

الجمهورية الجزائرية الديمقراطية الشعبية

ALGERIAN DEMOCRATIC AND PEOPLE'S REPUBLIC

Ministry of Higher Education  
and Scientific Research  
Chadli Bendjedid University  
El Tarf

Faculty of Natural and Life Sciences  
Department of Agronomic Sciences



جامعة الشاذلي بن جديد  
UNIVERSITE CHADLI BENDJEDID



وزارة التعليم العالي و البحث العلمي  
جامعة الشاذلي بن جديد  
الطارف

كلية علوم الطبيعة و الحياة

قسم العلوم الزراعية

Thesis

Presented with a view to obtaining a Master 2 Research Diploma  
«"Food Safety & Quality Assurance»

**Evaluation of the physicochemical, sensory properties  
and antioxidant activity of strawberry jellies made with  
natural pectins extracted from quince peel and seeds.**

THEME

Defended on: 24/06/2024

Presented by: **Miss BELHANI Soumaya**

In front of the following examination committee:

ALAYAT Amel	MCA	President	UCBET
BENMEZIANE Farida	Pr	Reviewer	UCBET
BOUANANI Samia	MCA	Supervisor	UCBET

**Academic year 2023–2024**

جامعة الشاذلي بن جديد الطارف - برقم 37 الطارف - الجزائر

Chadli Bendjedid University. El Tarf. BP: 37, El Tarf 76000 Algeria

فاكس +21338.30.15.28:الهاتف:08.97/73.70.13.87317/+

Phone:+21338.30.18.93/09.43/Fax:+21338.30.15.28http://www.univ-eltarf.dz

# *Gratitude*

First and foremost, I would like to thank Almighty God for giving me the strength, willpower and patience to complete this modest work.

I would like to express my most sincere thanks to my supervisor, Madame Bouanani Samia, who directed my work with great scientific rigor, patience, advice and availability throughout the production of this dissertation, as well as for the time he was willing to devote to us, without which this dissertation would never have seen the light of day.

I would like to express my deepest thanks to the members of the jury who agreed to judge our research:

-Madame Alayat Amel (MCA) for agreeing to chair the jury.

- Madame Benmeziane Farida (Pr), jury examiner.

We would like to express our sincere thanks to the entire team at the laboratory where we carried out our practical work.

We would also like to thank the staff at CARA for their hospitality and help.

Without forgetting all the professors who gave me the knowledge during these five university years.

I would also like to thank my family for their support throughout my studies and during the completion of this work.

I would like to thank all those who have contributed in any way to the realization of this work.

# *Dedication*

*Praise be to God with love, thanks and gratitude for the beginning and the end.*

*The journey was not short and should not have been the dream was not close, nor was the road fraught with facilities after five years of fatigue and hardship; here I am today standing on the threshold of my graduation, reaping the fruits of my labor and raising my hat with pride.*

*O God, praise be to you before you are satisfied, praise be to you if you are satisfied, and praise be to you after satisfaction because you helped me to complete this success.*

*With all love, I dedicate the fruit of my success and graduation*

*To the one who decorated my name with the most beautiful titles, who supported me without limits and gave me freely for nothing, to the one who taught me that the world is a struggle and its weapon is knowledge,*

*My first supporter in my journey, my support, my strength and my refuge after God, my pride and honor, my father*

*To the one who made paradise under her feet, embraced me with her heart before her hand, and facilitated my adversity with her prayers to the tender heart and the candle that was for me in the dark nights, the secret of my strength and success, my paradise, my mother.*

*To the one who supported me with love when I was in need, to the one who strengthened me and was the best help, to my brother.*

*To the angels that God blessed me with to know through them the taste of beautiful life, those angels who changed the concepts of love, friendship and support in my life, my sisters.*

*To the friends of the years, the companions of adversity and the inspirations of my success, to those who extended a helping hand to me when I needed it, my dear friends.*

## **Abstract**

Many research studies are focusing on improving the waste management system by extracting bioactive compounds and creating value-added products from various fruit wastes. The main objective of this study is to valorize quince by-products (peel and seeds) by pectin extraction and characterization, and to explore the effect of these pectins as natural gelling agents on the overall quality of strawberry jellies during 90 days of storage. All prepared samples (quince by-product powders and jellies) were analyzed for physicochemical properties bioactive content and antioxidant activity. The sensory profile of the prepared jellies was also studied. Pectin quality parameters such as equivalent weight, methoxyl content, galacturonic acid content and degree of esterification (over 70%), were found to be satisfactory. The results of the physicochemical analysis indicate that the extracted pectins have properties similar to those of commercial pectin. The prepared jellies recorded the highest levels of bioactive molecules and antioxidant activity. However, the results of sensory analysis revealed a slight loss in terms of color, taste, texture and overall acceptability during storage for CJ and QP4J jellies. Consequently, the results obtained proved that pectin extracted from quince peels (QP2J) improved the various sensory attributes of strawberry jelly in comparison with commercial pectin. Therefore, it can be concluded that pectin extracted from quince peel can be a better substitute for commercial pectin.

**Key words:** Valorization, quince peel and seeds, pectin, strawberry jellies, physicochemical characterization, bioactive molecules, antioxidant activity, sensory analysis.

## Résumé

De nombreuses recherches s'intéressent à l'amélioration du système de gestion des déchets par l'extraction de composés bioactifs, la création de produits à valeur ajoutée à partir de divers déchets fruits. L'objectif principal de cette étude est une valorisation de sous-produits de coing (pelure et pépins) par extraction et caractérisation de pectines ainsi que d'explorer l'effet des pectines extraites en tant que gélifiant naturel sur la qualité globale des gelées de fraise pendant 90 jours de stockage. Tous les échantillons préparés (poudre de sous-produits de coing et gelées) ont fait l'objet d'une étude des propriétés physico-chimiques, du contenu bioactif et de l'activité antioxydante. De plus, le profil sensoriel des gelées préparées a été également estimé. Les paramètres de qualité de la pectine tels que le poids équivalent, la teneur en méthoxyle, la teneur en acide galacturonique et le degré d'estérification (supérieur à 70 %), ont été jugés satisfaisants. Les résultats d'analyses physico-chimiques indiquent que les pectines extraites présentent des propriétés assez comparables avec la pectine commerciale. Ces gelées préparées ont enregistré les teneurs en molécules bioactives et activité antioxydante les plus élevées. Cependant, les résultats de l'analyse sensorielle ont révélé une légère perte en termes de couleur, de goût, de texture et d'acceptabilité globale pendant l'entreposage pour les gelées CJ et QP4J. Par conséquent, les résultats obtenus ont prouvé que la pectine extraite des pelures de coing (QP2J) avait un meilleur effet sur la qualité de la gelée de fraise que celle du contrôle. On peut donc conclure que la pectine extraite de pelure de coing peut être un meilleur substitut de la pectine commerciale.

**Mots clés :** Valorisation, pelure et pépins de coings, pectine, gelées de fraise, caractérisation physicochimique, molécules bioactives, activité antioxydante, analyses sensorielles.

## ملخص

تركز العديد من الدراسات البحثية على تحسين نظام إدارة النفايات من خلال استخلاص المركبات النشطة بيولوجيًا وإنتاج منتجات ذات قيمة مضافة من مختلف مخلفات الفاكهة. والهدف الرئيسي من هذه الدراسة هو تثمين المنتجات الثانوية للسفرجل (القشر والبذور) عن طريق استخلاص البكتين وتوصيفه، واستكشاف تأثير هذه البكتينات كعامل تبلور طبيعي على الجودة العامة لهلام الفراولة خلال 90 يومًا من التخزين. وقد تم تحليل جميع العينات المحضرة (مساحيق المنتجات الثانوية للسفرجل والهلام) من حيث المعايير الفيزيائية والكيميائية والمحتوى النشط بيولوجيًا والنشاط المضاد للأكسدة. كما تمت دراسة المظهر الحسي للهلام المحضر. وقد وجد أن معايير جودة البكتين مثل الوزن المكافئ ومحتوى الميثوكسيل ومحتوى حمض الجالاكتورونيك ودرجة الأسترة (أكثر من 70%) كانت مرضية. تشير نتائج التحليل الفيزيائي-الكيميائي إلى أن البكتين المستخلص له خصائص مماثلة إلى حد ما للبكتين التجاري. سجلت هذه الجيلي المحضرة أعلى مستويات من الجزيئات النشطة بيولوجيًا والنشاط المضاد للأكسدة. ومع ذلك، كشفت نتائج التحليل الحسي عن فقدان طفيف من حيث وبالتالي، فإن النتائج التي تم الحصول عليها أثبتت QP4J و CJ اللون والطعم والملمس والقبول العام أثناء التخزين لهلام حسن السمات الحسية المختلفة لجيلي الفراولة مقارنة بالبكتين (QP2J) أن البكتين المستخلص من قشور السفرجل التجاري. لذلك، يمكن استنتاج أن البكتين المستخرج من المنتجات الثانوية للسفرجل يمكن أن يكون بديلاً أفضل للبكتين التجاري.

**الكلمات الرئيسية:** التثمين، قشر السفرجل والبذور، البكتين، جيلي الفراولة، التوصيف الفيزيائي الكيميائي، الجزيئات النشطة بيولوجيًا، النشاط المضاد للأكسدة، التحليل الحسي.

## List of figures

	<b>Title</b>	<b>Page</b>
<b>Figure 1</b>	Photograph of the quince <i>Cydonia oblonga</i> .	<b>04</b>
<b>Figure 2</b>	Pectin molecule.	<b>09</b>
<b>Figure 3</b>	Pectin stability.	<b>11</b>
<b>Figure 4</b>	$\beta$ -elimination reaction.	<b>11</b>
<b>Figure 5</b>	Gelation as a function of pH and sugar concentration.	<b>12</b>
<b>Figure 6</b>	The different applications of pectin.	<b>14</b>
<b>Figure 7</b>	Simplified diagram of jam, jelly and marmalade production.	<b>17</b>
<b>Figure 8</b>	Raw materials used for pectin extraction.	<b>19</b>
<b>Figure 9</b>	Raw materials used to produce jellies.	<b>20</b>
<b>Figure 10</b>	Diagram of pectin extraction from quince peels.	<b>22</b>
<b>Figure 11</b>	Diagram of pectin extraction from quince seeds.	<b>23</b>
<b>Figure 12</b>	Determination of pectin physicochemical characteristics by titrimetric method	<b>24</b>
<b>Figure 13</b>	Jelly preparation diagram	<b>26</b>
<b>Figure 14</b>	pH measurement of prepared jellies	<b>27</b>
<b>Figure 15</b>	$^{\circ}$ Brix determination of strawberry jelly samples	<b>29</b>
<b>Figure 16</b>	Determination of moisture content	<b>30</b>
<b>Figure 17</b>	Determination of Ash content	<b>31</b>
<b>Figure 18</b>	Determination of color index.	<b>31</b>
<b>Figure 19</b>	Tasting session procedure (sample preparation and sensory evaluation sheets)	<b>33</b>
<b>Figure 20</b>	Evaluation of pH values of strawberry jellies.	<b>40</b>
<b>Figure 21</b>	Titrateable acidity values.	<b>41</b>
<b>Figure 22</b>	Total soluble solids and moisture content of strawberry jellies.	<b>42</b>
<b>Figure 23</b>	Ash content of strawberry jellies.	<b>43</b>
<b>Figure 24</b>	Color index values of strawberry jellies.	<b>44</b>
<b>Figure 25</b>	Evaluation of non-enzymatic browning of strawberry jellies.	<b>45</b>
<b>Figure 26</b>	Total polyphenol content of strawberry jellies.	<b>46</b>
<b>Figure 27</b>	Total anthocyanin content of strawberry jellies.	<b>47</b>
<b>Figure 28</b>	Total antioxidant activity values of prepared jellies.	<b>48</b>
<b>Figure 29</b>	Sensory attributes of freshly prepared jellies	<b>49</b>
<b>Figure 30</b>	(a) Average scores of jellies overall preference (b)Acceptance percentages of jellies overall preference	<b>51</b>
<b>Figure 31</b>	Sensory attributes of jellies after 03 months of refrigerated storage.	<b>51</b>
<b>Figure 32</b>	(a) Average scores of jellies overall preference (b)Acceptance percentages of jellies overall preference after storage	<b>53</b>

### List of tables

<b>Table 01</b>	Botanical classification of quince	<b>03</b>
<b>Table 02</b>	Assessment of the pectin content of some fruits.	<b>09</b>
<b>Table 03</b>	Characteristics of commercial pectin	<b>13</b>
<b>Table 04</b>	Physical, morphological and sensory characteristics of quince fruit.	<b>35</b>
<b>Table 05</b>	Physicochemical characteristics of quince peel and seeds powders.	<b>35</b>
<b>Table 06</b>	Physicochemical properties of pectins.	<b>36</b>
<b>Table 07</b>	Evaluation of the flow time of freshly prepared strawberry jellies and after storage.	<b>44</b>

## **List of abbreviations**

**AIS** : alcohol-insoluble substances

**MeO**: methoxyl content

**GUA**: galacturonic acid

**DE**: degree of esterification

**TSS**: Total soluble solids

**DM**: dry matter

**OM**: organic matter

**CCJ**: jelly made with commercial pectin (positive control)

**CJ**: Jelly made without pectin (negative control)

**QP4J**: jelly made with quince peels pectin (4mm)

**QP2J**: jelly made with quince peels pectin (2mm)

**QSJ**: jelly made with quince seeds pectin

**EAA**: equivalent ascorbic acid

**EGA**: equivalent Gallic acid

**QPI4** : Quince pectin peel (4mm)

**QPI2** : Quince pectin peel (2mm)

**PQS**: Quince seeds pectin

# Summary

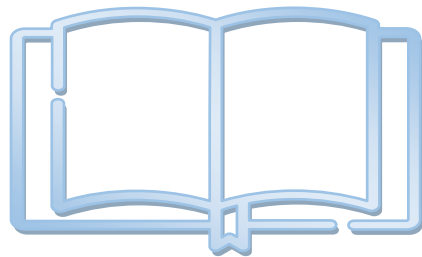
Gratitude	
Dedication	
Abstract	
List of figures	
List of tables	
List of abbreviations	
Introduction.....	<b>01</b>
I. Quince- General information.....	<b>03</b>
I.1. History.....	<b>03</b>
I.2. Classification and botanical description of quince fruit .....	<b>03</b>
I.3. Varieties .....	<b>04</b>
I.3.1. <i>Cydonia oblonga</i> « champion ».....	<b>04</b>
I.3.2. <i>Cydonia oblonga</i> « Monstrueux de Vranje ».....	<b>04</b>
I.3.3. <i>Cydonia oblonga</i> « du Portugal ».....	<b>05</b>
I.4. Benefits and uses .....	<b>05</b>
I.5. Use of quince fruit in the food industry.....	<b>05</b>
I.6. Use of quince by-products (peel and seeds) .....	<b>05</b>
II. Definition of pectin .....	<b>08</b>
II.1. Pectin structure.....	<b>08</b>
II.2. Main sources of pectin .....	<b>09</b>
II.3. Physicochemical properties .....	<b>10</b>
II.3.1. Solubility .....	<b>10</b>
II.3.2. Viscosity .....	<b>10</b>
II.3.3. Stability and degradation .....	<b>10</b>
II.3.4. Foaming and gelling properties .....	<b>11</b>
II.4. Optimum conditions for HM pectin gelation .....	<b>12</b>
II.5. Gelation of low-methyl pectin (LM) .....	<b>12</b>
II.6. Degree of HM and LM esterification.....	<b>13</b>
II.7. HM and LM pectin gelling process.....	<b>13</b>
II.8. Pectin applications.....	<b>13</b>
II.8.1. Food additive.....	<b>13</b>
II.8.2. Pharmaceutical industry .....	<b>14</b>
II.9. Pectin extraction and precipitation processes.....	<b>15</b>
III. General information on fruit jellies (strawberries) .....	<b>16</b>
III.1. Definition .....	<b>16</b>
III.2. Main ingredients of Jellies .....	<b>16</b>
III.2.1. Fruits .....	<b>16</b>
III.2.2. Sugar.....	<b>16</b>
III.2.3. Pectin .....	<b>16</b>
III.2.4. Citric acid .....	<b>17</b>
III.3. The manufacturing process .....	<b>17</b>
III.4. Strawberry jelly .....	<b>18</b>

