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Ministry of Higher Education and Scientific Research

University of Blida 1



Faculty of Natural and Life Sciences

Food Sciences Department

Dissertation for the Master's degree in

**Specialization** : Food Safety and Quality Assurance

**Field** : Food Sciences

**Domain** : Natural and Life Sciences

**Valorization and formulation study of an energy bar using a bakery by-product**

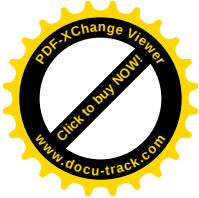
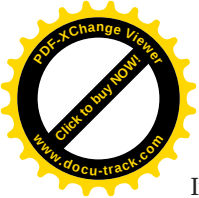
Presented by

**MALEK Aya**

**In the front of the jury :**

|                           |                     |                   |                    |
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**Academic Year 2024-2025**



## Acknowledgment

In the name of Allah, the Most Gracious, the Most Merciful, it is with sincere gratitude to Allah that the present project has been undertaken and completed.

We would like to express our deepest gratitude to our supervisor Dr. AOUES K, lecturer and teacher. Your consistent guidance, insightful feedback, and unwavering support have been instrumental in the successful completion of this work. Your expertise, patience, and encouragement have been invaluable ,providing us with the confidence and direction needed to navigate through the complexities of this research.

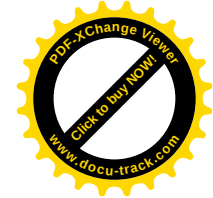
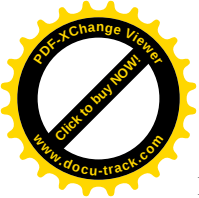
We would also like to extend our sincere appreciation to the president of the jury of our defense, Dr. BENLEMMANE S, a lecturer and teacher at Blida University. It is a great honor to have you on our jury. We extend our profound gratitude for your gracious consent to preside over this esteemed panel.

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## *Dedications*

I dedicate this project to myself... patience , courage and power that were a great part of me and i believe that hardship makes the human being stronger than ever and I believe for sure that I have realized a great project on my own by fighting bad conditions . I am sure that my project will see the light by being a company producing these healthy foods ,soon...Inch'Allah

It is to the family to whom i am closest that dedicate this thesis...To my cherished mother, whose infinite love, fortitude, and unwavering conviction in my capabilities have served as my guiding stars throughout my academic odyssey. I would like to express my deepest gratitude to my mother for her unwavering support, encouragement, and sacrifices. Her contributions have been instrumental in shaping my academic journey, motivating me to overcome challenges and pursue excellence.

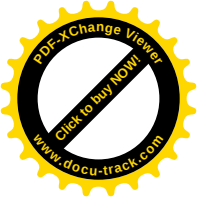
This modest undertaking is dedicated to my elder brother, the late Abdul Basit. He was a staunch and unyielding supporter, a loyal human being, and an invaluable companion. Your presence, support, and companionship were unwavering. The present author wishes to express the profound desire to be in the company of the aforementioned individual in order to bear witness to the personal development and achievements of the present author.

The present author is compelled to express the profound sense of loss that has been experienced over a considerable duration.

The profundity of this loss is beyond articulation, and the depth of my sentiments for you cannot be fully captured in writing.

I humbly beseech the Almighty to bestow upon you His infinite mercy and to grant you a celestial realm that encompasses the expanse of the heavens and the earth. In conclusion, I humbly request that this work be regarded as an ongoing charitable contribution in honor of your cherished, original, spontaneous and well-intentioned spirit.

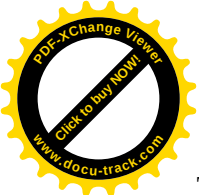
To my esteemed grandmother Kh'didja, whose unwavering support and fervent prayers are a constant source of strength for me, I humbly dedicate this academic end endeavor as a token of my profound gratitude and sincerest wishes for your longevity.



## Résumé

L'objectif de cette étude est de valoriser le pain rassis, un sous-produit significatif en Algérie, en concevant deux barres énergétiques destinées à une population cible de plus et de moins de 18 ans. Une étude approfondie menée auprès d'un échantillon de 123 participants, dont 65 % d'adultes et 35 % d'enfants et d'adolescents, a permis d'identifier les critères prépondérants qui influencent le choix des consommateurs. Il en ressort que le goût (23,3 %), la teneur en protéines (21,8 %) et le prix abordable (18,3 %) sont les principaux facteurs déterminants. Une texture mixte, à la fois croquante et fondante, est préférée par une large majorité des répondants, avec 68,9 % d'entre eux qui expriment une préférence pour cette caractéristique. En outre, 35 % des répondants indiquent leur préférence pour un prix situé entre 100 et 150 DA, suggérant une corrélation entre le prix et la texture préférée. Une analyse approfondie des données révèle que seulement 23,8 % des individus interrogés ont exprimé leur approbation des produits dérivés de sous-produits tels que le pain rassis. En outre, il est à noter que 47,5 % des répondants ont manifesté une indécision quant à ces produits, ce qui met en évidence un besoin pressant d'éducation et de communication. Les analyses physico-chimiques menées sur les échantillons révèlent des profils équilibrés. En effet, la Formulation 1 présente 17,10 % d'humidité, 16,21 % de matières grasses, 7,40 % de protéines et 1,67 % de cendres. La Formulation 2 affiche quant à elle 15,21 % d'humidité, 13,56 % de matières grasses, 6,31 % de protéines et 1,20 % de cendres. Ces résultats correspondent aux besoins des groupes cibles. L'intégration de pain rassis, de dattes et de graines de citrouille dans le régime alimentaire s'avère être un moyen efficace d'assurer un apport énergétique et minéral adéquat. Les analyses microbiologiques, effectuées selon les protocoles standards, révèlent une conformité aux normes en vigueur, avec des niveaux microbiens inférieurs aux seuils réglementaires. L'évaluation sensorielle révèle une appréciation générale, notamment en ce qui concerne la texture et le goût. Cependant, il a été démontré que l'optimisation de la complexité aromatique et de l'arrière-goût peut accroître significativement la satisfaction des consommateurs. Ces barres répondent ainsi aux critères nutritionnels, de sécurité et organoleptiques, tout en contribuant à la réduction du gaspillage. Dans cette perspective, les efforts futurs devront se concentrer sur l'éducation des consommateurs, l'optimisation produit et des essais approfondis pour favoriser leur adoption durable sur le marché algérien.

**Mots clés :** Valorisation, sous-produit, pain rassis, barre énergétique, nutritionnelle



## Abstract

The objective of this study is valorizing stale bread, a significant by-product in Algeria, by developing two energy bars for consumers over and under the age of 18. A survey of 123 participants (65% of whom were adults, and 35% of whom were children or teenagers) identified taste (23.3%), protein content (21.8%), and affordability (18.3%) as the primary criteria for choice. The majority of respondents, 68.9%, expressed a preference for a texture that is both crunchy and meltable. In contrast, 35% of respondents indicated a preference for a price between 100 and 150 DA. A mere 23.8% expressed approval for by-product products such as stale bread, while 47.5% remained undecided, underscoring a pressing need for educational initiatives and effective communication strategies. Physic-chemical analysis reveal balanced profiles: Formulation 1 contains 17.10% moisture, 16.21% fat, 7.40% protein, and 1.67% ash, while Formulation 2 contains 15.21% moisture, 13.56% fat, 6.31% protein, and 1.20% ash. These values correspond to the nutritional requirements of the target demographic. The incorporation of stale bread, dates, and pumpkin seeds contributes to a favorable energy and mineral intake. Conducting a thorough microbiological analysis has confirmed that the levels of microbial contaminants are consistently below the regulatory thresholds established by the relevant authorities. Sensory evaluation indicates a general appreciation, particularly with regard to texture and taste. However, further optimization of aromatic complexity and aftertaste has the potential to enhance satisfaction. These bars, therefore, meet nutritional, safety, and organoleptic criteria, while concomitantly contributing to the reduction of waste. In light of these observations, subsequent initiatives must prioritize consumer education, product optimization, and rigorous testing to facilitate their sustainable integration into the Algerian market.

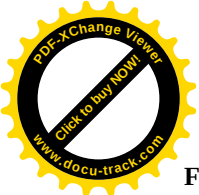
**Key words :** Valorization, by-product, stale bread, energy bar, nutritional .

## الملخص

الهدف من هذه الدراسة هو تثمين الخبز القديم ، وهو منتج ثانوي مهم في الجزائر، من خلال تصميم لوحين من ألواح الطاقة موجّهين إلى فئة مستهدفة من السكان الذين تزيد أعمارهم عن 18 عامًا أو أقل. حددت دراسة متعمقة لعينة مكونة من 123 مشاركًا، 65% منهم من البالغين و35% من الأطفال والمراهقين، المعايير الرئيسية التي تؤثر على اختيار المستهلك. وكان الطعم (23.3%) والمحتوى البروتيني (21.8%) والقدرة على تحمل التكاليف (18.3%) هي العوامل الرئيسية المحددة. القوام المختلط، سواء كان مقرمشًا أو ذائبًا في الفم، هو المفضل لدى الغالبية العظمى من المجيبين، حيث أعرب 68.9% منهم عن تفضيلهم لهذه الخاصية. بالإضافة إلى ذلك، أشار 35% من المشاركين في الاستطلاع إلى تفضيلهم لسعر يتراوح بين DA100 وDA150 ، مما يشير إلى وجود علاقة بين السعر والقوام المفضل. يكشف المزيد من التحليل للبيانات أن 23.8% فقط من المجيبين أعربوا عن موافقتهم على المنتجات المشتقة من المنتجات الثانوية مثل الخبز الذي لا معنى له.

وتجدر الإشارة أيضًا إلى أن 47.5% من المشاركين في الاستطلاع لم يحسموا أمرهم بشأن هذه المنتجات، مما يسلط الضوء على الحاجة الملحة إلى التثقيف والتواصل. تكشف التحليلات الفيزيائية والكيميائية التي أجريت على العينات عن ملامح متوازنة. تحتوي التركيبة 1 على محتوى رطوبة بنسبة 17.10%، ومحتوى دهون بنسبة 16.21%، ومحتوى بروتين بنسبة 7.40% ومحتوى رماد بنسبة 1.67%. تحتوي التركيبة 2 على نسبة رطوبة 15.21% ونسبة دهون 13.56% ونسبة بروتين 6.31% ورماد 1.20%. تتوافق هذه النتائج مع احتياجات المجموعات المستهدفة. وقد أثبت دمج الخبز القديم والتمر وبذور اليقطين في النظام الغذائي أنه وسيلة فعالة لضمان الحصول على كمية كافية من الطاقة والمعادن. كشفت التحاليل الميكروبيولوجية، التي أجريت وفقًا للبروتوكولات القياسية، عن الامتثال للمعايير الحالية، مع وجود مستويات ميكروبية أقل من العتبات التنظيمية. وكشف التقييم الحسي عن تقدير عام، خاصةً فيما يتعلق بالقوام والطعم. ومع ذلك، فقد تبين أن تحسين التعقيد العطري والمذاق يمكن أن يزيد بشكل كبير من رضا المستهلك. وبالتالي فإن هذه القوالب تلبي المعايير الغذائية ومعايير السلامة والمذاق الحسي، وتساعد في الوقت نفسه على تقليل الهدر. ومع وضع ذلك في الاعتبار، يجب أن تركز الجهود المستقبلية على تثقيف المستهلك وتحسين المنتج وتجربته.

**الكلمات المفتاحية:** التثمين، مخلفات الطعام، ألواح الطاقة، خبز قديم، التغذية.



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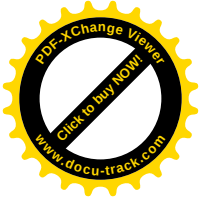
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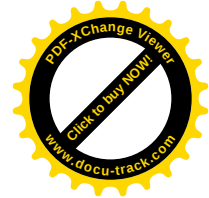
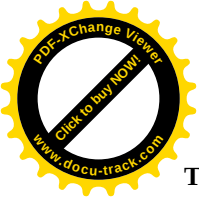


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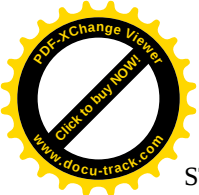
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## Abbreviations list



**ST : Stale bread .**

**BW : Bread waste.**

**LA : Lactic acid.**

**5-HMF : 5-Hydroxymethylfurfural.**

**BDO : 2,3-Butanediol.**

**SA : Succinic acid.**

**CFU : Colony Forming Units.**

**ETOH : Ethanol.**

**FAO : Food and Agriculture organization.**

**WHO : World Health Organization.**

**SD : Standard Deviations.**

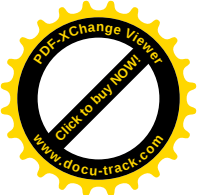
**NF : French norm.**

**NA : Algerian norm.**

**FDA : U.S Food and Drug Administration.**

**CAGR : Compound Annual Growth Rate.**

**L : Litter.**



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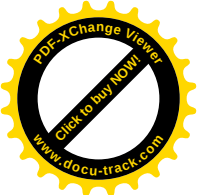
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CHAPTER I

Bread

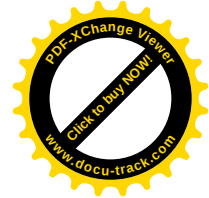
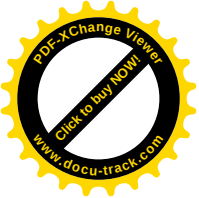
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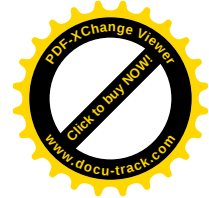
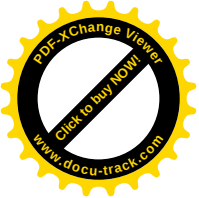


# Experimental Part

## CHAPTER I

### MATERIAL AND METHODS

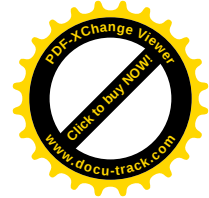
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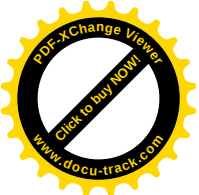
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## **Conclusion**



# Introduction

## Introduction

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Food waste represents a critical global issue, with approximately one-third of all food produced for human consumption being lost or wasted each year (FAO, 2023; Gustavsson et al., 2011). Bread, a staple food, contributes significantly to this problem, particularly in countries with high per capita consumption. Algeria has been identified as a nation with a notable consumption of bread, with an estimated annual per capita intake of 110 kilograms, second only to Turkey (Ammar et al., 2023; Statista, 2024). During Ramadan, there is a surge in bread consumption due to increased meal frequency and social gatherings, exacerbating the problem of bread waste (Bencheikh et al., 2023).

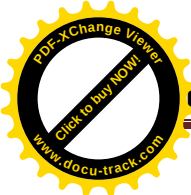
Stale bread, which constitutes a significant portion of bakery waste, is rich in carbohydrates and retains functional properties suitable for up-cycling into new food products (Gupta et al., 2023; Capanoglu et al., 2020). The utilization of stale bread in the realm of food innovation finds congruence with international sustainability strategies, which are oriented towards the mitigation of environmental impact and the generation of value-added products from food by-products (Mirabella et al., 2014; Galanakis, 2021).

Concurrently, Algerian dietary habits, notably breakfast routines, are undergoing a period of transition. According to Kherfi et al. (2022) and Djazagro (2023), the traditional breakfast consists of bread accompanied by coffee or tea, as well as butter, jam, or pastries. However, there has been a discernible shift toward convenient, nutrient-dense options such as energy bars, which is analogous to global trends in the "snackification" of food and the substitution of meals (Mintel, 2023; Research and Markets, 2025). In select markets, a significant proportion of consumers, amounting to up to 60%, have replaced conventional breakfast options with energy bars, signifying an escalating demand for portable and functional foods (Euromonitor, 2023).

The objective of this study is to develop and evaluate two energy bar formulations—one for adults (18+) and one for children and adolescents (<18)—using stale bread as a sustainable base. The objective of this study is to present a series of pragmatic, nutritionally sound, and ecologically sustainable alternatives to the conventional Algerian breakfast. These alternatives are designed to align with both consumer preferences and the pressing concern of bread wastage.

The research addresses the following questions:

1. Do energy bars formulated with stale bread meet consumer expectations for nutrition, safety, and sensory appeal?



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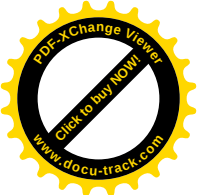
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2. Can these bars contribute effectively to food waste valorization?

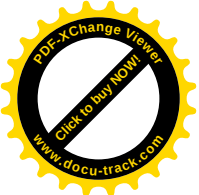
The hypotheses are:

1. Energy bars made from stale bread can achieve acceptable nutritional, microbiological, and sensory quality, and with sufficient consumer education, can be accepted as convenient, nutritious breakfast alternatives for diverse Algerian populations.
2. The use of stale bread in energy bar formulations contributes meaningfully to food waste valorization.

This study integrates a multifaceted approach, encompassing nutritional analysis, microbiological safety assessment, consumer surveys, and sensory evaluation, to comprehensively assess the feasibility and acceptance of these formulations. The initiative pursues a dual objective: to promote sustainable product development and to modernize Algerian dietary habits. By engaging in this practice, it contributes to the ongoing efforts in the realm of breakfast innovation and promotes environmental responsibility.

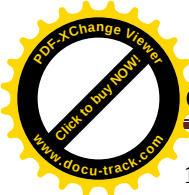


# **Bibliographical Part**



# **CHAPTER I**

## **Bread**



## CHAPTER I: Bread

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### 1\_Bread definition :

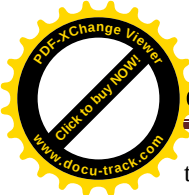
Bread constitutes a fundamental and indispensable food resource across numerous cultures. This foodstuff comprises a plethora of essential constituents, including but not limited to carbohydrates, proteins, fibers, lipids, salts, and vitamins. Collectively, these elements render bread a significant source of energy and nutrients. Moreover, bread constitutes an unstable, elastic, solid, and intricate matrix comprising baked dough and air, giving rise to a structure reminiscent of open foam or sponge. The solid part of the bread contains a continuous phase, which is composed of an elastic network of cross-linked gluten molecules (**Shewry, Halford, Belton, & Tatham, 2002**) and leached starch polymer molecules (**Damager, Engelsen, Blennow, Møller, & Moturia, 2010**). These molecules include primarily amylose, both un-complexed and complexed with polar lipid molecules, and a discontinuous phase. The phase of entrapped, gelatinized, swollen, and deformed. starch granules has been documented (**Aguirre, Osella, Carrara, Sanchez, & Buera, 2011; Gray & Be Miller, 2003**).

#### 1.1\_Stale bread definition :

The phenomenon of stale bread is attributable to the natural process of moisture loss and retro gradation. When bread is exposed to air, the moisture within the bread evaporates, causing it to become dry and hard. This process is accelerated in bread with a higher water content, such as artisanal or homemade bread (**Recipes.net 2024**)

#### 1.2\_Staling process :

The phenomenon of bread staling has been the subject of extensive research for over a century. The earliest documented research on staling was reported by **Boussingault** in 1852 (**Boussingault, 1852**), who demonstrated that the staling of bread is not attributable to the loss of moisture during the drying process. Instead, **Boussingault** concluded that the staling of bread could be reversed through moderate heating. Katz (**1928**) utilized X-ray diffraction to demonstrate that the crystallization of amylose and amylopectin (a manifestation of starch retrogradation) was responsible for the firming of bread over time. Despite extensive research efforts, the complete molecular mechanisms for bread staling remain elusive (**Gray & BeMiller, 2003**). Despite their simplicity, even rudimentary formulations of bread dough comprise numerous ingredients. Wheat flour, the primary component of bread, consists of intricate families of carbohydrates, proteins, and lipids, in addition to a substantial quantity of secondary metabolites (**Khakimov, Jespersen, & Engelsen, 2014**). These multifarious components exert a profound influence on the staling process of bread, as they undergo substantial alterations during



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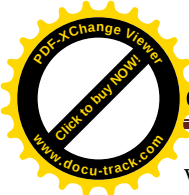
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the bread-making process and during the aging of the final product. Therefore, the staling kinetics are contingent upon a multifaceted equilibrium of input parameters (comprising dough ingredients, yeast, and enzymes), process parameters (encompassing mixing, proofing, baking, and cooling), and storage parameters (such as humidity and temperature).

The primary manifestation of bread staling is crumb firming. A mechanistic understanding of this phenomenon posits that alterations in the starch component (65-70% of the wheat flour) are predominantly responsible for bread staling. When starch is heated in the presence of water (i.e., during baking), it undergoes swelling and subsequently gelatinizes at a certain temperature. During this process, the native ordered structure—or crystallinity—of the starch granules will be lost, and a disordered polymeric "gel" network will be created. However, this starch gel is a metastable system, and upon aging, it will slowly recrystallize (retrograde). The predominance of staling as a crystallization process is substantiated by the observation that the staling of bread increases with decreasing storage temperature, a hallmark of crystallization processes, though not a prevalent approach in chemical reactions (**Fearn & Russell, 1982**). While it was demonstrated early on that the drying out of the bread does not explain the staling process (**Boussingault, 1852**), it has been shown that the moisture content of the bread is the major factor controlling the firming rate in the bread and that the moisture content is inversely proportional to the rate of firming (**Rogers, Zelezná, Lai, & Hoseney, 1988**). However, as bread undergoes the aging process, a migration of water occurs from the interior crumb to the exterior crust. This migration results in the evaporation of water from the surface of the bread.

