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Title

Study of some physicochemical and microbiological characteristics of date syrup

Presented by:

Mr. SADEKI Aissa

Jury

Full name	Grade	Quality
Mrs. ALLALI Khadidja	MCA	President
Mr. ADAMOU Alaa Dine	Professor	Examinator
Mrs. ZAMOUM Miyada	Professor	Supervisor
Miss HOUICHER Aicha	MA	Assistant supervisor

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رَبِّ زِدْنِي عِلْمًا
Rabbi Zidni Ilman
(My Lord, increase me in knowledge)

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إهداء

بسم الله الرحمان الرحيم

أهدي هذا العمل المتواضع الى نفسي أولا، نفسي التي ضاقت التعب والمشقة في خوض هذا الدرب الطويل في غاية تحقيق تلك الاحلام التي نستيقظ لأجلها.

فالحمد لله الذي وفقني ورزقني القوة وانار لي الطريق.

الى سندي، رفيقتي، عيني التي أبصر بها، المرأة الطيبة التي تطيب بها الحياة وتنير بها دنياي، 'أمي' الغالية، ادامك الله نبضا لحياتي.

الى عائلتي الفريدة والمتميزة، ابي العزيز، أختي وأخي.

الى أقاربي غريبي الأطوار والطيبين.

الى الأناس الطيبة التي كانت جزءا من هذا المشوار والذين تركوا أثرهم الطيب في حياتي: توفيق، بشير، احمد، طاهر، عمار، زكرياء، علي، طه، مريم، أمال، أساتذتي الطيبين: بن غية، مناصرة، شهرزاد.....

الاسم واللقب: عيسى صادقي **تحت إشراف**: زعموم ميادة

العنوان: دراسة بعض الخصائص الفيزيائية-الكيميائية والميكروبيولوجية لدبس التمر.

ملخص:

تنتمي الجزائر الى البلدان الأكثر انتاجا للتمور في عالم، حيث تنتج الجزائر كمية كبيرة من أنواع مختلفة من التمور (ذات جودة جيدة، وذات جودة منخفضة) مما يلزمها الخضوع لعمليات مختلفة لانتاج مواد مشتقة من اجل تسويقها. هدفت هذه الدراسة إلى تحقيق الاستفادة المثلى من التمر ذي الجودة المتدنية (أصناف القرباي والقبوري) عبر تحويله إلى دبس تمر، وتقييم خصائصه الفيزيوكيميائية والميكروبيولوجية مقارنةً بالدبس شبه الصناعي المتوفر في السوق المحلية، بالإضافة إلى دراسة تأثير التخزين لمدة سنتين على درجة 4°م على جودة المنتج.

أُنتج الدبس باستخدام الطريقة التقليدية الشائعة (الغسيل، النقع، الاستخلاص الميكانيكي، والتركيز بالغليان). ثم خضعت العينات لتحاليل شملت قياس المواد الصلبة الذاتية(Brix°) ، الرطوبة، الرقم الهيدروجيني(pH) ، الحموضة الكلية، الموصلية الكهربائية، بالإضافة إلى التعداد الميكروبي للبكتيريا الهوائية المتكافلة، الخمائر والعفن، والبكتيريا القولونية الكلية والبرازية.

أظهرت النتائج وجود فروق ذات دلالة إحصائية ($p < 0.0001$) بين العينات في جميع الخصائص الفيزيوكيميائية المدروسة، حيث تراوحت قيمة Brix° بين 64% - 75%، والرطوبة بين 21.07% - 35.06%، والرقم الهيدروجيني بين 4.34 - 4.92. كما سجلت العينات التقليدية قيماً أعلى في الموصلية الكهربائية مقارنةً بنظيراتها شبه الصناعية. من الناحية الميكروبيولوجية، كانت معظم العينات مطابقة للمواصفات القياسية الجزائرية، مع ظهور تعداد منخفض للبكتيريا الهوائية في عينتين وتلوث طفيف بالخمائر والعفن في عينتين أخريين.

أما بالنسبة لتأثير التخزين، فقد لوحظ انخفاض طفيف في محتوى الرطوبة والموصلية الكهربائية ودرجة الحموضة (pH)للدبس المخزن، بينما ارتفعت قيمة Brix° قليلاً، مما يشير إلى تركيز المنتج مع مرور الوقت.

أظهرت هذه الدراسة أن إنتاج دبس التمر من الأصناف منخفضة الجودة يمثل حلاً عملياً واقتصادياً لتثمينها والحد من الهدر الزراعي.

الكلمات المفتاحية: نخيل التمر، شراب التمر، التثمين، الخصائص الفيزيائية والكيميائية، الميكروبيولوجية، التخزين.

Full name: SADEKI Aissa **Directed by:** ZAMOUM Miyada

Theme: Study of some physicochemical and microbiological characteristics of date syrup

Abstract:

Algeria ranks among the world's top date-producing countries, yielding a significant quantity of various date types (both high and low quality), which necessitates diverse processing into derived products for marketing. This study aimed to valorize low-quality dates (Garbai and Gebouri varieties) by converting them into date syrup and evaluating their physicochemical and microbiological properties compared to semi-industrial syrups available on the local market, in addition to studying the effect of two-year storage at 4°C on product quality.

The syrup was produced using the common traditional method (washing, soaking, mechanical extraction, and concentration by boiling). The samples were then analyzed, measuring total soluble solids (°Brix), moisture content, pH, total acidity, electrical conductivity, along with microbiological enumeration of total mesophilic aerobic flora, yeasts and molds, and total and fecal coliforms.

The results showed statistically significant differences ($p < 0.0001$) between the samples in all physicochemical properties studied. °Brix values ranged from 64% to 75%, moisture from 21.07% to 35.06%, and pH from 4.34 to 4.92. The traditional samples also recorded higher values in electrical conductivity compared to their semi-industrial counterparts. Microbiologically, most samples complied with Algerian standard specifications, with low counts of aerobic bacteria in two samples and slight contamination by yeasts and molds in two other samples.

Regarding the effect of storage, a slight decrease in moisture content, electrical conductivity, and pH was observed in the stored syrup, while the °Brix value increased slightly, indicating product concentration over time.

This study demonstrated that producing date syrup from low-quality varieties represents a practical and economical solution for their valorization and the reduction of agricultural waste.

Keywords : Date palm, date syrup, valorization, physicochemical properties, microbiological quality, storage.

Nom et Prénom : SADEKI Aissa **Dirigé par :** ZAMOUM Miyada

Thème : Étude de quelques caractéristiques physico-chimiques et microbiologiques du sirop de dattes

Résumé :

L'Algérie compte parmi les plus grands pays producteurs de dattes au monde, produisant une quantité importante de différentes types de dattes (de bonne qualité et de qualité inférieure), ce qui nécessite des transformations diverses en produits dérivés pour leur commercialisation. Cette étude visait à valoriser des dattes de faible qualité (variétés Garbai et Gebouri) en les transformant en sirop de dattes et à évaluer leurs propriétés physico-chimiques et microbiologiques par rapport à des sirops semi-industriels disponibles sur le marché local, en plus d'étudier l'effet d'un stockage de deux ans à 4°C sur la qualité du produit. Le sirop a été produit en utilisant la méthode traditionnelle courante (lavage, trempage, extraction mécanique et concentration par ébullition). Les échantillons ont ensuite été analysés, mesurant les solides solubles totaux (°Brix), l'humidité, le pH, l'acidité totale, la conductivité électrique, ainsi que l'énumération microbiologique de la flore aérobie mésophile totale, des levures et moisissures, et des coliformes totaux et fécaux. Les résultats ont montré des différences statistiquement significatives ($p < 0,0001$) entre les échantillons pour toutes les propriétés physico-chimiques étudiées. Les valeurs de °Brix variaient entre 64% et 75%, l'humidité entre 21,07% et 35,06%, et le pH entre 4,34 et 4,92. Les échantillons traditionnels ont également enregistré des valeurs plus élevées de conductivité électrique par rapport à leurs homologues semi-industriels. Sur le plan microbiologique, la plupart des échantillons étaient conformes aux spécifications standard algériennes, avec de faibles dénombrements de bactéries aérobies dans deux échantillons et une légère contamination par des levures et moisissures dans deux autres échantillons. En ce qui concerne l'effet du stockage, une légère diminution de la teneur en humidité, de la conductivité électrique et du pH a été observée dans le sirop stocké, tandis que la valeur °Brix a légèrement augmenté, indiquant une concentration du produit au fil du temps. Cette étude a démontré que la production de sirop de dattes à partir de variétés de faible qualité représente une solution pratique et économique pour leur valorisation et la réduction du gaspillage agricole.

Mots-clés : Palmier dattier, sirop de dattes, valorisation, propriétés physico-chimiques, qualité microbiologique, stockage.

List of Abbreviation

- **ANOVA** – Analysis of Variance
- **CAGR** – Compound Annual Growth Rate
- **CF** – Coliforms Fecal
- **CFU** – Colony Forming Unit
- **CT** – Coliforms Total
- **DF** – Degrees of Freedom
- **FAO** – Food and Agriculture Organization
- **ISO** – International Organization for Standardization
- **J.O.R.A N** – Journal Officiel de la République Algérienne
- **MENA** – Middle East and North Africa
- **NF** – Norme Française
- **PCA** – Plate Count Agar
- **SDA** – Sabouraud Dextrose Agar
- **TA** – Titratable Acidity
- **TMAF** – Total Mesophilic Aerobic Flora
- **T.S.S** – Total Soluble Solids
- **VRBL** – Violet Red Bile Lactose Agar

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Introduction

Date palm (*Phoenix dactylifera* L.) forms for thousands of years, it has been a pillar of civilization and stability in arid and semi-arid regions, especially in our Arab region. It is not just a tree that bears fruit, but a cultural, economic and social legacy rooted in our history. The 'Tree of Life' was a rightful name given to it by the ancients because it is instrumental in securing food and combating desertification (**Al-Karmadi & Okoh, 2024**). This precious tree has contributed to the stability and development of human societies, with archaeological evidence indicating that its cultivation dates back more than five thousand years (**Zaid & de Wet, 2002**).

The fruit of this tree, dates, is a gift from nature in which the ingredients for complete food are embodied. They are distinguished by their superior nutritional value, being rich in easily digestible natural sugars, dietary fiber, and essential mineral elements, in addition to antioxidants that give them functional importance beyond simply being a source of energy (**Baliga et al., 2011**). The fruit undergoes multiple stages as it ripens, and the 'date' (Tamar) stage is the best time for food processing due to its high sugar and low moisture levels (**Al-Farsi et al., 2007**).

In the Algerian context, palm cultivation and date production occupy a strategic place in the national economy and the social fabric of the southern regions, as Algeria is among the largest producing countries in the world (**FAOSTAT**). The production chain is facing a major challenge due to the high number of lost dates that are classified as 'low quality dates' due to problems with size, shape, color, or incomplete ripening. (**Besbes et al., 2009**), which constitutes a significant waste of resources and a significant economic loss, especially in light of the limited marketing and manufacturing system and shortcomings in post-harvest technologies (**Benziouche & Cheriet, 2012**).

In the face of this dilemma, converting these low-quality dates into value-added products emerges as a practical and economic solution with a strategic dimension. Among these products, date syrup (rob) is one of the most promising solutions for valuing and benefiting from these dates. Date syrup is not just a natural sweetener, but a product rich in nutrients and bioactive compounds, making it an ideal ingredient in the health food industry and an excellent alternative to refined sugars (**Al-Farsi & Lee, 2008**).

Based on this reality, this study comes as an attempt to contribute to addressing this problem, by verifying the possibility of producing high-quality date syrup from local varieties with low marketing value (Garbai and Gebouri). It specifically aims to:

- Production of date syrup using simple traditional methods.
- Evaluate the physicochemical properties (solids content, moisture, acidity, pH, conductivity) of the date syrup produced and compare them with semi-industrial market products.
- Study of the microbiological quality of date syrup produced.
- Evaluate the effect of long-term storage (two years at a grade of 4°m) on the stability of these properties and product quality.

The results of this work will contribute to advancing the valorization of the local product and improving the value chains of Algerian dates.

Part I
Literature Review

Chapter 01
General overview of dates

1.1. The Date Palm (Phoenix dactylifera L.)

The date palm (*Phoenix dactylifera L.*), a monocotyledonous member of the Arecaceae family, ranks among the earliest fruit-bearing plant life domesticated through people, with archaeological and historic information tracing its cultivation returned over 5,000 years (**Zaid and de Wet, 2002; Gros-Balthazard et al., 2013**). Native to arid and semi-arid regions which includes North Africa and the Middle East, the date palm (*Phoenix dactylifera L.*) is surprisingly well tailored to wilderness climates, exhibiting terrific resistance to both drought and excessive temperatures (**Johnson et al., 2015**).

The species is characterized by means of a tall, solitary, and unbranched trunk that can attain as much as 30 meters in height, crowned with a dense cover of pinnate, feather-like leaves (Fig.01). Its deep and fibrous root machine allows efficient get entry to groundwater reserves, thereby improving its resilience in dry environments and contributing extensively to desertification manage efforts (**Al-Mssallem et al., 2013; Sayah and Ould El-Hadj, 2010**). Beyond its environmental role, the date palm is an essential dietary and socio-monetary useful resource, frequently called the "tree of existence" in wilderness communities for its multifaceted makes use of (**Al-Karmadi and Okoh, 2024**).

Figure 01 : Date palm *Phoenix dactylifera L.* (**Derkaoui and Senouci, 2021**).