Material And Methods .....	<b>19</b>
I. Materials .....	<b>19</b>
I.1. Plant material .....	<b>19</b>
I.1.1. Other materials.....	<b>20</b>
I.2. Methods.....	<b>20</b>
I.2.1. Physical characterization of quince fruit .....	<b>20</b>
I.2.2. Preparation of quince peel powder.....	<b>20</b>
I.2.3. Pectin extraction.....	<b>21</b>
I.2.3.1. Extraction of pectins (peels, seeds) .....	<b>21</b>
I.3. Physicochemical characterization of pectins .....	<b>24</b>
I.4. Preparation of Strawberry Jelly .....	<b>25</b>
I.5. Physicochemical characteristics of strawberry jellies .....	<b>27</b>
I.5.1. pH determination .....	<b>27</b>
I.5.1.1. Definition.....	<b>27</b>
I.5.1.2. Principle.....	<b>27</b>
I.5.1.3. Procedure .....	<b>27</b>
I.5.2. Titrable Acidity.....	<b>27</b>
I.5.2.1. Definition .....	<b>27</b>
I.5.2.2 Principle .....	<b>28</b>
I.5.2.3. Procedure .....	<b>28</b>
I.5.3. Determination of total soluble solids (°Brix) .....	<b>28</b>
I.5.3.1. Definition .....	<b>28</b>
I.5.3.2. Principle .....	<b>28</b>
I.5.3.3. Procedure .....	<b>28</b>
I.5.4. Moisture assessment (%)......	<b>29</b>
I.5.4.1. Definition.....	<b>29</b>
I.5.4.2. Principle.....	<b>29</b>
I.5.4.3. Procedure.....	<b>29</b>
I.5.5 Ash content (%)......	<b>30</b>
I.5.5.1. Definition .....	<b>30</b>
I.5.5.2. Principle .....	<b>30</b>
I.5.5.3. Procedure.....	<b>30</b>
I.5.6. Color index.....	<b>31</b>
I.5.7. Viscosity of jellies (flow test) .....	<b>31</b>
I.5.8. Determination of the browning index (BI) .....	<b>31</b>
I.5.9. Determination of active molecules.....	<b>32</b>
I.5.9.1. Determination of total anthocyanin content.....	<b>32</b>
I.5.9.1.1. Principle.....	<b>32</b>
I.5.9.2. determination Total phenolic content .....	<b>32</b>
I.5.10. determination Total antioxidant activity.....	<b>32</b>
I.6. Sensory analysis of prepared jellies.....	<b>32</b>
Results And Discussion.....	<b>35</b>
II. Physical characterization of quince fruit.....	<b>35</b>

II.1. Physicochemical properties and bioactive compounds of quince peels and seeds	35
II.2. Physicochemical properties of extracted pectin.....	36
II.2.1. Pectin yield.....	36
II.2.2. Solubility.....	37
II.2.3. Moisture content .....	37
II.2.4. Ash content .....	37
II.2.5. Equivalent weight.....	37
II.2.6. Methoxyl content MeO%.....	38
II.2.7. Galacturonic content %.....	38
II.2.8. Degree of esterification.....	39
II.3. Physicochemical properties and bioactive compounds of strawberry jellies.....	39
II.4. pH and titratable acidity (% citric acid) .....	39
II.5. Total soluble solids (TSS%).....	41
II.6. Moisture content (%).....	41
II.7. Ash % content.....	42
II.8. Color index.....	43
II.9. Viscosity of jellies (Flow test) .....	44
II.10. Non-enzymatic browning of jellies .....	45
II.11. Active molecule content.....	45
II.11.1. Total polyphenols content .....	45
II.11.2. Anthocyanin content.....	46
II.12. Total antioxidant activity.....	47
II.13. Sensory analysis of freshly prepared jelly samples and after 03 months of refrigerated storage	48
II.13.1. Evaluation of organoleptic characteristics of fresh jellies.....	48
II.13.1.1. Texture.....	49
II.13.1.2. Color.....	49
II.13.1.3. Taste.....	49
II.13.1.4. Aroma.....	50
II.13.1.5. Viscosity.....	50
II.13.1.6. Preference.....	50
II.14. Evaluation of organoleptic characteristics of jellies after 3 months' storage.....	51
II.14.1. Texture.....	52
II.14.2. Color.....	52
II.14.3. Taste or flavor.....	52
II.14.4. Aroma.....	52
II.14.5. Viscosity.....	52
II.14.6.Preference.....	52
Conclusion.....	55
References.....	57
Appendix.....	68



# Introduction



## **Introduction**

The importance of fruit for nutrition, health and the economy is well established. They are the best carriers of vitamins, essential minerals, dietary fiber, phenolic antioxidants, glucosinolates and other bioactive substances. In addition to these elements, they also provide carbohydrates and proteins. **(Alzamora et al., 2004).**

The industrial processing of fruit gives rise to a significant production of waste with an impact on the environment. In the Mediterranean region, the fruit processing industry is steadily expanding, recovering a large quantity of by-products that can be used as raw materials in other sectors of the agri-food industry, as foodstuffs or in pharmaceuticals **(Valizadeh and Sobhanirad, 2009).**

A by-product of the manufacturing process in the agri-food industry may first be valorized as a co-product before being considered as waste, in which case certain wastes become genuine raw materials **(Rihani, 1991).**

The valorization of these by-products has become a priority for manufacturers. Indeed, these wastes could be transformed into potentially marketable bio-products, such as pectin and essential oils, which can be extracted from bark and fruit with low market value.

Quince fruit is recognized as an inexpensive and widely available food source for these health benefits **(Karar et al., 2014)**. Several studies have shown its beneficial health properties including strong antioxidant and anti-radical activities, immunomodulatory effects. Quince fruit is an important health-promoting food source with anti-ulcer action and antimicrobial properties **(Antolín-Amérigo et al., 2015; Ercisli et al., 2015)**.

It is widely used in the food industry to produce juice, baby compote, marmalades, jams and jellies, thanks to its high nutritional potential. The highlight of quince is the large amount of pectin, which facilitates the production of the most varied sweets. **(Almeida Lopes, 2018)**. In addition, it also contains a high concentration of polysaccharide, making it a potential source of dietary fiber and pectin **(Elmizadeh et al., 2017)**.

Pectins are polysaccharides also known as polyacids or anionic polymers **(Walstra, 2003)**. These substances have been the subject of a great deal of research into their functions within the plant wall, their chemical structure and their characterization as additives. All this research has led to the development of numerous applications in fields as diverse as cosmetics, plastics and pharmaceuticals, but the most important use is in the food industry

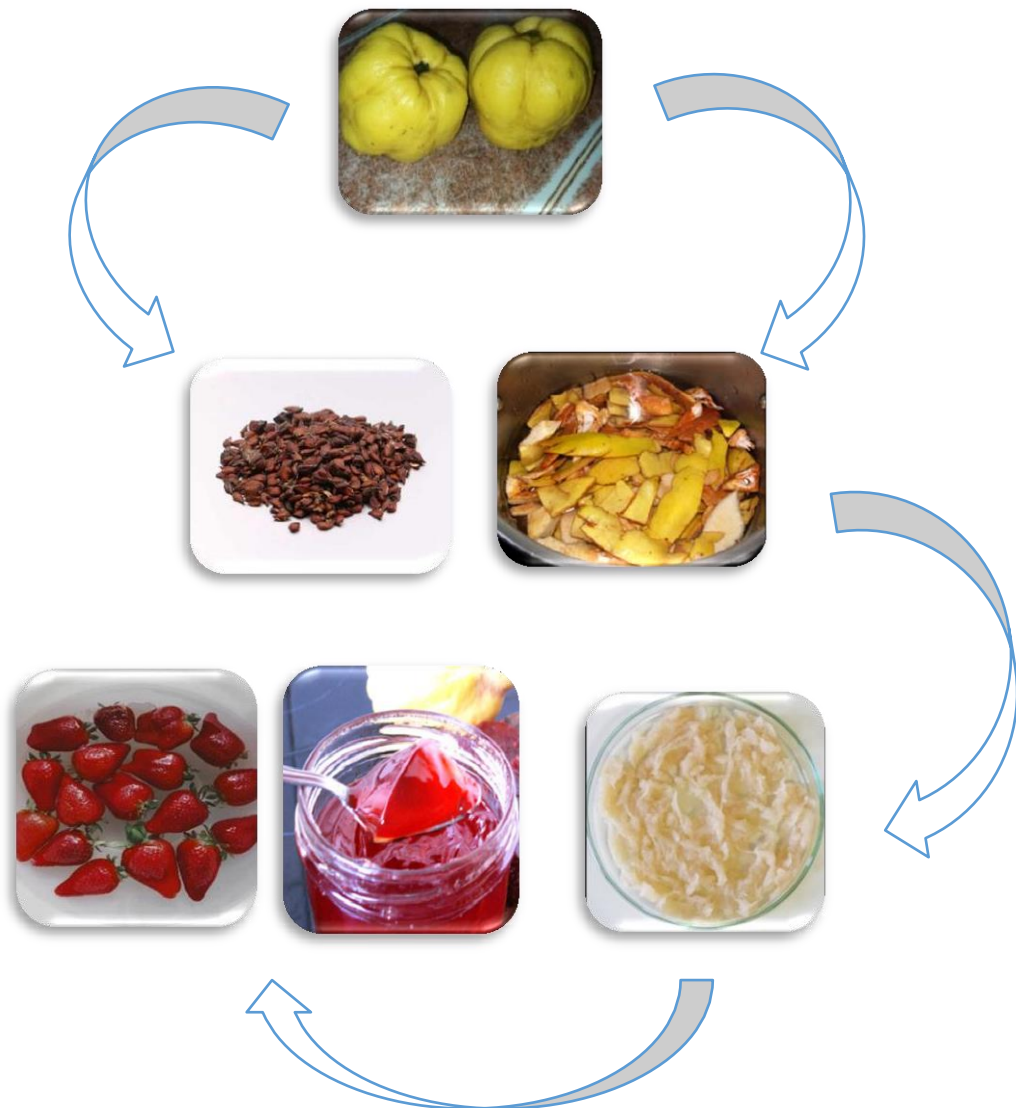
where pectins are mainly used as texture agents, gelling agents, stabilizers and thickeners (**Thakur et al., 1997; Mesbahi et al., 2005**).

Fruits are extremely perishable, as is the case with strawberries. It is a very fragrant, cone-shaped fruit, with achenes forming asperities on the bright red flesh, which ripens in summer on a very low-stemmed plant (**Jules, 2010**). It is generally eaten fresh or processed into products such as juice, nectar, purée, jam, jellies, cream, wine and strawberry syrup (**Jules, 2010; Giampieri et al., 2013**).

Jellies are products prepared from juices and/or aqueous extracts of one or more fruits mixed with sweet-tasting foodstuffs, with or without the addition of water, until a semi-solid jellied consistency is obtained (**Codex CXS 296-2009**).

The aim of this work is to valorize quince by-products (peel and seeds) by extracting and characterizing pectins, and to test their gelling and stabilizing effects in the manufacture of jellies from fruits with a medium-low pectin content, such as strawberries, in comparison with a commercial pectin.

# Part One : Bibliography



## I. Quince- General information

### I.1. History

*Cydonia oblonga* is a fruit tree more commonly known as quince. It belongs to the group of oldest cultural plants originating in Iran, Turkey and extending as far as Greece. It is cultivated in India, South Africa, the Middle East and Europe (Rop et al., 2011 ; Orhan, 2014).

Quince fruit goes by various other names:

Arabic: Sefarjal, Chinese: Wen po, English: quince, French: cognassier or coing, German: quitte or quittenbaum, Portuguese: marmelo, Russian, ajva, Spanish: membrillero, Swedish: kvitten (Almeida Lopes et al., 2018).

The ancient biblical name for quince translates as "Golden Apple" and quince cultivation was a common practice long before today's apple cultivation in the region formerly known as Mesopotamia (present-day Iraq) (Karar, 2014). Quinces are traditionally harvested in this region and then handled, cleaned, separated, then prepared as jam or stored for long winter months for consumption due to the lack of fruit during the season (Ercisli, 2015).

### I.2. Classification and botanical description of quince fruit

The quince tree *Cydonia oblonga* belongs to the Rosaceae family, the only representative of its genus *Cydonia* (Yuksel et al., 2013). It is a small tree (5 to 8 m high and 4 to 6 m wide) with deciduous leaves. Quince is a complex seeded fruit deriving from an infertile ovary (Audrey, 2014).

The quince classification is given as follows:

**Table 01.** Botanical classification of quince (Evreinoff, 1960).

Phylum	Class	Order	Family	Genus	Species
Magnoliophyta	Magnoliopsida	Rosales	Rosaceae	<i>Cydonia</i>	<i>Oblonga</i>

The quince fruit is pearly, golden and fragrant. It has a sour taste and contains seeds surrounded by mucous membranes. They are harvested when their color changes from green to yellow (Nimitula et al., 2005).



**Figure 1.** Photograph of the quince *Cydonia oblonga* (Hussain et al., 2021)

Quince are globular to elongated (6-8 cm in diameter), with an average weight of 50-80 g. The color of the fruit's epidermis changes from brown to light greening the initial development phase, to yellow at maturity. Quince seeds are brown, flattened on both sides and adhere to a white mucilage. There can be up to 50 seeds per fruit, The pulp is yellowish, consistent, slightly sweet, acid and astringent, however the pulp is not consumed in its natural form but is consumed as processed products such as jams, jellies, marmalades, compotes and cakes (Almeida Lopes et al., 2018).

Individual fruits can weigh up to 0.5 kg or more. Ripens in late autumn. Fruits contain seeds, which are poisonous. (Acikgoz, 2011)

### **I.3. Varieties**

Quince is more influenced by temperature than by soil type or rainfall. Quince tolerates heat better than cold, and can survive for long periods without water (Couplan, 2012).

Quince varieties are:

#### **I.3.1. *Cydonia oblonga* « champion »**

Obtained in New Jersey in the 19th century, this fruit has medium-sized pear-shaped berries. Its flesh is slightly yellow, tender and juicy, well-flavored and has a fine taste, making this fruit an ideal accompaniment to meats. The large, heavy fruit can weigh from 1 to 4 kg.

#### **I.3.2. *Cydonia oblonga* « Monstrueux de Vranje »**

It originates from Yugoslavia, where it was obtained in 1898. Elongated and paunchy, it produces very large fruits (some reaching a weight of 1.5 kg), almost hairless, pale green then golden yellow with brown markings, offering firm, delicately flavored flesh (Yamamoto, 2004).

### **I.3.3. *Cydonia oblonga* « du Portugal »**

It can reach 7 m in height. It bears larger flowers that give birth to elongated, slightly ribbed quinces, 8 to 15 cm long, dark yellow and covered with gray down. It should be reserved for southern regions, as it is resistant to cold. The golden, downy skin of the fruit conceals a brittle, yellow, highly-perfumed flesh, ideal for making jellies and liqueurs (Couplan, 2012).

### **I.4. Benefits and uses**

Currently, quince fruit has been recognized as an important and inexpensive source of nutrition that has several benefits for human health thanks to its biologically active ingredients, including antioxidants (Gheisari and Abhari, 2014), anti-ulcer, antimicrobial, antiallergic, anti-reproductive and anti-inflammatory agents (Postman, 2009). The fruit's gum is used in the treatment of burns, coughs, diabetes, urinary tract disorders, respiratory disorders, colds and asthma.

Quince contains high levels of pectin, proteins, amino acids, organic acids, phenols, flavonoids, aromatic oils, volatile terpenoids, vitamins and natural waxy components (Silva et al., 2005).

### **I.5. Use of quince fruit in the food industry**

Quince is mainly used to make marmalade, jams, jellies and cakes (Silva et al., 2004), as well as packaging for food preservation and in the manufacture of ice creams and mixed juices (Oliveira et al., 2007).

Quince has a low fat content and is an important source of organic acids, sugars, crude fiber and minerals such as potassium, phosphorus and calcium, as well as health-promoting constituents such as active phenolic compounds. It is also known to have hypoglycemic, anti-inflammatory, anti-carcinogenic, antimicrobial, anti-allergic and anti-ulcerative properties and act as a heart and brain tonic (Légua, 2013). Quince extracts have also been used in perfumes (Antolinet, 2015).

### **I.6. Use of quince by-products (peel and seeds)**

Quince is already widely used in the food industry for the production of juice, baby compote, marmalades, jams and jellies, thanks to its high nutritional potential. The highlight of quince is its high pectin content, which facilitates the production of a wide variety of sweets.

In agriculture, quince is commonly used as rootstock in apples, improving fruit productivity and quality, as well as propagating easily, and the mucilage involving the seeds can be used as a fruit coating such as gum arabic.

The development of quince fruit research has identified phytochemical compounds, mainly in the leaves and fruit peels, with promising potential for use in other areas through the development of herbal medicines (**Almeida Lopes, 2018**).

The by-products obtained from the industrial processing of vegetables and fruits present a major global issue as they transform into waste. However, their utilization as value-added products can contribute to solving this problem and aid in the recovery of valuable nutrient-rich biomass, such as dietary fibers and polyphenols (**Elleuch, et al., 2011**).

Quince seed extract has shown similar characteristics to Gum Arabic and, thus, has raised some interest among researchers. Quince (scientific name *Cydonia oblonga*) is a fruit native to the West Asian region, and its cultivation is especially high in Caucasus regions, Iran, Afghanistan, Dagestan, and Antalya (**Abbastabar et al., 2015**). The fruit seed mucilage is composed of three polysaccharide fractions, with the major fraction being a graft copolymer with a molecular weight of  $1.4 \times 10^6$  Da. The seed extract has shown very high emulsification and foaming properties (**Deng et al., 2019**). This is related to its high hydrophobic amino acid content, which gives the hydrocolloid exceptional surface activity (**Deng et al., 2019**). However, research up until now has concentrated mainly on the chemical and physical analysis of quince seed mucilage's water-soluble carbohydrates.

Quince juice pomace, another nutrient-rich industrial by-product, was already upcycled as a sustainable source of pectin (**Brown et al., 2014**) and antimicrobial ingredients for chewing candies (**Lele et al., 2018**). Regarding quince peel, it has been described as containing hydroxycinnamic acids (caffeoylquinic acids) and flavonols (quercetin and kaempferol glycoside derivatives), which are also found in the fruit pulp (**Essafi-Benkhadir et al., 2012; Stojanovic et al., 2017**). According to some studies (**B.T. Stojanovic et al., 2017**) (**A.S. Magalhães et al., 2009**), both quince peel and pulp extracts display antioxidant activity, including antihemolytic effects. The peel extract may actually be more effective in scavenging free radicals and inhibiting some microorganisms than the pulp (**Fattouch et al., 2007**). (**Alesiani et al., 2010**) investigated antioxidant and antiproliferative effects of compounds isolated from quince peel.

