DEMOCRATIC AND POPULAR REPUBLIC OF ALGERIA

MINISTERY OF HIGHER EDUCATION AND SCIENTIFIC RESEARCH

UNIVERSITY M'HAMED BOUGARA BOUMRTDES

Faculty of technology

Department of Process Engineering

Master's Thesis

In order to obtain the **MASTER's** degree in:

Specialization: Food Engineering

Field: Process Engineering

THEME

Study of physicochemical, biochemical and rheological characteristics of soft wheat bran incorporation into white flour on the sensory qualities of biscuits
(At the O.A.I.C's national laboratory)

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2023/2024

بسم الله الرحمن الرحيم

in the name of Allah, the most beneficient,
the most merciful

Abstract:

Soft wheat bran is the outer layer of soft wheat grains, composed of several beneficial nutrients for human health such as fiber, proteins, vitamins, minerals, and antioxidants. Due to its high nutritional value, it has emerged in the food industry, especially in biscuit manufacturing. However, adding bran can lead to side effects on the sensory properties of the final product.

This study aims to investigate the impact of adding soft wheat bran on the sensory appearance of biscuits. A witness sample and three samples of what flour with varying proportions of bran were prepared. Physicochemical, biochemical, and rheological analyses were conducted on these raw materials, in addition to sensory quality analysis of the final product.

Despite the nutritional value of soft wheat bran, previous analyses have shown that its addition affects specific outcomes within the required standards of dry biscuit manufacturing. Therefore, it was found that it influences the appearance of biscuits, with this effect varying depending on the percentage of bran added in each sample. Especially for the rheological characteristics.

In conclusion, the study suggests that soft wheat bran can be added in biscuit manufacturing to harness its nutritional benefits, with the optimal addition percentage identified as 10%.

Key words: soft wheat bran, soft wheat, wheat flour, biscuit, sensory quality, rheological characteristics.

Résumé :

Le son de blé tendre est la couche externe des grains de blé tendre, composée de plusieurs nutriments bénéfiques pour la santé humaine tels que les fibres, les protéines, les vitamines, les minéraux et les antioxydants. En raison de sa haute valeur nutritionnelle, elle a émergé dans l'industrie alimentaire, notamment dans la fabrication de biscuits secs. Cependant, l'ajout de son peut entraîner des effets secondaires sur les propriétés sensorielles du produit final.

Cette étude vise à examiner l'impact de l'ajout de son de blé tendre sur l'apparence sensorielle des biscuits. Un échantillon témoin et trois échantillons de farine avec des proportions variables de son ont été préparés de $10\%, 20\%\ et\ 30\%$. Des analyses physico-chimiques, biochimiques et rhéologiques ont été réalisées sur ces matières premières, ainsi qu'une analyse de la qualité sensorielle du produit final.

Malgré la valeur nutritionnelle du son de blé tendre, des analyses antérieures ont montré que son ajout affecte des résultats spécifiques conformes aux normes requises dans la fabrication de biscuits. Ainsi, il a été constaté qu'elle influence l'apparence des biscuits, cet effet variant en fonction du pourcentage de son ajouté dans chaque échantillon. Surtout pour les caractéristiques rhéologiques.

En conclusion, l'étude suggère que le son de blé tendre peut être ajouté dans la fabrication de biscuits pour exploiter ses avantages nutritionnels, avec un pourcentage d'ajout optimal identifié à 10%.

Mots clés : son de blé tendre, blé tendre, farine de blé, biscuit, qualité sensorielle, caractéristiques rhéologiques.

ملخص:

نخالة القمح اللين هي الغلاف الخارجي لحبوب القمح اللين، وتتكون من عدة مركبات غذائية مفيدة لصحة الإنسان مثل الألياف والبروتينات والفيتامينات والمعادن ومضادات الأكسدة. و بسبب القيمة الغذائية العالية للنخالة، بدأ ظهورها في الصناعات الغذائية، خاصة في صناعة البسكويت الجاف. ومع ذلك، إضافة النخالة قد تؤدي إلى تأثيرات جانبية على خصائص المنتج النهائي، خاصة من حيث الخصائص الحسية .

يهدف هذا العمل إلى دراسة تأثير إضافة نخالة القمح اللين على المظهر الحسي للبسكويت. تم تحضير عينة شاهدة بالإضافة إلى ثلاث عينات من الدقيق تحتوي على نسب مختلفة من النخالة 10%, 20%; 30 % ، وتم إجراء التحاليل الفيزيوكيميائية والبيوكيميائية والريولوجية لهذه المواد الأولية، بالإضافة إلى تحليل الجودة الحسية للمنتج النهائي.

رغم القيمة الغذائية العالية لنخالة القمح اللين، أظهرت التحاليل السابقة أن إضافتها تؤثر على النتائج المحددة ضمن المعايير المطلوبة في صناعة البسكويت. لذا، توصلنا إلى أنها تؤثر على مظهر البسكويت، ويختلف هذا التأثير باختلاف نسبة النخالة المضافة في كل عينة. و خاصة بالنسبة للخصائص الريولوجية

أخيرًا، توصلت الدراسة إلى أنه يمكن إضافة نخالة القمح اللين في صناعة البسكويت لاستغلال الفوائد الغذائية لها، وأن أفضل نسبة للإضافة هي 10%

الكلمات المفتاحية: نخالة القمح الطري، القمح الطري، دقيق القمح، البسكويت، الجودة الحسية, الخصائص الريولوجية

Acknowledgements

First and foremost, I thank Allah for guiding and enlightening me with understanding, for granting me knowledge of the sciences, and for instilling in me the courage and determination to complete this work.

I am profoundly grateful to my dear parents who have been instrumental in shaping the person I am today. Their unwavering dedication, the countless hours they devoted, and constant presence throughout my years of study have been invaluable. Their support has been a cornerstone of my journey, and I am forever grateful. I love you both immensely.

I thank my family for their unwavering support, understanding, and patience during this challenging yet rewarding endeavor. Their belief in me kept me motivated throughout.

I thank my supervisor, Mrs. HADERBACHE.L, for her invaluable guidance, encouragement, and expertise.

I also extend my thanks to the members of the jury for taking the time to comment, discuss, and evaluate my work.

I express my heartfelt gratitude to all the teachers in the Process Engineering Department of the University of Boumerdes for imparting their knowledge throughout my course.

I am deeply thankful to all my teachers throughout my academic career for their encouragement, support, and belief in my potential. Their influence will continue to inspire me as I face future challenges and opportunities.

I sincerely thank the director of the national laboratory of O.A.I.C, as well as the laboratory manager and the entire laboratory team, for their valuable assistance and support throughout this project. Your expertise and dedication have been crucial to its success.

I also wish to express my gratitude to all those who contributed, directly or indirectly, to the completion of this work.

Dedication

With deepest gratitude and love, I dedicate this success:

To me, it is a testament to my perseverance, determination, and resilience in the face of challenges. I am proud of the accomplishments I have experienced along the way.

To my dear parents, I am forever indebted to you for the love and support you have shared with me. This dedication is a small token to convey the immense respect and love I feel each day. Thank you, Mom and Dad, for everything you do. I am truly blessed to have parents like you.

To my brothers, you have always been my support and strength. Thank you for being my pillars of support, and for enriching my life with your unwavering presence.

To everyone I love and respect, your support, encouragement, and belief in me have been invaluable on this journey.

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Abbreviations

OAIC: The Algerian Interprofessional Cereals Office

UCA: Union of Agricultural Cooperatives.

CCLS: Cereals and Pulses Cooperatives.

UCC: Union of Cereal Cooperatives.

URCCLS: Regional Union of Cereal and Pulse Cooperatives.

DLN: The direction of the national laboratory

KDa: kilo Dalton

pH: Hydrogen potential.

P0: Weight of the empty capsule in grams.

Pi: Weight of the capsule + sample (after incineration) in g.

ISO: international standards.

NF: French standards.

EN: European standards.

NA: Algerian standards.

HC: Hydration coefficient.

V: Volume.

NC: Nitrogen content.

T: The normality of the sulfuric acid solution used in the titration.

PC : Proteins content.

H : Humidity.

WC: Water content.

AC: Ash content.

SDS: Sodium dodecyl sulfate.

FNI: Falling number index.

WG: Wet gluten.

DG: Dry gluten.

(*): average of values.

(σ): standard deviation.

Ie: Elasticity Index

P: Tenacity.

W: Baking force.

L: Extensibility.

G: Dough inflation index.

P/L: Configuration report.

Bibliographic part

General Introduction

Among the most consumed foods, we find soft wheat, which is considered the staple food of the Algerian people due to its high plant protein content. In recent years, the consumption of soft wheat has increased significantly.

Bread wheat derivatives, such as flour, are used in many traditional and modern baked goods. Scientific advancements and nutritional awareness have led to the discovery of the benefits of the outer layer of the soft wheat grain, known as bran. Bran is renowned for its richness in dietary fiber, vitamins, and minerals, although historically, it was first used for animal feeding. With advances in food processing technology, soft wheat bran has gained interest as an ingredient in various food products, including biscuits, which are popular worldwide. This trend combines traditional baking methods with contemporary nutritional science, reflecting a broader shift towards healthier eating and food production practices.

Moreover, there is an increasing focus on enhancing the nutritional profile of food products without compromising their sensory appeal. Biscuits provide an ideal platform for exploring these improvements through the incorporation of soft wheat bran.

This study aims to comprehensively investigate the physicochemical, biochemical, and rheological properties resulting from the inclusion of soft wheat bran into white flour in varying proportions, with particular emphasis on its impact on the sensory qualities of biscuits.

The research was conducted at the National Laboratory of the Algerian Professional Cereals Office (O.A.I.C.), which possesses extensive facilities and expertise to provide robust scientific and technological data. This study seeks to leverage soft wheat bran for the development of biscuit products by examining its effects when incorporated into white flour on dough properties and the sensory attributes of the final product.

Chapter I: Generalities on the Algerian Interprofessional Cereals Office “O.A.I.C”

Chapter I: Generalities on the Algerian Interprofessional Cereals Office “O.A.I.C”

I Presentation of the O.A.I.C

I.1 History

The Algerian Interprofessional Cereals Office (OAIC), established by ordinance on July 12, 1962, serves as the national operator responsible for public service in organizing the cereal market. Initially focused on cereal supply, price regulation, and stabilization, its mission expanded to include other agricultural products like pulses and forage seeds. The OAIC was delegated by the state with centrally managing price stabilization policies for cereals and pulses through periodic regulations, becoming the primary organization for supply, control, and support within the cereal sector. With government support, its role extended to supporting cereal production through technical, economic, and material assistance, infrastructure development, and seed production. In the early 1990s, in response to national economic reforms, the OAIC underwent structural and functional changes to adapt to new economic conditions, including price setting for cereals and market liberalization.

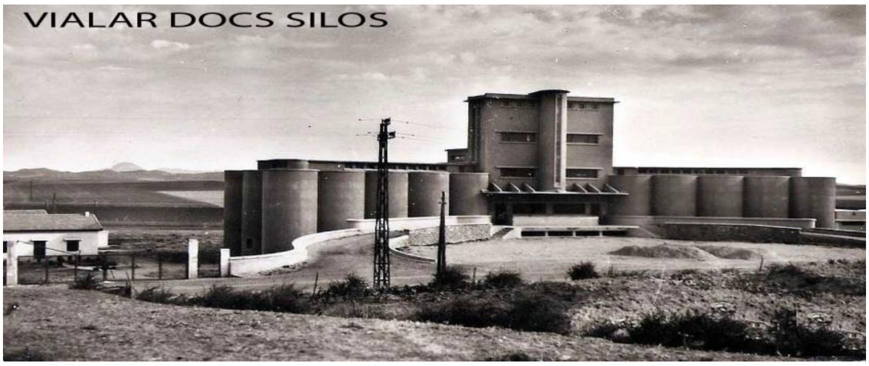


Figure 1 : OAIC birth 1962-old silos

I.2 Definition of the O.A.I.C

The Algerian Interprofessional Cereals Office (OAIC) is a national economic institution that has been working since Algeria's independence to ensure the country's cereal supply. It is considered as a crucial public entity in guaranteeing the nation's food security through the collection, storage, and distribution of cereals. Over the years, the OAIC's missions have expanded to align with government programs aimed at developing strategic sectors and securing the national demand for cereal products.

Figure 2: The Algerian Interprofessional Cereals office "OAIC"

I.3 Objective of the O.A.I.C

The Algerian Interprofessional Cereals Office is considered as an economic pillar of the state, enabling self-sufficiency by meeting the needs of consumers for dry cereals and legumes through importing, collecting, and storing them. It ensures adequate availability of cereals across the entire national territory. It organizes the collection of local production, supports farmers, and balances transportation costs, thereby contributing to the regulation of the cereal market in Algeria.

I.4 Services provided by the O.A.I.C

I.4.1 Services provided to businesses

- Carry out the national program for the importation of cereals and legumes under optimal conditions in terms of price, cost, quality, and timeliness.

- Organize the collection of national cereals and legume production, as well as the distribution of inputs to cereal farmers.

- Manage and implement, on behalf of the state, all actions supporting cereal production.

- Implement all measures aimed at ensuring equalization of transport costs.

- Stimulate national production of cereals, legumes, and derivatives through financial mechanisms and/or direct intervention.

- Implement the national policy for cereal development (by introducing modern agricultural methods) and strategic storage policy.

I.4.2 Services provided to citizens

- Ensuring adequate and continuous availability of cereals، legumes، and derivatives throughout the national territory.

- Providing as many sales points for cereals and legumes as possible across the entire national territory to facilitate the purchasing process for citizens.

- Ensuring the good quality of cereals and legumes at reasonable prices.

- Providing livestock feed for breeders.

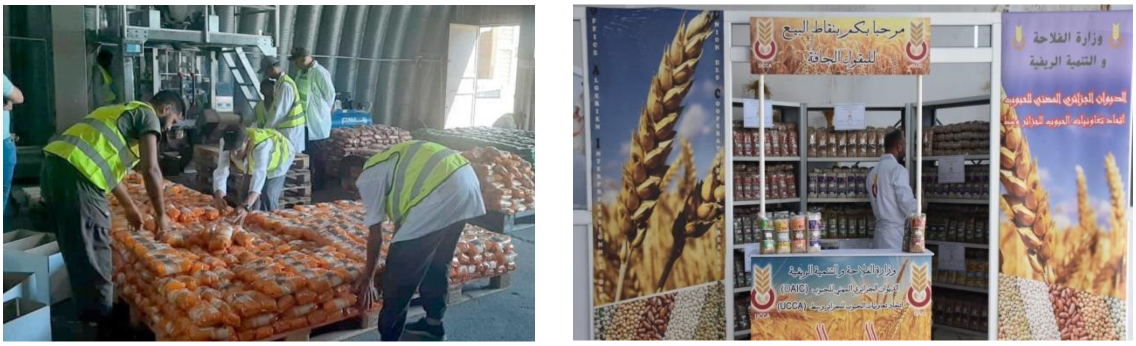


Figure 3: Services provided by the OAIC

This table summarizes the different services provided by the OAIC:

Table 1: Services provided by the OAIC

Services provided by the OAIC to businesses	**Services provided by the OAIC to citizens**
importation of cereals and legumes	adequate and continuous availability of cereals and legumes
Collection and storage	Providing sales points for cereals
Developing national cereals production	Providing livestock feed
Quality and price control	

I.5 The unions under the supervision of the O. A.I.C

The OAIC relies on service provider entities to carry out its missions. They operate under the auspices of the OAIC, due to their obligations regarding the regulation of the cereal market in Algeria, and their administrative, technical and financial attachment to the OAIC, These bodies are:

I.5.1 Union of Agricultural Cooperatives (UCA)

There are five unions of cereal and legume cooperatives, tasked with several responsibilities, including:

- Receiving products from imports.

