, low HDL, small and dense LDL particles), chronic low-grade inflammation, and oxidative stress, all promoted by the accumulation of particularly metabolically active and deleterious visceral adipose tissue. **(Busson,A, 2024)**

Nutritional recommendations emphasize moderate but sustainable weight loss (7-10% of body weight), achieved through a personalized low-calorie diet rich in fiber (30-40 g/day), monounsaturated fatty acids (olive oil, avocados), and omega-3 polyunsaturated fatty acids (oily fish, nuts), with a drastic reduction in refined carbohydrates, added sugars, and saturated fats. The Mediterranean diet has demonstrated superior effectiveness in improving all components of the syndrome. **(Alkhatib et al, 2019)**

Management also includes regular aerobic physical activity (150-300 minutes/week of moderate intensity) combined with resistance exercises (2-3 sessions/week) to improve insulin sensitivity, reduce visceral fat, and normalize blood pressure, with close medical monitoring to track changes in biomarkers and prevent long-term cardiovascular complications. **(hug, 2025)**

II.2. Cardiovascular Diseases and Diet

II.2.1. Hypertension

Cardiovascular diseases, the leading cause of death worldwide, are closely linked to diet. Insufficient consumption of fruits, vegetables, legumes, nuts, fish, and whole-grain dairy products is associated with an increased risk of mortality and major cardiovascular events, according to an international analysis of more than 240,000 adults in 80 countries. **(hug, 2025)**

A diet high in saturated fat and low in fiber promotes the development of atherosclerosis through an imbalance of the gut microbiota, leading to systemic inflammation that exacerbates the formation of atherosclerotic plaques in the arteries. This underscores the protective role of dietary fiber for cardiovascular health and the prevention of chronic inflammation. **(Zhang, D. et al, 2025)**

High blood pressure (hypertension), a major risk factor for strokes, myocardial infarctions and kidney failure, affects approximately 46% of affected adults who are unaware of it, but can be effectively combated by dietary modifications, in particular the adoption of the DASH (Dietary

Bibliographic Review

Approaches to Stop Hypertension) diet, which can reduce blood pressure by 8 to 14 mmHg without medication. **(Challa *et al*, 2023)**

The DASH diet emphasizes abundant consumption of fruits and vegetables (rich in potassium, magnesium and antioxidants), low-fat dairy products (sources of calcium), whole grains, poultry, fish, vegetables and nuts, while strictly limiting saturated and trans fats, red meat, added sugars and especially sodium, the intake of which should be reduced to less than 5 g/day (compared to 8.5 g on average) to decrease water retention and blood pressure.

Foods particularly beneficial for combating hypertension include spinach (rich in vasodilation nitrates), garlic (alliin with hypotensive properties), flax seeds (anti-inflammatory omega-3 fatty acids), dark chocolate with at least 70% cocoa (flavonoids that improve endothelial function), pomegranate (antioxidant polyphenols), and beets (natural nitrates). Conversely, it is imperative to avoid fried foods, fatty cheeses, processed foods high in hidden salt, and refined sugars, which promote weight gain and insulin resistance. **(Filippou & Tsioufis, 2024)**

II.2.2. Dyslipidemias

Dyslipidemias, characterized by an excess of fats in the blood (total cholesterol, LDL cholesterol, triglycerides) or an insufficient level of HDL cholesterol, constitute a major risk factor for atherosclerosis and cardiovascular diseases, resulting either from genetic causes (familial primary dyslipidemias) or from secondary factors such as a diet too high in saturated fats, trans fats, and sugars, coupled with a sedentary lifestyle, diabetes, or hypothyroidism. **(Nathalie, 2023)**

First-line nutritional management is based on a lipid-lowering diet rich in vegetables, fruits, whole grains, and lean proteins, while being low in processed foods, saturated fats (limited to <10% of total energy intake), and trans fats (which should be completely eliminated), with a drastic reduction in concentrated sugars and alcohol for hypertriglyceridemic patients. **(Levy, S. M., & Nessen, M, 2025)**

Particularly beneficial foods include those rich in soluble fiber (oatmeal, oat bran, beans, peas, barley, citrus fruits, strawberries, apples), which bind to fats in the intestine and reduce LDL cholesterol absorption by 5 to 10%, as well as legumes (lentils, chickpeas), nuts, almonds, oily fish (salmon, mackerel, sardines) providing anti-inflammatory omega-3 fatty acids, and plant sterols (2 g/day) which competitively inhibit intestinal cholesterol absorption. **(Levy, S. M., & Nessen, M, 2025)**

Bibliographic Review

Specific recommendations include limiting animal fats (butter, cheese, fatty meats, offal, egg yolks limited to 3 per week), replacing saturated and trans fats with unsaturated fats (olive oil, rapeseed oil, avocado, oilseeds), consuming skimmed or 1% dairy products without added sugar, and increasing the variety of vegetarian options (tofu, tempeh, beans) to reduce dietary cholesterol intake while maintaining adequate protein intake. **(Berger, S *et al*, 2015)**

The combined adoption of these dietary measures, along with moderate weight loss (5-10% of body weight) and regular physical activity (150 minutes/week), reduces LDL cholesterol by 15-30%, triglycerides by 20-50%, and increases HDL cholesterol by 5-10%, demonstrating the superior efficacy of personalized nutritional intervention as a cornerstone of the prevention and treatment of dyslipidemias before or in addition to pharmacological treatment with statins. **(Kirkpatrick *et al*, 2023)**

II.3. Adapted Nutritional Principles

Adapted nutritional principles for the prevention and management of cardiovascular diseases are based on adopting a Mediterranean or Cretan-style diet, rich in fruits, vegetables, and aromatic herbs, using high-quality cooking oils (olive and rapeseed), and favoring whole grains and legumes, which provide cardioprotective nutrients: antioxidants, omega-3 monounsaturated and polyunsaturated fats, dietary fiber, and complex carbohydrates. **(hug, 2025)**

Daily consumption should include at least 5 portions of fruits and vegetables (maximum 2 fruits + 3 portions of vegetables), rich in vitamins C and A and carotenoids that protect the arteries, as well as dietary fiber that stimulates intestinal transit and helps eliminate some of the bad LDL cholesterol. These foods should form a significant basis of all meals and snacks. **(hug, 2025)**

Oily fish (salmon, mackerel, sardines, herring) are recommended twice a week for their exceptional content of long-chain omega-3 fatty acids (EPA and DHA), which combat the formation of blood clots, lower plasma triglycerides, and exert an anti-inflammatory and anti-arrhythmic effect beneficial to cardiac function. **(hug, 2025)**

Seasoning fats should favor a combination of olive oil (rich in monounsaturated fatty acids) and rapeseed oil (source of plant-based omega-3), with a strict limitation of butter to a maximum of 10 g/day and the avoidance of industrial margarines, which are often of unsatisfactory quality,

Bibliographic Review

supplemented by a small handful of walnuts, almonds or hazelnuts 3 to 4 times a week to optimize the intake of protective substances. **(hug, 2025)**

Energy intake control aims to maintain a Body Mass Index (BMI) below 25 kg/m² and a waist circumference < 102 cm for men and < 88 cm for women, with sodium restriction to a maximum of 5 g of salt per day, limitation of added sugars and alcohol, and a balanced distribution of macronutrients including low glycemic index complex carbohydrates at each meal (whole grains, legumes, cooked al dente). **(Lichtenstein et al, 2021)**

II.4. Other Specific Pathologies and Conditions

II.4.1. Digestive Disorders

Digestive disorders, including irritable bowel syndrome (IBS), inflammatory bowel disease (IBD), and functional dyspepsia, are closely influenced by diet. Appropriate dietary hygiene can significantly relieve symptoms such as bloating, abdominal pain, diarrhea, and constipation. **(Cuffe, M. S. et al, 2025)**

For irritable bowel syndrome, the FODMAP dietary approach, offered by specialized nutrition units, involves temporarily limiting fermentable carbohydrates (oligosaccharides, disaccharides, monosaccharides, and polyols) found in certain fruits, vegetables, legumes, and dairy products, before a gradual reintroduction to identify individual triggers. This approach has demonstrated effectiveness in the majority of patients. **(hug, 2025)**

In cases of active inflammatory bowel disease (Crohn's disease and ulcerative colitis), it is recommended to choose foods containing soluble (soft) fiber and temporarily limit the consumption of insoluble (tough) fiber to promote healing of the intestinal lining and prevent irritation. Foods rich in prebiotic fiber, such as bananas and oats, can help reduce inflammation. **(Fitzpatrick et al, 2022)**

For digestive issues and functional disorders, a balanced diet rich in probiotics and prebiotics helps to limit digestive problems and restore the balance of the gut flora. This involves favoring cooked vegetables in puréed form to reduce the size of fibers that can irritate the intestinal lining, and eating meals at regular times in a calm environment. **(Murphy, S. P. et al, 2024)**

Nutritional management should be individualized and supervised by a healthcare professional, ensuring a varied and balanced diet rich in fruits and vegetables, legumes, and grains, while

avoiding repeated overeating, cooked fats, and processed foods that worsen digestive symptoms. **(Jadhav, 2023)**

II.4.2. Food Intolerances and Allergies

Food intolerances and allergies are two distinct adverse reactions to food, differing in their pathophysiological mechanisms: food intolerance is an irritant-type reaction, most often affecting the intestine, due to chemical compounds in food or the absence of digestive enzymes (such as lactase for lactose), while food allergy involves an abnormal and immediate immune response (mediated by IgE) to a specific food protein, which can lead to severe or even fatal reactions (anaphylactic shock). **(Sicherer & Sampson, 2024)**

The symptoms of food intolerances are primarily digestive and appear with a delay (a few hours to a few days after ingestion), including abdominal pain, nausea, vomiting, diarrhea, bloating, sometimes accompanied by fatigue, cold sweats, headaches, or mild skin reactions (eczema, psoriasis), and generally disappear when the offending food is stopped. **(Böhn *et al*, 2022)**

Food allergies, on the other hand, cause rapid symptoms (from a few minutes to 2 hours) that can affect several systems: cutaneous (urticaria, Quincke's edema), digestive (vomiting, diarrhea), respiratory (asthma, laryngeal edema) and cardiovascular (hypotension, anaphylactic shock), with the 14 major allergens regulated in Europe including cereals containing gluten, crustaceans, eggs, fish, peanuts, soy, milk, nuts, celery, mustard, sesame seeds, lupins, molluscs and sulfites. **(Sampson, 2004)**

Nutritional management of intolerances relies on the temporary or permanent avoidance of the problematic food (lactose-free diet, gluten-free diet for celiac disease, low-FODMAP diet for IBS), with gradual reintroduction under medical supervision to test tolerance, while the treatment of food allergy requires strict and permanent avoidance of the allergen, careful reading of labels, and the permanent possession of emergency treatment (adrenaline auto-injector, antihistamines) in case of accidental exposure. **(Staudacher & Whelan, 2017)**

Food desensitization (oral immunotherapy), available in specialized centers for certain allergies (milk, egg, peanut), involves administering increasing and controlled doses of the allergen over several months to induce partial or total immune tolerance, although this approach is not a definitive cure and must be maintained by regular consumption of the food to preserve the acquired tolerance. **(Cardenas, 2020)**

II.5. Nutritional Deficiencies and Malnutrition

Nutritional deficiencies and malnutrition refer to a state in which the body does not receive all the nutrients (proteins, lipids, carbohydrates) and micronutrients (vitamins, minerals, trace elements) necessary for its proper functioning, either due to insufficient or unbalanced diet, or to absorption or assimilation difficulties related to digestive disorders, with serious consequences for physical and mental health. **(Wells, J. C. *et al*, 2020)**

Malnutrition, as defined by the World Health Organization (WHO), covers three main groups of conditions: undernutrition (wasting, stunting, underweight), micronutrient-related malnutrition (deficiencies or excesses of essential vitamins and minerals), and overweight/obesity associated with chronic non-communicable diseases (diabetes, cardiovascular diseases, certain cancers), forming a double burden in many developing countries. **(Wells, J. C. *et al*, 2020)**

The symptoms of nutritional deficiencies are varied and depend on the nutrient that is deficient: an iron deficiency causes anemia with intense fatigue, paleness, shortness of breath and palpitations; a vitamin B12 deficiency leads to peripheral neuropathies, chronic fatigue and megaloblastic anemia; a vitamin D deficiency causes osteomalacia in adults (bone pain, muscle weakness) and rickets in children; a lack of zinc manifests as delayed wound healing, skin disorders and weakened immunity; and a magnesium deficiency causes muscle cramps, sleep disorders and cardiac arrhythmias. **(Camaschella, 2015)**

In children, protein-energy malnutrition leads to irreversible growth retardation, a major weakening of the immune system increasing vulnerability to infections (diarrhea, pneumonia, measles), lasting cognitive and learning disorders, muscle weakness and, in severe forms (kwashiorkor, marasmus), a high risk of mortality, while micronutrient deficiencies (vitamin A, iodine, iron) cause respectively night blindness and xerophthalmia, goiter and congenital hypothyroidism, and iron deficiency anemia with psychomotor retardation. **(Black *et al*, 2013)**

