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Présenté et soutenu publiquement par les étudiants :

1- Bounefour Aman
2- Kaddeche Bouchra
3- Saadaou Hadil
4-

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Certifie par la présente que les étudiants ont pris en considération l'ensemble des remarques, modifications et corrections formulées par les membres du jury lors de la soutenance qui s'est déroulée le 24/06/2026

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Study of the Effect of Ultra-Processed Food on Mineral Balance in a Population of the Wilaya of Skikda

Submitted by : Bounezour Amani
Saadani Hadil
Kaddeche Bouchra

Jury Member

Dr. Boulechfar Safia	**(MCA) President**	**Unv.20 august 1955-Skika**
Dr. Bouabdellah Narimene	**(MCB) Examiner**	**Unv.20 august 1955-Skikda**
Dr. Boushaba Sara	**(MCB) Supervisor**	**Unv.20 august 1955-Skikda**

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ABSTRACT

This exploratory cross-sectional study assesses the impact of ultra-processed food (UPF) consumption on mineral balance and metabolic health, while exploring the protective role of the Mediterranean diet among young adults in Algeria. To accomplish this, an investigation was conducted on 31 apparently healthy volunteers aged 15–35 years in the Wilaya of Skikda. Dietary habits were evaluated using a Food Frequency Questionnaire (FFQ), the NOVA classification, and a Mediterranean diet score, while biochemical analyses quantified serum iron, ferritin, sodium, potassium, chloride, and fasting blood glucose, with all data processed using GraphPad Prism 11. Findings indicated a high penetration of UPFs alongside reduced adherence to the Mediterranean diet template. Furthermore, statistical cross-analysis revealed subtle, sub-clinical alterations in electrolyte dynamics, glycemic control, and iron status, with ferritin functioning as an early inflammatory marker, all closely linked to daily dietary choices. In conclusion, this study highlights the silent, sub-clinical metabolic and nutritional consequences of modern diets before overt clinical symptoms manifest, emphasizing the need for preventive public health strategies in Algeria.

Keywords: Ultra-processed foods, Mineral balance, Mediterranean diet, Metabolic health, Skikda, Algeria.

ملخص

تهدف هذه الدراسة المقطعية الاستكشافية إلى تقييم تأثير استهلاك الأغذية فائقة المعالجة وبحث الدور الوقائي للحمية المتوسطية لدى فئة من الشباب في الجزائر. وشملت الدراسة الميدانية 31 متطوعاً أصحاء ظاهرياً تتراوح أعمارهم بين 15 و35 سنة بوِلاية سكيكدة، حيث تم تقييم سلوكهم الغذائي باستخدام استبيان التكرار الغذائي(FFQ) ، وتصنيفNOVA ، ومؤشر الحمية المتوسطية، بينما تضمن الشق المخبري معايرة حديد المصل، الفيريتين، الصوديوم، البوتاسيوم، الكلوريد، وسكر الدم الصيامي، مع تحليل البيانات عبر برنامج GraphPad Prism 11.وأظهرت النتائج تزايد استهلاك الأغذية فائقة المعالجة مقابل تراجع الالتزام بالحمية المتوسطية، كما كشف التحليل الإحصائي عن تغيرات وتقلبات فسيولوجية طفيفة ودون سريرية في مستويات الأملاح المعدنية، تنظيم السكر، وحالة الحديد (مع اعتبار الفيريتين مؤشراً التهابياً مبكراً)، ترتبط مباشرة بطبيعة الخيارات الغذائية اليومية. وتؤكد الدراسة في ختامها وجود تداعيات أيضية وتغذوية خفية للأنماط الغذائية الحديثة قبل ظهور الأعراض السريرية، مما يستدعي تعزيز استراتيجيات الصحة العامة الوقائية في الجزائر

الكلمات المفتاحية :الأغذية فائقة المعالجة، التوازن المعدني، الحمية المتوسطية، الصحة الأيضية، سكيكدة، الجزائر.

RÉSUMÉ

Cette étude transversale exploratoire évalue l'impact de la consommation d'aliments ultra-transformés (AUT) sur le bilan minéral et la santé métabolique, tout en explorant le rôle protecteur du régime méditerranéen chez de jeunes adultes en Algérie. Une approche quantitative a été menée auprès de 31 volontaires sains âgés de 15 à 35 ans dans la wilaya de Skikda. Les habitudes alimentaires ont été évaluées via un questionnaire de fréquence (FFQ), la classification NOVA et un score de régime méditerranéen, tandis que les analyses biochimiques ont quantifié le fer sérique, la ferritine, le sodium, le potassium, le chlorure et la glycémie à jeun, avec un traitement de données réalisé sur le logiciel GraphPad Prism 11. Les résultats montrent une forte pénétration des AUT et un recul de l'adhésion au modèle méditerranéen traditionnel. Les analyses croisées révèlent de discrètes fluctuations physiologiques sous-cliniques des électrolytes, de la glycémie et du statut martial, la ferritine servant de marqueur inflammatoire précoce, étroitement liées aux choix alimentaires quotidiens. En conclusion, cette étude met en évidence les conséquences nutritionnelles et métaboliques silencieuses des modes alimentaires modernes avant l'apparition de symptômes cliniques, soulignant l'importance des stratégies de santé publique préventives en Algérie.

Mots-clés : Aliments ultra-transformés, Bilan minéral, Régime méditerranéen, Santé métabolique, Skikda, Algérie.

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Bounezour Amani
Kaddeche Bouchra
&
Saadani Hadil

Dedication

This work is lovingly dedicated to my parents, whose endless support, warmth, and prayers have always been my greatest source of strength.

To my dear sisters, Haifa, Hanaa, and Malak, who bring light and joy into my life, and to whom I wish a lifetime of happiness and success.

To my grandparents, Lakhdar and Mahmoud, and my grandmothers, Aljia and Nawara, whose love, wisdom, and care will always remain deeply rooted in my heart.

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To everyone who believes in me, loves me, and sincerely wishes me success and excellence.

And finally, to myself—for all the effort, patience, and resilience that brought me here today.

-Hadil-

Dedication

I dedicate this humble work first to the cherished memory of my beloved grandmother. May Allah grant her the highest ranks in Paradise, and may she be among those who are proud of what I have become.

To my mother, whose joy in my success will surpass that of anyone else. Your love, sacrifices, prayers, and unwavering faith in me have been my greatest source of strength.

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♡

-Amani-

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-Bouchra-

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LIST OF ABBREVIATIONS

Abbreviation	Full Meaning
ANSES	French Agency for Food, Environmental and Occupational Health & Safety
AUT	Aliments Ultra-Transformés (French for Ultra-Processed Foods)
BMI	Body Mass Index
Cl^-	Chloride
CRP	C-Reactive Protein
DNA	Deoxyribonucleic Acid
EFSA	European Food Safety Authority
ELFA	Enzyme-Linked Fluorescent Assay
ET	Écart-Type (French for Standard Deviation)
Fe	Iron
FFQ	Food Frequency Questionnaire
g/L	Grams per Liter
GOD-POD	Glucose Oxidase - Peroxidase (Method for glucose assay)
IL-10	Interleukin-10
IL-1β	Interleukin-1 beta
IL-6	Interleukin-6
IRPs	Iron Regulatory Proteins
ISE	Ion Selective Electrode Method
kg/m^2	Kilograms per Square Meter
K^+	Potassium
MCA	Maître de Conférences Classe A
MCB	Maître de Conférences Classe B
mg/L	Milligrams per Liter
mmol/L	Millimoles per Liter
MUP / MUPs	Markers of Ultra-Processing
Na^+	Sodium

NCDs	Non-Communicable Diseases
ROS	Reactive Oxygen Species
rpm	Revolutions per minute
SD	Standard Deviation
TNF-α	Tumor Necrosis Factor-alpha
UK	United Kingdom
Unv.	University
UPF / UPFs	Ultra-Processed Foods
USA	United States of America
WHO	World Health Organization
µg/L	Micrograms per Liter

Introduction

Introduction

Over the past few decades, global dietary landscapes have experienced an unprecedented transformation collectively known as the nutrition transition (Popkin, 2006). Traditional dietary patterns, which were historically grounded in fresh, whole, or minimally processed raw ingredients, are rapidly being displaced by industrial formulations widely designated as ultra-processed foods (UPFs) (Monteiro et al., 2019). According to international scientific frameworks, UPFs are engineered products comprising primarily chemically modified substances extracted from basic food components, combined with cosmetic additives, emulsifiers, and industrial flavors designed to maximize hyper-palatability, sensory appeal, and commercial shelf-life (Monteiro et al., 2019; Moubarac et al., 2014). This systemic shift has fundamentally altered human nutrient exposure profiles on a global scale. The exponential rise in the consumption of these industrialized food products represents a major, multifaceted threat to contemporary public health. Robust epidemiological evidence systematically links a high dietary share of UPFs to a severe deterioration of overall dietary quality and a stark reduction in essential micronutrient density (Louzada et al., 2015). Chronic exposure to such patterns is established as a critical driver for the global burden of non-communicable diseases (NCDs), including visceral adiposity, metabolic syndrome, type 2 diabetes, dyslipidemia, and accelerated cardiovascular complications (Srour et al., 2019; Chen et al., 2023). The lack of an intact food matrix in these products alters human satiety mechanisms, raising urgent questions about their long-term outcomes (Fardet, 2016).

Beyond macro-structural diseases, an escalating dietary share of UPFs directly compromises the delicate homeostasis of systemic biomarkers and metabolic regulation within the human body. Due to their heavy industrial processing and formulation, these products alter essential electrolyte dynamics and fluid balance, driving subtle, sub-clinical physiological shifts (Giles and Dhaliwal,. 2022). Furthermore, the high glycemic index and glycemic load characteristic of heavily processed industrial carbohydrates trigger rapid blood glucose fluctuations and chronic metabolic stress (Basile et al., 2024). Over time, these silent systemic alterations degrade physiological equilibrium, modifying circulating biochemical markers before any overt clinical pathology manifests (Palmer and Clegg, 2016).

In middle-income nations and the North African territory, rapid demographic changes, accelerated urbanization, and the Westernization of local food environments have aggressively catalyzed this nutrition transition. Although national epidemiological registries mapping the precise penetration and biological effects of UPFs in Algeria remain significantly scarce,

observational evidence highlights a pronounced behavioral shift among Algerian youth toward modern, commercially prepared convenience items. This dietary transition severely threatens their compliance with traditional dietary archetypes, most notably the Mediterranean diet, which has historically served as a sustainable, protective baseline against metabolic and oxidative disorders (Bonaccio et al., 2021). Consequently, evaluating these dietary shifts before clinical symptoms manifest has become an immediate scientific priority.

Within this transitional framework, the traditional Mediterranean diet may operate as a crucial biological shield. Because this dietary pattern is fundamentally rich in fresh vegetables, fruits, whole grains, legumes, and seafood, it provides an abundance of natural antioxidants, dietary fibers, vitamins, and essential trace elements (Davis et al., 2015; Bach-Faig et al., 2011). This high-quality nutrient matrix can act as a physiological buffer, counterbalancing and mitigating the adverse oxidative, lipidemic, and inflammatory insults induced by modern ultra-processed ingestion (González and Calvo, 2016). Specific synergistic interactions within this diet have been shown to protect mineral metabolic homeostasis and lower systemic inflammatory markers (Papatesta et al., 2026; Chrysohoou et al., 2004).

To systematically achieve these objectives, this dissertation is structured into two main parts. The Literature Review comprises two chapters: Chapter I outlines the classification and formulation of ultra-processed foods (UPFs) using NOVA and SIGA principles, while Chapter II details the biological functions and homeostasis of essential minerals (iron, ferritin, sodium, potassium, chloride) and inflammatory markers.
The Study Overview and Results spans three chapters: Chapter III details the cross-sectional methodology and dietary assessments conducted on 31 volunteers in the Wilaya of Skikda. Chapter IV compiles the statistical analysis generated via GraphPad Prism 11 regarding dietary scores and biomarker correlations. Finally, Chapter V contextually discusses these findings against global literature, highlighting the protective role of the Mediterranean diet, followed by a conclusion outlining preventive public health strategies for Algeria.

Literature Review

CHAPTER I

Ultra-Processed Foods: Concept and Classification

I.1 Definition of ultra-processed foods

According to the NOVA food classification system, ultra-processed foods (UPFs) are industrial formulations made mostly or entirely from substances extracted from foods, derived from food constituents, or synthesized in laboratories, with little or no intact whole food remaining. They typically contain additives such as flavorings, colorings, emulsifiers, sweeteners, and preservatives, which are used to enhance palatability, appearance, and shelf life. These products are designed to be convenient, ready-to-consume, and highly pealing to consumers (Monteiro et al, 2019).

I.2 The NOVA classification system

I.2.1 Definition

The NOVA system is a food classification developed by researchers at the University of São Paulo, Brazil, led by Carlos Monteiro. It classifies foods according to the degree and type of industrial processing they undergo, as well as the physical, biological, and chemical processes applied before consumption (Monteiro et al., 2019).

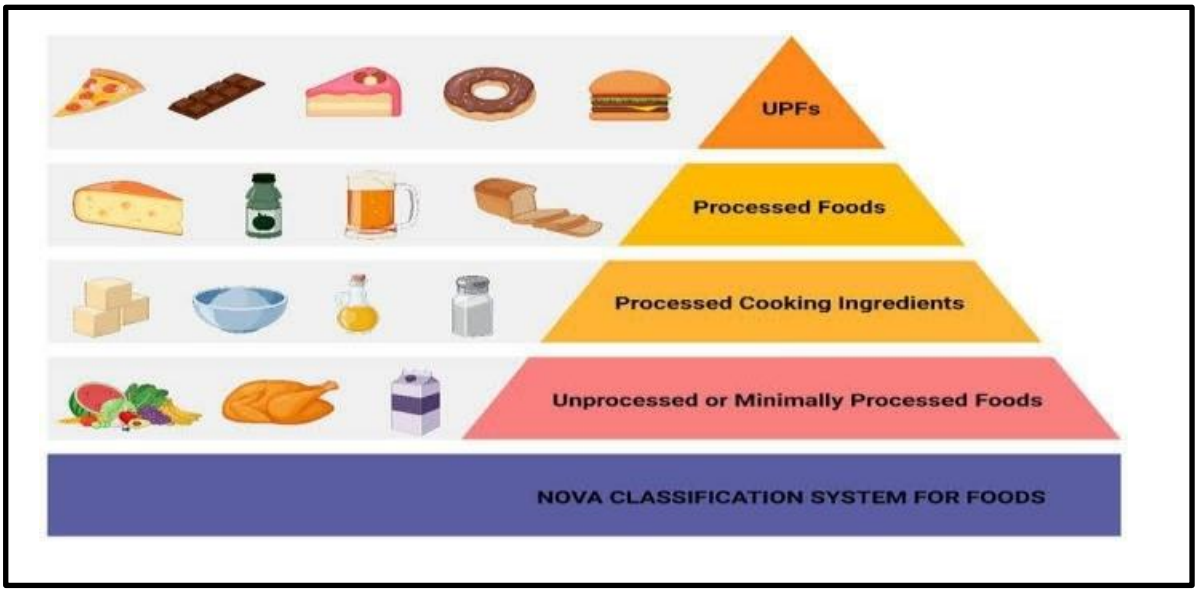


FIGURE I.1: Pyramid illustrating the four NOVA food groups according to the degree of processing (kounatidis., 2025).