Botanically, the date palm is classified as a dioecious species, meaning that male and female plant life develop on separate trees. This trait calls for human help for successful replica, and manual pollination has long been hired by farmers to decorate fruit manufacturing—a way still generally utilized in conventional date farming (**Sidhu and Singh, 2011**). As soon as the fruit

arises, it undergoes 5 ripening stages: Hababak, Kimri, Khalal, Rutab, and eventually Tamar. TAMR Diploma is primarily valuable inside the across the food processing for syrup production, as the fruit of this element is rich in herbal sugars-especially glucose and fructose-and it has a very low moisture content, resulting in sweetness (**Al-Farsi et al., 2007**). The biochemical characteristics of Tamr dates—particularly their high sugar content, natural antioxidants, and organic acids—make them ideal as natural sweeteners in food formulations, minimizing the need for synthetic additives or intensive drying processes (**Abbès et al., 2011**).

The date palm includes profound cultural and religious fee in plenty of Islamic and Arab societies, in which it has lengthy symbolized nourishment, generosity, and prosperity. Its significance is deeply rooted in non-secular texts like the Qur'an, which underscore its sacred feature and ancient significance inner early agricultural civilizations (**Al-Farsi and Lee, 2008).** This longstanding utility has also reinforced the symbolic and practical role of the date palm in cultural traditions and social practices throughout the Middle East and North Africa (Fig.02). In Tunisia, for instance, the date palm is not only a key agricultural crop but also an integral element of local customs, daily consumption habits, and rural identity (**Kassah, 1989**).

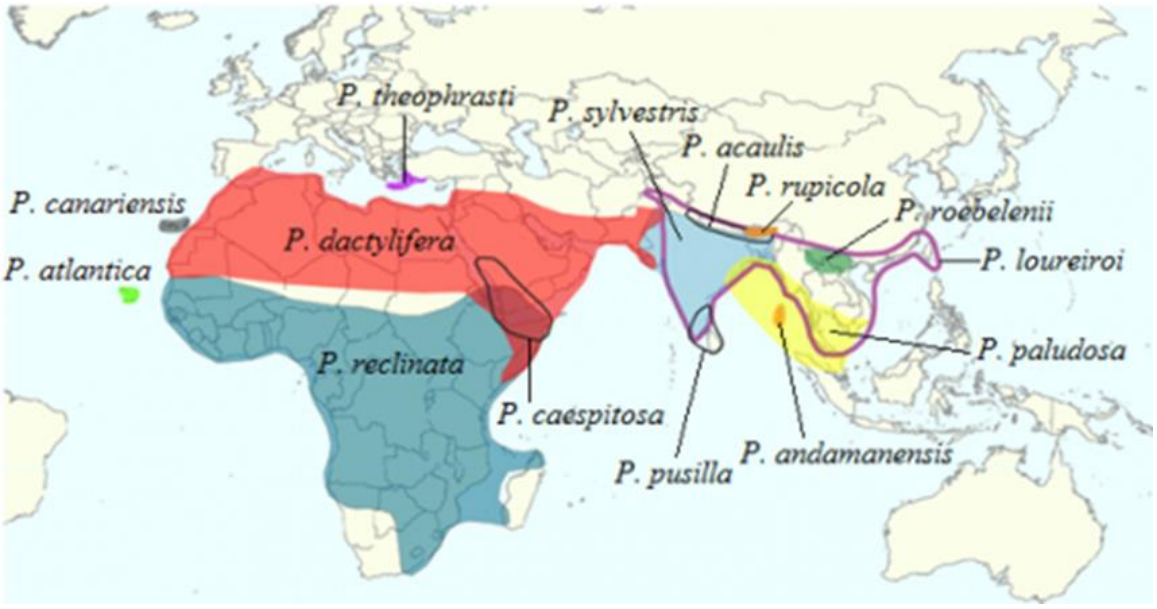


Figure 02: The distribution of *P. dactylifera* corresponds to the traditional cultivation area (**Gros-Balthazard et al., 2013**).

In the latest years, growing worldwide calls for useful foods and natural sweetness have greatly increased the recognition of debt palm derivatives, with date syrup (dips) health-conscious foods stand prominently inside the enterprise. Valuable for its rich material content

of herbal antioxidants, including polyphenols and flavonoids, date syrup has shown promising capacity to reduce oxidative pressure and increase health results (**Mansouri et al., 2005**). Moreover, its certainly low glycemic index, absence of gluten, and plant-based starting place make it specifically attractive to consumers adhering to vegan, gluten-loose, and diabetic-friendly diets (**Al-Farsi et al., 2007**). Its purposeful residences have further promoted its use as a nutrient-dense alternative to sophisticated sugar, especially in clean-label and enriched food products that prioritize both herbal composition and dietary enhancement (**Farahnaky et al., 2016**).

The considerable genetic variety of the date palm highlights its enormous monetary and dietary cost. Over 2,000 cultivars were documented international, every showing extremely good differences in characteristics which includes fruit length, sugar and fiber content, and resistance to pests and illnesses (**Hazzouri et al., 2019**). The genetic and phenotypic variety inside *Phoenix dactylifera* performs a vital role in helping breeding programs aimed at improving crop resilience, yield, and product first-class throughout diverse agro-ecological zones. This diversity permits the strategic selection of cultivars mainly suited to commercial programs, inclusive of syrup production, fruit drying, and cost-added processing (**Moussouni et al., 2017).** Specifically, semi-soft date varieties such as Ghars and Deglet Noor are highly favored in syrup production due to their elevated sugar content and favorable texture, which enhance extraction efficiency and syrup quality (**Besbes et al., 2009**). The species' vast adaptability to numerous soil and climate conditions also enables cultivar optimization primarily based on nearby agronomic requirements and end-use dreams, making sure both economic performance and product consistency (**Seddiki, 2015**).

In particular, varieties such as Deglet Nour, Medjool, and Ghars are highly valued in the production of date syrup due to their high soluble solids content (°Brix), soft and stable pulp texture, and elevated nutritional material, all of which contribute to efficient juice extraction and concentration (**Sayah and Ould El-Hadj, 2010 Mimouni and Siboukeur., 2011**). These cultivars no longer only offer technological advantages however additionally meet customer expectancies for suited flavor and uniformity in syrup-based totally merchandise (**Seddiki and Seddiki, 2024**).

1.2. Dates

Dates are the mature suitable for eating fruits of the *Phoenix dactylifera L*. Palm, a species local to the arid and semi-arid regions of the Middle East and North Africa. These end result

are famed no longer simplest for his or her cultural and non-secular importance, particularly in Islamic societies, however additionally for his or her top notch dietary and economic cost (**Zaid and de Wet, 2002**). As mentioned earlier, the development of date fruits progresses through 5 distinct maturation stages (Fig.03). Each stage affords unique physical and biochemical characteristics that shape the fruit's taste profile, texture, and functional applications. The Tamar stage (Fig.04), especially, indicates the final ripening section, marked by means of expanded sugar content and decreased moisture, which makes it especially suitable for commercial processing into products such as date syrup, paste, and flour (**Chniti, 2015**).

Figure 03: The five maturation stages of date fruit (**Benharzallah et al., 2014**).

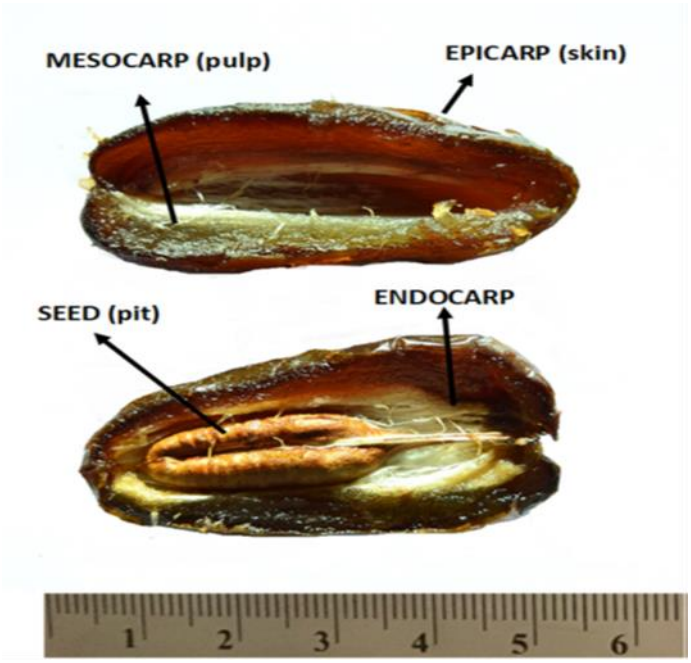


Figure 04: The anatomy of fruit of the date palm (Phoenix dactylifera L., cv. Confitera) at late Rutab stage (**Fernández-López et al., 2022**).

Dates are considered one of the oldest cultivated fruits in human records, with archaeological findings indicating their domestication over 5,000 years ago in regions consisting of Mesopotamia and North Africa (**Johnson et al., 2015**). Historically, dates have played a crucial

role in ensuring the survival of desert communities due to their extended shelf life and high caloric content, offering a reliable food source during harsh environmental conditions (**Benziouche and Cheriet, 2012**). Ancient societies ate up dates both as fresh fruits and in processed bureaucracy such as fermented liquids or sweeteners like syrup and vinegar (**Chniti, 2015**). In contemporary times, dates remain a dietary staple throughout many regions, especially in foremost generating countries like Algeria, Saudi Arabia, and Iran (**FAO, 2023**).

From a systematic angle, dates are appeared as a nutrient-dense fruit due to their high attention of herbal sugars—particularly glucose and fructose—as well as essential minerals such as potassium, magnesium, and iron (**Al-Farsi and Lee, 2008**). In addition, dates are wealthy in nutritional fiber, B-complicated nutrients, and polyphenolic compounds, which together make a contribution to their antioxidant capacity and ability healing advantages (**Baliga et al., 2011**). These dietary properties have sparked growing interest in incorporating dates into functional food products, especially for their ability to help regulate glycemic response and support digestive health due to their rich fiber and bioactive compound content (**Al-Farsi et al., 2007**). As an end result, dates have become a treasured raw cloth inside the development of fitness-focused sweetening alternatives along with date syrup (dibs), that's now widely regarded as a natural replacement for refined sugars (**Abbès et al., 2011**).

In enterprise settings, dates function an essential raw material for a huge range of high-value products, with date syrup (dibs) status out as one of the maximum large. Commonly produced from absolutely ripened Tamar-level end result, this syrup is in particular valued for its excessive attention of herbal sugars, vital minerals, and ideal sensory residences together with taste, consistency, and viscosity (**Farahnaky et al., 2016**).

1.2.1. Economic Importance of Dates

Dates are more than handiest a dietary staple in arid regions—they're additionally important agricultural resource for the duration of MENA global locations, wherein they play a key function in generating income and sustaining rural livelihoods. Countries like Algeria, Tunisia, and Egypt regard the date palm as a strategic crop, way to its ability to thrive in drought-inclined environments and its fantastic impact on neighbourhood ecosystems (Fig.05) (**El Hadrami and Al-Khayri, 2012**). In current years, global call for—specially from markets in Europe and Asia—has surged, pushed by the developing enchantment of dates as herbal, purposeful meals products (**Al-Alawi et al., 2017**). This shift aligns with broader developments favoring smooth-

label, fitness-orientated components and has fueled growing commercial interest in date-based totally exports (**Alhamdan et al., 2024**).

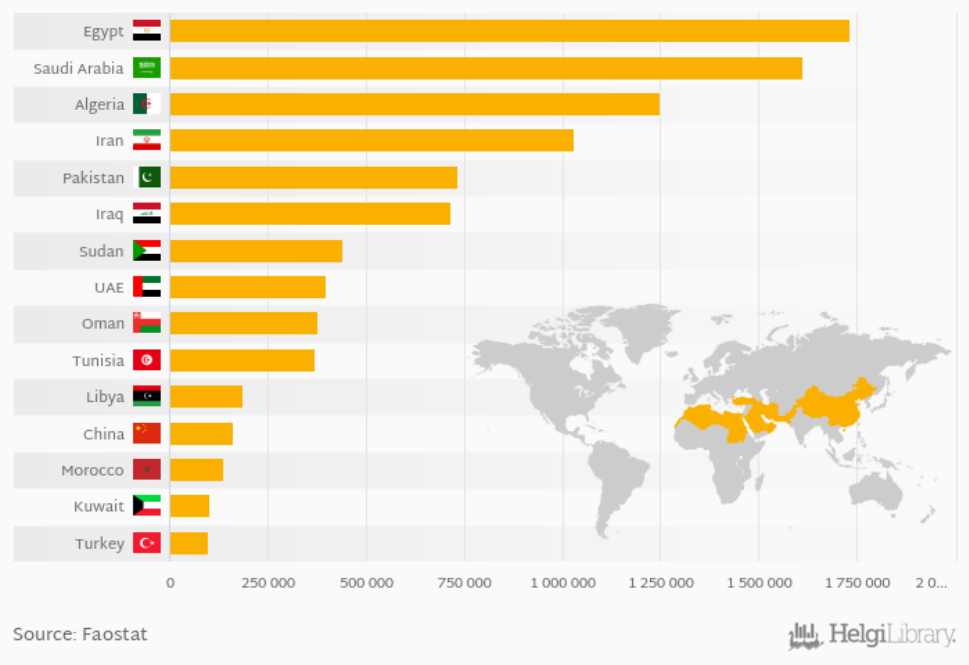


Figure 05: The main date-producing countries in the world 2022 (**FAOSTAT,2023**).

Beyond their function as a staple meal, dates exert a robust socioeconomic affect thru their transformation into value-introduced products such as syrup and paste, which might be widely processed in date-generating nations (**Boujnah and Harrak, 2012**). Additionally, derivatives like flour, vinegar, and alcohol have garnered hobby for his or her capability to diversify neighborhood agro-industrial sectors and decrease postharvest losses (**Chniti, 2015**). These fee-adding techniques drastically beautify rural employment via developing jobs not best in processing, however additionally in regions along with packaging, advertising, and logistics (**Ghayoor et al., 2016**). The emergence of small and medium-sized organizations inside the date industry displays the developing hobby in neighborhood processing and commercialization of date-based totally merchandise. In many MENA international locations, consisting of Algeria and the UAE, these corporations play an important role in rural development and employment generation, supported by using the strategic value positioned on date palm cultivation (**El Hadrami and Al-Khayri, 2012**).