These processes have the potential to result in the transfer of water from one component to another. This transfer may, in turn, contribute to the staling of bread. This is due to the fact that the properties of gels of starch and gluten are markedly influenced by water. Furthermore, starch retrogradation is dependent on the availability of water as a plasticizer. A substantial body of research has been dedicated to the study of the kinetics of moisture loss during bread baking and staling. This research has employed a variety of analytical methods, including in situ nuclear magnetic resonance (NMR) analysis and texture profile analysis (**Engelsen, Jensen, Pedersen, Nørgaard, & Munck, 2001**). In recent years, there has been an emphasis on the development of empirical and semi-theoretical models to predict moisture loss in bread (**Pour-Damanab, Jafary, & Rafiee, 2013**). These models have primarily focused on the moisture. During the process of baking, a certain amount of loss is inevitable. A significant number of scientific and industrial initiatives have been dedicated to the study of methods to retard the process of bread staling. This is due to the fact that a substantial amount of financial capital, energy, and food is



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wasted both by consumers and by industry. It has been demonstrated that several ingredients have the potential to retard the process of bread staling. Pentosans, which are a natural ingredient in wheat flour, act as a sponge and thus increase the water absorption, thereby retarding the staling process. A similar effect is produced by other ingredients, such as modified starches and salts. Emulsifiers are the most frequently used anti-staling agents. While the mechanisms by which they act are not yet fully understood, it is known that they form a complex with the amylose or amylopectin, thereby retarding, but not completely inhibiting, retro-gradation. Numerous studies have indicated that the addition of amylases to bread formulations reduces the firming of bread (**Miller, Johnson, & Palmer, 1953**). Three different mechanisms have been proposed to explain this phenomenon: (1) decreased starch retro-gradation, (2) decreased rigidity of the starch gel network, and (3) decreased starch/protein interactions. However, it is an irrefutable conclusion that the functional effect of  $\alpha$ -amylases in freshness is chiefly to act on amylopectin, forming soluble, low-molecular-weight branched-chain polymers. These polymers are less prone to retro-gradation and alter water availability and mobility. Consequently, these changes significantly impact starch gelatinization and retro-gradation. Evidently, enzymes possess the capacity to reduce production costs and enhance profits, while also improving sustainability.

### **1\_Bread consumption in Algeria :**

The Algerian Ministry of Commerce has published a report on the waste of bread during the month of Ramadan in 2021. The study, which was conducted from April 13 to 24 of that year, revealed that a total of 535 tons of bread were wasted during the first 12 days of Ramadan. This amounts to 2,139,884 units of bread, with an average of 45 tons of bread wasted per day, equivalent to 178,323 units. The financial value of this wasted bread was estimated at 20 million Algerian dinars . According to official statistics, the average daily consumption of bread in Algeria is 2.7 million units. The Ministry of Commerce has estimated the financial value of this wasted quantity at 20 million Algerian dinars, which is equivalent to more than 1.5 million Algerian dinars per day. As illustrated in Table 01, the provinces with the highest rate of bread waste .

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**Table 01 : HIGHEST RATES OF WASTE BREAD (Ahcene Youcef Benabdallah et al.,2022)**

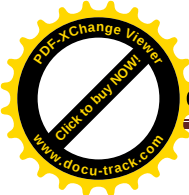
| N° | Province | Quantity of breads (units) |
|----|----------|----------------------------|
| 1  | Blida    | 321,924                    |
| 2  | Bechar   | 161,648                    |
| 3  | Tlemcen  | 150,696                    |
| 4  | Djelfa   | 139,364                    |
| 5  | Annaba   | 118,680                    |
| 6  | Tebessa  | 115,152                    |
| 7  | Oran     | 108,200                    |

### 4 \_Valorization types of stale bread :

The previous works have further demonstrated the untapped potential of bread waste as a valuable source for producing high value products within the circular bio-economy. For instance, **Narisetty et al. (2021)** discussed BW generation across the supply chain and its associated logistical challenges. The study also revealed numerous potential applications, such as the production of bio-plastics, bio-chemicals, bio-fuels, pharmaceuticals, and other renewable products, using the clean and high-quality fermentable sugars derived from bread waste through microbial fermentation. Similarly, **Ben Rejeb et al. (2022)** emphasized the valorization of bread waste into various valuable chemical building blocks, including aroma compounds, bio-hydrogen, enzymes, ethanol, glucose–fructose syrup, 5-hydroxymethylfurfural, lactic acid (LA), proteins, pigments, and succinic acid (SA). Another study by **Kumar et al. (2022)** highlighted that bread waste is a sustainable feedstock to produce a wide range of platform chemicals, including SA, LA, ethanol, 2,3-butanediol (BDO), and syngas.

#### 4.1 \_Bread waste (BW) generation :

Despite its significance in the human diet, bread possesses a relatively brief shelf-life of approximately three to six days at room temperature. This phenomenon can be attributed to the high nutrient content of the fruit, which renders it susceptible to decomposition and staling (**Taglieri et al., 2021; Bhardwaj et al., 2023; Immonen, 2023**). Furthermore, it has been demonstrated by **Ben Rejeb et al. (2022)** that the cooking process transforms the starch into a gelatinized form that is susceptible to microbial attack.



### A\_ The promotion of a circular bio-economy is a key component of the BW bio-refinery:

At present, the world is confronted with two interconnected challenges: the generation of a substantial amount of waste and the diminishing availability of fossil fuels. The conventional approach to waste reduction involves implementing waste management based on a hierarchical framework directive, which raises ecological and environmental concerns. The waste framework directive has been identified as a viable solution for decreasing food waste, including bread waste (**de Sadeleer et al., 2020**). A study by **Eriksson et al. (2015)** demonstrated the potential of bread waste to reduce greenhouse gas (GHG) emissions.

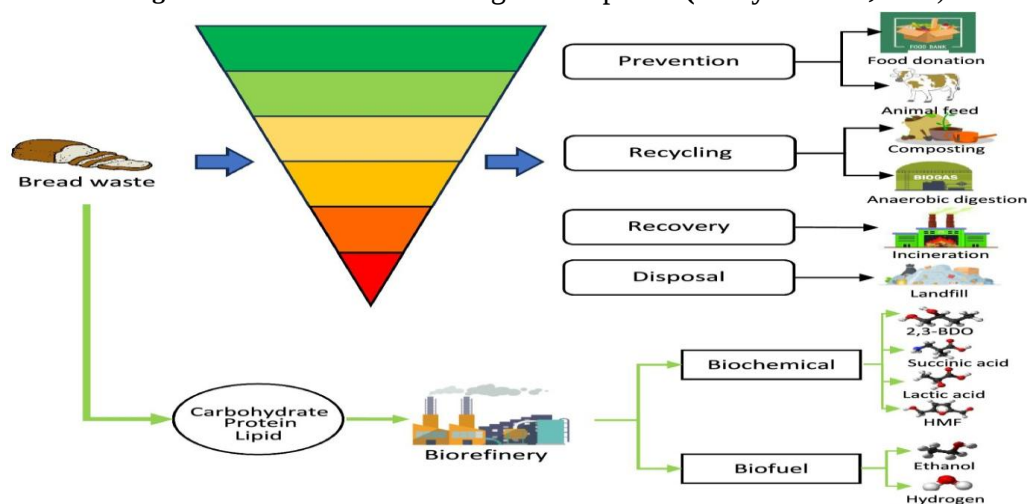
Nevertheless, priority should be given to waste prevention over waste management options, as the former has a more positive impact on the environment. This assertion is corroborated by a study conducted by **Slorach et al. (2020)**, which demonstrated that waste prevention is six times more effective in reducing greenhouse gases (GHGs) compared to targeted collection for anaerobic digestion (AD). **Vandermeersch et al. (2014)** also determined that the utilization of BW for animal feed had a more favorable environmental impact than anaerobic digestion. Consequently, the conclusions reached by **Brancoli et al. (2020)** demonstrate that the reduction of body weight (BW) through donation, source reduction, and the production of animal feed results in substantial environmental benefits when compared with anaerobic digestion (AD) and incineration.

Although the prevention of bread waste is imperative, its implementation may not always be viable. In such circumstances, the development of effective strategies for valorizing the surplus becomes paramount. One prospective approach entails the utilization of excess bread flour through the application of alternative methods, such as enzymatic and/or fermentation processes, to yield valuable new products. This concept has been proposed by **Gómez and Martínez (2023)** as a subject meriting further investigation. In the context of waste management strategies, the prioritization of reducing food waste, including BW, should be accorded a high level of importance. This approach is crucial for minimizing environmental impacts and mitigating the effects of climate change.

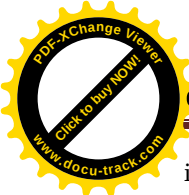
As an alternative solution, researchers are exploring the bio-refinery approach as a promising method to reduce the utilization of fossil fuel-based feed-stocks. The objective is to produce chemical and energy products from renewable sources, ensuring that these products are produced in a sustainable manner. The term "bio-refinery" draws inspiration from the processes observed in crude oil refineries and bears a close resemblance to the petroleum refining and petrochemical

industry. The objective of a bio-refinery is to facilitate the effective processing of biomass derived from plants, algae, agricultural waste, municipal waste, animal byproducts, and food waste. The end products of this process include energy, fuels, polymers, and food additives, among others (Sadhukhan et al., 2014). Moreover, the bio-refinery embodies a strategic approach that fosters the sustainability of the plant in its entirety by integrating processes that enhance energy efficiency, reduce water consumption, and mitigate emissions (Ubando et al., 2020; Thongchul et al., 2022). Presently, the commercial utilization of first-generation bio-refineries is centered on the production of bio-ethanol and bio-diesel.

Figure N°1 : Bread waste management options ( Hafyan et al.,2024)



Nonetheless, the utilization of edible substrates in these bio-refineries encompasses an ongoing discourse concerning the equilibrium between addressing the demands of the human population and confronting global food shortages (Malode et al., 2021; Thong et al., 2022). In order to circumvent the aforementioned issue, the utilization of non-edible feed-stocks in second-generation (2G) and third-generation (3G) bio-refinery approaches has garnered attention as a potential alternative (Hassan et al., 2019; Tong et al., 2022). Ligno-cellulosic biomass (LCB) has been the primary focus of research in 2G bio-refineries. Nonetheless, the commercialization of LCB-based bio-refineries has been accompanied by a number of challenges, primarily due to the recalcitrant nature of the material and the high costs associated with its pretreatment for efficient valorization (Chandel et al., 2020). Conversely, algal biomass is being explored for use in third-generation (3G) bio-refineries, which offer potential for sustainable bio-production. However, it is imperative to acknowledge that this technology has been exclusively evaluated in laboratory settings, and its implementation at an industrial scale remains elusive due to its cost-



inefficiency (**Kumar et al., 2022**). The viability of bio-based products in the commercial sector is contingent upon their cost-competitiveness (**Doddapaneni and Kikas, 2021**).

Platform chemicals derived from unavoidable food waste are of particular interest, as they have the potential to replace primary chemicals. For example, (**Sadhukhan et al. (2016)**) demonstrated the conversion of food waste into levulinic acid, and (**Sadhukhan et al. 2019**) demonstrated the utilization of seaweed for nutraceuticals, pharmaceuticals, cosmeceuticals, and health, personal, and home care products. The utilization of waste materials that are abundant, cost-effective, and rich in renewable and fermentable carbon represents a significant opportunity for expanding the biomass feedstock sector. Among the waste streams that have gained popularity due to their suitability as carbon feed-stocks for bio-refineries are those with high sugar content, including food, bakery, bread, fruit, and beverage waste.

As previously stated, BW is a starchy material that provides a clean and easily extractable source of fermentable sugars. In contrast, LCB feed-stocks require harsh physical, chemical, and enzymatic treatments.

The utilization of BW-based feedstock offers an additional benefit; namely, the absence of inhibitors in the resulting sugars (**Dymchenko et al., 2023**). This characteristic renders BW a promising carbon source for novel commercial processes. Alternative methods that employ chemical and enzymatic pretreatment processes to liberate fermentable sugars have been developed to complement this approach. BW is predominantly composed of polysaccharides and trace amounts of disaccharides, with a typical composition of 50–70% starch, 8–10% protein, and 1–5% fat (**Nair et al., 2017; Jung et al., 2022; Kumar et al., 2022; Narisetty et al., 2022a**).

Recent studies have examined alternative methods for recycling BW into marketable bio-chemicals and bio-fuels. These studies' findings underscore the significant potential of BW as a promising substrate for producing a wide range of valuable fermentable sugars, bio-chemicals, and bio-fuels. Furthermore, the biochemical products derived from BW discussed in this article are regarded as promising. According to the United States Department of Energy (US DOE) (**Werpy and Petersen, 2004**), these chemicals are considered to be among the top 12 platform chemicals. Furthermore, E4TECH is currently investigating their potential as attractive bio-based chemical products, taking into consideration both market attractiveness and UK strengths (**LB Net, 2017**).

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In addition, two bio-fuels derived from BW that show considerable promise are bio-ethanol and hydrogen ( $H_2$ ), both of which are expected to replace fossil fuel based energy in the future. Bio-ethanol is currently used as a blend in the transportation industry, in accordance with the European Union's Renewable Energy Directive, which aims to replace 10% of transport fuel with bio-fuels like bio-ethanol (**van Niekerk and Kay, 2020**).

A similar policy is in place in the UK with the Renewable Transport Fuel Obligation (RTFO), which requires fuel suppliers to source a portion of their fuel from renewable sources. The RTFO establishes an escalating target for bio-fuel production, increasing from 4.75% in 2020 to 12.4% by 2032 (**Küfeoğlu and Khah Kok Hong, 2020**). Moreover, hydrogen ( $H_2$ ) has emerged as a sustainable and promising source of energy, with the potential to generate zero emissions during combustion. Achieving the UK's net-zero emissions targets will require the development of a low-carbon  $H_2$  sector. The Energy Research Partnership (ERP) has provided an estimation of the current demand for  $H_2$  in the UK. The ERP reports that the demand is approximately 27 terawatt-hours per year (**Chari et al., 2023**).

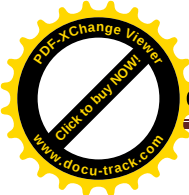
### **B\_ Bio-chemicals and bio-fuels from stale bread :**

The following section primarily emphasizes a range of economically viable bio-chemicals and bio-fuels derived from Bread Waste, along with an in-depth exploration of the methodologies employed in the conversion of Bread Waste into a diverse array of bio-products.

#### **Bio-chemicals :**

##### **1.1\_Butanediol :**

2,3-BDO is regarded as a high-value chemical that has found extensive application in various industries, including food production, chemical manufacturing, cosmetics, and pharmaceuticals (**Gadkari et al., 2023**). According to **Tinôco et al. (2021)** and **Maina et al. (2022)**, the 2,3-BDO market is projected to reach approximately \$220 million by 2027, with a compound annual growth rate (CAGR) of 3% from 2019 to 2027. The objective of the study conducted by **Narisetty et al. (2022b)** was to produce BDO in a sustainable manner from BW using *Enterobacter ludwigii*. The findings of the study indicated that under optimal conditions—defined as a solid loading of 10% w/v and an enzyme loading of 0.6 mg/g—enzymatic hydrolysis resulted in a BDO yield of 0.43 g/g glucose. In the context of fed-batch cultivation, BDO attained a concentration of 138.8 g/L after a duration of 96 hours, yielding a productivity of 0.48 g/g of brewery waste.



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### 1.1\_Succinic acid :

SA is a critical compound that is regarded as one of the twelve primary according to the United States Department of Energy (USDOE), the substance in question is a platform chemical. In 2022, the worldwide market for SA was valued at \$160.8 million, and it is projected to exhibit growth at an annual rate of According to **Escanciano et al.**, the annual rate of growth is estimated to be 6.5%, which is projected to result in a total of \$301.4 million by the year 2032.

The potential economic and sustainable impact of producing succinic acid of The utilization of renewable carbohydrate feed-stocks through the fermentation process is a critical aspect of the SA process. The substance under consideration possesses aesthetic qualities and has the potential to supplant the use of petroleum-based products currently in circulation. The manufacturing process is underway. **Leung et al. (2012)** utilized enzymes from *Aspergillus* extraction of sugars and amino acids is achieved through the utilization of *Awamori* and *Aspergillus oryzae*. This text is derived from BW. This hydrolysate was subsequently utilized for SA production by *Actinobacillus succinogenes* through solid-state fermentation. The following assertion is made:

The process of bacterial fermentation yielded 47.3 grams per liter of SA, resulting in an overall yield. The quantity was found to be 0.55 grams per gram of bread waste .

### 1.2\_Lactic acid :

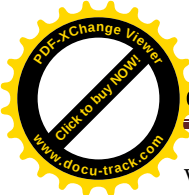
LA has been identified as a versatile platform chemical with a market potential of \$2.64 billion, attributed to its wide range of applications (**Shoaf and Engelberth, 2022**). **Cox et al. (2022)** conducted a study in which they investigated different hydrolysis (acidic and enzymatic) processes of bread waste to produce LA. Enzymatic hydrolysis was found to be the most effective method for producing glucose, with a maximum release of 98.6 g/L and a yield of 0.49 g glucose/g bread waste, as measured using Dextrozyme from Novozymes. In addition, the fed-batch fermentation process conducted with *B. Coagulans* resulted in a titer of 155.4 g/L LA, accompanied by a productivity and LA yield of 1.30 g/L and 0.42 g/g BW, respectively. **Sadaf et al. (2021)** explored the potential of bread waste as a rich source of reducing sugars for the production of LA. In conditions of simultaneous saccharification and fermentation, SKL-11 demonstrated the most significant LA production, reaching 56 milligrams per gram of bakery waste, which is equivalent to 28 grams per liter.

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### 1.3\_ 5-Hydroxymethylfurfural

5-Hydroxymethylfurfural (5-HMF) is a versatile platform chemical that can be transformed into a variety of useful materials. Its applications include areas such as medicine, chemistry, food science, pesticides, and the production of diesel fuel (**Kong et al., 2020**). According to the findings of **Albonetti et al. (2022)**, the anticipated global market value of 5-HMF is expected to attain a value of EUR 55 million by the year 2024, exhibiting a compound annual growth rate (CAGR) of 1.4%. In their 2018 study, **Yu et al.** investigated the potential of propylene carbonate (PC) and  $\gamma$ -valerolactone (GVL) as eco-friendly co-solvents in a binary solvent-water medium for the conversion of bread waste to 5-hydroxymethylfurfural (5-HMF) over  $\text{SnCl}_4$  as the catalyst. The study demonstrated that the PC/ $\text{H}_2\text{O}$  solvent system exhibited superior performance, achieving a significant 5-HMF yield of 20 mol%. On the other hand, the GVL/ $\text{H}_2\text{O}$  solvent system yielded a lower 5-HMF yield of 13.5 mol%. **Iris et al. (2017)** investigated the effects of selected media on the desired pathways (hydrolysis, isomerization, and dehydration). In the course of the experiment, it was demonstrated that the use of the polar aprotic solvent of acetonitrile (ACN)/hydrofluoric acid ( $\text{H}_2\text{O}$ ) was the most effective strategy for the synthesis of 5-hydroxymethyl-2-furfurylamine (HMFA) from Beta-Z-W. The yield of 5-HMF from Beta-Z-W was determined to be 0.217 g/g, representing the highest rate of 5-HMF production. The by product 5-hydroxymethyl-2-furfurylamine (HMFA) is a vital intermediate in the synthesis of pharmaceuticals, thus highlighting its significant industrial application with notable applications in synthesising pharmaceutical hardeners, epoxy resins, bio-fuels and furan-derived chemicals (**Gao et al., 2023b**). **Wu et al. (2023)** converted bread waste to HMFA using a cascade reaction in betaine:malonic acid (B:MA) water. They achieved a 30.3% yield of 5-HMF from bread waste in 45 min at  $190^\circ\text{C}$ . They converted the 5-HMF to HMFA using a specially engineered *E. coli* biocatalyst, they converted the 5-HMF into HMFA with a yield of 0.282 g HMFA/g bread waste at  $35^\circ\text{C}$  for 12 h.

**Gao et al. (2023a)** proposed an innovative approach to convert bakery waste into HMFA using a two-step method to convert bakery waste into HMFA. This method is based on tandem catalysis using the deep eutectic solvent betaine/formic acid as the chemical catalyst and as the chemical catalyst and *Escherichia coli* HILF as the biocatalyst. Initially, a chemical catalyst, betaine/formic acid, was used on the BW, which yielded 0.269 g 5-HMF/g bread waste. Subsequently, using a specialized *Escherichia coli* HILF biocatalyst, which efficiently converted 5-HMF to HMFA with a remarkable yield of 0.243 g HMFA/g BW within 6h.. **Zhang et al. (2023)** used a chemoenzymatic approach to synthesize 5-HMF to synthesize 5-HMF from bread



## CHAPTER I: Bread

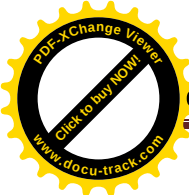
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waste for the production of 2,5-furandimethanol (FDM). This process involved a combination of catalysis using the deep eutectic solvent lactic acid :betaine as the chemocatalyst and the chemocatalyst and the HMFOMUT cell (biocatalyst): *E. coli* HMFMOU whole cell). The results showed that under the conditions of lactic acid :betaine (15 wt%) at 180°C for 15 min, the yield of 5-HMF yield reached 44.2 C mol% BW. In the presence of lactic H<sub>2</sub>O, the HMFOMUT efficiently converted 5-HMF from bread waste into FDM, achieving a remarkable productivity of 700 kg of FDM per kg of 5-HMF (equivalent to 230 kg of FDM per kg of bread waste).