The management of deficiencies and malnutrition relies on a varied diet enriched with essential nutrients (fruits, vegetables, animal or plant proteins, whole grains, dairy products), targeted supplementation under medical supervision (iron, folic acid, vitamin D, B12, multivitamins), and in severe cases of undernutrition, gradual refeeding with ready-to-use therapeutic foods (fortified peanut paste) or enteral/parenteral nutrition, accompanied by treatment of underlying

Bibliographic Review

conditions and close nutritional monitoring to prevent refeeding complications (refeeding syndrome). (Bhutta *et al*, 2017)

Table 3. Nutritional Deficiencies (Black *et al*, 2013)

TYPE / DEFICIENCY	CATEGORY	PRIMARY CAUSES	CLINICAL SIGNS	AT-RISK GROUPS	KEY INTERVENTIONS
Protein-Energy Malnutrition (PEM)	Macronutrient	Inadequate caloric/protein intake, poverty, famine	Kwashiorkor (oedema, skin lesions), Marasmus (severe wasting, muscle loss)	Children <5 yrs, low-income populations, conflict zones	Therapeutic feeding, RUTF, dietary diversification
Iron Deficiency Anaemia	Macronutrient	Low dietary iron, poor absorption, blood loss, parasitic infections	Fatigue, pallor, tachycardia, cognitive impairment, pica	Pregnant women, infants, adolescent girls, vegetarians	Iron supplementation, fortified foods, deworming
Vitamin A Deficiency	Macronutrient	Low intake of animal products/orange vegetables, fat malabsorption	Night blindness, xerophthalmia, increased infection susceptibility	Children <5 yrs, pregnant/lactating women, developing countries	Vitamin A supplementation, food fortification, dietary change
Iodine Deficiency	Macronutrient	Low soil iodine content, no iodized salt use	Goitre, hypothyroidism, cretinism, intellectual disability	Mountainous/land regions, pregnant women, neonates	Universal salt iodization, iodine supplementation
Vitamin D Deficiency	Macronutrient	Limited sun exposure, low dietary intake, malabsorption	Rickets (children), osteomalacia (adults), muscle weakness, immune dysfunction	Elderly, dark-skinned individuals, breastfed infants, indoor workers	Supplementation, fortified dairy/foods, safe sun exposure
Zinc Deficiency	Macronutrient	Low animal-source food intake, phytate-rich diets, diarrhoea	Growth stunting, impaired immunity, delayed wound healing, dysgeusia	Children, elderly, vegans, populations relying on cereal staples	Zinc supplementation, biofortified crops, dietary diversification
Folate / B12 Deficiency	Macronutrient	Low intake of leafy greens/animal products, malabsorption, alcoholism	Megaloblastic anaemia, neural tube defects (foetus), neuropathy	Pregnant women, vegans, elderly, patients on methotrexate/PPIs	Folic acid supplementation pre-conception, B12 injections, dietary advice

Hidden Hunger (Multiple Micronutrient Deficiency)	Multiple	Monotonous diets, low dietary diversity, poor food systems	Subclinical — reduced immunity, poor growth, impaired cognition with no obvious signs	2+ billion globally; women and children in low/middle-income countries	Multiple micronutrient supplementation, biofortification, food-based approaches
---	----------	--	---	--	---

III. INTELLIGENT SYSTEMS FOR PERSONALIZED NUTRITIONAL SUPPORT

III.1. Introduction to Artificial Intelligence in Healthcare

III.1.1. Definition of Artificial Intelligence

Artificial intelligence (AI) in healthcare refers to computer systems capable of performing tasks that normally require human intelligence, such as learning, reasoning, problem-solving, perception, and natural language understanding, using algorithms and machine learning models to analyze complex medical data and provide actionable insights to healthcare professionals. (Bajwa *et al*, 2021)

In medicine, artificial intelligence specifically involves using advanced machine learning models and algorithms to process medical data (patient records, medical images, genomic data, biomarkers) and provide healthcare professionals with important recommendations aimed at improving clinical outcomes, patient experience, and the efficiency of healthcare systems. (Esteva *et al*, 2019)

AI in healthcare encompasses the use of software, predictive algorithms, and AI-driven robots for the analysis and processing of raw or patient-specific medical data, enabling differential and early diagnosis, preventive and predictive medicine, individualized patient monitoring, personalized therapeutic decision support, and the automation of biological and medical imaging analyses. (Topol, 2019)

According to the Organisation for Economic Co-operation and Development (OECD), AI in the healthcare sector has the potential to address urgent challenges such as rising costs, systemic inefficiencies, and the growing demand for high-quality care by reducing administrative costs, streamlining bureaucratic tasks (planning, billing, electronic health record management), and improving diagnostic accuracy for the early detection of pathologies. (Jiang *et al*, 2017)

The French National Institute of Health and Medical Research (Inserm) distinguishes between "weak" AI, which specializes in specific tasks (image analysis, risk prediction, decision support), and "strong" AI (still hypothetical), which would aim to design a machine capable of reasoning like a human. Inserm emphasizes that current AI in healthcare is primarily used for interpreting medical images, automated triage, managing hospital patient flow, and personalized medicine based on patients' omics and clinical data. **(Topol, 2019)**

III.1.2. Contributions of AI in the Medical and Nutritional Fields

In the medical field, artificial intelligence has proven its worth in several key areas: the interpretation of medical images (early detection of cancers and radiological abnormalities), automated triage of patients in emergency departments, hospital flow management, prediction of postoperative complication risks, and differential diagnosis assistance, improving diagnostic accuracy by 15 to 30% and reducing medical errors. **(Selka, 2025)**

In nutrition, AI is transforming dietary practice by combining big data processing, machine learning, and pattern recognition to provide personalized, predictive, and preventative solutions. Applications can recommend specific diets, adjust daily calorie intake, and flag nutritional deficiencies to maximize each user's health. **(Audrey, 2024)**

AI-powered diet personalization adjusts meal plans based on individual calorie needs, dietary restrictions (vegetarian, gluten-free, allergies), health goals (weight loss, muscle gain, glycemic control), and lifestyle, while apps like Yuka and Open Food Facts use AI to analyze food composition and recommend healthier choices tailored to specific nutritional profiles. **(Zeevi et al, 2015)**

AI also enables the prediction of risks and the prevention of nutrition-related chronic diseases by identifying patterns associated with diabetes, hypertension, and obesity through the analysis of health and dietary data, allowing healthcare professionals to recommend proactive nutritional interventions even before symptoms appear. **(Beam & Kohane, 2018)**

Computer vision and deep learning now allow for the automatic monitoring of food consumption through simple photographs of meals, with accurate estimates of portion sizes, macronutrients, and micronutrients ingested. This provides dietitians with objective data to

develop more effective treatment plans and intervene earlier in the management of diet-related chronic diseases. (Abirami, 2024)

III.1.3. Nutritional Decision Support Systems

III.1.3.1. Expert Systems

Nutrition expert systems are artificial intelligence computer programs that replicate the reasoning and expertise of a human dietitian-nutritionist to provide personalized dietary recommendations, based on a structured knowledge base (nutritional rules, physiological needs, pathological contraindications) and an inference engine capable of deducing appropriate advice from the patient's individual data (age, sex, weight, height, physical activity, pathologies, food preferences). (Schafer *et al*, 2000)

These systems operate according to an "IF-THEN" logical architecture (production rules): for example, "IF the patient has type 2 diabetes AND their HbA1c > 7% THEN recommend a low-carbohydrate, low-glycemic-index diet with >35 g of fiber/day," allowing for the automation of clinical decision-making for standard cases while leaving the management of complex or atypical situations requiring human judgment to the healthcare professional. (Schafer *et al*, 2000)

Applications of expert nutrition systems include the automatic assessment of energy and nutritional needs according to Reference Intakes (RIs), the generation of personalized weekly meal plans that respect cultural and budgetary constraints, the detection of nutritional deficiencies or excesses from food diaries, and the dynamic adjustment of recommendations based on changes in clinical parameters (weight, blood glucose, lipid profile). (Shortliffe & Sepúlveda, 2018)

A major historical example is the NUTRI-EXPERT expert system, developed in the 1980s and 1990s. It was capable of establishing a comprehensive nutritional diagnosis from a structured questionnaire and proposing a dietary rebalancing plan adapted to associated pathologies (obesity, diabetes, dyslipidemia), demonstrating 85-90% concordance with human expert recommendations and paving the way for modern decision-support tools in clinical dietetics. (Jean, 1988)

Contemporary expert systems, integrated into professional software such as NutriPat, DietOffice, or Diafood, now combine knowledge bases updated according to the latest scientific

recommendations (SFD, ADA, ESPEN) with intuitive user interfaces, allowing dietitians to save time on repetitive tasks (calorie calculations, menu generation) and focus on therapeutic education, behavioral monitoring, and the patient-practitioner relationship. **(Shortliffe & Sepúlveda, 2018)**

III.1.3.2. Recommendation Algorithms

Nutritional recommendation algorithms are artificial intelligence systems that analyze a user's individual data (demographic profile, eating habits, health goals, taste preferences, budgetary and cultural constraints) to generate personalized suggestions for meal plans, recipes, and products, using collaborative filtering, content-based filtering, and machine learning techniques. **(Zeevi *et al*, 2015)**

These algorithms operate using three main approaches: collaborative filtering, which identifies users with similar profiles and recommends foods or diets that have worked for them (e.g., "users with your goals and metabolism have lost 5 kg with this Mediterranean diet"); content-based filtering, which recommends foods with nutritional properties similar to those already enjoyed by the user; and hybrid systems that combine both approaches with deep learning models to optimize the relevance and diversity of recommendations. **(Thierry, 2024)**

Consumer apps like MyFitnessPal, Yazio, and Nutrino use machine learning algorithms that dynamically adapt to the user's progress (changes in weight, body composition, and blood sugar) to adjust recommended calorie and macronutrient intake in real time, while advanced platforms like Viome and Nutrigenomix integrate genomic and metabolomic data to offer highly personalized dietary recommendations based on each individual's genetic profile and gut microbiota. **(Hassani & Silva, 2023)**

Multi-objective optimization algorithms, such as Multi-Objective Genetic Algorithms (MOGA), are used to solve the complex problem of the "optimal diet" by finding a balance between several conflicting constraints: minimizing food costs, maximizing nutritional density, respecting taste preferences, achieving a target weight, and maintaining environmental sustainability, thus generating feasible and scientifically validated weekly meal plans. **(Müller & Briend, 2013)**

Finally, recommendation algorithms now integrate computer vision and language models (LLM) to suggest healthy recipes based on a simple photograph of the refrigerator's contents,

Bibliographic Review

identifying available ingredients and proposing preparations adapted to specific dietary restrictions (vegan, gluten-free, low-FODMAP), thereby democratizing access to high-quality personalized nutrition and reducing food waste. **(Abirami, 2024)**

III.1.3.3. Machine Learning

Machine learning (ML) in nutrition refers to the set of algorithms capable of automatically learning from dietary, clinical, and behavioral data to identify complex patterns, predict health outcomes, and generate personalized recommendations without explicit rule programming, thus transforming dietary research and practice through a data-driven approach. **(Hassani & Silva, 2023)**

ML algorithms, including random forests, support vector machines (SVMs), and deep learning networks, are used to analyze massive volumes of heterogeneous data (food diaries, blood biomarkers, genomic data, physical activity measured by wearables) in order to predict individual glycemic responses to food, identify risk factors for obesity or diabetes, and optimize dietary plans for specific goals such as weight loss or metabolic control. **(Daniel, *et al.*, 2022)**

Concrete applications include Foodvisor and LogMeal, which use deep learning-trained computer vision models on hundreds of thousands of food images to automatically recognize photographed foods, estimate portions with 93% accuracy, and instantly calculate the complete nutritional composition (macronutrients, micronutrients, calories), thus eliminating tedious manual data entry and improving adherence to dietary monitoring. **(Abirami, 2024)**

Predictive machine learning (ML) models also make it possible to anticipate the risks of nutritional deficiencies or chronic diseases by detecting subtle correlations between dietary habits and health parameters. For example, an algorithm can identify that a patient with low fiber intake, a large waist circumference, and borderline fasting blood glucose has an 85% risk of developing type 2 diabetes within 5 years, enabling targeted preventive nutritional intervention. **(Beam & Kohane, 2018)**

Finally, machine learning facilitates the discovery of new associations between the gut microbiota and response to diets. ML models analyzing metagenomic data from thousands of individuals have revealed that microbiota composition predicts postprandial glycemic response better than the carbohydrate content of foods, paving the way for highly personalized dietary recommendations based on individual microbial profiles rather than population averages. **(Daniel, *et al.*, 2022)**

III.1.4. Smart Nutrition and e-Health

III.1.4.1. Mobile Nutrition Apps

Mobile nutrition apps are digital eHealth tools that use artificial intelligence, comprehensive food databases, and personalized algorithms to help users track their diet, achieve health goals (weight loss, muscle gain, glycemic control), and adopt sustainable eating habits. With over 16 million downloads recorded in France in 2023 and an annual growth rate of 17.1% in the global market, there were over 16 million downloads in France in 2023. **(Nadine, 2026)**