1.2.2. Main Date Palm Cultivars

The date palm (*Phoenix dactylifera L.*) is cultivated throughout greater than 35 nations, with about 3,000 identified varieties international. However, simplest a choose number of cultivars

are commercially massive, prized for his or her superior best, steady productiveness, and strong marketplace call for (**FAO, 2002**)

These cultivars range in vital trends along with texture (Fig.06), sugar composition, ripening duration, and environmental adaptability (**Belguedj, 2014**). In the Middle East and North Africa, Deglet Nour—usually called the "queen of dates"—is a few of the maximum prominent varieties global, valued for its semi-translucent appearance, easy texture, and delicately sweet taste. It is a first-rate export crop in Algeria, Tunisia, and Libya; in Algeria alone, Deglet Nour bills for extra than half of the nation's total date manufacturing (**FAO, 2023**). Another great cultivar is Medjool, at first from Morocco, that is liked for its big size and wealthy, caramel-like taste (**Zaid and de Wet, 2002**).

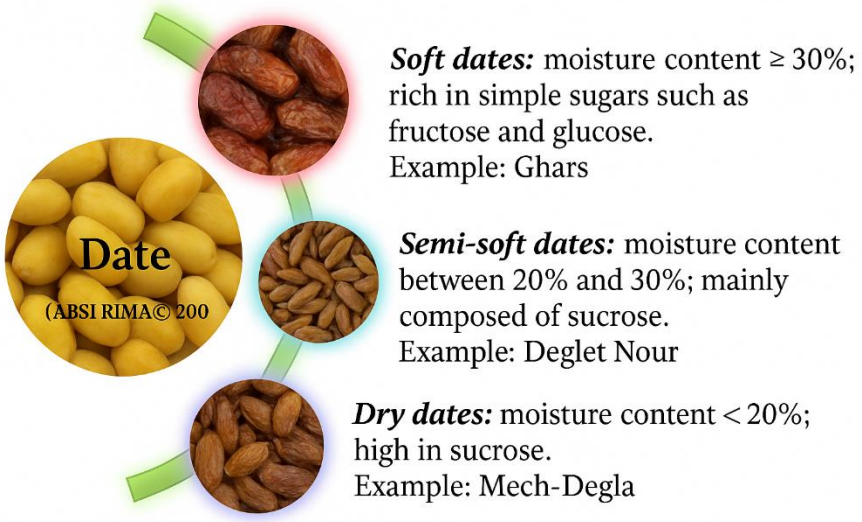


Figure 06: Classification of dates according to their consistencies (**Absi, 2010**).

Alongside globally renowned commercial types, many countries cultivate indigenous date palm cultivars that are well adapted to local climate and soil conditions. One such example is Khalas, a prominent variety widely grown in Saudi Arabia and the United Arab Emirates, favored for its semi-dry flesh, balanced sweetness, and superior performance in processing applications such as date syrup and paste production (**Aleid and Haddadin, 2023**). In Iraq, the *Zahidi* cultivar is extensively grown for its semi-dry nature, lengthy shelf existence, and suitability for bulk export. On the alternative hand, *Barhi* is a tender, delicate range typically ate up fresh; despite the fact that particularly perishable, it is gaining traction in area of interest markets due to its unique taste and texture (**Chao and Krueger, 2007**).The massive genetic variety found amongst date palm cultivars is essential for the crop's resilience to pests, diseases,

and weather variability. As an end result, numerous studies efforts are dedicated to keeping this genetic wealth via techniques like in vitro protection and molecular evaluation (**Sedra, 2011**). Maintaining this diversity is essential for advancing agricultural practices, improving postharvest handling, and enabling the development of innovative date-based products tailored to evolving market demands (**Moussouni et al., 2017**).

1.2.3. Nutritional Composition of Dates

Dates are pretty valued for its dense dietary content (Tab.01), which has lengthy supported their function as a nutritional staple in arid and semi-arid regions. Their composition is dominated by way of carbohydrates, with sugars—in particular glucose and fructose—making up 60% to 80% of the fruit's weight, providing a quick and herbal power supply (**Al-Farsi and Lee, 2008**). In addition to sugars, dates provide a mild quantity of nutritional fiber (6–11%), which plays a key characteristic in selling digestive fitness and lowering the hazard of chronic sicknesses (**Elleuch et al., 2011**). Although no longer particularly immoderate in protein, dates nevertheless encompass round 1–3% protein, such as severa crucial amino acids, albeit in smaller portions as compared to protein-wealthy components (**Habib and Ibrahim, 2009**). Their fat content is very low—typically less than 0.5%—yet includes beneficial unsaturated fatty acids such as oleic and linoleic acids (**Al-Farsi et al., 2007**). Moreover, dates are an excellent source of essential minerals, particularly potassium, calcium, magnesium, iron, and phosphorus, which support cardiovascular health, bone strength, and general metabolic function (**Al-Hooti et al., 2002**).

Table 01: Nutritional composition of date palm fruits at Rutab and Tamer stages (**Al-Mssallem et al., 2019**)

Nutrients	Rutab Stage	Tamer Stage
Moisture (g/100 g)	44.60	18.54
Macronutrients (g/100 g)		
Glucose	22.80	30.40
Fructose	19.40	29.40
Sucrose	4.03	11.60
Total sugars	46.23	71.40
Insoluble NSPs	5.89	5.76
Soluble NSPs	0.96	0.84
Total NSPs	6.85	6.60
Total carbohydrates	53.08	78.00
Protein	1.50	2.14
Fat	0.14	0.38
Micronutrients		
Minerals (mg/100 g)		
Sodium (Na)	90.9	32.9
Potassium (K)	486	713
Magnesium (Mg)	43.3	64.2
Calcium (Ca)	20.2	70.7
Phosphorus (P)	41.0	58.1
Manganese (Mn)	0.29	0.27
Iron (Fe)	0.64	0.83
Zinc (Zn)	0.24	0.27
Copper (Cu)	0.21	0.24
Selenium (Se)	0.24	0.31
Vitamins (mg/100 g)		
Water-soluble vitamins	n/a	5.79
Fat-soluble vitamins	n/a	0.024

Beyond their macronutrient content material, dates are a rich source of bioactive compounds, consisting of polyphenols (particularly flavonoids and phenolic acids) in addition to carotenoids and tannins, all acknowledged for his or her antioxidant, anti-inflammatory, and antimicrobial outcomes (**Biglari et al., 2008**). The tiers of these useful compounds can vary extensively based at the cultivar, the ripening level, and the way the end result are dealt with after harvest. For example, darker sorts and those harvested on the tamar level (fully ripe) typically include higher concentrations of phenolics and flavonoids, resulting in stronger antioxidant interest (**Chaira et al., 2009**). Dates also provide modest levels of nutrients, including diet A (from β-carotene),

numerous B-complicated nutrients inclusive of B1, B2, B3, and B6, and vitamin C. However, their typical vitamin content material is commonly decrease compared to clean end result like citrus or berries (**Favier et al., 1993**).Altogether, the combination of herbal sugars, nutritional fiber, essential minerals, and bioactive phytochemicals positions dates as a functional meals with terrific health benefits, making them an increasing number of appealing within the improvement of natural strength boosters and dietary supplements (**Vayalil, 2012**).

1.3. Date Processing: Derived Products

Thanks to their wealthy nutritional profile and abundance of health-promoting compounds, dates gift significant possibilities for transformation right into a huge range of value-introduced products (Fig.07). Studies display that round 30–40% of the date harvest in generating international locations is assessed as commercial grade due to flaws in size, colour, or uniform ripening. While those dates might not meet sparkling marketplace standards, they continue to be best for processing (**Besbes et al., 2009**). Instead of going to waste, those lesser-grade fruits may be converted into purposeful components along with date paste, flour, vinegar, ethanol, and mainly date syrup (**El Sohaimy and Hafez, 2010**). These by-product merchandise no longer handiest reduce postharvest losses however additionally assist the growth of numerous meals industries and beautify the nutritional price of meals systems. Among them, date syrup sticks out for its richness in glucose and fructose, vital minerals, and phenolic compounds attributes that provide it antioxidant and prebiotic homes (**Al-Farsi and Lee, 2008**).

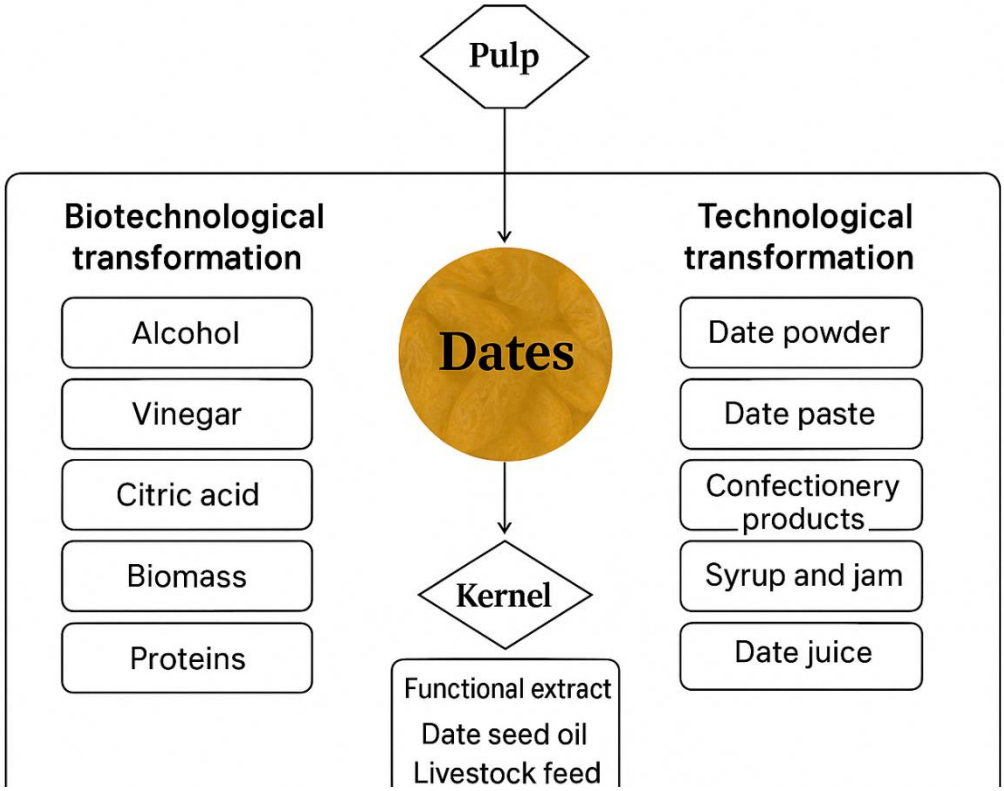


Figure 07 : Date technologies (**Boukhiar et al., 2009**)

1.3.1. Date Paste

Date paste is made by mechanically grinding soft or semi-soft dates into a smooth and uniform spread, a process that preserves much of the fruit's original nutritional composition (**Belguedj, 2014**). Widely used inside the confectionery, bakery, and snack industries, it serves as a herbal sweetener or filling thanks to its attractive taste and clean texture. Its excessive fiber and herbal sugar content, combined with a neutral pH and extended shelf lifestyles, make it especially well-applicable for health-orientated food products—mainly those geared toward lowering subtle sugar intake (**Al-Hooti et al., 2002; Mimouni et al., 2014).**

1.3.2. Date Flour

Date flour, produced by drying and grinding either date flesh or seeds, has gained increasing interest due to its high dietary fiber content and richness in essential minerals, making it a valuable ingredient in functional foods (**Benahmed, 2012**). It is usually included in gluten -free baking and used to complement grains and ripe items, especially for individuals with special diet desires. While its industrial use remains forced, the research indicates its ability to increase

rapid nutritional value and help in the development of health-oriented, price-introduction goods (**Amany et al., 2012**).

1.3.3. Date Vinegar

Date vinegar is produced through the acetic fermentation of date juice or its by way of-merchandise, which complements the attention of organic acids and bioactive compounds (**Matloob and Balakiti, 2016**). Traditionally hired in culinary and medicinal contexts, it has received recognition for its antioxidant and antimicrobial properties, positioning it as a precious factor in useful foods and health-oriented formulations (**Hachemi and Zouhani, 2015**).

1.3.4. Date Alcohol

Date alcohol is obtained by fermenting sugar-rich date juice using *Saccharomyces cerevisiae*, a yeast strain well-known for its efficiency in ethanol production (**Chniti et al., 2015**). This approach is commonly employed in each commercial ethanol manufacturing and the manufacturing of alcoholic beverages, mainly in regions where excess or decrease-grade dates are with ease available. As such, it presents a price-effective method of turning agricultural surplus into precious bio-products (**Al-Shahib and Marshall, 2003**).

1.3.5. Date Syrup

Date syrup, moreover known as dibs, is considered one of the most economically big derivatives of dates. It is usually extracted via strategies inclusive of hot water extraction, diffusion, or enzymatic hydrolysis, observed through filtration and awareness to gain a thick, certainly candy syrup rich in sugars (**Abbès et al., 2011; Mimouni and Siboukeur, 2011**). The final product is mainly rich in invert sugars—in the main glucose and fructose—which can be without problems digestible and offer brief electricity. In addition, date syrup consists of huge tiers of minerals together with potassium, calcium, and magnesium, in addition to bioactive compounds like phenolic acids and flavonoids, which impart antioxidant and antimicrobial houses (**Chaira et al., 2009**).