### C\_ Bio-fuels :

#### 1.1\_Bio-ethanol :

Bio-ethanol is a promising bio-fuel with a number of favourable properties, including combustion efficiency, high octane number and heat evaporation (**Narisetty et al., 2021**). Currently, the studies have been carried out to improve the production of bio-ethanol from production from bread waste. **Nikolaou et al. (2023)** investigated the feasibility of bio-ethanol production from BW by investigating two different experimental different experimental processes: Separate Hydrolysis and Fermentation (SHF) and simultaneous saccharification and fermentation (SSF). The investigation showed that the optimal conditions for bio-ethanol production were under SSF conditions, specifically at 20% solids loading, an enzyme loading, an enzyme loading of 20  $\mu$ L/g starch, and 2% w/w *Saccharomyces cerevisiae*, maintained at 35°C for 48 hours. This means that conditions resulted in a bio-ethanol concentration of 87.5 g/l. **Narisetty et al. (2022a)**, carried out a comprehensive study on bioethanol production from BW, where the optimisation of the saccharification process both acid and enzymatic hydrolysis, was also investigated. Solid and acid/enzyme loading. Enzymatic hydrolysis showed optimal glucose release, reaching 97.9 g/L at a solids loading of 20% w/v. This was equivalent to 95.9% of the maximum theoretical yield. The resulting hydrolysate was then subjected to fermentation for ethanol production. Ethanol titres, yields and productivity were 114.9 g/L, 0.49 g/g and 3.2 g/l.h, respectively. **Ünalet et al. (2022)** also investigated the improvement of bio-ethanol production. investigated the effect of temperature (25 and 30 °C) and nitrogen supplementation (with or without 20 g/L peptone) on the bio-ethanol production from BW. Average ethanol yield using BW at 30 °C was  $0.49 \pm 0.005$  g ethanol/g BW with  $95.75\% \pm 0.93$  of the maximum theoretical ethanol yield with theoretical ethanol yield with nitrogen supplementation. **Mihajlovski et al. (2020)** carried out the enzymatic hydrolysis of BW with a newly isolated *Hymenobacter* sp.



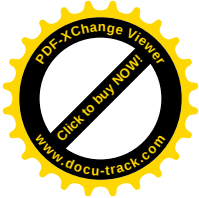
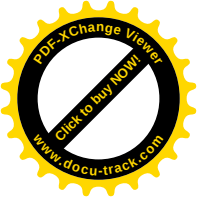
*Hymenobacter* sp. CKS3 strain. Using the new strain resulted in 19.89 g/L reducing sugars with a maximum bio-ethanol concentration of 17.3 g/L after concentration of 17.3 g/L after 24 h of fermentation. **Han et al. (2019)** developed a two-step enzymatic hydrolysis and ethanol fermentation along with the effect of enzyme volume on performance. The maximum ethanol production and yield (46.6 g/L and 1.12 g/g dry cake) were achieved after 40h of fermentation.

### 1.2\_Hydrogen :

Hydrogen is recognised as a promising clean energy source for the future, because it produces no pollutants when burned, and has a higher calorific value (120-142 MJ/kg) than methane (50 MJ/kg) and ethanol (26.8 MJ/kg) (**Sillero et al .**) **Adessi et al. (2018)** carried out a two-step process involving lactic fermentation and photofermentation to convert BW to H<sub>2</sub>. The most favorable results were obtained using *Lactobacillus amylovorus* DSM20532, followed by photo-fermentation using *Rhodospseudomonas palustris* 42OL, together with ferric citrate and magnesium sulphate supplementation. This method yielded 3.1 mol H<sub>2</sub>/mol glucose, with an energy recovery of an energy yield of 54 MJ/t dry matter. investigated the acceleration of hydrolysis to increase substrate conversion efficiency through two-stage enzymatic hydrolysis prior to dark fermentation for H<sub>2</sub> production using BW. Two-stage enzymatic hydrolysis showed an improvement in nutrient conversion efficiencies, with starch conversion at 96.6% and glucose yield at 0.521 g/g BW and the maximum H<sub>2</sub> yield was achieved at 103 ml H<sub>2</sub>/g BW. **Han et al.(2016b)** proposed a novel bio-hydrogen production from BW using a continuous stirring tank reactor (CSTR). At a chemical oxygen demand (COD) concentration of 6,000 mg/l, the system achieved an H<sub>2</sub> production rate of 7.4 L/(ld) and an H<sub>2</sub> yield of 109.5 ml hydrogen/g BW from BW using a Continuous Stirred Tank Reactor (CSTR). At a oxygen demand (COD) concentration of 6,000 mg/L, the system achieved a system achieved a H<sub>2</sub> production rate of 7.4 L/(ld) and a H<sub>2</sub> yield of 109.5 ml hydrogen/g BW. 109.5 ml hydrogen/g BW.

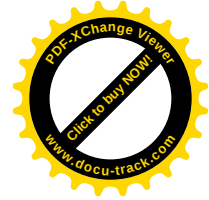
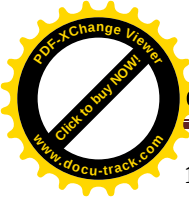
**Table N 2:** Essential Elements of Stale Bread Valorization and Bio-Refinery (original table )

| Aspect                                         | Key point                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Circular Bio-Economy &amp; Bio-Refinery</b> | <ul style="list-style-type: none"> <li>- Bio-refinery approach uses bread waste to produce chemicals, fuels, and materials, reducing reliance on fossil fuels.</li> <li>- Focus on sustainability: energy efficiency, water reduction, and emission control.</li> <li>- First-generation bio-refineries use edible feedstocks; second and third generations use non-edible (e.g., lingo-cellulosic or algal biomass).</li> <li>- Bread waste is a promising feedstock due to high sugar content and ease of processing.</li> </ul>                                                                                   |
| <b>Valorization Products</b>                   | <p><b>Bio-chemicals:</b></p> <ul style="list-style-type: none"> <li>- 2,3-Butanediol (BDO): Used in food, chemicals, cosmetics, pharmaceuticals.</li> <li>- Succinic Acid (SA): Platform chemical with a growing market.</li> <li>- Lactic Acid (LA): Versatile, high market value, produced efficiently from bread waste.</li> <li>- 5-Hydroxymethylfurfural (5-HMF): Used in medicine, food, and fuel; market value rising.</li> </ul> <p><b>Bio-fuels:</b></p> <ul style="list-style-type: none"> <li>- Bio-ethanol: Used as a transport fuel blend.</li> <li>- Hydrogen: Clean energy, zero emissions</li> </ul> |



# **Chapter II**

## **Energy bar**



## Chapter II: Energy bar

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### 1\_Energy bar definition :

Cereal bars are made from a mixture of compressed foods. The whole is bound together with a binder, cut and shaped into a bar. They are a ready-to-use product that is both simple and practical. They can be prepared using a variety of ingredients . (Carvalho et Conti Silva, 2018).

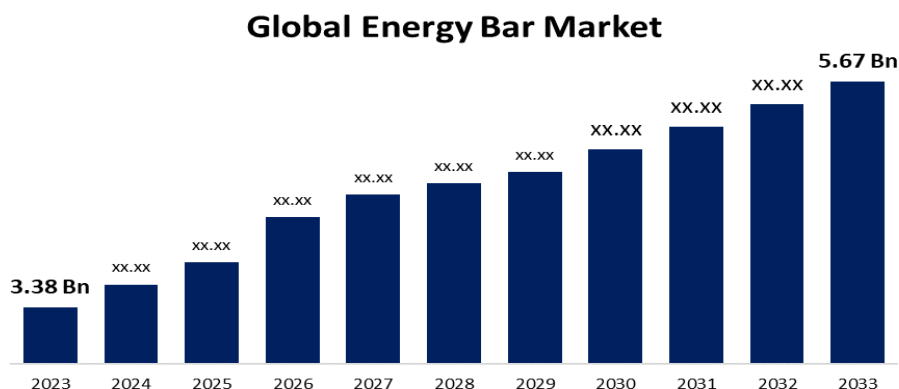
Energy bars are healthy, convenient and portioned snacks that provide adequate amounts of nutrients (Ho et al., 2016). Also known as snack bars, they are typically marketed as 'ready-to-eat' whole grain-based formulations (Svisco et al., 2019). Energy bars are dense and portable food products in which fat, protein and carbohydrates are the main sources of calories. They therefore provide energy when consumed and can often replace a meal. An energy bar (45-80 g) provides approximately 200-300 kcal (840-1,300 kJ), 3-9 g fat, 7-15 g protein and 20-40 g carbohydrate, according to Tiwari et al. (2016).

The findings of Smith and Wilds (2009) indicated that the ingestion of cereal bars during the early and mid-morning hours was associated with favorable mental health outcomes and enhanced cognitive performance in comparison with alternative snacks, such as crisps, sweets, chips, biscuits and cakes.

### 2.The world market for energy bars :

The global cereal bar market is projected to expand at a compound annual growth rate **CAGR (Compound Annual Growth Rate)** of 8.5% until 2026, according to **Mordor Intelligence (2020)**. These snacks are gaining popularity due to their reputation as an accessible method of obtaining nutrients throughout the day. Consequently, the snack market has transitioned from primarily conventional bars to the development of functional and more innovative products (Klerks et al., 2022). A number of studies have been conducted in the realm of literature to explore the potential of enriching bars with functional ingredients. These endeavors have involved the incorporation of soy products (Aramouni & Abu-Ghoush, 2011; Lobato et al., 2012), banana peel flour (Carvalho & Conti-Silva, 2018), pear, apple, and date fiber (Bchir et al., 2018), and tempeh (Melo et al., 2020). As indicated in the works of Maia et al. (2021), Stelick et al. (2021), Vitorino et al. (2020), Nielsen & Jacobsen (2009), Hogan et al. (2012), Szydlowska et al. (2020), and others, a number of different materials have been used in the study, including flours, brewery spent grains, fish protein concentrate, fish oil, dairy proteins, whey protein concentrate, and bioactive ingredients .

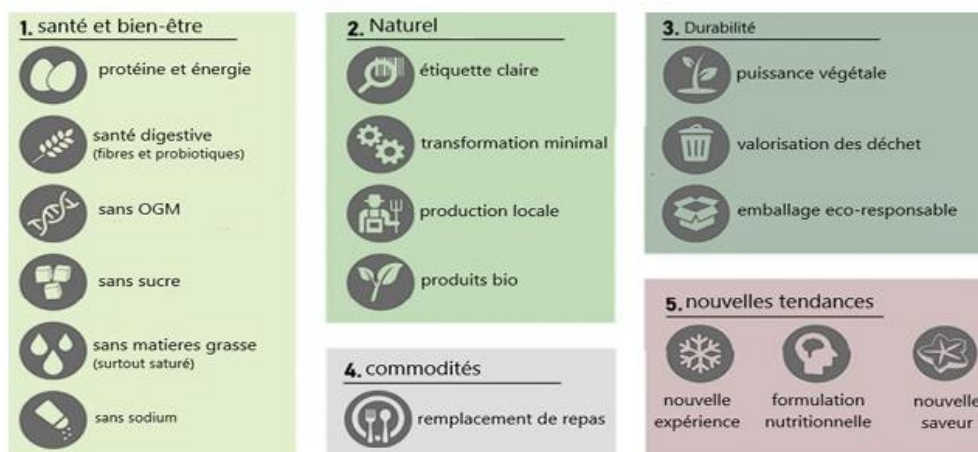
Figure N°2 : Global energy bar market forecast (Spherical Insights, 2024)



### 3. Trends in the development of new energy bars :

A comprehensive analysis of the prevailing market trends and developments in the domain of cereal bars is facilitated by leveraging scientific research and industry market reports. The analysis encompasses pivotal trends such as health and wellness, naturalness, sustainability, and convenience. These trends reflect the top five positioning strategies employed in all regions worldwide, following their introduction from 2017 to 2018 (**Boukid, 2022**). The following terms are associated with health and wellness: "high protein," "gluten-free," "high fiber," "no additives/preservatives," and "vegan." The latter is linked to health, well-being, and sustainability.

Figure N 3: Summary of current trends in the development of new cereal bars (**Boukid 2022**)



## CHAPTER II :Energy bar

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### 5\_Different types of energy bar :

In contemporary society, characterized by its frenetic pace and numerous demands on people's time, consumers frequently seek nourishment in the form of healthy, ready-to-eat foodstuffs. a plethora of energy bar types exists, categorized as follows: high-carbohydrate (with a carbohydrate content of over 70%), high-protein (with a protein content ranging from 5 to 20%), whole grains (comprising oats, muesli, wheat, corn, and rice), and chocolate, multi fruit bars (Boukid et al., 2022). Energetic bars have been shown to supply the body with useful substances, including proteins, fats and carbohydrates, which are known to replenish energy (Jabeen et al., 2020). In some cases, these bars may also contain vitamins, minerals and antioxidants. It was a reasonable expectation that the production would take place.

As Ivanov et al. (2021) have demonstrated, there is an increasing consumption of food products formulated for specific sporting activities. Energy bars are widely regarded as a suitable foodstuff for athletes, given their ability to enhance physical performance and fortify the body (Smith, 2020).

### 6.1 .Energy bar composition :

#### 6.1.1.Pumpkin seeds :

##### Definition :

The seeds of the pumpkin plant (*Cucurbita maxima*) are also referred to as pumpkin seeds. *Cucurbita L* is a member of the plant in question belongs to the *Cucurbitaceae* family. The pumpkin (*Cucurbita*) is a perennial plant. The subject is a 12-meter-long climber stem with green produce. It is a leafy green vegetable that comes in a variety of shapes, sizes, weights, and colors (Chahal et al., 2021). As stated in the research by Ahmad and Khan (2019), the seeds of the pumpkin plant are typically characterized by their ovate-elliptical morphology. These seeds are often noted for their abundance, and they are frequently described as being yellowish-white in coloration. In addition, the seeds are frequently reported to possess a soft texture and a pleasant flavor profile.



**Figure N 4 :** Pumpkin seeds (original photo )

### 6.1.2.Nutritional profile :

Pumpkin seeds have a variety of applications. These substances are characterized by a high protein content, in addition to significant quantities of carbohydrates, fat, and fiber. It has been determined that minerals and vitamins are essential for moral well-being. As posited by **Koklu et al. (2021)**, human well-being is a multifaceted concept that encompasses a wide range of factors and dimensions. Additionally, seeds Include all nine essential amino acids, along with their composition of the substance under consideration is characterized by a high lipid content, with a percentage ranging from 40% to 50%. This lipid content is noteworthy for its inclusion of elements deemed to be essential for the subject's well-being. Fatty acids of the omega-3 and omega-6 categories are the subject of this investigation. The Families of fatty acids play an indispensable role in a variety of domains.

The subject under discussion is metabolic processes. Furthermore, a review of the literature reveals that seeds contain significant quantities of bioactive components, such as Trigonelline, nicotinic acid, carotenoids, and D-chiroInositol (**Seymen et al., 2016; Chatain et al., 2017**). As stated by **Lestari and Meiyanto (2018)** and **George et al. (2020)**. The presence of vitamin E has also been observed in pumpkin seeds .The substance under consideration contains four tocotrienols and tocopherol, specifically  $\alpha$ ,  $\beta$ ,  $\gamma$ , and  $\delta$ . As **Dotto and Chacha (2020)** have demonstrated, isomers.

## CHAPTER II :Energy bar

**Table 3 :Nutritional Values of Pumpkin seeds per 100g (Mir et al.,2019)**

| Components                       | Nutritional Values | RDA Percentage |
|----------------------------------|--------------------|----------------|
| <b>Carbohydrates</b>             | 10.71 grams        | 8 Percent      |
| <b>Energy</b>                    | 559Kcal            | 28 Percent     |
| <b>Total Fats</b>                | 49.05g             | 164 Percent    |
| <b>Protein</b>                   | 30.23g             | 54 Percent     |
| <b>Fiber</b>                     | 6g                 | 16 Percent     |
| <b>Cholesterol</b>               | 0mg                | 0 Percent      |
| <b>Micronutrients (Vitamins)</b> |                    |                |
| <b>B9 (Folic acid)</b>           | 58 micro gram      | 15 Percent     |
| <b>B3 (Niacin)</b>               | 4.8mg              | 31.0 Percent   |
| <b>B5</b>                        | 0.75mg             | 15.0 Percent   |
| <b>B6</b>                        | 0.14mg             | 11.0 Percent   |
| <b>B2</b>                        | 0.15mg             | 12 Percent     |
| <b>B1(Thiamin )</b>              | 0.272mg            | 23 Percent     |
| <b>Vit. C</b>                    | 0.272mg            | 3.0 Percent    |
| <b>Vit. A</b>                    | 16 IU              | 0.50 Percent   |
| <b>Vit. E</b>                    | 35.1mg             | 272mg          |
| <b>Major Minerals</b>            |                    |                |
| <b>Na+</b>                       | 7.0mg              | 0.5 Percent    |
| <b>K+</b>                        | 809.9mg            | 17.0 Percent   |
| <b>Mineral Deposits</b>          |                    |                |
| <b>C+</b>                        | 46.0mg             | 4 1/2 Percent  |
| <b>Cu</b>                        | 1.43mg             | 148.0 Percent  |
| <b>Fe (Iron )</b>                | 8.8mg              | 110.0 Percent  |
| <b>Mg</b>                        | 592mg              | 148 Percent    |
| <b>Mn</b>                        | 4.54 mg            | 195 Percent    |
| <b>P</b>                         | 1232mg             | 175 Percent    |
| <b>Se</b>                        | 9.40 micro gram    | 17.0 Percent   |
| <b>Zn</b>                        | 7.8mg              | 17.0 Percent   |

## CHAPTER II :Energy bar

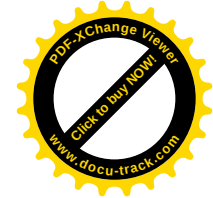
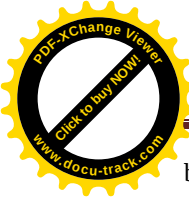
| Phytochemicals      |               |     |
|---------------------|---------------|-----|
| Beta-Carotenoid     | 9 micro gram  | --- |
| Beta-Crypto Xanthin | 1 micro gram  | --- |
| Lutein-Zeaxanthin   | 74 micro gram | --- |

### 6.1.3.Health benefits :

Pumpkin seeds contain a high proportion of fiber, which has been demonstrated to be efficacious in a variety of contexts. The following symptoms have been documented: constipation, satiety, and decreased blood glucose and intestinal transit time, as defined by **Nyam et al. (2013)**. The pumpkin (*Cucurbita pepo*) is a member of the gourd family (*Cucurbitaceae*). It has been well-documented that seeds possess laxative properties, exerting an effect on the sphincter. A substantial body of research has demonstrated that bladder reduction is associated with a reduced risk of developing cardiovascular disease. The medication has been demonstrated to reduce triglyceride levels, protect the liver, and alleviate anxiety. Areas that merit particular attention include, but are not limited to, the following: reproductive health, biliary vesicle, and protection of bones. A compendium of properties has been demonstrated, including anti-neoplastic, antihypertensive, anti-diabetic, anti-hypercholesterolemic, anti-tumor, antifungal, antibacterial, anti-inflammatory, anti-oxidant, anti-rheumatic, anti-acid, antidepressant, antimicrobial, anti-metabolite, and anti-thelminthic characteristics. As indicated by **Amin and Thakur (2013)**, the subject exhibits immune-modulatory properties. This assertion is corroborated by the works of **Kaur et al. (2020)** and **Chahal et al. (2021)**.

### *Cucurbitaceae* family plants seeds-based energy bars and their application for athletes :

In response to the increasing interest among athletes, The objective is to provide natural, convenient, and healthy foods. The objective of this undertaking is to enhance the nutritional and functional qualities of the subject. The value of snack foods is determined by the alteration of their nutritional content. The most challenging aspect of producing a satisfactory energy bar is The amalgamation of diverse ingredients is meticulously executed, ensuring the integration of each component aligns with the intended purpose. The product is characterized by its aesthetic qualities, encompassing both visual appeal and sensory experience, including taste. In order to meet particular nutritional requirements, as determined by the most recent research. The following assertion is made: The food is subjected to a process of cooking or baking, during which the mixture is continuously agitated to prevent the formation of falling apart As indicated



## CHAPTER II :Energy bar

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by Ahmad et al. (2017) and Omran (2018), the phenomenon under investigation is characterized by a state of disintegration.

### 6.1.4.Pumpkin seed-based energy bar :

Umme et al. (2021) prepared the energy bar using the following ingredients:

The following ingredients are listed, along with their respective quantities: oats (10 g).

The ingredients utilized in this study included cornflakes (10 g), chickpeas (5 g), and pumpkin seed flour (15 g).

The following ingredients were utilized:

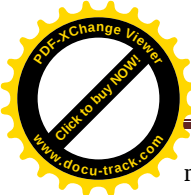
- Nuts (7 g).
- Raisins (6 g).
- Skim milk powder (10 g).

The following ingredients are required: water (6 g), sunflower oil (10 g), salt (0.2 g), and lecithin. The following ingredients are required: glucose syrup (10 g), and brown sugar (10 g). The study posits that the preparation of an energy bar with these ingredients. It is reasonable to hypothesize that these components will satisfy the requisite daily requirements. The ingestion of protein. The following investigation will address the nutritional value of this energy. The bar's nutritional analysis revealed an energy value of 412.72 kcal, with a carbohydrate content of 73.19%. The composition of the substance is as follows: 9.74% protein, 9.05% fat, 3.10 milligrams of calcium, and 0.2 milligrams of iron. The quantity of magnesium is 153.45 milligrams, while the quantity of phosphorus is 450.75 milligrams. The quantity of potassium is 220.45 milligrams

### 6.2.Date fruit :

#### Definition :

Date fruit (*Phoenix. dactylifera*) is considered to be one of the most significant crops within the *Arecaceae* family. It has been cultivated since ancient times, with records of its cultivation dating back over 4000 years, primarily in Middle Eastern and Northern African countries, with a



notable presence in arid and semi-arid regions. The cultivation of this plant has been undertaken chiefly for the purposes of cultural enhancement, nutritional sustenance, environmental management, religious observance and social development (**Ibrahim et al., 2021**). Dates are available in a variety of forms, with more than 600 different types cultivated globally. These include Ajwa, Barhe, Halawi, Khlas, Lulu, Medjool, and Sukkari, which vary in shape and organoleptic properties. The classification of dates according to their ripening stages can be categorised into five primary types: The following names are to be considered: Hababouk, Kimri, Khalal, Bisir, Rutab and Tamer. All five stages may be processed and used in diverse manners. A plethora of food products can be manufactured from the various stages of dates, including, but not limited to, dried dates, date paste, date syrup, date jam, date butter, and pickled dates. Furthermore, it is important to note that date waste can be processed to produce a variety of by-products. For instance, date pits can be used to produce coffee and oil (**Hussain et al.,2020; Ibrahim et al., 2021; Echegaray et al.,2020; Siddiq et al.,2012**).