- Distributing products to the Cereals and Pulses Cooperatives (CCLS).

- Inter-cooperative regulation.

I.5.2 Cereals and Pulses Cooperatives (CCLS):

There are 46 Cereals and Pulses Cooperatives (CCLS) responsible for providing services throughout the national territory, including:

- Collecting, distributing, processing, storing, and marketing cereals, pulses and fodder grains.

- Providing support and assistance to producers in all production-related operations, by providing specialized technical staff and agricultural equipment at reduced rates.

I.5.3 Union of Cereal Cooperatives (UCC)

The Union of Cereal Cooperatives (UCC) is responsible for logistics and providing the followings, at the lowest cost, for the benefit of the CCLS and UCA:

- Equipment and materials.
- Packaging, wires, strings and other supplies.
- Spare parts.
- Treatment products.

I.5.4 Regional Union of Cereal and Pulse Cooperatives (URCCLS)

The Regional Union of Cereal and Pulse Cooperatives (URCCLS) is responsible for transportation, including:

- Transport of products between the port and all storage units of the CCLS.
- Distribution of cereals and pulses from the desert to various bodies.
- Collection of cereal and pulse harvests.

The unions under the supervision of OAIC are shown in the following diagram and their national distribution in figure 5:

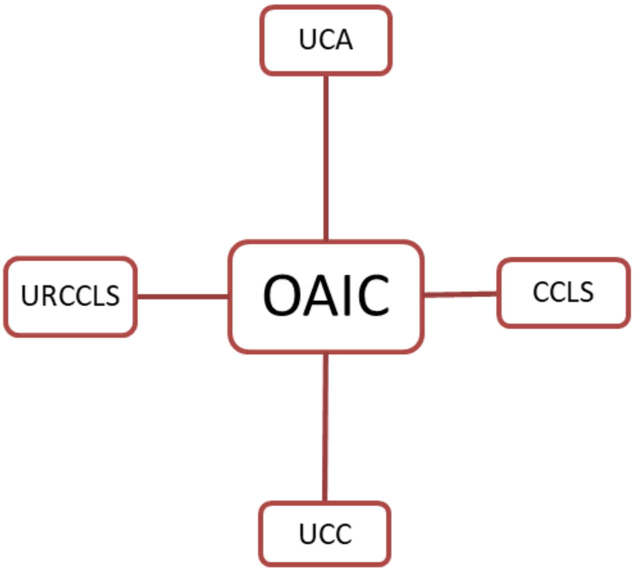


Figure 4: Unions under the supervision of the O.A.I.C

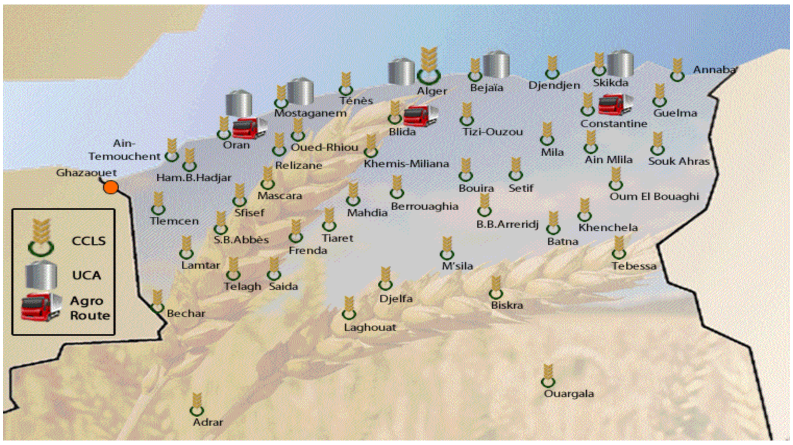


Figure 5: Distribution of the unions under the supervision of the O.A.I.C

I.6 Presentation of the OAIC’s national laboratory (Cheraga-Algiers)

I.6.1 Role of the national laboratory

The National Cereals Laboratory, located in Algiers, plays a vital role in controlling and ensuring the quality of local and imported cereals, pulses, and their derived products. The laboratory conducts physicochemical, technological, biochemical, and microbiological analyses in accordance with Algerian and international standards. It also performs grading and milling operations. Its crucial role includes evaluating the technological quality of cereals, characterizing new varieties, and participating in product approval. The national laboratory provides wheat suitable for various uses for processors. Based on analysis results, it issues compliance certificates attesting to the quality of cereals. These certificates are often necessary to ensure that products meet required standards. In addition to quality control activities, it conducts research to improve analysis and storage methods, develop new technologies, and promote innovation in the field of cereals to enhance yields and crop quality. Furthermore, the laboratory contributes to the development of Algerian standards, collaborates with research institutions, mentors students, and participates in national events.

I.6.2 Products processed at the OAIC's national laboratory

Local and imported grains processed at the OAIC's national laboratory are divided into two categories:

I.6.3 The cereals

Cereals and their derivatives form the staple diet in Algeria. They play a crucial role in the agricultural system, both nationally and globally and are considered as a primary source of human and animal nutrition. The grains treated at the National Laboratory of the OAIC are:

- Soft wheat and its derivative product "flour"
- Hard wheat and its derivative product "semolina"
- Barley.
- Rice.

I.6.4 Protein crops

Protein crops (legumes), which are a rich source of protein, play a crucial role in the diet in Algeria. The OAIC has taken measures to secure the supply of legumes in the country, including the importation of large quantities of these commodities. These initiatives aim to make these staple foods accessible at an affordable price, thereby contributing to the establishment of sustainable food security in Algeria.

The legumes processed at the national laboratory of the OAIC (DLN) are:

- White beans.
- Lentils.
- Chickpeas

Products processed at the OAIC's national laboratory are shown in the following

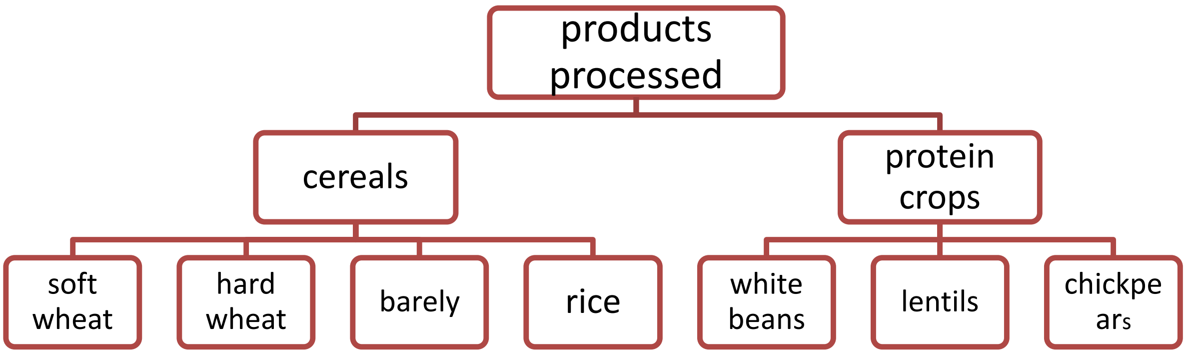


Figure 6: Products processed at the OAIC's national laboratory

Chapter II: Soft wheat and its derivatives (wheat bran, flour)

Chapter II: Soft wheat and its derivatives (wheat bran, flour)

II General information about soft wheat grains

II.1 Definition and description of the soft wheat plant

Soft wheat is a monocotyledonous plant belonging to the Poaceae family. It is characterized by its medium size and the formation of a tillering plateau at the soil level, from which emerge leafy stems. These stems, erect and 60 to 100 cm long generally have five to seven nodes and three or four true leaves. The highest leaf, called the flag leaf, supports the inflorescence. The leaves are composed of a glabrous or pubescent sheath, a 1 mm long membranous ligule, and a flat, pubescent surface limb, measuring 10 to 60 cm long and 10 to 15 mm wide. The inflorescence is presented in the form of a simple, linear or oblong, bilateral spike measuring 5 to 18 cm long. The fertile spikelet, oval and laterally compressed, 10 to 15 mm long and 9 to 18 mm wide, contains 2 to 4 fertile florets, with reduced florets at the apex. They persist on the plant and are supported by a pair of similar oval, coriaceous glumes of 6 to 11 mm long. The fertile florets are characterized by two glumes (lemma and palea), with the lemma oval, cactaceous, 12 to 15 mm long, presenting 5 to 9 nerves. The fertile florets have three anthers and an ovary, pubescent at the apex, with a fleshy appendage under the insertion point of the style (Figure 7).

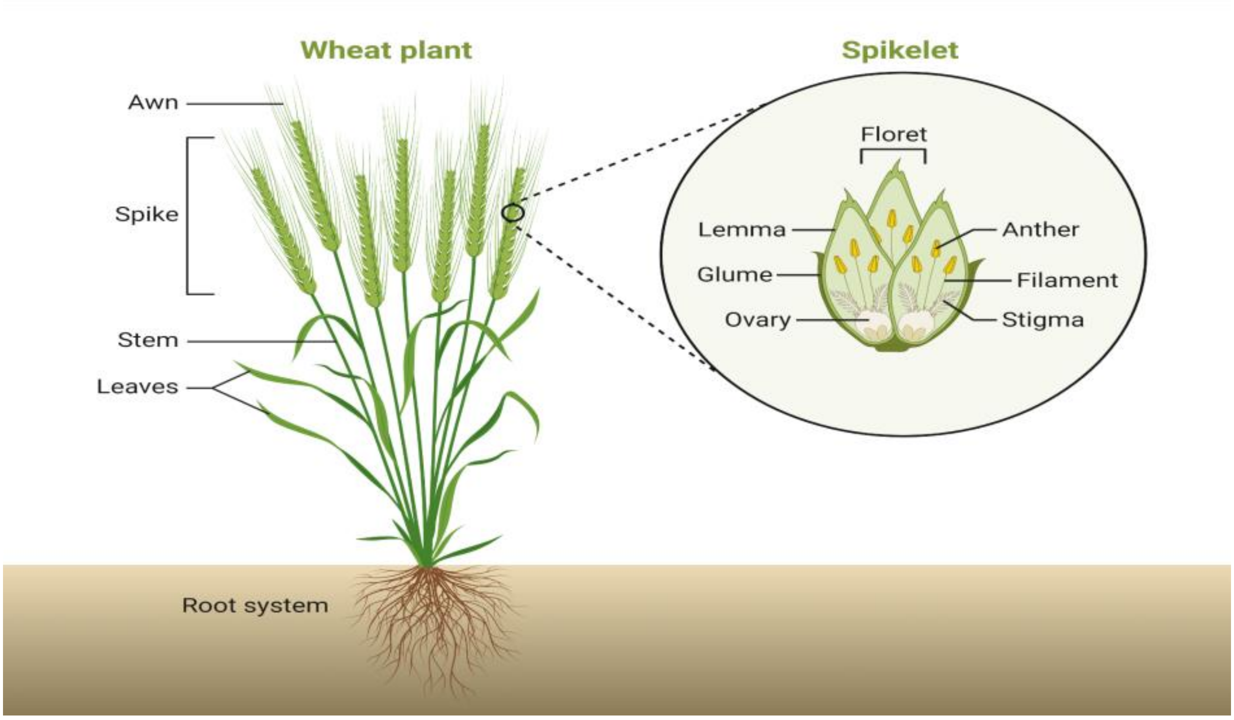


Figure 7: Soft wheat plant

II.2 Consumption and production of soft wheat in Algeria

Soft wheat is a vital component of the Algerian diet, accounting for about 60 % of food consumption, with an average annual consumption of 9 to 12 million tons of soft wheat and durum wheat. This prompted the Algerian government to focus on enhancing soft wheat production to meet the growing domestic demand and to reduce dependence on imports. The annual production of soft wheat ranges from 1 to 2.4 million tons. In 2002, production reached 2 million tons, then 4.3 million tons in 2003 (Source: Agricultural Services), a total cereal production in 2024 is estimated at 3.5 million tonnes similar to 2023. Cereal output remains about 22 percent below the five-year average, mainly driven by a decline in the wheat harvest which represents about 70 percent of the total output (www.FAO.org). The quantity and quality of production are affected by various factors, including climatic conditions such as temperature and rainfall, soil characteristics, fertilization practices, and cultivation schedules. The differences can also be attributed to the genetic traits of different wheat varieties. Algeria is a major importer of wheat (Table 2). This situation may continue for several years due to wheat shortages (Chellali, 2007) and insufficient yields and consumption needs due to population growth. The most important countries from which Algeria imports wheat are France and Canada. The 2023/24 cereal import requirements (July/June) are forecast at about 14 million tons, representing the highest volume of cereal imports compared to the previous five years. The average consumption of Algerian cereals between 1961 and 2023 (in 2023 it's estimated at more than 220 kg/year) is shown in the following table:

Table 2: Average consumption of Algerian cereals (kg per inhabitant per year) between 1961 and 2005,(FAO, 2007-Food patterns in Algeria 2024).

Period	1961	1970	1980	1990	2000	2003	2005	2023
Consumption kg/capita/year	110	120	182	193	190	201	215	220

II.3 Structure of the soft wheat grain

The grain of wheat is characterized by a bristle and is marked on the surface by a longitudinal groove whose fold sometimes reaches the median layer of the grain. This grain is composed of three essential parts: the envelopes, the meal part, and the germ.

II.3.1 The envelope (bran)

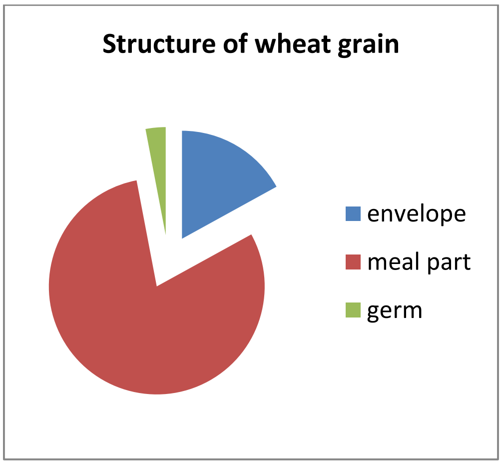
This cellulosic membrane is formed by several layers of overlapping cells, representing 12 to 17 % of the total weight of the grain. Its role is to protect the seed during its formation in the ear and limit the entry of bacteria while allowing the passage of air and water. It is composed of six tissues: the epidermis of the nucellus, the seminal tegument or testa (seed envelope), tubular cells, cross cells, mesocarp, and epicarp.

II.3.2 The meal part (endosperm)

Representing 80 to 82 % of the total weight of the grain, it occupies almost the entire interior of the grain and is mainly composed of tiny grains of starch and gluten. This part contains the essential energy reserves to feed the seedlings during germination. The meal part is used to produce flour.