Due to its wealthy content of effortlessly digestible sugars, vital minerals, and antioxidant compounds, date syrup is drastically utilized in fitness-targeted products like electricity liquids, little one substance, and diabetic-friendly sweeteners. Its natural, vegan, and gluten-free profile makes it appealing for smooth-label food markets. In date-generating areas, it plays a key function in agro-commercial enterprise development and price-introduced food innovation (**Al-Farsi and Lee, 2008**).

Chapter 02
Date Syrup

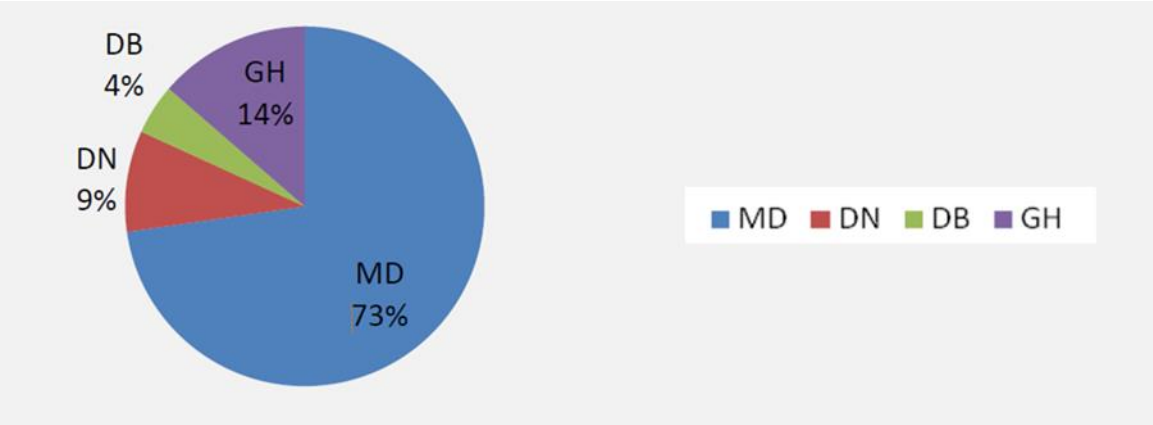
2.1. Date Syrup

Date syrup, regarded in Arabic as “dibs,” is a conventional and widely esteemed natural sweetener produced by the thermal concentration of juice extracted from soft or overripe dates (**Chaira et al., 2009**). It stands as one of the most important date-based products in terms of both the nutrition profile and market value, with its global appeal, the natural and plant-based sweetness has been expanded to the increasing consumer demand (**Al-Hooti et al., 2002; Belguedj et al., 2015**).

This syrup is traditionally thick, dark, and extraordinarily sweet, normally because of its excessive content material of invert sugars, mainly glucose and fructose, which make up approximately 65–80% of its overall composition (**Al-Hooti et al., 2002**). Beyond its sugar content material, date syrup also provides important minerals such as potassium, calcium, and magnesium (**Farahnaky et al., 2016**), and carries several bioactive compounds including phenolics, flavonoids, and carotenoids, which contribute to its strong antioxidant activity (**Hachemi and Zouhani, 2015**).

The production of date syrup involves several critical stages, beginning with the careful selection of high-quality, fully ripened dates, followed by thorough washing to eliminate dust, soil, and potential microbial contaminants (**Seddiki and Seddiki, 2024**). Depending on the variety (Fig. 08) and processing method, dates are overwhelmed or soaked to maximize juice extraction (**Besbes et al., 2009**). Once extracted, the juice is clarified via methods which include sedimentation, filtration, or enzymatic treatment to remove suspended particles and improve the syrup’s clarity (**Al-Farsi and Lee, 2008**). The clarified juice is then concentrated (typically through thermal evaporation or vacuum methods) until it achieves a Brix level exceeding 70°, thereby ensuring desirable sensory attributes and functional properties (**Abbès et al., 2011**).

Traditional household preparation often involves direct boiling, a method that can degrade heat-sensitive nutrients and phenolic compounds (**Chaira, 2015**). In assessment, contemporary business processes use vacuum awareness at decreased temperatures, which higher preserves antioxidants and improves dietary nice (**Bouhlali et al., 2017**).



MD: Mech Degla DB: Degla Beida DN: Deglet Nour GH: Ghars

Figure 08: Varieties used for the manufacture of date syrup (**Belguedjat al., 2015**).

Nutritionally, date syrup offers a clean benefit over refined sugar and corn syrup. In addition to supplying carbohydrates for energy, it consists of vital micronutrients which include potassium, calcium, magnesium, and iron, in conjunction with nutritional fiber and polyphenolic antioxidants (**Farahnaky et al., 2016**). Research has validated that date syrup features as a useful sweetener, showing antimicrobial, anti-inflammatory, and prebiotic results. These homes are largely attributed to its wealthy content material of phenolics, flavonoids, and carotenoids, which enhance its fitness-supportive fee (**Habib and Ibrahim, 2009; Al-Hooti et al., 2002**). Moreover, it's obviously high osmotic pressure due to glucose and fructose concentrations exceeding 70%, inhibits microbial growth, making an allowance for prolonged shelf existence without the want for artificial preservatives (**Chaira et al., 2009**).

2.2. Worldwide Statistics on Date Syrup Production and Market

Globally, date syrup manufacturing represents a substantial segment of the date processing industry, in large part pushed by way of developing call for natural sweeteners and functional food elements. Consumer traits closer to plant-based totally and minimally processed alternatives have elevated interest in date syrup because of its dietary cost and clean-label attraction (**FAO, 2023**). The Middle East and North Africa place maintains to dominate this region, accounting for over 50% of global date-primarily based product exports, with international locations along with Iran, Saudi Arabia, and Egypt leading production and trade (**FAO, 2023**). In specific, Iran has emerged as a key participant, supported via favorable agro-climatic situations and authorities-led packages promoting brought-fee merchandise like date syrup and vinegar (**El Hadrami and Al-Khayri, 2012**).

The international market for date syrup was valued at approximately 1.42 USD Billion in 2022 and is expected to reach 2.61 USD Billion by 2032, developing at a compound annual boom fee (CAGR) of 6.3% (**Market Research Future, 2022**). The global date syrup marketplace is expanding swiftly, especially in North America and Europe, fueled by way of growing fitness consciousness and the call for for easy-label, plant-primarily based sweeteners. In North America, date syrup is gaining traction among clients averting refined sugars—marked via a projected CAGR of 6.7%, with the U.S. Leading at 80% market proportion in 2023. In Europe, intrest in artisanal and organic food has pushed the marketplace to over 31% proportion, with a CAGR of 7.1% (**Persistence Market Research, 2023**). These markets value it due to the fact its low glycemic index, antioxidant residences, and its feature as a plant-primarily based alternative to processed sugars (**Al-Farsi and Lee, 2008**).

In addition to its nutritional blessings, the date syrup industry generates by-products which include date press cake, contains nutritional fiber, phenolics, and residual sugars. These via-merchandise can be repurposed into animal feed or as elements in useful ingredients, contributing to waste discount and sustainability in agro-commercial processing (**Aleid and Haddadin, 2023**).

❖ Date syrup in Algeria

In Algeria, the valorization of dates through syrup production stays incredibly restricted compared to the overall country wide output, despite the country Being one of the international's leading producers of dates (**Benziouche & Cheriet, 2012; Belguedj, 2014**). While high-quality cultivars such as Deglet Nour are especially exported or consumed fresh, huge quantities of low-grade dates remain underutilized. Recent researches states that only a small fraction of these 2-grade dates is estimated in a round of-15-20%-have been processed in promotional products. containing syrup, paste, or vinegar (**Houssni et al., 2022**). Meanwhile, large postharvest losses persist due to inefficient harvesting practices, poor handling, and lack of adequate marketing infrastructure, leading to considerable waste and economic loss (**Benziouche and Cheriet, 2012; Belguedj et al., 2015**).

2.3. Methods of Date Syrup Production

Date syrup is produced via diverse extraction and awareness strategies, from artisanal boiling to business-scale technology. Traditional practices, together with immersion in warm water or direct heating. continue to remain common in many parts of the Middle East and North Africa due to their accessibility and low operational costs. However, those methods are frequently

restrained through low sugar extraction yields and inconsistent syrup quality (**Mimouni and Siboukeur, 2011**).

In assessment, present day industrial techniques along with enzymatic extraction, diffusion strategies, and vacuum-assisted evaporation, are preferred for his or her ability to enhance the retention of bioactive compounds, ensure microbial protection, and improve product stability (**Abbès et al., 2011**). These procedures normally contain sequential steps which includes fruit choice, washing, enzymatic hydrolysis, filtration, and concentration, each of which influences key physico-chemical properties together with viscosity, color, and °Brix (**Al-Hooti et al., 2002**).

The choice of extraction technique regularly depends on the cultivar and desired final characteristics; as an instance, smooth-fleshed sorts like Deglet Nour might also undergo diffusion or hot extraction, whilst drier types are higher applicable for enzymatic hydrolysis to beautify yield (**Abbès et al., 2011**). Although emerging technologies like microwave-assisted processing provide advantages in preserving pleasant and reducing processing time, their broader adoption remains restricted due to high system expenses and technical complexity (**Reyens, 1997**).

2.3.1. Extraction by Pressing

Pressing represents an honest mechanical method for extracting juice from dates. In this manner, dates that have been wiped clean and had their pits eliminated are robotically compressed to reap their juice, that's finally filtered and concentrated into syrup. This technique is especially appropriate for tender and semi-gentle date types, as they produce an excessive extract yield with minimum exposure to warmness-related degradation (**Al-Farsi et al., 2007**).

2.3.2. Soaking Process in Water at Low Temperature

The cold-water soaking approach is a non-thermal method hired in date syrup production, wherein dates are immersed in water at ambient temperatures to facilitate the diffusion of soluble sugars. **Fennir et al. (2003)** reported that this method yields approximately 42% of the whole sugars, supplying moderate extraction efficiency at the same time as minimizing thermal degradation and colour darkening. **Al-Safy and Ali (2023)** similarly found that cold soaking, even though much less efficient than thermal strategies, contributes to step forward sensory first-rate and lighter syrup colour, in particular whilst most effective date cultivars are decided on.

This method is usually used in traditional practices because its application is ease and low cost. This helps preserve the nutritional quality of dates and prevents carimalization. However, it is time consuming and provides limited microbial protection until pasteurization (**Al-Hooti et al., 2002; Saddi, 2012**).

2.3.3. Soaking Process in Water at High Temperature

Unlike cold soaking, warm water extraction employs better temperatures (60–90°C) to hurry up the discharge of sugars and soluble solids from date pulp. This approach reduces processing time and complements microbial protection, even if it can cause heat-sensitive antioxidants and colorful compounds (thermal decline) (**Babes et al., 2009**).

The method is normally accompanied through filtration and awareness via open-pan boiling or vacuum evaporation. While efficient, it calls for cautious temperature law to avoid caramelization or excessive browning (**Habib and Ibrahim, 2009**).

2.3.4. Diffusion Process

The diffusion method includes setting date pulp in a container where heat water constantly passes thru, allowing sugars and different soluble compounds to diffuse into the water. This technique is properly-ideal for massive-scale operations, providing excessive extraction performance without the thermal damage related to direct heating (**Kchaou et al., 2022**).

2.3.5. Enzymatic Extraction

Enzymatic extraction uses enzymes like pectinase and cellulase to break down cell walls, releasing sugars and enhancing both yield and clarity, this is particularly effective for processing fibrous date varieties. For example, **Abbès et al. (2011)** reported a rise in TSS from 66 g to 72 g per 100 g, and a sharp decline in turbidity, using enzyme treatment at 50 °C for 120 min on hard date types.

While enzyme-assisted extraction is pretty green, it calls for cautious manipulate of things together with pH, temperature, and response time. Nonetheless, the high value of enzymes and worries concerning residual enzymatic activity present ability barriers (El-**Sharnouby et al., 2009**).

2.4. Essential Physico-Chemical Parameters for Date Syrup

The exceptional and business rate of date syrup relies in massive element on its physico-chemical houses that are critical indicators of its protection (Table 02), nutritional fee, sensory developments, and shelf balance. These parameters embody moisture content material, pH and

acidity, sugar attention (measured in °Brix), viscosity, and colour—every of which performs a particular function in defining the product's identity and suitability for consumption or similarly industrial use (**Al-Farsi et al., 2007**). Monitoring and controlling the ones parameters are vital to make sure that the final product complies with food safety requirements and purchaser expectancies (**Codex Alimentarius, 2022**).

Table 02: Chemical composition of date syrup (**Benkreif at al., 2024**).

Components	**(Benharzallah and Bouhureira, 2014)**	**(Maimouni and Siboukeur, 2015) (Ghars Variety)**
Water content	16	13.7
Soluble solids	84	86.3
Total sugars	79.45	80.73
Reducing sugars	4.87	79.96
Protein	0.83	1.15
Pectins	1.46	3.86

2.4.1. Water Content

Moisture content is a key physicochemical parameter in date syrup, drastically influencing its texture, balance, microbial protection, and shelf lifestyles. Elevated moisture stages can promote microbial growth, specially yeasts and molds, which compromises the syrup's protection and shortens its storage length. Conversely, too low a moisture content material can cause crystallization or an overly thick texture, decreasing purchaser attraction. (**Abbès et al., 2011**). Typically, notable date syrup contains between 20% and 30% moisture, depending at the extraction and concentration strategies used (**Al-Hooti et al., 2002**).

2.4.2. pH and Acidity

Date syrup pH and titratable acidity are important parameters that affect its chemical balance, shelf lifestyle and common sensory characteristics. Date syrup usually consists of a pH between 4.0 and 5.0, which creates a mild acidic environment that prevents the boom of malfunctioning microorganisms (**Al-Farsi et al., 2007**). This acidity in most cases effects from clearly occurring natural acids—such as malic, succinic, and citric acids—which become barely focused throughout the syrup manufacturing process (**Habib and Ibrahim, 2009**).