### 6.2.1.Nutritional profile of dates :

A comprehensive analysis of the nutritional composition of dates reveals that the fruit is predominantly comprised of carbohydrates, fiber, and protein, with minimal content of fat. The presence of significant micronutrient levels has been demonstrated, comprising vitamins such as thiamine, riboflavin, C, and E; minerals including potassium and magnesium; and various phytochemicals. This section provides an analysis of the nutritional composition of date fruit. The fruit is primarily composed of carbohydrates, fiber, and protein, with low amounts of fat. It also contains significant amounts of micronutrients, including vitamins such as thiamine, riboflavin, C, and E; minerals such as Potassium and magnesium, as well as various phytochemicals, have been identified as significant components in this analysis. This section offers a comprehensive overview of the nutritional characteristics of various date varieties cultivated globally.

## CHAPTER II :Energy bar

**Table 4 :** Chemical composition of different date fruit varieties (range in %) (*Assirey et al.,2015; Hussain et al.,2020; Amadou et al.,2016; Aljutaily 2021* )

| Date Varieties           | Carbohydrates | Fiber     | Lipids    | Protein    |
|--------------------------|---------------|-----------|-----------|------------|
| <b>10 date varieties</b> | 71-79         | --        | 0.12-0.72 | 1.72-4.73  |
| <b>20 date varieties</b> | 47.8-81.4     | --        | --        | --         |
| <b>12 date varieties</b> | --            | 2.70-8.00 | 0.10-0.67 | 1.57-5.10  |
| <b>Sukkari</b>           | 76.25         | 4.35      | 3.15      | --         |
| <b>General Range</b>     | 47-81         | 2-8       | 0.1-3.1   | <b>1-5</b> |

### **Functional/Pharmacological effects of date fruit :**

#### **6.2.1.a.Anti-oxidant Effects :**

The elevation of the body's antioxidant system, otherwise known as the elimination of oxidative stress, a state caused by the excess production of free radicals, can be achieved by consuming dates. Oxidative stress is known to lead to the development and progression of various diseases. A substantial body of research has demonstrated a notable correlation between the antioxidant potential of dates and their phytochemical composition. For instance, phenolic acids present in dates (*Fernández-López et al., 2020; Echegaray et al., 2020*). It has been demonstrated that these substances can act as potent free radical scavengers. In vivo studies have shown that the ingestion of certain phenolic acids, such as gallic and ferulic acids, results in an increase in antioxidant enzymes in cardiac tissue samples from animal models (*Yeh et al., 2009*). A series of in vivo investigations conducted on animals exposed to diverse toxicants revealed that date extracts, administered at concentrations ranging from 100 to 1,000 milligrams per kilogram of body weight, exhibited a substantial capacity to enhance antioxidant marker levels, including glutathione transferase, catalase, and glutathione reductase. Furthermore, the presence of malondialdehyde has been detected (*Abdel-Magied et al., 2018*). Date pits have also been shown to promote antioxidant capacity. In a recent double-blind, randomized, controlled trial, the consumption of 26 g of date seed powder before workouts daily for two weeks showed positive effects by improving different oxidative stress markers, such as superoxide dismutase, glutathione peroxidase, and malondialdehyde (*Moslem et al., 2022*).

## CHAPTER II :Energy bar

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### 6.2.1. b.Anti-Inflammatory Effects :

In addition to enhancing the antioxidant system, the consumption of dates has been shown to reduce the body's inflammatory state. This is a pivotal system in the development and progression of various diseases. A reduction in the inflammatory state is also attributed to the strong antioxidant potential of dates. Inflammatory states are mostly initiated due to oxidative stress caused by free radicals (**Fernández-López et al., 2020; Echegaray et al., 2020**). The administration of 5 g kg<sup>-1</sup> body weight of date pit powder to carbon tetrachloride (CCl<sub>4</sub>)-induced rats for a period of two weeks resulted in significant improvements in the levels of certain pro-inflammatory cytokines, including tumor necrosis factor (TNF-) and interferon gamma (IFN-) (**Saryono et al., 2019**). A systematic review of the extant literature revealed a positive correlation between the ingestion of date pits and improvements in pro-inflammatory cytokine levels, including TNF- and IL (**Dardjito, E et al., 2019**). A multitude of studies have yielded consistent results subsequent to the ingestion of dates or their pits (**Al-Zeiny et al., 2022; Saryono et al., 2019; Ali Haimoud et al., 2016**).

### 6.2.1. c.Anti-Hyperglycemic Effects :

Notwithstanding the high sugar content of dates, a number of in vivo studies have documented the occurrence of hypoglycemic effects subsequent to the ingestion of dates. For instance, **El Abed et al., 2017** demonstrated that the administration of an aqueous ethanolic date extract at a dosage of 200 mg/kg body weight to animal models resulted in a significant alleviation of postprandial glycemia. The positive effects were attributed to inhibitory activities against certain enzymes associated with type 2 diabetes, including glucosidase, an intestinal enzyme that plays a role in regulating glucose availability for intestinal absorption (**Bedekar et al., 2010**). In a recent in vivo study, alloxan-induced diabetic rats were administered Ajwa date pulp or pit powders at 7 and 1.5 g per 100 g of rat chow for a period of four weeks. The results demonstrated that Ajwa date pits significantly mitigated blood glucose levels in comparison to the control group. Conversely, date pulp exhibited outcomes that were not as favorable, suggesting a substantial anti-hyperglycemic effect. The following investigation will address the consequences of date pits (**Imran et al., 2020**). A recent in vivo study was performed in dexamethasone-induced subjects. In addition, the oral administration of a date palm extract at doses ranging from 200 to 400 milligrams per kilogram of body weight in diabetic rabbits resulted in anti-diabetic effects. The observed effects were attributed to the enhancement of glucose uptake stimulation, the augmentation of cellular glycogen synthesis, and/or the preservation of pancreatic cells against

## CHAPTER II :Energy bar

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the deleterious effects of dexamethasone injection, as previously documented in (Abdullah *et al.*,2020). The ingestion of date fruits in their whole form has been demonstrated to manifest notable anti-diabetic effects, contingent upon the specific variety of date consumed. A comprehensive review of existing literature and subsequent meta-analysis has substantiated that the incorporation of diverse date varieties into the dietary regimen of individuals afflicted with diabetes has been efficacious in the amelioration of glycemic parameters (Mirghani *et al.*,2021). However, the current systematic review includes only five research studies, which limits the generalizability of the findings. As Mirghani *et al.*,2021 observes, the paucity of studies precludes confirmation of the significance of the results. A randomized control trial conducted on type 2 diabetic patients demonstrated that the daily consumption of 50 g of Lulu date, in conjunction with standard oral anti-diabetic medications, for a duration of two weeks, did not result in a significant reduction in blood glucose levels when compared to the control group (Wijayanti *et al.*,2019). Consequently, it can be posited that diabetic patients may benefit from the conscientious consumption of dates. Further studies are necessary to investigate the hypoglycemic effects of dates and to substantiate the claims that have been made.

Though date fruit is generally considered low in glycemic load, a study examining the glycemic index (GI) of five different date varieties in healthy individuals showed that the intake of 50 g of dates with available carbohydrates equivalent to 50 g of glucose had an average GI ranging from 30 to 69 (Mahmoud *et al.*,2019). In a subsequent clinical trial, healthy individuals were administered 50 g of 17 different date varieties in the Tamar stage. The range of GIs was from 42.8 to 74.6, with the two varieties, Ajwa and Shagra, exhibiting the lowest values of GIs, 8.5 and 9.2, respectively (AlGeffari *et al.*,2016). Notwithstanding the maturation stage of the dates, other experiments demonstrated that both the Bisir and Tamar stages exhibited comparable GIs of 54–55 on average (Jarrar *et al.*,2019). Conversely, the high fiber and polyphenol content of dates has been shown to positively influence glycemia by enhancing the gut micro-biome profile associated with the development of type 2 diabetes (Sikalidis *et al.*,2020). Polyphenols have been demonstrated to engage in a multitude of enzymatic processes that are facilitated by the gut micro-biome (Al-Dashti *et al.*,2021).

Concurrently, the process of bacterial fermentation results in the breakdown of fiber, leading to the production of short-chain fatty acids. These by-products have been observed to induce the expression of various transporters, which play a crucial role in the subsequent processes. For the maintenance of glucose homeostasis (Bozbulut *et al.*,2019).

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### 6.2.1. d.Anti-Hypercholesterolemia Effects :

The potential of dates to reduce cholesterol levels has been demonstrated by scientific evidence, attributing this effect to their high fiber content and bioactive phytochemicals. Date extracts with concentrations ranging from 125 to 1,000 milligrams per kilogram of body weight were orally administered to hyper-cholesterolemic rabbits for a period of 10 weeks. The administration of date extracts resulted in enhancements in lipid metabolism, as evidenced by a reduction in total cholesterol, low-density lipoprotein (LDL), and other relevant parameters. Triglycerides are a type of fat found in the body. In contrast, the high-density lipoprotein (HDL) level demonstrated an increase in comparison with the control group (**Hasan et al.,2010**). In a separate study, the administration of 300 and 600 mg kg<sup>-1</sup> BW of a date suspension over a 14-day period resulted in a decrease in total cholesterol, triglyceride, and LDL levels, while concurrently increasing HDL levels. This observation suggests the potential anti-hypercholesterolemic properties of dates (**Ahmed et al.,2016**). According to the extant reports, date pits have demonstrated efficacy in this regard. The cholesterol-lowering properties of date pit extracts were investigated in a study on diet-induced hypercholesterolemia in rats. The rats were administered date pit extracts at concentrations ranging from 0.25 to 1 g/kg Body Weight for a duration of 21 days. The findings of the study demonstrated a substantial dose-dependent enhancement in lipid metabolism, as indicated by a decrease in total cholesterol and LDL levels, as well as the atherogenic index (**Saryono et al.,2017** ).

The properties of dates are subject to variation depending on the variety; this variation has been demonstrated in the case of the Hallawi and Ajwa varieties. Research indicates that these two varieties are more effective in enhancing lipid metabolism in animal models than the Aseel and Khudravi varieties.

### 6.2.1. e.Anti-Tumor Effects :

The quest for effective anti-tumor agents is of paramount importance in the research field, given the plethora of deleterious side effects associated with prevailing cancer treatments, such as radiotherapy. Chemotherapy is a therapeutic intervention that involves the use of antineoplastic agents to target and destroy rapidly dividing cells, particularly those found in cancerous tissues. The functional properties derived from fruits' phytochemicals, such as flavonoids and other phenolic compounds, have been linked to anti-tumor activities ( **Hazafa et al.,2020 ; Samec et al 2021**)

## CHAPTER II :Energy bar

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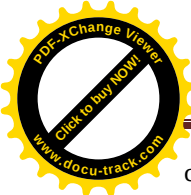
Date fruit has been demonstrated to have significant antitumor potential due to its high content of various bio-active phytochemicals. For instance, the bioactive compounds rutin and quercetin, derived from Ajwa dates, were orally administered to breast tumor mutagenic mice at a dosage of 5 mg/kg body weight for 11 days in a synergistic manner with an injection of doxorubicin, a chemotherapeutic agent frequently used against breast cancer (**Godugu et al., 2020**). The present study demonstrated that the incorporation of Ajwa dates into the standard treatment regimen for pediatric cancer patients resulted in substantial enhancements in patient outcomes. The study population exhibited a reduced frequency of hospital admissions due to fever-associated neutropenia and a diminished risk of infection when compared with the control group.

The group that was not subject to intervention. Conversely, patients devoid of Ajwa dates exhibited a higher mortality rate, primarily due to disease progression associated with infections (**AlJaouni et al.,2019**). In a separate recent study employing rat models of hepatocellular carcinoma (**Zein et al.,2022**), the oral administration of 400 milligrams of date extracts from Barhi per kilogram of body weight on a daily basis was found to promote antitumor activities.

The process is mediated by the inhibition of cell proliferation. The investigation revealed that the Barhi date extract exerts inhibitory effects on critical signaling pathways related to cellular growth and functions. These pathways include PTEN and AKT, which are also known as phosphatase and tensin homolog and protein kinase B, respectively. The aforementioned assertion is demonstrably false. In addition, date leaf extracts were reported to exhibit significantly stronger antitumor activities than date pulp or pit extracts. The results demonstrated that the phenolic contents of date leaf extracts were responsible for this enhanced activity, the antioxidant capacity of the date leaf extract was found to be considerably higher than that of the pulp or pit. A series of in vitro studies were conducted, yielding consistent positive results with extracts. The subject of this investigation encompasses a variety of date varieties and components, including pits and leaves (**Al-Sayyed et al.,2021**),(**Al-Zeiny et al.,2022**),(**Alobaidi Khalid et al.,2019**),(**Khan et al.,2022**).

### 6.2.2. Dates Energy bar :

The utilization of diverse fruits in the formulation of snack bars has gained significant popularity. The development of fruit-based bars has been undertaken to provide a nutritious snack option that is rich in natural sugars, vitamins, and minerals, along with bio-nutritive



components, thereby addressing consumers' daily nutritional requirements (Ayad et al., 2020) . The utilization of date fruit can be considered a favorable choice in the development process.

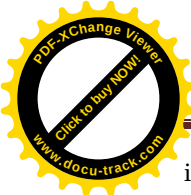
Dates have been identified as a promising ingredient for energy bars due to their nutritional and functional properties. The exploration of dates for this purpose dates back to the 1970s, when Kamel and Kramer (Kamel et al., 1977) conducted a pilot study aimed at developing snack bars using dates as a high-carbohydrate and low-protein fruit. This initiative was driven by the widespread cultivation of dates in regions experiencing persistent protein shortages. Subsequent to this, the primary objective has been the protein enrichment of The process of preparing and producing data-based bars is underway.

### 6.2.3. Possible Functional Ingredients Used in Date Bars :

Depending on the manufacturing target, date bars can be formulated with only one or two ingredients or with many several ingredients. With regard to the enrichment of protein, a wide variety of protein sources can be utilized in the preparation of date bars, encompassing both dairy and plant-based ingredients. Proteins encompass milk powders and their byproducts, including whey concentrates and isoleucine. The subject of this investigation includes latex, soy proteins, and other plant-derived proteins, such as those derived from sunflower and vetch. A plethora of additional ingredients can be incorporated to formulate nutritionally balanced, functional, flavorful, and palatable date bars. These ingredients may include cereals, such as oats, wheat, rice, or barley, as well as legumes, including Legumes such as chickpeas and soybeans, as well as dried fruits including cherries, apricots, apples, and pears, and nuts such as almonds, peanuts, walnuts, and pistachios, are utilized in the recipe, in addition to small amounts of spices for seasoning, including salt, cardamom, cinnamon, and ginger. The delivery of functional attributes is possible through the utilization of these distinct ingredients. Additionally, the incorporation of novel ingredients can result in the manifestation of significantly more pronounced functional attributes. The following functional attributes have been identified: plant seeds and fruit polyphenol extracts (Jabeen et al., 2020),( Rehman et al., 2020).

### 6.2.4. Date nutrition bar for athletes :

A novel nutrition bar, specifically formulated to promote the health and well-being of athletes, was developed by a research team in the Food Microbiology and Biotechnology Laboratory at North Carolina A&T State University. The foundation of this bar was developed by the team's ingenuity, utilizing dates as the primary ingredient. According to the extant literature, the



## CHAPTER II :Energy bar

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ingestion of dates has been demonstrated to have a significant impact on the growth and functionality of human microbiota, including *Lactobacillus*, and to have an indirect effect on health ( Ayad et al., 2016; Mjalli et al., 2019). The ingredients utilized in the production of the nutrition bar consist of pitted soft dates.

The following ingredients are considered complementary: gluten-free oats, powdered whole grains, a protein source (ideally in powdered form, such as milk or whey protein), and other nutrient-rich materials. The incorporation of oats into the composition of the product resulted in an enhancement of its nutritional and sensory characteristics (Munir et al., 2018). The product formulation was developed by modifying the procedure utilized by Aljaloud, Colleran, & Ibrahim (2020). The oats were meticulously ground in a food processor until they achieved a smooth particle size that was analogous to the texture of flour. The pitted dates and all other ingredients were incorporated into the oats, and the mixture was agitated until a homogeneous consistency was achieved. The mixture was subsequently transferred to a flat pan lined with a baking sheet and manually compressed. The product's surface is meticulously crafted to ensure a uniform and polished finish. The pan was subjected to a temperature of 250°C within the oven.

The initial step in the procedure is a five-minute heating period. This is followed by a rapid cooling phase in the refrigerator at a temperature of 4°C for a duration of 30 minutes. The bars were extracted from the pan and meticulously divided into equal-sized rectangular bars. The bars can be coated with a variety of ingredients, including but not limited to almonds, sesame seeds, hazelnuts, sunflower seeds, and chia seeds, etc..

### 6.3.Walnuts :

#### Definition :

Despite the well-documented health benefits of walnuts, largely due to their high fat content, they are also a remarkable source of protein and other nutrients. According to the USDA, walnuts contain 654 calories per 100 grams, 15.23 grams of protein and 65.21 grams of fat. Walnut trees are native to the eastern North American continent, but have since become a common agricultural crop in China, Iran, and several US states, including California and Arizona (Mayhew AJ., et al., 2016). The walnut fruit is characterized by a shell that conceals a wrinkled, globular nut. Walnut is the common name for any of the large, deciduous trees in the genus *Juglans* of the flowering plant family *Juglandaceae*, known as the walnut family (Aune D et al., 2016). In both culinary and botanical contexts, the term "walnut" is used. In the culinary realm,

## CHAPTER II :Energy bar

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"walnut" refers to the edible, ridged seed of the walnut tree. In botany, "walnut" is used to refer to the hardwood of the same tree. The walnut is cut into two flat segments for commercial sale (Guasch-Ferré M et al, 2017). Walnuts come in two forms: raw or roasted and salted or unsalted.

### 6.4.Coconut :

#### Definition :

Coconut (*Cocos nucifera*) is considered to be one of the most significant crops cultivated in tropical regions, serving as a staple food source for numerous populations, including those in Asian cultures and island communities, for centuries. The edible portion of the coconut (i.e. the meat and water contained within the fruit) is derived from the endosperm tissue (Lopes & Larkins, 1993). The various products of coconut include coconut oil, tender coconut water, coconut cake, raw kernel, coconut shell, coconut toddy, copra, coconut leaves, wood-based products, coir pith, etc. As stated in the APCC (2004) report, more than 11 million farmers, mostly smallholders with low income, grow the tree in 90 countries. It is cultivated for multiple utilities, mainly for nutritional and medicinal values. Coconut is cultivated on more than 189.5 million hectares globally, yielding an estimated 16,943 million nuts during the 2010-11 period, with an average productivity of 8,937 nuts per hectare. In the Pacific region, the benefits of coconut cultivation encompass various applications, including food and beverage production, the provision of shade for other crops, land stabilization, weaving, fuel, containers, construction materials, and numerous other uses.

#### 6.4.1.Nutritional profile :

Coconut possesses a wide range of applications. The tender coconut is a specimen of the coconut genus, which is in turn a member of the palm family. Water (TCW), otherwise known as the liquid endosperm, has been demonstrated to be an excellent natural The beverage under consideration is characterized by a soft consistency and a sweet taste. The coconut's caloric value is 17.4/100 g. Water has been found to contain vitamin B, specifically nicotinic acid B3, with a concentration of 0.64 milligrams per milliliter. Pantothenic acid (B5) and biotin were found to be present at concentrations of 0.52 µg/mL and 0.02 µg/mL, respectively. Riboflavin B2 was found to be present in concentrations below 0.01 µg/mL, while folic acid was detected at 0.003 µg/mL. A negligible amount of thiamine B1 and pyridoxine B6 has been detected (National nutrient database for standard reference, Nuts, coconut water 2008),( Bawalan DD et al.,2006).

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### 6.5\_Chocolate :

The popularity of chocolate around the world can be attributed to its flavorful nature. The subject of this investigation is components and health benefits, as it contains high levels as stated by **Tan et al. (2021)**, the presence of polyphenols has been identified. A recent Market Analysis Report (2023) has estimated the global chocolate market size to be 113.16 billion USD in 2021. The report has also forecasted that the market will grow at a compound annual growth rate **CAGR ( Compound Annual Growth Rate)** of 3.7% from 2022 to 2030. Chocolate is defined as a homogenous mixture of products containing a minimum of 35% cocoa solids on a dry matter basis, with a minimum of 18% cocoa butter and a minimum of 14% fat-free cocoa solids, as outlined in the *Codex Alimentarius* (2016). Primary chocolate products are classified into three distinct categories: dark chocolate, milk chocolate, and white chocolate. These categories are distinguished by their varying content of cocoa solids, milk fats, and cocoa butter (**Afoakwa et al., 2007**). As asserted by **Velciov et al. (2021)**, the composition of dark chocolate consists of A higher percentage of cocoa solids (35–85%), which is associated with semisweet chocolate, is synonymous with extra-dark chocolate. Conversely, extra-dark chocolate is synonymous with bittersweet chocolate.