I.2.2 NOVA food groups

According to Monteiro et al. (2019), foods are classified in the four groups that are summarized in the following table (**Table I.1**). This system is widely recognized as a relevant tool for research and public health policies (Ares et al., 2016).

Table I.1 Classification of foods according to the NOVA Food groups (Monteiro et al., 2019).

Groups	Description	Examples
1. Unprocessed or Minimally Processed Foods	Natural foods of plant or animal origin subjected only to simple processes without substantial alteration of their nutritional properties.	Fruits, vegetables, milk, eggs, fresh meat, fish.
2. Processed Culinary Ingredients	Substances extracted from Group 1 foods or from nature and used in food preparation and cooking.	Vegetable oils, butter, sugar, salt, starch.
3. Processed Foods	Products made by adding salt, sugar, oil, or other culinary ingredients to Group 1 foods to increase durability or improve taste.	Canned vegetables, cheese, freshly baked bread, salted nuts, canned fish.
4. Ultra-Processed Foods (UPFs)	Industrial formulations made mostly or entirely from substances derived from foods and additives, with little or no whole foods.	Soft drinks, packaged snacks, instant noodles, breakfast cereals, reconstituted meat products, cookies.

I.3 The SIGA classification system

I.3.1 Definition of SIGA

The SIGA classification is a scientific system for assessing the degree of food processing, proposed in the scientific literature in 2020 as an extension of the NOVA classification. It is based on a multidimensional approach to food quality evaluation, considering not only the level of industrial processing but also its impact on the food matrix, the content of added ingredients

such as sugars, fats, and salt, as well as the number and nature of markers of ultra-processing and the levels of certain additives associated with potential health risks (Davidou et al., 2020).

Based on these criteria, the system categorizes food products into several groups, enabling a more comprehensive assessment of their quality and supporting efforts toward product reformulation (Flora, 2019)

I.3.2 Classification according to SIGA

SIGA is a more complex classification system compared to NOVA. It is based on 3 core criteria and distinguishing 9 classes of products.Generally, SIGA considers a food as ultra-processed if it contains at least one purified and/or denatured ingredient. Those can be cosmetic additives like colouring or texture enhancers, or additives for preservation, like antioxidants or preservatives that have been assessed as posing a risk to human health.The three criteria to classify foods are: the degree of processing, assessed through markers of ultra-processing (MUP1 and MUP2); health risk assessment, based on evaluations from WHO, EFSA, and ANSES; and nutritional thresholds, derived from UK Food Standards Agency recommendations, which distinguish between nutritionally balanced products and those high in sugar, fat, and/or salt.(Frank et al., 2018)

Based on the three criteria, the siga classification distinguishes between 9 groups (Figure II.1).

Group A are the un-/or minimally processed foods

- Group AO foods have an intact initial matrix like raw fruit, vegetables, eggs, raw fish and meats or milk.

- Group A1 contains products with a degraded raw matrix like fresh juices or stake, but also culinary ingredients used at home like salt, oils and sugar. They can be cooked, grinded, fermented or refined.

Group B consists of processed foods like cheese, bread, canned fish or canned vegetables.

Processing can be done by e.g. salting, smoking, sugaring or fermenting.

- Group B1 foods have added sugar, salt and fat proportions within the recommendations.

- Group B2 foods contain at least one of these nutrients is above the threshold.

Group C consist of UPFs and is split in 5 subgroups in total.

- Group CO contains UPFs with one single MUP1 and based on their salt/fat and sugar content are split into

•CO1 (below threshold).

•CO2 (above threshold).

- Group C1 foods contain several MUP1.

- Group C2 hold UPFs that contain one MUP2 or multiple MUP1.

- Group C3 contains UPFs with multiple MUP1 and/or MUP2 and a sugar/salt or fat content above the threshold.(Frank et al., 2018).

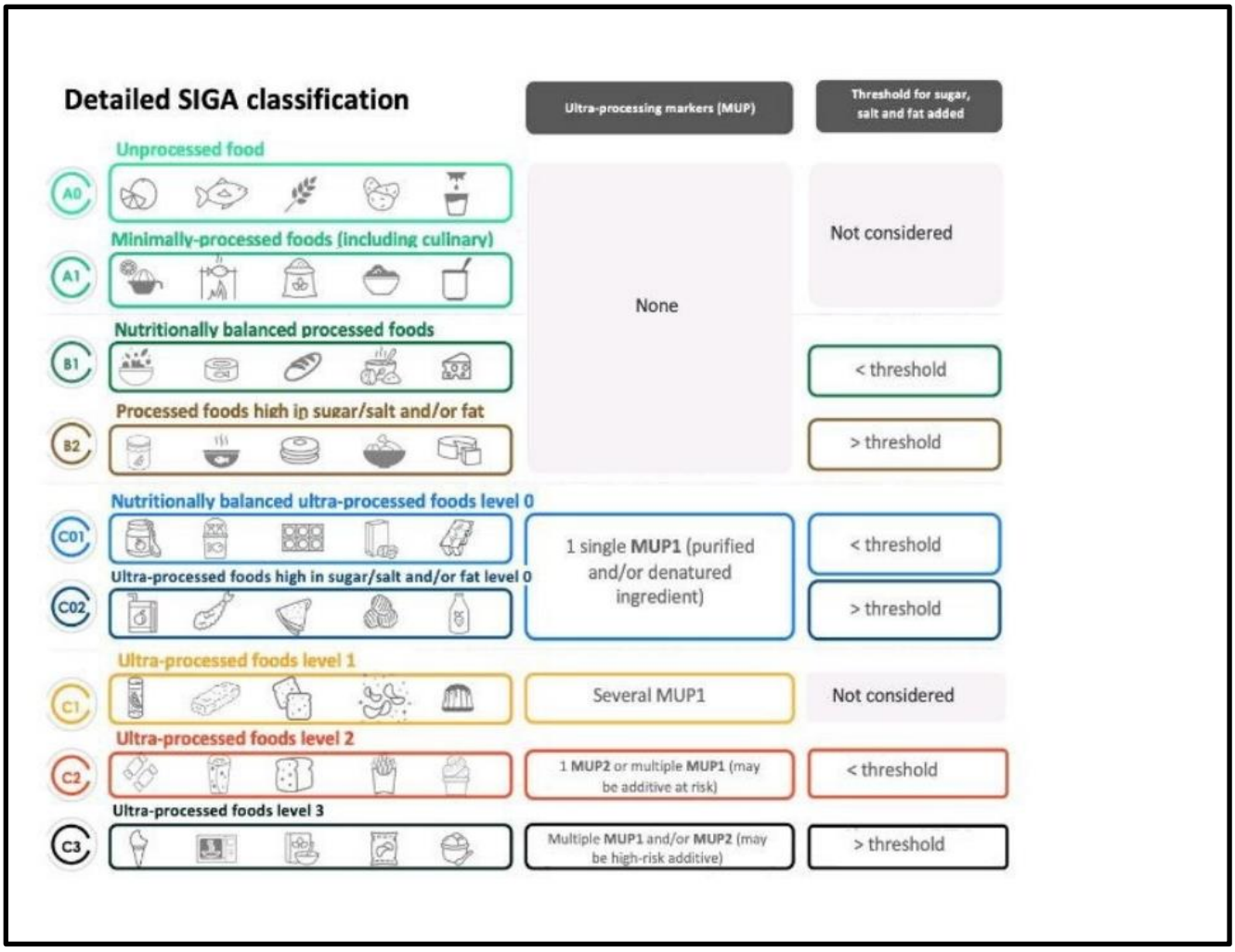


FIGURE I.2: Overview of the SIGA Classification According to the Degree of Food Processing (Frank et al., 2018).

CHAPTER II
Minerals and Inflammatory Biomarkers

II.1 Definition and classification of minerals

II.1.1 Minerals

The term "mineral" is opposed in chemistry to the term "organic," which refers to all substances related to carbon (Reymond, 1993). In the human body, two classes of minerals can be distinguished: trace elements and macrominerals (Burdin, 2014).

II.1.2 Macrominerals

These are the major mineral salts, present in gram quantities (Burdin,2014), or macrominerals, which are found in amounts greater than 0.01% of the human body (Reymond, 1993): Sodium (Na), Potassium (K), Chlorine (Cl), Calcium (Ca), Phosphorus (P), and Magnesium (Mg) (Burdin, 2014).

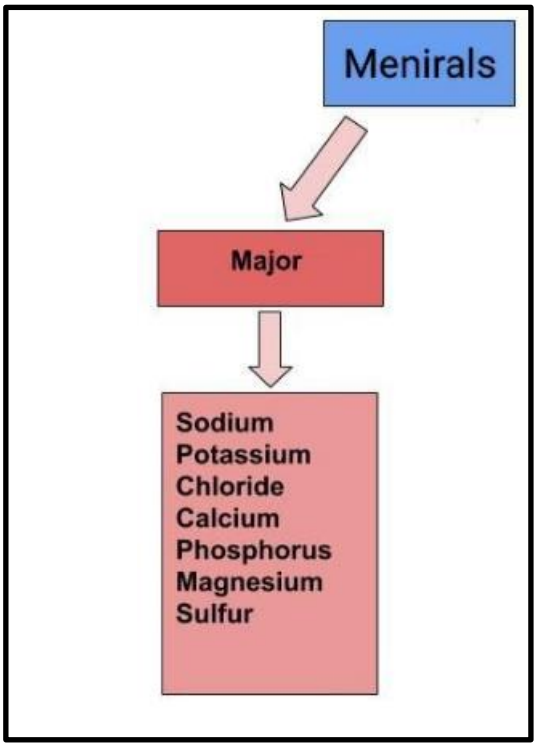


FIGURE II.1 :Types of minerals in human nutrition: major minerals (Giles and Dhaliwal ,2022).

II.1.3 Trace elements

The term "trace element" comes from the Greek word “oligos,” meaning “small” or “scarcely abundant.” Indeed, trace elements are inorganic elements present in the body in very small amounts, less than 1 mg/kg of body weight (Sperte, 2016). They act as enzyme cofactors that

are essential in combating free radicals. Among these trace elements, copper, selenium, and manganese have well-defined roles (Odile and Paster, 2005).

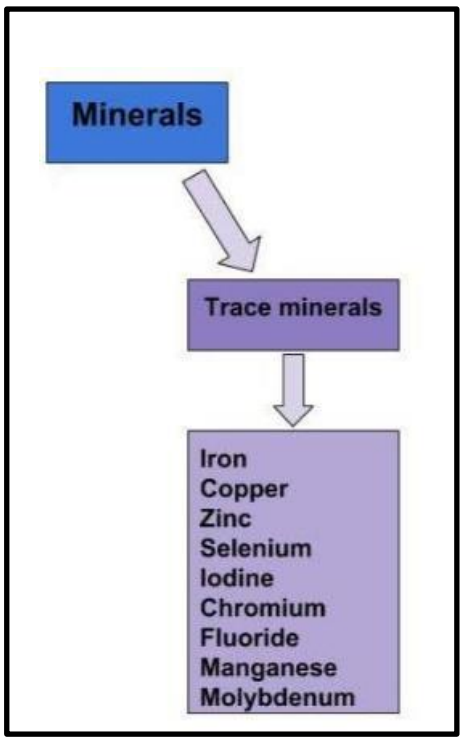


FIGURE II.2: Types of minerals in human nutrition: trace minerals (Giles and Dhaliwal, 2022).

II.2 Minerals

II.2.1 Iron (FER)

Iron (Fe) is a transition metal with atomic number 26, located in group 8 and period 4 of the periodic table. It has an atomic mass of 55.845 g/mol and commonly exists in the oxidation states Fe^{2+} and Fe^{3+}, which are important for many biological and chemical processes (Brady et al., 2017).

II.2.1.1 Biological role

Iron is an essential mineral involved in several vital biological processes. It plays a crucial role in oxygen transport as a component of hemoglobin and myoglobin, as well as in DNA synthesis and electron transport through various enzymes such as cytochromes and catalase (Rodgers and Gilreath., 2019; Gómez-Ramírez et al., 2019).

Iron is also stored in the body mainly in the form of ferritin and hemosiderin, which help regulate iron levels and prevent toxicity (Gafter-Gvili et al., 2019).

II.2.1.2 Absorption and metabolism

Iron absorption occurs mainly in the duodenum and proximal jejunum. Dietary iron exists in two forms: heme iron, which is easily absorbed, and non-heme iron, which is less efficiently absorbed (De Loughery., 2019).

For absorption, ferric iron (Fe^{3+}) must be reduced to ferrous iron (Fe^{2+}), then transported into enterocytes where it is either stored as ferritin or exported into circulation via ferroportin and bound to transferrin (Shokrgozar and Golafshan., 2019).

Iron metabolism is tightly regulated by hepcidin, which controls iron release into the bloodstream by inhibiting ferroportin activity (Demosthenous et al., 2019).

Dietary factors also influence absorption: vitamin C enhances iron absorption, whereas phytates, polyphenols, and calcium reduce its bioavailability (Chuncharunee et al., 2019).

II.2.2 Ferritin

Ferritin is an intracellular protein responsible for iron storage and plays a crucial role in maintaining iron homeostasis in the body. It is composed of 24 subunits forming a nanocage structure capable of storing up to 4500 iron atoms. This protein sequesters excess iron in a non-toxic form and releases it when the body requires it, thereby preventing both iron deficiency and iron-induced oxidative damage, Ferritin is synthesized by nearly all nucleated cells, with the highest production occurring in hepatocytes, macrophages, and bone marrow cells, reflecting its central role in iron storage and metabolism. Additionally, ferritin serves as an important biomarker of iron status and is also involved in inflammatory, immunological, and pathological processes (Kotla et al., 2022).