MyFitnessPal remains the leading app with its collaborative database of over 20 million foods, offering precise tracking of calories, macronutrients, and micronutrients, synchronization with activity trackers (Fitbit, Apple Watch, Garmin), and a supportive community. It's ideal for users who want granular control over their diet, down to the gram. **(Emily, 2026)**

Foodvisor and Nutrola represent the next generation of AI-powered smart apps: Foodvisor uses deep learning image recognition to automatically identify photographed foods and estimate portions with 93% accuracy, while Nutrola, voted the best app of 2026, combines a database 100% verified by nutritionists with multimodal tracking (photo, voice, text) and automated meal planning based on over 150 scientific studies. **(Emily, 2026)**

Cronometer stands out for its scientific rigor, with USDA-verified nutritional data and detailed tracking of 84 micronutrients (vitamins, minerals, amino acids, fatty acids), essential for vegans, elite athletes, and patients on strict therapeutic diets requiring absolute precision. **(Everett, 2025)**

Keenoa, a smart food diary prescribed by dietitians, allows users to photograph meals for simplified and secure tracking, with the unique advantage that all food and nutritional data is sent directly to the healthcare professional for integrated clinical monitoring and rapid intervention in case of deviations. **(Moyen et al, 2022)**

III.1.4.2. Dietary Tracking Platforms

Dietary tracking platforms are comprehensive digital solutions, often cloud-based, that allow users and healthcare professionals to monitor food intake in real time, analyze long-term nutritional trends, and dynamically adjust dietary plans, going beyond a simple mobile application through deep integration with electronic health records and connected devices. **(Lieffers & Hanning, 2019)**

Bibliographic Review

NutriScan stands out as an AI-powered food tracking platform specifically designed for French cuisine. It instantly recognizes traditional dishes (coq au vin, bouillabaisse, crêpes) from a simple photograph, provides a complete real-time nutritional analysis (calories, macros, micronutrients, Nutri-Score), and offers multimodal recording (photo, voice, text) tailored to local eating habits. **(Shao *et al*, 2021)**

MonSuiviDiet is a French professional platform certified HDS (Health Data Hosting) that connects dietitians and patients: patients use a free app to keep a digital food diary, record their feelings, and ask questions, while professionals access all this data via a secure dashboard to optimize consultations and save time on calculations. **(Lieffers & Hanning, 2019)**

This platform allows dietitians to proactively intervene when dietary deviations are detected, adjust recommendations in real time, and monitor changes in clinical parameters (weight, body composition, biomarkers) without waiting for the next appointment, thus transforming nutritional monitoring into a continuous and responsive process. **(Lieffers & Hanning, 2019)**

MyFitnessPal offers a consumer-friendly platform with a massive database of over 14 million foods, macro tracking features, intermittent fasting and physical activity tracking, as well as a global support community, but is limited to individual use without direct clinical integration with healthcare professionals. **(Chen & Kurniawan, 2020)**

FatSecret offers a free and comprehensive alternative with an intuitive food diary, a barcode scanner, weight and waist circumference tracking, and a motivating community news feed, particularly suited to users looking for a simple and accessible solution without a paid subscription. **(Marine, 2022)**

Professional platforms like Nutrilog and DietOffice are specifically designed for dietitians and nutritionists, generating detailed reports that can be used in consultations, complying with French nutritional guidelines (ANC, PNNS), and integrating scientifically validated databases for optimal clinical accuracy. **(Müller *et al*, 2022)**

These platforms are transforming nutritional care by enabling continuous monitoring between consultations, objective measurement of actual consumption, and early detection of dietary problems, while also raising ethical challenges regarding the protection of sensitive health data under the European GDPR regulation. **(Lieffers & Hanning, 2019)**

III.1.5. Advantages and limitations of existing systems

The major advantages of intelligent nutrition systems lie in their ability to offer unprecedented nutritional personalization by analyzing large amounts of personal data (age, sex, lifestyle, medical history, eating habits, genetic data) to create meal plans tailored to each individual, recommend specific diets, adjust daily calories, and flag nutritional deficiencies to maximize each user's health. **(Zeevi *et al*, 2015)**

These systems enable real-time and continuous dietary monitoring through AI-powered image recognition, eliminating tedious manual data entry and significantly improving adherence to dietary tracking. Applications like Foodvisor achieve 93% accuracy in identifying foods and estimating portions from a single photograph. **(Abirami, 2024)**

Smart platforms facilitate access to high-quality nutritional expertise at a lower cost, democratizing the prevention and management of diet-related chronic diseases for populations who cannot afford regular consultations with a registered dietitian, while also providing professionals with decision-support tools to optimize their consultations. **(Lieffers & Hanning, 2019)**

However, a major problem concerns data privacy and security: these systems require access to sensitive personal health and dietary information, and if this data is not properly protected according to GDPR standards, it could be misused, stolen, or resold for commercial or advertising purposes. **(Abirami, 2024)**

Another critical risk is that of algorithmic bias: if the training data for AI models is not sufficiently diverse (underrepresentation of certain ethnicities, age groups, lifestyles, or rare diseases), the generated recommendations could be inaccurate, or even dangerous, for some groups of people, thus perpetuating health inequalities. **(Abirami, 2024)**

Consumer AI systems like ChatGPT present a risk of generating erroneous, incomplete, or outdated information that appears plausible but is scientifically incorrect: tests have revealed suboptimal menu suggestions for diabetic or hemodialysis patients, as well as the generation of entirely fabricated scientific references with known authors but nonexistent article titles. **(Ayers *et al*, 2023)**

Excessive reliance on technology is another drawback: AI can provide useful information, but it should never replace the clinical expertise, professional judgment, and human therapeutic

Bibliographic Review

relationship of nutritionists and dietitians, particularly for complex cases, multiple pathologies, or eating disorders requiring a psychological approach. **(Abirami, 2024)**

Finally, AI-generated advice may fail to consider users' real social, cultural, economic, emotional, or psychological barriers (food insecurity, culinary traditions, food phobias, depression), leading to theoretically optimistic but impractical recommendations in daily life, highlighting the need for human oversight to adapt plans to contextual realities. **(Topol, 2019)**

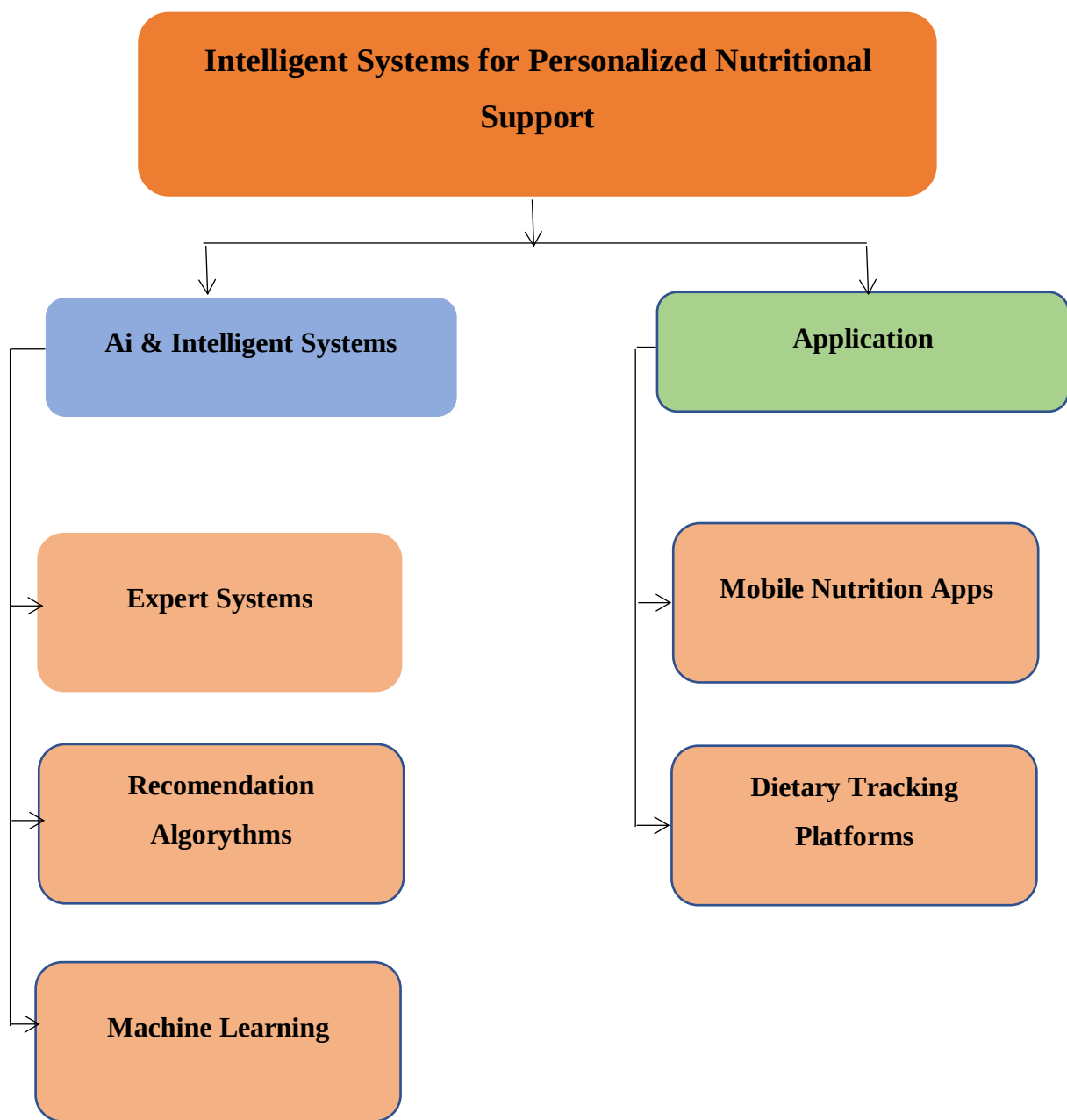


Figure 1. Intelligent systems for personalized nutrition support

Materials & Methods

Materials & 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.

I. Implementation of a Personalized Nutritional System based on Consumer Pathologies

I.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 flavourings, and other industrial markers in the ingredient list.

The application maintains two complementary databases. The first is the Algerian food database (AlgerianFoodDatabase), 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.

Materials & Methods

I.3. Web Application Description: Subscriber and Expert

I.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.

I.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:

Materials & Methods

- 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.

I.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.

Table 4. Development Tools and 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

Materials & Methods

CSS3 (Custom Properties)	Standard	Responsive layout and theming
JavaScript (ES2020)	ES2020	Dynamic UI and fetch API calls
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

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.

I.5. Web Application Interfaces

This section describes each interface that makes up **DZsain** the 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 experts.

Results & Discussion

Chapter 03 : Results & Discussion

The results obtained highlight the features of DZsain, an application developed to assist consumers in evaluating their dietary choices within the Algerian context. The system relies on two complementary mechanisms for identifying food products: barcode reading compliant with the GS1 standard, and the extraction of information from images of nutritional composition tables. The application integrates a database specifically dedicated to products marketed in Algeria, enabling the automatic calculation of the EWG score for each analyzed reference. It also provides a personalized assessment taking into account the user's health characteristics, particularly declared medical conditions and potential food allergies.

One of DZsain's primary strengths lies in the fact that its database was entirely designed by the development team. It was built through a data collection effort carried out directly in the field. Nutritional data were manually recorded from labels on food products available on the Algerian market. Each entry underwent a rigorous verification process to ensure compliance with applicable regulatory standards. This methodology guarantees the reliability, relevance, and appropriateness of the stored information with respect to the specificities of the national context.

In this section, we present the results obtained from testing the application on a dairy cheese product representative of the Algerian market. The various functional interfaces are described and analyzed using annotated figures illustrating the system's main features. Finally, a comparison is drawn between the performance and services offered by DZsain and those provided by internationally available digital solutions.

I. Presentation of DZsain Interfaces

I.1 Login Interface

The DZsain login interface (Figure 2) is exclusively intended for nutrition specialists authorized to access and manage the Algerian food database integrated into the platform. Its design is based on a simple, clean, user-centered structure, consisting of a field for the institutional email address in the format expert@DZsain.dz, a password entry field, and a validation button labeled "Log In." A link to return to the interface intended for the general public is also available, ensuring smooth navigation between the application's different functional spaces.

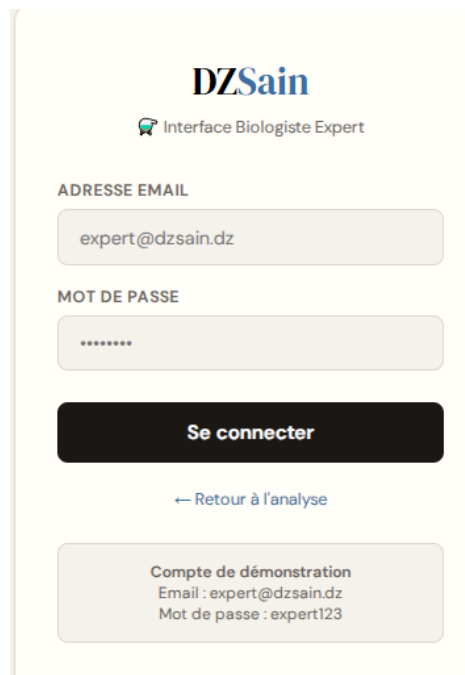


Figure 2. DZsain Secure Login Interface — Expert Biologist Space.