The U.S. Food and Drug Administration (**FDA**) has established a standard of identity for milk chocolate that requires a minimum of 10% chocolate liquor, 12% milk solids, and 3.39% milk fat (**USFDA, 2023**). White chocolate, in contrast, is composed of a blend of cocoa butter, sugar, and flavorings. However, due to its lack of cocoa solids, it is not regarded as a genuine chocolate product (**Afoakwa et al., 2007; Harvard School of Public Health, 2023**).

A substantial body of research has been conducted on the effects of dark chocolate consumption, and the results have revealed several health benefits (**Engler et al., 2004; Morze et al., 2020**). Dark chocolate contains a higher concentration of flavonol-rich cocoa solids compared to milk chocolate, which has been associated with the development of major non communicable diseases (**Engler et al., 2004; Harvard School of Public Health, 2023; Morze et al., 2020**). The demand for dark chocolate has increased among consumers who perceive it to have significant health benefits. Dark chocolate is known to contain a higher percentage of antioxidants. However, concerns have been raised regarding its caloric content and cariogenicity, particularly in comparison to other sugar-based products (**Afoakwa, 2016**).

## CHAPTER II :Energy bar

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### 6.7\_Dark chocolate:

Chocolate is typically classified into three primary categories: dark, milk, and white chocolate. The coloration of chocolate is attributed to the amount of cocoa solids present, with darker chocolate having a higher percentage of cocoa solids and a deeper brown hue. The composition of chocolate is determined by the proportion of cocoa utilized in a specific formulation (**Lee R et al.,2005**). The presence of multiple types of chocolate is attributable to the varying proportions of cocoa in their respective formulations. Dark chocolate, also referred to as black chocolate, is produced by incorporating fat and sugar into the cocoa process. The substance under consideration is chocolate devoid of any significant quantity of milk, or, to be precise, a chocolate that contains a minimal amount of milk. Dark chocolate can be consumed directly or incorporated into culinary preparations. For the latter purpose, thicker bars are typically available, typically with cocoa percentages ranging from 70% to 99%, which are suitable for baking purposes (**Pucciarelli DL et al.,2008**).

### 6.8 \_Nutritional profile :

Cocoa products have been demonstrated to be highly nutritious. The chocolate is a particularly abundant source of energy, protein, magnesium, calcium, iron, and riboflavin, all of which are essential for optimal health and well-being, mental health and heart function (**Cooper KA et al.,2008**). Cocoa seeds have been shown to be rich in copper, sulfur, and vitamin C. Dark chocolate is naturally rich in flavonoids (**Arts IC et al.,1999**). It is hypothesized that these compounds have the capacity to reduce blood pressure and offer protection against heart disease, among other potential benefits (**Buijsse B et al.,2007**) . Variations in the amount of theobromine present in different types of chocolate have been observed. Theobromine levels are elevated in dark chocolates, with an approximate range of 10 grams per kilogram , as compared to the lower range of 1 to 5 grams per kilogram observed in milk chocolates (**Bruinsma K et al.,1999**). It is noteworthy that theobromine content in dark chocolates consistently exceeds that of lower-quality chocolate varieties. Cocoa beans inherently contain an amount of theobromine that typically ranges from 300 to 1,200 milligrams per ounce. However, the theobromine content of superior chocolate can exceed this range, typically ranges from 300 to 1,200 milligrams per ounce. However, the theobromine content of superior chocolate can exceed this range.

## CHAPTER II :Energy bar

\*Results given as mean  $\pm$  standard deviation of triplicate analyses of three samples. Different letters in the same column indicate a significant difference by Duncan test at ( $p < 0.05$ ) confidence levels.

**Table N 5 :** Proximate composition (% , mean values) of some tips of Dark chocolate (Velciov, Ariana-Bianca et al. (2021)

| Samples                    | Protein | Fat     | Carbohydrates | Moisture | Minerals |
|----------------------------|---------|---------|---------------|----------|----------|
| Dark chocolates            | 4.27+-  | 30.12+- | 59.20+-       | 1.22+-   | 1.72+-   |
| with 40% cocoa mass (DC40) | 0.48a   | 3.46    | 3.50a         | 0.50a    | 0.61a    |
| Dark chocolates            | 9.82+-  | 41.06+- | 35.20+-       | 1.31+-   | 2.11+-   |
| with 70% cocoa mass (DC70) | 1.56a   | 4.14b   | 2.47b         | 0.40a    | 0.61a    |
| Dark chocolates            | 11.32+- | 43.61+- | 26.80+-       | 1.39+-   | 2.24+-   |
| with 80% cocoa mass (DC80) | 2.52b   | 3.73b   | 2.48c         | 0.37a    | 0.64a    |

### 6.9\_Health benefits of dark chocolate :

Recent findings have revealed the presence of dark chocolate. It has been demonstrated to engender a number of salutary effects. A plethora of health benefits have been attributed to dark chocolate, including the following, alleviation of cardiovascular disease , protection against heart disease, stroke prevention, alleviation of hypertension (high blood pressure), regulation of blood sugar and insulin dependence, reduced risk of type II diabetes, antioxidant protection, alleviation of colds and coughs, reduced cancer risk, reduced risk of colon cancer, slowing aging, increased immune function, slowing the progression of AIDS, DNA repair and protection, Alzheimer's protection, alleviation of premenstrual syndrome, prevention of alopecia (Baron AM et al.,1999).

### 7. Chocolate energy bar :

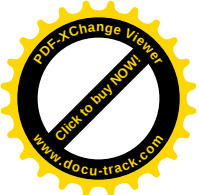
The utilization of premium-quality raw materials, such as dates (*Phoenix*), is imperative to ensure the efficacy and consistency of the final product. The following ingredients are included in the product: dates (*Phoenix dactylifera*), oats (*Avena sativa*), raisins, rice crispies. The nut

## CHAPTER II :Energy bar

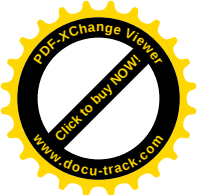
sample included almonds and cashews, while the honey sample was a blend of multiflora. The samples in this study included chocolate (dark) and seeds (sunflower and watermelon). The items under consideration were obtained from the local market in Ahmedabad, Gujarat, India. Table 1 illustrates the proportion of The following ingredients are present in treatments T-1, T-2, and T-3. The dry ingredients, such as nuts, were subjected to a process of coarser grinding. The item was exposed to an elevated temperature of 125°C for a duration of 10 minutes through the process of roasting. The mixture The substance was transferred into a mold and permitted to cool at room temperature. The raisins were then weighed and chopped into pieces measuring 2–3 millimeters. The dry blend was gradually augmented with chopped raisins and dates, followed by thorough integration. The objective was to ensure that the syrup and honey were added in such a manner that no dry ingredient remained uncoated. To this end, the ingredients were weighed and added gradually, with the mixture being incorporated thoroughly (Chandegara et al.,2025).

**Table N 6:** the proportion of ingredients used in treatments T-1, T-2, and T-3 for a product containing dates (*Phoenix dactylifera*), oats, raisins, rice crispies, nuts, honey, chocolate, and seeds (Chandegara et al., 2025)

| Ingredients   | Treatments |     |     |
|---------------|------------|-----|-----|
|               | T1         | T2  | T3  |
| Oats          | 34         | 30  | 26  |
| Honey         | 15         | 15  | 15  |
| Chocolate     | 10         | 14  | 18  |
| Nuts          | 10         | 10  | 10  |
| Seeds         | 10         | 10  | 10  |
| Dates         | 8          | 8   | 8   |
| Rice crispies | 8          | 8   | 8   |
| Raisin        | 5          | 5   | 5   |
| <b>Total</b>  | 100        | 100 | 100 |



# Experimental Part



# **CHAPTER I**

## **MATERIAL AND METHODS**

## CHAPTER I: MATERIAL AND METHODS

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### 1. Objective and approach

The objective of this study is to develop a high-energy cereal bar by valorizing stale bread, which is combined with nitrite-rich ingredients. The aim is to offer a sustainable and nutritionally balanced alternative to traditional breakfast foods for kids and students. The formulation process is guided by consumer preferences, as determined by a targeted questionnaire, and the resulting product is evaluated for its nutritional, microbiological, and sensory properties to ensure both health benefits and broad consumer appeal.

The duration of the project was five months, from February 11<sup>th</sup> 2025, to June 2025. The experimental work was conducted in the following establishment :

- ✓ Laboratory of the Algerian Center for Quality Control and Packaging ALGER .
- ✓ Hygiene laboratory of the district of BLIDA .

### 2\_ Methodology :

The method employed in this study is outlined as follows:

#### 2.1 Survey :

The questionnaire was developed with the objective of acquiring data regarding consumers' preferences concerning healthy snacks. It is under consideration comprises a series of inquiries targeting both social and socio-economic demographics, in addition to an examination of consumer behaviors. The questionnaire under consideration combines closed questions—of the binary (yes/no/maybe) or multiple-choice variety—with semi-closed and open-ended inquiries. The examination will comprise multiple choice and semi-closed questions. The product has been designed with two distinct consumer categories in mind: children, university students .

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### 2. 2 Energy bar formulation :

**Table N :** Ingredients used in energy bar

| Ingredient           | Source                                                                          |
|----------------------|---------------------------------------------------------------------------------|
| Stale Bread          | Comes from home, collected and stored in a food bag in a dry, cold environment. |
| Normal pumpkin seeds | Bought at the market by the weight of 80g .                                     |
| Dates                | Commercial purchase by weight of 500g .                                         |
| Walnut               | Store-bought by weight of 200g .                                                |
| Coconut              | Comes from market by weight of 80g .                                            |
| Dark Chocolate       | Comes from OPTILLA, bought and packed in a 250g plastic bag .                   |

#### Energy bar fabrication :

Following a period of meticulous testing and rigorous experimentation that spanned five months, the energy bar recipe was finalized, at which point the desired characteristics were confirmed.

Each iteration presented an opportunity to refine the ingredients, proportions, and preparation techniques.

**Figure N 5:** Some pieces of energy bar made at home on the left coated with dark chocolate and on the right coated with brown chocolate (original photo)



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### 1<sup>st</sup> formulation :

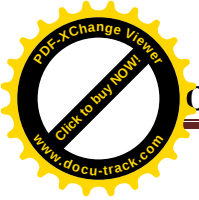
The recipe for this bar was formulated by combining stale bread with a small amount of dates. It was developed for consumption by students and has minimal content of pumpkin seeds.

**Table N 7 :** Percentage of ingredients used in the 1<sup>st</sup> formulation ( original table )

| Ingredients           | (%) |
|-----------------------|-----|
| Stale bread           | 70  |
| Dates                 | 20  |
| Walnuts               | 7   |
| Pumpkin seeds         | 5   |
| Coconut               | 5   |
| Chocolate for coating | 7   |

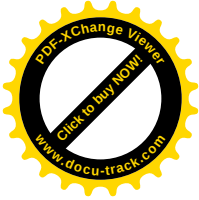
### 2<sup>nd</sup> formulation :

The formulation of the bar under consideration incorporates dates and walnuts, a choice informed by the objective of achieving a sweet taste and a high concentration of brain-derived nutrients. The product is intended for consumption by children and adolescents.



## CHAPTER I: MATERIAL AND METHODS

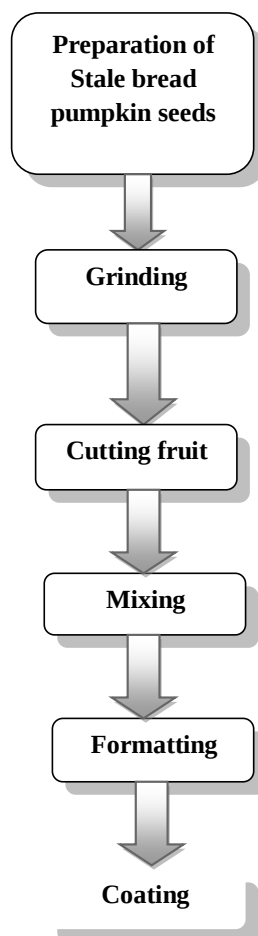
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**Table N 8 :** Percentage of ingredients used in the 2<sup>nd</sup> formulation (original table )

| Ingredients           | %   |
|-----------------------|-----|
| Stale bread           | 30  |
| Dates                 | 100 |
| Walnuts               | 3   |
| Pumpkin seeds         | 3   |
| Coconut               | 1   |
| Chocolate for coating | 7   |

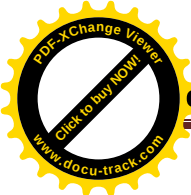
Figure N °6 : Energy bar manufacturing diagram (original diagram )



✓ **Diagram explantation :**

### **Preparation of Ingredients**

- **Stale Bread and Pumpkin Seeds:** These raw materials are selected and prepared for processing. Stale bread is typically dried to reduce moisture content, enhancing its shelf stability and suitability for grinding. Pumpkin seeds are cleaned to remove impurities and ensure food safety.
- **Grinding:** The stale bread and pumpkin seeds are mechanically reduced in particle size using grinding equipment. This step increases the surface area of the ingredients, facilitating better mixing and texture integration



## CHAPTER I: MATERIAL AND METHODS

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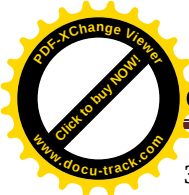


### Cutting of Date Fruit

- **Date Processing:** Dates are selected, pitted, and cut into smaller pieces. This ensures uniform distribution within the mixture and contributes natural sweetness and chewy texture to the final product.

### Mixing

- **Homogeneous Blend:** The ground bread, pumpkin seeds, and chopped dates are combined in a mixer. Thorough mixing is crucial to achieve a homogenous matrix, ensuring consistent flavor, texture, and nutritional value throughout each bar
- **Binder Integration:** Depending on formulation, a binder (such as honey or syrup) may be added during mixing to ensure cohesiveness and proper structural integrity of the bars
- **Forming into Bars**
  - **Compaction and Shaping:** The mixed ingredients are transferred to a forming machine or manually pressed into molds. This step compacts the mixture into a uniform slab or bar shape, optimizing structural stability and portion control
  - . □ **Setting:** The formed bars may be allowed to set or are briefly baked or cooled to stabilize their structure and enhance texture
- **Coating with Dark Chocolate**
  - **Chocolate Tempering:** Dark chocolate is melted and tempered to ensure proper crystallization and a glossy finish.
  - **Enrobing:** The bars are coated with tempered dark chocolate using an enrobing machine or by manual dipping. This step provides a protective barrier, improves shelf life, and enhances sensory appeal



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### 3. Methods of analysis used :

#### 3.1 Determination of water content ( ISO 11294 December 1994) :

The determination of the water content of a product is achieved through a drying process conducted at a temperature of  $103 \pm 2^{\circ}\text{C}$  in an oven operating under atmospheric pressure. This process is continued until the mass of the product remains virtually constant.

The process is continued until a practically constant mass is obtained, with atmospheric pressure acting as the driving force.

##### - Procedure :

-First, weigh 5 g of purslane powder to the nearest 1 mg. Then, put it into a capsule that's already dried out and tared, including the lid. The capsule should be handled with forceps.

- Place the open capsule with the test plug and its cap in the oven and leave for 3 hours.

for 3 hours, the time being counted from the moment the oven temperature reaches  $102.8^{\circ}\text{C}$  .

- Quickly remove the capsule from the oven, cover it and place it in the desiccator (between 30 and 45min). As soon as the capsule has cooled to laboratory temperature, weigh to the nearest 1 mg. Repeat until the mass has stabilized.

-Make two determinations for each sample.

##### ❖ Expression of results :

The water content, expressed as a percentage by mass, is given by the following formula:

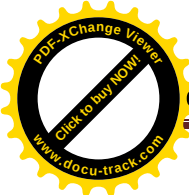
$$H\% = (m_0 - m_1) / m_0 \times 100$$

**H**: water content, in percentage by mass.

**m<sub>0</sub>**: mass, in grams, of test sample.

**m<sub>1</sub>**: mass, in grams, of test sample after drying.

##### ❖ Repeatability :



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Take as a result the arithmetic mean of the two values obtained, provided that the difference between the results of two determinations, carried out simultaneously or rapidly by the same analyst, must not exceed 0.15 g water per 100 g sample. It should be noted that this method does not measure water content per se. The correct term for the result of this method should be “mass loss”, which corresponds not only to water content but also all volatile compounds under operational drying conditions.

### 3.2. Determination of ash content (NA 732-1991 ; NF V 03-720 1981) :

Ash is the mineral residue that remains after a product has been incinerated. This is typically expressed as a percentage by mass in relation to dry matter .

#### -Principle :

Incineration of a test sample in an oxidizing atmosphere at a temperature of  $550 \pm 10^\circ\text{C}$  , until complete combustion of the organic material has taken place, and a constant mass .

#### -Procedure :

-Prepare the pods for incineration immediately before use, by heating them for 10 min in an oven set at  $550 \pm 10^\circ\text{C}$ , then allowing them to cool to room temperature in a desiccator and weighing them to the nearest 0.1 mg .

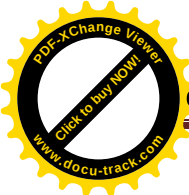
#### Samples preparation :

-Immediately determine the moisture content using the method described above. If you wish to relate the ash content to the product as it is, it is not necessary to determine the moisture content.

-Weigh into the prepared scoop, to the nearest 10 mg, from 2 to 6 g of the test sample, depending on the presumed ash content. Spread the material in a layer of uniform thickness, without compacting it.

-Moisten the test sample in the basket with 1-2 ml of 95% ethanol to ensure even incineration (optional step).

#### - Pre-incarnation :



## CHAPTER I: MATERIAL AND METHODS

-Place the basket and its contents at the entrance of the oven, preheat it to  $550 \pm 10^\circ\text{C}$  , leave the door open until the material ignites, then remove the basket. .

Make sure the solid particles of the material do not burn too quickly.

### -Incarnation :

-Once the flame is extinguished, carefully place the incinerator basket in the bottom of the furnace and leave it for 3 hours, until any carbonaceous particles that may be in the residue.

-Remove the pod from the oven and cool on the heat-resistant plate for 1 min, then in the desiccator to room temperature.

-Weigh, to the nearest 1 mg, the basket containing the residue, quickly, because of the hygroscopic nature of the ash.

-Repeat heating and weighing (after cooling) until a constant mass is obtained. mass, i.e. until the difference between two successive weightings, separated by 1 h of additional heating of additional heating, does not exceed 0.2 mg.

-Perform at least two determinations on the same sample.

### ❖ Expression of results :

The ash content, expressed as a percentage by mass of dry matter, is equal to :

$$\text{Ash content (\%DM)} = \frac{m_1}{m_0} \times 100 \times 100 / (100 - H)$$

$m_0$  : mass, in grams, of test sample .

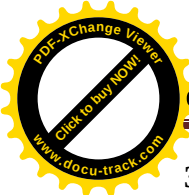
$m_1$ : mass, in grams, of the residue .

$H$  : water content of the sample, expressed as a percentage by mass.

### Repeatability :

Take as a result the arithmetic mean of the two determinations, provided that the difference between the results of two determinations must not exceed :

- ✓ 0.02 (%) (absolute value) for ash levels below 1% (m/m).
- ✓ 2 (%) of average value for ash levels above 1% (m/m).



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### 3.3.Determination of fat content (Soxhlet extraction NF V03-905) :

#### -Principle :

The solid feed is weighed and placed in a cellulose cartridge. The sample is continuously extracted with a suitable boiling solvent (n-hexane or petroleum ether) which gradually dissolves the fat. The fat-containing solvent is returned to the flask in successive successive spills caused by a siphon effect in the side elbow. As only the solvent can evaporate again, the fat accumulates in the flask until extraction is complete.

#### -Procedure:

- Accurately weigh out approx. 10 g of sample (previously dried), immediately place the test sample in the cartridge of the soxhlet extractor and cover it with glass absorbent cotton.
- The fat collection flask is dried, weighed and placed on the heater.
- Assemble the Soxhlet.
- Add a quantity of hexane corresponding to two siphoning.
- Extraction runs for 6 hours.
- Once extraction is complete, place the flask containing the fat and hexane in a ROTAVAPOR to recover most of the solvent.
- Eliminate the last traces of solvent by placing the flask containing the fat in a oven at  $103 \pm 2^\circ\text{C}$  for 1 hour, leave the flask to cool in the desiccator and then weigh it.

#### ❖ Expression of results :

Fat content, expressed as a percentage by mass of dry matter, is given by the following formula :

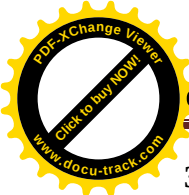
$$\frac{M2 - m_1}{m_0} \times 100 / 100 - H$$

**m<sub>0</sub>**: mass, in grams, of the test sample .

**m<sub>1</sub>** : mass, in grams, of the balloon .

**M2** : mass, in grams, of balloon and fat after drying .

**H** : water content of test sample, in (%) by mass .



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### 3.4.Determination of protein content (Kjeldahl method) NA.1158/1990 :

Depending on their exact amino acid composition, food proteins contain from 15 to 18 % nitrogen (average 16 %). Some food constituents also contain nitrogen, which is assayed together with protein nitrogen, but since foods contain only small quantities of these constituents, the error is negligible, so the nitrogen content is proportional to the protein.

#### **-Principle :**

The sample is mineralized in sulfuric acid containing digestion catalysts (metal salts) and potassium sulfate (boiling point enhancer). The ammonium sulfate releases ammonia after the addition of sodium hydroxide. The ammonia is steam-distilled and captured in a boric acid solution for subsequent titration with hydrochloric acid .