II.3.3 The germ

Constituting 2 to 3 % of the total weight of the grain, the germ is the embryo of the future plant. It is located at the end of the groove (dorsal face) of the grain and is composed of the coleoptile, the gemmule, the radicle, the coleorhiza, the coleoptile, and the scutellum (figure 8).



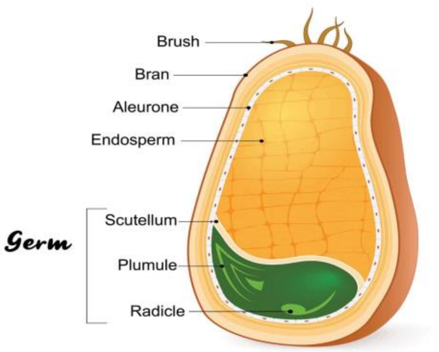


Figure 8: Structure of the soft wheat grain

II.4 Biochemical composition

The grain is mainly composed of starch (approximately 70 %), and proteins (10 to 15 % depending on the varieties and growing conditions). Other components, which are minor in weight (only a few percent), include lipids, cellulose, free sugars, minerals, and vitamins (Feillet, 2000).

II.4.1 Proteins

II.4.1.1 Soluble Proteins

Albumins

Wheat grain contains 5 to 10 % of its total proteins as globular proteins that are soluble in water. These proteins are primarily found in the outer layers of the grain and the germ (Jeantet et al., 2007).

Globulins

5 to 10 % of the total wheat proteins are globular and soluble in diluted salt solutions. They are found in the peripheral parts of the grain, just like albumins (Jeantet et al., 2007).

II.4.1.2 Insoluble proteins

Gliadins and glutamines are insoluble in water, but during kneading, they can absorb a lot of water, stick together, and form a more or less soft and elastic substance: gluten. Hydrated gluten gives dough its rheological properties (Berland and Roussel, 2005).

Gliadins (40 to 50 % of the total wheat proteins) are soluble in alcoholic solutions. They are mainly found in the endosperm or almond of the wheat grain, and they make up gluten, which gives it viscous characteristics (Jeantet et al., 2007).

Glutamines represent 30 to 40 % of the total wheat proteins; they are soluble in acid or alkaline solutions and give gluten its elastic characteristics, cohesion, and resistance to deformation.

II.4.1.3 Metabolic proteins

These proteins are enzymes whose biological role is to catalyze various reactions. The most common ones include amylases, catalases, proteases, and lipoxygenases (Boudreau and Menard, 1992).

II.4.2 Enzymes in carbohydrate metabolism

II.4.2.1 α and β amylases

Enzymes that break down carbohydrate reserves during grain germination and during the conversion of starch into fermentable sugars: maltose-glucose (Frénot and Vierling, 2001).

II.4.2.2 Alpha-amylases

These are endoenzymes with a molecular mass ranging from 50 to 60 kDa. They randomly hydrolyze α (1, 4) bonds of amylose and amylopectin chains in starch, except for the terminal bonds (Feillet, 2000).

II.4.2.3 Beta-amylases

Specific enzymes for linear chains release maltose molecule by attacking simultaneously the non-reducing end of amylose and the non-reducing branches of amylopectin (Boudreau and Menard, 1992).

II.4.2.4 Invertase

It converts sucrose into reducing sugars (Kiger and Kiger, 1967).

II.4.2.5 Maltase

Found in small quantities, and capable of hydrolyzing a portion of maltose (Kiger and Kiger, 1967)

II.4.3 Protein metabolism enzymes (proteases)

Their maximum activity is at pH=3.8 (Feillet, 2000). Proteases would play an important role during long-term wheat storage (Boudreau and Menard, 1992).

II.4.4 Lipid metabolism enzymes (lipases)

They are mainly located in the aleurone layer. Their activity increases rapidly during germination (Feillet, 2000).

II.4.5 Carbohydrates

They are composed of simple sugars (mono, di, and tri-saccharides) and complex sugars (starch, cellulose, pentosans) (Belitz et *al.*, 1987).

Simple sugars are present in large quantities in the germ, while starch makes up almost the entirety of the carbohydrates in the endosperm (Vierling, 2008).

II.4.5.1 Starch

Starch is a complex sugar, part of the carbohydrate family, and represents the majority of carbohydrates, making up 59 % of the total, distributed as follows: 25 % amylose and 75 % amylopectin. It is found in the endosperm, with the central zone being richer than the peripheral zone. In contrast, the bran and germ contain little starch (Fredot, 2006).

II.4.5.2 Amylose

Amylose is a linear homopolymer consisting of 500 to 6000 D-glucose units (in the form of o-glucopyranose linked by a (1,4) bonds and a very small number of a (1,6) bonds) (Feillet, 2000).

II.4.5.3 Amylopectin

Amylopectin is a branched polymer consisting of a mean chain length of 20 to 50 glucose molecules, with glycoside linkages at the branching points of alpha -+ 1-6 (Boudreau and Menard, 1992).

II.4.5.4 Pentosans

Pentosans are non-starchy polysaccharides that are constituents of plant cell walls; they are the main components of the cell walls of the endosperm, making up 70 to 80 %, and representing 6 to 8 % of the grain (Feillet, 2000).

II.4.6 Indigestible polysaccharides

II.4.6.1 Cellulose

It is formed by a chain of D-glucose molecules, associated by (1-4) bonds. Cellulose fibers form an insoluble crystalline structure, with little affinity for water, and are resistant to enzymatic attack and physical deformation (Feillet, 2000).

II.4.7 Lipids

The main fats in wheat and germ are fatty acids (palmitic, stearic, oleic, linoleic, and linolenic acids), simple glycerides (mainly triglycerides, but also mono and diglycerides), glycolipids (galactoglycerides), and phospholipids. They are unevenly distributed in the grain: the germ and aleurone layers are particularly rich in them. The lipids in the bran contribute to the structure of the cell walls (Feillet, 2000).

II.4.8 Mineral matter

Wheat grains contain mineral matter in small proportions and are unevenly distributed. Thus, 80 % of the ashes are found in the envelopes, while 20 % are in the endosperm. Potassium, phosphorus, calcium and magnesium are the most abundant minerals in wheat (Doumandji et *al.,* 2003).

II.4.9 Vitamins

The only liposoluble vitamin present is vitamin E with 1.4 mg/100 g of dry matter, and vitamin C is almost absent. Wheat is an interesting source of vitamins in the B group. The vitamins are also distributed as follows: B1 is present for 2/3 in the scutellum associated with the germ, niacin at 80 % in the protein layer, and vitamin E mainly in the germ (Vierling, 2008). The biochemical composition of soft wheat is shown in brief in table 3.

Tab 3: The biochemical composition of soft wheat

Soluble proteins	Albumins Globulin
Insoluble proteins	Gliadins Glutamines
Metabolic protein	Amylases Catalases proteases lipoxygenases
Enzymes in carbohydrate metabolism	α-amylase β-amylase invertase maltase Protein metabolism enzymes Lipids Metabolism enzyme
Carbohydrate	Starch Amylose Cellulose
Lipids	Fatty acids Simple glycerides Phospholipids
Minerals matter	Potassium Phosphors Calcium Magnesium
Vitamins	E C B1

II.5 Soft wheat varieties grown in Algeria

The cultivation of soft wheat in Algeria is influenced by both global and local economic factors, as well as consumer demand and the availability of local endemic varieties. The varieties of soft wheat grown in Algeria include several types, such as *NESSER*, *RHUMEL*, and *ZIDENE*, etc. Each variety has its unique features, as shown in table 4.

Table 3: Biochemical composition of soft wheat

Soluble proteins	Albumins, Globulin
Insoluble proteins	Gliadins, Glutamines
Metabolic protein	Amylases, Catalases, proteases, lipoxygenases
Enzymes in carbohydrate metabolism	α-amylase, β-amylase invertase, maltase Protein metabolism enzymes Lipids metabolism enzyme
Carbohydrate	Starch, Amylose, Cellulose
Lipids	Fatty acids, Simple glycerides, Phospholipids
Minerals matter	Potassium, Phosphors, Calcium, Magnesium
Vitamins	E, C, B1

Table 4: Soft Wheat Varieties Grown in Algeria NESSER/RHUMEL.

	Variety	***NESSER***	***RHUMEL***
Morphological Characteristics	**Spike**	White with divergent awns	Spike with elongated reddish-brown awns, semi-compact with divergent awns
	Straw	Short	Short, full, reddish
	Grain	Amber, ovoid	Reddish, slightly elongated
	Disease Resistance	Moderately tolerant to rust and septoria	-Moderately tolerant to brown rust. -Tolerant to black rust and powdery mildew. -Susceptible to septoria, charcoal, and yellow rust
Technological Characteristic	**Thousand Grain Weight**	Medium	Medium
	Zeleny Index	Very good bread-making quality	Very good bread-making strength.
Alveograph Characteristics	**Bread making strength**	Very high	Very tenacious dough.
	Swelling (G)	Good	/
General information	**Use**	Corrective wheat	Corrective wheat
	Productivity	Good	Good
	Adaptation Zone	High plateaus, interior plains	High plateaus

II.6 General information on soft wheat derivatives

II.6.1 Soft wheat bran-generalities

Soft wheat bran, originated from the outer protective layer of the wheat kernel, is a nutrient-dense ingredient rich in fiber and essential nutrients. It's obtained from soft wheat during processing operations that transform it into white flour, using low-temperature heat treatment to maintain its beneficial properties. This light brown bran is adaptable and suits a range of dietary preferences, including those of vegetarians, vegans and individuals with specific dietary restrictions. Whether in whole, granular or flour form, organic soft wheat bran serves as a valuable enhancement to a variety of dishes, enriching their nutritional profile and fiber content.

II.6.2 Composition of soft wheat bran

The composition of soft wheat bran varies depending on factors such as the specific variety, growing conditions, employed extraction methods and the milling process, sampling techniques and their interactions. These factors directly affect the starch content within the bran.

Wheat bran is composed of different tissues with distinct properties and compositions, namely the pericarp, testa (seed coat), and aleurone layer (Hemery et al., 2007).

II.6.2.1.1 Precarp

The outer layers of wheat bran, constituting around 4-5 % of the grain's weight, are primarily made up of robust cell walls rich in cellulose, cuticle materials, and complex xylan with a notable abundance of arabinose and ferulic acid (Hemery et al., 2007). Additionally, the pericarp of the wheat grain harbors substantial levels of lignin, encompassing structural polysaccharides that contribute to its superior plasticity compared to other layers (Antoine et al., 2003). The cortex serves a crucial function in providing mechanical protection and bolstering resistance against pathogens.

II.6.2.1.2 Testa (seed coat)

Constituting 1 % of the grain's weight, the testa contains the majority of grain’s alkylresorcinols, ranging from 220 to 400 mg/100 g. Alkylresorcinols exhibit antioxidant properties and demonstrates anti-mutagenic and anti-bacterial activities (Parikka & Wähälä, 2009). The alkyl side chains' lipophilic nature enables membrane modulation effects, with the primary role being the protection of membranes against lipid peroxidation.

II.6.2.1.3 Aleurone layer

The aleurone layer, comprising 6 to 9 % of the wheat grain's weight, is composed of living cells rich in proteins and gluten. Its primary functions include metabolite storage, reserve hydrolytic enzyme synthesis, and protecting its sturdy wall structure. This intricate tissue is a significant source of essential nutrients, with around 40 % minerals (Antoine et al., 2003) and 20 % bran proteins (Pomeranz, 1988) concentrated within the aleurone layer.

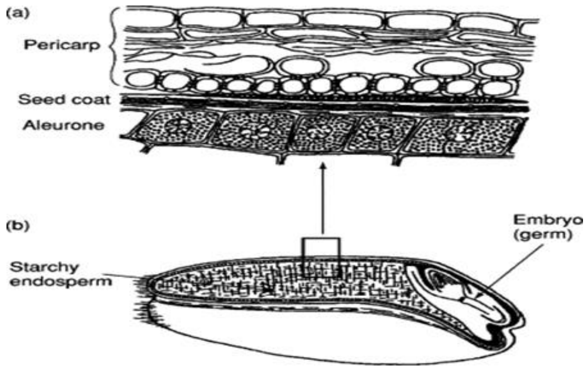


Figure 9: Soft wheat bran compositions

II.6.3 Biochemical compositions of soft wheat bran

Soft wheat bran typically consists of various biochemical components, including:

Dietary Fibers: Mainly cellulose, hemicelluloses (arabinoxylans), and β-glucans, which contribute to its high fiber content.

Proteins: Soft wheat bran contains proteins, although in lower amounts compared to the endosperm. These proteins include gluten proteins and non-gluten proteins such as globulins and albumins.

Lipids: Soft wheat bran contains lipids, primarily unsaturated fatty acids such as linoleic acid and oleic acid.

Minerals: It is rich in minerals such as potassium, phosphorus, magnesium, and calcium, which are important for various physiological functions.

Vitamins: Soft wheat bran contains vitamins, including B vitamins (thiamine, riboflavin, niacin) and E vitamin.

Enzymes: The most important enzymes we find are amylases, proteases, lipases and phytases.

Phytochemicals: It also contains phytochemicals such as phenolic compounds, flavonoids and antioxidants, which contribute to its potential health benefits.

II.6.4 Health benefits of soft wheat bran

Incorporating soft wheat bran into one's diet offers a multitude of health advantages for humans, outlined as follows:

II.6.4.1 Nutrient profile

Wheat bran is a valuable reservoir of vital nutrients like proteins, vitamins and antioxidants, crucial for supplying the body with essential elements that enhance overall human health.

II.6.4.2 Antioxidant

The beneficial antioxidant phytochemicals, such as phenolic acids and alkylresorcinols, in whole-wheat grains are predominantly found in the bran fractions. The bran fractions account for 83 % of the total phenolic content (Adom et *al.,* 2005). As a result, the bran fraction exhibits higher antioxidant activity compared to other milled fractions (Liyana-Pathirana and Shahidi, 2007).

II.6.4.3 Heart health

Antioxidant phytochemicals found in wheat bran fractions regulate cellular redox balance, safeguarding essential molecules like proteins, and membrane lipids from oxidative harm. Additionally, they contribute to lowering total cholesterol and triglyceride levels in the blood, thereby reducing the risk of chronic diseases such as cardiovascular disease (Zhou et *al*., 2004).

II.6.4.4 Gastrointestinal Health

The phenols found in wheat bran are predominantly attached to sturdy cell wall structures, allowing them to reach the colon intact and be metabolized by gut bacteria, (Andreasen et *al*., 2001), it can offer intestinal health advantages such as alleviating bloating, reducing abdominal gas, easing constipation, and supporting regular bowel movements. Furthermore, these phenols can foster the proliferation of beneficial gut bacteria, thereby enhancing gut health and creating a favorable gut environment.

II.6.4.5 Mental health

Wheat bran fractions are rich in B-group vitamins such as thiamine, riboflavin, niacin, pantothenic acid, pyridoxine, biotin, and folates, as well as vitamin B and E and carotenoids. These essential nutrients play a significant role in supporting mental health (Fardet, 2010).