Date syrup's first-rate relies upon on both pH (measuring hydrogen ion attention) and titratable acidity (general acid content as % citric acid equal). While pH suggests microbial safety, titratable acidity affects taste, stability, and shelf life. These parameters are essential for assessing product nice and protection (**Seddiki and Seddiki, 2024**).

2.4.3. Sugar Content (°Brix)

Sugar content is one of the most important quality parameters in date syrup, because it at once influences sweetness, renovation, and customer acceptability. It is commonly measured in ranges Brix (°Brix), which reflect the awareness of total soluble solids, especially sugars which include glucose and fructose that end result from the herbal hydrolysis of sucrose throughout thermal or enzymatic treatment (**Mimouni et al., 2014**). These invert sugars contribute extensively to the syrup's herbal sweetness and one-of-a-type taste profile (**Chaira et al., 2009**).

High-fantastic date syrup commonly famous Brix values among 70° and 80°Brix. Such concentrations decrease water activity, thereby decreasing microbial growth and extending shelf life. However, if the Brix stage exceeds the gold general variety, glucose might also additionally crystallize through the years, causing undesirable texture changes all through garage (**Al-Farsi and Lee, 2008**).

2.4.4. Viscosity

Viscosity is a key physico-chemical property inside the assessment of date syrup, as it without delay influences processing efficiency, packaging suitability, sensory texture, and various commercial makes use of. It denotes the syrup's internal resistance to glide, which is largely decided by using elements which includes sugar concentration and water content (**Gabsi et al., 2013**), The viscosity of date syrup is extensively influenced through °Brix stages, thermal conditions, and the breakdown of polysaccharides. As °Brix will increase, the syrup turns into denser and greater viscous, improving its richness but also complicating its pumpability and packaging behavior. Other contributors factors include residual fiber and pectin, which affect float and storage balance. It is necessary to closely monitor the viscosity, as it affects the overall sensory profile and the buyer happiness. Reports comparing syrup crafted from one-of-a-kind date cultivars recommend that both temperature and extraction methods play critical roles in final viscosity ranges (**Farahnaky et al., 2016; Mimouni and Siboukeur, 2011**).

The viscosity of the date syrup usually falls within the range of two hundred to 2,000 MPa·S at 25 ° C, which vary according to the date variety and the unique extraction or concentration method is applied. Products obtained through vacuum evaporation often show high viscosity,

as this technique reduces thermal decline. In comparison, enzymatic remedies usually bring about decrease viscosity however offer advantages in terms of readability and simplicity of pouring (**Al-Farsi and Lee, 2008**).

2.4.5. Color and Appearance

Color is an important sensory parameter in date syrup, intently prompted by the form of dates utilized, the processing approach, and thermal intensity. Dark colorations generally end result from Maillard reactions and sugar caramelization, that are intensified via high-temperature and prolonged heating durations at some point of syrup preparation According to **Mimouni and Siboukeur (2011)**, darker colour often correlates with a richer taste profile however may also signal immoderate thermal degradation of sugars or phenolic compounds. Additionally, varietal variations including the ones found in Ghars and Deglet Noor make contributions to preliminary color version, even as attention methods like open boiling or vacuum evaporation appreciably regulate final syrup appearance (**Reyens, 1997**).

2.5. Microbiological Characterization of Date Syrup

The microorganism quality of the date syrup, especially when produced using traditional methods, is affected by many factors, including raw material hygiene, water quality, processing environment and storage conditions. Traditional date syrup, known as "Rob" in some areas, is often manufactured in artisan settings with limited microbial control measures, which increases the possibility of suspension by coliforms, yeasts, and molds (**Houssni et al., 2022; Mimouni et al., 2022**).

Mimouni and Sibker (2011) highlighted that artisan syrup obtained by proliferation or spontaneous evaporation can maintain a high microbial load until it is processed in semi-industrial conditions. In addition, the role of coliform as a hygiene indicator, although originally established in dairy processing, has become increasingly relevant in evaluating sanitary conditions of traditional syrup production (**Martin et al., 2016**). Their presence is not necessarily a sign of fecal contamination, but reflects poor handling or insufficient hygiene during the processing stages.

2.6. The Use of Date Syrup in Other Industries

Date syrup is gaining reputation as a multifunctional element, valued not handiest for its function as a traditional sweetener however also for its utility in lots of food merchandise, as a result of its excessive sugar and polyphenol content (**Al-Farsi and Lee, 2008**). Thanks to its herbal mix of antioxidants and antimicrobial compounds, date syrup isn’t simply sweet—it

facilitates preserve meals sparkling, too. Studies display it works as a natural preservative, making it a high-quality healthy for healthier snacks like power bars or yogurt, wherein it provides flavor whilst extending shelf life (**Matloob and Balakiti, 2016**). In addition, it's a clever choice for health-conscious eaters: date syrup (specially from smooth types like Ghars) has a decrease effect on blood sugar in comparison to refined sweeteners. That's why it's popping up in diabetic-friendly meals and well-being products (**Mimouni, 2015**).

Date syrup has validated promising ability beyond the food industry, specifically in pharmaceutical and beauty fields, due to its excessive content of phenolic compounds that make a contribution to antioxidant and anti-inflammatory properties. These bioactive capabilities assist its incorporation into skin care and nutraceutical products focused on oxidative strain and inflammation (**Matloob and Balakiti, 2016**). In parallel, scientific research have confirmed the efficacy of date syrup as a fermentation substrate in the production of bioethanol, leveraging surplus or industrial derivative syrups to support sustainable biotechnological packages. Through microbial strategies related to Saccharomyces cerevisiae, date syrup can be transformed into precious bio-based totally compounds which includes ethanol and natural acids (**Chniti, 2015**).

Part II
Experimental Study

Chapter 03
Material and Methods

Our work was conducted in the laboratory of the Department of Agronomic Sciences, TELIDJI AMAR University – Laghouat. The objective of this study was to produce date syrup from two varieties of low-quality dates and to compare their physicochemical and microbiological properties with those of commercial date syrup available in the Algerian market. In addition, the study aimed to evaluate the effect of storage time at 4°C on these properties by analyzing the same date syrup before and after a storage period of two years, without the use of additives.

3.1. Materials

In our study, we used two types of dates: Garbai and Gebouri (old Ghars, one year or more old). These samples were chosen because they are considered low-quality dates, have a low price, and are available in the Algerian market.

Figure 09: Dates used (**A**: Garbai ; **B:** Gebouri) (Original,2025)

3.2. Methodology

3.2.1. Extraction and Production of Date Syrup

In this study, date syrup was prepared following the traditional method described by **Houssni et al. (2022)** (Fig.10).

The process began with washing and sorting the dates to remove any impurities. The fruits were then immersed in hot water to soften the pulp and promote the release of soluble sugars.

After soaking, the dates were manually kneaded and pressed to extract the juice, which was subsequently filtered using clean cloth to eliminate fibers and seeds. The clarified juice was then subjected to continuous heating until it reached a concentrated, viscous consistency, thus yielding the final syrup without the use of additives.

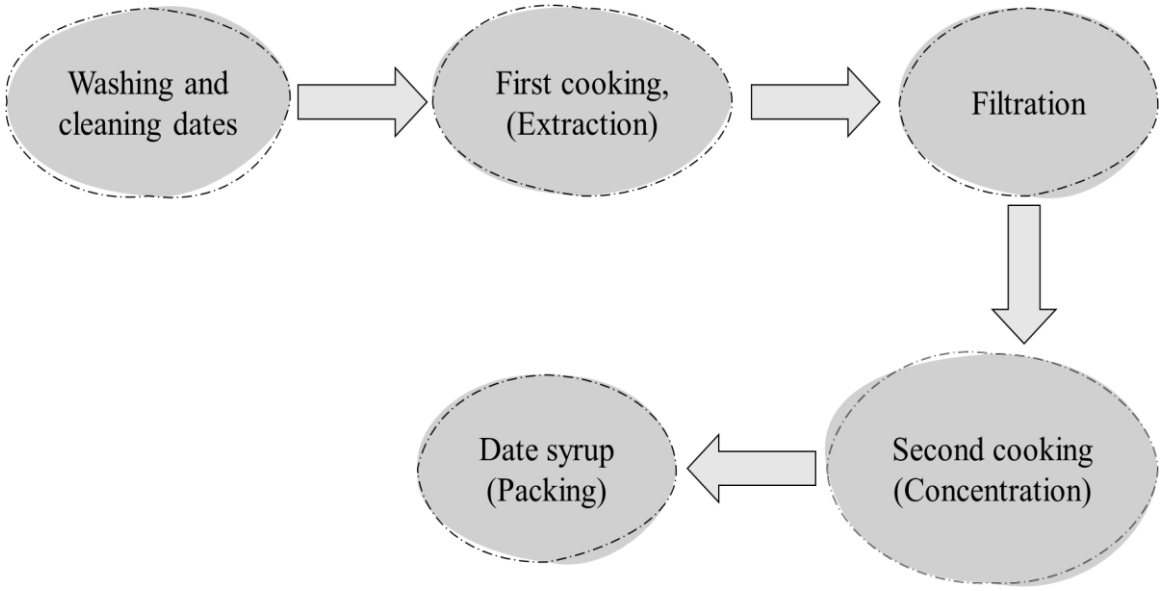


Figure 10: Diagram summarizing the different stages of the traditional preparation of date syrup (**Houssni et al., 2022**).

3.2.2. Physico-Chemical Analysis

3.3.1.1. Sample Preparation

The samples used in this study consisted of five samples, which are as follows:

- Sample 01 : Traditional Gebouri date syrup
- Sample 02 : Traditional Garbai date syrup
- Sample 03: Semi-industrial date syrup Algeria
- Sample 04: Semi-industrial date syrup Biskra
- Sample 05: Stored traditional date syrup

Figure 11 : date syrup's symples (Original ; 2025)

3.3.1.2. Determination of Total Soluble Solids (T.S.S) (NF V05-109)

The degree of Brix (%) is determined by measuring the rate of soluble solids using a Refractometer. Its measurement method is based on the refraction of light created by the nature and concentration of solutes (**Djerfaf and Hadjadj, 2023**). (Three repetitions for each sample)

Figure 12 : Refractometer (ATAGO Master-α "Alpha"). (Original, 2025)

3.3.1.3.Determination of Conductivity (NF T90-111)

Conductivity is measured using a Conductivity meter. The principle is to immerse the electrode in a Becher containing sample solution (Fig.13) while washing the electrode well with distilled water before and after each operation. The results are expressed in µs /cm (**Laouar et al., 2021**). (Three repetitions for each sample)

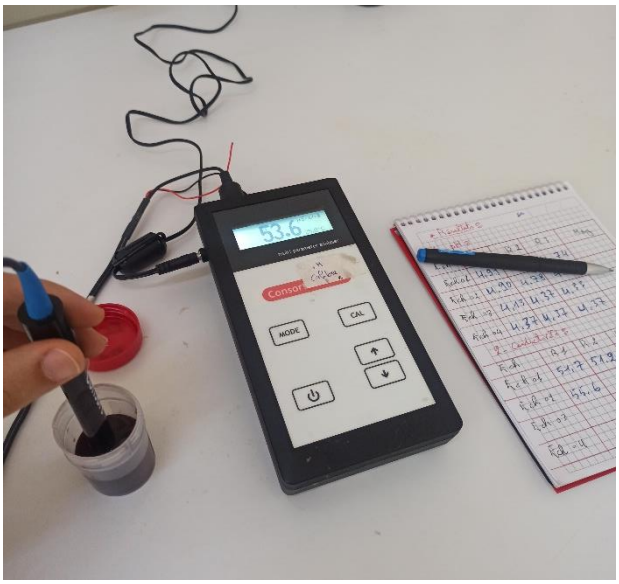


Figure 13: Electrical conductivity measurement (Original, 2025)

3.3.1.4. Determination of Moisture Content (NF V 05-105 1974)

The water content was determined according to the NF V 05-105 (January 1974) standard, which specifies the gravimetric method for moisture measurement in food products. The method involves drying the sample at a temperature (usually 105°C) until it has a constant weight, and then calculating the moisture percentage by measuring the weight loss.

First, the empty capsules were dried in an oven for 15 minutes at 103 ± 2 °C to eliminate any residual humidity and then weighed accurately. Subsequently, 5 g of each sample was introduced into the pre-dried capsules, which were reweighed to obtain the initial mass. The capsules containing the samples were then placed in a drying oven maintained at 105 ± 2 °C for three hours. After this period, the capsules were removed from the oven, cooled to room temperature in a desiccator to prevent moisture uptake, and weighed again. The drying–cooling–weighing cycle was repeated until a constant weight was achieved, ensuring complete removal of free water. To avoid possible caramelization of sugars, the drying time was progressively reduced to 30 minutes in the final repetitions (**Seddiki and Seddiki, 2024**). (Three repetitions for each sample)

The water content is calculated according to the following formula:

$$H\% = (M1 - M2)/P.100$$

So That:

H %: Humidity.

M1: Mass of the capsule containing the material fresh before tempering (g).

M2: Mass of the capsule containing the fresh material after tempering (g).

P: Mass of the test sample (g).

- The dry matter content is calculated as follows:

$$MS\% = 100 - H\ \%$$

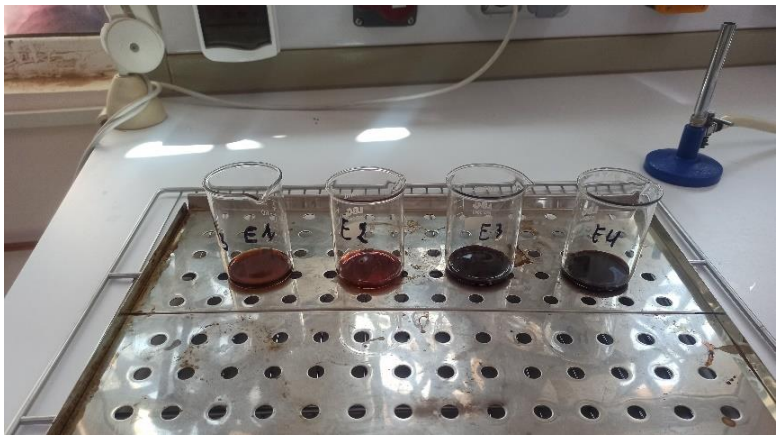


Figure 14: Determination of Moisture Content (Original, 2025).