#### **❖ Reagents used :**

- ✓ Sulfuric acid 98%, nitrogen-free.
- ✓ Catalyst: 3 g copper sulfate penta-hydrate and 100 g potassium sulphate .
- ✓ 50 % NaOH soda solution .
- ✓ Hydrochloric acid HCl 0.1 N .
- ✓ 20 g/l boric acid solution .
- ✓ Colour indicator: methyl red, Congo red.

#### **-Procedure**

##### **> Mineralization:**

-Weigh, to the nearest 1 mg, from 0.1 to 4 g of the homogenized sample, depending on the presumed protein content and add 3 g of catalyst mixture.

-The water content is determined beforehand to obtain a dry matter result.

-Then pour in 20 ml sulfuric acid, add a few glass beads and stir.

-Heat slowly, then boil until the mixture is clear and pale blue in color pale blue.

-Heat for a further 15 minutes, then cool to room temperature.

-Carefully dilute with distilled water (40 ml) and transfer to a 100 ml flask. After cooling, make up to the mark (100 ml).

##### **> Distillation :**

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- Alkalize 10 ml of the mineralization solution with the sodium hydroxide solution, then steam distillation .

|                     | Cereal bar |
|---------------------|------------|
| <i>G.A.M.T</i>      | ×          |
| <i>E. coli</i>      | ×          |
| <i>S. aureus</i>    | ×          |
| <i>Salmonella</i>   | ×          |
| <i>Moississures</i> | ×          |

- The distillation outlet tube should be immersed in approx. 20 ml of the boric acid/indicator mixture.

### ➤ Titration :

- The entire distillate is titrated with hydrochloric acid until the initial color of the indicator (red in the case of methyl red) is obtained of the indicator (red in the case of methyl red).

### ➤ Blank determination :

- Carry out the same steps as above, but without adding a sample.

### ❖ Expression of results :

Protein content, expressed as a percentage by mass of dry matter, is calculated using the following formula :

$$(V1 - V2) \times 1.4008 \times F / M$$

**V1** : volume, in millilitres, of HCl 0.1N required for blank determination .

**V2** : volume, in millilitres, of 0.1N HCl required for sample determination .

**F** : mass, in grams, of test sample .

**M** : The conversion factor depends on the nature of the food, and is often 6.25 .

The factor 1.4008 corresponds to the amount of nitrogen titrated by 1 ml of HCl 0.1 N and is expressed in mg/ml .

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### 4. Microbiological analysis

According to Official Journal No. 35 of 1998, the germs found in the samples studied are listed in the following table :

X = analyse realized

**Table N 10** : Germs wanted according to JORA N°39 of 2017

#### ✓ Samples preparation

This is the protocol defined by IANOR standardized methods According to Algerian regulations (JORA N° 38 of June 22, 2017).

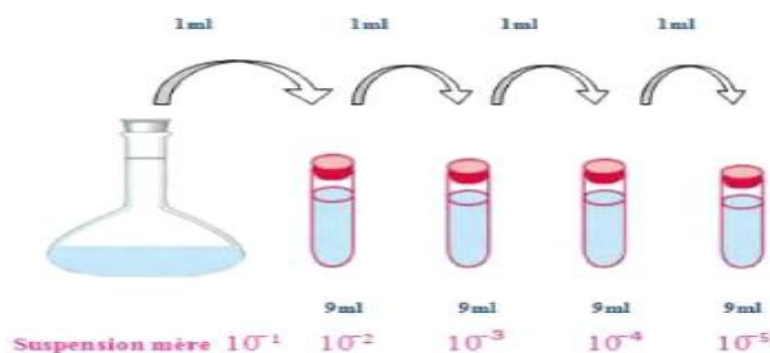
#### ☒ Preparation of the parent suspension:

It should be noted that 10 g of each sample is taken and diluted in a bottle containing 90 ml of TSE. The mixture is placed in a sterile stomacher bag and introduced into the stomacher grinder for 1 to 2 min to homogenize it, then the coarse particles are left to settle for a maximum of 15 min maximum .

#### -Preparation of decimal dilutions :

Once the stock solution has been prepared, the  $10^{-2}$  dilution is made by removing 1 ml of the sterile pipette, into 9 ml of TSE. Dilutions  $10^{-3}$  and  $10^{-4}$  will be prepared in the same way from the previous dilutions.

**Figure N 7** : Method for preparing the stock solution and decimal dilutions

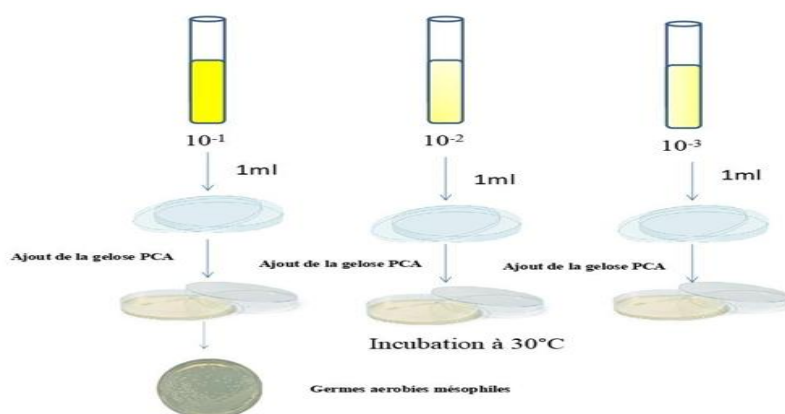


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### 4.1. Research and detection of Total Aerobic Mesophilic Flora (FAMT) (NF V 08-011, NF EN ISO 4833, AFNOR 2003) :

This is aerobic mesophilic flora: all microorganisms can grow, except those that are demanding and strict anaerobes. In labeled Petri dishes, take a pipette and, starting with the last dilution, take 1 ml of dilution which will be distributed as a drop at the bottom of the corresponding dish. Repeat for the second dish. Continue up to the next dilution, without changing the pipette to the first dilution. The drops are then covered with a layer of super cooled PCA agar (Plat Count Agar), and homogenized with circular movements. Care is taken to ensure that the agar is not too hot, so as not to kill the bacteria. Once gelled, incubate at 30° C for 72 hours. Readings are taken every 24h .

**Figure N 8 :** Total aerobic mesophilic flora enumeration protocol (FAMT)



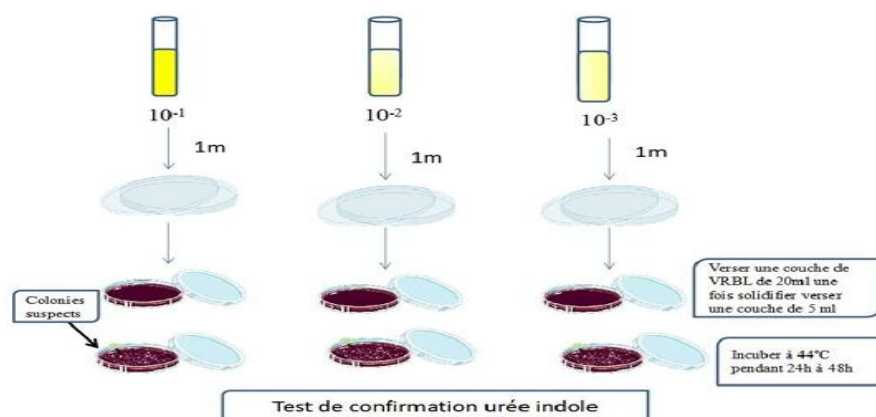
### 4.2. Research and detection of Escherichia coli :

Thermotolerant coliforms or fecal coliforms are a subgroup of total coliforms capable of fermenting lactose at a temperature of 44° C. They are counted on VRBL agar (Lactose Bile Agar with Crystal Viole and Neutral Red). Place 1ml of dilution according to the official diary in an annotated Petri dish. Pour 12ml of medium cooled to 44 °C - 47° C. Homogenize perfectly and leave to solidify on a cold surface. Pour a further 4 ml of medium or white agar to form a second layer and allow to solidify. Incubate at 44° C for 18 to 24 hours. All red colonies with a diameter of 0.5 mm or more, after 24 hours incubation at 44° C are considered Thermotolerant or Fecal .

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For *Escherichia coli*, which belongs to the thermotolerant Coliforms group, the test technique is to identify at least 3 colonies characteristic of thermotolerant Coliforms on each plate. Aspirate the colony using a Pasteur pipette fitted with a bulb. Separately replicate each colony and inoculate in urea indole medium. Incubate medium 18-24h at 37°C. The indole test is carried out in the latter tubes after addition of Kovacs reagent.

**Figure N 9 :** Detection and enumeration of *E. Coli*

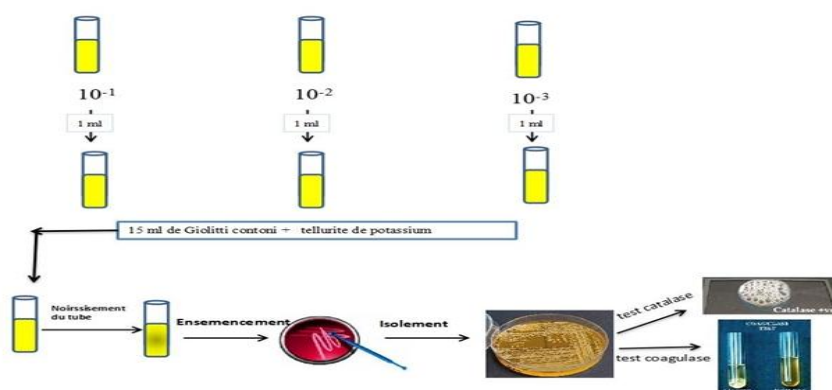


### 4.3. Research and detection of *Staphylococcus aureus* :

These microorganisms are spherical in shape, dividing in several planes and forming more or less regular clusters or tetrads. They are immobile or mobile, non-spore-forming and Gram-positive. They are tested by pouring 1ml of each dilution in Giolitti Cantoni broth, with the addition of potassium tellurite, for incubation for 24 to 48 hours. Positive tubes are inoculated into Chapman selective medium after incubation at 37°F for 24 hours, a catalase test is performed using oxygenated water. Half of each catalase-positive colony is sub-cultured in brain heart broth (BHIB). The tubes incubated 18h at 37°C Mix 0.1 ml BHIB broth with 0.3 ml plasma in a sterile tube and incubate at 37°C for 24 hours .

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**Figure N 10 :** Detection for and enumeration of *Staphylococcus aureus*



### 4.4. Research and detection of salmonella :

According to the Algerian standard (JORA. N° 44 .23 July 2017). Salmonella testing involves four(4) steps : Pre-enrichment, enrichment, isolation and identification.

**Day 1:** Pre-enrichment in liquid non-selective medium: Take 25 grams of sample into a 225 ml vial of buffered peptone water (BPW, a non-inhibitory nutrient medium). incubated at 37°F for 18h. This step allows the recovery of Salmonella bacteria that have undergone physical or chemical (heat treatment, freezing, dehydration, preservatives).

**Day 2:** Enrichment with liquid selective media: (containing inhibiting agents active on germs that compete with Salmonella). Enrichment is carried out on two different selective media:

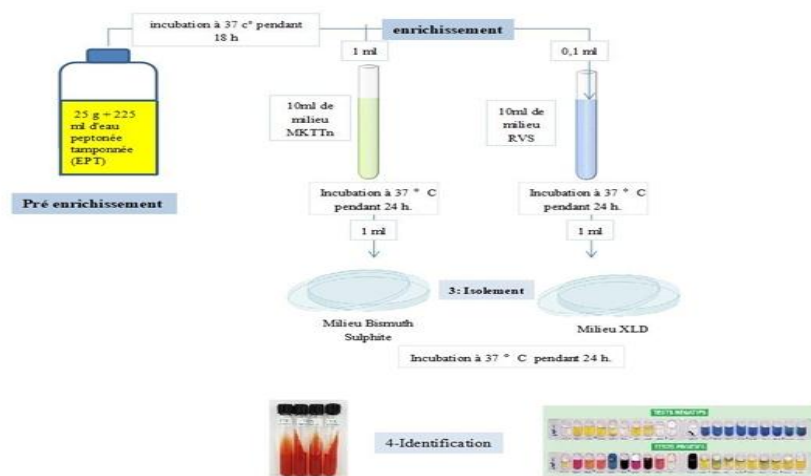
- Rappaport-Vassiliadis medium with soy (RVS broth), 10 ml per tube.
- Muller- Kauffmann Au Tetra Thionate- Novobiocin (MKTTn) medium (10 ml per tube). Enrichment is carried out using the culture already prepared.
- 1 ml of the culture obtained after pre-enrichment is inoculated into a tube containing 10 ml RVS broth and also transfer 0.1 ml of the culture obtained after pre-enrichment into a tube containing 10 ml MKTTn broth.
- Incubate the seeded RVS broth at 41.5°C for 24 h and the MKTTn broth at 37°C for 24 h.

**Day 3:** Isolation: Isolation is carried out on two selective media: Bismuth Sulphite agar and Xylose Lysine Deoxycholate (XLD) agar by streaking 0.1 ml of the culture in obtained in RVS and MKTTN broth after incubation, plates are incubated for 24 h at 37°F.

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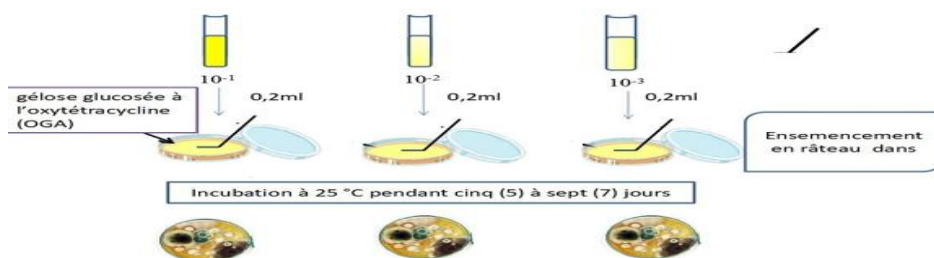
**Confirmation:** For confirmation, at least one colony is taken from each plate of each of the selective media (XLD) and (Bismuth Sulphite), at least one colony considered to be or four colonies, if the first is negative.

**Figure N 11 :** Research and enumeration of *Salmonella* sp

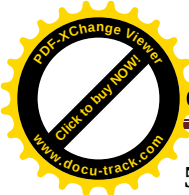


### 4.5. Research and detection of Mould (AFNOR NF V 08-052) :

Mold are eukaryotic, filamentous, aerobic, acidophilic (optimum pH =3 to 7) and mesophilic, growing on foods with low water activity, they are frequent contaminants of foodstuffs. They are determined by counting filamentous, cottony colonies obtained after plating on a selective culture medium: oxy-tetracycline glucose agar (OGA) or Sabouraud agar with chloramphenicol agar. Incubation takes place at 25°C for 5 days.



**Figure N 12 :** Mould detection and enumeration.



### 5. Sensory analysis of the energy bar :

According to the standards established by **AFNOR V09-014 of April 1982**, sensory analysis is defined as a method for evaluating the organo-leptic qualities (appearance, smell, color, texture, etc.) of foods. The basis of this phenomenon is the human capacity for discrimination, quantification, and description of sensory perceptions. The five classical senses of sight, hearing, touch, smell, and taste are widely accepted as the fundamental means by which humans perceive and interpret their environment.

These devices are characterized by their capacity for measurement and controllability. To this end, a dual approach was undertaken, incorporating both a ranking test and a rating test.

#### 5.1. Choice of tasting panel :

The selection of panelists is contingent upon the nature of the test and is determined by the availability of each taster. This includes individuals of both genders, ranging from students to encompassing children as well .

#### 5.2. Ranking test :

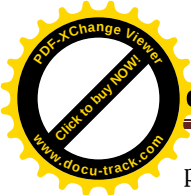
The tasters were tasked with ranking the acceptance-coded samples from least to most acceptable. The scale ranges from least to most acceptable, as indicated by **Watts et al. (1991)**. The experiment involved the presentation of three samples of elaborate bars to each taster in a precise order, coded (Power bar I, Power bar II). The subjects were provided with the opportunity to sample the substance multiple times. The sample is hereby presented for consideration .

#### 5.3. Descriptive test :

The organ-oleptic property descriptors employed for the evaluation of the bars encompass the attributes of color and aroma. The following characteristics are observed: Texture, taste, smell and visual .

#### 5.4. Tasting test :

Tasters are requested to evaluate the intensity of each sensory descriptor as it is experienced, employing a scale that ranges from 1 to 5. This evaluation is to be conducted as the tasting process unfolds. As the tasting progresses, the following observations are made. Tasters are

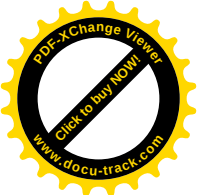


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provided with water between each tasting to ensure adequate hydration. For further elucidation, please refer to the following sources: The following tasting sheet is provided in the appendix .



## **CHAPTER II**

# **RESULTS AND DISCUSSION**

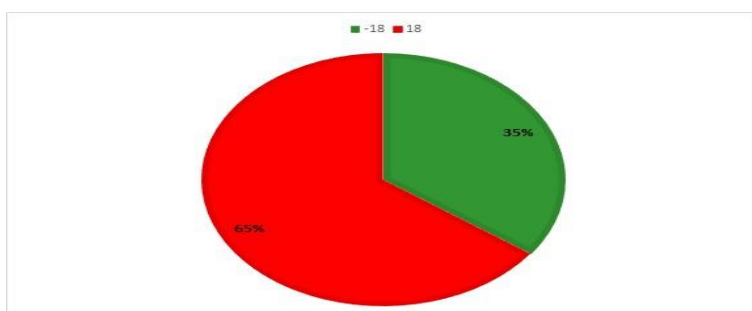
## CHAPTER II: RESULTS AND DISCUSSION

### 1. Results and discussion of the survey :

The survey was administered to a total of 123 participants, who were divided into two distinct age categories: university students and adults aged 18 years and above, and children under 18 years. The adult participants were drawn from a diverse array of settings, including university settings, public locations, and online platforms, ensuring a broad and representative sample of individuals within this age group. The selection of children was conducted from primary schools situated within the same geographic region as the participating universities. This approach to participant inclusion was designed to capture a wide spectrum of healthy snack preferences across different life stages and social environments. The objective was to enhance the generalizability and relevance of the findings for both adult and child populations. The survey instrument is available in the appendix.

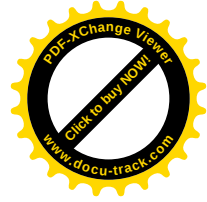
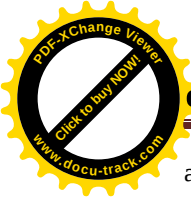
#### 1. Age :

**Figure N 13 : Participant Distribution by Age**



The pie chart above shows the distribution of the participant by age category , which the value of 65 % illustrates the percentage of participant more than 18 old ( students ..) and the value of 35 % shows the percentage of participants less than -18.

The distribution observed, with 65% of respondents aged over 18 versus 35% under 18, highlights an over-representation of young adults among the participants, even though the target population also includes children and teenagers. This discrepancy may be attributed to enhanced accessibility for university students, who may demonstrate a heightened propensity to engage in online survey participation. Consequently, the study's findings are more indicative of the perceptions and habits of young adults, which may restrict the generalizability of the results to



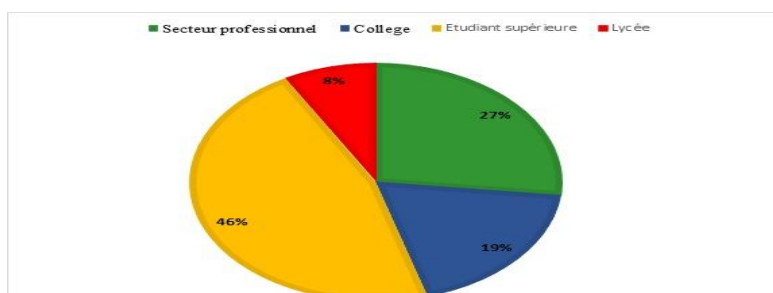
## CHAPTER II: RESULTS AND DISCUSSION

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all the age groups initially targeted. This finding aligns with the observations documented in the scientific literature, which underscore the significance of meticulous sample selection to ensure the validity of conclusions pertaining to the eating behaviors of young individuals (**Story & French, 2004; Larson et al., 2019**).

## 2. Field of activity :

Figure N 14 : Participant distribution of field of activity



The results of the questionnaire, as illustrated in Figure 2, The participants in this study are distributed across various fields of activity, as depicted in the following breakdown: 46 % are enrolled in higher education, 27 % are employed in the professional sector, 19 % are enrolled in middle school, and 8 % are enrolled in high school. This diversity facilitates the examination of dietary behaviors and preferences according to a variety of socio-educational profiles, thereby offering a more profound understanding of the specific needs of each group.

**1. Superior student (46 %) :** The majority of the sample are university students. Confronted with time constraints, limited financial resources, and substantial academic pressure, these young adults frequently resort to easily accessible, high-calorie snacks. Research indicates a strong preference among students for fast food, which can result in nutritional imbalances (**Sogari et al., 2018**). However, an increasing awareness of health concerns is prompting a shift towards healthier alternatives, including natural, nutrient-rich snacks (**Laska et al., 2015**).