II.6.4.6 Cancer risk reduction

Adding wheat bran to the diet can help prevent various types of cancers, particularly colon and breast cancer. Wheat bran is abundant in dietary fibers, which are plant cell walls known for their cancer-protective properties. Additionally, wheat bran contains essential nutrients and phytochemicals like phytic acid, phenolic acids, lignans, flavonoids and antioxidants, all of which contribute to its potential cancer-fighting benefits.

II.6.4.7 Weight control

High-fiber foods like wheat bran promote a sense of fullness and satisfaction, leading to decreased food consumption and calorie intake.

II.7 Wheat flour

II.7.1 Definition of wheat flour

Wheat flour is the product made from the grains of soft wheat, by grinding processes in which the bran and the germ are partially removed, and the remainder is reduced to a sufficiently fine powder and used for making various food products like biscuits, bread, cakes and pasta.

II.7.2 Chemical composition of wheat flour

Soft wheat grains are rich in carbohydrates, proteins, fats, minerals, vitamins, enzymes, and other compounds. The chemical composition of soft wheat can vary significantly based on factors like type, variety, season, location, and cultivation conditions, leading to distinct differences in the chemical composition of each type of commercial white wheat flour. The chemical composition of soft white wheat is shown in table 5:

Table 5: The chemical composition of white wheat (Fredot, 2005)

Composition g/100g	**White wheat**
Protein	10
Lipids	1.3
Starch	70
Simple sugars	1.5
Fiber	3.5
Minerals(mg)	
Potassium	140
Sodium	3
Phosphorus	120
% phytic phosphorus	30-40%
Calcium	16
Ca/P	0.13
Magnesium	20
Iron	1.2
Vitamins (mg)	
B1 (thiamine)	0.1
B2 (riboflavin)	0.05
B3 (niacin)	0.6
B6 (pyridoxine)	0.2
E (α-tocopherol)	0.3
Energy intake kcal	345

II.7.3 Desired characteristics of flour

In the food industry, there are several types of flour depending on the desired final food product: pastry, biscuit, bread, pizza dough, pasta, semolina, etc. and to choose the appropriate flour, the following points must be taken into consideration:

II.7.3.1 The hardness of wheat

Durum wheat (hard wheat) is favorable for producing flour dedicated to semolina or pasta production, while soft wheat is used to produce bread flour (flour dedicated to bread, pastry, and biscuit production).

II.7.3.2 Protein Content (Gluten)

Gluten is a protein found in wheat grain. Soft wheat with higher protein content is suitable for bread making. It will provide the elasticity and extensibility qualities needed for bread dough. On the other hand, soft wheat with lower protein content is more suitable for pastries and biscuits, where properties like a more brittle dough and lower water absorption are desired (Fu, Wang & Dupuis, 2017).

II.7.3.3 Proportion of bran

This proportion is measured using the ash content indicator and is the main criterion for classifying wheat flour for the general public. The higher the ash content, the more bran the flour contains. Bran includes the wheat's outer layer and germ. Whole-wheat flour contains all the nutrients present in wheat grain (outer layer, albumen, and germ). Whole meal flour contains only parts of the outer layer and albumen of the wheat grain. While white flour will be composed only of the albumen part.

II.7.3.4 Water absorption rate

The water absorption rate is an important parameter for determining the functional properties of flour (Fu, Wang & Dupuis, 2017). Flour with higher water absorption is preferred for bread production (improved dough handling properties, better taste and structure of bread) (Fu et al., 2017). On the other hand, with a lower water absorption rate, it is preferable to produce pastries and biscuits.

II.8 Biscuits

II.8.1 Definition of biscuit

The term "biscuit" originates from the original British word "Bis-Cuit," signifying a double baking process. This method involves initially baking the dough at the bottom, akin to bread, followed by placement in the compartments above the oven to decrease moisture content. Biscuit encompasses small baked goods, typically flat in shape, made from wheat flour with additions like sugar, creating a category that includes crackers and the more indulgent cookies. These products are known for their extended shelf life.

II.8.2 The biscuit value

The biscuit value is the ability of flour to be valorized in biscuit production. It must adapt to various transformation techniques for the manufacture of biscuits. The biscuit value of the dry biscuit type is primarily characterized by the homogeneity of the dimensional measurements of the biscuits, sufficient resistance to breakage, and correct machinability of the dough.

The conditions of using biscuit flour by professionals in the biscuit industry lead to diverse qualitative expectations, which depend on various factors such as the quantity and quality of proteins, the state of starch, etc. This technological value is mainly dependent on the intrinsic characteristics of wheat (genotype and phenotype) or flour, which are linked to biochemical composition and technological tests. It can be appreciated through physical, biochemical and rheological tests.

II.8.3 The biscuit manufacturing process

The biscuit manufacturing process involves different steps to obtain the desired final product. These steps are presented in the following diagram:

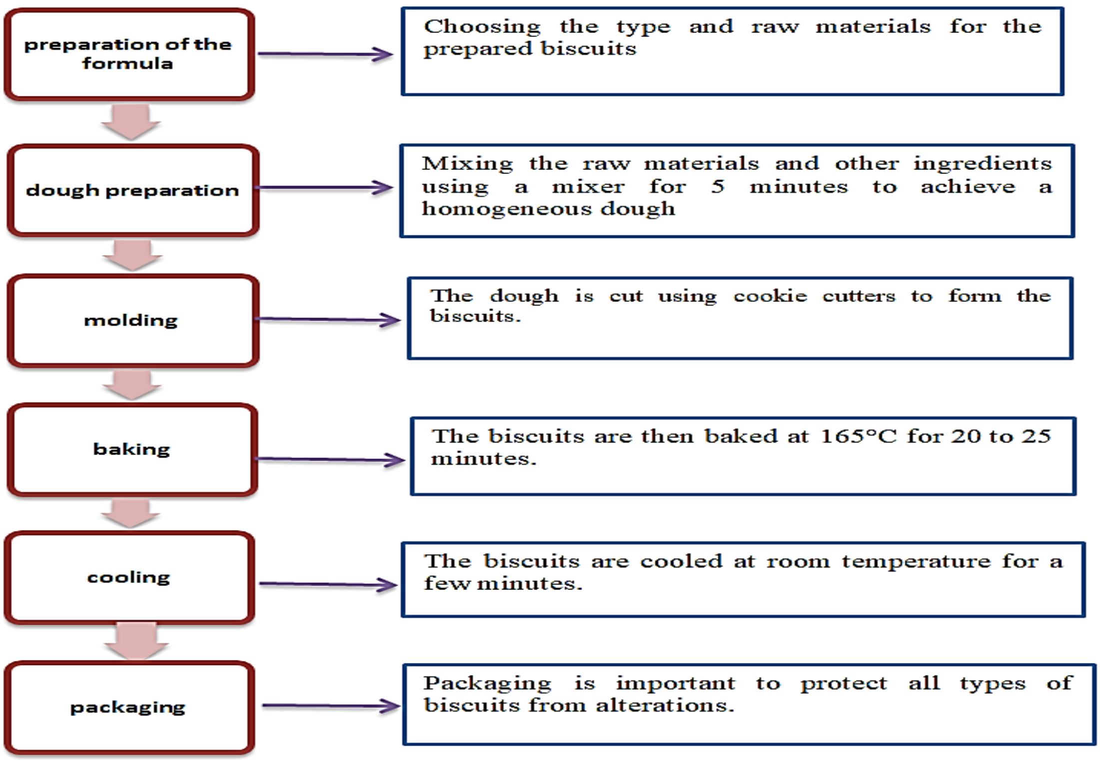


Figure 10: The biscuit manufacturing process

II.8.4 The Baking Process of Biscuits

During baking, biscuits undergo three main stages:

➢ **Development:**

When dough enters the oven, it forms a thin film on the surface that thickens due to water evaporation. The film must be elastic and its elasticity is directly proportional to the oven temperature. High temperatures can cause the film to become thick, trapping gases and leading to surface cracks. Fat particles melt and tend to move to the surface rather than staying in their initial position. Heat (32-99°C) increases the dough's volume by stretching it, as observed by Boudreau and Menard (1992).

➢ **Solidification:**

Starch gelatinization plays an important role in the internal structure of biscuits. Depending on the dough's moisture content, gelatinization begins at 52°C and continues up to 93°C. During baking, there is evaporation of aromas and migration of water not only from the dough to the oven atmosphere, but also from the gluten to the starch.

The proteins from the flour, milk and other ingredients start to denature from 63°C onwards, depending on their nature. This denaturation ensures the structure and rigidity of the biscuit. Around 74°C, the proteins undergo an irreversible denaturation process, becoming less soluble and less extensible. This marks the final stage of dough expansion and gives the biscuit its final appearance (Boudreau and Menard, 1992).

➢**Coloration:**

The browning of the surface is caused by the caramelization of sugar, the Maillard reaction, the dextrinization of starch, and the roasting of the wheat part. It begins around 149°C with sugar caramelization, and then between 188 and 205°C, starch gradually converts into dextrin. The products of caramelization and Maillard reactions yield a wide range of colors. Although protein denaturation inevitably leads to a decrease in nutritional value, the gain in flavor is highly appreciated. The formation of dextrin on the surface of the product, while contributing to the caramelization phenomenon, ensures the shiny appearance sought after by bakers.

The practical part

Chapter III: Experimental Approach

Chapter III: Experimental Approach

III.1 Material and methods

III.1.1 Study zone

The analyses were carried out as follows:

The physicochemical, biochemical and rheological analyses were carried out at:

- The national laboratory of the OAIC in Cheraga, Algiers.
- Engineering faculty's laboratory of Boumerdes.

These analyses were performed to evaluate the impact of incorporating soft wheat bran into commercial white flour. The research was conducted in these well-equipped laboratories to ensure reliable and accurate data collection and analysis for the study.

III.1.2 Plant material

The plant material for this study comprises (figure 11):

- White soft wheat flour of a commercial industrial type.
- Soft wheat bran of a Canadian variety, imported by OAIC.

The study was conducted from 11/03/2024 till 29/05/2024.

Figure 11: Plant material

III.1.3 Samples preparation

We have witness sample and 3 blends:

➢Witness sample: Consists 100% of flour.

➢Blends: There are 3 blends; in each blend we have two incorporations

The steps are showen in annex (1).

Table 6: Preparation of blends (incorporations)

Blend	Sample	Wheat flour %	Wheat bran %
/	Witness (flour)	100	0
1	A B	90 90	10 10
2	A B	80 80	20 20
3	A B	70 70	30 30

III.2 Methods for analyzing raw materials

III.2.1 Physicochemical analyses

Physicochemical analyses allow us to study the physical and chemical characteristics of our samples.

III.2.1.1 Determination of water content (humidity).

The water content is determined according to the European standard EN ISO 712:2009.

Principle

The reference method involves drying a sample to a temperature between 130°C and 133°C under defined operating conditions. The observed mass loss is equivalent to the amount of water present in the product, expressed as a percentage.

Procedure

At the beginning of the experiment, using an analytical balance, we measure the initial mass of the empty metal capsules, each equipped with a lid and a crucible providing a suitable surface for uniform distribution of the sample, noted as m_0. Then we take 5±1 g of the sample and record this mass as m_1.

The capsules are then placed in an isothermal oven with adjustable electric heating to maintain a constant temperature between 130 and 133°C for 1.5 hour. After this period, the capsules are quickly removed, covered, and placed in a desiccator. The capsules are arranged side by side and allowed to cool for 45 minutes. Finally, we weigh the closed capsules (crucible + lid) to obtain the final mass, noted as m_2.

Expression of results

Water Content in Percentage is given by the following Formula:

$$TE\ \% = \frac{(m0+m1)-m2}{(m0+m1)} \times 100$$

m_0: Empty Capsule Mass in grams.
m_1: Test Sample Mass in grams.
m_2: Test Sample Mass after heating (g) (dry matter + capsule) in grams.

Figure 12: Equipment used for determining water content

III.2.1.2 Determination of Ash Content

The ash content of a test sample is determined by measuring the mineral residue remaining after complete incineration, which allows for the analysis of the mineral composition of the test sample.

Principle

The principle is based on the incineration of the product in a muffle furnace set between 530 and 600°C (for soft wheat derivatives) until the complete combustion of the organic matter. The mineral residue remaining after this incineration corresponds to the ash content of the test sample.

Procedure

Initially, we used an analytical balance to measure the weight of the empty capsules, and the results are recorded as P_0 (taking care to identify the type of test sample under each one to avoid any confusion). Then we add 3 g of each sample. The samples are placed in a muffle furnace heated to 550°C for 5 hours, allowing the product to be consumed and transformed into a grey matter. After removing the capsules from the furnace, they are cooled in a desiccator. Finally, each capsule is weighed again, and the results are recorded as P_i.

Figure 13: Equipment used for determining Ashe's content

Expression of Results

The ash content as a percentage is given by the following formula:

$$AC\% = \frac{Pi - P0}{test\ sample} \times 100$$

P_i: Weight of the capsule + sample (after incineration) in g.
P_0: Weight of the empty capsule in grams.
Test sample: Weight of the sample

III.2.2 Biochemical Analyses

Biochemical analyses allow us to study the biological and chemical characteristics of our test samples.

III.2.2.1 Determination of Nitrogen Content and Calculation of Crude Protein Content by the Kjeldahl Method

The determination of the nitrogen content and the calculation of the crude protein content by the Kjeldahl method comply with the European Standard EN ISO 20483:2013.

Principle:

The principle of the measurement is based first on the mineralization of the organic matter of the samples in the presence of a catalyst, using sulfuric acid at 420°C for 2 hours under a fume hood. Then, the reaction products are alkalinized by sodium hydroxide, and finally, the released ammonia is distilled and recovered in a boric acid solution, which is then titrated with a sulfuric acid solution to determine the nitrogen content and calculate the crude protein content.

Procedure:

Sample Preparation: Initially, using an analytical balance, we weighed 1g of each sample.

Mineralization: Next, we placed the sample in the mineralization tube, added 7.5g of catalyst and 20 ml of sulfuric acid (annex 2), and then carefully mixed to ensure complete wetting. Afterwards, the tubes were placed in the preheated mineralization block at 420°C for 2 hours. Then, we let them cool for 3 hours.

Distillation: Subsequently, we cautiously added 50 ml of distilled water to the cooled tube and let it cool. Then, we added 50 ml of boric acid and 3 drops of methyl red indicator to the Erlenmeyer flask, and proceeded with the distillation (annex 2).

Titration: Finally, we performed the titration using the sulfuric acid solution. The determination of the equivalence point was carried out by visual colorimetry.

Blank Test: A blank test was performed using the reagents without the sample.

Figure 14: Equipment used for determining the crude protein content

Expression of Results: The nitrogen content is given by the following formula:

$$NC=\frac{V\times(T\times0.014\times100)}{(100-H)}\times 100$$

NC: The nitrogen content.

V: The volume in milliliters of the sulfuric acid solution needed for the sample.

0.014: The expression in grams of the quantity of nitrogen equivalent to the use of 1 ml of a sulfuric acid solution.

T: The normality of the sulfuric acid solution used in the titration (0.1N).

H: The humidity.

- Calculate the crude protein content of the dry product by multiplying the obtained value for the nitrogen content by a conversion factor suitable for cereals (annex 3).

PC=NC×5.7

PC: Proteins content.

5.7: Conversion factor suitable for cereals.