The separation of access rights is a fundamental element of DZsain's architecture. This organization clearly distinguishes the space intended for end users — primarily oriented toward consulting nutritional information — from the environment reserved for experts, dedicated to entering, verifying, and updating food product data. This access rights management mechanism, based on a distinction between user and expert profiles, aligns with best practices recommended for health information systems, where preserving data quality, consistency, and reliability is of paramount importance (**Vos et al, 2023**).

From an ergonomic standpoint, the interface adheres to the essential principles of readability and visual simplicity. The strong contrast between text elements and the background facilitates easy reading, while the input fields are clearly identifiable and well-structured. Furthermore, the presence of a demonstration account presented in a separate section reflects a commitment to supporting new users. This pedagogical approach aims to facilitate the tool's adoption and to enable professionals tasked with administering the database to quickly familiarize themselves with its features.

I.2 Main Interface: Health Profile and Dashboard

Figure 3 illustrates DZsain's main interface, whose design is based on a functional division into two complementary spaces. On the left, the section titled "Health Profile" allows the user to enter their medical characteristics by selecting, through dropdown menus with checkboxes, various conditions such as type 1 or type 2 diabetes, ulcerative colitis, gastric ulcer, celiac disease, or arterial hypertension. This same section also offers the option to indicate various food allergies or sensitivities, including those to eggs, tree nuts, seafood, preservatives, food coloring agents, or sesame seeds.

The panel on the right groups the elements related to product analysis. It features a central area for displaying results, initially empty and accompanied by the message "No analysis in progress." This section also includes a summary history of previously conducted analyses, showing for each product its EWG score along with the date and time of the assessment performed (Figure 3).

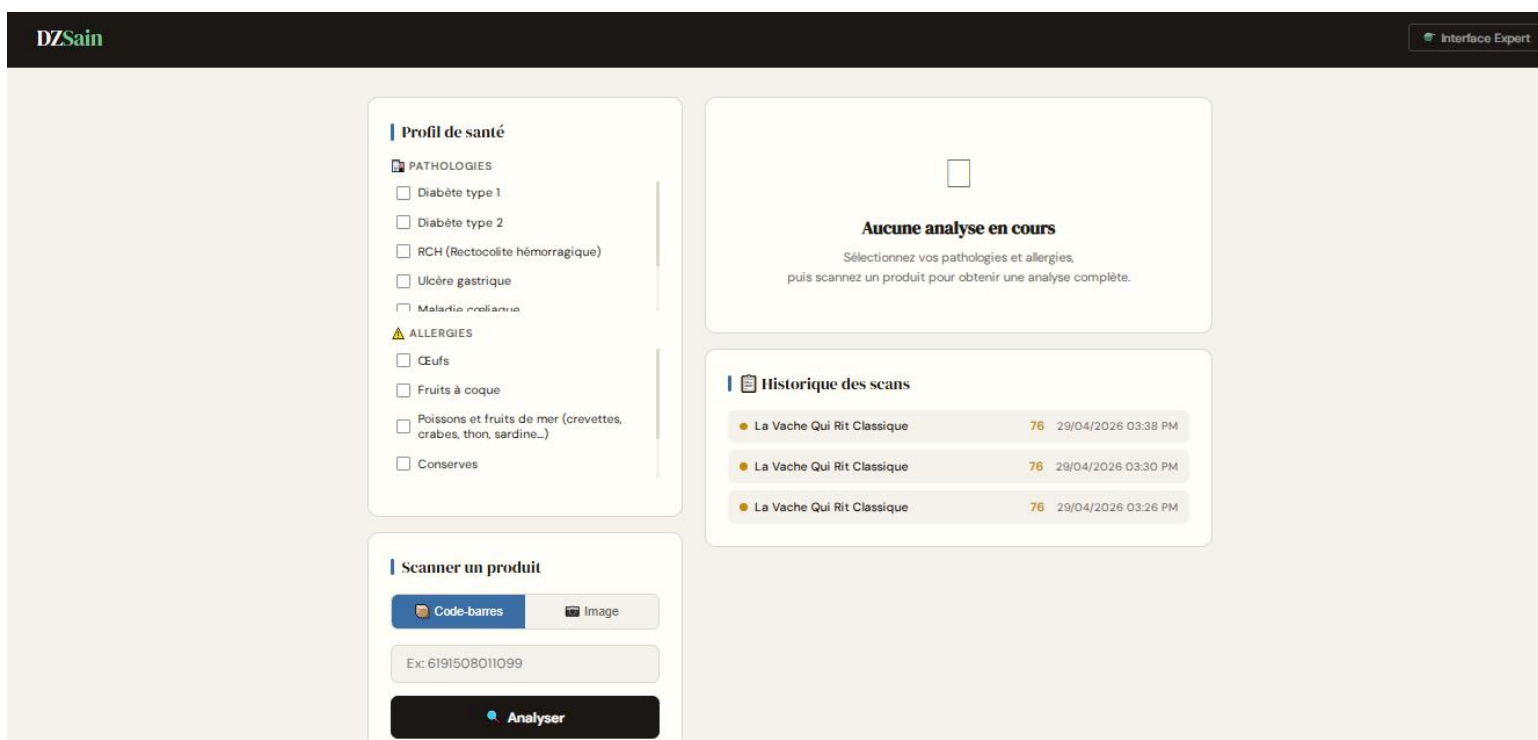


Figure 3. DZsain Main Interface — Health Profile, Analysis Area, and Scan History.

The architecture of this interface reflects a user-centered approach based on the principle of prior personalization. Before analyzing any food product, the user is invited to define their health profile, thereby allowing the system to automatically adapt the interpretation of nutritional data according to the declared medical constraints and specific needs. This approach

Chapter 03 : Results & Discussion

is consistent with current directions in mobile health application (mHealth) development, which emphasize the importance of considering individual clinical characteristics in nutritional decision-support tools (Hou *et al*, 2020) (Lieffers *et al*, 2018).

Moreover, the presence of an analysis history enriches the application with a temporal dimension that is essential for monitoring dietary habits. By displaying the names of analyzed products, their EWG scores, and the dates of consultation, this feature ensures traceability of user interactions with the system. Although still limited in its current version, it represents a promising foundation for the future development of evolving dietary behavior analyses and for the establishment of long-term personalized nutritional support.

I.3 Health Profile Detail: Medical Conditions and Allergies

Figure 4 provides a detailed view of the "Health Profile" section, highlighting the diversity and precision of the medical information that can be entered by the user. This interface allows the selection of several chronic conditions, including type 1 diabetes, type 2 diabetes, ulcerative colitis (UC), gastric ulcer, celiac disease, irritable bowel syndrome (IBS), and arterial hypertension. It also offers the option to indicate various food allergies or sensitivities, including those to eggs, tree nuts, seafood such as shrimp, crab, tuna, and sardine, canned goods, food coloring agents, and sesame seeds.

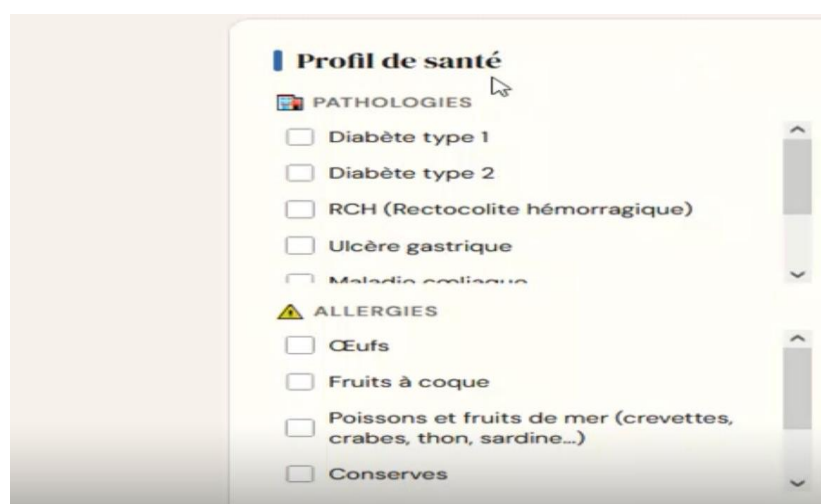


Figure 4. Detail of the "Health Profile" Panel — Selection of Medical Conditions and Food Allergies.

Chapter 03 : Results & Discussion

The integration of these conditions into the application is grounded in precise epidemiological and nutritional considerations. The selected diseases correspond to some of the most frequently observed chronic conditions in the Algerian population, for which specific dietary recommendations play a major role in clinical management. According to data from the 2019 National Health Survey (MSPRH, 2019), the prevalence of diabetes reaches approximately 12.3% among adults over the age of 35, while arterial hypertension affects nearly one-third of this population group. Given their high prevalence and strong dependence on dietary habits, these two conditions represent priorities within a personalized nutritional approach.

Regarding food allergies, the proposed selection covers the main allergens recognized at the international level. It is based on the references established by the Codex Alimentarius (CAC/GL 23-1997, revised version) and the provisions of European Regulation No. 1169/2011 (EU, 2011), some requirements of which are incorporated into Algerian regulations on food labeling (**Executive Decree 05-484, amended in 2013**).

The specific inclusion of food coloring agents among the categories of potential allergens is of particular relevance in the context of confectionery and industrial sweets, which are extensively represented among the foods evaluated in this study.

I.4 Scan Feature: Barcode Entry and Analysis

Figure 5 presents the module dedicated to the identification and analysis of food products, located in the lower section of the left panel of the user interface. This feature provides two distinct product recognition methods. The first is based on entering a barcode compliant with the GS1-13 standard, while the second allows the import of an image containing the nutritional information table. The interface includes an input field illustrated with a sample barcode format (e.g., 61915p8011099), accompanied by a button labeled "Analyze," whose activation triggers the product evaluation process. The display also shows that the "Arterial Hypertension" option has been pre-selected in the user's health profile, allowing the analysis to be tailored to the declared medical characteristics.

The screenshot displays a web application interface for product analysis. It features three main sections: 1. Allergy selection on the top left with checkboxes for 'Intestin irritable (SII)', 'Hypertension artérielle' (checked), and a group of food allergies including 'Poissons et fruits de mer', 'Conserves', 'Colorants alimentaires', and 'Graines (sésame...)'. 2. A 'Scanner un produit' section at the bottom left with 'Code-barres' and 'Image' buttons, a text input field containing 'Ex: 61915p8011099', and an 'Analyser' button. 3. A 'Historique des scans' section on the top right showing a list of previous scans for 'La Vache Qui Rit Classique' with scores of 76 and timestamps from 29/04/2026.

Figure 5. Scan Module — GS1 Barcode Entry and Analysis Initiation.

The adoption of the GS1-13 barcode as the primary identifier represents a technically and operationally sound choice. This international standard is widely used for identifying food products marketed in Algeria, particularly within the framework of the country's integration into the GS1 Algeria network. Since each code is uniquely assigned to a specific combination of product, brand, and format, it ensures precise and unambiguous recognition. However, the performance of this mechanism is closely dependent on the richness and comprehensiveness of the internal database, which must associate each identifier with the corresponding nutritional information in order to enable reliable analysis.

The second method, based on the use of images of nutritional tables, provides a complementary solution that is particularly useful for artisanal or locally produced products whose barcodes are not yet included in the database. This approach generally relies on optical character recognition (OCR) technologies and machine learning-based image analysis methods. However, the quality of the results remains highly dependent on the accuracy of data extraction from the label. Comparable platforms, such as Open Food Facts, use similar processes, although several studies have shown that their performance can vary depending on the quality, legibility, and capture conditions of the submitted images (**Brugailières et al, 2021**).

I.5 Analysis Results: EWG Score and Nutritional Data

Figure 6 presents the detailed results generated by DZsain following the analysis of a pasteurized processed cheese marketed on the Algerian market, identified by its barcode. This interface constitutes the central element of the application's nutritional evaluation process. The

Chapter 03 : Results & Discussion

analyzed product receives an EWG score of 76.0 out of 100, placed in the "Moderate" category, visually represented by an orange color indicator. The displayed nutritional information reveals a sugar content of 0.0 g/100 g, a saturated fat concentration of 12.3 g/100 g, a sodium intake of 1,200.0 mg/100 g, a fiber content of 0.0 g/100 g, a protein content of 10.0 g/100 g, and an energy value indicated as 0.0 kcal. The interface also integrates a section dedicated to compatibility with the user's health profile. In this case, since "Arterial Hypertension" was previously selected, the system automatically generates an alert indicating a high sodium content that could pose a risk to blood pressure control.



Figure 6. Analysis Result for a Reference Processed Cheese — EWG Score 76/100, Nutritional Profile, and Health Compatibility.

The assignment of an EWG score of 76/100 places this product in an intermediate category reflecting an overall satisfactory level of nutritional quality, while highlighting certain elements requiring particular vigilance. The EWG Food Scores system, developed by the Environmental Working Group (EWG, 2012), is based on a multidimensional assessment integrating the product's nutritional characteristics, its degree of industrial processing, and the potential risks associated with certain ingredients, particularly additives or allergenic substances. In this context, the score obtained reflects an acceptable nutritional profile, although sodium and saturated fatty acid contents represent limiting factors.