Ferritin also contributes to cellular protection by limiting the formation of reactive oxygen species (ROS) through iron sequestration. Its synthesis is tightly regulated according to cellular iron levels via iron regulatory proteins (IRPs), ensuring balance between iron storage and utilization. Moreover, ferritin levels increase during inflammation, acting as an acute-phase protein and reflecting immune system activity (Kotla et al., 2022)

II.2.3 Sodium (Na^+)

Sodium (Na) is an alkali metal with atomic number 11, located in group 1 and period 3 of the periodic table. In biological systems, sodium exists predominantly as the Na^+ ion and is the

principal extracellular cation involved in maintaining osmotic balance, fluid homeostasis, nerve impulse transmission, and muscle contraction. (Mahan and Raymond, 2020)

II.2.3.1 Biological role

Sodium (Na^+) is a major extracellular electrolyte that plays a fundamental role in maintaining physiological homeostasis, including nerve impulse transmission, muscle contraction, and metabolic regulation. It also contributes significantly to the regulation of extracellular fluid volume by controlling water distribution in the body compartments (Minegishi et al., 2020).

Sodium is essential for maintaining osmotic balance. It helps regulate blood pressure and ensures proper hydration by controlling the movement of water between intracellular and extracellular compartments (Giles and Dhaliwal, 2022).

II.2.3.2 Regulation of fluid balance

Sodium is absorbed mainly in the small intestine and distributed in the extracellular fluid. The kidneys play a central role in sodium homeostasis by regulating its excretion according to the body's needs. When sodium intake increases, renal excretion also increases to maintain balance, and this process is closely linked to water regulation (Minegishi et al., 2020).

Renal regulation of sodium is also controlled by hormonal systems such as the renin–angiotensin–aldosterone system, which helps maintain blood pressure and fluid balance. In addition, sodium balance depends on dietary intake and adaptive physiological mechanisms that ensure homeostasis (Giles and Dhaliwal., 2022).

II.2.4 Potassium(K^+)

Potassium (K) is an alkali metal with atomic number 19, located in group 1 and period 4 of the periodic table. In the body, it exists mainly as the K^+ ion and is the principal intracellular cation involved in nerve transmission, muscle contraction, and fluid balance. (Gropper and Smith, 2021)

II.2.4.1 Biological role

Potassium (K^+) is the principal intracellular cation in the human body and is essential for maintaining normal cellular function. It plays a critical role in nerve impulse transmission, muscle contraction, cardiac electrical activity, and the maintenance of membrane potential. Potassium also contributes to acid–base balance, protein synthesis, and cellular metabolism.

Adequate potassium intake is associated with normal cardiovascular function and blood pressure regulation (Palmer and Clegg, 2016).

II.2.4.2 Absorption and metabolism

Potassium is efficiently absorbed in the small intestine, with most dietary potassium entering the bloodstream through passive diffusion. Approximately 98% of total body potassium is located within cells, mainly in skeletal muscle. Potassium homeostasis is regulated primarily by the kidneys, which adjust urinary potassium excretion according to dietary intake and physiological needs. Hormones such as aldosterone, insulin, and catecholamines play important roles in potassium distribution and regulation, ensuring stable extracellular potassium concentrations necessary for normal physiological function (Weiner and Wingo, 1997).

II.2.5 Chloride (Clor)

Chloride (Cl^-) is the major extracellular anion derived from chlorine, an element with atomic number 17 located in group 17 and period 3 of the periodic table. It contributes to fluid balance, acid-base regulation, and gastric acid formation. (Gropper and Smith, 2021)

II.2.5.1 Biological role

Chloride (Cl^-) is one of the main essential electrolytes in the human body. It plays a key role in maintaining acid–base balance and osmotic equilibrium. Chloride contributes to the regulation of fluid distribution between intracellular and extracellular compartments. It is also a major component of gastric hydrochloric acid (HCl), which is essential for digestion and protein breakdown. In addition, chloride works together with sodium and potassium to maintain normal osmotic pressure and proper cellular function (Guyton and Hall, 2021)

II.2.5.2 Absorption and metabolism

Chloride is mainly absorbed in the small intestine, particularly in the jejunum. Its absorption occurs mainly through passive transport mechanisms driven by electrochemical gradients, often coupled with sodium absorption. In some intestinal regions, active transport mechanisms may also contribute (Russo et al., 2003).

II.3 Inflamatory marker c-raective protein (CRP)

C-reactive protein (CRP) is an acute-phase protein composed of five identical subunits, primarily synthesized by hepatocytes and released into the bloodstream during inflammatory

processes (Lydyard et al., 2002; Weil and Batteux., 2003). It is considered a major biological marker of acute inflammation.

Its production is mainly induced by interleukin-6 (IL-6), which is secreted by macrophages and activated lymphocytes, and to a lesser extent by other pro-inflammatory cytokines such as IL-1β (Black et al., 2004).

II.3.1 Biological role

CRP plays a key role in the inflammatory response. It binds to damaged, necrotic cells as well as pathogens, facilitating their recognition and elimination (Black et al, 2004; Pepys and Hirschfield, 2003)It enhances phagocytosis by neutrophils and macrophages and activates the complement system, thereby contributing to the amplification of the inflammatory response (Black et al., 2004; Pepys and Hirschfield., 2003)

Furthermore, CRP stimulates the activation of neutrophils and monocytes and promotes the secretion of pro-inflammatory cytokines such as IL-6 and TNF-α, highlighting its pro-inflammatory role (Black et al., 2004). However, CRP also exerts anti-inflammatory effects by inducing the production of anti-inflammatory cytokines such as IL-10 and IL-1 (Pepys and Hirschfield 2003).

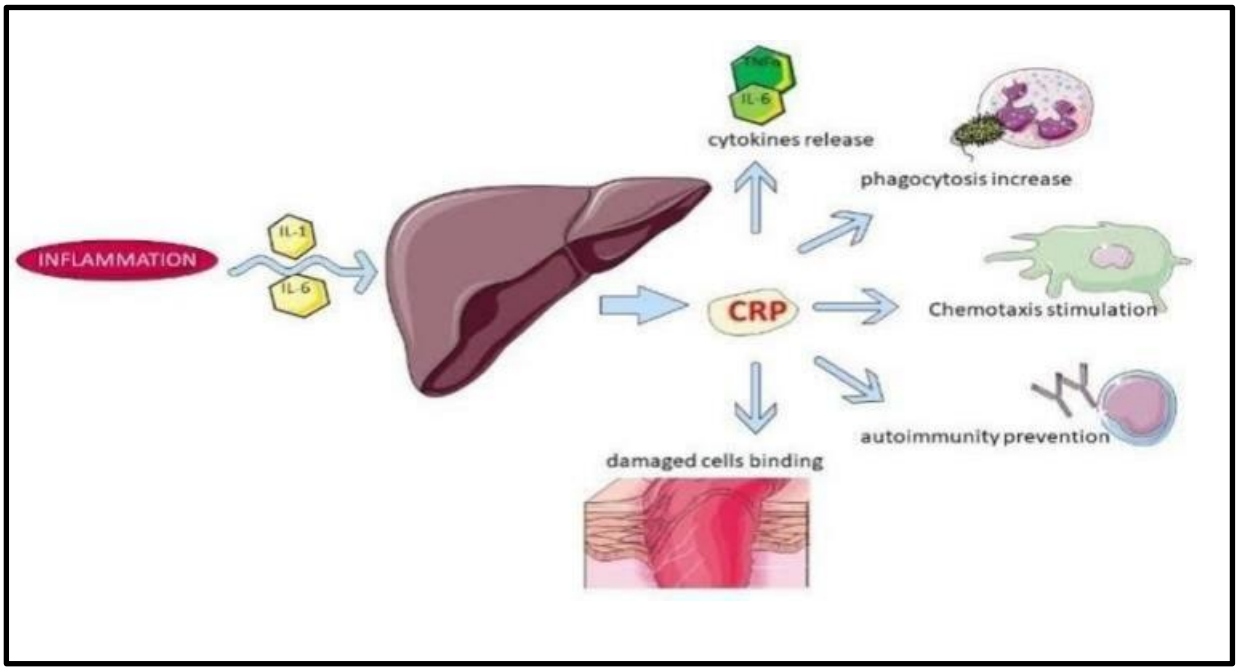


FIGURE II.3: Mechanisms of action of C-reactive protein (CRP) during inflammation (Anonymous, 2022).

II.4 Relationship between crp , ferritin and inflammation

During inflammation, cytokines such as interleukin-6 (IL-6) stimulate the liver to produce CRP and increase the synthesis of hepcidin, a key regulator of iron metabolism. Hepcidin inhibits iron export from enterocytes and macrophages by degrading ferroportin, resulting in reduced intestinal iron absorption and decreased iron release into circulation. Consequently, iron becomes sequestered in storage sites, leading to increased ferritin concentrations and reduced serum iron levels. Therefore, elevated CRP is often associated with alterations in iron metabolism and may contribute to the development of functional iron deficiency during inflammatory conditions. Thus, the association between CRP, ferritin, and inflammation provides valuable insight into the distinction between iron deficiency and inflammation-related changes in iron metabolism (Wang et al., 2025).

Study Overview and Results

CHAPTER III

Materials and Methods

III.1 Study population

This descriptive cross-sectional study was conducted on 31 volunteers aged between 16 and 32 years, including both males and females. Participants were recruited at the Medical Analysis Laboratory Dr Boumerzoug Lamia, Skikda, Algeria.

Inclusion criteria

Participants were included if they:

-Were aged between 16 and 32 years.

-Were residents of the Wilaya of Skikda.

-Agreed to participate voluntarily in the study and provided informed consent.

Exclusion criteria

Participants were excluded if they:

-Suffered from any disease affecting mineral metabolism or inflammatory status.

-Were receiving medical treatment that could influence the studied biochemical parameters.

-Followed a special therapeutic diet.

-Had undergone recent surgery or suffered from acute illness at the time of sampling.

All participants completed a food frequency questionnaire (FFQ) designed to collect demographic and lifestyle information, including age, sex, smoking habits (tabagisme), physical activity (sports practice), and dietary habits. The questionnaire also assessed the frequency of ultra-processed food consumption.

Anthropometric measurements including body weight and height were collected, and Body Mass Index (BMI) was calculated according to the following formula:

$$BMI = \frac{Weight\ (Kg)}{Height\ (m)^2}$$

The classification of BMI categories was performed according to the World Health Organization (WHO) criteria (WHO., 2000).

WHO 2000. Obesity: preventing and managing the global epidemic. Report of a WHO consultation. World Health Organization technical report series.

Table III.1: BMI categories.

Category	**BMI (kg/m²)**
Underweight	<18.5
Normal weight	18.5–24.9
Overweight	25.0–29.9
Obesity	≥30.0

III.2 Blood sampling

Venous blood samples were collected from fasting volunteers (11 fasting hours) under suitable hygienic conditions.

Blood samples were centrifuged using a Biobase BK-1032 centrifuge at 4000 rpm for 4 minutes in order to obtain serum for biochemical analyses.the serum samples were analyzed using automated analyzers available at the laboratory. The evaluated biochemical parameters included serum iron (Fe), ferritin, blood glucose (glycemia), electrolytes such as sodium (Na^+), potassium (K^+), chloride (Cl^-), and C-reactive protein (CRP).

The analyses were performed according to the manufacturers' instructions using appropriate reagents and standard laboratory protocols.

III.3 Biochemical assay

Reagents and equipment used in biochemical analysis are summarized in table III.2

Table III.2: Analytical equipment and reagents used.

PARAMETER	AUTOMATE USED	Reagent_
Serum iron (Fe)	Mindray BS-200	Biolabo Iron Reagent Kit
Ferritin	Mindray CL-900i	VIDAS Ferritin Kit
CRP	Mindray CL-900i	BioSystems Turbidimetric CRP Kit
glycemia	Mindray BS-200	Kit Enzymatic Glucose
Sodium, potassium, chloride	Diamond ProLyte	Ion Selective Electrode Method (ISE)

			
A . Biobase BK-1032 Centrifuge	B : Mindray BS-200	C : Mindray CL-900i	D :Diamonde ProLyte

FIGURE III.1: Laboratory equipment used in the present study.

a. Iron measurement

Iron bound to transferrin is released in an acidic medium and reduced from ferric iron (Fe^{3+}) to ferrous iron (Fe^{2+}). Ferrous ions react with a chromogenic reagent to form a colored complex, the intensity of which is directly proportional to the iron concentration in the sample. (Cook et al., 1974)

Reactions:

$Fe^{3+} \rightarrow Fe^{2+}$

Fe^{2+} + Chromogen → Colored complex

b. Ferritin measurement

Serum ferritin measurement based on the Enzyme-Linked Fluorescent Assay (ELFA) principle. Ferritin present in the sample binds specifically to anti-ferritin antibodies, forming immune complexes. The fluorescent signal generated is proportional to the ferritin concentration in the sample. (Worwood, 1997)

c. C-reactive protein (CRP) measurement

The method is based on the agglutination reaction between CRP present in the sample and latex particles coated with specific anti-CRP antibodies. The resulting turbidity is directly proportional to the CRP concentration and is measured photometrically. (Pepys et Hirschfield, 2003)

Reaction:

CRP + Anti-CRP coated latex particles → Immune complexes (agglutination)

d. Glucose measurement

Serum glucose concentration was determined using an enzymatic glucose kit based on the GOD-POD method Glucose is oxidized by glucose oxidase to gluconic acid and hydrogen peroxide. In the presence of peroxidase, hydrogen peroxide reacts with chromogenic compounds to produce a colored complex whose absorbance is proportional to glucose concentration. (Trinder, 1969)

Reactions:

$$\text{Glucose} + O_2 + H_2O \rightarrow \text{Gluconic acid} + H_2O_2$$

$$H_2O_2 + \text{4-aminoantipyrine} + \text{Phenol} \rightarrow \text{Quinoneimine dye} + H_2O$$

e. Electrolyte measurement (Na^+, K^+ and Cl^-)

Each ion is detected by a selective membrane generating an electrical potential proportional to its concentration in the sample. (Bakker, 1991)

III.4 Dietary assessment

Participants completed a semi quantitative Food Frequency Questionnaire (FFQ) designed to assess the consumption of foods during the last six months. The questionnaire included 119 food items classified into 26 food categories, comprising both minimally processed foods and ultra-processed foods (UPFs). The FFQ was specifically developed to evaluate the intake of ultra-processed foods and investigate their potential impact on the individual's mineral status. Participants reported their usual frequency of consumption for each food item over the previous six months.