III.2.2.2 Determination of Sedimentation Index (Zeleny Test)

The Zeleny test is determined according to the international standard ISO 5529:2007 and the French standards NF ISO 565 and NF EN ISO 3696.

Principle

The principle of the measurement is based on the ability of flour proteins to swell in an acidic environment. The experimental flour prepared from soft wheat is suspended in a solution of lactic acid and 2-propanol in the presence of a dye. After defined times of agitation and rest, the obtained volume of the deposit corresponds to the sedimentation of the flour particles.

Procedure

Initially, we weighed two test portions of 3.2 g from each test sample. The tests were carried out under normal lighting conditions, and protected from direct sunlight. Then, the test portion was placed in a 100 ml flat-bottomed and graduated cylindrical test tube. Using a pipette or an automatic dispenser, we add 50 ± 0.5 ml of bromophenol blue ($C_{19}H_{10}Br_4O_5S$) solution. We cap the test tube and then shake it while keeping it in a horizontal position, shaking it longitudinally from right to left, twelve times in each direction, over a range of approximately 18 to 20 cm, in about 5 seconds. Afterwards, we place the test tube in a mechanical shaker, then start the stopwatch and turn on the shaker. After 5 min, we remove the test tube from the shaker and, using a pipette or automatic dispenser, add 25 ± 2 ml of the

Zeleny solution to its contents (annex 4). We place the test tube back in the shaker and continued shaking for 5 min, to give a total shaking time of 10 min. Then, we remove the test tube and place it in a vertical position. We allow the contents of the test tube to stand for exactly 300 ± 5 s and then note the volume of the deposit to the nearest ml.

The number indicating the volume, expressed in ml, of the deposit represents the sedimentation index.

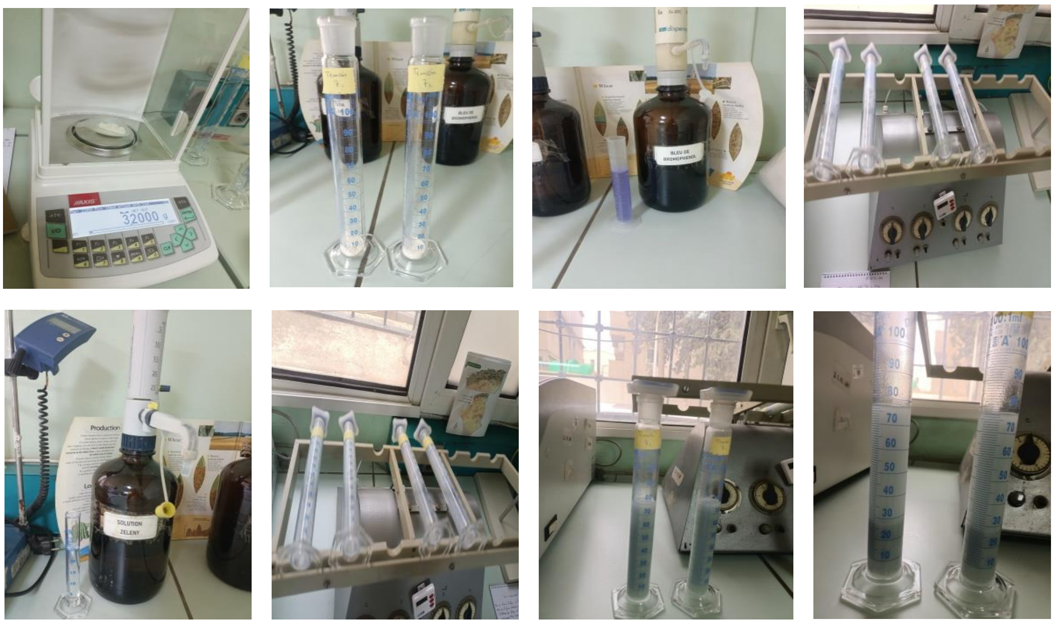


Figure 15: Equipment used for determining the Zeleny test

Expression of Results

The sedimentation index is given by the arithmetic mean of the results of two determinations; provide that they do not differ by more than two units.

III.2.3 Rheological Analyses

Rheological analyses allow us to study the mechanical characteristics of our test samples.

III.2.3.1 Determination of the Hagberg-Perten Falling Number Index

The falling number index is determined according to the international standard ISO 3093.

Principle

The principle of the method is based on the measurement of α-amylase activity, it's estimated using the starch present in the sample as a substrate. The determination is based on the rapid gelatinization capacity of an aqueous suspension of flour or whole meal placed in a boiling water bath The measurement of starch paste liquefaction by the α-amylase present in the sample.

Procedure

For water content determination and test sample see annex 5

Determination of Falling Number using the "falling number" apparatus:

We filled the water bath to the overflow level, opened the cooling system tap, and connected the Falling Number determination apparatus, bringing the water to a boil. Then, we placed the weighed test sample into a clean and dry viscometric tube. Add 25 ± 0.2 ml of distilled water at 22 ± 2°C using an automatic dispenser or pipette.

Immediately after sealing the viscometric tube with the cap, we vigorously shook it vertically 20 to 30 times to obtain a homogeneous suspension. Then, we removed the cap and scraped any material adhering to the base of the cap in the tube, and with the viscometric stirrer, we also scraped any material adhering to the tube walls.

Immediately after, we weighed the viscometric tube with the stirrer through the lid opening and placed them in the boiling water bath. We activated the stirring head of the apparatus. The apparatus then automatically performed the various test steps. The test was considered complete when the viscometric stirrer reached the bottom of the gelatinized suspension. Finally, we read the time displayed by the apparatus timer. This time constitutes the Falling Number.

Figure 16: Equipment used for determining the Hagberg-Perten Falling Number Index

Expression of Results

The Hagberg-Perten Falling Number is given by the time displayed on the timer of the "Falling Number" apparatus in seconds.

III.2.3.2 Determination of wet and dry gluten content (by manual method)

Wet and dry gluten are determined according to the European standard EN ISO 21415-1:2007.

Principle:

In this method, wet gluten is manually extracted from the dough prepared from our samples using a sodium chloride solution. Then, the dough is washed with water and weighed. The obtained wet gluten ball is then dried to obtain dry gluten.

Procedure:

Firstly, using an analytical balance, we weighed 10 g of each sample test portion and transferred them quantitatively into the mortar. Subsequently, we added 5 ml of sodium chloride solution drop by drop while continuously mixing the sample with the grinding head to form a dough ball, ensuring to avoid sample losses. Any dough residues adhering to the container or grinding head should be collected with the dough ball.

After forming a dough ball, we placed it under a drip of tap water, noting the emergence of a white substance, which is gluten. We continued the extraction until no more gluten was observed coming out. This process should be conducted over a rectangular plastic sieve to prevent potential dough loss. Additionally, most of the washing solution adhering to the gluten ball should be removed by gently squeezing it three times.

Next, we weighed the dough ball to determine the wet gluten mass and the results are recorded as (m_1), and then placed it on parchment paper before drying it in an oven at 130°C for 2 hours to obtain dry gluten. Finally, we removed the dry dough balls from the oven and placed them in a desiccator at room temperature for approximately 30 minutes, then we weighed them, and the results are recorded as (m_2).

Expression of Results

-The wet and dry gluten content are given as a percentage of every test sample weight.

-The hydration coefficient is expressed as follows:

$$HC\% = \frac{m1-m2}{m1} \times 100$$

HC: hydratation coefficient.

m_1: wet gluten weight.

m_2: dry gluten weight.

Figure 17: Equipment used for determining the wet and dry gluten content (by manual method)

III.2.3.3 Alveograph CHOPIN test

The alveograph test is determined according to the Algerian standard NA 19122:2016.

Principle:

The behavior of a paste formed from a mixture of each sample and saltwater is evaluated during deformation. A paste disk (dough) is subjected to a constant air flow. Initially, it resists pressure, and then it expands into a bubble shape according to its extensibility and bursts. This evolution is measured and reported as a curve called the "alveogram".

Procedure

Preliminary Operations

We used the water content values of our samples according to the specific method of ISO 712. Next, we prepared a quantity of sodium chloride solution and placed it in the dedicated reservoir of the device to prepare the paste (Annex 4).

Kneading

We weighed 250 grams of each sample using an analytical balance, then placed it in the kneader and locked the system. Next, we measured the water content of the sample and sent the instructions to the Alveolab. The dough fermented for 8 minutes, after which we stopped the motor and opened the lid with a plastic spatula. After closing the lid, we restarted the motor for an additional 6 minutes of kneading, during which we lubricated the extrusion accessories. Finally, after a total of 8 minutes, we stopped kneading and extruded the dough pieces.

Preparation of dough pieces

After preparing the machine by reversing the direction of rotation of the kneader, clearing the extrusion passage, and oiling the receiving plate, we proceeded to the dough pieces preparation. We removed the first centimeter of dough, cut the dough strip, and extruded five dough pieces successively without interruption, replacing the receiving plate each time. The fifth dough piece was left waiting. Then, the first four dough pieces were laminated, cut, and placed in the 25°C thermostatic chamber of the alveograph. These steps were repeated with the fifth dough piece to complete the process.

Alveograph Test

After 28 minutes of kneading, we took the first dough and placed it on the pre-lubricated loading pad. We then pressed the "start test" button, which lifted the pad with the dough onto the plate until the test area. Once the dough was in place, it was crushed while measuring the pressure in the bubble. The deformation curve then appears on the screen. The test automatically stops when the bubble bursts. The plate then unlocks, and a scraper disengages the dough, which falls into the recovery bucket.

Figure 18: Equipment used for determining the Alveograph test

Results Expression:

The results are measured from the curves obtained using the AlveoPC model, which also measures the evolution of pressure in the bubble and reports it in the form of a curve called alveogram (Annex 6).

The alveogram allows the calculation of the following characteristic parameters:

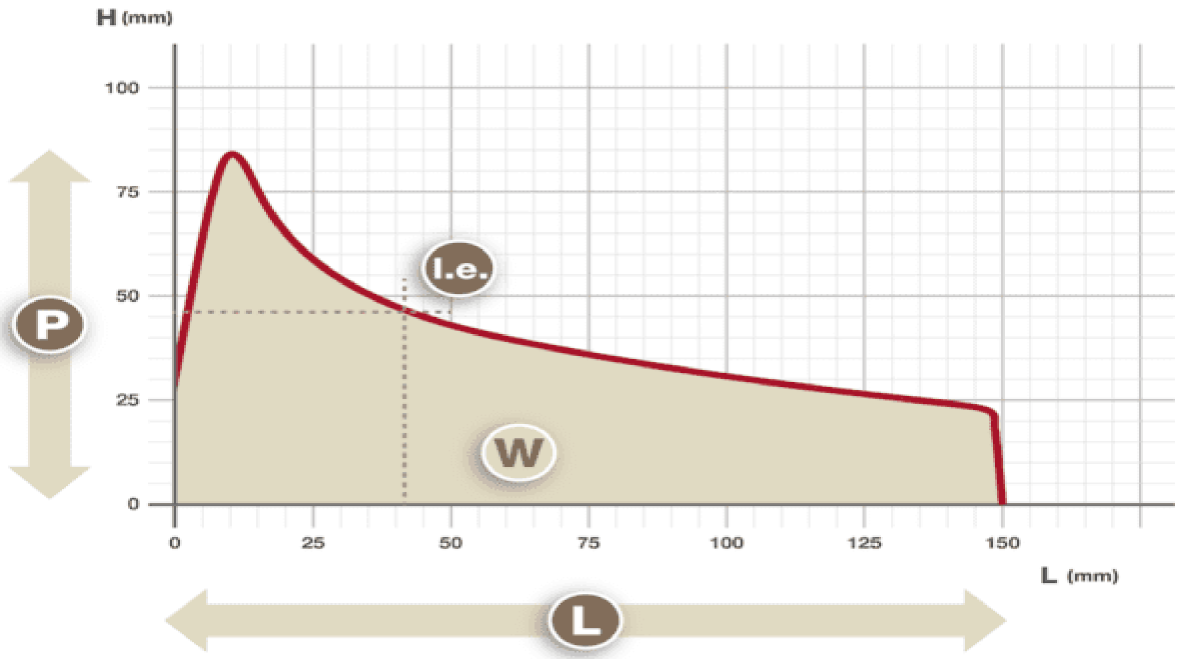


Figure 19: Alveogram

Ie: elasticity Index (P200/P)× 100, in %
L or G: Average abscissa at Rupture (swelling index).
P: Maximum Pressure
W: Deformation Work

Chapter IV: Results and interpretation

IV Results and interpretation

IV.1 Witness sample study

The studied witness sample contains 100% of commercial flour.

IV.2 Physicochemical characteristics:

The results of the physicochemical analyses of the witness sample are recorded in the table 7.

Table 7: physicochemical analysis results of witness sample.

Sample	Water content %	Ash content %
Witness	14.32	0.48

IV.2.1 Water content:

Measuring the water content in the cereal sector is a crucial operation that offers three main benefits:

-Technological interest: for the rational management of harvesting, drying, storage, or industrial processing operations.

-Analytical interest: to relate the results of analysis of any product to a fixed base (dry matter or standard moisture content).

-Commercial and Regulatory interest: commercial contracts and regulatory standards set moisture content thresholds from which bonuses and deductions are applied.

In biscuit production, the water content is variable depending on the product type. In the case of certain weakly hydrated biscuit doughs, this humidity may cause disruptions in manufacturing (Godon and William, 1991).

According to the results in the table 8, we notice that:

The witness sample has water content of 14.32%, this value falls within the range (12.60 - 14.70 %) provided by (Souci et al., 1994) and is below the maximum of 15.5 % set by (FAO, 1996). The results obtained are within the tolerance limits of current legislation.

Several key factors influence the water content of this flour sample. The temperature and humidity of the ambient air play a crucial role in affecting the hygroscopic state of the product, with increased water absorption in humid air conditions. Additionally, the milling method and the amount of water introduced before milling the wheat directly affect the final water content of the flour. The quality of soft wheat, storage conditions, and the duration of flour storage are also determining factors that influence its hydration level.

High water content can lead to microbial proliferation and enzymatic activity that can deteriorate the nutritional value and organoleptic quality of the product.

IV.2.2 Ash content:

The measurement of ash content for soft wheat derivatives is primarily of regulatory interest: It enables the classification of flours according to types defined by regulations.

According to Roussel (2002), the determination of ash content enables the assessment of its richness in envelopes, thus knowing its nutritional importance. According to the results in the table 7, we notice that:

The witness sample has an ash content of 0.48%, according to the Algerian classification of flours; the type of this flour is T45. It is used for pastry and biscuit production and is considered very white flour.

This value of ash content can be explained by several factors such as:

- Genetic factors (mineral richness, mineral distribution, grain hardness, and granulomere).
- Ecological factors (soil, climate, farming methods, amendments, physiological and pathological states).
- Technical factors (cleaning, conditioning, extraction rate, milling method, special treatments).

IV.3 Biochemical Characteristics:

The results of the biochemical analyses of the witness sample are recorded in the table 8.

Table 8: Biochemical analyses results of witness samples

Sample	PC %	SDS ml
Witness	10.24	30
PC : Proteins crud content SDS : Sedimentation index (Sodium Dodecyl Sulfate)		

IV.3.1 Proteins crud content:

The crude protein content is a quantitative test that measures the quantity of crude proteins (gluten) obtained from the nitrogen content of our samples after applying the procedure described according to the Kjeldahl method.