Detailed analysis shows that the sodium concentration reaches 1,200 mg per 100 g of product, a particularly high value for this food category. According to the World Health Organization's

Chapter 03 : Results & Discussion

recommendations, total daily sodium intake should not exceed 2,000 mg in adults (WHO, 2023). A 100 g serving of this cheese alone thus provides approximately 60% of the recommended daily limit. Under these circumstances, the warning issued by DZsain to individuals suffering from arterial hypertension appears fully justified and consistent with the nutritional recommendations currently advocated for the prevention and management of this condition (Sacks *et al*, 2019).

Regarding saturated fatty acids, the observed content of 12.3 g/100 g exceeds the threshold generally considered high in nutritional assessment references such as the Nutri-Score (Hercberg *et al*, 2019).

Such a composition would therefore have contributed to a less favorable rating within this classification system. The convergence of results obtained through different nutritional evaluation methods reinforces the credibility of the approach adopted by DZsain and confirms the relevance of using the EWG score for assessing the nutritional quality of food products.

I.6 Clinical Alert Display and Scan History

Figure 7 complements the previously presented results by highlighting the section titled "Health Profile Compatibility." This section displays the alert associated with arterial hypertension in two distinct and complementary visual forms. The first consists of a structured list format providing precise details about the nature of the alert — specifically, a high sodium concentration (1,200 mg/100 g) likely to increase blood pressure risk. The second takes the form of a summarized banner consolidating the essential information so as to enhance its visibility and comprehension. The figure also highlights the scan history, in which three successive scans of the same product performed at different times (3:26 PM, 3:30 PM, and 3:38 PM) are recorded, each associated with an identical EWG score of 76.

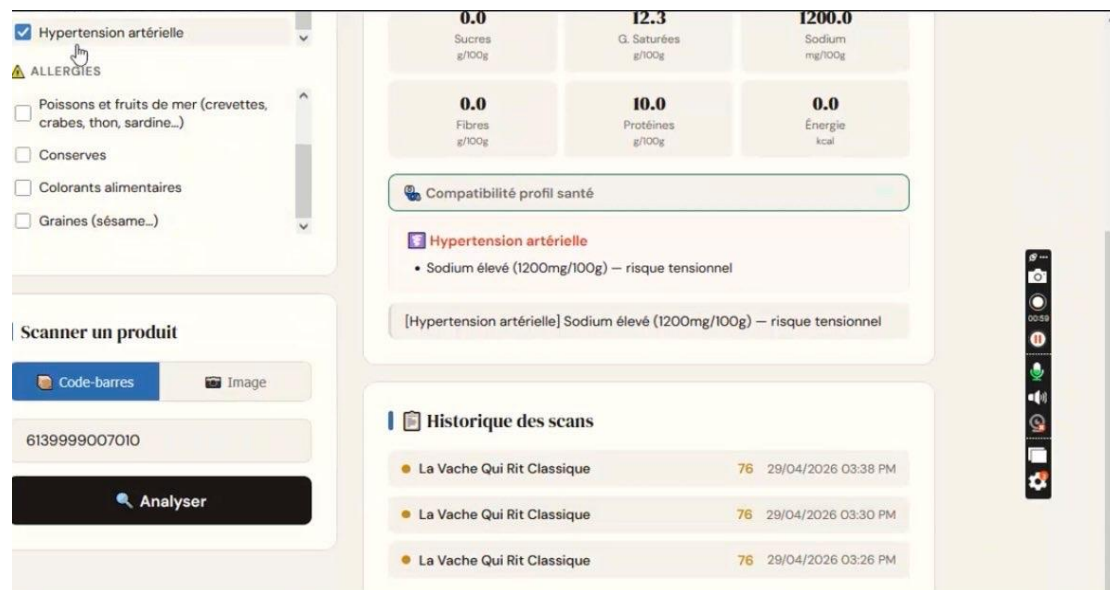


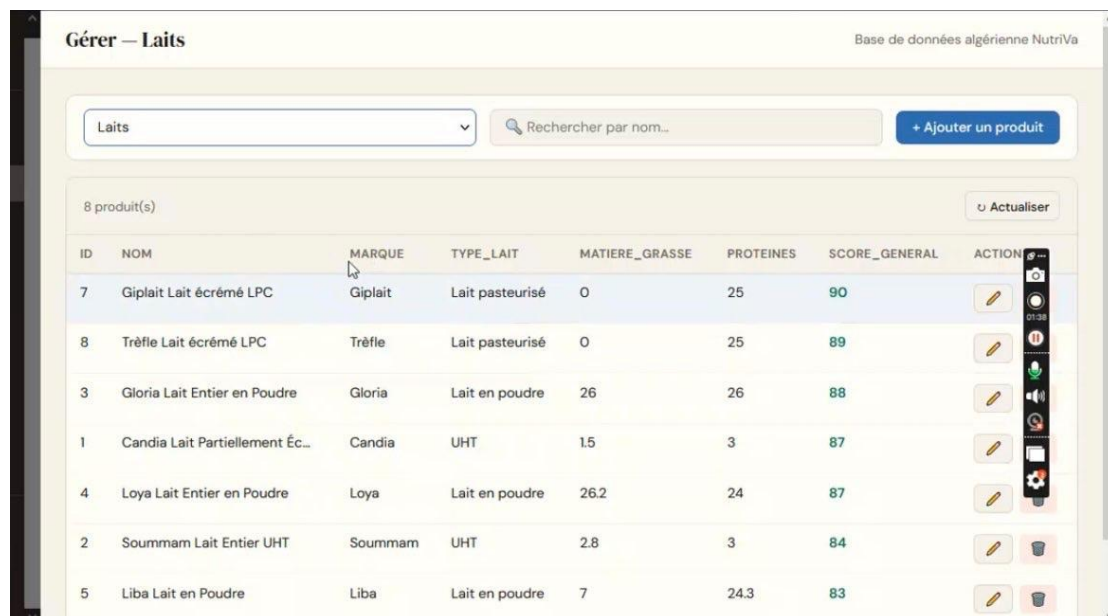
Figure 7. Health Compatibility Alert for Arterial Hypertension and Multiple Scan History.

The use of a dual alert presentation format reflects an approach aimed at optimizing the communication of health-related information. By combining a detailed description with an easily identifiable visual summary, the application enhances the user's perception and interpretation of nutritional risks. This strategy is consistent with recommendations in the field of digital health support systems, which advocate for the use of multiple modes of delivering critical information in order to improve comprehension and encourage the adoption of health-promoting behaviors (Tansil *et al*, 2022).

Furthermore, the display of multiple successive analyses of the same product demonstrates DZsain's ability to record and retain data generated during user interactions. The presence of a chronological history allows past evaluations to be traced and constitutes a first level of consultation habit tracking. Although this feature remains limited in its current version, it represents a promising foundation for the future integration of a digital food diary. Such tools are widely used in advanced nutritional monitoring applications and have demonstrated their value in supporting individuals with chronic diseases, particularly diabetes and arterial hypertension, by facilitating the long-term monitoring of dietary behaviors (Burke *et al*, 2019).

I.7 Expert Interface: Milk Database Management

Figure 8 presents the management interface designed for expert biologists to administer the "Milk Products" category within the DZsain database. This interface displays a table grouping several dairy products marketed on the Algerian market, along with their main nutritional and descriptive characteristics. For each product, the brand, type of milk (pasteurized, UHT, or powdered), fat content, protein concentration, and the overall score assigned by the evaluation algorithm are listed. Specific controls allow the modification or deletion of existing records, while an add function facilitates the integration of new entries. Products are presented in descending order of their scores, ranging from 90 to 83, enabling an immediate comparison of their relative nutritional quality.



The screenshot shows a web interface titled "Gérer — Laits" with a subtitle "Base de données algérienne NutriVa". It features a search bar with the text "Lait(s)" and a button "+ Ajouter un produit". Below the search bar, it indicates "8 produit(s)" and an "Actualiser" button. The main table lists the following products:

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

Figure 8. Expert Biologist Interface — Management of the "Milk Products" Category in the DZsain Database.

This interface constitutes the administrative component of DZsain and plays a central role in the maintenance, updating, and enrichment of the food database. Its primary value lies in the integration of products specifically available on the Algerian market, which are often absent from major international nutritional databases. This localization represents one of the platform's key strengths, as several studies have highlighted the low level of coverage of North African food products in global nutritional reference frameworks (**Branca *et al*, 2020**).

Chapter 03 : Results & Discussion

An analysis of the scores assigned to different types of milk reveals a hierarchy consistent with international nutritional recommendations. Skimmed pasteurized milks generally receive higher scores than whole UHT milks, primarily due to their reduced saturated fatty acid content. This classification aligns with the World Health Organization's guidelines aimed at limiting the consumption of saturated fats in the context of cardiovascular disease **prevention (WHO, 2023)**.

The consistency observed between the generated results and public health recommendations contributes to validating the relevance of the scoring system integrated into DZsain.

The interface also highlights a differentiated management of deletion rights. Some products have a deletion option materialized by a specific icon, while others do not. This distinction suggests the existence of a protection mechanism designed to preserve reference data deemed essential to the database's integrity. Historical or extensively validated products thus appear to be protected against accidental deletion, whereas more recent or still-pending entries can be modified or removed. An explicit formalization of this data management policy would nevertheless represent a desirable improvement for expert users.

The comparative evaluation of DZsain against the leading international digital nutritional information solutions clearly identifies its distinctive features and development prospects. Among the most widely used platforms is Open Food Facts, which today constitutes one of the largest collaborative open-source databases in the world, with several million products referenced across more than 160 countries (**Vos et al., 2023**).

Despite this extensive coverage, the representation of Algerian products remains limited, both in quantity and quality of available data. DZsain stands out in this regard through a data collection strategy targeted at the national market and a validation process carried out by qualified experts, ensuring better alignment with local realities.

Certain mobile applications widely distributed in Europe base their evaluations on a combination of criteria including nutritional quality, the presence of additives, and organic certification. Unlike these approaches, which are primarily based on the Nutri-Score, DZsain adopts the EWG Food Scores methodology, which places particular emphasis on the degree of industrial processing and potentially concerning ingredients. In addition, the integration of a

Chapter 03 : Results & Discussion

clinical compatibility module that accounts for individual pathologies and allergies constitutes a distinctive feature rarely offered by mainstream consumer tools.

Other international applications focus primarily on caloric tracking, weight management, or the counting of daily energy intake. Although they possess particularly large databases, they generally incorporate neither a global assessment of nutritional quality nor a personalized analysis of risks associated with specific medical conditions. DZsain thus adopts an orientation more strongly centered on prevention, nutritional education, and the management of chronic diseases.

Certain American platforms also combine nutritional assessment with pedagogical tools designed to guide consumers in their dietary choices. They offer, in particular, targeted alerts for certain medical conditions and alternative product recommendations. Although their geographic coverage remains essentially limited to the North American market, their educational approach constitutes a relevant source of inspiration for the future evolution of DZsain, particularly with regard to contextualized recommendations and personalized nutritional guidance.

The Nutrinet-Santé study represents, for its part, a remarkable example of the use of digital technologies for large-scale nutritional data collection and analysis. Even though its objective differs from that of DZsain, this initiative demonstrates the potential of digital tools in the epidemiological surveillance of dietary behaviors and could inspire the future integration of a population-level dimension within the platform.

The scoring system adopted by DZsain is based on the EWG Food Scores methodology developed by the Environmental Working Group. This approach evaluates foods along three complementary dimensions: nutritional quality, degree of industrial processing, and ingredient characteristics. Nutrients considered concerning — such as added sugars, saturated fatty acids, sodium, or certain additives — directly influence the calculation of the final score, which is expressed on a scale from 0 to 100, with higher values corresponding to products with the most favorable profiles.

The choice of this methodology appears particularly relevant in the Algerian context. On one hand, the progressive increase in the consumption of ultra-processed products observed since

Chapter 03 : Results & Discussion

the early 2000s justifies the consideration of the degree of food processing (**Moubarek *et al*, 2021**).

On the other hand, the attention given to additives addresses the growing expectations of consumers regarding transparency and food safety. Finally, the nutritional criteria used remain consistent with the reference nutritional values defined in national regulations.

From a regulatory standpoint, DZsain operates within the Algerian legal framework governing nutritional labeling of pre-packaged foods. Regulatory provisions mandate the declaration of essential parameters such as energy value, proteins, carbohydrates, lipids, and sodium. The data provided by manufacturers thus constitute the primary source of information used by the application for the calculation of nutritional scores and the generation of health alerts.

DZsain's relevance is evident at several levels. For consumers, the application facilitates the interpretation of nutritional data that is often complex and difficult to use without specific knowledge (**Grunert & Wills, 2007**).

For professionals in the food sector, it can also serve as a monitoring tool for detecting potential inconsistencies in nutritional declarations or for tracking the evolution of the quality of marketed products. This dimension aligns with the general objectives of consumer protection and the fight against fraudulent practices provided for by national legislation.

It should nevertheless be noted that Dzsain does not replace laboratory analyses. The results provided rely exclusively on information declared by manufacturers and should be considered as decision-support indicators rather than as proof of regulatory compliance. This distinction is essential in order to avoid any confusion between nutritional assessment and official certification.