Previous studies have investigated the properties of the fiber-rich products from quince (*Cydonia oblonga*) wastes after aqueous or ethanol extraction, but they did not evaluate the properties and possible applications of the resulting extracts (**Escalada Pla et al., 2010**)

**(Pereira et al., 2023)**. A recent study analyzed the acetone extraction of *C. oblonga* fruits, but it did not characterize the resulting substrate **(Herrera-Rocha et al., 2022)**. Both extracts and the resulting substrates have been characterized for the peels of *Cydonia oblonga* but not of other by-products **(Othman et al., 2022; Pereira et al., 2023)**. These peel extracts were shown to be rich in polyphenols and have significant antioxidant activity, and the substrate was found to be rich in fiber.

## II. Definition of pectin

Pectin, from the Greek word pektos, meaning “jelly-like”. They were first isolated from plant extracts by Henri Braconnot in 1825. At the beginning of the 20th century, pectin was extracted for the first time.

Pectin is the most structurally complex family of polysaccharides found in nature. It accounts for approximately 35 % of the primary walls of dicots and non-grass monocots, 2-10% of the primary walls of grasses and other commelinoids, and up to 5% of the walls of woody tissues. Pectin is abundant in the walls surrounding growing and dividing cells, in the cell walls of the soft parts of the plant, in the central lamina and in the corners of cells. Pectin is also present in the junction zone between cells with secondary walls, including xylem and fiber cells in woody tissues. Pectin is a component of all the walls of higher plants, and of the walls of gymnosperms, pteridophytes, bryophytes and Chara, a charophycean alga considered the closest existing relative of land plants.

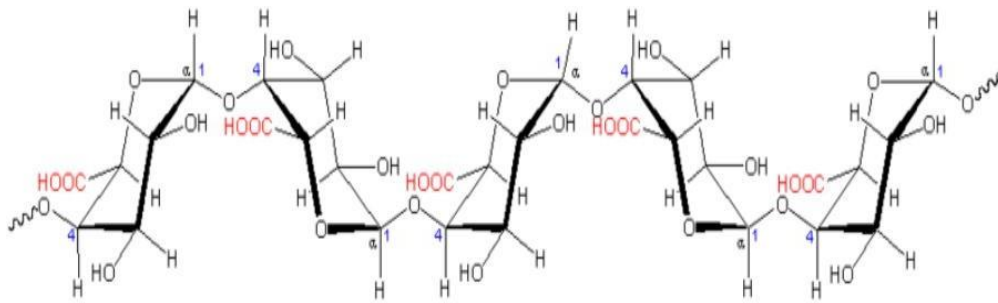
There are many pectic substances, including protopectins, which are hydrolyzed pectins, and pectins, which are partially or fully esterified polygalacturonic acids. Then there are pectinates, which are pectin salts, and pectic acids, which are essentially non-esterified polygalacturonic acids. Finally, pectates are pectic acid salts (**Liu et al., 2003**).

From a nutritional point of view, pectins are considered to be soluble fibers with a high water retention capacity, water being a good solvent for pectin.

### II.1. Pectin structure

Pectins are a family of plant cell wall polysaccharides, rich in galacturonic acid and covalently bonded (**Albersheim et al., 1996**). Galacturonic acid accounts for around 70% of pectin and all pectic polysaccharides contain galacturonic acid bound to the O-1 and O-4 positions.

Pectic polysaccharides are made up of galacturonan and rhamnogalacturonan main chains and arabinan and galactan side chains (**Schols et al., 2002**).



**Figure 2.** Pectin molecule (Schols et al, 2002).

A whole series of substitutions, which rarely make it a simple homogalacturonic structure, can be found along the main chain. Carboxylic acid functions are more or less esterified with methanol (Fishman et al., 1986). Hence the determination of the degree of methoxylation (DM) of pectin, defined as the number of methylated carboxylic functions per hundred galacturonic acid units in the main chain. The three entities, homogalacturonan, rhamnogalacturonan and side chains of neutral oses (galactans, arabans, xylans, etc.) form the constituent domains of pectin (Yapo et al., 2006).

The water-solubility of pectic substances decreases with decreasing DM (Lopes da Silva et al., 2006). Highly methylated pectin are therefore highly soluble in water.

## II.2. Main sources of pectin

Pectin is naturally contained in the endocarp of fruit in the form of protopectins, which are released as pectins during cooking. The pectin content of fruit varies according to the type of fruit and its ripeness (Michel, 2002) (Tab.2).

**Table 02.** Assessment of the pectin content of some fruits. Michel (2002)

<b>Poor fruit</b>	cherries, peaches, blueberries, grapes
<b>Medium-Rich fruit</b>	strawberries, raspberries, blackberries
<b>Rich fruit</b>	currant, plum, blackcurrant, apricot
<b>Very rich fruit</b>	lemons, apples, oranges

### II.3. Physicochemical properties

Pectic substances have several physico-chemical properties. Those, which are important for their analysis and justify their use in the agricultural and food industries, are:

#### II.3.1. Solubility

From a nutritional point of view, pectins are considered soluble fibers with a high water retention capacity, as water is a good solvent for pectin. Pectin is a water-soluble biopolymer that yields viscous solutions. In addition, pectin has gelling properties (Yokoi et al., 2002). Solutes of up to around 4% (w/w) can be prepared. Water solubility decreases with decreasing DM (Lopes da Silva et al., 2006).

#### II.3.2. Viscosity

Viscosity is the parameter that relates shear rate to stress. Viscosifying agents have the property of modifying the behavior of the continuous phase, without forming junction zones, unlike gelling agents and certain stabilizers. Pectin (highly methylated) has this characteristic due to its high molecular weight. It is therefore used in fruity drinks (Tilly, 2010).

LM pectin, on the other hand, are typically viscoelastic, with each of their components able to be modified according, for example, to the calcium content of the reaction medium. This pectin are widely used in jams, jellies and marmalades.

The viscosity of fully methylated pectin solutions is independent of pH, unlike pectin solutions with free carboxyl functions (Thibault, 1980).

#### II.3.3. Stability and degradation

Pectins in solution in an acidic medium are stable; however, de-esterification and depolymerization reactions (hydrolysis or  $\beta$ -elimination) can occur under given PH and temperature conditions. At temperatures below 10°C, de-esterification predominates, whereas at higher temperatures, depolymerization takes place more rapidly and can lead to total pectin degradation (Schols et al., 2002). Under alkaline conditions and at low temperatures, ester groups are saponified (Figure 3). The  $\beta$ -elimination reactions of the O4 substituents are accelerated at temperatures above 60°C (Oosterveld et al., 1996) according to the mechanism where the hydrogen at C5, made more acidic by the methyl ester group, is attacked by the hydroxide ion. This leads to an arrangement with electron transfer, resulting in the breaking of the glycosidic bond and the formation of a double bond between C4 and C5, which is

conjugated with that of the carboxyl function (Morris et al., 2002) (figure 4).

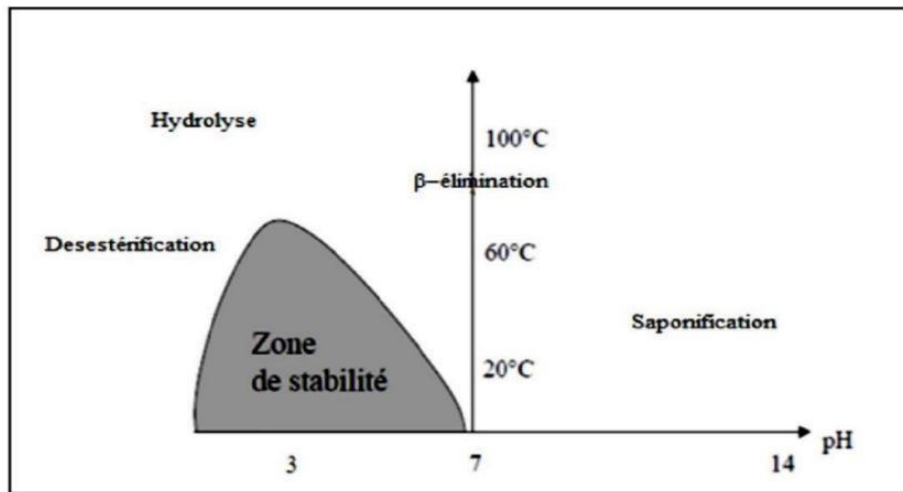


Figure 3. Pectin stability (Renard, 2010)

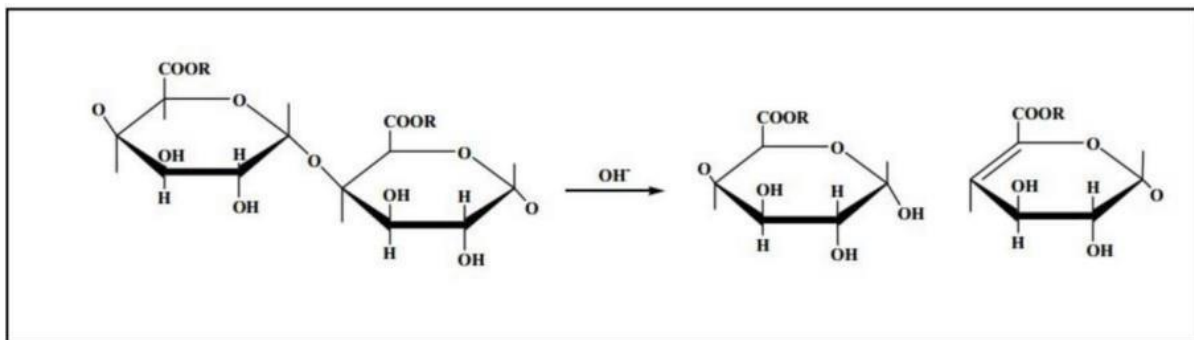


Figure 4.  $\beta$ -elimination reaction (Donato, 2004).

#### II.3.4. Foaming and gelling properties

The molecular origin of pectin's considerable emulsifying and foaming power is character.

Pectins are widely used in the food industry for their gelling, thickening and stabilizing properties. Commercially, it is extracted mainly from citrus peels (lemon and lime) and apple pomace. Under certain well-defined conditions, pectin can form a visco-elastic solution and a structural network that are widely exploited in jams, jellies and marmalades. Functional properties are sensitive to the degree of esterification (DE), the value of which depends on the type of plant tissue from which the pectin is extracted.

Highly methylated pectins ( $DE \geq 50\%$ ) form a gel in an acid medium with a high sugar content ( $>50\%$ ), while low-methylated pectins ( $<50\%$  DE) form a gel by different mechanisms in the presence of calcium ions (Akhtar et al., 2002; Dennapa et al., 2006; Lopes da Silva et al., 2006).

HM pectin gels are weaker than LM pectin gels, and their diminishing stability is affected by the charge distribution along the homogalacturonan chain, the average molecular weight of homogalacturonan, the ionic concentration of the solution, and the nature of the cross-linking cation. Gel formation is inhibited by increasing the degree of acetylation of homogalacturonan and by the presence of rhamnogalacturonan I regions attached to homogalacturonan (O'Neill et al., 2001).

Relative gelling efficiencies with highly methylated pectin compared on the basis of molar concentrations of monosaccharide residues rather than their simple concentrations by weight, under acidic conditions (pH 3.0) followed the order: glucose > sucrose > fructose. Sorbitol [CH<sub>2</sub>OH -(CHOH)<sub>4</sub> -CH<sub>2</sub>OH] and xylitol [CH<sub>2</sub>OH -(CHOH)<sub>3</sub> -CH<sub>2</sub>OH ] were found to be comparable to glucose in their ability to induce pectin gelation (Tsoga et al., 2004).

#### II.4. Optimum conditions for HM pectin gelation

According to Michel, (2002), gelling depends on pectin content, sugar content and pH. A balance between these three factors ensures good gelation (Fig. 5). pH is an important factor. In practice, it should be between 2.9 and 3.3, but this depends on the quality of the pectin. Gel rigidity decreases with temperature. Mechanical shocks during the gelling/cooling phase break the gel (cloudy gel).

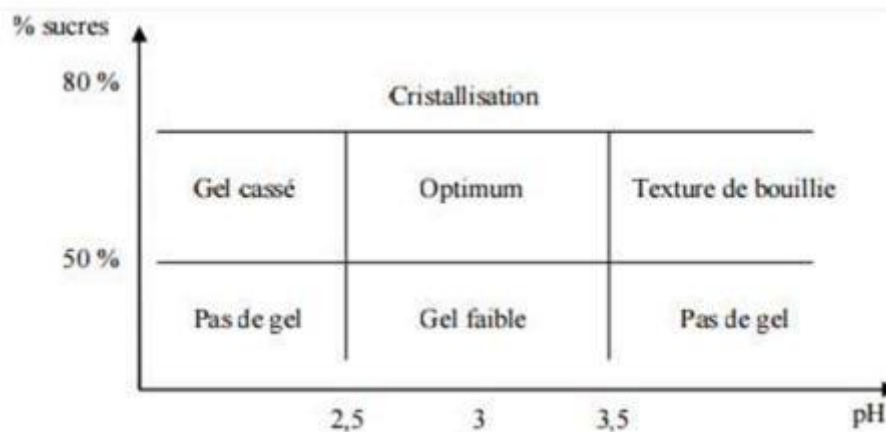


Figure 5. Gelation as a function of pH and sugar concentration (Michel, 2002).

#### II.5. Gelation of low-methyl pectin (LM)

Pectins with a DM < 50 are known as low-methyl pectin. They have a wider range of applications than HM pectin. These pectins form thermoreversible food gels in the presence of divalent ions, in this case the cation Ca<sup>++</sup>, the only one used in the food industry (Yapo,

2007), but in a wider pH range from 2.8 to 7 and in the absence of sucrose (Guillotin, 2005).

## II.6. Degree of HM and LM esterification

D-galacturonic acids (GalA) linked by  $\alpha$ -(1 $\rightarrow$ 4) bonds can be esterified by methanol on the (C6) carboxyl group (Tillmann et al., 2002). The degree of methylation (DM) is defined as the percentage of carboxyl groups esterified with methanol (Bonnin et al., 2002; Levigne et al., 2002). DM can often reach values of up to 70-80%.

## II.7. HM and LM pectin gelling process

For standardized production, it is useful to use commercially available pectin. They are classified according to their methylation level, which defines their use in terms of their jelling speed (Tab. 3).

**Table 03.** Characteristics of commercial pectin (Michel, 2002).

Methylation rate	Gelling speed pH	Use
>74	Ultrarapide < 3 min 3,1-3,5	Whole fruit, non-acidic fruit
71 – 74	Faste 3 to 7 min 2,9-3,3	Home made jam
66 – 69	Médium 15 to 22 min 2,8-3,1	Sour jam
60 – 65	Slow > 30 min 2,6-2,9	Jelly, very acid jelly, vacuum-packed jam

## II.8. Pectin applications

### II.8.1. Food additive

Pectins were first used in the preparation of jams, jellies, marmalades, and preserves, which are spreadable gels (N'BeMiller, 2001; Marathe et al., 2002). The formation of protein-polysaccharide complexes can be used to enhance the functional properties of proteins. Protein-pectin interactions improve the solubility, emulsification, gelation and foaming behavior of protein concentrates (Barrera et al., 2002).

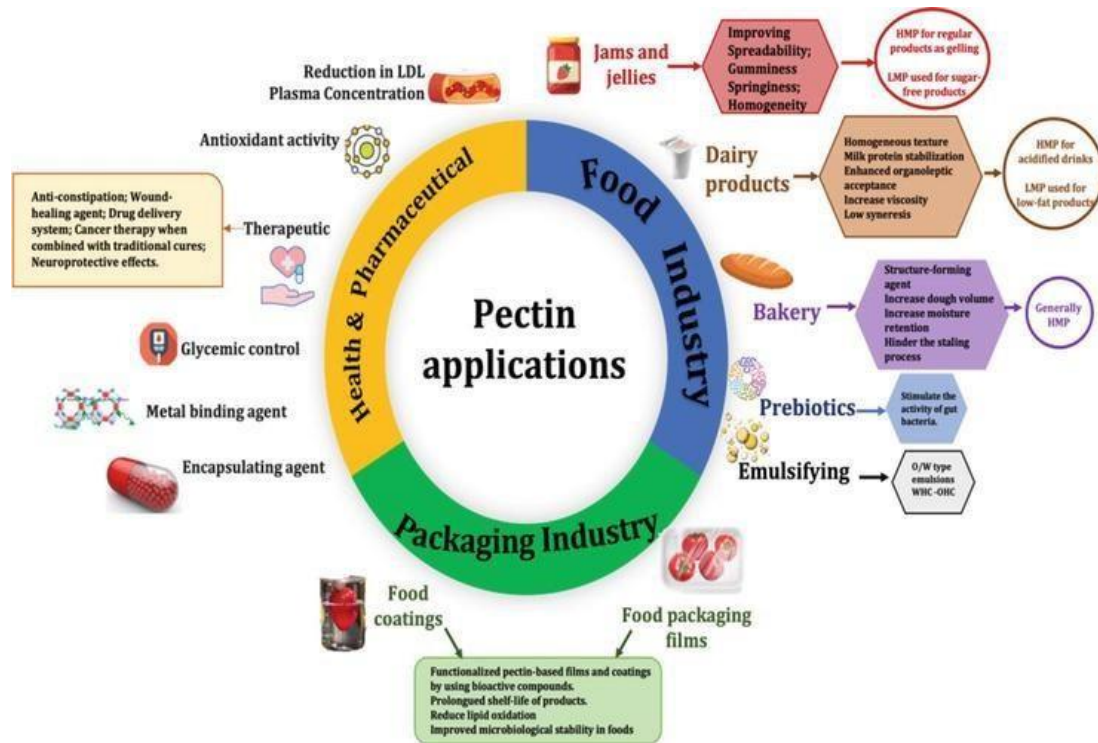


Figure 6. The different applications of pectin. (Cortés-Camargo et al., 2023).