Table III.2: Normal food categories

Categories (normal foods)	Examples
Vegetables	Spinach ,Beetroot ,Broccoli, Sweet potato Potato and Sweet pepper
Fruits	Orange ,Banana ,Kiwi
Peanuts and nuts	Almonds, Walnuts, Cashews and Pistachios
Grains	Sesame, Seeds
Cereals	Couscous, Barley Cake ,Semolina,Baghrir,Brown Rice,White Rice
Meat	Beef Lamb, Chicken
Organ meats	Beef Liver, Lamb Liver and Chicken Liver
Fish	Sardines , Tuna
Legumes	Lentils ,Chickpeas, Beans
Dairy products	Whole, Milk ,Powdered Milk
Eggs	
Homemade pastries	Homemade Biscuits ,Homemade Desserts ,Homemade Jam
Honey	
Dark chocolate	
Stimulant drinks	Coffee, Tea
Mineral water	Bottled mineral water

Table III.3 Categories (AUTs) food

Categories (AUTs)	Examples
Ultra-processed cereals	Industrial Bread, Processed Pizza ,Dough and Pizza Sauce ,Breakfast Cereals
Sauces	Mayonnaise, Ketchup ,Seasoning Mixes (or Seasoning Preparations)
Salty snacks	Canned Meat ,Jumbo Meat Products ,Canned Tuna
Sweet products	Industrial Cake, Hard Candy ,Gum ,Flan Powder and Flavored Yogurt
Processed cheese	Kiri ,Camembert
Margarine	Regular margarine, flavored margarine

Ready meals	Instant noodles, canned meals
Fast food	Hamburger, pizza, fried chicken
Sugar	White sugar

The obtained scores were used to estimate habitual food consumption patterns, with particular emphasis on ultra-processed food intake and its association with mineral balance.

Table III.4: Frequency scoring system used in the FFQ

Consumption Frequency	Score	Consumption Frequrency	Score
Never during the last 6 months	0	Twice per week	6
Once in 6 months	1	3-6 times per week	7
2-5 Times in 6 months	2	Once per day	8
Once per month	3	Twice per day	9
3 times per months	4	3 or more times per day	10
Once per week	5		

III.5 Statistical analysis

Statistical analysis was performed using GraphPad Prism version 11.0 (GraphPad Software, San Diego, CA, USA). Initially, all collected data were entered, organized, and tabulated using Microsoft Excel. The prepared database was then imported into GraphPad Prism for statistical analysis. Comparisons between the two study groups (0–5 and 6–10) were carried out to evaluate differences in the studied parameters and to assess the impact of adherence to the Mediterranean diet. Results are presented as mean ± standard deviation (SD). Comparisons between groups were performed using the unpaired t-test with Welch's correction. Statistical significance was concluded when $P < 0.05$ expressed in symbol (*) and when $P < 0.01$ expressed in symbol (**) or $P < 0.001$ expressed in symbol (***).

CHAPTER IV

RESULTS

IV.1. General description of study population

Table 2 summarizes the general characteristics of the study population. A total of 31 participants were included in this study. The mean age of the participants was 23.23 ± 3.83 years. The mean body mass index (BMI) was 24.95 ± 3.23 kg/m². Regarding smoking habits, most participants were non-smokers (90.3%), whereas smokers represented only 9.7% of the study population. Concerning physical activity, 58.1% of the participants reported regular sport practice, while 41.9% did not practice any sport activity. The detailed characteristics of the study population are presented in Table IV.1.

Table IV.1: General characteristics of the study population (n = 31)

Parameter	Mean ± SD / n /(%)
Age (years)	23.23 ± 3.83
BMI (kg/m²)	24.95 ± 3.23
Sport practice	18 (58.1%)
No sport practice	13 (41.9%)
Smokers	3 (9.7%)
Non-smokers	28 (90.3%)

IV.2. Impact of intake on biochemical parameters

IV.2.1. NOVA 1,2,3

The tables bellow shows the results of comparaison of biochemichal parameters according to food intake scores.

Table IV.2 : PEANUTS CATEGORY

PEANUTS			
PARAMETER	(0_5)	(6_10)	*P*
	MEAN ± SD	**MEAN ± SD**	
Iron (ug/L)	60.24±32.61	63.99±24.69	0.5281
Ferritine (ug/L)	36.29±34.75	31.22±16.52	0.6825
NA(mmol/L)	137.02±2.52	126.53±3.00	0.8461
K (mmol/L)	4.27±0.36	4.05±0.38	0.5272
Cl (mmol/L)	104.75±1.71	96.42±1.62	0.4895
GLYCEMIA g/L	0.86±0.08	0.70±0.06	0.5863
CRP (mg/l)	13.23±14.88	10.08±8.05	0.4768

In the PEANUTS category, no significant differences or variance heterogeneity were observed between the two groups (0–5 vs. 6–10) for Iron, Ferritin, Sodium, Potassium, Chloride, Glycemia, or CRP (all $P > 0.05$).

Table IV.3 : FISH CATEGORY

FISH			
PARAMETER	(0_5) **MEAN ± SD**	(6_10) **MEAN ± SD**	*P*
Iron (ug/L)	61.77±30.31	56.91±7.58	0.7937
Ferritine (ug/L)	35.26±31.22	35.02±13.96	0.9898
NA(mmol/L)	136.70±2.24	139.92±5.32	0.052
K (mmol/L)	4.30±0.37	4.39±0.41	0.6839
Cl (mmol/L)	104.50±1.71	105.84±1.05	0.2007
GLYCEMIA g/L	0.86±0.07	0.86±0.01	0.9638
CRP (mg/l)	13.24±13.46	6.30±1.86	0.3897

In the FISH category, no significant differences or variance heterogeneity were observed between the two groups (0–5 vs. 6–10) for Iron, Ferritin, Sodium, Potassium, Chloride, Glycemia, or CRP (all $P > 0.05$).

Table IV.4 :OFFAL CATEGORY

OFFAL			
PARAMETER	(0_5) **MEAN ± SD**	(6_10) **MEAN ± SD**	*P*
Iron (ug/L)	60.52±30.38	65.41±33.41	0.7703
Ferritine (ug/L)	35.29±31.47	38.01±24.47	0.8716
NA(mmol/L)	137.14±2.99	136.66±0.93	0.7586
K (mmol/L)	4.31±0.38	4.34±0.39	0.9079
Cl (mmol/L)	104.36±1.77	104.56±1.65	0.9464
GLYCEMIA g/L	0.86±0.07	0.88±0.05	0.4593
CRP (mg/l)	13.69±13.71	7.20±7.19	0.3704

In the OFFAL category, no significant differences or variance heterogeneity were observed between the two groups (0–5 vs. 6–10) for Iron, Ferritin, Sodium, Potassium, Chloride, Glycemia, or CRP (all $P > 0.05$).

Table IV.5 : MEAT CATEGORY

MEAT			
PARAMETER	(0_5) **MEAN ± SD**	(6_10) **MEAN ± SD**	*P*
Iron (ug/L)	60.41±25.22	59.93±30.61	0.4253
Ferritine (ug/L)	32.35±13.06	35.19±31.20	0.765
NA(mmol/L)	91.37±1.41	137.13±2.87	0.7091
K (mmol/L)	3.19±0.64	0.36±4.31	0.5597
Cl (mmol/L)	68.60±0.33	104.77±1.70	0.1106
GLYCEMIA g/L	0.60±0.02	0.86±0.07	0.4853
CRP (mg/l)	17.98±17.12	12.33±13.05	0.5363

In the MEAT category, no significant differences or variance heterogeneity were observed between the two groups (0–5 vs. 6–10) for Iron, Ferritin, Sodium, Potassium, Chloride, Glycemia, or CRP (all $P > 0.05$).

Table IV.6: HOME BAKERY PRODUCTS CATEGORY

Home bakery products			
PARAMETER	(0_5) **MEAN ± SD**	(6_10) **MEAN ± SD**	*P*
Iron (ug/L)	65.34±29.75	62.38±30.10	0.8298
Ferritine (ug/L)	33.03±19.28	35.22±30.93	0.8699
NA(mmol/L)	136.93±1.80	136.95±2.86	0.9834
K (mmol/L)	4.42±0.23	4.28±0.39	0.4055
Cl (mmol/L)	104.14±1.37	104.69±1.73	0.4853
GLYCEMIA g/L	0.85±0.07	0.86±0.07	0.9032
CRP (mg/l)	15.45±17.53	11.26±11.45	0.4743

In the Home bakery products category, no significant differences or variance heterogeneity were observed between the two groups (0–5 vs. 6–10) for Iron, Ferritin, Sodium, Potassium, Chloride, Glycemia, or CRP (all $P > 0.05$).

Table IV.7 :MINERAL WATER CATEGORY

MINERAL WATER			
PARAMETER	(0_5) **MEAN ± SD**	(6_10) **MEAN ± SD**	*P*
Iron (ug/L)	67.39±40.24	62.65±29.61	0.8309
Ferritine (ug/L)	28.40±6.18	35.24±29.71	0.751
NA(mmol/L)	135.60±0.35	137.04±2.71	0.4682
K (mmol/L)	4.18±0.22	4.32±0.37	0.6095
Cl (mmol/L)	102.60±0.53	104.72±1.62	0.0801
GLYCEMIA g/L	0.90±0.02	0.85±0.07	0.3753
CRP (mg/l)	25.27±26.81	11.16±11.46	0.1281

In the MINERAL WATER category, no significant differences or variance heterogeneity were observed between the two groups (0–5 vs. 6–10) for Iron, Ferritin, Sodium, Potassium, Chloride, Glycemia, or CRP (all $P > 0.05$).

Table IV.8 : EGGS CATEGORY

EGGS			
PARAMETER	(0_5) **MEAN ± SD**	(6_10) **MEAN ± SD**	*P*
Iron (ug/L)	67.35±33.13	61.68±28.20	0.6629
Ferritine (ug/L)	28.96±19.05	36.50±31.33	0.5509
NA(mmol/L)	135.97±0.52	137.23±2.96	0.2757
K (mmol/L)	4.37±0.25	4.29±0.40	0.6036
Cl (mmol/L)	104.98±2.74	104.47±1.35	0.481
GLYCEMIA g/L	0.91±0.07	0.84±0.06	0.0764
CRP (mg/l)	15.70±16.99	11.02±11.60	0.3993

In the EGGS category, no significant differences or variance heterogeneity were observed between the two groups (0–5 vs. 6–10) for Iron, Ferritin, Sodium, Potassium, Chloride, Glycemia, or CRP (all $P > 0.05$).

Table IV.9 : CHEESE CATEGORY

CHEESE			
PARAMETER	(0_5)	(6_10)	*P*
	MEAN ± SD	**MEAN ± SD**	
Iron (ug/L)	73.70±65.69	61.80±25.24	0.517
Ferritine (ug/L)	30.33±45.47	35.28±27.65	0.7825
NA(mmol/L)	136.02±0.92	137.05±2.78	0.535
K (mmol/L)	4.21±0.45	4.32±0.36	0.6228
Cl (mmol/L)	106.86±2.76	104.34±1.36	**0.0102***
GLYCEMIA g/L	0.92±0.60	0.85±0.07	0.1145
CRP (mg/l)	2.72±2.29	13.07±12.86	0.1808

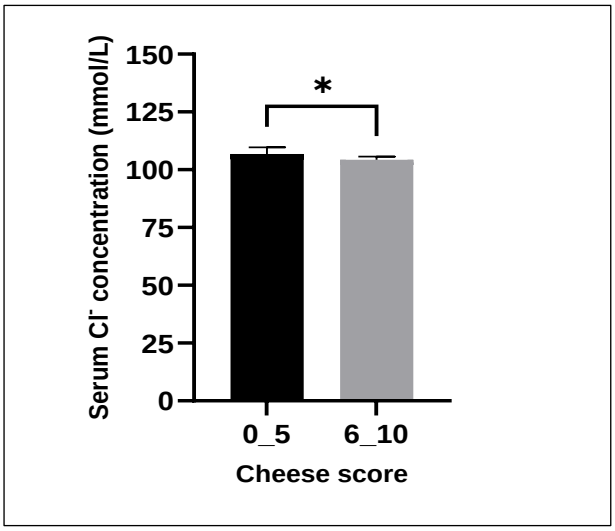


FIGURE IV.1 Significant correlations of CHEESE category score.

In the Cheese category, chloride was significantly lower in the 6–10 group (*P* = 0.0102*****), while all other parameters were no nsignificant (*P* > 0.05).

Table IV.10 : HONEY CATEGORY

HONEY			
PARAMETER	(0_5)	(6_10)	*P*
	MEAN ± SD	**MEAN ± SD**	
Iron (ug/L)	64.23±30.15	44.53±5.38	0.3709
Ferritine (ug/L)	34.65±29.57	36.99±18.63	0.9136
NA(mmol/L)	136.64±2.15	141.40±6.43	**0.0122***
K (mmol/L)	4.29±0.36	4.59±0.36	0.2778
Cl (mmol/L)	104.54±1.71	105.16±0.43	0.6229
GLYCEMIA g/L	0.86±0.07	0.82±0.04	0.4314
CRP (mg/l)	12.48±12.93	6.16±3.18	0.502

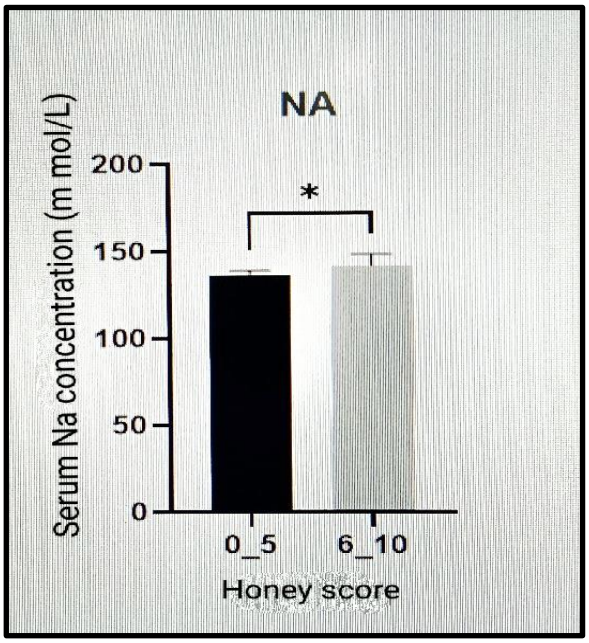


FIGURE IV.2: Significant correlations of Honey category score.

In the Honey category, sodium was significantly lower in the 6–10 group ($P = 0.0122$), while all other parameters were nonsignificant ($P > 0.05$).