3.3.1.5. Determination of pH (NF T90-014)

pH is measured using a pH meter. The principle is to immerse the electrode in a Becher containing sample solution (Fig.15), while washing the electrode well with distilled water before and after each operation, the results are measured directly (Same principle as measuring Conductivity). (Three repetitions for each sample)

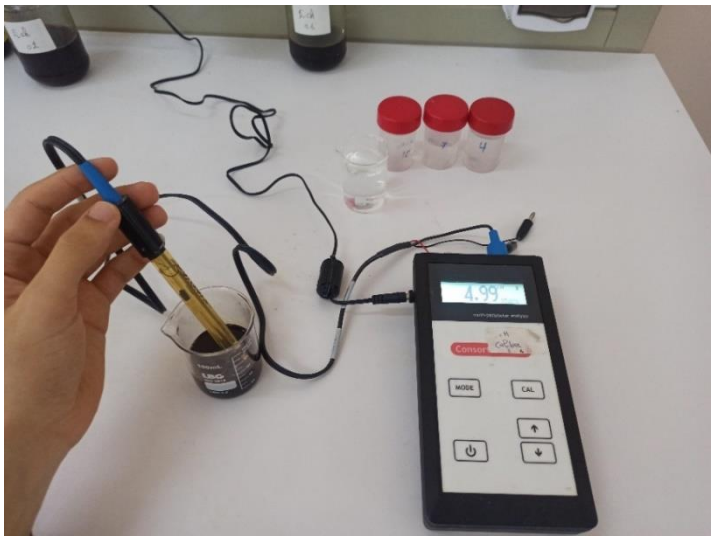


Figure 15: pH measurement (Original, 2025)

3.3.1.6. Determination of Acidity NF V 05-101 (1974)

Date syrup's titratable acidity was analyzed via volumetric titration with a standardized sodium hydroxide (NaOH) solution (0.1 N), which involved the use of phenolphthalein as an indicator (**Laouar et al., 2021**) (Three repetitions for each sample). Results were expressed as a percentage of the predominant acetic acid, calculated using the formula:

$$AT(g\ /\ 100g) = \frac{v \times N \times 0{,}060 \times 100}{P}$$

AT: Concentration of acetic acid in g/l.

P: Sample mass (g)

V = Volume of NaOH consumed (mL)

N = Normality of NaOH solution (0.1N)

0.06 = Factor for the conversion of titrable acidity to acetic acid equivalent

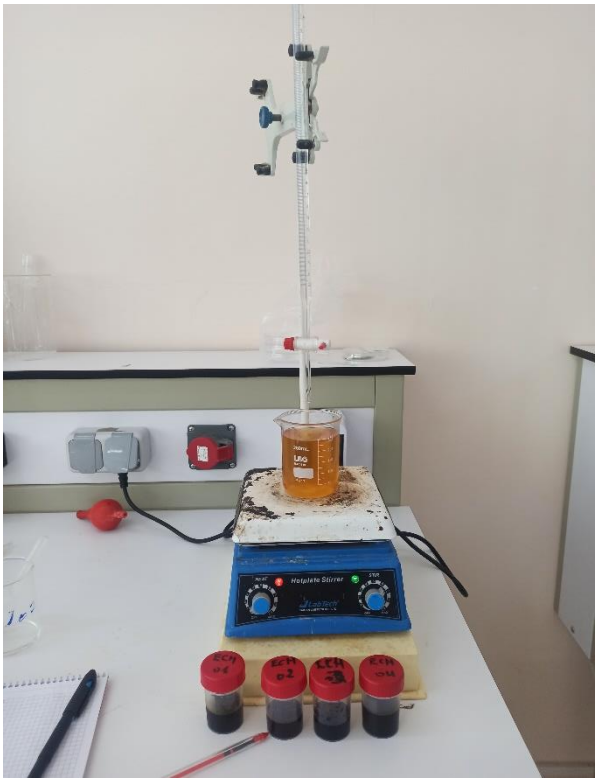


Figure 16: Total acidity titration (Original, 2025)

3.3.2. Microbiological Analyses

- Preparation of dilutions:

In this part, we performed a series of dilutions (10^{-1} to 10^{-6}) for each sample using a sterile saline solution, The dilution series was performed under aseptic conditions inside a biosafety cabinet to prevent external contamination (**Benkreif et al., 2024**)

3.3.2.1. Detection of Total Mesophilic Aerobic Flora

Total aerobic mesophilic flora (TMAF) refers to the set of aerobic microorganisms capable of developing at an optimal temperature of 30 °C. TMAF is a microbiological indicator that allows the evaluation of the overall bacterial load present in a food or on a surface (**Souti and Karouaz, 2014**). The standard method is to seed the samples, after appropriate dilution, on Plate Count Agar (PCA) (**Annexe B**) medium followed by incubation at 30 °C for 72 3 hours (**ISO 4833-2:2013**). Viable colonies are then enumerated and expressed in colony-forming units per gram or milliliter (CFU/g or CFU/mL).

A sterile micropipette with a capacity ranging from 100 to 1000 µl was used to transfer 0.1 ml from each prepared dilution (10^{-1}, 10^{-3}, and 10^{-5}) of the samples. The aliquots were inoculated onto the surface of Plate Count Agar (PCA) using the surface spread method, ensuring even distribution of microorganisms. For each dilution, three Petri dishes were prepared in parallel to increase the accuracy and reliability of the results. The inoculated plates were then incubated at 30 °C for 72 hours. After the incubation period, the microbial colonies were counted and recorded for further calculation of the microbial load in the samples (**Darkaoui and Senouci, 2021**).

3.3.2.2. Detection of Total and Fecal Coliforms (AFNOR 3M 01/02-09/89 C)

Coliforms are considered one of the indicators of the sanitary and hygenic quality of water and food. It is classified as aerophile or facultatively anaerobic, gram-negative, and non-spore-forming, capable of fermenting lactose and producing acid and gas at a temperature of 32-35°. Three groups of coliforms have been classified “thermophilic,” which include Escherichia coli of fecal origin; “thermophilic and ubiquitous”; and “psychrotrophic,” which are capable of fermenting lactose at a temperature of 44-45°, the only reliable indicator of fecal contamination is *E. coli* (**Martin et al., 2016**).

A sterile micropipette (100–1000 µl) was used to transfer 01 ml from each prepared dilution (10^{-1}, 10^{-3}, and 10^{-5}) of the samples. The aliquots were then inoculated onto the solid VRBL medium (**Annexe B**) and spread evenly on the surface to ensure uniform colony development.

For each dilution, three Petri dishes were prepared in parallel to enhance the reliability of the results. The plates were incubated at 30 °C for the enumeration of total coliforms, while incubation at 44 °C was applied for the detection of fecal coliforms. After incubation, the colonies were examined and counted to determine the microbial load of coliform bacteria in the tested samples (**Djerfaf and Hadjadj, 2023**).

3.3.2.3. Detection of Yeasts and Molds (NF V08-059)

Yeasts and fungi are considered general indicators of food safety, as they indicate the quality of its preparation, storage and use. They are detected in foods using various protocols such as ISO 21527/NF V08-059.... Etc. It reproduces when appropriate conditions are available, such as a temperature of 20-25°C, as well as oxygen, and is characterized by its long reproduction time.

In this study, we determined the presence of yeasts and molds using Sabouraud Dextrose Agar (SDA) as the selective medium (**Annexe, B**). A sterile micropipette was used to transfer 0.1 ml from each dilution (10^{-1}, 10^{-3}, and 10^{-5}), which was inoculated onto the agar surface using the surface spread technique. For each dilution, three Petri dishes were prepared to ensure reliability of the results. The inoculated plates were then incubated at 25 °C for 5 to 7 days, allowing sufficient time for the development of yeast and mold colonies. After incubation, the colonies were examined and counted to evaluate the level of fungal contamination in the analysed samples (**Khamloul, 2023**).

Table 03 : Culture Conditions of Microorganisms

Germs sought	Medium	Dilution	Inoculation method	Incubation temperature	incubation period
FMAT	PCA	$10^{-1}/10^{-3}/10^{-5}$	Surface	30°C	72h
CT & CF	VRBL	$10^{-1}/10^{-3}/10^{-5}$	Surface	30°C/44°C	72h
Y & M	SDA	$10^{-1}/10^{-3}/10^{-5}$	Surface	25°C	5/7 Days

3.4. Statistical analyzes

The collected data were processed using the analysis of variance (**ANOVA**) method at **p<0.05,** test was applied to evaluate the significance of differences between mean values, using the **XLSTAT 2024.4.2.1426** software.

Chapter 04
Results and Discussion

4.1. Date Syrup Production

The date syrup consumed in this study was obtained using the traditional extraction method. It shows a brown color with varying degrees of intensity, the syrup derived from the Gebouri variety shows a dark brown color, while the syrup derived from the Garbai variety is light brown (Fig. 17). These differences can be explained by the intrinsic composition of each cultivar as well as the effect of the extraction and concentration process. As reported by **Julai et al., (2023)**, syrups produced through open-heat evaporation tend to develop a darker color due to more intense Maillard reactions and caramelization, whereas milder treatments such as vacuum evaporation generally result in a lighter color. In addition, the higher levels of reducing sugars and phenolic compounds in some varieties enhance the formation of melanoidins during heating, thereby deepening the syrup's color.

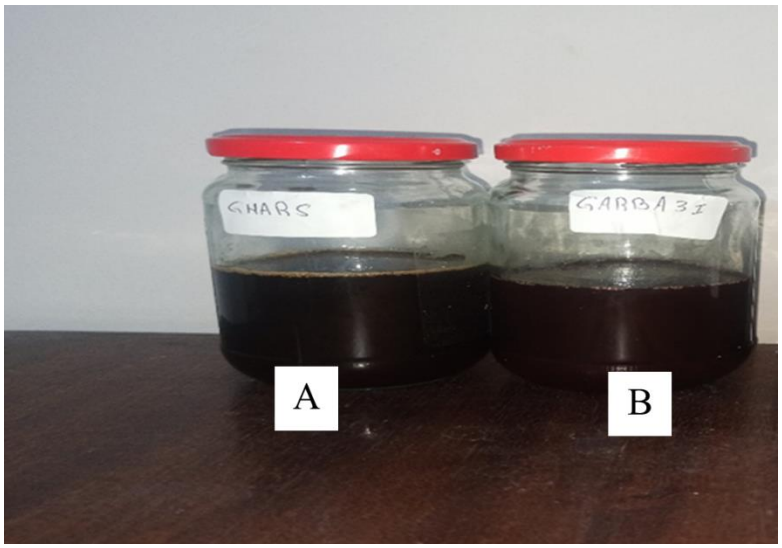


Figure 17: Date syrup, A: Gebouri, B: Garbai

4.2. Physicochemical analysis

4.2.1. Total Soluble Solids (T.S.S%)

The T.S.S% results for date syrup samples are organized in the following chart (Fig.18):

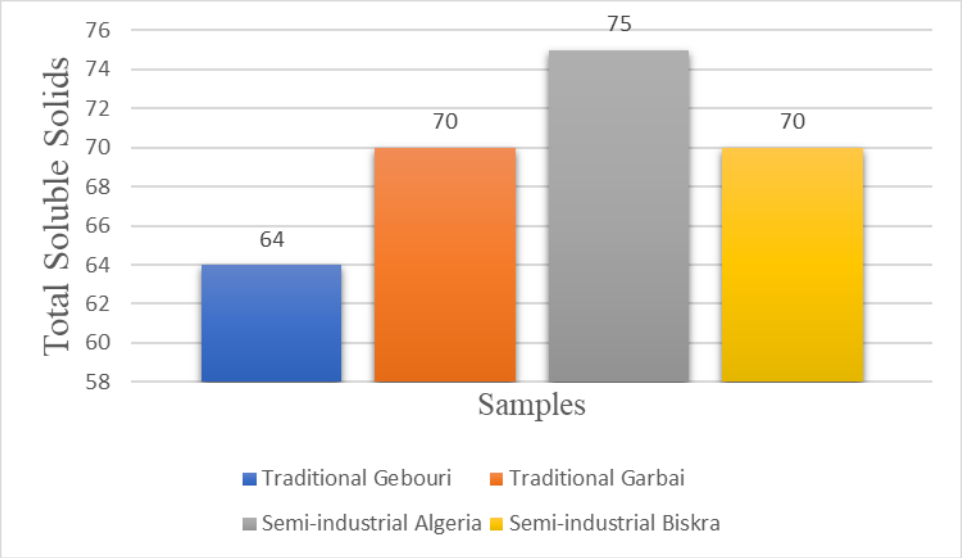


Figure 18: Total Soluble Solids of date syrup samples

The chart shows the results we obtained for T.S.S (%), where the highest value was recorded for semi-industrial Algeria date syrup (75%), while the lowest value was for traditional Garbai date syrup (64%), while for semi-industrial date syrup Biskra (70%) and traditional Gebouri date syrup (70%) were aligned with each other.