### II.8.2. Pharmaceutical industry

Until 2002, pectin was one of the main ingredients used in sore throat lozenges as a softener. In cosmetics, it acts as a stabilizer and is used in wound-healing preparations and especially in medical adhesives, such as colostomy devices (Pranati et al., 2011). As a natural prophylactic, pectin acts against toxic cation poisoning. It has been shown to be effective in removing lead and mercury from the gastrointestinal tract and respiratory organs. When injected intravenously, it reduces the coagulation time of blood samples. As a result, it is useful for controlling hemorrhage or local bleeding.

Combinations with other colloids have been widely used to treat diarrhoea, particularly in young children (Pranati et al., 2011). In controlled-release formulations, pectin hydrogels are found in tablets as a binder (Sriamornsak, 2003).

### II.9. Pectin extraction and precipitation processes

According to the Official Journal of the European Communities, the code for pectin is E440. According to the same source, pectin are obtained by extraction, in aqueous medium, of

natural strains of appropriate edible plants, generally citrus fruits or apples. The only authorized organic precipitants are methanol, ethanol and 2-propanol.

Pectin are classified according to their mode of extraction, either with hot water for highly methylesterified pectin, or with divalent cation chelating agents (EDTA, ammonium oxalate) for weakly methylesterified pectin, and with hot dilute acid for protopectin (polygalacturonic acid). Pectic substances, a group of amorphous polysides, act as intracellular cement. In the food industry, pectin are used for their gelling and thickening properties. Lemon peel and apple pulp, by-products of the juice industry, are generally used as raw materials for pectin extraction. Pectin can be extracted from cell walls by physical, chemical and enzymatic methods. Physical methods, such as extrusion-cooking or microwave-assisted extraction, can be employed (**Panouillé et al., 2006**).

Extraction of pectin from the raw material is usually carried out by acid treatment (pH 1.5 - 3) at elevated temperature (70 to 90°C), using hydrochloric acid, nitric acid or, in some cases, sulfuric acid. This step enables the extraction and solubilization of pectin materials from plant tissues (**Lopes da Silva et al., 2006**). The pectin extract is then separated from the skin or pulp residues by filtration or centrifugation. The pectin is then separated from the purified extract by precipitation with alcohol (isopropanol, ethanol, or methanol) or by precipitation with insoluble salts, with the addition of a polyvalent cation, usually aluminum (**Lopes da Silva et al., 2006**). The resulting precipitate is washed with alcohol and filtered to remove soluble impurities, before being dried and ground to powder.

### **III. General information on fruit jellies (strawberries)**

#### **III.1. Definition**

Jellies are products prepared from juices and/or aqueous extracts of one or more fruits mixed with foodstuffs imparting a sweet taste, with or without the addition of water, until a semi-solid jellied consistency is obtained (**Codex CXS 296-2009**).

#### **III.2. Main ingredients of Jellies**

In the present study, we are talking about strawberry jelly, whose essential ingredients are fruit (strawberry), sugar, pectin and citric acid.

##### **III.2.1. Fruits**

The quality of a processed product depends first on the quality of the raw material used. For fruit, the quality criteria are:

- Variety: varieties suitable for fresh consumption are not necessarily suitable for processing.
- Ripeness: the aroma of ripe fruit is generally more pronounced
- Cleanliness: fruit soiled with soil contains a higher microbial load than clean fruit
- Purity: spoiled fruit must be eliminated. Fruit (squash and apple) is mixed in three different proportions (**Benamara et al., 2003**).

##### **III.2.2. Sugar**

Sugar plays an important role in food technology thanks to its functional properties: nutritional and organoleptic. Sugar also lowers the water activity ( $a_w$ ) of the medium, which has a stabilizing effect on the multiplication and growth of fungal and bacterial flora. As a general rule, to ensure good preservation of the product without altering its taste, the quantity of sugar to be added is in the order of 60 to 65% of the final product. Commercial granulated white sugar is used. Sugar can also be added in the form of a syrup made from the same quantity of sugar mixed with very little water (**Benamara et al., 2003**).

##### **III.2.3. Pectin**

The jelly-like setting obtained when fruit and sugar are cooked together is due to a substance called pectin found in fruit. The rigidity of the gel increases with the pectin content of the fruit. If the fruit used is low in pectin, you can add commercially available pectin powder or liquid. The dose used varies, but in all cases, it should not exceed 10g/Kg of fruit (**Benamara et al., 2003**).

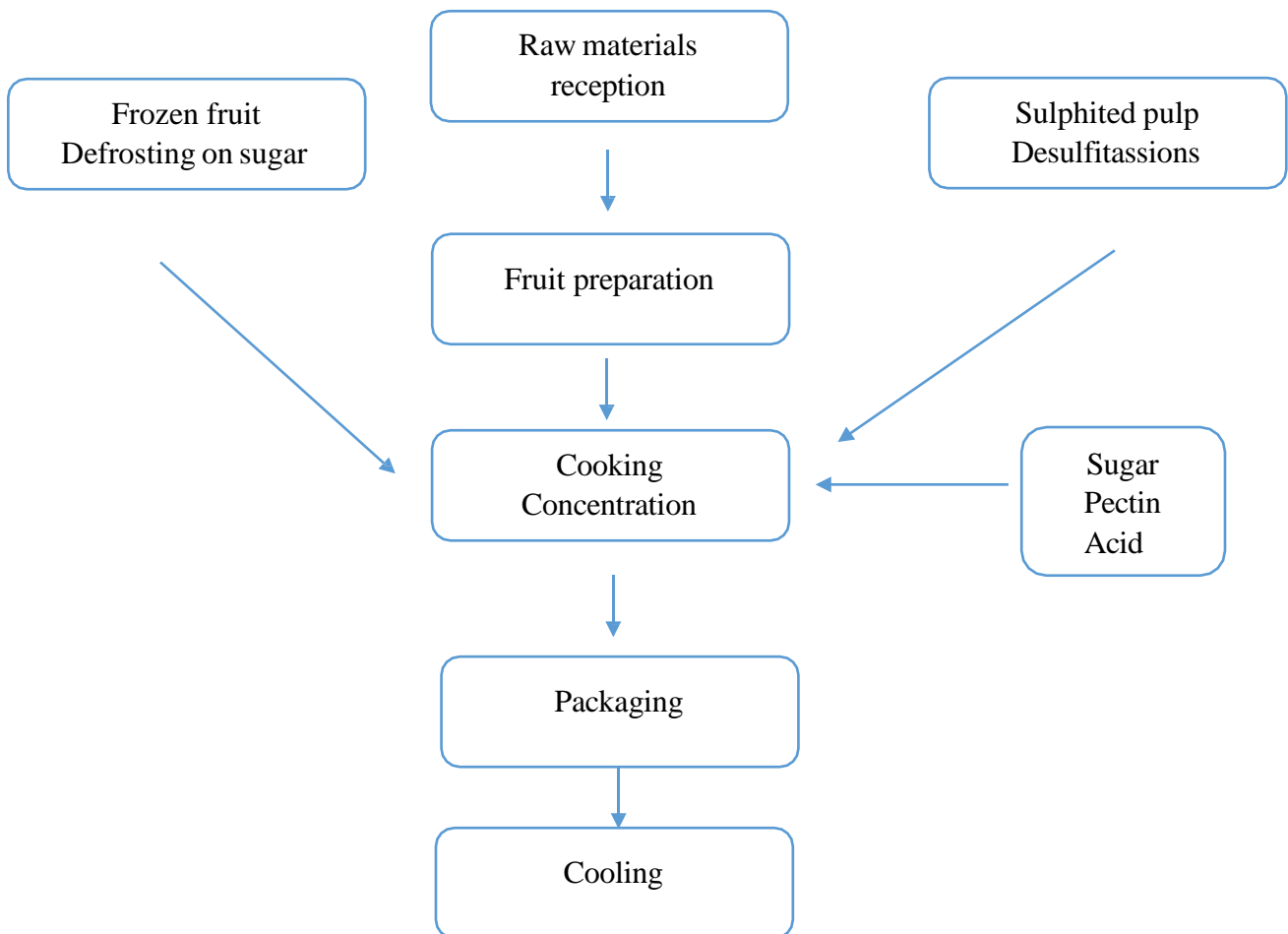
### III.2.4. Citric acid

Citric acid occurs naturally in fruit, but in different proportions, so the amount to be added depends on its content in the fruit mixture, so that it does not exceed 5g/kg of product.

The role of citric acid is to adjust the pH (by lowering it) to between 3.3 and 3.5, to promote gelling, to enable sucrose inversion, to preserve color, and to improve taste while preserving the product (Benamara et al., 2003).

### III.3. The manufacturing process

The jam, jelly and marmalade manufacturing process comprises several successive stages (diagram) Simplified diagram of jam, jelly and marmalade manufacturing.



**Figure 7:** Simplified diagram of jam, jelly and marmalade production.

(Albagnac et al., 2002)

### III.4. Strawberry jelly

Strawberry cultivation underwent essential innovations in the 19th century. In England in particular, the cultivar Keen's Seedling spread throughout Europe and the United States. The strawberry is a highly fragrant, cone-shaped fruit whose achenes form asperities on the bright red flesh, which ripens in summer on a very low-stemmed plant (Jules, 2010). It requires a drained, humus-rich soil that is hardy in all but the harshest climates (**Santich, 2013**).

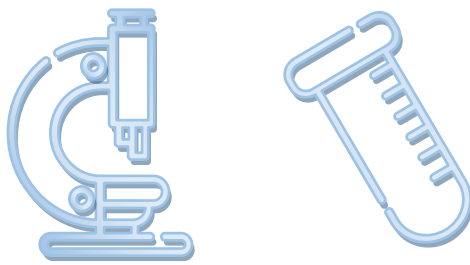
This fruit must be harvested at full maturity to achieve the best quality in terms of flavor and color. The main change in fruit composition generally associated with ripening occurs when the fruit is still attached to the mother plant (**Cordenunsi et al., 2003**).

Strawberries do not keep well, even in a cool place: they need to be eaten quickly and washed just before consumption. It is generally eaten fresh, but many strawberries are processed, such as juice, nectar, purée, jam, jellies (**Giampieri et al., 2013**), cream, wine and strawberry syrup (**Jules, 2010**). Its low pectin content means that pectin must be added when making strawberry jam (**Santich, 2013**).

Jelly is made in the same way as jam, but the fruit is first strained so that only the juice remains during cooking. This explains its more homogenous texture than jam or marmalade: to achieve the desired consistency for jam or jelly, pectin and acidity need to be in balance. Sugar content also plays an important role in this balance (**FAO, 1995**).

In the recent past, flavor and appearance were the most important attributes of fresh fruit and vegetables, but nowadays consumers are more concerned about the food safety and nutritional value of confectioned products (**Cordenunsi et al ., 2003 ; Crespo et al ., 2010 ; Giampieri et al ., 2012**).

# Material and Methods



The present study was carried out at the CARAJUS quality control laboratory (EL-Chatt, El-Tarf) and the FSNV biochemistry and phytochemistry laboratory at Chadli Ben djedid University, El-Tarf, over a three-month period.

The aim of this work was to enhance the value of quince by-products (peel and seeds) by extracting and characterizing pectins, and to test their gelling and stabilizing effects in the manufacture of fruit jellies.

To achieve our objectives, we followed the following steps:

**Step 1:** Physico-chemical characterization of quince fruit, peels and seeds.

**Step two:** Extraction of pectin from quince peels and seeds using the ultrasound method.

**Third step:** Preparation of fruit jellies from extracted pectin in comparison with a commercial pectin (NH pectin).

### I. Materials

#### I.1. Plant material

The quince fruit was purchased from the market in October 2023 in the commune of Ain El Assel -El Tarf-.



**Figure 8:** Raw materials used for pectin extraction. (Belhani, 2024).

The strawberries used to prepare the jellies were purchased in February 2024 from the market in the commune of Ain El Assel (wilaya of El-Tarf).

The commercial pectin is "NH pectin" from the "Farandole" brand, manufactured in Algiers.



**Figure 9:** Raw materials used to produce jellies. (Belhani, 2024).

### **I.1.1. Other materials**

The list of products and materials used during the experimental phase are summarized in Appendix 1.

## **I.2. Methods**

### **I.2.1. Physical characterization of quince fruit**

Physical characteristics were assessed on 10 randomly selected fruits. The fruit and seeds were weighed using a balance, while the length and diameter of the fruit were determined using a caliper.

### **I.2.2. Preparing quince powder**

Quince fruits were washed to remove surface impurities. Then it was peeled, dried, and ground. The resulting peel and seed powders were preserved for physicochemical characterization, such as yield, moisture, dry matter, ash, organic matter, and total polyphenols, as well as the determination of their antioxidant activities.

On the other hand, quince peels with a thickness ranging from 2 to 4 mm were bleached and then frozen to be used for pectin extraction.

### I.2.3. Pectin extraction

Pectin have been extracted from alcohol-insoluble substances (AIS) of quince peel and seed powders.

#### I.2.3.1. Extraction of pectins (peels, seeds)

AIS (20 g) was suspended in an aqueous solution of HCl hydrochloric acid (200 - 400 ml, pH = 2- 2.2). The mixture was incubated at 80°C in a water bath for 1h to 1h30min and the extract obtained was then filtered. In the peel pectin extraction step (4mm), an additional concentration step was added. Dissolved pectin was recovered by alcoholic precipitation with ethanol. The precipitated pectin was centrifuged, and the pellet obtained underwent several successive washes with 60% ethanol and acetone. The pectin obtained was dried (40°C, 24h) and ground to obtain a yellowish powder (**Figure 10**).

The same procedure was followed for the extraction of pectin from seed powder (10 g / 400 ml acid solution) (**Figure 11**).

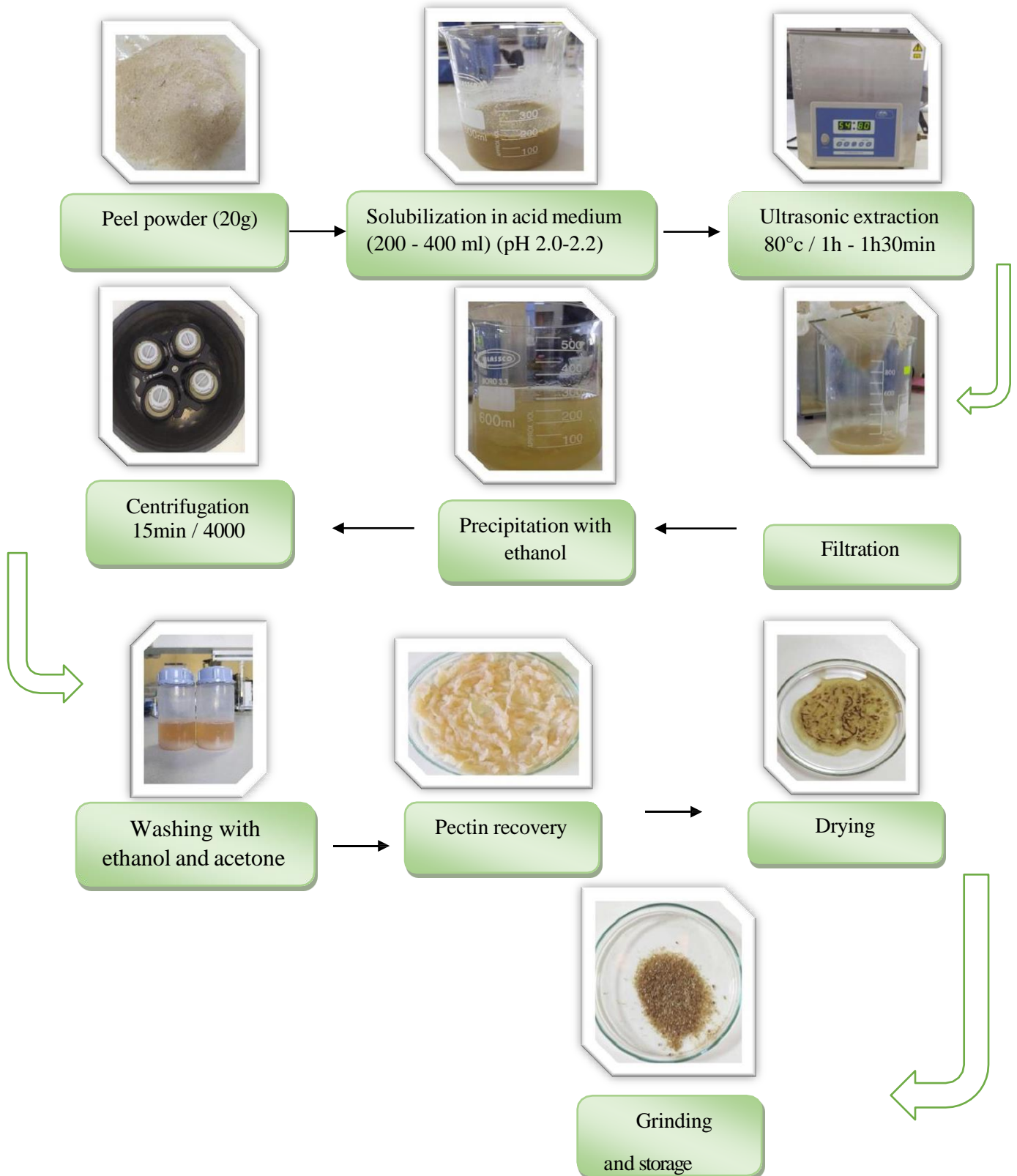


Figure 10: Diagram of pectin extraction from quince peels. (Belhani, 2024).