Certain limitations of the current version must also be taken into account. The first concerns the still incomplete coverage of the database, which remains representative of certain food categories without encompassing all products available on the Algerian market. The progressive expansion of this database, accompanied by a rigorous validation protocol including reference analyses, constitutes a major priority for future developments.

Another limitation lies in the nutritional table image analysis module. The performance of the image processing algorithms used has not yet been subjected to exhaustive validation across all

Chapter 03 : Results & Discussion

labeling formats encountered on the Algerian market, whose graphic and typographic presentations can be highly heterogeneous.

Furthermore, the real impact of the application on users' dietary behaviors has not yet been evaluated in the framework of controlled clinical studies. Yet, the scientific literature shows that the effectiveness of mobile nutrition applications depends strongly on user adherence and the quality of the support provided (**Lieffers *et al*, 2018**).

A rigorous clinical evaluation therefore appears indispensable to confirm the added value of DZsain in terms of public health.

Finally, several development avenues have been identified to enrich the platform's features. Among the most promising prospects are the integration of a recommendation system offering nutritionally more favorable alternatives, the development of native mobile applications for iOS and Android environments, interconnection with connected biometric devices such as glucometers and blood pressure monitors, and the establishment of a longitudinal nutritional dashboard enabling users to track the evolution of their dietary habits over time.

III. Nutritional Diseases: Epidemiological Context and Relevance to the NutriVa Application

III.1. Definition and Classification of Nutritional Diseases

Nutritional diseases are defined as a group of health disorders resulting from an imbalance in dietary intake, whether due to a deficiency in essential nutrients, their excessive consumption, or the ingestion of harmful or contaminated food substances. These diseases are generally divided into two main categories: malnutrition-related deficiency diseases, such as anemia resulting from iron and folate deficiencies, and diseases of dietary excess associated with diets rich in added sugars, saturated fats, sodium, and ultra-processed foods. The latter category represents the most prominent challenge in contemporary Algeria, encompassing type 1 and type 2 diabetes, arterial hypertension, dyslipidemia, obesity, cardiovascular diseases, and certain chronic inflammatory diseases of the digestive tract, such as ulcerative colitis and celiac disease.

In light of this classification, the significance of the DZsain application stems from its direct addressing of diseases linked to dietary excess and poor food quality. Rather than limiting itself

Chapter 03 : Results & Discussion

to an abstract analysis of a product's nutritional content, the application connects this analysis to the user's actual medical condition, thereby transforming it from an informational tool into an effective preventive mechanism.

Understanding the clinical value of the DZsain application requires an examination of the scientifically documented relationship between the dietary components monitored by the application and each of the diseases included in the user's health profile.

First: Diabetes (Type 1 and Type 2): Type 2 diabetes is closely linked to excessive consumption of simple sugars, saturated fats, and high glycemic index foods. Studies have demonstrated that targeted dietary intervention contributes to preventing the onset of this disease in at-risk populations by between 40% and 58% (**Knowler *et al*, 2002**).

From this perspective, DZsain enables individuals with diabetes to immediately access the sugar content of each product, thereby supporting their daily dietary decisions.

Second: Arterial Hypertension: Sodium is the most prominent dietary factor in the nutritional pathogenesis of high blood pressure. The World Health Organization recommends that daily sodium intake should not exceed 2,000 mg in adults (**WHO, 2023**).

As demonstrated by the application's results in the case of the processed cheese analyzed, this type of product alone may provide up to 60% of the recommended daily allowance, thereby substantiating the scientific rationale behind the alert generated by the application.

Third: Dyslipidemia: Saturated and trans fats contribute to elevated levels of low-density lipoprotein cholesterol (LDL) and reduced high-density lipoprotein cholesterol (HDL), predisposing individuals to the development of atherosclerosis and cardiovascular diseases. DZsain monitors the saturated fat content of each product and incorporates it into the EWG score calculation criteria, making it a directly relevant tool for the dietary management of patients with dyslipidemia.

Fourth: Chronic Kidney Disease: Individuals suffering from chronic kidney disease are required to follow a strictly controlled diet with rigorous restrictions on potassium, phosphorus, sodium, and protein intake. Scientific evidence indicates that non-adherence to dietary restrictions accelerates the rate of renal function deterioration. The integration of this condition

into the DZsain health profile enables the generation of precise alerts concerning sodium content and other related nutritional components.

Fifth: Chronic Inflammatory Bowel Diseases and Celiac Disease: These conditions necessitate the exclusion of specific components such as gluten and pro-inflammatory foods, making thorough verification of the ingredients listed on product labels an essential health requirement.

III.3.2. Food Allergies: An Indispensable Preventive Dimension

Food allergies represent a field of paramount importance in nutritional health, as allergic reactions may be life-threatening in cases of severe sensitivity, such as anaphylactic shock. DZsain incorporates within its health profile a broad spectrum of allergens internationally recognized in accordance with the requirements of the Codex Alimentarius and European Union Regulation No. 1169/2011 — requirements that have been partially reflected in Algerian food labeling regulations. This comprehensive coverage confers a clear preventive value upon the application, particularly in the context of a food market characterized by diverse products and complex formulations.

Conclusion

DZsain constitutes an innovative initiative adapted to the specificities of the Algerian context in the field of digital nutritional decision-support tools. By relying on a national food database developed and validated by specialists, on the internationally recognized EWG Food Scores methodology, and on a personalized evaluation system accounting for the user's medical conditions and allergies, the application provides a concrete response to public health challenges related to improving dietary behaviors and preventing chronic diseases.

The experiments conducted using a pasteurized processed cheese representative of the Algerian market confirmed the proper functioning of the system's main components. The results obtained demonstrate the effectiveness of the barcode-based product identification process, the EWG score calculation capability, the detailed display of nutritional characteristics, the generation of alerts tailored to the user's medical profile — particularly in the presence of high sodium content for individuals suffering from arterial hypertension — as well as the recording and preservation of the history of conducted analyses. In addition, the interface dedicated to expert biologists, illustrated through the management of the milk product category, highlights the relevance of an architecture based on a separation of roles between users and experts in order to ensure the reliability, consistency, and updating of data.

The comparative analysis conducted with the leading international nutritional information solutions shows that DZsain possesses several distinctive advantages. Its first asset lies in the constitution of a database specifically dedicated to food products marketed in Algeria. The second concerns the integration of a clinical compatibility module enabling analyses to be adapted according to declared medical conditions and allergies. Finally, the use of the EWG methodology provides a multidimensional assessment that takes into account not only the nutritional composition of products, but also the presence of additives and their degree of industrial processing. These elements reinforce the application's relevance in the context of the nutritional transition currently underway in Algeria and align with national guidelines for the prevention of diet-related diseases.

Despite the encouraging results obtained, certain limitations remain. The database coverage is still incomplete in relation to the diversity of products available on the national market. Furthermore, the performance of the nutritional table image analysis module has not yet been systematically validated at a large scale. Finally, the real impact of the application on users' dietary behaviors and health indicators has not yet been evaluated within the framework of

dedicated clinical studies. These various aspects represent priority areas for the platform's future developments. Addressing them through a rigorous scientific approach — involving, in particular, laboratories specializing in food analysis and research teams in clinical nutrition — will serve to strengthen the system's robustness and enhance its scientific and operational value.

Through its integrated approach, DZsain illustrates the potential of information and communication technologies applied to the nutritional and food sciences. This synergy between digital innovation and nutritional expertise aligns with current international trends aimed at developing tools capable of supporting individuals in their dietary choices and contributing to the reduction of the growing burden of chronic non-communicable diseases associated with dietary habits.

References

- ABBAS, H. A. (2021). *Analyse microbiologique des produits*. Mostaganem: Université Abdelhamid IbnBadis-Mostaganem.
- Abirami, V. (2024, Aout 15). *L'IA dans la nutrition : Rationalisation d'une alimentation saine grâce à la vision par ordinateur*. Retrieved from ultralytics:<https://www.ultralytics.com/fr/blog/ai-in-nutrition-streamlining-healthy-eating-with-computer-vision>
- Abrams, E. M., Gibson, P. G., & Kalayanamitra, R. (2015). Fooducate app: Can it help patients with food allergies? *Annals of Allergy, Asthma & Immunology*, 115(6), 528–529. <https://doi.org/10.1016/j.anai.2015.09.013>
- Alain, T. (2009, Janvier 9). *Hello, y-a-t-il de la noisette dans des cookies sans noisette ?* Retrieved from allergique: <https://www.allergique.org/Hello-y-a-t-il-de-la-noisette-dans-des-cookies-sans-noisette.html>
- Alkhatib, A., Jaleel, A., Muhammad Tariq, M. N., Feehan, J., Apostolopoulos, V., Cheikh Ismail, L., Stojanovska, L., & Al Dhaheri, A. S. (2021). The role of bioactive compounds from dietary spices in the management of metabolic syndrome: An overview. *Nutrients*, 14(1), 175. <https://doi.org/10.3390/nu14010175>
- Amawi, A., AlKasasbeh, W., Jaradat, M., Almasri, A., Alobaidi, S., Abu Hammad, A., Bishtawi, T., Fataftah, B., Turk, N., Al Saoud, H., Jarrar, A., & Ghazzawi, H. (2024). Athletes' nutritional demands: A narrative review of nutritional requirements. *Frontiers in Nutrition*, 10, 1331854. <https://doi.org/10.3389/fnut.2023.1331854>
- Andrea Vania, A., Frelut, M.-L., Nègre, V., & Weghuber, D. (2020). *L'approche nutritionnelle de l'obésité*. Brussels, Belgium: European Childhood Obesity Group.

ANOR. (n.d.). *Algerian standards NA 6369 / NA 6370 relating to water intended for human consumption*).

ANSES. (2021). *Actualisation des références nutritionnelles françaises en vitamines et minéraux*. Maisons-Alfort: Agence nationale de sécurité sanitaire de l'alimentation, de l'environnement et du travail.

Audrey, D. (2024, NOVEMBRE 11). *L'intelligence artificielle et le domaine de la nutrition : révolution et perspectives*. Retrieved from perfodiet: <https://www.perfodiet.com/lintelligence-artificielle-et-le-domaine-de-la-nutrition-revolution-et-perspectives/>

Ayers, J. W., Poliak, A., Dredze, M., Leas, E. C., Zhu, Z., Kelley, J. B., Faix, D. J., Goodman, A. M., Longhurst, C. A., Hogarth, M., & Smith, D. M. (2023). Comparing physician and artificial intelligence chatbot responses to patient questions posted to a public social media forum. *JAMA Internal Medicine*, 183(6), 589–596. <https://doi.org/10.1001/jamainternmed.2023.1838>

Bailey, R. L., & Stover, P. J. (2023). Precision Nutrition: The Hype Is Exceeding the Science and Evidentiary Standards Needed to Inform Public Health Recommendations for Prevention of Chronic Disease. *Annual Review of Nutrition*, 385–407.

Bajwa, J., Munir, U., Nori, A., & Williams, B. (2021). Artificial intelligence in healthcare: Transforming the practice of medicine. *Future Healthcare Journal*, 8(2), e188–e194. <https://doi.org/10.7861/fhj.2021-0095>

Beam & Kohane. (2018). Big data and machine learning in health care. *Jama*, 1317-1318.