The interest of the protein content is to evaluate the quality of the flour. It's expressed as a percentage. According to the results, we notice that:

The protein content of the witness flour is 10.24 %. Biarnais (1987) showed that flours with less than 9 % protein produced dough that was difficult to work with and less resistant to development. Above 12 %, the dough retracts significantly and becomes uncontrollable in length. Several authors (Gaines, 1990; Souza et *al.*, 1994; ECM, 1996; Charun and Morel, 2001; Fustier, 2006) have shown that the protein content of flour is between 9 % and 12 %, so our result is good for use in biscuit production.

This value of protein content is influenced by pedoclimatic conditions, fertilizer nature, especially nitrogen fertilizer, and heat degree (Oudin, 1998; Levyl et *al.*, 2009).

IV.3.2 Sedimentation Index "Zeleny":

The sedimentation index (SDS) is a qualitative test, which is a number indicating the volume expressed in milliliters of the deposit obtained under specified conditions, from an assessment method of one of the factors of the quality of soft wheat related to the baking strength of the flour. This test has two main purposes:

- Regulatory interest: it is used as a criterion in defining the minimum conditions for intervention.
- Technical interest: it allows for the classification of wheat according to its qualities.

The sedimentation test value for flour depends on several factors, particularly the quality of the wheat and the used analytic method.

The SDS (Sodium Dodecyl Sulfate) test measures the ability of proteins to swell. The volume of sediment depends on the amount of water absorbed and the swelling of gluten proteins in an acidic medium. This value is related to the quality of proteins and gluten formation, which is important for bread making.

For our witness flour, the SDS test value is 30 ml, according to the standard; this value is between 28 and 38 ml, which is a very good value.

IV.4 Rheological Characteristics

The results of the rheological analyses of the witness sample are recorded in the table 9.

Table 9: Rheological analysis results of witness flour.

Sample	FNI (s)	FNI (s) (*)	WG %	DG %	HC %
Witness	393 378	385.5	21.9	8.5	61.18

FNI(s): falling number index.
FNI (*)%: average of falling number index of two samples.
WG%: wet gluten content.
DG%: dry gluten content.
HC%: hydratation coefficient.

IV.4.1 The Hagberg-Perten falling number:

The Hagberg-Perten falling number is an important parameter in the cereal industry that measures the amylose activity (α, β) of cereals. It is used to evaluate the quality of cereals and flours, particularly to determine if they are suitable for biscuit production. Excessive or insufficient presence of α-amylase can degrade the biscuit value.

According to Motquin (2007), as amylose activity increases, the gel becomes more fluid and viscosity decreases, resulting in a shorter falling number. Conversely, if amylose activity is weak, viscosity increases and the falling number will be longer.

Enzymatic activity also plays a significant role in the characteristics of the obtained dough. If the falling number value is low (between 60 and 160 seconds), it indicates strong enzymatic activity, which can lead to sticky dough, biscuits that tend to tear or lack texture, or a very dark-colored crust On the other hand, a high falling number (above 400 seconds) reveals a large amount of starch, which can result in longer fermentation, a biscuit with insufficient development, and a very pale crumb.

The falling number of biscuit flour according to the Algerian standard is between 180 and 280 s, and according to the international standard is between 260 and 320 s.

The value of the falling number of the flour is directly linked to the Maillard reaction, a chemical reaction between sugars (starch) and amino acids that occurs during the baking of biscuits. The falling number measures the amylase activity of the flour, which affects the Maillard reaction, responsible for the color, aroma, and taste of food. A high falling number value can lead to a weak Maillard reaction, affecting the quality and appearance of biscuits.

For our witness flour, we have a falling number value of 385.5 (s), which is above the Algerian and the international standard. This value indicates that the used wheat for the production of this witness flour has a weak amylase activity. This means that the wheat has undergone a certain amount of degradation, which can affect the quality of the flour and finished products (biscuits).

IV.4.2 Gluten content:

Gluten, mainly derived from the insoluble fraction of proteins, has the ability to form a viscoelastic network that influences the properties of extensibility, elasticity and tenacity, thus impacting the behavior of the dough during manufacturing and the quality of the final product, such as biscuits. Wet gluten, composed primarily of two protein fractions (gliadin and glutenin) in hydrated form, is a viscoelastic substance.

The composition of gluten is a determining factor in the strength of flour. The quantity and quality of the latter are responsible for the rheological characteristics of the dough; the hydrated gluten confers on the dough its impermeability and its viscoelastic characteristics, tenacity, elasticity and extensibility (Roussel et al. 2006). Hard-textured biscuits require gluten with high extensibility and a limited degree of elasticity.

According to Boudreau and Menard (1992), the wet gluten content of flour varies between 20 and 24 % and for the dry gluten flour with a content of 7 to 9 % dry gluten is sufficient for biscuit making according to Kiger and Kiger (1967).

The wet and dry gluten contents for our control flour are 21.9 % and 8.5 % respectively; these contents are very close to the values cited in the literature for biscuit making.

The value of the hydration coefficient of flour is the measure of the amount of water that the flour can absorb. It is expressed as a percentage and varies depending on the quality of the flour and its type.

The hydration coefficient influences the flour's ability to absorb water. This may require an adjustment for water added to the recipe to maintain appropriate consistency and workability of the biscuit dough.

HC is important for determining the consistency of the dough. Medium white flour has hydrations rates of 60 to 66 %.

The quality of biscuits is strongly influenced by the hydration coefficient of the used flour. An appropriate hydration coefficient is essential for obtaining high-quality biscuits. A low hydration coefficient results in dry biscuits, while a high coefficient leads to soft biscuits.

For our witness flour, the hydration coefficient is 61.18%, so it’s compliant with standards.

IV.4.3 Alveograph CHOPIN test:

The primary interest of the alveograph is to predict the suitability of flour for use in the production of biscuits. It provides parameters that characterize the dough « P », « L », « G », « W » and « Ie » and predict the quality of different flour or calculate the proportions of incorporation to obtain a sought-after quality product.

The alveographic measurement strictly follows the law of mixtures (additivity of alveographic results). It tests the improving power of additives, defines the optimal dose and highlights the cereals whose storage conditions have not been optimal. The obtained curves from these cereals are very characteristic. The results of the CHOPIN alveograph of the witness flour are illustrated in Table 10 and Figure 20.

Table 10: Alveograph results for witness flour

Parameter	P (mmH_2O)	L (mm)	G (cm^3)	W ($10.10^{-4}J$)	P/L	Ie %
Witness flour	92	62	17.5	206	1.48	50.1

W: This is the deformation work, representing the total surface of the curve, serving as a baker's value for the dough (expressed in 10^{-4} J), which is the most commonly used result.

♦**P:** This is the tenacity index, representing the maximum pressure within the bubble, indicating the resistance of the dough (expressed in mm).

♦**L or G:** This is the extensibility index, measuring the average abscissa at the point of rupture, determining the extensibility of the dough (expressed in mm)., which is proportional to the volume of the bubble G (expressed in cm^3)

P/L: This is the configuration ratio of the curve, characterizing flour based on its tenacity or extensibility, with high ratio indicating tenacious flour and low ratio indicating extensible flour.

♦**Ie:** This is the elasticity index, which represents the elastic character of the dough (Kitissou, 1995). According to Dankou (2005), the Ie highlights the variations in the curve's drop, and it should be low for biscuit flour (Feillet, 2000). He adds that the higher the Ie, the stronger the dough's elasticity (expressed in percentage).

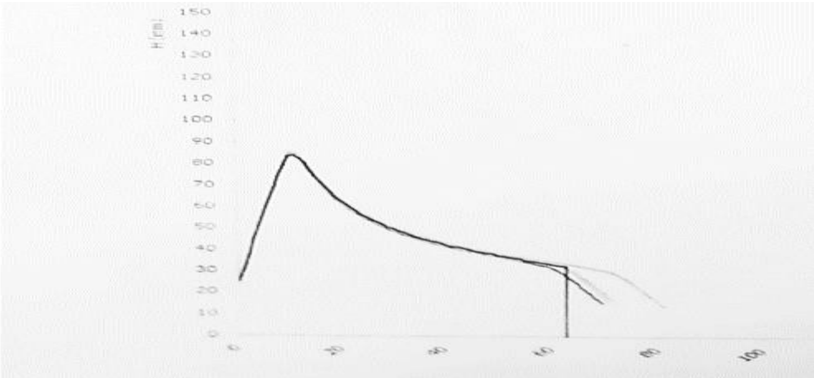


Figure 20: Alveogram of witness flour.

According to Calvel (1984), it is necessary to take into account, in addition of (W), all the characteristics (P, G, L, and P/L). According to Dubois (1988), Godon (1991), Feillet (2000) and Bourson (2009), biscuit flour should correspond to:

A baker's force "W" between 60 and 150.10^{-4} J, but the Algerian standard requires a force between 130 and 180.10^{-4} joules. While AFNOR V03-710 standard specifies:

-W < 130: very low-quality flour.

-130 < W < 160: good-quality flour.

-160 < W < 250: very good-quality flour.

A swelling "G" below 24 cm^3, a tenacity "P" of 30 to 60 mm H_20, an extensibility "L" of 90 to 125 mm and a configuration ratio "P/L" between 0.25 and 0.80.

These measured parameters vary depending on the biochemical characteristics of the flours (quality and quantity of proteins), agronomic criteria (method of wheat planting used), and genetic criteria (wheat variety) (Reynard and Thery, 1998).

The analysis of the results obtained shows that our control flour regarding to the obtained "P", "L", "W", and "P/L" parameters is far from the required limit for biscuit flour, but the "G" parameter fits well within the established range for biscuit flours. Therefore, this flour does not have the characteristics of biscuit flour, except for the swelling index "G".

V Blends study

The blends studied are commercial flour incorporations with soft wheat bran in different proportions.

V.1 Influence of the incorporation rate of soft wheat bran on the physicochemical characteristics of the blends

The results of the physicochemical analyses of blends are recorded in the table 11.

Table 11: Physicochemical analysis results of blends.

Blend	Sample	WC %	WC(*) %	WC(σ)%	AC %	AC(*) %	AC(σ)%
B1 (90/10)	a b	14.12 14.20	**14.16**	**0.04**	0.75 0.82	**0.78**	**0.035**
B2 (80/20)	a b	13.89 13.92	**13.90**	**0.015**	1.13 1.23	**1.18**	**0.05**
B3 (70/30)	a b	13.66 13.68	**13.67**	**0.01**	1.57 1.83	**1.70**	**0.13**

WC: water content; AC: ash content.
WC (*)%: average of water content of two samples a and b ; AC (*)%:average of ash content of two samples A and B.
WC (δ)%: standard deviation of the water content of two samples A and B; AC (δ)%: standard deviation of the ash content of two samples a and b
B1: blend 1 (90% wheat flour and 10% wheat bran); B2: blend 2 (80% wheat flour and 20 % wheat bran); B3: blend 3 (70% wheat flour and 30% wheat bran).

V.1.1 Water content:

The water content of the different blends oscillates between 13.67 and 14.16 %. These water contents decreases as the incorporation of wheat bran rate increases, reaching a minimum value of 13.67% when the incorporation rate is 30 %. These results are consistent with the previous research of Aboudaou (2011) and Akhmoum Dahbia (2016).

The water content of the blend falls within the range of biscuit flour, which is between 12 and 16 % according to Kiger and Kiger (1967).

Pentosans are a type of complex carbohydrate found primarily in the cell walls of plants, particularly in grains like soft wheat, rye and barley. They are composed of pentose sugars, which are monosaccharides with five carbon atoms (e.g., xylose, arabinose). Pentosans play a significant role in the structure and properties of plant cell walls, contributing to their strength and ability to retain water.

Soft wheat bran tends to absorb the humidity, because it is rich in pentosans. Although present in small quantities, it can absorb up to 15 times their weight in water. This also explains why samples with a higher percentage of wheat bran have a much higher water absorption capacity.

V.1.2 Ash content:

According to the results, we observe the blends in mineral matters (ashes) compared to the witness flour. The ash content of the different blends oscillates between 0.78 and 1.70 %. With the increase in the percentage of wheat bran in each blend, we notice that the values of ash content are also increased. This is because the envelopes (soft wheat bran) are rich in mineral matter and fibers, so the ash is mainly contained in the bran.

These ash contents of the blends are higher than those recommended by Biarnais (1987) and Aboudaou (2011), which set intervals of 0.48 - 0.60 % and 0.73 - 0.89 %, respectively, for flours intended for baking.

V.2 Influence of the incorporation rate of soft wheat bran on the biochemical characteristics of the blends.

The results of the biochemical analyses of blends are recorded in figure 21.

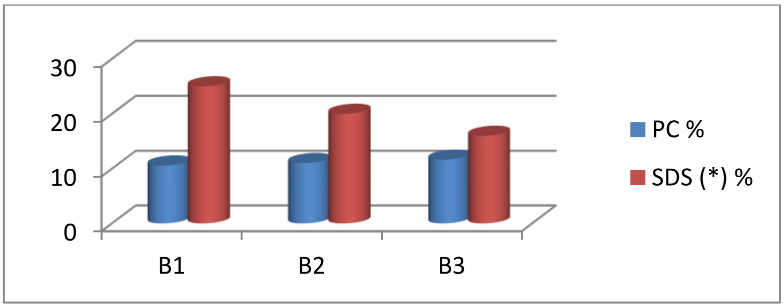


Figure 21: Influence of the incorporation rate of soft wheat bran on the biochemical characteristics of the blends

(PC%: proteins content. SDS (*)%: average of sodium dodecyl sulfate (Zeleny) of two samples A and B).

V.2.1 Proteins content:

According to the results, we notice a proportional increase in the incorporation rate of the protein content of the different blends; and this is explained by the presence of a quantity of proteins in the envelope (in the aleurone layer) in addition to their presence in the endosperm.

The protein content of the different blends oscillates between 10.59 and 11.64 %. These protein contents are higher than 9 % and lower than 12 %. Therefore, we can say that our incorporations have acceptable protein content and can be used in baking.

V.2.2 Sedimentation Index “Zeleny”

According to the results, we notice that the incorporation of soft wheat bran decrease of 5 units reduces the volume of sediment for blends 1 and 2, the SDS test values are 25 and 20 ml. According to standards, these values are between 18 and 28 ml, and these are good values for biscuit production. For blend 3, we obtained a value of 16 ml; this value is less than 18 ml, so it is an insufficient value.

The incorporation of bran affects the hydration power of proteins; there is an inverse relationship between the Zeleny test value and the percentage of wheat bran added. The more bran in the samples, the more the Zeleny test value decreases.

The richness of globular proteins in soft wheat and the presence of gluten in very small quantities reduce the expansion of protein sediment. Otherwise, many authors (Adrian, 2004; Berland and Roussel, 2005) have reported the presence of damaged carbohydrates in the sediment.

V.3 Influence of the incorporation rate of soft wheat bran on the rheological characteristics of the blends

The results of the rheological analyses of blends are recorded in the table 12.

Table 12: Rheological analysis results of blends.