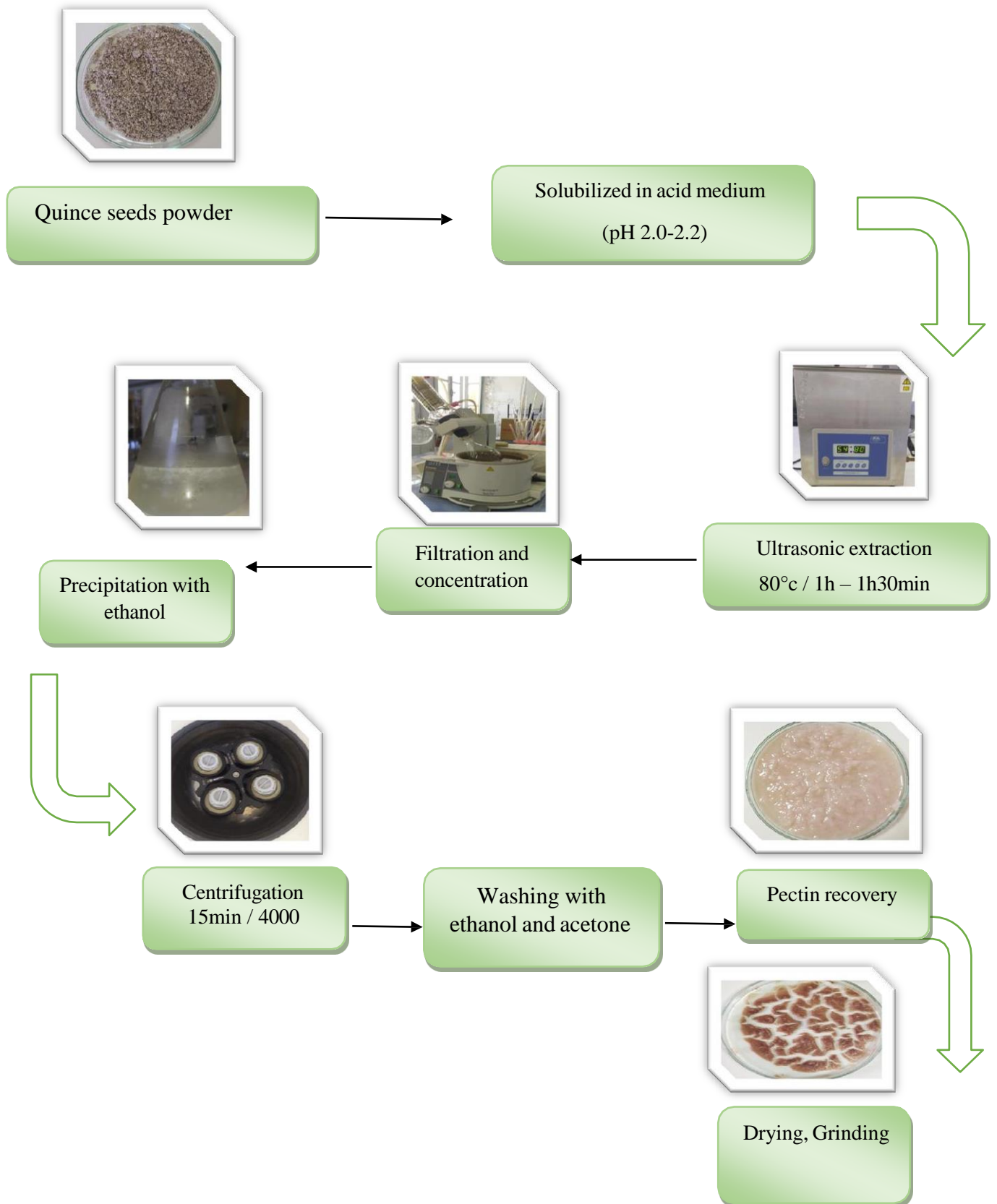


Figure 11: Diagram of pectin extraction from quince seeds. (Belhani, 2024).

### I.3. Physicochemical characterization of pectins

A chemical characterization of peptic substances from a particular source material requires a determination of the solubility, moisture, ash, equivalent weight, the degree of esterification (DE%), methoxyl (MeO) and galacturonic acid content (GUA%). The equivalent weight of pectin was determined by the titrimetric method or the saponification process (**Figure 12**). The degree of pectin esterification (DE) is calculated from MEO% and GUA%. Pectin belong to one of two groups defined by their degrees of esterification, which are expressed by their proportion of the  $-\text{COOCH}_3$  ester function to the  $-\text{COOH}$  acid function (**Combo et al., 2001**).



**Figure 12:** Determination of pectin physicochemical characteristics by titrimetric method (**Belhani, 2024**)

### I.4. Preparation of Strawberry Jelly

Strawberry jelly was prepared according to the process of **Shivani et al. (2022)** with a few modifications. First, the strawberries were washed and cut into pieces. These were boiled in a volume of water for 10 to 15 minutes. The extract obtained was then filtered. Sugar, citric acid and pectin were added to the strawberry extract. The resulting mixture was cooked over low heat (80°C) to the final point (60-69°Brix) (Figures 11 and 12). The resulting jellies were poured into sterile jars and then stored at 4°C.

Five jelly formulations were prepared (Jelly made without pectin (negative control); jelly made with commercial pectin (positive control); jelly made with quince peels pectin (2mm and 4 mm) and jelly made with quince seeds pectin) (**figure 13**). The physicochemical and sensory characteristics of the jellies were assessed.

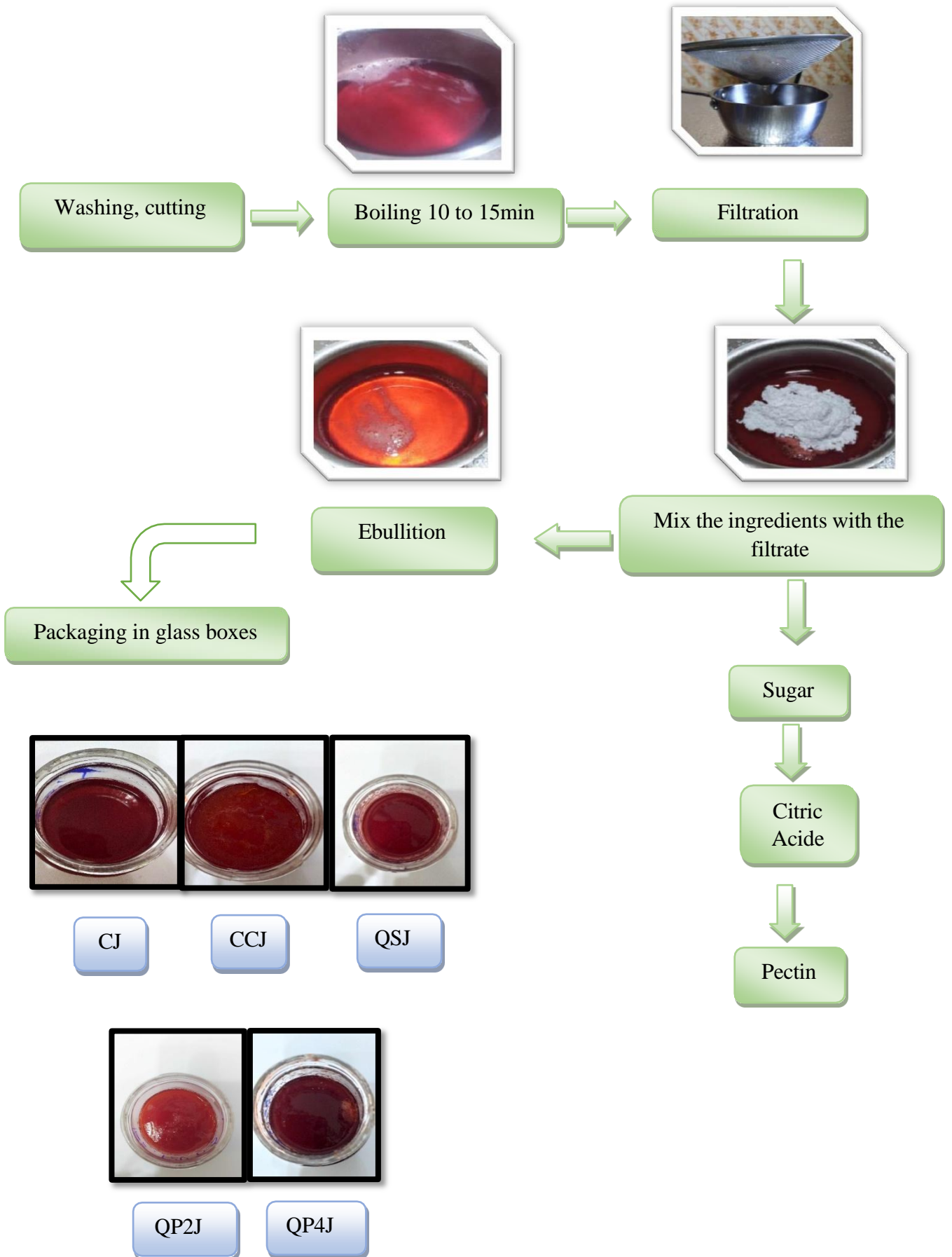


Figure 13: Jelly preparation diagram (Belhani, 2024).

## I.5. Physicochemical characteristics of strawberry jellies

### I.5.1. pH determination

#### I.5.1.1. Definition

The pH is a parameter that determines the suitability of foods for preservation, and is one of the main obstacles that microbial flora must overcome to ensure their proliferation. A pH of between 03 and 06 is highly favorable to the development of yeasts and molds. (Brissonn et al., 1994).

#### I.5.1.2. Principle

A digital pH meter is used to determine the pH of the product.

#### I.5.1.3. Procedure

Insert the pH meter electrode directly into the sample. When the first reading is complete, the electrode is wiped with distilled water and dried with tissue paper. Thus, as a continuous series, all further samples are determined in the same way. (Hasnain et al., 1990).



Figure 14: pH measurement of prepared jellies (Belhani, 2024).

### I.5.2. Titratable acidity

#### I.5.2.1. Definition

Most fruits, vegetables and their by-products contain acid or a mixture of acids. Titratable acidity or total acidity is used to determine the total concentration of acid contained in a product. (Brissonnet et al., 1994).

### **I.5.2.2. Principle**

Titrateable acidity is determined by neutralizing the acid present in a known quantity (weight or volume) of sample using a base (NaOH). Evaluation is by titration using a color indicator; phenol phthalein (Nielsen, 2010).

### **I.5.2.3. Procedure**

1 gram of the sample was solubilized in 20 ml of distilled water. The obtained solution was stirred and titrated with a 0.1N NaOH solution to a PH =  $8.1 \pm 0.2$ . The titrateable acidity was calculated according to the following formula:

$$\text{Acidity (\%)} = \text{titrant volume} \times 0.7$$

**Where:**

0.7 is the citric acid factor.

## **I.5.3. Determination of total soluble solids (°Brix)**

### **I.5.3.1. Definition**

Total soluble solids (TSS) are the most important quality parameters used to indicate the sweetness of fresh and processed horticultural food products, in research laboratories and in various processing plants.

TSS or sugar content includes carbohydrates, proteins, organic acids, fats and minerals. TSS content is generally obtained by evaluating Brix degrees.

The °Brix value can be used as a measure of the ripeness, flavor and quality of many fruits and vegetables at different stages of fruit production. It can also be used to determine the level of sweetness of fruit and vegetables at the time of harvest, sale and processing. (Ranganna, 2003).

### **I.5.3.2. Principle**

Total soluble solids (TSS) are calculated according to the method explained by (Mazumdar et al., 2003) using a digital refractometer.

### **I.5.3.3. Procedure**

A drop of strawberry jelly was placed on the refractometer prism, which had been cleaned and dried with distilled water. The Brix level was read directly on the display.



**Figure 15:** °Brix determination of strawberry jelly samples (Belhani, 2024).

#### **I.5.4. Moisture assessment (%)**

##### **I.5.4.1. Definition**

Moisture content is defined as the weight lost during drying (Audigie et al., 1978).

##### **I.5.4.2. Principle**

Moisture or dry matter is determined by oven drying (AOAC, 2000). This method consists in evaporating the water contained in the raw material by drying in an oven at 103-105°C to constant weight.

##### **I.5.4.3. Procedure**

First, the mass of the clean and empty crucibles is measured (M1). 0.2 g (Me) of each jelly sample contained in the crucibles is then placed in an oven at 103°C for 3 hours. The crucible plus dried sample was cooled in the desiccator prior to weighing. Repeat the operation several times until a constant weight is obtained. Then, the mass of the crucible containing the dried sample (M2) is determined. The moisture percentage is calculated according to the following formula:

$$\text{Moisture (\% )} = \left[ \frac{M1 - M2}{Me} \right] \times 100$$

**With:**

Me: Mass (g) of sample;

M1: Mass (g) of the assembly (crucible + sample) before steaming; M2: Mass (g) of the whole (crucible + sample) after steaming.

The percentage of dry matter (MS %) is expressed according to the following formula:

$$\text{DM\%} = 100\% - \text{moisture \%}$$



**Figure 16:** Determination of moisture content. (Belhani, 2024).

### **I.5.5. Ash content (%)**

#### **I.5.5.1. Definition**

Mineral matter or ash is the residue obtained after the destruction of organic matter by calcination. The ash content has been determined by the **AOAC** method (1990).

#### **I.5.5.2. Principle**

Ash determination is based on the destruction of all organic matter under the effect of high temperature ( $500 \pm 25 \text{ C}^\circ$ ).

#### **I.5.5.3. Procedure**

Porcelain cups containing 01 g of sample are placed in a muffle furnace, preheated to  $550 \pm 15^\circ\text{C}$  for 05 hours. The white ashes obtained are cooled with the crucible in a desiccator at room temperature, and then the crucible is weighed after cooling.

The ash content is given by the following formula:

$$\text{Ash (\%)} = \left[ \frac{(M_2 - M_0) \times 100}{M_1 - M_0} \right]$$

**With:**

M0: Mass (g) of the empty crucible;

M1: Mass (g) of the whole (crucible + sample) before incineration; M2: Mass (g) of the whole (crucible + ash) after incineration.

The percentage of organic matter (OM %) is expressed according to the following formula:

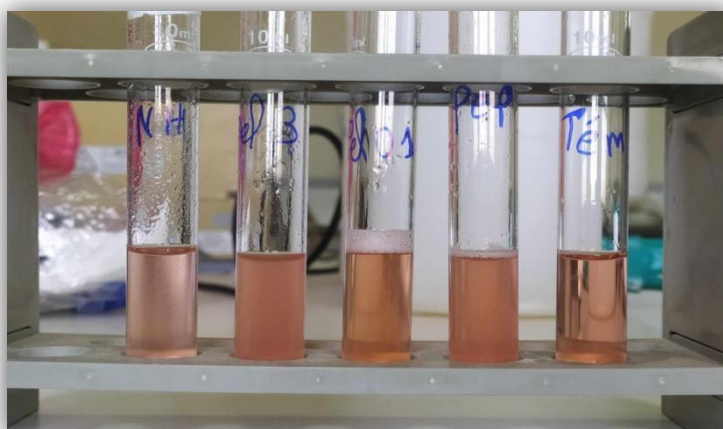
$$\text{OM\%} = 100\% - \text{Ash \%}$$



**Figure 17:** determination of Ash content (Belhani, 2024).

### **I.5.6. Color index**

The color index is expressed as the absorbance value at 420 nm.



**Figure 18:** Determination of color index. (Belhani, 2024).

### **I.5.7. Viscosity of jellies (Flow test)**

The viscosity of a gel is a fluid's resistance to flow under gravity. The test measure the time (seconds) it takes for a viscous product to flow in a given distance interval through an inclined stain resistant metal graduated.

### **I.5.8. Determination of the browning index (BI)**

The browning index was determined by measuring the absorbance of aqueous jelly extracts at 420 nm and 510 nm using a spectrophotometer.

## **I.5.9. Determination of active molecules**

### **I.5.9.1. Determination of total anthocyanin content**

#### **I.5.9.1.1. Principale**

Anthocyanin content was determined by the differential pH method with some modifications **(De Moura et al., 2012)**.

The absorbance of Solutions at 510 nm ( $\lambda_{max}$ ) for anthocyanin content and at 700 nm for haze correction were measured using a UV-Vis spectrophotometer (Mini 1240 SHIMADZU). TAC results for Strawberry jelly were expressed in mg cyanidin-3-O-glucoside/kg.

### **I.5.9.2. Determination of total phenolic content**

Total polyphenol content expressed as (mg EGA/g) gives an overall estimate of the content of different classes of phenolic compounds contained in the fruit extract analyzed. Phenolic content was assessed using the **Folin-Ciocalteu** method.

## **I.5.10. Total antioxidant activity**

The test is based on the reduction of molybdenum Mo (VI) present as molybdate ions  $MoO_4^{2-}$  to molybdenum Mo (V)  $MoO_2^+$  in the presence of the extract or an antioxidant agent. This reduction takes the form of a greenish complex (phosphate/Mo(V)) at acid pH **(Prieto et al., 1999)**. The increase in coloration of the molybdenum (VI) complex in the presence of antioxidant is measured by absorbance at  $\lambda = 695$  nm.