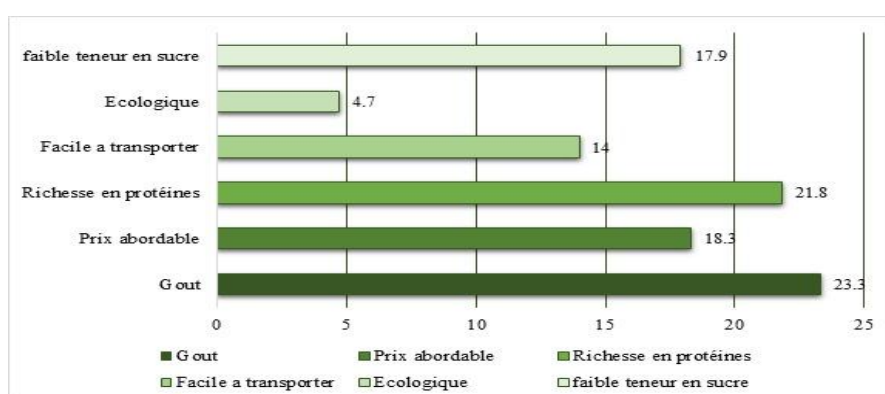
**2. Professional sector (27 %) :** A considerable proportion of these individuals are employed adults, constituting approximately one-fourth of the total population. The dietary practices of office workers are frequently influenced by the demands of their professional environment, particularly the pace of work and the availability of meals. Research indicates that professionals prioritize snacks that balance convenience and nutritional quality, with an emphasis on weight management and chronic disease prevention (**Rydén & Hagströmer, 2018**). Interventions targeting this demographic should promote the consumption of foods rich in dietary fiber, beneficial fats (such as omega-3 fatty acids), and essential micronutrients to support metabolic health and reduce the risk of chronic disease (**Slavin, 2013**).

## CHAPTER II: RESULTS AND DISCUSSION

**3. Middle and high school students (27 % total) :** Middle and high school have specific nutritional needs that are linked to their rapid growth and cognitive development. The influence of the social and school environment on eating habits has been demonstrated to be a significant factor in the development of these habits (Story *et al.*, 2002). A study by Pearson *et al.* (2009) revealed that middle and high school students may exhibit more impulsive eating behaviors and a preference for sugary or fatty foods. These findings underscore the need for adapted educational strategies to encourage more balanced choices. School programs incorporating nutrition awareness have been shown to be effective in improving eating habits in this age group (Contento, 2011).

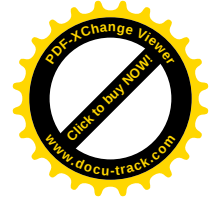
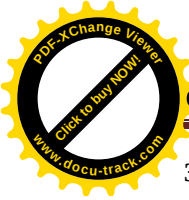
### 3. Privileged criteria in a snack :

**Figure N 15 :** Distribution of Preferred Criteria for Snack Selection



**1. Taste :** The results of the study indicate that taste is the most significant criterion for 23.3 % of the participants, thereby confirming that sensory pleasure is a key factor in food selection, even in the context of snacks. The significance of taste has been extensively documented, as it exerts a considerable influence on satisfaction and the propensity for repeat consumption (Rusmevichientong *et al.*, 2021).

**2. Affordability :** Cited by 18.3 % of respondents, is also a determining factor, particularly among young adults and students, for whom budget is a major constraint. As demonstrated in Arroyo's (2020) study, a multifaceted interplay among factors including weight control, health, economic value, and food choices emerges as a salient phenomenon.



## CHAPTER II: RESULTS AND DISCUSSION

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**3. Richness in protein :** The protein richness component, which was valued by 21.8 % of the participants, reflects an important nutritional trend. Protein is imperative for muscle development and recovery, sustained satiety, and weight management (**Jäger et al., 2017**). The consumption of protein snacks has been demonstrated to facilitate optimal recovery following physical exertion and assist in the maintenance of muscle mass (**Bird et al., 2022**).

As stated by **Tomé (2009)**, dietary proteins are essential for providing the body with amino acids, which are vital for metabolism and tissue synthesis. Moreover, the incorporation of protein in snacks has been demonstrated to curtail the consumption of sugars and fats, thereby fostering optimal nutritional equilibrium (**Nutripure, 2025**). This emphasis on protein in snacks is part of a global trend in which consumers seek functional foods that offer a combination of convenience and health benefits (**Fitness World Nutrition, 2025**). Official dietary recommendations also encourage the regular consumption of a variety of protein-rich foods (**Canada's Food Guide, 2024**).

**4. Low sugar content :** The low sugar content (17.9 %) and high protein content (21.8 %) are indicative of a growing consumer awareness of the impact of macronutrients on health. The consumption of protein-rich, low-sugar snacks has been demonstrated to promote satiety and contribute to weight management (**Mattes & Campbell, 2016**). This assertion is supported by research examining the satiety and nutritional quality of snacks.

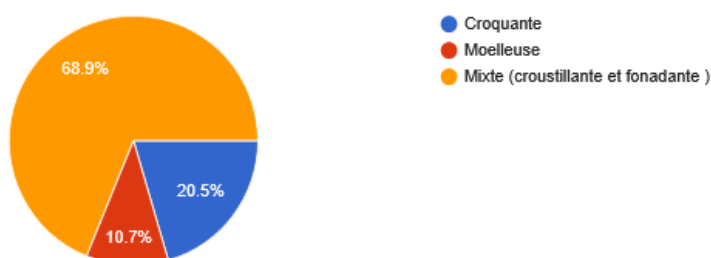
**5. Ease of transportation :** The ease with which snacks can be transported (14 %) is indicative of a significant practical necessity, particularly for individuals who engage in physical activity on a regular basis. This dimension has been a focal point in contemporary research on eating habits, with scholars emphasizing the pivotal role of convenience in food selection (**Rusmevichientong et al., 2021**).

**6. Ecological :** The low percentage (4.7%) of participants who indicated that ecological aspects were important in their choice of energy bars probably reflects a more general trend among consumers, where ecological considerations are often secondary to factors such as taste, nutrition, and price (**Smith & Lee, 2020; Garcia & Thompson, 2019**). Accordingly with the findings of international studies, eco-friendly packaging, and sustainable ingredients have been demonstrated to increase the likelihood of consumer purchase, though these factors generally exert minimal influence in comparison to health or sensory benefits in the decision-making process (**Wang & Chen, 2021**).

## CHAPTER II: RESULTS AND DISCUSSION

### 4. Preferences on snack texture :

Figure N 16 : Distribution preferences on snack texture



The pie chart illustrates the distribution of participants' preferences concerning the texture of energy bars. The predominant preference was for a mixed texture, characterized by both crunchy and melting sensations (68.9 %), followed by a crunchy texture (20.5 %), and finally, a soft texture (10.7 %). These results underscore the pivotal role of sensory attributes, particularly texture, in the selection of energy snacks.

#### 1. Mix ( crunchy and melt-able texture ) :

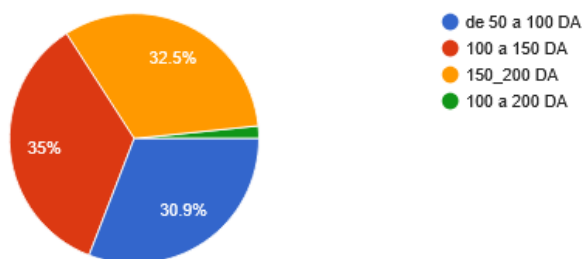
The consumer preference for a texture that is both crunchy and melt-able reflects the search for a balanced sensory experience, combining the pleasure of crunchiness with melting sweetness, which promotes greater product acceptability (Bolhuis & Forde, 2020). Texture exerts a direct influence on chewing speed, bolus formation, and, consequently, satiety and quantity consumed (Bolhuis & Forde, 2020; Frontiers in Nutrition, 2022) .

3. **Crunchy and soft texture** : The crunchy texture, which was appreciated by 20.5 % of respondents, is often associated with freshness and a sensation of density. In contrast, the soft texture, which was preferred by 10.7 % of respondents, is characterized by its ease of chewing and its ability to provide comfort, particularly for specific consumer groups (Krasina et al., 2021). These disparities in preferences may also be associated with the composition of the bars, particularly the content of fiber and texture-related ingredients (Krasina et al., 2021).

### 5. Buying price :

Figure N 17 : Distribution of consumer pricing expectations

## CHAPTER II: RESULTS AND DISCUSSION



The results demonstrate the disaggregation of prices that participants are willing to pay for the product. A substantial proportion of respondents, constituting 35 % of the total, expressed a preference for a price range between 100 and 150 DA. This preference was closely followed by 32.5 % of respondents, who indicated a predilection for a price bracket between 150 and 200 DA. A further 30.9 % of respondents indicated a preference for a lower price range, between 50 and 100 DA, while a very small proportion (1.6 %) expressed readiness to pay between 100 and 200 DA.

**1. 100\_150 DA :** The findings indicate a notable degree of price sensitivity, characterized by a pronounced preference for affordable products, predominantly within the 100-150 DA range. This tendency aligns with the findings of studies indicating that price is a pivotal factor in the decision to purchase, particularly among budget-constrained demographics such as students and young working professionals (**Grunert et al., 2018**).

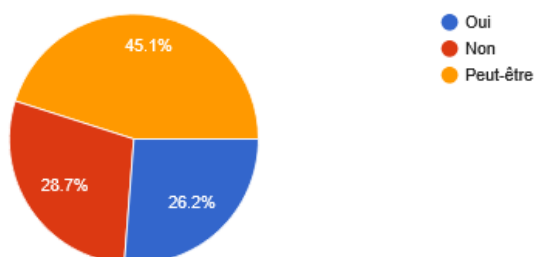
**2. 150\_200 DA :** Subsequently, 32.5% of respondents indicated a preference for a slightly higher range, specifically between 150 and 200 DA. This high proportion suggests that a significant proportion of consumers are prepared to invest more, probably due to an increased perception of the nutritional value, quality, or benefits associated with the product (**Lusk & Briggeman, 2009**).

**3. 50\_100 DA :** Conversely, 30.9 % of the participants indicated a preference for a lower range, specifically between 50 and 100 DA, suggesting heightened price sensitivity, particularly among consumers with constrained budgets, such as students or entry-level professionals (**DelVecchio et al., 2007**).

**4. 100\_200 :** A negligible percentage (1.6 %) of respondents expressed a willingness to pay within the range of 100 to 200 DA. This inclination could be indicative of a certain degree of hesitation or a lack of precision in their perception of the acceptable price.

## 6. Consumer preference for whey-based products (food waste) :

Figure N 18 : Acceptability of products derived from food waste: the case of whey



The results indicate that 26.2 % of the participants expressed a willingness to purchase a product derived from food waste, such as whey, while 28.7 % expressed reluctance to do so. A significant proportion of the respondents, constituting 45.1% of the total, have not yet reached a definitive decision and have indicated their ambivalence through the option of "maybe." These figures are indicative of a certain hesitancy and a lack of confidence or information regarding products derived from food waste.

**1. Yes :** The moderate acceptability (26.2 %) of products derived from food waste is primarily attributable to the negative perception that consumers may have towards food by-products, frequently associated with lower quality or safety (Aschemann-Witzel et al., 2015). This mistrust is compounded by a dearth of information regarding the environmental, economic, and nutritional benefits associated with food waste recovery, a subject that remains under-explored by the general public.

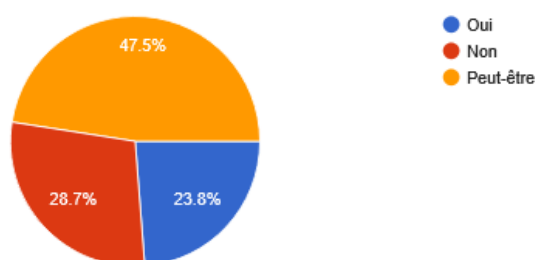
**2. Maybe :** The significant proportion of undecided respondents (45.1 %) indicates a substantial opportunity for food industry stakeholders and public authorities. Enhanced communication and awareness-raising initiatives have the potential to bolster confidence in and acceptance of these innovative, sustainable products (Sheppard et al., 2020).

**3. No :** The refusal exhibited by 28.7 % of the participants exemplifies the psychological and cultural barriers associated with the concept of "food waste." This concept necessitates targeted interventions to modify negative representations and promote these resources as viable and responsible food alternatives.

## CHAPTER II: RESULTS AND DISCUSSION

### 7. Evaluating the perception of stale bread incorporated into foods :

Figure N 19 : Breakdown of participants' opinions on the use of stale bread in food products



The pie chart illustrates the responses of questionnaire participants regarding the incorporation of stale bread into food products. The responses indicate that 23.8 % of the participants expressed support for this incorporation, while 28.7 % expressed opposition. A relative majority of 47.5 % of respondents remained undecided, expressing a "maybe" response.

**1. Yes :** The relatively low acceptance rate (23.8 %) can be attributed to limited consumer awareness and understanding of the environmental and nutritional benefits of up-cycling food waste. The valorization of byproducts, such as whey, has been demonstrated to contribute to the reduction of food waste and the creation of value-added products. This approach is in alignment with the objectives of sustainable food systems (Sheppard et al., 2020). However, the negative connotations associated with the terms "food waste" or "by-product" often hinder consumer acceptance (Aschemann-Witzel et al., 2015).

**2. Maybe :** The significant proportion of undecided respondents (47.5 %) underscores a pivotal opportunity for the implementation of educational and awareness campaigns. A substantial body of research has demonstrated that transparent communication regarding the safety, quality, and benefits of food products derived from waste can remarkably enhance consumer acceptance (Stancu et al., 2016).

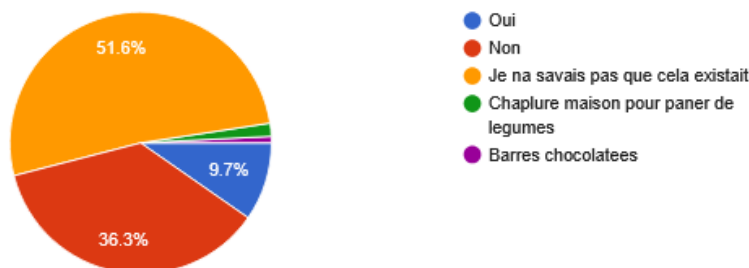
**3. No :** The refusal rate (28.7 %) is indicative of psychological and cultural barriers, whereby consumers may associate food waste-derived products with inferior quality or safety concerns. The successful navigation of these obstacles necessitates the implementation of targeted communication strategies, educational initiatives, and, on occasion, sensory innovations

## CHAPTER II: RESULTS AND DISCUSSION

designed to instill confidence and foster engagement among consumers (Aschemann-Witzel et al., 2015).

### 8. Purchase of stale bread-based food products :

**Figure 20 :** Distribution of participants purchasing of stale bread-based food products



The results indicate that 51.6 % of the participants were unaware of the existence of stale bread-based food products. Of the remaining responses, 36.3 % indicated that they had never purchased breadcrumbs, 9.7 % had already purchased them, while 1.6% had purchased breadcrumbs for the purpose of breeding vegetables and 0.8 % had purchased energy bars made from stale bread. The findings indicate a significant gap in knowledge and limited purchasing experience regarding these innovative products derived from the valorization of stale bread.

#### 1. Consumer awareness of stale bread products :

The majority of participants who were unaware of the existence of these products (51.6 %) indicated that this was due to a lack of information and visibility on food innovations linked to the valorization of stale bread. This dearth of awareness constitutes a significant impediment to acceptance and utilization. As demonstrated in an Algerian study on the incorporation of stale bread flour into animal feed, there is considerable potential for valorizing stale bread in terms of its nutritional and sustainable benefits (Benazzouz et al., 2015).

#### 2. Consumers' non purchase of stale bread products :

The finding that 36.3 % of respondents had never purchased these products indicates a certain reluctance, which is likely associated with negative perceptions regarding the quality, safety, or sensory characteristics of by-product foods (Aschemann-Witzel et al., 2015).

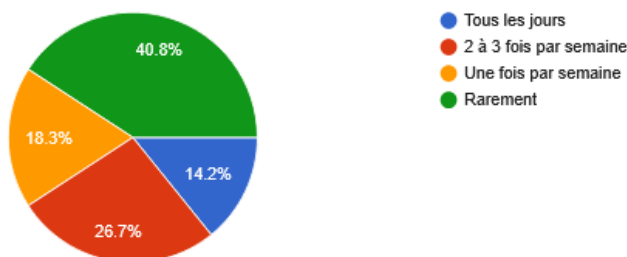
## CHAPTER II: RESULTS AND DISCUSSION

### 3. Consumers' purchase of stale bread products of energy bars and vegetable beading :

The 9.7% of consumers who have already purchased these products demonstrate that a segment of consumers is ready to adopt these sustainable alternatives. The low shares for specific products, such as breadcrumbs (1.6 %) and energy bars (0.8 %), indicate that these applications are still marginal in the market, requiring further development and promotion (**Projet ANR  $\mu$ COSMOS, 2024**).

### 9. Snack purchase frequency:

**Figure N 21 :** Distribution of snack purchase frequency



The pie chart provides a visual representation of the frequency with which participants purchase snacks. The results indicate that 40.8% of the participants purchased snacks rarely, 26.7 % purchased snacks two to three times per week, 18.3 % purchased snacks once per week, and 14.2 % purchased snacks daily. This distribution is indicative of the diverse dietary patterns observed among the study population.

**1. Rarely :** The majority of participants (40.8 %) who purchase snacks infrequently may reflect a tendency to limit consumption of products often rich in sugars and fats. This tendency is in line with international recommendations to promote a healthy, balanced diet (**World Health Organization, 2020**).

**2. 2 to 3 times per week :** The 26.7 % of consumers who report snacking two to three times weekly correspond to a moderate consumption rate, a frequency that has been observed in contemporary society, where snacks are utilized to bridge the gaps between meals (**Mattioli et al., 2021**).

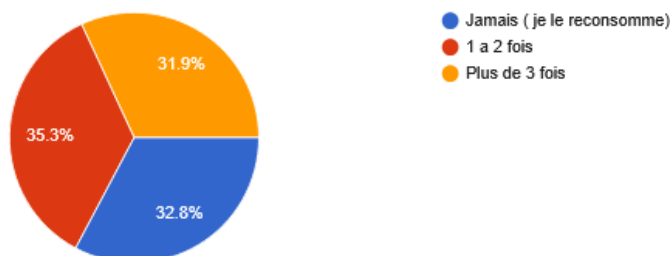
**3. One time in week and every day :** The 18.3 % and 14.2 % of consumers who purchase snacks on a weekly or daily basis, respectively, constitute a substantial segment of the population

## CHAPTER II: RESULTS AND DISCUSSION

for whom snacks are an integral component of their dietary regimen. This frequency has the potential to pose nutritional risks if the consumed products are deficient in essential nutrients (Pérez-López et al., 2021).

### 10. Weekly Frequency of Throwing Away Stale Bread at Home :

**Figure N 22 :** Distribution of weekly frequency of throwing away stale bread at home



The results indicate that 35.3 % of participants discard stale bread once or twice a week, while 32.8 % never discard it, opting instead to re-consume it. The remaining subjects reported disposing of stale bread at least three times per week. This analysis elucidates the diverse management strategies employed for stale bread within household contexts.

**1. Never :** The high proportion (32.8 %) of participants who never discard stale bread but rather re-consume it exemplifies a practice of reducing food waste, in accordance with international recommendations to valorize unsold or expired food (FAO, 2019). This approach is instrumental in mitigating food losses and fostering more sustainable consumption patterns

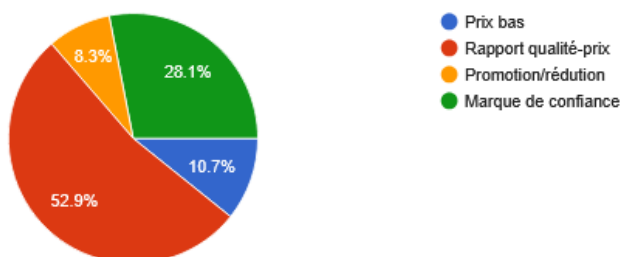
**2. 1 to 2 times per week :** The 35.3 % of respondents who discard stale bread once or twice a week are indicative of moderate food waste management, a phenomenon often associated with traditional dietary habits or a paucity of strategies for valorizing stale bread (Gustavsson et al., 2011).

**3. More than 3 times per week :** The 31.9 % of the population who dispose of stale bread more than three times per week reflect a considerable amount of food waste, which may be associated with a lack of awareness regarding environmental issues or with practical constraints (Aschemann-Witzel et al., 2015). This phenomenon poses a significant challenge to the implementation of public policies aimed at reducing waste.

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### 11. The most important economic factor in a consumer purchase :

**Figure N 23 :** Distribution of the most important economic factor in a consumer purchase



The purchasing behavior of consumers is influenced by various economic factors, including the perceived value of the product or brand, confidence in the product or brand, the cost of the product or brand, and promotions and discounts. The pie chart below illustrates the distribution of the economic factors consumers consider most important when making purchases: value for money (52.9 %), a lack of confidence (28.1 %), low prices (10.7 %), and promotions and discounts (8.3 %).

**1.Value for money 52.9 % :** The pie chart indicates that the majority of consumers (52.9 %) prioritize value for money as the predominant economic factor. Consequently, consumers prioritize achieving an optimal balance between product or service quality and cost, emphasizing overall value as a primary purchasing criterion, rather than solely focusing on price.

**2. A lack of confidence 28.1 % :** The analysis revealed that a lack of trust constituted 28.1 % of the responses, underscoring the pivotal role that trust in the product, brand, or seller plays in the purchasing decision. A dearth of trust can impede the act of purchase, even in cases where the value for money is appealing.

**3. Low prices 10.7 % :** A survey revealed that 10.7 % of consumers indicated that low price is an important criterion, though it is not the sole determinant. It is evident that consumers are no longer merely seeking the most economical option; rather, they are seeking a product that offers an optimal balance between cost and quality.