Blend	Sample	FNI (s)	FNI(*) (s)	FNI(σ) (s)	WG %	WG(*) %	WG(σ) %	DG%	DG(*) %	DG (σ)%	HC%	HC(*) %	HC(σ)%
B1 (10/90)	A B	397 380	**388.5**	**8.5**	24.7 24.5	**24.6**	**0.1**	9.6 9.6	**9.6**	**0**	61.13 60.81	**60.96**	**0.16**
B2 (20/80)	A B	377 394	**385.5**	**8.5**	25.4 25.4	**25.4**	**0**	10.1 10	**10.05**	**0.05**	60.23 60.62	**60.42**	**0.195**
B3 (30/70)	A B	356 349	**352.5**	**3.5**	26.4 26.4	**26.4**	**0**	10.6 10.3	**10.45**	**0.15**	59.84 60.98	**60.41**	**0.57**

FNI (*)(s): average of falling number index of two samples a and b; FNI (δ)(s): standard deviation of falling number index
WG (*)%: average of the wet gluten content of two samples A and B; WG (δ)%: standard deviation of the wet gluten content
DG (*)%: average of the dry gluten content of two samples A and B; DG (δ)%: standard deviation of the dry gluten content
HC (*)%: average of the hydration coefficient of two samples A and B; HC(δ) %: standard deviation of the hydration coefficient

V.3.1 The Hagberg-Perten falling number:

The results of the Hagberg-Perten falling number show that the falling numbers of our blends vary as 388.5, 385.5 and 352.5 s respectively. We notice that each time the bran incorporation rate increases, the falling number value decreases, what means that the two parameters are inversely proportional. These falling number values do not conform to the international standard (260-320 s).

Soft wheat bran contains natural enzymes, particularly alpha-amylases, which can affect the falling number. The falling number measures the amount of amylolytic enzymes present in the flour, and the addition of wheat bran could potentially increase this enzymatic activity, thus reducing the falling number.

On the other hand, the addition of soft wheat bran to the flour can modify the physicochemical composition of the flour, which could indirectly affect the falling number.

V.3.2 Gluten content:

The wet and dry gluten content for our blends depends on the proportion of each ingredient (flour and wheat bran), and their amount influence the wet and dry gluten content of the blend.

According to the results, we notice a slight proportional increase of the wet and dry gluten content of the different blends with the bran incorporation rate; and this fact is explained by the presence of the gluten in the wheat bran (in the aleurone layer) in addition to their presence in the endosperm.

According to Boudreau and Menard (1992), the wet gluten content of flour varies between 20 and 24 % and for the dry gluten; it is between 7 and 9 % according to Kiger and Kiger (1967). According to research, we found that the gluten content of wheat bran is generally between 8 and 14 %. Our contents are superior to the values cited in the literature for biscuit making.

The incorporation of wheat bran into white flour increases the wet and dry gluten content of the blends, which can influence the technological quality of the biscuits (their texture and resistance).

For the hydration coefficient of the blends, we notice an inversely proportional relationship with the wet and dry gluten content, and with the bran incorporation rate. As each time the incorporation rate is increased; we recorded a slight decrease in the value of the hydration coefficient.

V.3.3 Alveographic characteristics

The results of Alveographic characteristics of the different blends are grouped in the table 13.

Table 13: Alveographic characteristics of blends (by Alveograph CHOPIN)

Parameter	P (mm)	L (mm)	G (cm³)	W(10^{-4} j)	P/L	Ie %
Blend 1	109	31	12.4	141	3.52	0
Blend 2	139	39	13.9	169	3.56	0

♦ For the blend 3 (70% white flour + 30% wheat bran): We were unable to extract the dough because it was very hard.

According to the parameters of the alveogram, we notice that the characteristics of the dough blends measured by the alveograph are very influenced by the incorporation rate of white flour and soft wheat bran. The alveogram of the blends show quite different curves with varying characteristics.

♦The tenacity « P »:

The tenacity (P) varies with the incorporation rate of the two ingredients. It increases with the increase in bran incorporation rate and passes by 30 mm from blends 1 to bland 2. These values are not included in biscuit flour standards (30 to 60 mm). This tenacity is linked to:

- The quantity and quality of gluten in the blends (essentially the rate of Gluténines), which are responsible of tenacity and elasticity (Branlard et *al.*, 1992), and whose content increases as the incorporation rate of bran increases.
- The particle size of the flour and the amount of damaged starch as well as those of the pentosans fraction (Godon and Loisel, 1997).

♦ Extensibility « L »:

The extensibility of the dough "L" in the case of the two blends 1 and 2 increases with the increase in bran incorporation rates, but it is lower than the extensibility of the witness flour. These values fall outside the range of a biscuit flour (90 to 120 mm). This extensibility, which remains linked to the ratio of gliadins to glutenin and the pentosans content of the dough, is an important characteristic in the formation of the biscuit and especially its shape (Godon and Loisel, 1997).

♦ The dough inflation index “G”:

The dough inflation increases with the increase in the incorporation rate of bran for in blends 1 and 2. This increase indicates that there are proteins at the level of soft wheat bran, and this inflation depends on the quality of these proteins.

♦ **The baking force "W":**

The baking force varies with the incorporation rate of flour and wheat bran. It increases with the increase in bran incorporation rate.

For blend 1, the value of W is acceptable, and for blend 2, it is not too far from the range of biscuit flour (60.10^{-4} to 150.10^{-4} J).

The baking force of the blends is lower than that of the witness flour. One of the causes is the composition of wheat bran and its proteins quality (Ibanoglu, 2002; Adrian, 2004).

The baking force "W" is linked to the gluten content in the blends and the properties of the used wheat proteins (for the production of flour and soft wheat for our blends). According to Feillet (2000), the variability of the baking force "W" can be explained by the content of Gliadins and Glutenine and also by the availability of certain sulfur-containing amino acids (methionine, cysteine) that provide intramolecular disulfide bridges through which gliadins associate, and by the decrease in intermolecular interactions that favor dough strength.

♦ **The "P/L" Configuration Report:**

The "P/L" configuration report translates the overall balance of the alveogram, indicating the balance between the tenacity and extensibility of formed doughs (Dubois, 1996). It is an important criterion for evaluating the quality of flours in baking, as it allows determining whether the dough is easy to work with or not.

The "P/L" configuration reports for both blends 1 and 2 are very close. It increases proportionally with the bran incorporation rate. These values are outside the range of biscuit flour that requires a P/L ratio between 0.25 and 0.8.

A P/L ratio below 0.5 indicates very extensible flours, while a ratio above 0.5 indicates more rigid flours. Our blends fall into the second case.

VI Biscuits study

The test of fabrication allowed for the development of 4 types of biscuits:

♦Control Biscuit: made with **100**% of soft wheat flour "BC"

♦Biscuit Blend 1: made with 90% of soft wheat flour and 10% of wheat bran "BI 10%"

♦Biscuit Blend 2: made with 80% of soft wheat flour and 20% of wheat bran "BI 20%"

♦Biscuit Blend 3: made with 70% of soft wheat flour and 30% of wheat bran "BI 30%"

VI.1 Sensory evaluation of biscuits

The sensory analysis aims to evaluate the preference and acceptability of a product by an informed consumer. This analysis focuses on the study of the organoleptic and sensory characteristics of the manufactured biscuits. It involves well detailed descriptions. In our case, we have only retained the preference and acceptability tests. The jury's judgment will be based on their personal appreciation of the presented biscuits. The result will be established based on the number of points assigned according to the different evaluated organoleptic criteria.

The results of our biscuits organoleptic and sensory analyses are presented in the table 14.

Table 14: Global Sensory Quality Comparison of Biscuits

Types of biscuits	Criteria for Evaluation					Total/50 and note
	Surface state/10	Color/10	Hardness/10	Taste/10	Smell /10	
BC	8	7	6	8	7	36 Acceptable
BI 10%	7	9	7	9	10	42 Good
BI 20%	6	7	7	6	9	35 Acceptable
BI 30%	4	5	6	5	7	27 bad

VI.1.1 The influence of bran incorporating on the quality of five characteristics:

The incorporation of wheat flour with wheat soft bran in biscuit production appears to significantly modify the majority of the biscuit's sensory characteristics.

The modification of the surface, color, hardness, taste, and odor of biscuits can occur depending on the percentage of wheat flour incorporation with soft wheat bran starting from 10%.

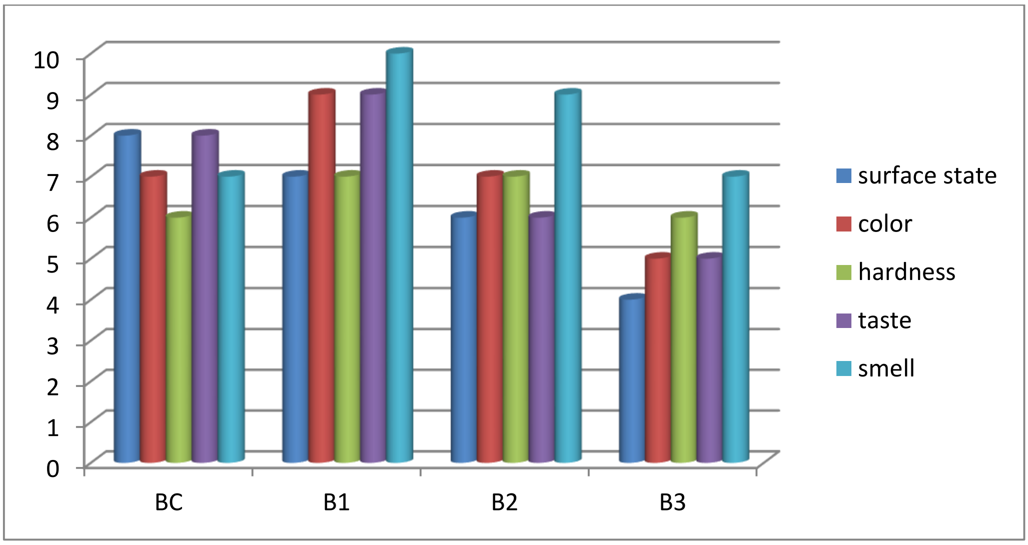


Figure 22: Global Sensory Quality Comparison of Biscuits

Surface State:

The incorporation of white wheat flour and wheat bran in biscuit production leads to the appearance of a rough surface (BI 10%) compared to the control biscuit (BC). This effect becomes more noticeable when the incorporation rate is higher (BI 30%). The alteration in surface state is characterized by roughness and cracks.

Color:

Color is a crucial parameter in the acceptance of biscuits, and its appearance begins during the final stages of the cooking process. We note that high incorporation rates of wheat bran (20% and 30%) alter the color. The 10% rate significantly improves the color with an optimum at 10%.

Dough for BI 10% Dough for BI 20% Dough for BI 30%

Figure 23: Biscuit Doughs Made with Different bran incorporation rates

The development of the color is the result of numerous complex reactions, such as the Maillard reaction or caramelization, which involve two stages during non-enzymatic browning. These reactions are dependent on several parameters related to the cooking process, such as temperature and humidity, but are also highly sensitive to formulation components color.

Hardness:

Hardness is a characteristic of texture, and a hard biscuit offers strong resistance to rupture and/or deformation “W”. The incorporation of bran improves the hardness of biscuits compared to the control biscuit (BC).

The hardness of biscuits made with soft wheat bran is influenced by factors such as its particle size. Additionally, water content plays a crucial role in determining the texture of biscuits. Biscuits with lower moisture content tend to be harder compared to those with higher moisture content. This is because moisture affects the interactions between ingredients during mixing, dough formation, and baking. Hardness of biscuits is proportional to bran incorporation rate.

Taste:

Taste is the ensemble of gustatory, olfactory and chemical sensations perceived when the food is in the mouth. According to the table, we note that the incorporation in wheat flour of wheat bran up to approximately 20 % improves the taste of biscuits with an optimum at an incorporation rate of 10 %. This improvement is due to the sweet and hazelnut flavors in wheat bran and its richness in proteases, which release peptides involved in the flavor of biscuits (Godon, 1991). For the biscuit "BI 30 %", the taste was judged unpleasant.

Odor:

We note that the bran incorporation rates in wheat flour with 10 and 20 % improve the odor of enriched biscuits. The aroma, represented by a set of volatile odorants at the crust and crumb levels, generally forms during cooking. These volatile compounds are the result of several non-enzymatic reactions primarily affecting sugars and fat.

According to this interpretation, we can say that a 10 % incorporation rate produces the highest overall quality for the surface state, color, taste, and smell of the biscuits. However, for biscuit hardness, a 20 % incorporation rate is optimal.

Considering the global sensory studied properties for the different biscuits, we have chosen the biscuit with a 10 % bran incorporation rate in wheat flour as the one that presents the best characteristics.

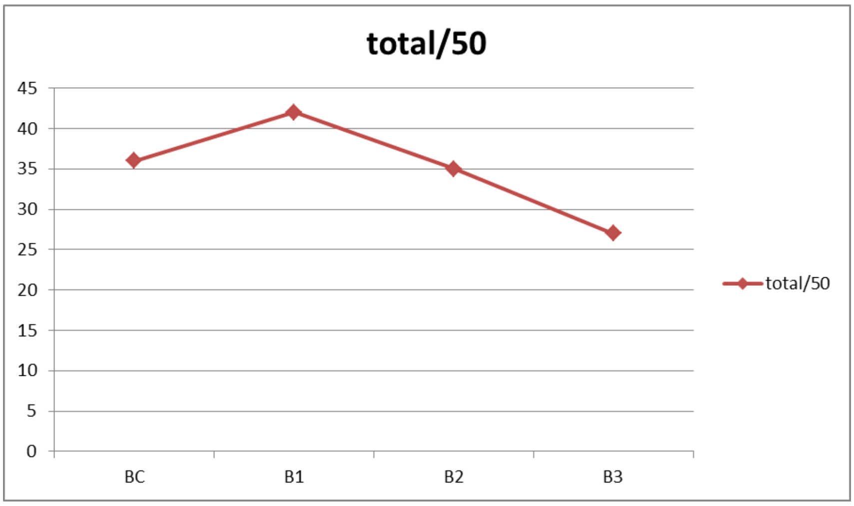


Figure 24: Global Sensory Quality of Biscuits

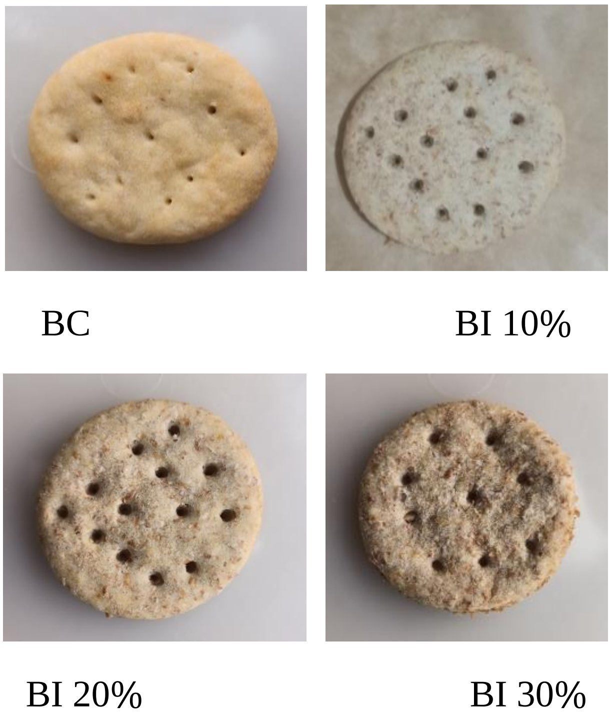


Figure 25: Baked blends biscuits.