Total antioxidant activity is determined according to the method reported by **(Prieto et al., 1999)**. Antioxidant capacity is expressed as milligram Ascorbic Acid Equivalent mg per g Sample (mg EAA/g Ech).

## **I.6. Sensory analysis of prepared jellies**

The panel was made up of 15 men and women aged between 20 and 50. The strawberry jelly formulations were presented with letter codes (CJ, CCJ, QP4J, QP2J, and QSJ). Panalists were asked to evaluate the prepared jellies in terms of appearance, color, texture, taste, odor and viscosity. Each attribute studied was evaluated on sensory analysis sheets. Penalist acceptance was determined using a 5-point hedonic scale:

**1 point:** Do not like it at all; **2 points:** don't like much; **3 points:** indifferent; **4 points:** like a little; **5 points:** like a lot.



**Figure 19:** Tasting session procedure (sample preparation and sensory evaluation sheets).  
(Belhani, 2024).

# Results And Discussion



**II. Physical characterization of quince fruit**

Physical and morphological characteristics are among the criteria used to assess quince fruit quality. The results are shown in the following table (Tab 04)

**Table 04.** Physical, morphological and sensory characteristics of quince fruit.

Characteristics		
<b>Fruit shape</b>	Round	Round
<b>Color of the fruit</b>	greenish yellow	Deep yellow
<b>Taste</b>	Very astringent	slightly astringent
<b>Skin appearance</b>	Cottony surface appearance	Smooth
<b>Average weight (g)</b>	281.6 ± 28.69	574.0 ± 100.94
<b>Languor (cm)</b>	83.97 ± 5.57	97.24 ± 5.29
<b>Width (cm)</b>	81,29 ± 3,98	97.65 ± 3,9
<b>Seed weight (g)</b>	1	/
<b>Seed yield (%)</b>	0,1%	/
<b>Fresh peel weight (g)</b>	33.7 ± 3.65 (2mm) 67.14 ± 7.13 (4mm)	50.01± 5.3 (2mm) 101.33 ±15.28 (4mm)
<b>Peel yield (%)</b>	1.2 - 2.5	2.94 - 5.88
<b>AIS %</b>	11	14.3

**II.1. Physicochemical properties and bioactive compounds of quince peels and seeds**

The physicochemical properties, total polyphenol content and antioxidant activity of quince peels and seeds are summarized in Table 05.

**Table 05.** Physicochemical characteristics of quince peel and seed powders.

	Ash %	OM%	Moisture%	DM %	Polyphenols µg EAG/g MS	TAC (mg EAA/g MS)
<b>Peels</b>	6,39%	93,61	5,29%	94,71	2,418	0,960
<b>Seeds</b>	10,9%	89,1	66,6(94,6)	33,4(5,4)	/	/
<b>AIS2</b>	/	/	/	/	0,492	0,379
<b>AIS4</b>	/	/	/	/	1,060	0,765

**II.2. Physicochemical properties of extracted pectin**

The physicochemical properties (yield, appearance, solubility, ash %, moisture%, MeO, DE, GUA %) of pectin are summarized in Table 06.

**Table 06.** Physicochemical properties of pectins.

	<b>Commercial Pectin</b>	<b>Pectin QP14</b>	<b>Pectin QP12</b>	<b>Pectin QPS</b>
<b>Yield %</b>	/	13.03	7.68	18.92
<b>Aspect</b>	White	Caramel	Dark yellow	Pink beige
<b>Solubility (water)</b>	Soluble	Soluble	Soluble	Soluble
<b>Solubility (ethanol)</b>	Insoluble	Insoluble	Insoluble	Insoluble
<b>Ash%</b>	26,64	2.3±0.19	2.6±0.13	1.6 ±0.29
<b>OM%</b>	74,36	/	/	/
<b>Moisture %</b>	0.2	6.54	6.23	3.9
<b>DM %</b>	0.98	/	/	/
<b>Equivalent weight</b>	625	1666,67	5000	1250
<b>MeO%</b>	6.51	13,02	13.02	12.4
<b>GUA%</b>	65.12	84.48	77.44	84,48
<b>DE%</b>	34.05 ±3.2	86.30 ± 0.85	90.9±6.43	83,33 ± 5.4

**II.2.1. Pectin yields**

Table 06 shows the extraction yields, moisture and ash contents of quince by products pectins. The yield of QP14 ,QP12 and QPS were 13.03%,68% and 18.92%, respectively which our results were similar with ambarella peel pectin (10 to 13%) and mango peel pectin (4.6 to 18.5%) extracted by deionized water (Koubala et al., 2008a; Koubala et al., 2008b).

The results obtained show that peel thickness determines the amount of pectin present the yields of pectin extracted from quince peel decrease with the decrees of the peel thickness. Indeed, quince pulp also contains pectin (6.06 to 10.49) (Acikgoz, 2010; Qin et al., 2019).

Pectin yield depends on the type of raw material and preliminary processing methods. The extraction process, variety, and stage of ripeness can affect the quantity and quality of extracted pectin (Kar et al., 1999 ; Azad et al., 2014).

### **II.2.2. Solubility**

Extracted pectin were soluble in hot water and insoluble in ethanol or acetone. In general, sample heating (80°C) and/or ultrasonic treatment improved solubility. However, this is not the case for pectin in their salt form (**Tribault et al., 1991**).

### **II.2.3. Moisture content**

The moisture content of pectin extracted from QP14, QP12 and QPS are 6.54, 6.23 and 3.9% respectively, higher than the moisture content of commercial pectin (0.2%). Our results were lower than those found for quince fruit Acikgoz, (2010). So, commercial pectin is very well dried compared to pectins extracted from quince by-products. Moisture is a very important factor in pectin preservation. A low moisture content increases storage times and inhibits the growth of microorganisms that affect pectin quality through the production of hydrolytic enzymes (pectinases) (**Mohamad zadeh et al., 2010**).

### **II.2.4. Ash content**

The results obtained show that the ash content of QP14, QP12 and QPS pectins were  $2.3 \pm 0.19$ ,  $2.6 \pm 0.13$  and  $1.6 \pm 0.29\%$  respectively, while that of commercial pectin is of the order of 26%. The ash content of pectins extracted from quince by-products is lower than that of commercial pectin. According to **Acikgoz (2010)**, the ash content of quince fruit pectin was estimated to 2.47%, compared with commercial pectin ( $11.33\% \pm 0.57\%$ ). These results are higher than those obtained for QP14 and QPS but lower than those obtained for QP12 and commercial pectin (**Tab. 06**).

The higher galacturonic acid and lower ash contents of pectin are the two criteria for its purity. A low ash content is favorable for gel formation. The maximum limit for ash content for better quality pectin gels is 10% (**Ismail et al., 2012**).

### **II.2.5. Equivalent weight**

Equivalent weight is generally used to test the gel-forming effect of pectin. High equivalent weight would have higher gel-forming effect equivalent or combining weight in the range of 250-350 will form the gel in the presence of calcium or magnesium ion regardless of whether sugar is present or not (**Nguyen and Pirak, 2019**). The equivalent weight of commercial pectin (625 g) is lower than the equivalent weight of QP14, QP12 and QPS pectin (1666, 5000 and 1250 respectively). From these results, we conclude that QP12 pectin recorded the highest

equivalent weight. The equivalent weight can vary depending on the degree of ripening of the raw material. According to (Azad et al., 2014). Our results are higher than the equivalent weight of pectin obtained after orange peel extraction (1250) (Zanelle and Taranto, 2015).

### II.2.6. Methoxyl content MeO%

Methoxyl content is a very important factor in controlling the time and ability of pectin gels to form (Constella and Lozano, 2003). The methoxyl content of the pectin extracted in our study ranged from 12.4 to 13.02, which is higher than that recorded for commercial pectin (6.51). Our results are very similar to those found by Zanelle and Taranto, (2015) who reported that the methoxyl content of orange peel pectin (14.13) is significantly higher than that of commercial pectin (2.02%).

### II.2.7. Galacturonic content %

Galacturonic acid indicates the degree of pectin purity. The estimated percentage of galacturonic acid is calculated based on equivalent weight and methoxyl content. GUA contents of 84.48, 77.44, 84.48 and 65.12 were recorded for QPI4, QPI2, QPS and commercial pectin respectively.

The GUA contents reported in our work were close to that reported by Acikgoz, (2010) of quince pectin (over 70 %). It is recommended that the galacturonic acid content of pectin should exceed 65% (Food Chemicals Codex, 1996).

Our finding were higher than thoses reported by Devi et al. (2014) and Virk & Sogi (2004), conducted study on extraction of pectin from citrus fruit peel and reported GUA content of 51.04 percent and reported 62.82 percent in apple peel waste pectin respectively. Low value of GUA means that the extracted pectin might have a high amount of protein, starch and sugars in the precipitated pectin (Ismail et al., 2012).

According to these results, the purity of pectin extracted from quince peels is higher than that of commercial pectin 65%. These finding were similar to those reported by Ismail et al. (2012).

### **II.2.8. Degree of esterification**

The degree of esterification is a key factor to determine conformation and rheological properties of pectin.

The degree of esterification is determined by the titration method. It is a very important parameter for determining the nature of pectin (highly or low methylated) and therefore for highlighting different characteristics such as gelling conditions. The degree of esterification values of commercial pectin 34.05% is lower than QP14, QP12 and QPS pectin extracted from quince by-products 71.5%, 90.9% and 83.83% respectively. The extracted pectin can be classified as high methylation pectin in that their DE >50%.

Low-methylated pectin are often used in the food industry as gelling agents in low-sugar products such as low-calorie jellies and jams or confectionery (**Tang et al., 2011**). Thus, as a gelling agent, thickener, and stabilizer. It can also be used as a fat substitute in baked goods and to stabilize acidic protein drinks such as yogurt.

While high-methoxy pectin is the form traditionally used for canning applications, it has been shown to have a better ability to protect tablets in the upper gastrointestinal tract (**Wakerlya et al., 1996**).

### **II.3. Physicochemical properties and bioactive compounds of strawberry jelly**

Strawberry jellies prepared with pectin extracted from quince seeds and peels have been evaluated for a number of physicochemical parameters. The results obtained are presented in the following figures.

### **II.4. pH and titratable acidity (% citric acid)**

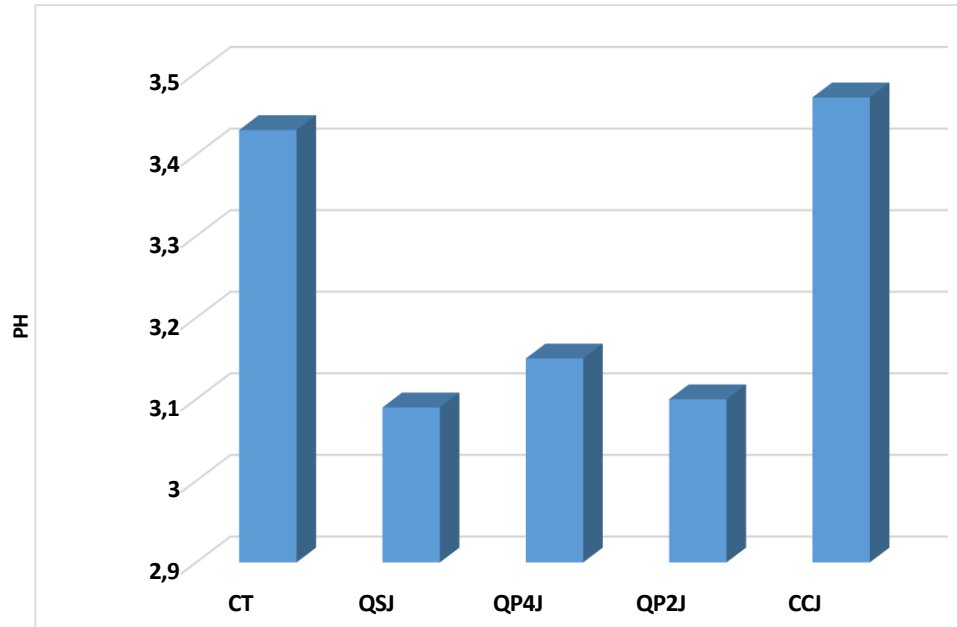
Variations in pH values and titratable acidity (expressed as % citric acid) of strawberry jellies were determined, and the results are shown in figures 20 and 21.

Titratable acidity (%) is an indicator of total acid content and is a better predictor of the impact of acid content on flavor than other measures such as pH (**Sadler et al., 2010**).

**Figure 21** shows the pH values for the strawberry jellies studied. The results indicate that there are differences between the pH values of all the preparations. Sample CCJ recorded the highest pH value (3.47), followed by CJ (3.43), QP4J (3.15) and QP2J (3.10). Sample QSJ recorded the lowest value (3.09). These results are in line with **FAO/WHO Food Codex standards, 1995**, which require a relatively acidic pH (2.8 to 3.9) at the end of the process

(jam or jelly).

Our results are superior to those obtained by **Shivani et al., 2022**, who found that the pH range of nectarine jelly varies between 2.56 and 2.63.



**Figure 20:** Evaluation of pH values of strawberry jellies.

**CCJ:** jelly made with commercial pectin (positive control); **CJ:** Jelly made without pectin (negative control); **QP4J:** jelly made with quince peels pectin (4mm); **QP2J:** jelly made with quince peels pectin (2mm); **QSJ:** jelly made with quince seeds pectin

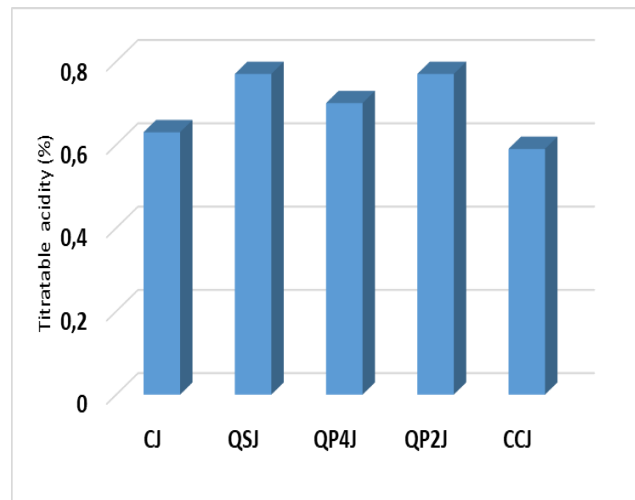
The titratable acidity of all strawberry jelly samples ranged from 0.59 to 0.77.

The lowest percentages were observed in the CCJ and CJ control samples (0.59 and 0.63% respectively). However, the highest rates were observed for QP2J and QSJ jellies.

**Garcia-Viguera et al., 1999**, reported values between 0.6 and 1.2 g/100g for strawberry jam, close to those obtained in the present study.

**Aslanova et al., 2010** recorded acidities of 0.44; 0.5 and 0.22 g/100g for apricot, cherry and strawberry jams, respectively. From these results, we can see that the acidity of strawberry jam (0.22 g/100g) is lower than our results.

Variations in titratable acidity are influenced by parameters such as harvest season, sugar content and fruit variety.



**Figure 21:** Titratable acidity values.

**CCJ:** jelly made with commercial pectin (positive control); **CJ:** Jelly made without pectin (negative control); **QP4J:** jelly made with quince peels pectin (4mm); **QP2J:** jelly made with quince peels pectin (2mm); **QSJ:** jelly made with quince seeds pectin.

### II.5. Total soluble solids (TSS%)

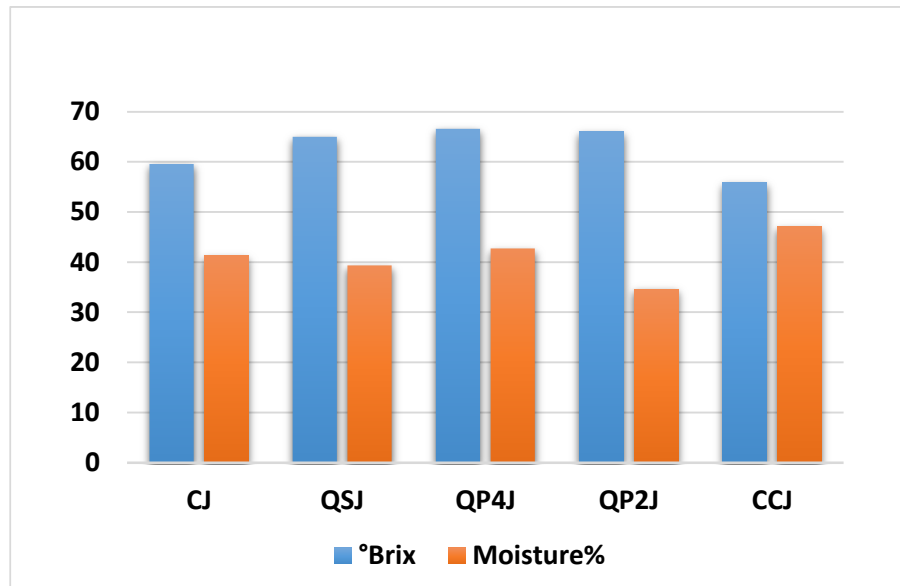
Total soluble solids ( $^{\circ}$ Brix), in addition to firmness, are measures of internal quality attributes in determining fruit maturity (**Peng et al., 2008**). TSS increases with maturity and is used as an indicator of soluble simple sugars or acids (**McGlone et al., 1998**).