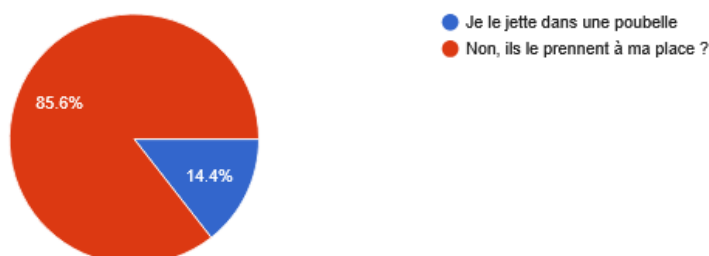
**4. Promotion- discount :** Finally, it was found that promotions and discounts influence 8.3 % of consumers, showing that these commercial incentives have a limited impact. While these

## CHAPTER II: RESULTS AND DISCUSSION

elements may garner attention and potentially stimulate a single purchase, they lack the capacity to create a lasting impression in and of themselves.

### 12. Consumer behavior towards bread leftovers: between disposal and domestic recycling:

**Figure N 24 :** Consumer behavior towards bread leftovers: between disposal and domestic recycling



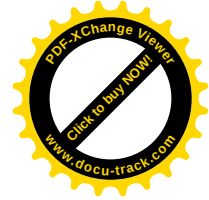
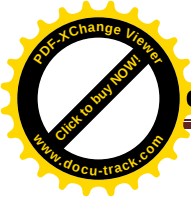
The pie chart reveals that 85.6 % of consumers opt to collect leftover bread at home, while 14.4% dispose of it directly in the garbage. This distribution is indicative of a variety of attitudes toward food waste management.

**1. Collecting leftover bread at home :** The preponderance of consumers who engage in the recycling of bread scraps within their households (85.6 %) signifies a mounting cognizance of the pressing concerns pertaining to food waste and its recovery. This initiative is part of a broader effort to reduce food waste in the home, wherein consumers seek to reuse or recycle surplus bread rather than discarding it. Recent studies have demonstrated the efficacy of domestic management of food waste, particularly bread, in achieving substantial contributions to the overall reduction of waste (**Ananda et al., 2024**).

**2. Disposing the bread in the garbage :** Conversely, 14.4 % of consumers discard their leftover bread in the garbage, constituting direct waste and a loss of resources. This phenomenon is frequently associated with a lack of awareness, cultural habits, or practical constraints, including the scarcity of time or space for the management of organic waste. The persistence of this behavior underscores the significance (**Allipour Birgani et al., 2023**) of educational initiatives and public policies designed to promote the sorting and recovery of food waste .

### 1.2 Results and discussion of the nutritional and physic-chemical analysis of energy bars :

**Table N 11 :** Nutritional values of 3 energy bars ( original table )



## CHAPTER II: RESULTS AND DISCUSSION

| Parameter in (%) | 1 <sup>st</sup> Bar              | 2 <sup>nd</sup> Bar   | An energy bar model 1            | An energy model 2                         |
|------------------|----------------------------------|-----------------------|----------------------------------|-------------------------------------------|
| Humidity (%)     | 17.10                            | 15.21                 | ~12                              | 8-10 %                                    |
| Fat (%)          | 16.42                            | 13.56                 | 25                               | 14-16 %                                   |
| Proteins (%)     | 7.40                             | 6.31                  | 10                               | 10-12 %                                   |
| Ash (%)          | 1.67                             | 1.20                  | 2                                | -                                         |
| Key composition  | Balanced dates and pumpkin seeds | Mostly dates, walnuts | Oats, carob, dates, sesame seeds | Oats, brown rice syrup, nuts, dried fruit |

In the interest of conducting a rigorous and comprehensive study, this investigation will include two control bars. This approach will facilitate a meaningful comparison of the results obtained from the two bars. The initial control bar was selected from a study on the formulation of a bar based on oat flakes and sesame seeds **Bougherara et al. (2021)** enabling an objective assessment of its nutritional characteristics. The second control bar was selected from commercially available products and sourced from a major global company. This approach facilitates a comparison between Power Bar and a widely recognized and consumed product, offers a complementary perspective on the results obtained.

For the purpose of this study, the nutritional principles of Power Bar energy bars have been selected for analysis, with a particular focus on protein, fat, ash, and moisture. These parameters are considered essential in the evaluation of nutritional quality. A thorough examination of these components is essential to gain a comprehensive understanding of the composition of the two bars and to assess their potential as a snack or food product.

**Water content:** The higher moisture content observed in the 1st and 2nd Bars (17.10% and 15.21%) compared to control bars (8–12%) aligns with findings that increased moisture improves texture and sensory acceptance but reduces microbial stability and shelf life due to higher water activity (**Martínez-Sánchez et al., 2024; Silva et al., 2016**). Hydrophilic ingredients like fruits and fibers contribute to moisture retention, while lipids reduce it (**Martínez-Sánchez et al., 2024; La Cordée, 2019**).

## CHAPTER II: RESULTS AND DISCUSSION

**Fat Content:** The moderate fat content in the bars (16.42% and 13.56%) is consistent with formulations balancing energy density and nutritional quality, as fats provide sustained energy essential for endurance (Bougherara et al., 2021; Jeukendrup & Gleeson, 2019). Nuts and seeds are key sources of unsaturated fats contributing to this profile (La Cordée, 2019; Archana et al., 2024).

**Protein Content:** The relatively lower protein content (7.40% and 6.31%) compared to controls (10–12%) reflects formulations focused more on energy provision via fats rather than muscle maintenance or recovery (Bougherara et al., 2021; Jeukendrup & Gleeson, 2019). Protein-rich ingredients like pumpkin seeds improve protein levels but were underutilized here (Archana et al., 2024; Prisukhina & Ermosh, 2020).

**Ash Content:** Ash content variation (1.67% and 1.20%) indicates differences in mineral content, essential for physiological functions (Al Jaloudi et al., 2024; Bilge et al., 2016). The 1st Bar's higher ash suggests mineral-rich ingredients such as seeds contribute to enhanced mineral profiles (Al Jaloudi et al., 2024).

**Ingredient Composition:** The use of balanced dates and pumpkin seeds in the 1st Bar and mostly dates and walnuts in the 2nd Bar explains the differences in nutritional parameters, as seeds tend to increase protein and mineral content, while walnuts contribute more to fat (Archana et al., 2024; Prisukhina & Ermosh, 2020).

### 1.3. Results and Discussion of µbiological analysis of the three energy bars :

**Table N 12 :** Results of µbiological analysis of the three bars (original )

| infections agents            | 1 <sup>st</sup> Bar | 2 <sup>nd</sup> Bar | Limit CFU/g     |
|------------------------------|---------------------|---------------------|-----------------|
| <b>TAMC</b>                  | 80                  | 40                  | 10 <sup>4</sup> |
| <b>Escherichia Coli</b>      | Total lack          | Total lack          | 30              |
| <b>Staphylococcus aureus</b> | Total lack          | Total lack          | 10 <sup>3</sup> |
| <b>Mold</b>                  | Total lack          | Total lack          | 10 <sup>3</sup> |
| <b>Salmonella</b>            | Total lack          | Total lack          | 0               |

## CHAPTER II: RESULTS AND DISCUSSION

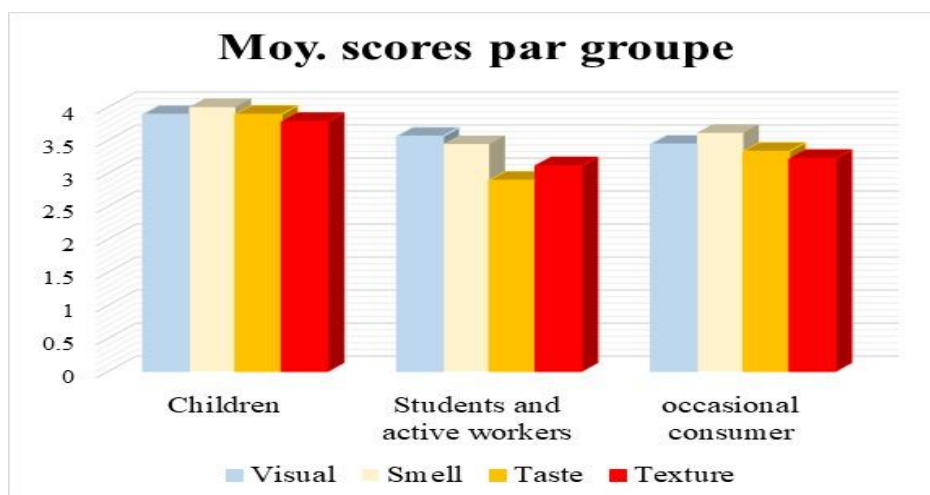
The table N 12 shows the results of the two energy bars ( 1<sup>st</sup> formulation and 2<sup>nd</sup> formulation ) for the detection of the infections agents mentioned in the table above .

A microbiological assessment of the energy bars was conducted to evaluate their safety and hygienic quality. The total aerobic microbial count (TAMC) for both products was significantly below the established regulatory threshold, with values of 80 and 40 colony-forming units per gram (CFU/g) for the first and second bars, respectively, compared to the permissible limit of  $10^4$  CFU/g. The presence of pathogenic microorganisms of concern—namely, *Escherichia coli*, *Staphylococcus aureus*, and *Salmonella*—was not detected in either sample, as confirmed by standard culture-based methods. Furthermore, the absence of mold colonies was noted, indicating adherence to the established microbiological criteria for spoilage organisms. The findings indicate that both energy bars comply with international food safety standards for ready-to-eat products. Specifically, the TAMC levels in both energy bars were found to be well within the acceptable limits, and the absence of specified food-borne pathogens and spoilage microorganisms was confirmed.

This microbiological profile lends substantiation to the conclusion that the products are suitable for consumption and meet the stringent requirements for microbiological safety in the food section.

### 1.4 Results and discussion of 1<sup>st</sup> formulation :

**Figure N 25 :** Average Sensory Scores (Visual, Smell, Taste, Texture) by Consumer Group (Children, active workers and occasional consumer ) in the 1<sup>st</sup> formulation



## CHAPTER II: RESULTS AND DISCUSSION

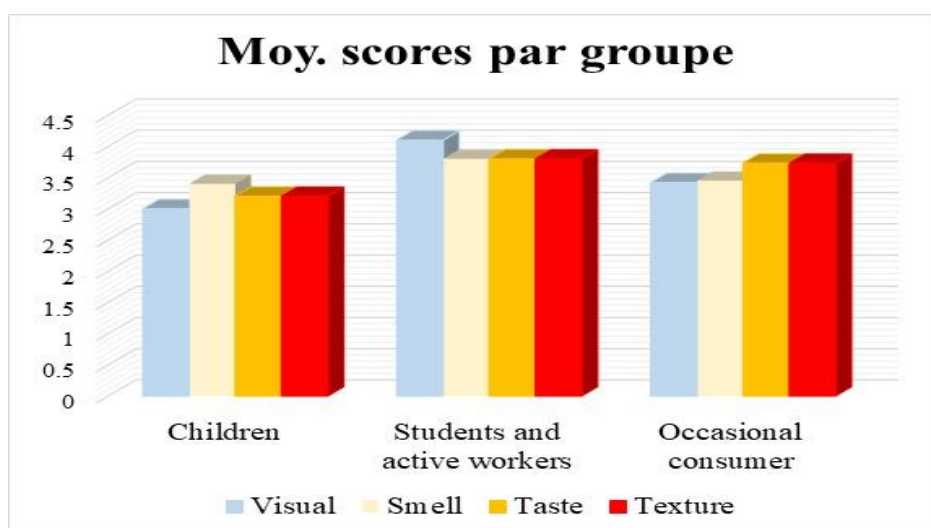
The results of the sensory evaluation of chocolate-covered bars indicate that participants of various age groups exhibited a favorable response. The mean score assigned by children to the visual component was 3.9 out of possible 4 then students, workers and occasional consumer gave results close to 3.7.

For the criteria of smell and taste and texture, children gave the highest results with a score of 3.8, while students, active workers and occasional consumer gave a score of 3.6 in visual and 3.9 in smell then texture was 3 in both of the two categories.

Finally, gustatory score was 3.8 in students, active workers while occasional consumer gave 3.1

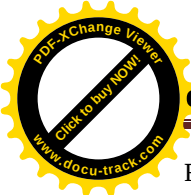
### 1.5. Results and discussion of 2<sup>nd</sup> formulation:

**Figure N 26:** Average Sensory Scores (Visual, Smell, Taste, Texture) by Consumer Group (Children, Students and active workers, occasional consumer ) in the 2<sup>nd</sup> formulation.



The results of the sensory evaluation of chocolate-covered bars indicate that participants of various age groups exhibited a moderate response. In terms of taste and texture perception, children assigned a mean rating of 3 then smell gave a score of 3.3 while visual was 2.9.

In the term of taste, smell and texture , students and active workers gave the same results of 3.5 while visual was the highest score of 4.

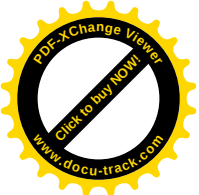


## CHAPTER II: RESULTS AND DISCUSSION

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For occasional consumer, smell and visual criteria were evaluated with the score of 3 while texture and taste gave the same results with 3.6.



# Conclusion

## Conclusion

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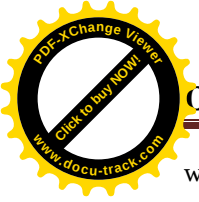
This study offers significant insights into the potential for valorizing stale bread through the development of two energy bar formulations, each tailored to the preferences and needs of Algerian consumers above and below 18 years of age. The survey results indicated that the most influential factors in snack selection are taste, protein content, and affordability, with a clear preference for a texture that is both crunchy and meltable. The majority of the participants were adults, and price sensitivity was evident, with the predominant consumer preference falling within the price range of 100–150 DA. It is noteworthy that the acceptance of products derived from food waste, such as stale bread, remains limited; only approximately 25% of respondents expressed clear support, while nearly 50% were undecided. This highlights the importance of consumer education and transparent communication.

Nutritional analysis demonstrated that both energy bar formulations achieved balanced profiles, with appropriate moisture, fat, protein, and ash contents for their respective age groups. The incorporation of stale bread, in conjunction with dates and seeds, resulted in a favorable nutritional composition, thereby supporting both energy provision and mineral intake. These results indicate that up-cycled bakery by-products can be utilized effectively to create nutritious snacks that align with local dietary preferences.

The safety of both formulations was confirmed through microbiological analysis, which revealed microbial counts well below the established regulatory thresholds. This finding demonstrates that, when properly processed, the inclusion of stale bread does not compromise food safety, addressing a key concern for consumers and regulators alike.

Sensory evaluation further indicated good overall acceptability, particularly for texture and taste, which were in line with consumer expectations. The reception of both bars was favorable among both adults and younger participants. However, there is potential for further refinement in the flavor complexity and aftertaste to optimize consumer satisfaction.

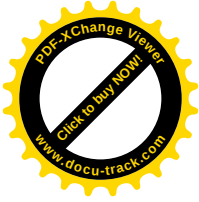
In the future, it would be advisable for researchers to concentrate on the implementation of targeted educational campaigns with the aim of improving the public's perception and acceptance of up-cycled food products. These campaigns should place particular emphasis on the safety, nutritional value, and environmental benefits of up-cycled food products. Subsequent product optimization endeavors should prioritize the consideration of sensory preferences and the exploration of additional flavor and texture combinations. The expansion of consumer trials and collaboration with educational institutions, including schools and universities, as well as with

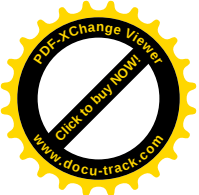


## Conclusion

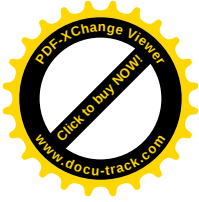
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workplaces, will contribute to the development of broader acceptance of these energy bars and their establishment as a viable, sustainable alternative in the Algerian market.





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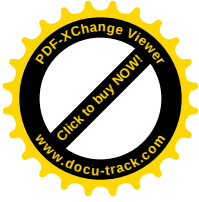
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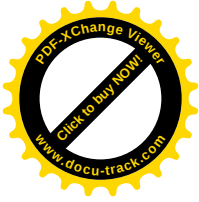
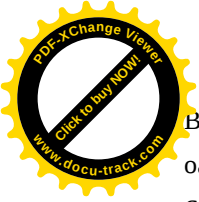
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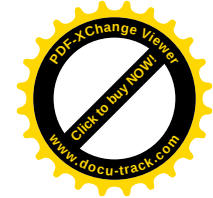
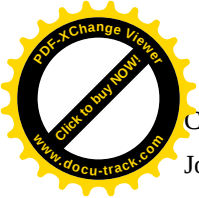
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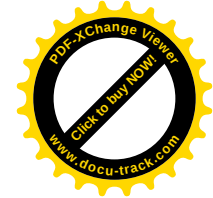
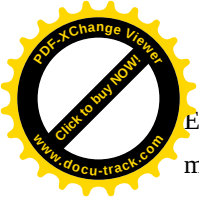
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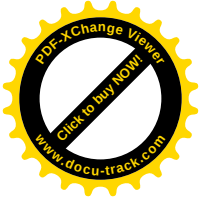
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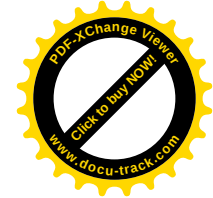
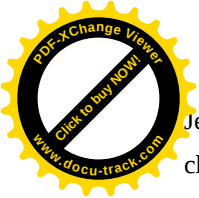
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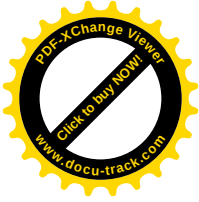
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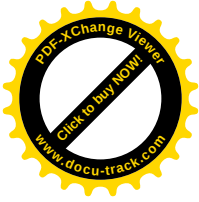
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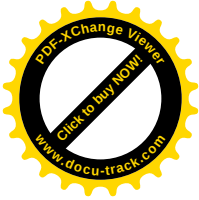
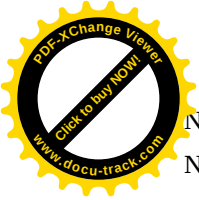
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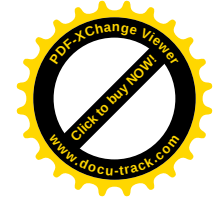
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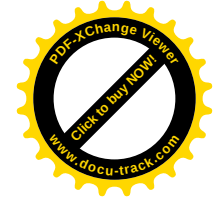
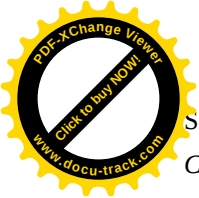
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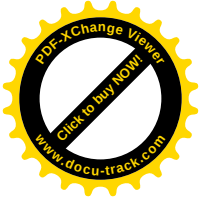
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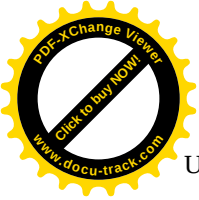
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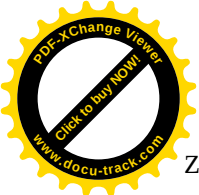
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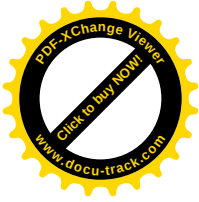
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## Appendices

### Tasting sheet

\* Age : .....

You have 3 Power Bar samples in front of you. Please place them on the scale, referring to the following concepts.

- ☒ **Mark 5** : Very good = exceptional quality, highly satisfying taste experience .
- ☒ **Mark 4** : Good = appreciable quality, positive taste experience .
- ☒ **Mark 3** : Acceptable = average quality, an acceptable but not outstanding taste experience .
- ☒ **Mark 2** : Poor = very unsatisfactory quality, unpleasant taste experience .
- ☒ **Mark 1** : Very poor = extremely disappointing quality, a highly negative taste experience .

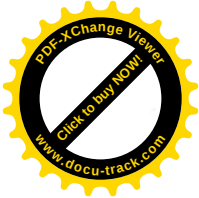
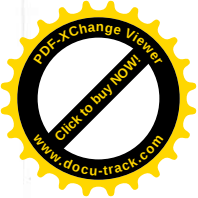
|              | Texture | Taste | Smell | Visual |
|--------------|---------|-------|-------|--------|
| Power Bar I  | .....   | ..... | ..... | .....  |
| Power Bar II | .....   | ..... | ..... | .....  |
| Power Bar II | .....   | ..... | ..... | .....  |

2) Survey link :

<https://forms.gle/sViYnER9JEoX8fVS7>

3) Tools used in the physic-chemical and nutritional analysis :

| Tool                                                                              | Function              |
|-----------------------------------------------------------------------------------|-----------------------|
|  | Sample mineralization |
|  | Sample distillation   |



People's Democratic Republic of Algeria

Ministry of Higher Education and Scientific Research

University of Blida 1



Faculty of Natural and Life Sciences

Food Sciences Department

Dissertation for the Master's degree in

**Specialization** : Food Safety and Quality Assurance

**Field** : Food Sciences

**Domain** : Natural and Life Sciences

**Valorization and formulation study of an energy bar using a bakery by-product**

Presented by

**MALEK Aya**

In the front of the jury :

|                           |                     |                   |                    |
|---------------------------|---------------------|-------------------|--------------------|
| <b>Dr. BENLEMMANE S .</b> | <b>MCB</b>          | <b>U. Blida 1</b> | <b>President</b>   |
| <b>Dr. MEKCHICHE S .</b>  | <b>MCB</b>          | <b>U. Blida 1</b> | <b>Examiner</b>    |
| <b>Dr. AOUES K .</b>      | <b>MCA</b>          | <b>U. Blida 1</b> | <b>Promoter</b>    |
| <b>Pr. AMMAD F.</b>       | <b>Professor</b>    | <b>U. Blida 1</b> | <b>Invited</b>     |
| <b>Ms. OUBLIL Y.A .</b>   | <b>Lab engineer</b> | <b>CACQE</b>      | <b>Co-Promoter</b> |

**Academic Year 2024-2025**