Table IV.11 : DARK CHOCOLATE CATEGORY

DARK CHOCOLATE			
PARAMETER	(0_5)	(6_10)	*P*
	MEAN ± SD	**MEAN ± SD**	
Iron (ug/L)	60.27±30.73	68.59±27.59	0.4732
Ferritine (ug/L)	34.53±33.54	35.37±16.11	0.941
NA(mmol/L)	136.64±2.54	137.58±2.94	0.3686
K (mmol/L)	4.22±0.33	4.50±0.38	**0.0483***
Cl (mmol/L)	104.50±1.77	104.75±1.48	0.7026
GLYCEMIA g/L	0.85±0.07	0.86±0.06	0.959
CRP (mg/l)	13.40±14.06	9.29±8.81	0.4064

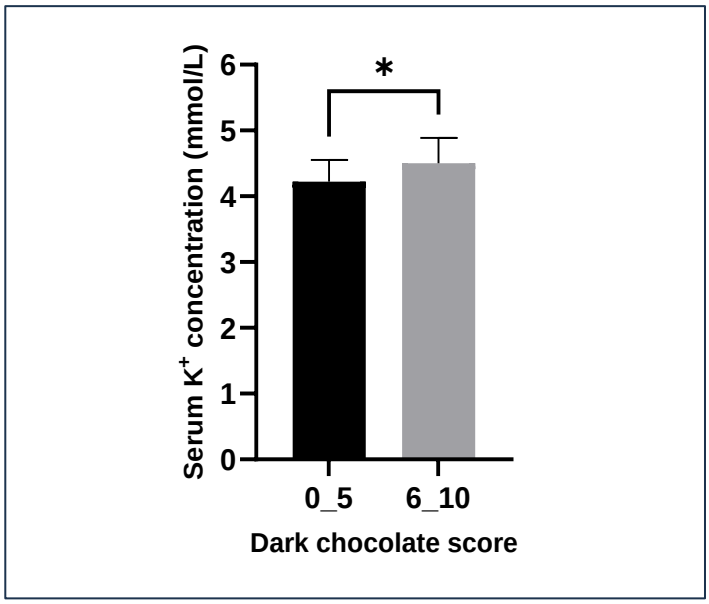


FIGURE IV.2: Significant correlations of DARK CHOCOLATE category score.

In Dark chocolate, potassium was significantly lower in the 6–10 group ($P = 0.0483$), while all other parameters were nonsignificant ($P > 0.05$).

Tables IV.12 :PULSES CATEGORY

PULSES			
PARAMETER	(0_5)	(6_10)	*P*
	MEAN ± SD	**MEAN ± SD**	
Iron (ug/L)	48.20 ±15.42	69.00 ±30.18	**0.0297***
Ferritine (ug/L)	41.54 ±44.20	31.64 ±16.70	0.5135
NA(mmol/L)	136.25 ±0.91	137.33 ±1..25	0.1954
K (mmol/L)	4.18 ±0.34	4.33 ±0.30	0.3093
Cl (mmol/L)	104.99 ±2.15	104.31 ±1.16	0.2935
GLYCEMIA g/L	0.89 ±0.07	0.84 ±0.06	0.1167
CRP (mg/l)	18.74 ±18.76	9.39 ±8.53	0.1586

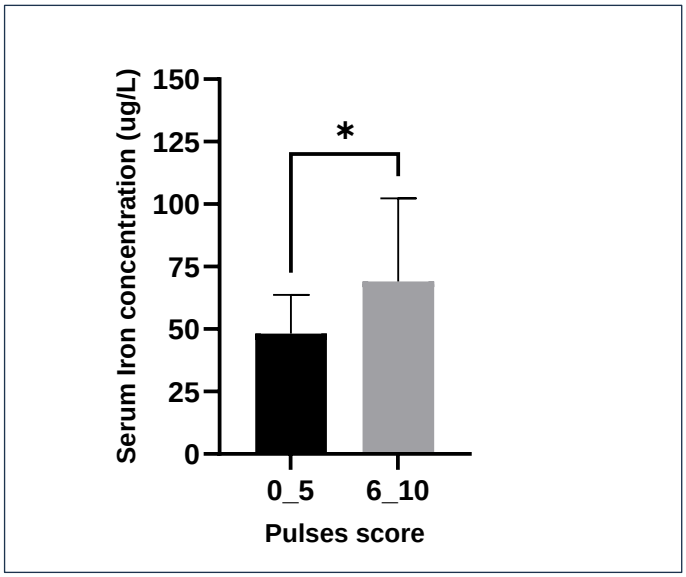


FIGURE IV.3 : Significant correlations of PULSES category score.

This section evaluates Mediterranean diet adherence and its role in In the Puldses category, IRON was significantly lower in the 6–10 group ($P = 0.0297$), while all other parameters were nonsignificant ($P > 0.05$).

IV.2.2. NOVA 4

Table IV.13: PREPARED MEALS CATEGORY

PREPARED MEALS			
PARAMETER	(0_5)	(6_10)	*P*
	MEAN ± SD	**MEAN ± SD**	
Iron (ug/L)	59.61±28.15	74.94±40.97	0.3488
Ferritine (ug/L)	35.81±31.28	32.76±19.52	0.8525
NA(mmol/L)	137.05±2.94	136.85±0.92	0.9089
K (mmol/L)	4.30±0.37	4.36±0.39	0.774
Cl (mmol/L)	104.53±1.71	105.16±1.69	0.5
GLYCEMIA g/L	0.85±0.07	0.87±0.05	0.6821
CRP (mg/l)	13.28±13.60	8.26±6.41	0.4795

In the prepared meals category, no significant differences or variance heterogeneity were observed between the two groups (0–5 vs. 6–10) for Iron, Ferritin, Sodium, Potassium, Chloride, Glycemia, or CRP (all $P > 0.05$).

Table IV.14 : PROCESSED MEATS CATEGORY

PROCESSED MEATS			
PARAMETER	(0_5)	(6_10)	*P*
	MEAN ± SD	**MEAN ± SD**	
Iron (ug/L)	55.65±26.65	70.27±32.37	0.1878
Ferritine (ug/L)	37.26±36.60	33.15±20.37	0.7065
NA(mmol/L)	136.61±1.30	137.36±3.63	0.463
K (mmol/L)	4.23±0.38	4.40±0.34	0.2268
Cl (mmol/L)	104.27±1.48	104.87±1.87	0.341
GLYCEMIA g/L	0.86±0.06	0.85±0.08	0.4689
CRP (mg/l)	14.96±16.20	9.61±7.74	0.2589

In the processed meats category, no significant differences or variance heterogeneity were observed between the two groups (0–5 vs. 6–10) for Iron, Ferritin, Sodium, Potassium, Chloride, Glycemia, or CRP (all $P > 0.05$).

Table IV.15: CEREALS CATEGORY

CEREALS UT			
PARAMETER	(0_5)	(6_10)	*P*
	MEAN ± SD	**MEAN ± SD**	
Iron (ug/L)	58.33±25.51	67.60±34.29	0.4083
Ferritine (ug/L)	30.64±17.47	39.77±37.60	0.401
NA(mmol/L)	136.48±1.54	137.49±3.50	0.3163
K (mmol/L)	4.25±0.28	4.38±0.43	0.3315
Cl (mmol/L)	104.10±1.39	105.04±1.86	0.1299
GLYCEMIA g/L	0.87±0.07	0.84±0.07	0.2048
CRP (mg/l)	13.60±14.77	10.97±10.75	0.5813

In the CEREALS category, no significant differences or variance heterogeneity were observed between the two groups (0–5 vs. 6–10) for Iron, Ferritin, Sodium, Potassium, Chloride, Glycemia, or CRP (all $P > 0.05$).

Table IV.16: WHITE SUGAR CATEGORY

WHITE SUGAR			
PARAMETER	(0_5)	(6_10)	*P*
	MEAN ± SD	**MEAN ± SD**	
Iron (ug/L)	72.35±32.57	61.57±29.50	0.5053
Ferritine (ug/L)	28.75±19.13	35.69±30.11	0.6603
NA(mmol/L)	135.94±0.92	137.10±2.81	0.4291
K (mmol/L)	4.51±0.36	4.28±0.36	0.2567
Cl (mmol/L)	105.42±3.15	104.46±1.38	0.5884
GLYCEMIA g/L	0.88±0.08	0.85±0.07	0.5652
CRP (mg/l)	8.19±6.50	12.65±13.26	0.5184

In the WHITE SUGAR category, no significant differences or variance heterogeneity were observed between the two groups (0–5 vs. 6–10) for Iron, Ferritin, Sodium, Potassium, Chloride, Glycemia, or CRP (all $P > 0.05$).

Table IV.17 : SAUCES CATEGORY

SAUCES			
PARAMETER	(0_5) **MEAN ± SD**	(6_10) **MEAN ± SD**	*P*
Iron (ug/L)	58.16±35.90	65.74±26.79	0.5154
Ferritine (ug/L)	27.96±23.53	39.40±31.84	0.3092
NA(mmol/L)	137.41±3.09	136.74±2.51	0.5232
K (mmol/L)	4.38±0.40	4.28±0.35	0.4773
Cl (mmol/L)	105.16±2.05	104.23±1.38	0.1499
GLYCEMIA g/L	0.87±0.08	0.85±0.07	0.401
CRP (mg/l)	10.96±13.71	13.05±12.51	0.673

In the SAUCES category, no significant differences or variance heterogeneity were observed between the two groups (0–5 vs. 6–10) for Iron, Ferritin, Sodium, Potassium, Chloride, Glycemia, or CRP (all $P > 0.05$).

Table IV.18 : SALTY FOOD CATEGORY

SALTY FOOD			
PARAMETER	(0_5) **MEAN ± SD**	(6_10) **MEAN ± SD**	*P*
Iron (ug/L)	60.95±33.64	62.81±24.76	0.872
Ferritine (ug/L)	40.88±35.99	27.62±15.69	0.2431
NA(mmol/L)	136.28±1.50	138.09±3.71	0.0798
K (mmol/L)	4.18±0.34	4.48±0,34	**0.0292***
Cl (mmol/L)	104.12±1.08	105.31±2.17	0.0631
GLYCEMIA g/L	0.88±0.06	0.82±0.07	**0.0304***
CRP (mg/l)	15.32±16.05	8.70±4.45	0.1774

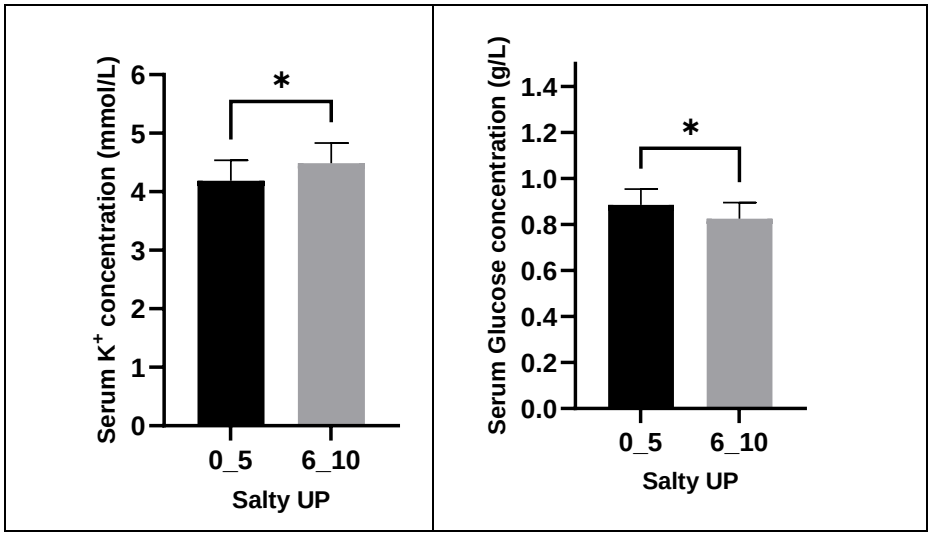


FIGURE IV.4 : Significant correlations of Salty Food category score.

In the Salty foods category, potassium and glycemia were significantly lower in the 6–10 group ($P = 0.0292$ and $P = 0.0304$), while other parameters were nonsignificant ($P > 0.05$).

Table IV.19 :SAGARY FOOD CATEGORY

SUGARY FOOD			
PARAMETER	(0_5) **MEAN ± SD**	(6_10) **MEAN ± SD**	*P*
Iron (ug/L)	40.03±13.21	63.53±30.79	0.3448
Ferritine (ug/L)	43.96±2.89	34.40±31.24	0.6064
NA(mmol/L)	137.36±2.45	136.99±2.81	0.8295
K (mmol/L)	4.38±0.37	4.30±0.37	0.7433
Cl (mmol/L)	105.32±0.21	104.53±1.77	0.4571
GLYCEMIA g/L	0.90±0.07	0.85±0.07	0.3035
CRP (mg/l)	27.48±20.64	10.87±11.05	**0.0318***

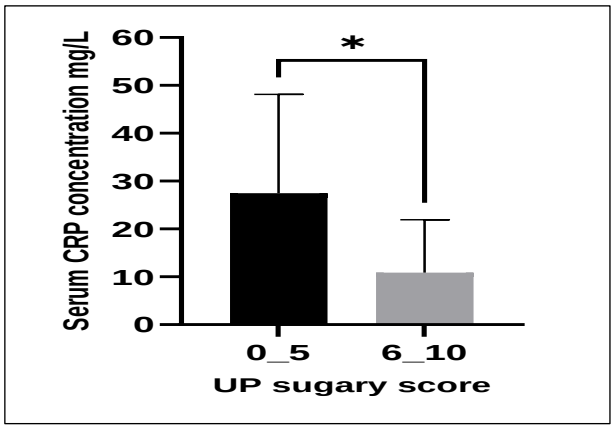


FIGURE IV.5 : Significant correlations of SUGARY FOOD category score.

In the Sugary foods category, CRP was significantly lower in the 6–10 group ($P = 0.0318$), while all other parameters were no nsignificant ($P > 0.05$).