**Figure 22** shows the  $^{\circ}$ Brix values of the jellies studied. The highest value was recorded for the QSJ sample (68%), followed by QP4J (66.6%), QP2J (66%) and CJ (59%), while the lowest value was recorded in the positive control (55.8%). In fact, the pectin extracted from quince by-products favored gelation and jelly concentration, which increased the total soluble solids content compared with the positive control.

Our results are lower than those obtained by **Lago-vanzela et al., 2011**, **Nachtigall, and Zambiasi (2006)**, who reported TSS values of 72 and 73% for Jambolane and hibiscus jelly respectively.

### II.6. Moisture content (%)

The relationship between moisture content and equilibrium relative humidity is an essential factor in technological processes in the food industry. Water can be a useful element in the formulation of products such as jellies.



**Figure 22:** Total soluble solids and moisture content of strawberry jellies.

**CCJ:** jelly made with commercial pectin (positive control); **CJ:** Jelly made without pectin (negative control) **QP4J:** jelly made with quince peels pectin (4mm); **QP2J:** jelly made with quince peels pectin (2mm); **QSJ:** jelly made with quince seeds pectin.

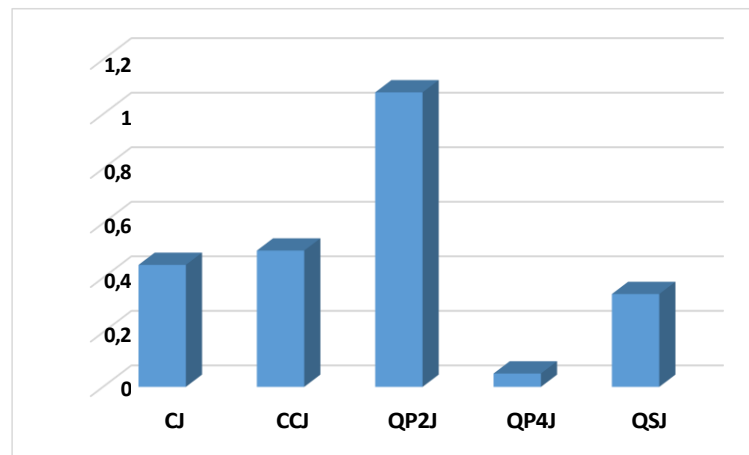
**Figure 22** shows that the moisture contents of the various strawberry jelly formulations range from 34 to 47%, with the highest content observed in the CCJ positive control and the lowest in the QP2J sample.

These moisture contents are lower than those obtained by **Nishiyama-Hortense et al., 2022** and **Lago-vanzela et al., 2011** who reported a moisture content of 55% for grape juice candy and 47% Jambolane jelly.

### II.7. Ash % content

Ash is the inorganic residue of a product after incineration of organic matter. Ash can contain a variety of inorganic compounds, including Sodium (Na), Potassium (K), Calcium (Ca)...etc. The ash content of jellies is illustrated in **figure (23)**, ranging from 0.34 to 1.08%. The lowest content was recorded for sample QP4J, while the highest content was observed for sample QP2J. The CJ and CCJ control samples were close in value (0.49% and 0.50%).

Our results are close to those obtained by **DEGMARA et al., 2019**, who found values between 0.2 and 0.4% for strawberry jams.



**Figure 23:** Ash content of strawberry jellies.

**CCJ:** jelly made with commercial pectin (positive control); **CJ:** Jelly made without pectin (negative control) **QP4J:** jelly made with quince peels pectin (4mm); **QP2J:** jelly made with quince peels pectin (2mm); **QSJ:** jelly made with quince seeds pectin.

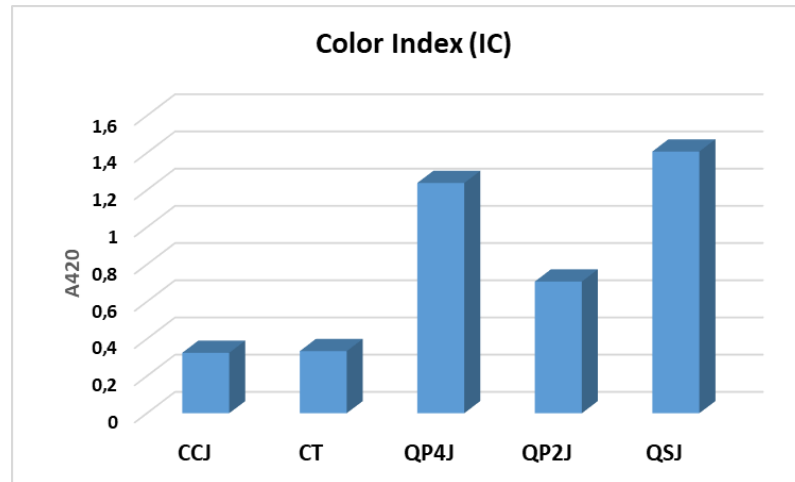
## II.8. Color index

The color of jam and jelly is very important, as it largely determines the organoleptic quality of the finished product (Temagoult., 2017).

The color index results obtained show differences between samples (figure 24). The QSJ jelly (1.40) recorded the highest color index, and the lowest value was recorded for the CCJ sample (0.32), followed in descending order by QP4J (1.23); QP2J (0.70) and CJ (0.33).

In the absence of a colorimeter, only the OD was measured. Color variation was assessed visually during sensory analysis. Although this method may appear subjective, it remains essential in our case.

Indeed, sugars are responsible for developing the brown color of many cooked foods through the Maillard reaction and caramelization, which break down under the effect of heat into new molecules that give color to products such as caramel sauces, caramelized fruits and confectionery. The color index varies proportionally with anthocyanin content, and studies have shown that pectin strengthens and stabilizes color (Anonymous, 2019).



**Figure 24:** Color index values of strawberry jellies.

**CCJ:** jelly made with commercial pectin (positive control); **CJ:** Jelly made without pectin (negative control); **QP4J:** jelly made with quince peels pectin (4mm); **QP2J:** jelly made with quince peels pectin (2mm); **QSJ:** jelly made with quince seeds pectin

### II.9. Viscosity of jellies (Flow test)

This test is used to determine the viscosity of the jellies and the type and amount of pectin added.

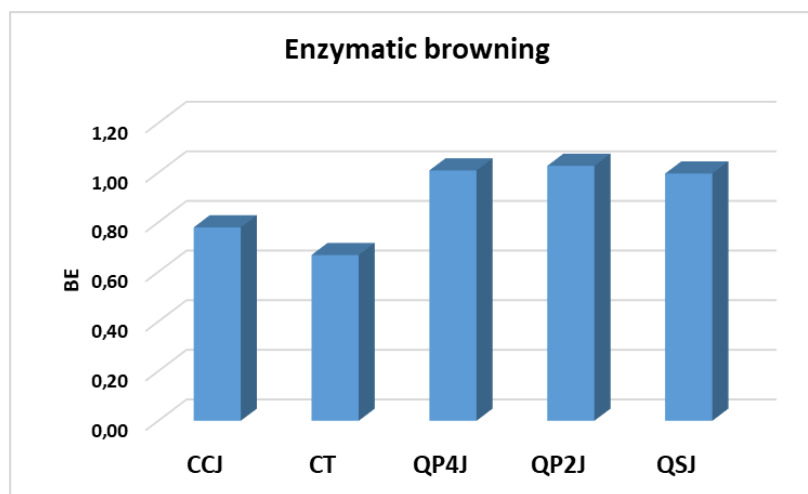
**Table 07.** Evaluation of the flow time of freshly prepared strawberry jellies and after storage

samples	Flow time (min) (freshly prepared)	Flow time after storage(min) 02
CCJ	<b>1.23.69</b>	<b>1.00.76</b>
CJ	<b>0.02.00</b>	<b>0.02.50</b>
QSJ	<b>0.30.66</b>	<b>0.19.86</b>
QP2J	<b>0.65.30</b>	<b>0.77.27</b>
QP4J	<b>0.48.19</b>	<b>0.39.84</b>

The table 7 shows the values of the flow time. When compared to Control jelly, the addition of pectin from quince peels produces jelly that are more consistent than negative control (CJ). On the other hand, the CJ and QSJ sample were the least consistent (lowest time covered), despite the presence of added pectin. After storage, QP2J became more consistent, however there are a decrease in the consistence (viscosity) of QSJ sample.

## II.10. Non-enzymatic browning

Non-enzymatic browning is the reaction of food sugars with amino acids and heat during thermal processing, also known as the Maillard reaction. Non-enzymatic browning results for our samples are in descending order of 1.03, 1.01, 1.00, 0.78, and 0.67 for QP2J, QP4J, QSJ, CCJ, and CJ jellies respectively **figure 25**. These results are close to the 0.61 obtained for pomegranate jam (Y. Yun et al., 2023). The browning undergone by the jelly is due to the Maillard reaction that takes place during cooking. Indeed, enzymatic browning is adversely affected by lower pH and heat treatment. However, BNE is favored by heat treatments and can still occur at a low pH of around 4.0 (Besbes et al., 2009).



**Figure 25:** Evaluation of non-enzymatic browning of strawberry jellies.

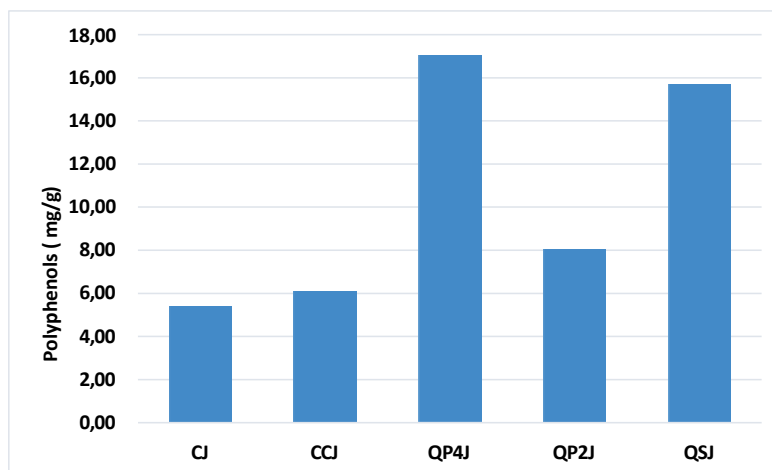
**CCJ:** jelly made with commercial pectin (positive control); **CJ:** Jelly made without pectin (negative control); **QP4J:** jelly made with quince peels pectin (4mm); **QP2J:** jelly made with quince peels pectin (2mm); **QSJ:** jelly made with quince seeds pectin.

## II.11. Active molecule content

### II.11.1. Total polyphenols content

**Figure 26** shows the total polyphenol content of the strawberry jellies studied.

The total polyphenol content of the samples analyzed ranged from 17 to 5.5 mg/g for samples QP4J and CJ. These results are lower than those reported by **Hebbache et al. (2013)** and **Meenaks et al.(2014)** for strawberry and sea buckthorn jam, with respective levels of 193.59 mg EAG/100 g and 226.8 mg EAG/100 g.



**Figure 26:** Total polyphenol content of strawberry jellies.

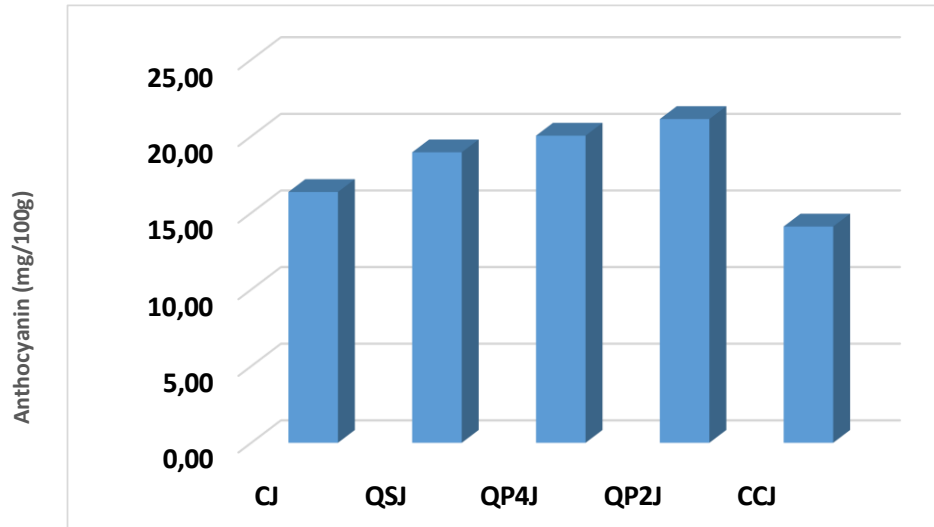
**CCJ:** jelly made with commercial pectin (positive control); **CJ:** Jelly made without pectin (negative control); **QP4J:** jelly made with quince peels pectin (4mm); **QP2J:** jelly made with quince peels pectin (2mm); **QSJ:** jelly made with quince seeds pectin.

### II.11.2. Anthocyanin content

Anthocyanins belong to the flavonoid class. They are pigments present in the vacuoles of plant cells that can give colorations ranging from red to blue depending on chemical structure, pH and the presence of co-pigments (**Ignat et al., 2011**).

QP2J and QP4J jellies and QSJ prepared with pectins extracted from quince peels and seeds showed the highest values (20 and 19 and 18 mg /100g respectively) followed by CJ jellies. However, the lowest value was recorded for CCJ jelly.

These results are higher than those obtained by **Nan-Jung Jung et al., 2012**, which are in the order of 0.8 and 2.64 mg/100g for strawberry jam. Anthocyanin levels vary according to variety, growing conditions, ripening stage, storage conditions and assay method (**Gil et al., 2000 ; çam et al., 2009**).



**Figure 27:** Total anthocyanin content of strawberry jellies.

CCJ: jelly made with commercial pectin (positive control); CJ: Jelly made without pectin (negative control); QP4J: jelly made with quince peels pectin (4mm); QP2J: jelly made with quince peels pectin (2mm); QSJ: jelly made with quince seeds pectin.

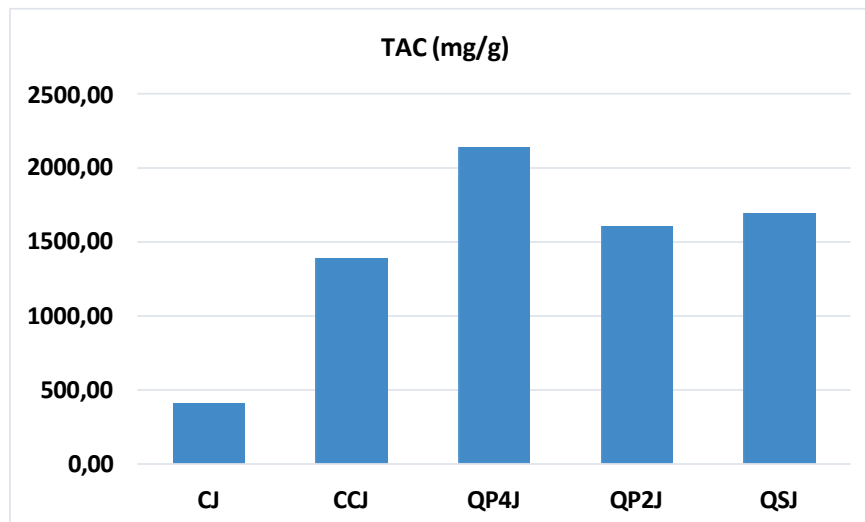
## II.12. Total antioxydant activity

**Figure 28** summarizes the results obtained for total antioxidant activity. Jellies QP4J and QSJ followed by QP2J presented the highest values (2100, 1690 and 1600 mg EAA/g) followed by jellies CCJ and CJ with antioxidant activities of 1386 and 400 mg/g respectively.

Our results are lower than those obtained by **HEBBACHE et al. (2013)** for strawberry jams, which ranged from 5985.81 and 7769.55 mg EAA/100 g (FIG2).

The results of the present study show that reducing power is proportional to the phenolic compound content of the jellies studied.

Several studies have attributed the reducing capacity to molecules other than phenolic compounds, such as ascorbic acid or carotenoids. **Slusarczyk et al. (2009)** and **Jayaprakasha et al. (2008)** have shown that antioxidant activity can be affected by many factors, including the structure of phenolic compounds and synergistic interactions with various antioxidants. In addition, it can also be affected by the analytical method used and the extraction conditions (**Abrantes et al., 2007; Slusarczyk, 2009**).



**Figure 28:** Total antioxidant activity values of prepared jellies.

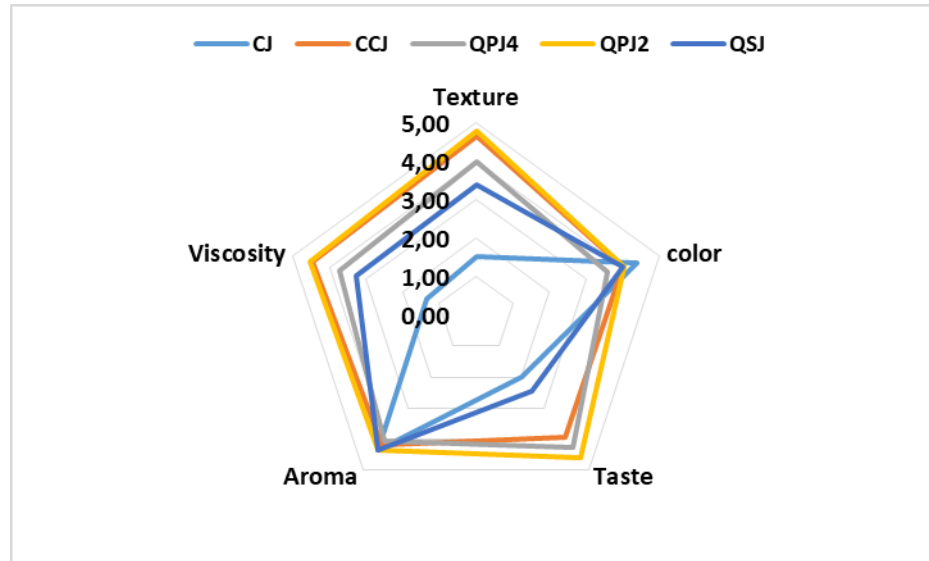
**CCJ:** jelly made with commercial pectin (positive control); **CJ:** Jelly made without pectin (negative control); **QP4J:** jelly made with quince peels pectin (4mm); **QP2J:** jelly made with quince peels pectin (2mm); **QSJ:** jelly made with quince seeds pectin.