The statistical analyzes (Tabl.04) has shown that the results are very highly significant (<0.0001):

Table 04: Analysis of variance (Total Soluble Solids)

Source	Degrees of Freedom	Sum of Squares	Mean squares	F	Pr > F	Significance codes of p-values
Model	3,000	193,000	64,333	193,000	**<0,0001**	***
Error	8,000	2,667	0,333			
Corrected Total	11,000	195,667				

Computed against the model Y = Mean(Y)

*Significance codes : 0 < *** < 0.001 < ** < 0.01 < * < 0.05 < . < 0.1 < ° < 1*

*** (highly significant) / ** (very significant) / * (significant)

. (marginally significant) / ° (not significant)

The TSS values obtained in our study for traditional stored date syrup (66%) and Garbai date syrup (64%) fall within the range reported by (**Laouar et al., 2021**) (64–75%). However, they are lower than those documented by **Maimouni (2009)** (72.66–74.88%). Similarly, the TSS content of traditional Gebouri date syrup (70%) close to the findings of **(Belguedj et al., 2015)** (71.5–78.7%).

The difference of the initial quantity of soluble solids is related to the extraction method used as well as the concentration method (**Belguedj et al., 2015; Burapalit, 2018**), and the quality of dates and the pulp:water ratios have an effect on the concentration of soluble solids in date syrup (**Abbès et al., 2011**).

4.2.2. Electrical Conductivity

The results we obtained showed that the conductivity was high for Gebouri traditional date syrup, Garbai traditional date syrup, and semi-industrial Biskra date syrup 2840 µS/cm, 1130 µS/cm, 955 µS/cm, respectively. While it was low for semi-industrial Algerian date syrup 277 µS/cm. (Fig. 19)

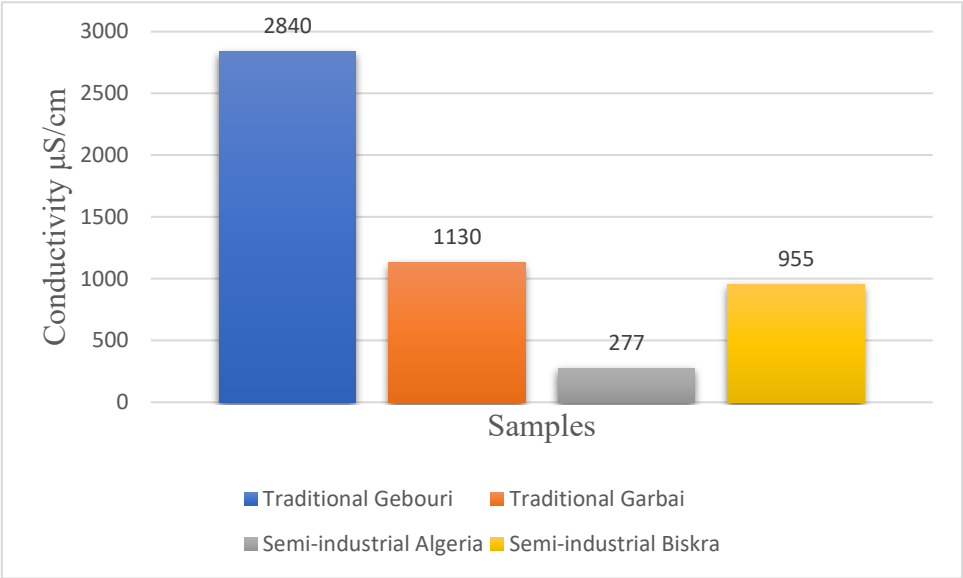


Figure 19: Electrical conductivity of date syrup samples

The statistical analyzes (Tabl.05) has shown that the results are very highly significant (<0.0001):

Table 05: Analysis of variance (Conductivity µS/cm)

Source	Degrees of Freedom	Sum of squares	Mean Squares	F	Pr > F	Significance codes of p-values
Model	3,000	10697468,250	3565822,750	2536,448	**<0,0001**	***
Error	8,000	11246,667	1405,833			
Corrected Total	11,000	10708714,917				

Computed against the model Y = Mean(Y)

*Signifiance codes : 0 < *** < 0.001 < ** < 0.01 < * < 0.05 < . < 0.1 < ° < 1*

*** (highly significant) / ** (very significant) / * (significant)*

. (marginally significant) / ° (not significant)

Our results were compared with **Zaied and Meddas, (2023)** results, as they were approximately within the same ranges, where the aforementioned conductivity values were between 1.39 µS/cm and 2.4 µS/cm. Compared to **Benyagoub et al., (2011)** results 3.38 µS/cm & 3.73 µS/cm were low.

This difference in results is due to several factors, such as the quality of the dates, their mineral composition, the quality of the used water or temperature, as well as viscosity, which affects the movement of ions (**Mimouni, 2009; Zaied and Meddas, 2023**).

4.2.3. Moisture Content

The results of the humidity obtained for all samples are shown in the following figure:

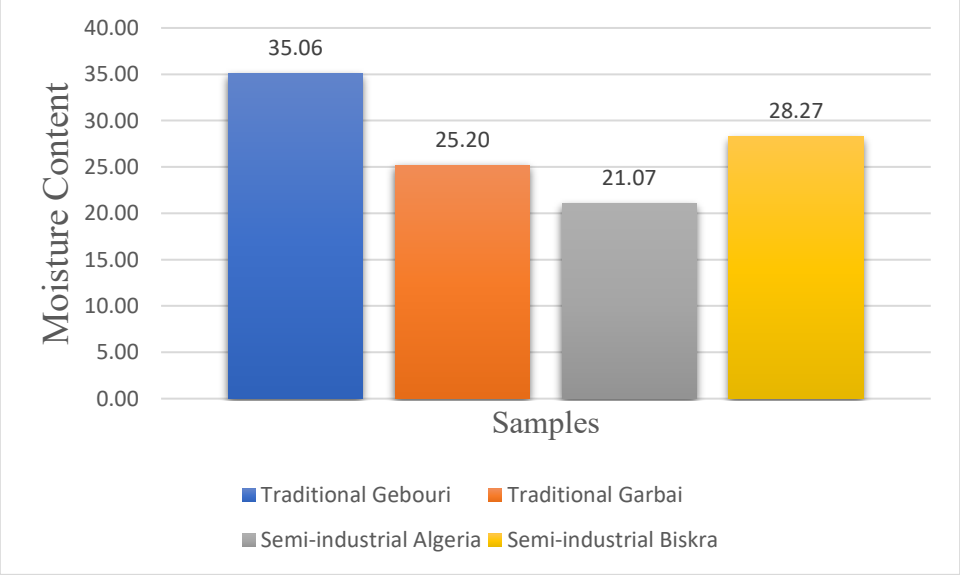


Figure 20: Moisture Content of date syrups

The results vary from 21.07% to 35.06%, where the highest percentage was for traditional date syrup Gebouri 35.06%, while the lowest percentage was for semi-industrial date syrup Algeria 21.07%.

The statistical analyzes (Tab. 06) has shown that the results are very highly significant (<0.0001):

Table 06: Analysis of variance (Humidity%)

Source	Degrees of Freedom	Sum of Squares	Mean Squares	F	Pr > F	Significance codes of p-values
Model	3,000	312,980	104,327	710,552	**<0,0001**	***
Error	8,000	1,175	0,147			
Corrected Total	11,000	314,155				

Computed against the model Y = Mean(Y)

*Significance codes : 0 < *** < 0.001 < ** < 0.01 < * < 0.05 < . < 0.1 < ° < 1*

*** (highly significant) / ** (very significant) / * (significant)

. (marginally significant) / ° (not significant)

The humidity level in the traditional date syrup Gebouri 35.06%, traditional date Garbai 25.20% was high compared to the results presented by (**Al-Houthi et al., 2002**) 16.76%-16.25 % and (**Farahnaky et al., 2020**) 24.07%.

The humidity of the traditional date syrup Garbai 25.20% was lower than traditional date syrup Gebouri 35.06%, which protects it from microbial alteration risks (**Abdelfatah, 1990**). The difference in results related to the methods of preparing date syrups and pulp:water ratios (**Boussaid,2020**).

Water activity is considered one of the most subtle parameters to govern the kinetics of food degradation, so even slight changes would drastically alter the speed of microbial growth and biochemical reactions. Water is broadly recognized as a life-sustaining medium for microorganisms, and it is this availability that plays a key role in microbial growth in foods. While low water values tend toward product stability and shelf life, a higher water content in date syrup seems to encourage spoilage microorganisms such as molds, yeasts, and aerobic mesophilic flora. These findings reveal how much importance is attributed to water content in

terms of safety and preservation potential for traditional date syrups (**Seddiki and Seddiki, 2024; Elmejhed et al., 2024)**.

4.2.4. Determination of pH

The pH results for each sample varied, and the values ranged between 4.34 and 4.92, as shown in the following Figure:

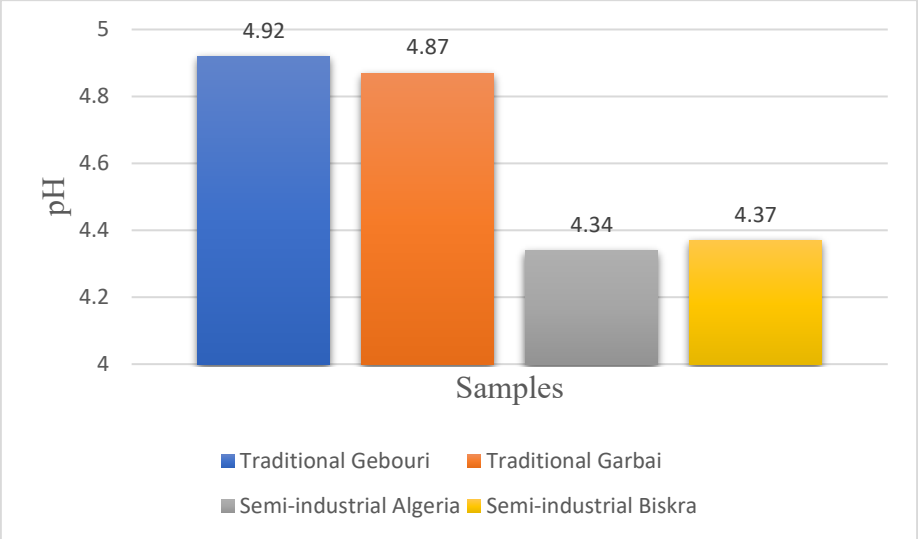


Figure 21: pH values of the date syrups studied.

The results showed that the pH value of semi- industrial date syrup in Algeria, as well as semi- industrial date syrup in Biskra, was low 4.34±0.03, 4.38±0.01, respectively, as for the traditional date syrup Gebouri, and the traditional date syrup Garbai were the highest 4.92±0.04, 4.87±0.05 respectively.

The statistical analyzes (Tab.07) has shown that the results are very highly significant (<0.0001):

Table 07: Analysis of variance (pH%)

Source	Degrees of Freedom	Sum of Squares	Mean Squares	F	Pr > F	Significance codes of p-values
Model	3,000	0,910	0,303	194,658	**<0,0001**	***
Error	8,000	0,012	0,002			
Corrected Total	11,000	0,922				

Computed against the model Y = Mean(Y)

Signifiance codes : 0 < *** < 0.001 < ** < 0.01 < * < 0.05 < . < 0.1 < ° < 1

*** (highly significant) / ** (very significant) / * (significant)

. (marginally significant) / ° (not significant)

The pH value of traditional Gebouri date syrup of 4.92 is close to the value mentioned by (**Maimouni and Siboukeur, 2011**) of 4.90±0.02 for date syrup "Ghars".

The pH value of a food item also comes as a deciding parameter for the type of microorganisms which are able to survive and thrive in the medium. In the case of date syrup, pH variations during the storage duration may affect microbial stability as well as microbial activity directly. The lower pH also prevents the growth of many varieties of spoilage as well as pathogenic microorganisms, and the higher pH might help the environment for microbial growth (**Adegbanke et al., 2025**). The pH level of the date syrup thus becomes a significant parameter for determining the latter's microbiological safety as well as shelf-life quality.

These changes in the pH value are due to several reasons, including the quality of dates as well as temperature due to thermal degradation of sugars into organic acids and potential addition of preservatives (**Mimouni and Siboukeur, 2011**).

4.2.5. Titratable acidity

The results for the acidity obtained were: 1.02(g/100g), 1.12(g/100g), 1.70(g/100g), 2.07, for traditional date syrup Gebouri, traditional date syrup Garbaai, semi-industrial date syrup Algeria, and semi-industrial date syrup Biskra, respectively (Fig.22).

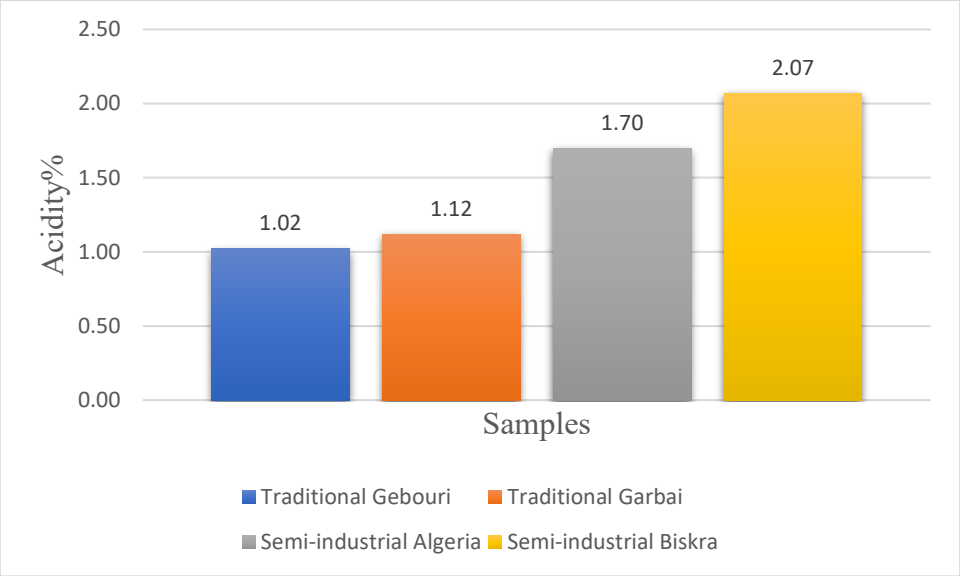


Figure 22: Titratable acidity values of dates syrup samples

The statistical analyzes (Tab.08) has shown that the results are very highly significant (<0.0001):

Table 08: Analysis of variance (Titratable acidity)

Source	Degrees of Freedom	Sum of Squares	Mean Squares	F	Pr > F	Significance codes of p-values
Model	3,000	2,211	0,737	4422,183	**<0,0001**	***
Error	8,000	0,001	0,000			
Corrected Total	11,000	2,212				

Computed against the model Y = Mean(Y)

Signifiance codes : 0 < *** < 0.001 < ** < 0.01 < * < 0.05 < . < 0.1 < ° < 1

*** (highly significant) / ** (very significant) / * (significant)

. (marginally significant) / ° (not significant)

Our results of 1.02(g/100), 1.12(g/100g), 1.03(g/100g) are higher than the results obtained by (**Zaied and Meddas, 2023**) 0.51g/100g, 0.74g/100g for date syrup "Ghars". Despite this, it is lower than the results obtained by (**Djafri et al., 2020**) 4.48g/100g for date syrup "Ghars".