Tables IV.20 : MARGARINE CATEGORY

MARGARINE			
PARAMETER	(0_5) **MEAN ± SD**	(6_10) **MEAN ± SD**	*P*
Iron (ug/L)	53.99±23.95	77.15±32.95	**0.031***
Ferritine (ug/L)	30.02±33.21	32.86±21.15	0.7717
NA(mmol/L)	137.15±3.37	136.63±0.76	0.6099
K (mmol/L)	4.27±0.39	4.36±0.33	0.5336
Cl (mmol/L)	105.01±1.70	103.91±1.40	0.0715
GLYCEMIA g/L	0.88±0.06	0.82±0.07	**0.0232***
CRP (mg/l)	11.70±12.79	12.66±12.85	0.8406

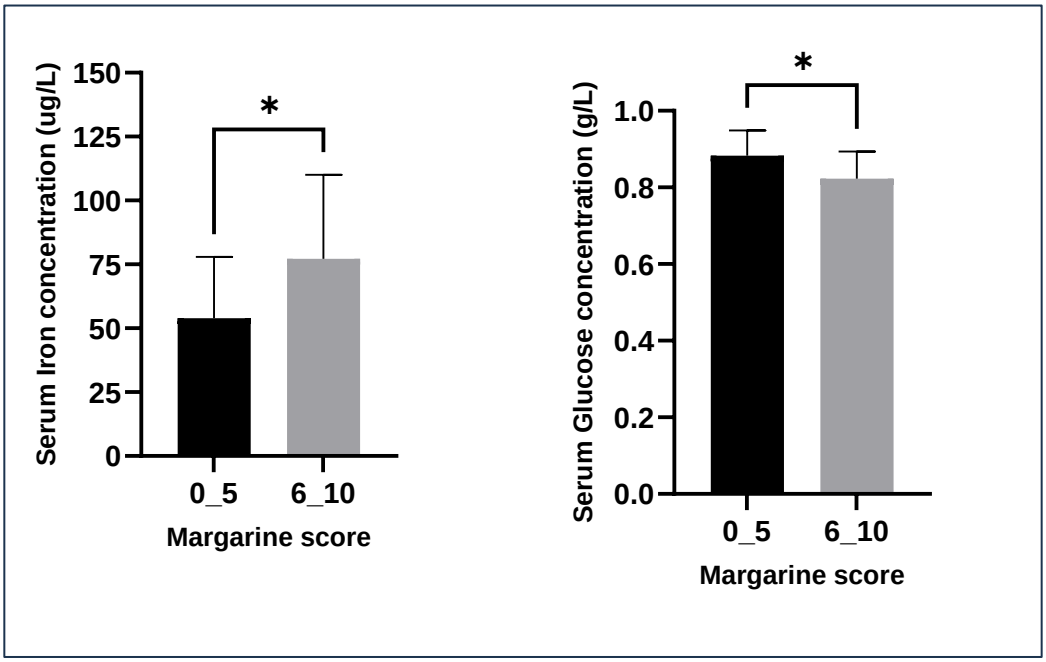


FIGURE IV.6 : Significant correlations of MARGARINE category score.

In the Margarine category, iron and glycemia were significantly lower in the 6–10 group (P = 0.031 and P = 0.0232), while all other parameters were no nsignificant (P > 0.05).

Table V.21 :FAST FOOD CATEGORY

FAST FOOD			
PARAMETER	(0_5) **MEAN ± SD**	(6_10) **MEAN ± SD**	*P*
Iron (ug/L)	54.50±8.98	62.26±30.18	0.7294
Ferritine (ug/L)	23.63±24.61	36.26±30.23	0.571
NA(mmol/L)	137.59±3.69	136.99±2.74	0.7728
K (mmol/L)	4.77±0.05	4.27±0.36	0.0709
Cl (mmol/L)	107.78±3.16	104.38±1.37	**0.0042****
GLYCEMIA g/L	0.90±0.11	0.85±0.07	0.449
CRP (mg/l)	5.13±0.58	13.14±13.20	0.1878

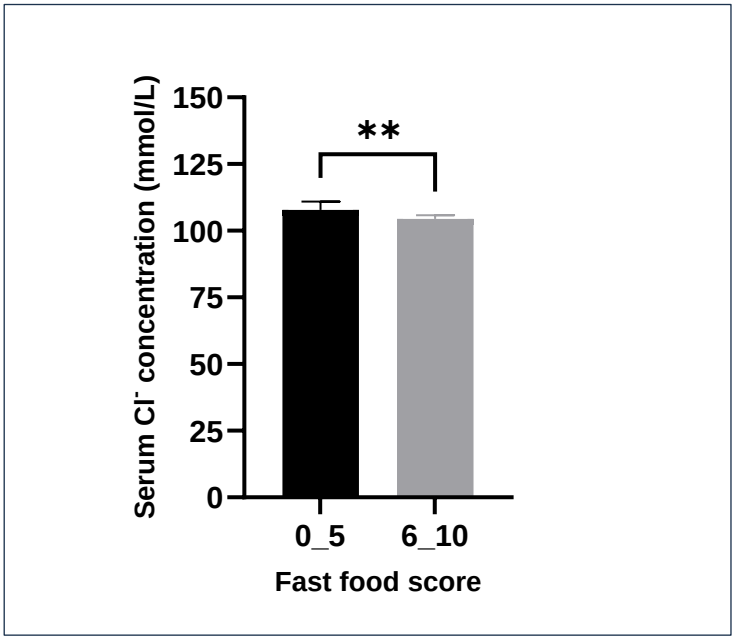


FIGURE IV.7 : Significant correlations of FAST FOOD category score.

In the Fast food category, chloride was significantly lower in the 6–10 group (P = 0.0042), while all other parameters were nonsignificant (P > 0.05).

Table IV.22 : DAIRY PRODUCTS CATEGORY

DAIRY PRODUCTS			
PARAMETER	(0_5) **MEAN ± SD**	(6_10) **MEAN ± SD**	*P*
Iron (ug/L)	65.00±6.37	62.68±32.92	0.8781
Ferritine (ug/L)	60.76±51.91	29.71±20.46	**0.0276***
NA(mmol/L)	137.67±1.58	136.76±2.88	0.5051
K (mmol/L)	4.09±0.46	4.33±0.33	0.1749
Cl (mmol/L)	103.98±1.21	104.61±1.69	0.4378
GLYCEMIA g/L	0.81±0.04	0.86±0.07	0.1519
CRP (mg/l)	14.30±14.21	11.92±12.71	0.7103

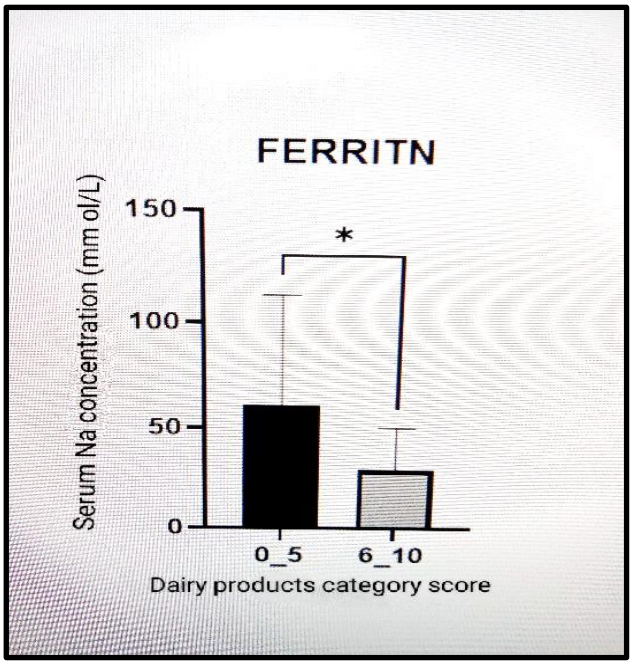


FIGURE IV.8: Significant correlations of DAIRY PRODUCTS category score.

In the Dairy products category, ferritin was significantly lower in the 6–10 group ($P = 0.0276$), while all other parameters were nonsignificant ($P > 0.05$)

Table IV.23 : STIMULANT DRINKS CATEGORY

STIMULANT DRINKS			
PARAMETER	(0_5)	(6_10)	*P*
	MEAN ± SD	**MEAN ± SD**	
Iron (ug/L)	58.97±33.14	63.89±26.83	0.6562
Ferritine (ug/L)	30.35±22.54	38.49±33.76	0.4599
NA(mmol/L)	136.73±2.94	137.19±2.58	0.6552
K (mmol/L)	4.26±0.34	4.32±0.39	0.6544
Cl (mmol/L)	104.72±2.06	104.56±1.35	0.7948
GLYCEMIA g/L	0.89±0.07	0.83±0.06	**0.0305***
CRP (mg/l)	10.46±9.77	13.80±14.71	0.4861

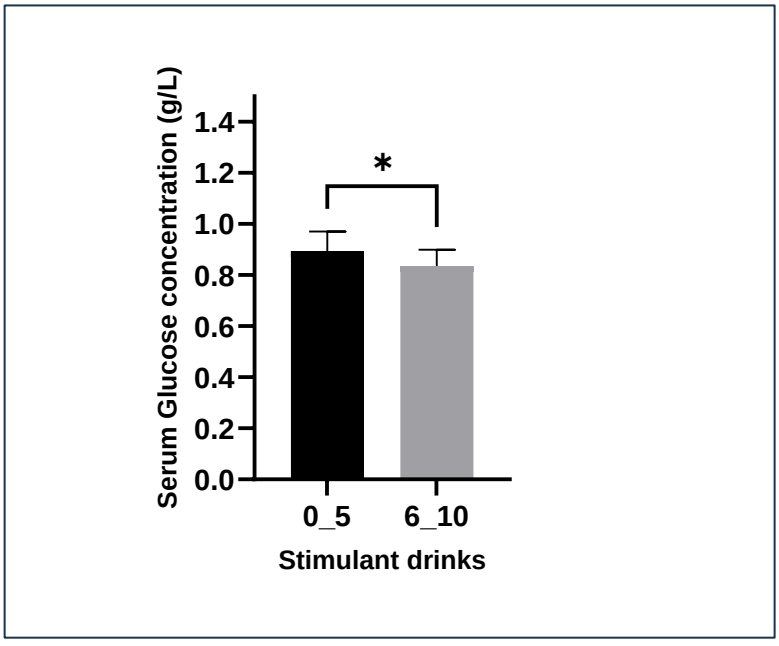


FIGURE IV.9 : Significant correlations of STIMULANT DRINKS category score.

In Stimulant drinks, glycemia was significantly lower in the 6–10 group ($P = 0.0305$), while all other parameters were nonsignificant ($P > 0.05$).

IV.3. Impact of mediterranean diet

mitigating modern dietary risks. The following data and graphs delineate compliance scores among the participants, illustrating how traditional staples interact to support systemic homeostasis.

Table IV.24 : WHITE SUGAR CATEGORY

WHITE SUGAR			
PARAMETER	(0_5)	(6_10)	*P*
	MEAN ± SD	**MEAN ± SD**	
LEGUMES	8.75 ± 0.95	8.48 ± 1.19	0.67
FRUITS	9 ± 1.41	9.08 ± 1.01	0.89
CEREALS	8.75 ± 1.25	9.26±1.00	0.36
PULSES	6.75 ± 2.21	5.73 ± 1.80	0.31
FISHS	3.5 ± 1.29	3.32 ± 2.01	0.86

No significant differences were observed between groups for vegetables, fruits, cereals, legumes, and fish consumption ($P > 0.05$) between (0_5) vs (6_10) groups.

Table IV.25 : SAUCES CATEGORY

SAUCES			
PARAMETER	(0_5)	(6_10)	*P*
	MEAN ± SD	**MEAN ± SD**	
LEGUMES	8,45±1,21	8,89±1,05	0,68
FRUITS	9,18±0,98	09±1,12	0,66
CEREALS	9,27±1,01	9,4±1,07	0,69
PULSES	5,45±1,51	06±2,03	0,45
FISHS	3,27±1,42	3,39±2,20	0,88

No significant differences were observed between groups for vegetables, fruits, cereals, legumes, and fish consumption ($P > 0.05$) between (0_5) vs (6_10) groups.

Table IV.26 : MARGARINE CATEGORY

MARGARINE			
PARAMETER	(0_5)	(6_10)	*P*
	MEAN ± SD	**MEAN ± SD**	
LEGUMES	8.63 ±1.11	9.33 ±0.86	0.17
FRUITS	9.05 ±1.07	9.22 ±0.83	0.68
CEREALS	8.94 ±1.05	9.54 ±0.93	0.13
PULSES	5.27 ±1.84	6.63 ±1.56	0.05
FISHS	3.05 ±2.29	4.10 ±1.10	0.19

No significant differences were observed between groups for vegetables, fruits, cereals, legumes, and fish consumption ($P > 0.05$) between (0_5) vs (6_10) groups.

Table IV.27 :CEREALS CATEGORY

CEREALS UT			
PARAMETER	(0_5)	(6_10)	*P*
	MEAN ± SD	**MEAN ± SD**	
LEGUMES	8,43±1,22	8,67±1,15	0,56
FRUITS	09±01	9,08±1,16	0,76
CEREALS	9,21±0,97	9,08±1,16	0,84
PULSES	5,26±1,86	06±2,04	0,34
FISHS	2,8±1,97	3,83±1,75	0,17

No significant differences were observed between groups for vegetables, fruits, cereals, legumes, and fish consumption ($P > 0.05$) between (0_5) vs (6_10) groups.

Table IV.28 :FAST FOOD CATEGORY

FAST FOOD			
PARAMETER	(0_5)	(6_10)	*P*
	MEAN ± SD	**MEAN ± SD**	
LEGUMES	8 ± 0	8.52 ± 1.19	0.55
FRUITS	9.5 ± 0.70	9.03 ± 1.07	0.56
CEREALS	8.5 ± 2.12	9.22 ± 0.97	0.35
PULSES	6 ± 1.41	5.74 ± 1.91	0.85
FISHS	3.5 ± 2.12	3.23 ± 1.90	0.056

No significant differences were observed between groups for vegetables, fruits, cereals, legumes, and fish consumption ($P > 0.05$) between (0_5) vs (6_10) groups.

Table IV.29 : CHEESE CATEGORY

CHEESE			
PARAMETER	(0_5)	(6_10)	*P*
	MEAN ± SD	**MEAN ± SD**	
LEGUMES	8,67±1,15	8,56±1,19	0,88
FRUITS	09±01	9,08±1,08	0,90
CEREALS	8,33±1,53	9,27±0,96	0,14
PULSES	06±01	5,78±1,92	0,84
FISHS	05±00	3,15±1,94	0,12

No significant differences were observed between groups for vegetables, fruits, cereals, legumes, and fish consumption ($P > 0.05$) between (0_5) vs (6_10) groups.

Table IV.30 :SUGARY ULTRA-PROCESSED FOOD CATEGORY

SUGARY ULTRA-PROCESSED FOOD			
PARAMETER	(0_5)	(6_10)	*P*
	MEAN ± SD	**MEAN ± SD**	
LEGUMES	7,67±1,15	8,68±1,14	0,16
FRUITS	09±01	9,08±1,08	0,90
CEREALS	8,67±1,53	9,23±0,99	0,38
PULSES	4,67±2,52	5,92±1,76	0,27
FISHS	02±01	3,5±1,94	0,20

No significant differences were observed between groups for vegetables, fruits, cereals, legumes, and fish consumption ($P > 0.05$) between (0_5) vs (6_10) groups.

Table IV.31 :SALTY ULTRA PROCESSED FOOD CATEGORY

SALTY ULTRA PROCESSED FOOD			
PARAMETER	(0_5)	(6_10)	*P*
	MEAN ± SD	**MEAN ± SD**	
LEGUMES	8,5±1,25	8,7±1,06	0,67
FRUITS	8,88±1,05	9,36±1,03	0,24
CEREALS	9,11±0,96	9,27±1,19	0,69
PULSES	5,5±1,58	6,27±2,19	0,28
FISHS	2,78±1,70	4,27±1,95	**0,04***

No significant differences were observed between groups for vegetables, fruits, cereals, and legumes ($P > 0.05$). A significant difference was observed for fish consumption ($P = 0.04$), with higher intake in the 6-10 group.