Berger, S., Raman, G., Vishwanathan, R., Jacques, P. F., & Johnson, E. J. (2015). Dietary cholesterol and cardiovascular disease: A systematic review and

- meta-analysis. *The American Journal of Clinical Nutrition*, 102(2), 276–294. <https://doi.org/10.3945/ajcn.114.100305>
- Bhutta, Z. A., Berkley, J. A., Bandsma, R. H. J., Kerac, M., Trehan, I., & Briend, A. (2017). Severe childhood malnutrition. *Nature Reviews Disease Primers*, 3(1), Article 17067. <https://doi.org/10.1038/nrdp.2017.67>
- Black, R. E., Victora, C. G., Walker, S. P., Bhutta, Z. A., Christian, P., de Onis, M., Ezzati, M., Grantham-McGregor, S., Katz, J., Martorell, R., & Uauy, R. (2013). Maternal and child undernutrition and overweight in low-income and middle-income countries. *The Lancet*, 382(9890), 427–451. [https://doi.org/10.1016/S0140-6736\(13\)60937-X](https://doi.org/10.1016/S0140-6736(13)60937-X)
- Branca, F., Demaio, A., Udomkesmalee, E., Baker, P., Bhutta, Z. A., & Hawkes, C. (2020). A new nutrition manifesto for a new nutrition reality. *The Lancet*, 395(10217), 8–10. [https://doi.org/10.1016/S0140-6736\(19\)32606-7](https://doi.org/10.1016/S0140-6736(19)32606-7)
- Brugailières, P., Delamaire, C., Dubuisson, C., Volatier, J.-L., & Havard, S. (2021). Identification of the healthfulness of food products sold in France through an open food database: Application to fruit juices and nectars. *Nutrients*, 13(5), 1618. <https://doi.org/10.3390/nu13051618>
- Burke, L. E., Ma, J., Azar, K. M. J., Bennett, G. G., Peterson, E. D., Zheng, Y., ... Spring, B. (2019). Current science on consumer use of mobile health for cardiovascular disease prevention. *Circulation*, 132(12), 1157–1213. <https://doi.org/10.1161/CIR.0000000000000232>
- Busson, A. (2024, December 16). Syndrome métabolique : cinq signes à retenir. ELSAN. <https://www.elsan.care/fr/pathologie-et-traitement/maladies-endocriniennes/syndrome-metabolique-cinq-signes-a-retenir>

- Cacciarella, D. (2024, Marc 10). Les hommes et les femmes ont-ils vraiment des besoins nutritionnels différents ? *frequencemedicale*.
- Camaschella. (2015). Iron-deficiency anemia. *New England Journal of Medicine*, 1832–1843.
- Cardenas, J. (2020, Juin 23). *Traitement des allergies alimentaires*. Retrieved from doctissimo: <https://www.doctissimo.fr/sante/allergies/allergie-alimentaire/allergie-alimentaire-traitement>
- Carretero-Krug et al. (2024). Nutritional Status of Breastfeeding Mothers and Impact of Diet and Dietary Supplementation: A Narrative Review. *Nutrients*, 301.
- Laithier, C., Coulon, J.-B., Vuitton, D. A., Lortal, S., & Loukiadis, E. (2025). Bénéfices et risques pour la santé de la consommation de fromage. *La Revue du Praticien*, 75(7), 779–786.
- Challa, H. J., Ameer, M. A., & Uppaluri, K. R. (2023). DASH diet: A review of its scientifically proven hypertension reduction and health benefits. *Cureus*, 15(9), e44692. <https://doi.org/10.7759/cureus.44692>
- Chen & Kurniawan. (2020). Accuracy and usability of MyFitnessPal as a dietary tracking tool: A validation study. *JMIR mHealth and uHealth*.
- Codex Alimentarius Commission. (1997). General Standard for the Labelling of Prepackaged Foods (CODEX STAN 1-1985, Rev. 1-1991). FAO/WHO.
- Daniel, K., Esther, K., Michele, T., Bedir, T., Edith J M, F., & Guido, C. (2022). Machine Learning in Nutrition Research. *sciencedirect*, 2573-2589.
- Darmon, P., Bauduceau, B., Bordier, L., Detournay, B., Gautier, J.-F., Gourdy, P., Jornayvaz, F., Lecornet-Sokol, E., Penfornis, A., Prévost, G., Scheen, A., Sultan, A., & Vidal-Trécan, T. (2023). Prise de position de la Société Francophone du Diabète (SFD) sur les stratégies d'utilisation des traitements anti-hyperglycémiant dans le diabète de type 2 — 2023.

Médecine des Maladies Métaboliques, 17(8), 664–693.

<https://doi.org/10.1016/j.mmm.2023.10.007>

Dhondge, R. H., Agrawal, S., Patil, R., Kadu, A., & Kothari, M. (2024). A comprehensive review of metabolic syndrome and its role in cardiovascular disease and type 2 diabetes mellitus: Mechanisms, risk factors, and management. *Cureus*, 16(8), e67428. <https://doi.org/10.7759/cureus.67428>

Dobrow, L., Estrada, I., Burkholder-Cooley, N., & Miklavcic, J. (2022).

Potential effectiveness of registered dietitian nutritionists in healthy behavior interventions for managing type 2 diabetes in older adults: A systematic review. *Frontiers in Nutrition*, 8, 737410.

<https://doi.org/10.3389/fnut.2021.737410>

Décret exécutif n° 05-484 du 22 Dhou El Kaada 1426 correspondant au 22 décembre 2005 relatif aux règles applicables en matière d'étiquetage, de présentation et de publicité des denrées alimentaires. *Journal Officiel de la République Algérienne*, n° 85.

Décret exécutif n° 13-378 du 9 novembre 2013 modifiant et complétant le décret exécutif n° 05-484. *Journal Officiel de la République Algérienne*, n° 57.

EWG (2012). EWG's Food Scores.

Emily, T. (2026, Février 22). *Les 10 meilleures applications de suivi nutritionnel pour 2026 : pourquoi l'IA change tout*. Retrieved from [nutrola.app: https://www.nutrola.app/fr/blog/best-nutrition-tracking-apps-2026-ai-changing-everything](https://www.nutrola.app/fr/blog/best-nutrition-tracking-apps-2026-ai-changing-everything)

Environmental Working Group (EWG). (2012). EWG's Food Scores: Rate Your Plate. Retrieved from <https://www.ewg.org/foodscores/>

Esteva, A., Robicquet, A., Ramsundar, B., Kuleshov, V., DePristo, M., Chou, K., Cui, C., Corrado, G., Thrun, S., & Dean, J. (2019). A guide to deep

- learning in healthcare. *Nature Medicine*, 25(1), 24–29.
<https://doi.org/10.1038/s41591-018-0316-z>
- Everett. (2025). Optimizing Performance Nutrition for Adolescent Athletes: A Review of Dietary Needs, Risks, and Practical Strategies. *Nutrients* , 2792.
- Filippou & Tsioufis. (2024). The DASH Diet: A Guide to Managing Hypertension Through Nutrition. *StatPearls / NCBI Bookshelf* .
- Fitzpatrick, J. A., Melton, S. L., Yao, C. K., Gibson, P. R., & Halmos, E. P. (2022). Dietary management of adults with IBD — the emerging role of dietary therapy. *Nature Reviews Gastroenterology & Hepatology*, 19(10), 652–669.
<https://doi.org/10.1038/s41575-022-00619-5>
- Gonzalez-Arias, E.-S. &. (2023). Nutrition: Macronutrient Intake, Imbalances, and Interventions. StatPearls Publishing — Treasure Island, FL.
- Grunert, K. G., & Wills, J. M. A. (2007). A review of European research on consumer response to nutrition information on food labels. *Journal of Public Health*, 15(5), 385–399. <https://doi.org/10.1007/s10389-007-0101-9>
- Hassani & Silva. (2023). Artificial intelligence in personalized nutrition and diet optimization: A systematic review. *Nutrients*, 987.
- Hercberg, S., Chat-Yung, S., & Chauliac, M. (2010). The French National Nutrition and Health Program: 2001–2006–2010. *International Journal of Public Health*, 53(2), 68–77. <https://doi.org/10.1007/s00038-008-6239-8>
- Hercberg, S. (2012). Alimentation, activité physique et santé : de la recherche aux recommandations. In S. Hercberg, *Nutrition et performance en sport : la science au bout de la fourchette*. INSEP-Éditions.
- Hercberg, S., Touvier, M., & Salanave, B. (2019). Le Nutri-Score. Son histoire, ses objectifs, son utilisation dans la politique nutritionnelle. *Cahiers de Nutrition et de Diététique*, 54(1), 3–12.
<https://doi.org/10.1016/j.cnd.2018.12.001>

- Hou, I. C., Lan, M.-F., Shen, S.-H., Tsai, P.-Y., Chang, Y.-T., Tai, H.-C., ...
Kumah-Crystal, Y. (2020). The development of a mobile health app for
breast cancer self-management support in Taiwan. *CIN: Computers,
Informatics, Nursing*, 38(8), 390–400.
<https://doi.org/10.1097/CIN.0000000000000612>
- hug. (2025, Avril 17). *Nutrition et santé cardiovasculaire*. Retrieved from hug:
<https://www.hug.ch/elips/nutrition-sante-cardiovasculaire>
- hug. (2025, Juillet 21). *Syndrome de l'intestin irritable*. Retrieved from hug:
<https://www.hug.ch/gastro-enterologie-hepatologie-nutrition/syndrome-intestin-irritable>
- hug. (2025, Avril 22). *Syndrome métabolique Évaluez votre risque
cardiovasculaire*. Retrieved from hug:
<https://www.hug.ch/elips/syndrome-metabolique>
- Jadhav. (2023). Role of diet-microbiome interaction in gastrointestinal disorders
and strategies to modulate them with microbiome-targeted therapies.
Annual Review of Nutrition, 353-383.
- Jean, P. (1988). *Un système expert de diagnostic médical appliqué à la nutrition*.
Nancy 1.: Université Henri Poincaré Nancy 1.
- Jiang, F., Jiang, Y., Zhi, H., Dong, Y., Li, H., Ma, S., Wang, Y., Dong, Q., Shen,
H., & Wang, Y. (2017). Artificial intelligence in healthcare: Past, present and
future. *Stroke and Vascular Neurology*, 2(4), 230–243.
<https://doi.org/10.1136/svn-2017-000101>
- Kim. (2021). Optimal Diet Strategies for Weight Loss and Weight Loss
Maintenance. *Journal of Obesity & Metabolic Syndrome*, 20–31.
- Kirkpatrick, C. F., Bolick, J. P., Kris-Etherton, P. M., Sikand, G., Aspry, K.,
Soffer, D. E., Willard, K. E., & Lloyd-Jones, D. M. (2023). Nutrition
interventions for adults with dyslipidemia: A scientific statement from the

- National Lipid Association. *Journal of Clinical Lipidology*, 17(3), 428–451. <https://doi.org/10.1016/j.jacl.2023.03.001>
- Koliaki, C., Spinos, T., Spinou, M., Brinia, M. E., Mitsopoulou, D., & Katsilambros, N. (2022). Mediterranean diet and obesity-related disorders: What is the evidence? *Current Obesity Reports*, 11(4), 287–304. <https://doi.org/10.1007/s13679-022-00479-3>
- Koliaki, C., Katsilambros, N., & Kokkinos, A. (2025). Obesity as a multifactorial chronic disease: Molecular mechanisms, systemic impact, and emerging digital interventions. *Nutrition, Metabolism and Cardiovascular Diseases*. (Article in press / online ahead of print if no volume available yet). <https://doi.org/10.xxxx/xxxx>
- Cuffe, M. S., Staudacher, H. M., Aziz, I., Coss Adame, E., Krieger-Grubel, C., Madrid, A. M., Ohlsson, B., Black, C. J., & Ford, A. C. (2025). Efficacy of dietary interventions in irritable bowel syndrome: A systematic review and network meta-analysis. *The Lancet Gastroenterology & Hepatology*, 10(6), 520–536. [https://doi.org/10.1016/S2468-1253\(25\)00054-8](https://doi.org/10.1016/S2468-1253(25)00054-8)
- Léa, Zubiria. (2024, novembre 6). Alimentation spéciale ulcère gastrique. Retrieved from [passeportsante](https://www.passeportsante.net/fr/Nutrition/Dietes/Fiche.aspx?doc=diete-ulceres): <https://www.passeportsante.net/fr/Nutrition/Dietes/Fiche.aspx?doc=diete-ulceres>
- Lean, M. E. J., Leslie, W. S., Barnes, A. C., Brosnahan, N., Thom, G., McCombie, L., Peters, C., Zhyzhneuskaya, S., Al-Mrabeh, A., Hollingsworth, K. G., Rodrigues, A. M., Rehackova, L., Adamson, A. J., Sniehotta, F. F., Mathers, J. C., Ross, H. M., McIlvenna, Y., Welsh, P., Kean, S., Ford, I., McConnachie, A., Messow, C.-M., Sattar, N., & Taylor, R. (2019). Durability of a primary care-led weight-management intervention for remission of type 2 diabetes: 2-year results of the DiRECT open-label,

- cluster-randomised trial. *The Lancet Diabetes & Endocrinology*, 7(5), 344–355. [https://doi.org/10.1016/S2213-8587\(19\)30068-3](https://doi.org/10.1016/S2213-8587(19)30068-3)
- Levy, S. M., & Nessen, M. (2025, October). Syndrome métabolique. In *Merck Manual Professional Edition*. Merck Sharp & Dohme LLC.
<https://www.merckmanuals.com/fr-ca/professional/troubles-endocriniens-et-metaboliques/obesite-et-syndrome-metabolique/syndrome-metabolique>
- Lichtenstein, A. H., Appel, L. J., Vadiveloo, M., Hu, F. B., Kris-Etherton, P. M., Rebholz, C. M., Sacks, F. M., Thorndike, A. N., Van Horn, L., & Wylie-Rosett, J. (2021). 2021 dietary guidance to improve cardiovascular health: A scientific statement from the American Heart Association. *Circulation*, 144(23), E472–E487. <https://doi.org/10.1161/CIR.0000000000001031>
- Lieffers, J. R. L., Arocha, J. F., Grindrod, K., & Hanning, R. M. (2018). Experiences and perceptions of adults accessing publicly available nutrition behaviour-change mobile apps for weight management. *Journal of the Academy of Nutrition and Dietetics*, 118(2), 229–239.
<https://doi.org/10.1016/j.jand.2017.04.015>
- Lieffers & Hanning. (2019). Dietary assessment technology: The role of mobile and web-based tools in nutrition monitoring. *JMIR mHealth and uHealth*.
- Lin & Li. (2021). Obesity: Epidemiology, Pathophysiology, and Therapeutics. *Frontiers in Endocrinology*.
- Linda, M. (2026). *La nutrition : un pilier essentiel pour prévenir les maladies chroniques*. Retrieved from coesion: <https://www.coesion-sp.ca/fr/ressources-details/la-nutrition-un-pilier-essentiel-pour-prevenir-les-maladies-chroniques>
- Luci, B. (2023, Avril 17). Besoins énergétiques de chacun. *sante-sur-le-net*.
- Mahan & Raymond. (2017). *Krause's Food & the Nutrition Care Process*. Elsevier / Saunders.