Acidity not only serves as a principal parameter for the microbial stability of date syrup but also significantly influences the latter's organoleptic characteristics. An increase in acidity may also affect the eventual general taste of the syrup, as increased acidity would tend to give a less sweet but a sharper sensation potentially impacting the balance/ sweetness perception of the syrup **(Adegbanke et al., 2025)**. The latter variation during the span of storage may thus serve a double impact: one affecting the potential for microbial growth, the other the product's organoleptic properties

These differences are due to diverse sugar profiles (e.g., fructose/glucose ratios) and thermal decomposition during processing, which generates organic acids (**Al-Farsi et al., 2005**).

4.3. Microbiological Analyses

The health quality of the food product is one of the first concerns in the world, and conducting microbiological analyzes is considered one of the most important procedures. For example, the number of germs is often high in fruit juice, despite extraction processes and heat treatments, but they cannot improve the health quality of the food if the raw material is of poor quality (**Mimouni et al., 2022**).

In our study, we conducted microbiological analysis on date syrup samples in order to detect the following microorganisms: Total coliforms, Fecal coliforms, Total Mesophilic Aerobic Microflora, Yeast and Molds.

The results of the microbiological analyzes we performed are shown in the following table:

Table 09: Microbiological analyzes of syrup samples after 72h.

Samples	Microorganismes cfu/ml			
	Total coliforms	Fecal coliforms	Total Mesophilic Aerobic Microflora	Yeast and Molds
Gebouri traditional date syrup	Absence	Absence	Absence	Absence
Garbai traditional date syrup	Absence	Absence	4.2×10^{3}	Presence
Semi-industrial date syrup Algeria	Absence	Absence	Absence	Presence
Semi-industrial date syrup Biskra	Absence	Absence	Absence	Absence
Stored traditional date syrup	Absence	Absence	3.63×10^{3}	Absence
Norme	10^{6}	310^{3}	$<10^{5}$	10^{3}

This table shows the results in “CFU/ml” of the microbiological analyzes that we conducted for 5 different samples of date syrup, Gebouri traditional date syrup, Garbai traditional date syrup, stored traditional date syrup, which we prepared, as well as semi-industrial date syrup Algeria and semi-industrial date syrup Biskra, which are syrup of dates sold on the market in Laghouat.

These results showed the complete absence or low presence of these germs (<15) of the germs that were searched for, such as: Total coliforms and Fecal coliforms, same results mentioned at (**Attallah et al., 2021; Barkat, 2024**). Also, Total Mesophilic Aerobic Microflora appeared only in the sample 02 “Garbai traditional date syrup”, and the sample 05 “Stored traditional date syrup”. While Yeast and Molds appeared in samples 02 “Garbai traditional date syrup”, and 03 “semi-industrial date syrup Algeria” only.

The results were compared according to the standards set by the Official Gazette of the Republic of Algeria (**J.O.R.A N° 39 du 02 Juillet, 2017**).

The presence of Total Mesophilic Aerobic Microflora in the sample 02 “Garbai traditional date syrup”, and the sample 05 “Stored traditional date syrup” (4.2×10^{3} CFU/ml - 3.63×10^{3}

CFU/ml) did not exceed critical values < 10^5 > related to international Algerian standards (**J.O.R.A N° 39 du 02 Juillet, 2017**). The results also showed the presence of fungi in the traditional date syrup Gqrbaai and the semi-industrial date syrup Algeria at a very small numbers <5.

❖ **Total Mesophilic Aerobic Microflora**

The following figure shows the total mesophilic aerobic microflora that appeared in traditional date syrup Garbai:

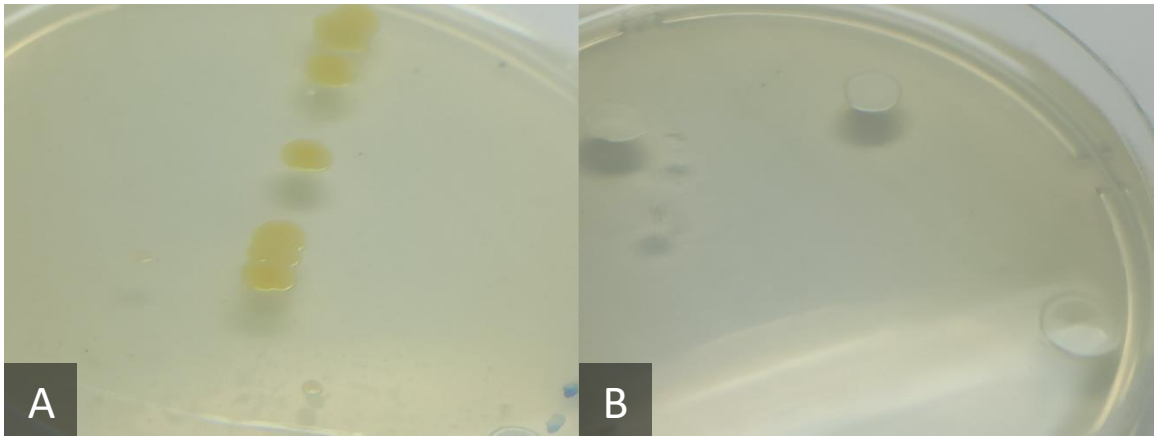


Figure 23: Macroscopic observation of colonies developed on the PCA medium. (Original, 2025).

The colonies appear in the picture with the characteristics:

-A: The colony appeared small, circular with undulate margins, slightly raised, smooth and glistening in surface, mucoid and viscid in consistency, and yellow in color.

-B: The colony appeared small, circular with entire margins, slightly raised, smooth and glistening in surface, mucoid and viscid in consistency, and white in color.

❖ **Yeast and Molds**

The following figure shows one of the germs that multiplied in a sample of traditional date syrup Garbai, and in semi-industrial date syrups Algeria:

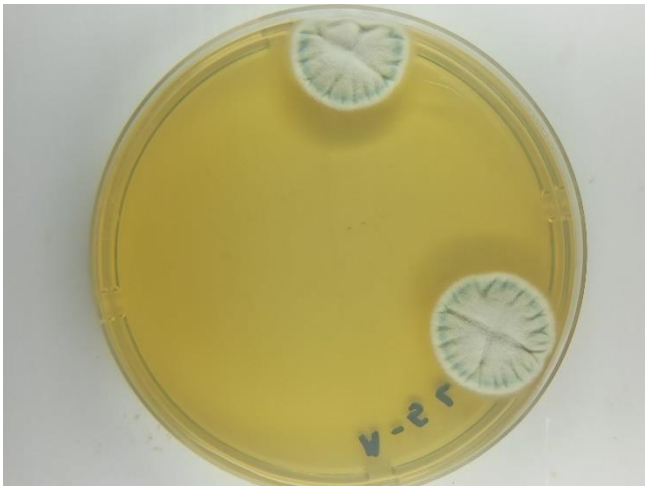


Figure 24: Macroscopic observation of molds in culture medium (Original, 2025)

Regardless of the mineral and carbohydrate components of date syrup that make it a suitable environment for microorganisms, it is characterized by a high concentration of sugars, as well as a pH that makes it unsuitable for disease-causing microorganisms (**Mimouni et al., 2022**). This may explain the absence of Total coliforms and Fecal coliforms in the results of all date syrup samples studied.

On the other hand, these properties, along with the percentage of water in date syrup, are considered a preferred environment for yeasts and fungi due to their excessive growth in environments or foods with relatively high humidity (**Beuchat, 1983**).

The germs that appeared in the samples we studied are due to contamination that occurred during one of the production stages or during storage, and may have occurred during the analysis procedure (**Guiraud, 2012; Guiraud, and Rosec, 2004**).

- In addition to the comparative analysis between the different types of date syrup, particular attention was given to evaluating the effect of storage time on syrup quality. For this purpose, the physicochemical parameters of the same date syrup sample were assessed before storage and after a two-year storage period at 4°C, without the addition of preservatives. (Tab.10) shows the changes that occurred in the values of physicochemical properties during the storage period.

Table 10: Physiochemical properties before and after storage

Parameters	New syrup	Stored syrup
pH	4.92	4.38
Conductivity µS/cm	2840	1296
D° Brix %	64	66
Humidity %	35.06	30.80
Acidity (g/100g)	1.02	1.03

As shown in the (Tab.10), the pH of the syrup decreased by 4.38 to 4.38 from 4.92 to 4.38, the same result is mentioned by **Elhefian (2024)**, indicating a slight increase in acidity over time. Electrical conductivity also decreased significantly from 2840 µs/cm to 1296/s/cm, which suggests a decrease in soluble ions during storage. The ° Brix value increased from 64% to 66%, while the humidity declined from 35.06% to 30.80%, showing water loss in the storage period. The total acidity remained relatively stable, slightly changed from 1.02 to 1.03 g/100 g. Overall, these results indicate that storage at 4 ° C leads to a slight change in the syrup structure, slight acidification, concentration of soluble solids and lack of water content, while the total acidity remains almost constant.

One of the reasons for the low pH may be the bacterial activity of the aerobic flora, as shown by the results of microbiological analyses. According to **Guiraud (2012)**, the development of aerobic mesophilic flora in food matrices is frequently linked to biochemical modifications, including acidification, which alters the physicochemical balance of the product. In sugar-rich products such as date syrup, even low levels of contamination can cause significant changes in acidity during extended storage, as observed in our results.

Conclusion

The present study highlighted the significance of valorizing low-nice Algerian dates via the traditional production of date syrup, by that specialize in Gerbai and Gebouri varieties, which might be regularly omitted in commercial markets due to their limited consumer appeal, this work established that such cultivars can serve valuable raw materials for producing syrups with acceptable physico-chemical and microbiological characteristics. The syrups produced are secure and practical, and the outcomes show that they may be in compliance with international standards in phrases of °Brix, pH, moisture content material, acidity, and conductivity.

The analyses showed clear differences in °Brix, moisture, acidity, and electrical conductivity between the samples, largely reflecting the influence of the date varieties as well as the processing and production methods applied. From a microbiological standpoint, the findings were largely reassuring, as most samples met the required safety standards, confirming the overall quality and suitability of the product.

TSS level differed between 64% for traditional Garbai syrup and reached up to 75% for semi-industrial Algerian syrup, while traditional Gebouri and semi-industrial Biskra syrups were the same at 70%. The level of moisture differed between 21.07% (semi-industrial Algeria) and reached up to 35.06% (traditional Gebouri), which reflects the variation by the treatment process. The pH level for traditional syrups (Gebouri: 4.92, Garbai: 4.87) differed compared with semi-industrial syrups (Algeria: 4.34, Biskra: 4.38). The acidity level reflected the inverse situation from a level of 1.02 g/100 g for Gebouri syrup up to a level of 2.07 g/100 g for Biskra syrup. Electrical conductivity reached the maximum for traditional Gebouri (2840 µS/cm) but reached the minimum for semi-industrial Algeria (277 µS/cm).

Interestingly, the study on long-term storage (two years) showed that the produced date syrup retained good stability and flexibility, with only minor changes in its physicochemical properties. These variations can be attributed to natural chemical and enzymatic reactions occurring during the storage period (**Jafarnia et al., 2016**).

In the end, this work adds useful knowledge for both scientists and local producers looking to make better date syrup in Algeria. We showed that even date varieties often seen as 'low quality' can be turned into a valuable product. We also learned how the syrup changes when stored for a long time. These findings are a practical guide for improving how we make and preserve syrup.

Looking ahead, there are several prospectives areas for further research and improvement based on the findings of this thesis:

- Study the properties of date syrup extracted from another type of low-quality dates.
- Improving the traditional extraction method.
- Add natural additives to maintain quality for a longer period of time.

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Appendices

Appendix A: Date syrup production (Original, 2025)

Appendix B: Growth medium

SDA = Sabouraud Dextrose Agar

Dextrose	**40.00 g**
Peptone	**10.00 g**
Agar	**15.00 g**
pH	**5.6 ± 0.2**

VRBL = Violet Red Bile Lactose Agar

Peptone	**7.00 g**
Yeast extract	**3.00 g**
Bile salts	**1.50 g**
Lactose	**10.00 g**
Sodium chloride	**5.00 g**
Neutral red	**0.03 g**
Crystal violet	**0.002 g**
Agar	**15.00 g**
pH	**7.4 ± 0.2**

PCA = Plate Count Agar

Casein peptone	**5.00 g**
Yeast extract	**2.50 g**
Glucose	**1.00 g**
Agar	**15.00 g**
pH	**7.0 ± 0.2**