Table IV.32: PREPARED FOOD CATEGORY

PREPARED FOOD			
PARAMETER	(0_5)	(6_10)	*P*
	MEAN ± SD	**MEAN ± SD**	
LEGUMES	8.33 ± 1.12	9.66 ± 0.57	0.0579
FRUITS	8.83 ± 1.12	10 ± 0	0.0523
CEREALS	9.08 ± 1.07	9.66 ± 0.57	0.3676
PULSES	1.75 ± 1.75	2.64 ± 2.16	0.2241
FISHS	2.95 ± 1.73	5 ± 2	**0.0417***

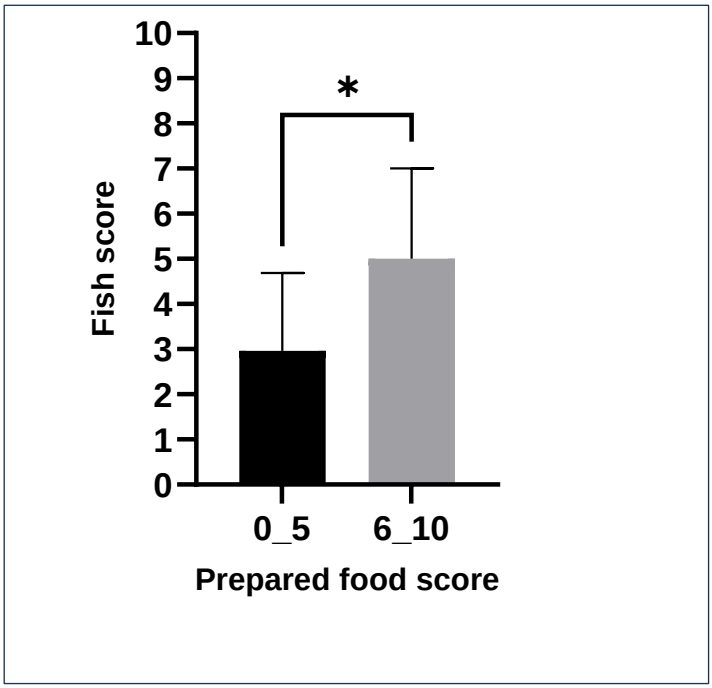


FIGURE IV.10 PREPARED FOOD category score.

No significant differences were observed between groups for vegetables, fruits, cereals, and legumes ($P > 0.05$). A significant difference was observed for fish consumption ($P = 0.0417$), with higher intake in the 6-10 groups.

Table IV.33: PREPARED MEAT CATEGORY

PREPARED MEAT			
PARAMETER	(0_5)	(6_10)	*P*
	MEAN ± SD	**MEAN ± SD**	
LEGUMES	8 ± 1.03	9 ± 1.08	**0.02***
FRUITS	8.46 ± 0.99	9.23 ± 1.01	0.054
CEREALS	8.85 ± 1.02	9.38 ± 1.04	0.20
PULSES	4.85 ± 1.95	6.64 ± 1.27	**0.009****
FISHS	2.86 ± 2.13	3.69 ± 1.49	0.25

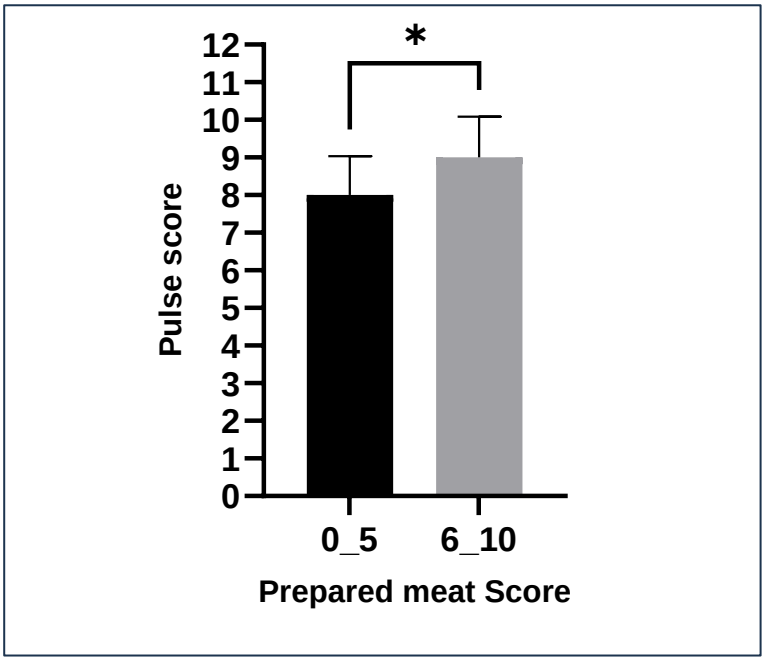


FIGURE IV.11 PREPARED MEAT category score.

No significant differences were observed between groups for fruits, cereals, and fish consumption ($P > 0.05$). Significant differences were observed for vegetables ($P = 0.0215$) and legumes ($P = 0.0082$), with higher values in the 6-10 groups.

CHAPTER V

Discussion

Discussion

The present study investigated the relationship between the consumption of ultra-processed foods (UPFs) and selected biochemical parameters related to mineral status, glycaemic regulation, and inflammation among a specific cohort of young adults in the Wilaya of Skikda, Algeria. The study population consisted of 31 participants aged between 16 and 32 years, all recruited locally, who presented a relatively healthy profile. This baseline health status may explain why most biochemical parameters remained within normal physiological ranges. Despite the small sample size, several significant associations were identified, shedding light on the early metabolic impacts of dietary transitions within this Skikda-based population.

The increasing consumption of UPFs has become a major public health concern worldwide. According to Monteiro et al., (2019), these products already account for more than half of the total dietary energy consumed in high-income countries like the USA, Canada, and the UK, and between one-fifth and one-third in middle-income countries such as Brazil, Mexico, and Chile. While regional and epidemiologic data for the Wilaya of Skikda remain scarce, the local dietary transition, rapid urbanization, and the increasing Westernization of regional food environments suggest that youth in Skikda are experiencing a similar upward trend in UPF intake.

The widespread displacement of traditional diets by UPFs is driven by their convenience (imperishable, ready-to-consume), hyper-palatability, and aggressive marketing strategies, often funded by vast corporate budgets (Monteiro et al., 2019). However, identifying these foods poses a challenge; the food manufacturing industry is not legally obliged to state industrial processes on food labels, making confident identification difficult for consumers and researchers alike (Monteiro et al., 2019). To overcome this limitation, this study utilized the NOVA classification, which is recognized systematically as the most specific, coherent, clear, comprehensive, and workable framework for identifying ultra-processed foods based on the extent and purpose of industrial processing (Monteiro et al., 2019; Moubarac et al., 2014). Additionally, incorporating integrative approaches like the SIGA classification could further refine risk assessment by combining markers of ultra-processing with nutritional thresholds within the local market.

Our analysis revealed critical interactions between dietary habits and mineral biomarkers among the evaluated volunteers in Skikda. A significant increase in serum iron concentration was observed among participants with higher legumes consumption (69.00 ± 30.18 µg/L) compared to low-frequency consumers (48.20 ± 15.42 µg/L; P = 0.0297), reinforcing the

positive contribution of legumes to iron status in this local group. Regarding electrolyte concentrations, significant differences emerged based on specific food items. while potassium concentrations were significantly higher among dark chocolate consumers (4.50±0.38 mmol/L vs 4.22 ± 0.33 mmol/L; *P* = 0.0483). This finding is entirely consistent with the biochemical composition of cocoa. Indeed, dark chocolate with a high cocoa content represents a major plant-derived source of potassium, providing between 483 and 854 mg of K^+ per 100 g. (USDA Food Data Central, 2026). Besides, the combined high content of organic phosphorus and methylxanthines (theobromine) in dark chocolate may influence the kinetics of transcellular ion transport and renal excretion. (Latif, 2013).

Furthermore, chloride concentrations were significantly higher in participants belonging to the 0–5 fast-food consumption category than in those in the 6–10 category (107.78±3.16 vs 104.38±1.37 *P* = 0.0042). Regarding chloride, the most significant findings were observed in participants with low consumption of cheese, fast food, and sugar. This observation may be explained by the potential influence of other chloride-rich foods, particularly ultra-processed foods (UPFs), which may have confounded these associations within the cohort.

These alterations underscore the metabolic risks associated with UPFs. As established in the literature, an increased dietary share of UPFs leads to a severe deterioration of overall nutritional quality and a drastic reduction in essential micronutrient density (Louzada et al., 2015). The high content of sodium and lack of essential minerals in UPFs directly drive electrolyte imbalances (Giles and Dhaliwal, 2022). Chronic exposure to such patterns, particularly elevated sodium coupled with reduced potassium intake, constitutes a major pathophysiological risk factor for the development of hypertension and impaired cardiovascular health (Palmer and Clegg, 2016). Ultimately, these nutritional shifts are heavily linked to long-term chronic conditions, including dyslipidemia, accelerated lipid profile deterioration, obesity, metabolic syndrome, and cardiovascular diseases (Rauber et al., 2015; Srour et al., 2019).

In terms of glycemia a significant difference was observed among stimulant drink consumers within our sample, with lower fasting glycemia values in the high-consumption group (0.83 ± 0.06 g/L) compared to the low-consumption group (0.89± 0.07 g/L; *P* = 0.0305). Interestingly, the same trend was observed for some ultra-processed foods, notably margarine and salty ultra-processed products, suggesting that the association between dietary habits and fasting glycemia may not be limited to stimulant drink consumption alone. Although experimental studies indicate that ultraprocessed foods induce high glycaemic responses and have low satiety potential

(Fardet, 2016) beside association with higher Type 2 Diabetes risk (Chen et al., 2023), a recent study published by Basile et al. (2024) failed to reach a significant difference of glycaemic index and glycaemic load, that measure the quality and quantity of carbohydrates in food based on their effect on postprandial blood glucose, between minimally processed foods and UPF.

The lack of association between the inflammatory biomarker CRP and the intake of any type of UPF is in the line with other studies rolled on small samples, contrary to what is found in larger cohorts as confirmed by a recent review carried by Ciaffi et al., (2025). On the other hand, experimental evidence shows that UPFs create a hostile gut environment, altering the microbiota composition and selecting for opportunistic microbes that promote diverse forms of inflammatory and metabolic diseases (Monteiro et al., 2019; Zinöcker and Lindseth, 2018). This gut-mediated mechanism drives chronic low-grade inflammation, reflected by alterations in systemic inflammatory markers such as C-reactive protein (CRP) and ferritin (Kotla et al., 2022). Because ferritin acts as an acute-phase reactant, inflammatory processes can elevate its levels independently of actual body iron stores, complicating the assessment of iron metabolism in cohorts facing sub-clinical systemic inflammation (Kotla et al., 2022).

Interestingly, the assessment of the Mediterranean diet revealed that elements of traditional, healthy eating habits persisted among the participants from Skikda, since higher scores were registered in matter of vegetables, fruits and legumes intake. Most Mediterranean diet components did not vary significantly based on UPF consumption. However, fish consumption was significantly higher among participants with greater consumption of salty UPFs (4.27 ± 1.95 vs. 2.78 ± 1.70; $P = 0.04$). Similarly, those with higher prepared-food consumption exhibited significantly greater fruit intake (10 ± 0 vs. 8.83 ± 1.12; $P < 0.0001$) and fish consumption (5 ± 2 vs. 2.95 ± 1.73; $P = 0.0417$). This indicates a transitional dietary pattern where young adults in Skikda integrate modern processed convenience foods without entirely abandoning traditional Mediterranean staples, and probably this could be an explanation for the absence of a detectable effect of UPF on different parameters.

Because the Mediterranean diet is fundamentally rich in fruits, vegetables, legumes, and fish, it provides an abundance of antioxidants, dietary fiber, vitamins, and essential minerals (Davis et al., 2015; Bach-Faig et al., 2011). This high-quality nutrient intake may act as a crucial biological buffer, counterbalancing and mitigating some of the adverse metabolic, lipid, and inflammatory effects induced by UPF consumption (González and Calvo, 2016; Bonaccio et al., 2021). A cross-sectional survey of a nationally representative sample of adults in Greece

concluded that a high adherence to Mediterranean diet may have a protective effect against iron deficiency (Papatesta et al., 2026). Despite a low intake of red meat in this dietary pattern, the synergistic effects of vitamin C and organic acids, which promote the absorption of plant-derived non-heme iron, contribute to maintaining iron metabolic homeostasis. Furthermore, A study carried out on 1514 men and 1,528 women by (Chrysohoou et al., 2004) proved that participants who were in the highest tertile of the diet score had, on average, 20% lower CRP levels.

A major strength of this study is its multi-dimensional approach, simultaneously assessing dietary habits, mineral biomarkers, glycemic regulation, and inflammatory status, while leveraging both the rigorous NOVA classification system and Mediterranean diet indicators within a specific local context. Background limitations must be noted. The cross-sectional design prevents the determination of definitive causal relationships. Most importantly, the relatively small sample size (n = 31) limits the statistical power to detect subtler associations and restricts the generalization of these findings to the broader population of Skikda or Algeria as a whole. Besides, cross-sectional studies prevent showing a notable effect over time especially in a youth population.

Conclusion and Perspectives

Conclusion and perspectives

The present study was conducted to investigate the relationship between ultra-processed food consumption and selected biochemical parameters among young Algerian adults. The findings of this study revealed several significant associations between the consumption of certain food categories and biological parameters related to mineral status, glycemic regulation, and inflammation. These results suggest that dietary habits may contribute to variations in metabolic and nutritional indicators, even within a relatively healthy population. In addition, the assessment of Mediterranean diet adherence highlighted the importance of maintaining healthy dietary practices as part of an overall balanced lifestyle. Although the majority of the measured parameters remained within normal physiological ranges, the observed associations emphasize the potential role of food quality in preserving health and preventing metabolic disorders. The results also support current concerns regarding the increasing presence of ultra-processed foods in modern diets and their possible implications for public health. Furthermore, the findings obtained in this study highlight the importance of adopting healthier dietary habits from an early age.

As dietary behaviors established during youth often persist into adulthood, promoting balanced diets rich in minimally processed foods may contribute to reducing the burden of chronic diseases and improving overall quality of life. In this context, public health initiatives and nutritional awareness programs could play a key role in encouraging healthier food choices among young populations. Despite certain limitations, particularly the relatively small sample size and the cross-sectional design, this study provides useful preliminary data on the dietary habits of young Algerian adults and their relationship with selected biochemical markers. These findings may contribute to a better understanding of the nutritional challenges associated with dietary transition and increasing food industrialization.