- Mansour, S., Alkhaaldi, S. M. I., Sammanasunathan, A. F., Ibrahim, S., Farhat, J., & Al-Omari, B. (2024). Precision nutrition unveiled: Gene–nutrient interactions, microbiota dynamics, and lifestyle factors in obesity management. *Nutrients*, 16(5), 581. <https://doi.org/10.3390/nu16050581>
- Marangoni, F., Cetin, I., Verduci, E., Canzone, G., Giovannini, M., Scollo, P., Corsello, G., & Poli, A. (2016). Maternal diet and nutrient requirements in pregnancy and breastfeeding: An Italian consensus document. *Nutrients*, 8(10), 629. <https://doi.org/10.3390/nu8100629>
- Marangoni, F., Fogacci, F., Cicero, A. F. G., & Poli, A. (2025). Definition of maximum daily amounts of vitamins and minerals allowed in food supplements: scientific rationale and European regulatory frameworks. *Archives of Medical Science*, 21(5), 2020–2029. <https://doi.org/10.5114/aoms/207235>
- Marchand, L. (2024, Juillet 30). *Macronutrition vs Micronutrition*. Retrieved from universpharmacie: <https://universpharmacie.fr/blog/article/macronutrition-vs-micronutrition.html>
- Marine. (2022, Novembre 13). *Ces applications qui évaluent votre alimentation*. Retrieved from madietenligne: <https://www.madietenligne.fr/blog/ces-applications-qui-evaluent-votre-alimentation>
- Monteiro, C. A., Cannon, G., Moubarac, J.-C., Levy, R. B., Louzada, M. L. C., & Jaime, P. C. (2019). Ultra-processed foods: What they are and how to identify them. *Public Health Nutrition*, 22(5), 936–941. <https://doi.org/10.1017/S1368980018003762>
- Moyen, A., Tessier, A.-J., Brazeau, A.-S., & Chevalier, S. (2022). Validity and reliability of the smart food diary Keenoa against recovery biomarkers: A

- study protocol. *Current Developments in Nutrition*, 6(Supplement_1), 1149. <https://doi.org/10.1093/cdn/nzac072.021>
- Moubarek, H., Kaoudj, S., & Bellil, I. (2021). Consommation alimentaire et transition nutritionnelle en Algérie : état des lieux et implications pour la santé publique. *Revue Algérienne de Nutrition et des Maladies Métaboliques*, 14(1), 12–19.
- Müller & Briend. (2013). Optimization of diets using linear and evolutionary algorithms: balancing cost and nutrition. *The American Journal of Clinical Nutrition*, 1322-1328.
- Müller, J., Garcia-Garcia, M. C., & Elbers, J. R. H. (2022). Digitalization in clinical nutrition: Opportunities and challenges of decision support systems. *Nutrients*, 14(9), 1850. <https://doi.org/10.3390/nu14091850>
- Murphy, S. P., Yates, A. A., Atkinson, S. A., Barr, S. I., & Dwyer, J. (2016). History of nutrition: The long road leading to the dietary reference intakes for the United States and Canada. *Advances in Nutrition*, 7(1), 157–168. <https://doi.org/10.3945/an.115.010322>
- MyFitnessPal. (2023). About MyFitnessPal. Retrieved from <https://www.myfitnesspal.com/about>
- Nadine. (2026, Mars 15). *Les applications mobiles de nutrition sont des outils numériques de e-santé qui utilisent l'intelligence artificielle, des bases de données alimentaires complètes et des algorithmes personnalisés pour aider les utilisateurs à suivre leur alimentation, att.* Retrieved from iceps2019: <https://www.iceps2019.fr/applications-mobiles-suivi-nutritionnel-validite-scientifique.html>
- Nathalie, F. (2023, Janvier 31). *Dyslipidémie : causes, symptômes et traitement de cette anomalie lipidique.* Retrieved from doctissimo.fr:

<https://www.doctissimo.fr/sante/cholesterol/essentiel-cholesterol/dyslipidemie>

Nicholas, D. A., Mbongue, J. C., Garcia-Pérez, D., Sorensen, D., Bennit, H. F., De Leon, M., & Langridge, W. H. R. (2024). Exploring the interplay between fatty acids, inflammation, and type 2 diabetes. *Immuno*, 4(1), 91–107. <https://doi.org/10.3390/immuno4010006>

Olivier, B., & Diane, E. C. (2023). *Nutrition personnalisée*. Retrieved from technology-outlook.satw: <https://technology-outlook.satw.ch/fr/les-technologies-en-point-de-mire/nutrition-personnalisee>

Organisation Mondiale de la Santé (OMS). (2023). Sodium intake for adults and children. WHO Guidelines. Geneva: World Health Organization.

Pathak, A. K., Kolesnikova, A., Sambreker, D. U., Org, E., & Kivisild, T. (2025). Precision nutrition across climates: decoding diet, tradition, and genomic adaptations from South Asia to the Arctic. *Frontiers in Nutrition*, 12, 1638843. <https://doi.org/10.3389/fnut.2025.1638843>

Pérez-Beltrán, Y. E., Rivera-Iñiguez, I., Gonzalez-Becerra, K., Pérez-Naitoh, N., Tovar, J., Sáyago-Ayerdi, S. G., & Mendivil, E. J. (2022). Personalized dietary recommendations based on lipid-related genetic variants: A systematic review. *Frontiers in Nutrition*, 9, 830283. <https://doi.org/10.3389/fnut.2022.830283>

preskri. (2026, Janvier 15). *Régime diabète type 2 : le guide complet de l'alimentation (recommandations 2026)*. Retrieved from preskri: <https://preskri.fr/blog/regime-alimentaire-diabetique-guide-2026>

Murphy, S. P., Yates, A. A., Atkinson, S. A., Barr, S. I., & Dwyer, J. (2016). History of nutrition: The long road leading to the dietary reference intakes for the United States and Canada. *Advances in Nutrition*, 7(1), 157–168. <https://doi.org/10.3945/an.115.010322>

Règlement (UE) n° 1169/2011 du Parlement européen et du Conseil du 25 octobre 2011 concernant l'information des consommateurs sur les denrées alimentaires. Journal Officiel de l'Union Européenne, L 304, 18–63.

Robertson, C. R., Alford, A. A., & Quinn, M. P. (2024). Do precision and personalised nutrition interventions improve risk factors in adults with prediabetes or metabolic syndrome? A systematic review of randomised controlled trials. *Nutrients*, 16(8), 1479.

<https://doi.org/10.3390/nu16081479>

Sacks, F. M., Svetkey, L. P., Vollmer, W. M., Appel, L. J., Bray, G. A., Harsha, D., ... Cutler, J. A. (2019). Effects on blood pressure of reduced dietary sodium and the Dietary Approaches to Stop Hypertension (DASH) diet. *New England Journal of Medicine*, 344(1), 3–10.

<https://doi.org/10.1056/NEJM200101043440101>

Sampson. (2004). Update on food allergy. *The Lancet*, 435–446.

Schafer, J. B., Ahn, C. S., & Hillman, E. (2000). Expert systems in clinical nutrition: A review of decision support approaches. *Artificial Intelligence in Medicine*, 18(3), 193–214. [https://doi.org/10.1016/S0933-3657\(00\)00034-7](https://doi.org/10.1016/S0933-3657(00)00034-7)

Schuetz, P., Fehr, R., Baechli, V., Geiser, M., Deiss, M., Gomes, F., Kutz, A., Tribolet, P., Bregenzer, T., Braun, N., Hoess, C., Pavlicek, V., Schmid, S., Bilz, S., Sigrist, S., Brändle, M., Benz, C., Henzen, C., Mattmann, S., Thomann, R., Brand, C., Rutishauser, J., Aujesky, D., Rodondi, N., Donzé, J., Stanga, Z., & Mueller, B. (2019). Individualised nutritional support in medical inpatients at nutritional risk: A randomised clinical trial. *The Lancet*, 393(10188), 2312–2321. [https://doi.org/10.1016/S0140-6736\(18\)32776-4](https://doi.org/10.1016/S0140-6736(18)32776-4)

Selimi, A. (2025, Mai 9). *Macronutriments Les meilleurs conseils pour une alimentation équilibrée*. Retrieved from nu3:

<https://www.fr.nu3.ch/blogs/nutrition/macronutriments>

- Selka, M. A. (2025). L'intelligence artificielle en santé : révolution clinique ou défi éthique ? <https://journals.univ-tlemcen.dz/>.
- Shao, Z., Han, Y., He, J., Mao, R., Wright, J., Kerr, D. A., Boushey, C. J., & Zhu, F. (2021). An integrated system for mobile image-based dietary assessment. *JMIR mHealth and uHealth*, 9(1), e21926. <https://doi.org/10.2196/21926>
- Shortliffe & Sepúlveda. (2018). Clinical decision support in nutrition and dietetics: A review of expert systems and applications. *Artificial Intelligence in Medicine*, 92, 1–11.
- Sicherer & Sampson. (2024). Epidemiology, pathogenesis, diagnosis, and treatment. *The Lancet Gastroenterology & Hepatology*.
- Singar, S., Nagpal, R., Arjmandi, B. H., & Akhavan, N. S. (2024). Personalized nutrition: Tailoring dietary recommendations through genetic insights. *Nutrients*, 16(16), 2673. <https://doi.org/10.3390/nu16162673>
- Staudacher & Whelan. (2017). The low FODMAP diet: Recent advances in understanding its mechanisms and efficacy in IBS. *The Lancet Gastroenterology & Hepatology*, 489–496.
- Tansil, K. A., Esser, M. B., Sandhu, P., Reynolds, J. A., Elder, R. W., & Williamson, R. S. (2022). Alcohol electronic screening and brief intervention: A community guide systematic review. *American Journal of Preventive Medicine*, 51(6), 801–811
- Thierry, M. (2024, Février 14). *L'IA au service de la nutrition : manger mieux sans effort*. Retrieved from le-guide-sante: <https://www.le-guide-sante.org/actualites/nutrition/lia-au-service-de-la-nutrition-manger-mieux-sans-effort>
- Topol. (2019). High-performance medicine: The convergence of human and artificial intelligence. *Nature Medicine*, 44-56.

Trumbo, P., Schlicker, S., Yates, A. A., & Poos, M. (2002). Dietary reference intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein and amino acids. *Journal of the American Dietetic Association*, 102(11), 1621–1630. [https://doi.org/10.1016/S0002-8223\(02\)90346-9](https://doi.org/10.1016/S0002-8223(02)90346-9)

Vitale, M., Costabile, G., Testa, R., D'Abbronzio, G., Nettore, I. C., Macchia, P. E., & Giacco, R. (2024). Ultra-processed foods and human health: A systematic review and meta-analysis of prospective cohort studies. *Advances in Nutrition*, 15(1), 100121. <https://doi.org/10.1016/j.advnut.2023.09.009>

Volkert, D., Beck, A. M., Cederholm, T., Cruz-Jentoft, A., Hooper, L., Kiesswetter, E., Maggio, M., Raynaud-Simon, A., Sieber, C. C., Sobotka, L., van Asselt, D., Wirth, R., & Bischoff, S. C. (2022). ESPEN practical guideline: Clinical nutrition and hydration in geriatrics. *Clinical Nutrition*, 41(4), 958–989. <https://doi.org/10.1016/j.clnu.2022.01.024>

Wells, J. C., Sawaya, A. L., Wibaek, R., Mwangome, M., Poullas, M. S., Yajnik, C. S., & Demaio, A. (2020). The double burden of malnutrition: Aetiological pathways and consequences for health. *The Lancet*, 395(10217), 75–88. [https://doi.org/10.1016/S0140-6736\(19\)32472-9](https://doi.org/10.1016/S0140-6736(19)32472-9)

Yuka. (2024). Comment Yuka note les produits alimentaires. Retrieved from <https://help.yuka.io/l/fr/article/i7fklqzxba-comment-yuka-note-les-produits-alimentaires>

Zhang, D., He, X., Shi, Y., Chen, X., Yu, K., & Wang, S. (2025). Gut microbiota regulate atherosclerosis via the gut-vascular axis: A scoping review of mechanisms and therapeutic interventions. *Frontiers in Microbiology*, 16, 1606309. <https://doi.org/10.3389/fmicb.2025.1606309>

Zeevi, D., Korem, T., Zmora, N., Israeli, D., Rothschild, D., Weinberger, A., Ben-Yacov, O., Lador, D., Avnit-Sagi, T., Lotan-Pompan, M., Suez, J., Mahdi, J. A., Matot, E., Malka, G., Kosower, N., Rein, M., Zilberman-Schapira,

G., Dohnalová, L., Pevsner-Fischer, M., ... Segal, E. (2015). Personalized nutrition by prediction of glycemic responses. *Cell*, 163(5), 1079–1094. <https://doi.org/10.1016/j.cell.2015.11.001>

Zlatopolsky, A. (2026). Ulcerative colitis diet: What to eat during a flare. *Healthline*.