General Conclusion

General Conclusion

The main goal of this study is to valorize soft wheat bran through its incorporation into biscuit manufacturing processes. This aims to ensure that the resulting flours meet the specific standards required for biscuit production, thereby enhancing the nutritional profile and sensory qualities of baked biscuits.

To achieve this work, three blends were prepared, each containing different proportions of soft wheat bran, to evaluate their impact on the sensory attributes of the biscuits compared to witness flour.

Studying the physicochemical, biochemical and rheological characteristics of these blends is a multifaceted exploration into how this alteration affects both the composition and sensory attributes of the final biscuit product.

Through this work, we concluded and drew the following conclusions:

- The incorporation of soft wheat bran with white flour affects the physicochemical characteristics of the blends.
- Soft wheat bran contains insoluble fibers and small amounts of damaged gluten and starch, which affects the biochemical characteristics.
- The enzymes and gluten present in soft wheat bran affect the rheological characteristics of the blends.
- For the CHIPON alveographic test, the characteristics of the dough mixtures measured by the alveograph are significantly affected by the amount of soft wheat bran added to the flour. The incorporation of soft wheat bran compromises the formation and quality of the gluten network, which directly results in alterations of the alveographic characteristics of the dough.
- The compositions of soft wheat bran and its solid particles affect the sensory quality of biscuits.
- The sensory quality of bran-enriched biscuits depends on the balance between aspects such as surface condition, color, taste and odor. Consumer preferences vary depending on their overall acceptance of bran-enriched products.

At the end of this study and based on our results, we conclude that the addition of soft wheat bran affects the physicochemical, biochemical, rheological characteristics and sensory quality. This effect depends on the percentage of added wheat bran. We can say that the optimal percentage of incorporating bran with white flour for biscuits is 10 %.

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Annexes

Annexes

Annex 1: Preparation of samples

Step 1: Preparation of the white wheat flour

In a basin, a 5 kg bag of commercial white flour was emptied and manually agitated with a spoon. The flour was left to rest for 4 hours to allow it to stabilize and stop any ongoing reactions. After that, using an electronic scale, 1 weights of the commercial flour were measured, as shown in Table 1. Each sample was placed in a sterilized plastic bottle to preserve the integrity of the samples and mitigate the risk of external contamination that may influence subsequent analyses or testing.

Tab: The 1 weights of the commercial flour sample

Blend	Sample	Weight of flour (g)
-	Witness	1000
1 (90/10)	A B	900 900
2(80/20)	A B	800 800
3(70/30)	A B	700 700

Fig: Preparation of the weights

Step 2: preparation of the soft wheat bran sample

A quantity of soft wheat bran was manually sieved using a sieve to remove any impurities. The sieved bran was placed in a basin. 6 weights of the soft wheat bran were measured, as shown in the following table:

Tab: the 6 weights of the soft wheat bran sample

Blend	Sample	Weight of soft wheat bran (g)
1(90/10)	A B	100 100
2(80/20)	A B	200 200
3(70/30)	A B	300 300

Fig: Preparation of the soft wheat bran sample

Step 3: Preparation of blends (incorporations)

In another bowl, the weights of the flour and bran for each group are incorporated and mixed well manually with a spoon until a homogeneous mixture is obtained.

Fig: Preparation of mixtures (incorporations)

➢Each sample is placed in a sterilized plastic bottle (resulting in 7 samples).
➢Mechanical agitation is performed using a CHOPIN device.

Fig: 7 samples

Fig: Mechanical agitation by CHOPIN

The samples are left to cool at room temperature.

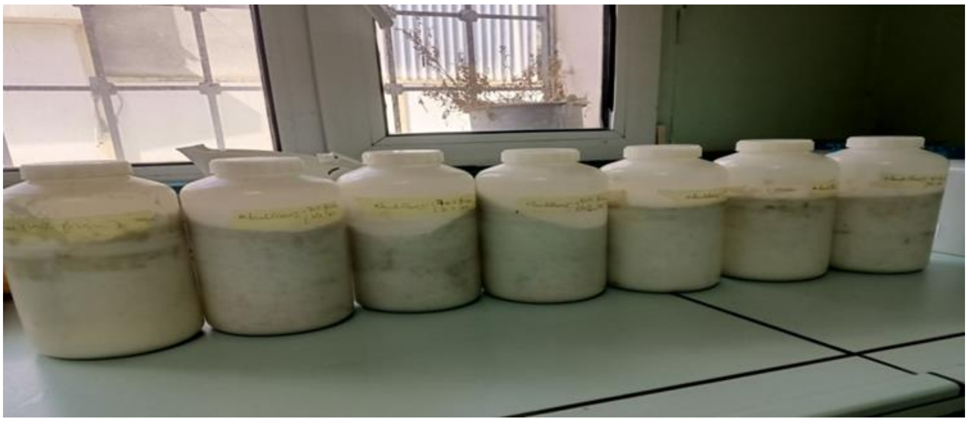

Fig: Cooling of samples

Samples were stored in plastic bags at room temperature in order to be studied.

Fig: Preservation of Samples

Annex 2: Catalyst

Prepare the catalyst with the following composition:

♦Copper sulfate pentahydrate [$CuSO_4$, $5H_2O$] = 2.8%

♦Titanium dioxide [TiO_2] = 2.8%

♦Potassium sulfate [K_2SO_4] = 94.3%

♦Ensure the homogeneity of the mixture of these components.

Sulfuric Acid:

♦Concentration of 95% (mass fraction); concentration [H_2SO_4] = 18 mol/l; density at 20°C [H_2SO_4] = 1.84 g/ml.

Preparation of Boric Acid:

♦Weigh 40 g of boric acid powder.

♦Dissolve in 1l of distilled water.

♦Allow the mixture to agitate as long as possible using a mechanical agitator.

Annex 3: Factors for converting nitrogen content to protein content

Tab: Conversion factor table for nitrogen to protein.

Type of product	Nitrogen to protein conversion factor
Soft wheat	5.7
Hard wheat	5.7
Milling products	5.7 or 6.25
Wheat for animal feed	6.25
Barley	6.25
Oats	5.7 or 6.25
Rye	5.7
Triticale	6.25
Maize	6.25
Pulses	6.25

Annex 4: Zeleny Solution

Mix intimately 180 ml of diluted lactic acid with 200 ml of 2-propanol (isopropanol) between 99% and 100% (v/v), and complete to 100 ml with distilled water.

Mix well, store in a glass bottle with a stopper, and use the reagent only after 48 hours of rest.

Annex 5: Water Content Determination

To determine the falling number of our test samples with a water content of 15 % by mass fraction, we used the water content values previously calculated using the specific method in ISO 712.

Test Sample

We performed the Falling Number determination on two test samples simultaneously or quickly one after the other.

Initially, we weigh the test sample mass for each sample. Refer to the table (1) column (2), which indicates the test sample mass to be taken according to the different water contents. For example, for the control sample with a water content value of 14.32 %, according to Table (1), the equivalent water content value is 14.40 %, and from column (2), the equivalent test sample mass is 6.95 g. Therefore, using an analytical balance, we weigh the test sample at 6.95g.

Tab: The test sample mass according to the different water contents

WC %	Test sample for a nominal mass of 7 g at 15% WC	Test sample for a nominal mass of 9 g at 15% WC	WC %	Test sample for a nominal mass of 7 g at 15% WC	Test sample for a nominal mass of 9 g at 15% WC
(1)	(2)	(3)	(1)	(2)	(3)
9.0	6.40	8.20	13.6	6.85	8.80
9.2	6.45	8.25	13.8	6.90	8.85
9.4	6.45	8.25	14.0	6.90	8.85
9.6	6.45	8.30	14.2	6.90	8.90
9.8	6.50	8.30	14.4	6.95	8.90
10.0	6.50	8.35	14.6	6.95	8.95
10.2	6.55	8.35	14.8	7.00	8.95
10.4	6.55	8.40	15.0	7.00	9.00
10.6	6.55	8.40	15.2	7.00	9.05
10.8	6.60	8.45	15.4	7.05	9.05
11.0	6.60	8.45	15.6	7.05	9.10
11.2	6.60	8.50	15.8	7.10	9.10
11.4	6.65	8.50	16.0	7.10	9.15
11.6	6.65	8.55	16.2	7.15	9.20
11.8	6.70	8.55	16.4	7.15	9.20
12.0	6.70	8.60	16.6	7.15	9.25
12.2	6.70	8.60	16.8	7.20	9.25
12.4	6.75	8.65	17.0	7.20	9.30
12.6	6.75	8.65	17.2	7.25	9.35
12.8	6.80	8.70	17.4	7.25	9.35
13.0	6.80	8.70	17.6	7.30	9.40
13.2	6.80	8.75	17.8	7.30	9.40
13.4	6.85	8.80	18.0	7.30	9.45

Annex 6: Kneading solutions

Tab: volume of sodium chloride solution to be added during kneading

WC of flour %	V of solution to add ml	WC of flour %	V of solution to add ml	WC of flour %	V of solution to add ml
8	155.9	11	142.6	14	129.4
8.1	155.4	11.1	142.2	14.1	129
8.2	155	11.2	141.8	14.2	128.5
8.3	154.6	11.3	141.3	14.3	128.1
8.4	154.1	11.4	140.9	14.4	127.6
8.5	153.7	11.5	140.4	14.5	127.2
8.6	153.2	11.6	140	14.6	126.8
8.7	152.8	11.7	139.6	14.7	126.3
8.8	152.4	11.8	139.1	14.8	125.9
8.9	151.9	11.9	138.7	14.9	125.4
9	151.5	12	138.2	15	125
9.1	151	12.1	137.8	15.1	124.6
9.2	150.6	12.2	137.4	15.2	124.1
9.3	150.1	12.3	136.9	15.3	123.7
9.4	149.7	12.4	136.5	15.4	123.2
9.5	149.3	12.5	136	15.5	122.8
9.6	148.8	12.6	135.6	15.6	122.4
9.7	148.4	12.7	135.1	15.7	121.9
9.8	147.9	12.8	134.7	15.8	121.5
9.9	147.5	12.9	134.3	15.9	121
10	147.1	13	133.8	16	120.6
10.1	146.6	13.1	133.4		
10.2	146.2	13.2	132.9		
10.3	145.7	13.3	132.5		
10.4	145.3	13.4	132.1		
10.5	144.9	13.5	131.6		

Annex 7: Alveograph Chopin and blend's alveogram

Fig: Alveograph Chopin

For blend 1 (90% of white flour + 10% wheat bran)

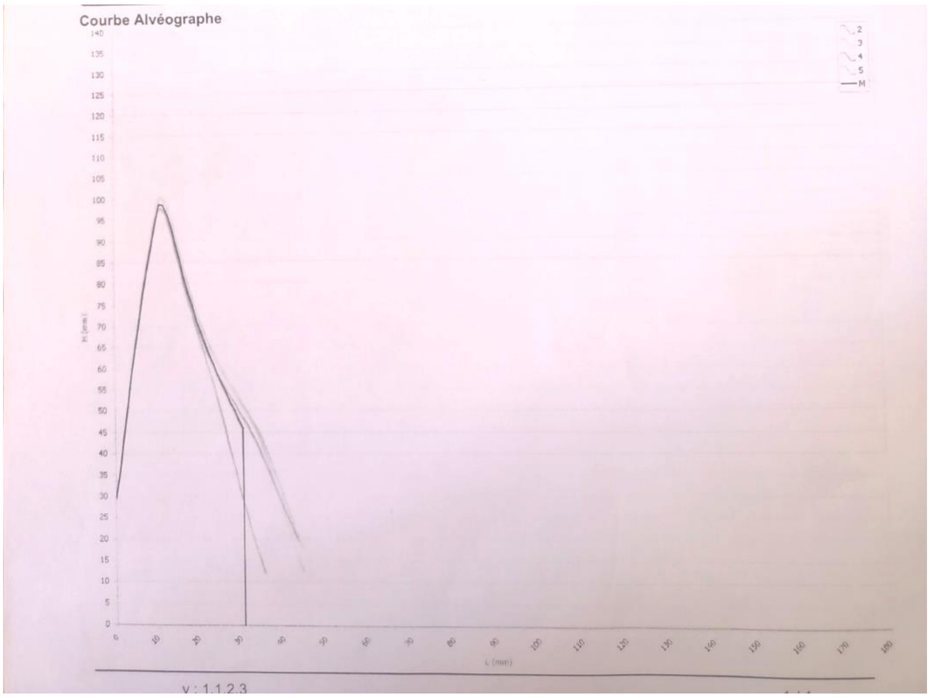

Fig: Alveogram for blend 1.

For blend 2 (80% white flour + 20% wheat bran).

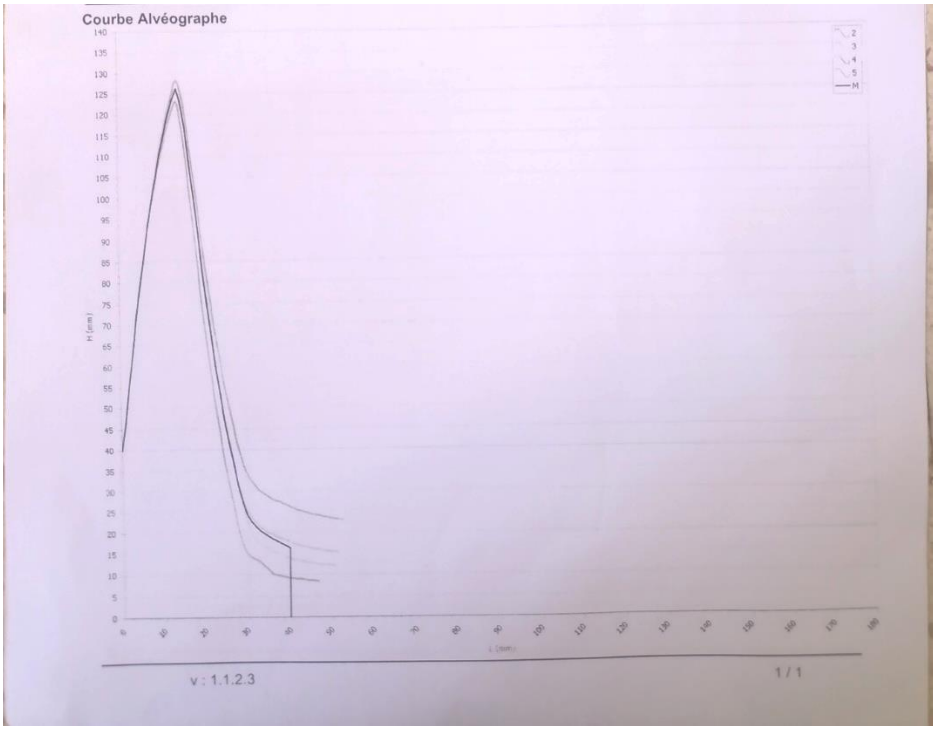

Fig: Alveogram for the blend 2