Further studies involving larger populations and additional biological parameters are necessary to confirm these observations and to better characterize the long-term effects of ultra-processed food consumption. Promoting nutritional education and encouraging the consumption of minimally processed foods remain essential strategies for improving dietary quality and supporting long-term health.

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Appendix

I. APPendix 1 : Consent

لجمهورية الديمقراطية الشعبية الجزائرية

جامعة 20 أوت 1955 سكيكدة

كلية العلوم

قسم علوم الطبيعة والحياة

اقرار بالموافقة على بحث بدون فائدة مباشرة للمشاركين من مجموعة متطوعين يجرى لهم تحاليل مصل الدم

عنوان البحث:

دراسة تأثير الأطعمة فائقة المعالجة على مستويات المعادن والدهون في مصل الدم لدى فئة من سكان ولاية سكيكدة.

الجزء الأول – معلومات للمشارك في البحث:

أ. الغرض من البحث: قد تساعدنا هذه الدراسة في فهم مدى تأثير الأطعمة الفائقة المعالجة على تراكيز المعادن والدهون في مصل دم الانسان وبالتالي على صحته.

ب. وصف البحث: تتمثل هذه الدراسة في طلب الإجابة عن استبيان يقيم نوعية الغذاء لدى المشاركين وذلك بغرض قياس تردد استهلاك الأطعمة التي تؤثر على تراكيز المعادن والدهون لا سيما الأطعمة الفائقة المعالجة. كما يتم جمع عينة دم بغرض قياس كميات الحديد، الفيريتين، المغنيزيوم، الصوديوم، البوتاسيوم، الكلور، الاحماض الدهنية، الكولسترول، البروتينات الدهنية منخفضة الكثافة، البروتينات الدهنية مرتفعة الكثافة والسكر.

إذا قمت بالموافقة على المشاركة في هذه الدراسة، سيتم سحب عينة دم من الوريد (في المختبر المخصص لذلك) وسيتم الحصول على معلومات تتعلق بحالتك الصحية وعاداتك في الاكل.

ج. المدة المتوقعة للدراسة:

المدة اللازمة لإنهاء الدراسة كاملة : هي المدة اللازمة لحصولك على نتائج دراسة المعايير الاعتيادية لمصل الدم.

د. المخاطر والإزعاجات المحتملة: عملية سحب الدم مشابهة لأي عملية سحب من أجل الفحوص المخبرية.

ز.الفوائد المرجوة: لن تكون هناك فائدة مباشرة لك عند المشاركة في هذه الدراسة ولكن من خلال مشاركتك، قد تساهم في تحسين معرفتنا للعلاقة بين عاداتك الغذائية، ومستويات المعادن والدهون.

ط. تكاليف المشاركة: لن تكون هناك أي تكاليف من جراء المشاركة في هذه الدراسة.

ي. المكافآت المالية: لن تكون هناك أي مكافآت مالية لدى مشاركتك في هذه الدراسة.

ك. المشاركة الطوعية: المشاركة في هذه الدراسة طوعيه وإذا قررت عدم المشاركة فإنك لن تتعرض لأي مضايقات.

ل. : السرية: كمشارك في هذه الدراسة ستكون هويتك ومحتويات ملفك الطبّي سرية في جميع المنشورات المتعلقة بنتائج الدراسة كما سيبقي رقم

سجلك الطبي سري في الحدود التي يسمح بها القانون.

الجزء الثاني: تفويض من المشارك بالدراسة التي لا يتوقع منها فائدة مباشرة للمشارك:

اسم المشارك: ----------

1. **أقر بأنني قد قرأت – أو شرح لي بلغة مفهومة لدي – هذه المعلومات المتعلقة بمشاركتي في هذا البحث المعنون: " تأثير الأطعمة فائقة المعالجة على مستويات المعادن والدهون في مصل الدم لدى فئة من سكان ولاية سكيكدة" وأن المشرفين عن البحث أوضحوا لي طبيعة وأهداف هذه الدراسة والإزعاجات، كما أقر بأنه قد أتيحت لي الفرصة لتوجيه جميع الأسئلة المتعلقة بموضوع الدراسة وتلقيت الإجابات الوافية.**
2. **أفهم بأن هذه الدراسة ليس لها أي فائدة علاجية مباشرة لي ومع ذلك أتطوع بالمشاركة.**
3. **وأفهم بأن لي مطلق الحرية بسحب هذا التفويض وإنهاء مشاركتي بهذه الدراسة في أي وقت.**
4. **أوافق على أن يكون هذا الإقرار كمشاركة طوعيه في هذا البحث الطبي.**
5. **كما أؤكد بأنني قد قرأت (أو قرأ لي) هذا التفويض وأن كل المعلومات اللازمة قد تمت تعبئتها بدقة قبل توقيعي عليه.**

توقيع المريض: _____التاريخ : _____

توقيع الباحث:_____ التاريخ : _____

II. APPendix 2 : Food frequency questionnair FFQ

إستبيان تردد الغذاء لمدة ستة أشهر

FOOD FREQUENCY QUESTIONNAIR

رقم الهاتف لأي استفسار [redacted]

أولا : يطلب منك ملأ المعلومات التالية **الرقم.....**

الإسم: .....

اللقب: .....

العمر: .....

الجنس: ☐ **ذكر** ☐ انثى

الوزن.....كغ

الطول.....سم

هذا الاستبيان يطرح اسئلة تتعلق بعادتك الغذائية ,بالضبط لتناولك للاغذية المعالجة بشكل مفرط خلال الستة اشهر الاخيرة.

نصائح وإرشادات لفهم كيفية الإجابة:

_يطلب منك الإجابة على كل الأسئلة دون ترك سؤال واحد .

_يطلب منك الإجابة بوضع علامة (x) مرة واحدة في كل سطر.

_اجب مرة واحدة على كل غداء , من فضلك لا تضع عدة علامات للغذاء الواحد.

_من فضلك استخدم قلم الرصاص للإجابة في حالة الخطا امسح بالمماة.

[اذا كنت غير متأكد من عدد المرات التي تتناول فيها غذائك ,حاول مابوسعك قدير اجابتك اي بصفة عامة كم من مرة تستهلك هذا الغذاء.]

اجب على كل الأسئلة

الرياضة

منذ متى تمارس الرياضة؟

.....

كم عدد ساعات ممارستك للرياضة في الاسبوع؟

.....

التدخين

هل انت مدخن؟

☐ نعم ☐ لا

اذا اجبت بنعم :

منذ متى ؟

.....

كم عدد السجائر التي تدخنها في اليوم؟

.....

الأمراض

هل تعاني من امراض مزمنة؟

☐ نعم ☐ لا

اذا اجبت بنعم فاذكر اسم المرض :

.....

منذ متى تعاني من هذا المرض؟

.....

هل لديك حساسية من غذاء معين؟

☐ نعم ☐ لا

هل تتناول ادوية؟

☐ نعم ☐ لا

اذا اجبت بنعم :

اذكر اسم الدواء\الأدوية :

.....

ماهي مدة تناولها؟

.....

ماهي مدة تكرارها؟

.....

المكملات الغذائية :

خلال الأشهر الستة الأخيرة هل تناولت مكملات غذائية؟

☐ نعم ☐ لا

اذا اجبت بنعم :

ماهو اسم المكمل \المكملات:

.....

هل تتناول المكملات بشكل منتظم؟

.....

يرجى تحديد فترة ومدة أخذك للمكملات خلال الستة أشهر الماضية:

.....

ثالثا: الاغذية (يجب وضع علامة (x) واحدة لكل سؤال)

الخضر	مرة في اليوم	مرتين في اليوم	3او اكثر في اليوم	6_3مرات في الاسبوع	2مرات في الاسبوع	مرة في الاسبوع	3_2مرات في الشهر	مرة في الشهر	5_2مرات في 6 اشهر	مرة في 6اشهر	لم اتناوله خلال اخر6اشهر
سبانخ											
شمندر											
بروكلي											
كرنب											
بطاطا											
بطاطا حلوة											
طماطم نيئة											
فلفل حلو											
بقدونس											
سلطة خضراء											
زيتون											
كرفس											

الفواكه	مرة في اليوم	مرتين في اليوم	3او اكثر في اليوم	6_3مرات في الاسبوع	2مرات في الاسبوع	مرة في الاسبوع	3_2مرات في الشهر	مرة في الشهر	5_2مرات في 6 اشهر	مرة في 6اشهر	لم اتناوله خلال اخر6اشهر
برتقال											
ليمون											
موز											
رمان											
تفاح											
اجاص											
فراولة											
تمر											
فواكه اخرى											
كيوي											

المكسرات	مرة في اليوم	مرتين في اليوم	3او اكثر في اليوم	6_3مرات	2مرات في الاسبوع	مرة في	3_2مرات في الشهر	مرة في	5_2مرات في	مرة في 6اشهر	لم اتناوله خلال اخر6اشهر

Appendix

			في الاسبوع		الاسبوع		الشهر	6 اشهر		
لوز										
كاجو										
جوز										
فستق										
سمسم										
زريعة										
كسكس شعير										
الاكل التقليدي	مرة في اليوم	مرتين في اليوم	3او اكثر في اليوم	3_6مرات في الاسبوع	2مرات في الاسبوع	مرة في الاسبوع	2_3مرات في الشهر	مرة في الشهر	2_5مرات في 6 اشهر	مرة في 6اشهر	لم اتناوله خلال اخر6اشهر
كسكس سميد											
عجائن تقليدية											
حساء خضر (شربة....)											
طاجين زيتون											
طاجين جلبانة											
دولمة											
محاجب											
مسمن\بغرير											

اللحوم	مرة في اليوم	مرتين في اليوم	3او اكثر في اليوم	3_6مرات في الاسبوع	2مرات في الاسبوع	مرة في الاسبوع	2_3مرات في الشهر	مرة في الشهر	2_5مرات في 6 اشهر	مرة في 6اشهر	لم اتناوله خلال اخر6اشهر
لحم البقر											
لحم الغنم											
كبدالبقراو الغنم											

Appendix

دجاج										
كبد الدجاج										
ديك رومي										
سلمون										
سردين او anchois										
تونة كاملة										
ماكولات بحرية اخرى										

حبوب و بقوليات	مرة في اليوم	مرتين في اليوم	3او اكثر في اليوم	3_6مرات في الاسبوع	2مرات في الاسبوع	مرة في الاسبوع	2_3مرات في الشهر	مرة في الشهر	2_5مرات في 6 اشهر	مرة في 6اشهر	لم اتناوله خلال اخر6اشهر
عدس											
حمص											
فاصولياء											
فول											
ارز بني											
ارز ابيض											
شوفان											
خبزابيض(فرينة)											
خبزاكسرة قمح											
خبزاكسرة شعير											

البيضاحليب مشتقاته	مرة في اليوم	مرتين في اليوم	3او اكثر في اليوم	3_6مرات في الاسبوع	2مرات في الاسبوع	مرة في الاسبوع	2_3مرات في الشهر	مرة في الشهر	2_5مرات في 6 اشهر	مرة في 6اشهر	لم اتناوله خلال اخر6اشهر
حليب كامل الدسم											
حليب نصف دسم											

حليب بودرة										
حليب ببودرة الشكلاطة										
لبن\رايب										
ياغورت طبيعي										
جبن										
زبدة\سمن حيواني										
بيض										

الحلويات	مرة في اليوم	مرتين في اليوم	3او اكثر في اليوم	3_6مرات في الاسبوع	2مرات في الاسبوع	مرة في الاسبوع	2_3مرات في الشهر	مرة في الشهر	2_5مرات في 6 اشهر	مرة في 6اشهر	لم اتناوله خلال اخر6اشهر
حلويات تقليدية (مقروط...)											
بسكويت منزلي											
تحلية											
مربى منزلي											
عسل											
زريرة\روينة											
شكلاطة سوداء											

المشروبات	مرة في اليوم	مرتين في اليوم	3او اكثر في اليوم	3_6مرات في الاسبوع	2مرات في الاسبوع	مرة في الاسبوع	2_3مرات في الشهر	مرة في الشهر	2_5مرات في 6 اشهر	مرة في 6اشهر	لم اتناوله خلال اخر6اشهر
القهوة											
الشاي											
ماء معدني											
عصائر طبيعية											

بالنسبة للقهوة و الشاي هل تشرب

☐قبل الوجبات حدد الفترة الزمنية.....

Appendix

☐ عدد الوجبات حدد الفترة الزمنية.....

الماكولات المعالجة	مرة في اليوم	مرتين في اليوم	3او اكثر في اليوم	6_3مرات في الاسبوع	2مرات في الاسبوع	مرة في الاسبوع	3_2مرات في الشهر	مرة في الشهر	5_2مرات في 6 اشهر	مرة في 6اشهر	لم اتناوله خلال اخر6اشهر
الخبز الصناعي (برغر,توست...)											
عجينة و صلصلة البيتزا المصنعة											
مايونيز											
كاتشب											
حليب بالشكلاطة\فنيلا\فراولة											
لحوم معلبة (كاشير,مرقاز,)											
جومبو											
تونة\سردين معلبة											
هابرغر\طاكوس\ شاورما											
دجاج مقلي											
بطاطا مقلية											
البيتزا او اطباق جاهزة مجمدة											
البسكويت المالح والمقرمشات											
شيبس(chips)											

حبوب الافطار										
الكعك الصناعي (مادلين,كوكيز.....)										
الكرواسون \دونات الصناعي										
كريم ديسير\ موس شكلاطة										
الحلوى الصلبة										
العلكة										
السكر الابيض										
الاجبان المصنعة (كاممبير,لافاش كيري)										
ياغورت منكه معطر(فراولة....)										
الصلصات المصنعة(بيشاميل,كريمة الخفق..)										
الشكلاطة المعدلة (بالحليب,محشوة بالكراميل)										
مارغرين										
مستحضر تتبيل (vinaigrette)										
فلان مسحوق										
الأيس كريم الصناعي										
شاي مثلج										
قهوة معدلة(كابتشينو, محلاة.....)										
حلويات (Patisseries)										

العصائر الجاهزة										
الدهن الصناعي (نوتيلا.....)										
المعكرونة الصناعية (اندومي....)										
الحساء الصناعي										
السلطات المعلبة										
Smoothieجاهز										
sirop										
Puré صناعي										
Gauffres, Guimauves صناعية										

بالنسبة للمشروبات المصنعة

هل تشرب ☐ كاس ☐ كاسين ☐ 3او اكثر

بالنسبة للياغوت،فلان،تحليات

هل تتناول ☐ حصة ☐ حصتين ☐ 3او اكثر

(Barre de chocolat) بالنسبة للشكلاطة

هل تتناول ☐ قطعة ☐ قطعتين ☐ 3او اكثر

بالنسبة للشيبس

هل تتناول ☐ كيس ☐ كيسين ☐ 3او اكثر