### II.13. Sensory analysis of freshly prepared jelly samples and after 03 months of refrigerated storage

The aim of sensory analysis is to describe the organoleptic characteristics of products objectively, according to well-defined criteria: texture, color, taste, and aroma. Sensory attributes are perceived when our sensory organs interact with stimuli from the world around us (**Kemp et al., 2011**). The hedonic quality of strawberry jelly is judged according to: Texture, color, taste, aroma, viscosity and overall preference.

#### II.13.1. Evaluation of organoleptic characteristics of fresh jellies

The average sensory attribute values of the fresh jellies studied are shown in **figure 29**.



**Figure 29:** Sensory attributes of freshly prepared jellies

**CCJ:** jelly made with commercial pectin (positive control); **CJ:** Jelly made without pectin (negative control); **QP4J:** jelly made with quince peels pectin (4mm); **QP2J:** jelly made with quince peels pectin (2mm); **QSJ:** jelly made with quince seeds pectin

#### II.13.1.1. Texture

It is the sensation a food gives you when you touch it or eat it. It corresponds to the hardness, roughness or flakiness of a foodstuff. The QPJ2 sample received the highest average score (firmer structure), followed by CCJ, then the QPJ4 sample, which presented a melting texture.

Classification : QPJ2 > CCJ > QPJ4 > QSJ > CJ.

#### II.13.1.2. Color

Color is defined in a three-dimensional space: hue (red, blue, green, yellow, pink, etc.), luminosity (light-dark) and saturation (bright or dull, grayish) (**Bauer et al., 2010**). The color of a food may be due to its natural constituents (natural pigments such as carotenes, chlorophyll, etc.), or to added authorized food coloring agents (**Jellinek, 1985**).

The color of elaborated jellies is similar, varying from bright red to dark red. This variation is due in particular to the non-enzymatic browning (Maillard reaction) promoted by heat treatment during jelly preparation.

#### II.13.1.3. Taste

Taste is the sensation perceived by the gustatory organ when stimulated by certain soluble substances (**AFNOR, 1992**). The gustatory organ (the perceives flavors (or tastes) papillae

of the tongue) when stimulated by certain soluble substances. These include salty, sweet, sour and bitter sensations (**Delacharlerie et al., 2008**).

The tasters appreciated the jellies in terms of sugar content and acidity, but the jellies most appreciated by all tasters were those made with QP2J and QP4J quince peel pectin. The QP2J formulation received the highest average score, followed by QP4J, CCJ, QSJ and finally CJ.

Ranking: QP2J > QP4J > CCCJ > QSJ > CJ.

#### **II.13.1.4. Aroma**

The olfactory organ perceives these properties: odor by "sniffing" certain volatile substances, aroma by retro-nasal route during tasting (**AFNOR, 1992**). All the jelly samples had a characteristic strawberry aroma, which was noted by the tasters as all formulations received very similar average scores. The strawberry aroma was most distinctive in the CJ sample (4.3), followed by jellies prepared with pectin extracted from peels, followed by CCJ and finally QSJ.

Classification : CJ > QP2J > QP4J > CCJ > QSJ.

#### **II.13.1.5. Viscosity**

Viscosity can be defined as the total resistance to movement of a fluid in a flow with or without turbulence. Viscosity is measured in pascals-seconds (Pa. s).

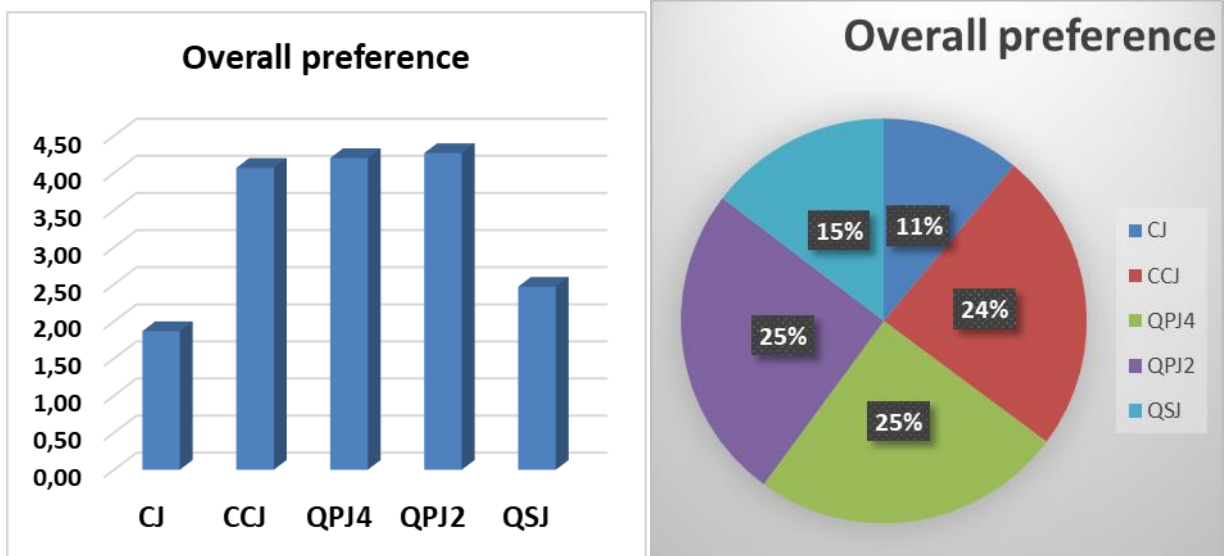
According to the scores shown in figure (29), there are significant differences in the viscosity of all jellies. The QPJ2 and CCJ jellies were the most appreciated by the panalists, with the highest score awarded to QP2J (4.5), followed by CCJ (4.4), QP4J (3.8), QSJ (3.2), then CJ (1.3).

Classification : QP2J > CCJ > QP4J > QSJ > CJ.

#### **II.13.1.6. Preference**

In terms of overall preference, the QP2J jelly was the one most appreciated by all the panalists, followed in decreasing order by the QPJ4 jelly, CCJ, QSJ and lastly the CJ negative control (**figure 31**).

Classification : QP2J > QP4J > CCJ > QSJ > CJ.

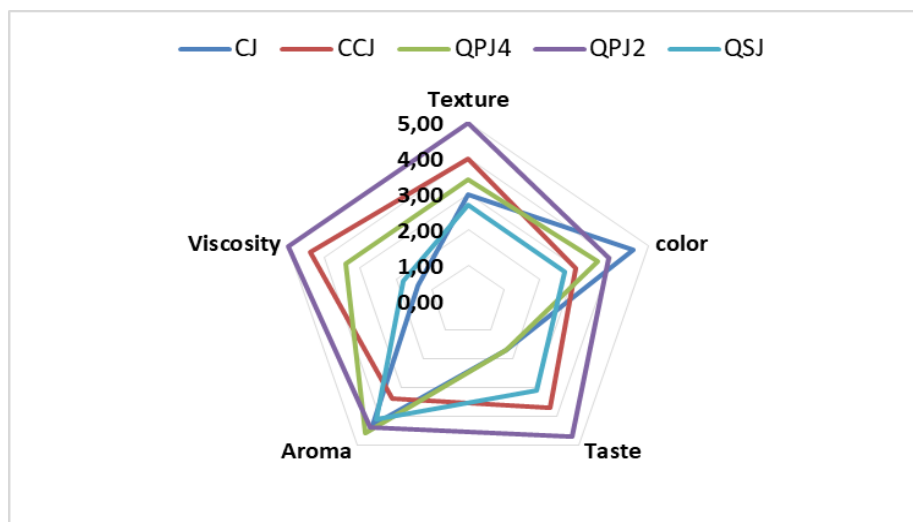


**Figures 30:** (a) Average scores of jellies overall preference and (b) Acceptance percentages of jellies overall preference

CCJ: jelly made with commercial pectin (positive control); CJ: Jelly made without pectin (negative control); QP4J: jelly made with quince peels pectin (4mm); QP2J: jelly made with quince peels pectin (2mm); QSJ: jelly made with quince seeds pectin

#### II.14. Evaluation of organoleptic characteristics of jellies after 3 months' storage

Average sensory attribute scores for the jellies studied after 3 months of refrigerated storage are shown in **figure 31**.



**Figure 31:** Sensory attributes of jellies after 03 months of refrigerated storage.

CCJ: jelly made with commercial pectin (positive control); CJ: Jelly made without pectin (negative control); QP4J: jelly made with quince peels pectin (4mm); QP2J: jelly made with quince peels pectin (2mm); QSJ: jelly made with quince seeds pectin

### **II.14.1. Texture**

The results obtained from the sensory analysis of jelly texture after 3 months represent a decrease in score for the average score for the QSJ sample compared with the score obtained in the fresh analysis. In comparison with the other samples, they have kept almost the same texture as the fresh samples.

Classification : QP2J > CCJ > QP4J > QSJ > CJ.

### **II.14.2. Color**

After three months' storage, the color of the CJ jelly was the most appreciated by the tasters, with the exception of sample CCJ, whose color became pale.

Classification : CJ > QP2J > QP4J > CCJ > QSJ.

### **II.14.3. Taste or flavor**

After 3 months' storage, the QP4J sample became less appreciated by the panalists (sour and a little bitter), as it received the lowest score (1.70).

The overall decrease in pH (more acidic) could be due to ascorbic acid degradation, pectin hydrolysis, and other acidic compounds (**Imtiaz et al., 2010**).

Classification : QP2J > CCJ > QSJ > QP4J > CJ.

### **II.14.4. Aroma**

In terms of aroma, there was a slight decrease in average scores for all samples, with the smallest decrease observed for sample CCJ.

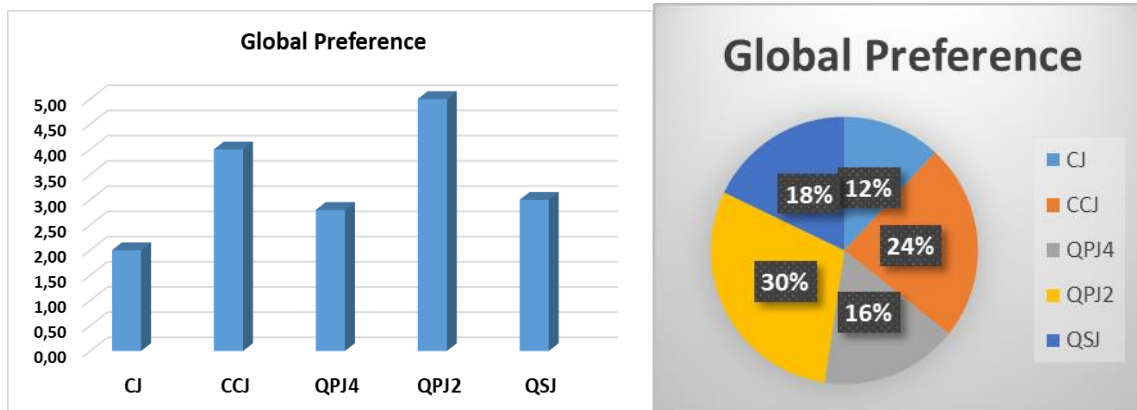
### **II.14.5. Viscosity**

The average scores in terms of viscosity in **Figure 31** show a slight diminution for samples QSJ and QP4J compared with the average scores in **Figure 29**.

Classification : QP2J > CCJ > QP4J > QSJ > CJ.

### **II.14.6. Preference**

In terms of overall preference, the QP2J jelly was the most appreciated by all juries, followed in descending order by the CCJ jelly, QSJ, QP4J and lastly the CJ sample (**figure 32**).



**Figures 32:** (a) Average scores of jellies overall preference and (b) Acceptance percentages of jellies overall preference after storage

**CCJ:** jelly made with commercial pectin (positive control); **CJ:** Jelly made without pectin (negative control); **QP4J:** jelly made with quince peels pectin (4mm); **QP2J:** jelly made with quince peels pectin (2mm); **QSJ:** jelly made with quince seeds pectin

# Conclusion

**Conclusion**

The present study was carried out in the context of the valorization of quince by-products. The objectives of this study were to extract hydrocolloids, such as, pectin from quince peel and seeds, and then to study the gelling and stabilizing effect of pectin in the manufacture of strawberry jellies.

Quince by-products, extracted pectin and strawberry jellies were subjected to physico-chemical analyses (pH, humidity, acidity, ash, Brix, BNE, color index, degree of esterification, appearance, etc.), evaluation of active molecules (total polyphenol and anthocyanin content), and the total antioxidant activity of raw materials. In addition, certain sensory attributes (texture, color, aroma, taste, viscosity, and preference) of the jellies were evaluated during a three-month storage period.

The following conclusions can be drawn from the results obtained. :

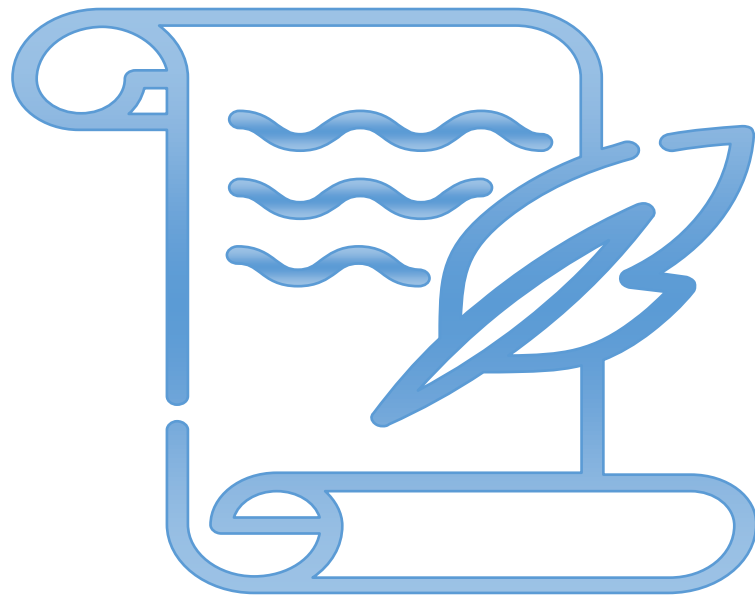
- The richness of quince peels and seeds in active molecules, which correlates positively with their antioxidant activity.
- Based on galacturonic acid content and degree of esterification, these pectin can be classified as highly methylated.

A novelty jelly has been produced by adding pectin extracts from quince-derived products as one of the ingredients. The low pH of the jellies makes them microbiologically safe.

- Jellies made with pectin extracted from quince by-products showed the highest antioxidant activity compared with control jellies.
- The functional properties of the jellies contributed significantly to improving their organoleptic qualities and overall acceptance. There was no significant difference in preference between jellies prepared with commercial pectin and pectin extracted from quince peel.

This study has led to a better understanding of the need to use pectin extracted from quince peels and seeds in food processing. Research into the use of other native fruits as sources of pectin is therefore recommended to increase access to pectin in most processing industries.

# References



**References**

- Abbastabar, B., Azizi, M. H., Adnani, A., & Abbasi, S. (2015).** Determining and modeling rheological characteristics of quince seed gum. *Food Hydrocolloids*, 43, 259–264. <https://doi.org/10.1016/j.foodhyd.2014.05.026>
- Acikgoz, C.,(2011).** Extraction and Characterization of Pectin Obtained from Quince Fruits (*Cydonia vulgaris pers*) Grown in Turkey. *Asian Journal of Chemistry*. 23(1), 149-152.
- AFNOR. 1992.** ISO 5492. Analyse sensorielle. Vocabulaire In Analyse sensorielle Paris. pp (9- 30).
- Akhtar, M., Dickinson, E., Mazoyer, J. & Langendorff, V. (2002).** Emulsion stabilizing properties of depolymerized pectin. *Food Hydrocolloids*, 16 (3), 249-256.
- Albersheim P, Darvill AG, O’Neill MA, Schols HA, Voragen AGJ. (1996).** An hypothesis: the same six polysaccharides are components of the primary cell walls of all higher plants. In *Pectins and Pectinases*. Edited by Visser J, Voragen AGJ. Amsterdam. Elsevier Sciences B.V.,47-53
- Alesiani, D., Canini, A., D’Abrosca, B., DellaGreca, M., Fiorentino, A., Mastellone, C., Monaco, P., Pacifico, S. (2010).** Antioxidant and antiproliferative activities of phytochemicals from quince (*Cydonia vulgaris*) peels, *Food Chem*. 118 199–207.
- Almeida Lopes, M. M., A. Guimarães sanches, K. O. de souza, De oliveira silva, E. (2018).** Quince—*Cydonia oblonga*. *Exotic Fruits*. Academic Press. 363- 368.
- Al-Snafi, A. E. (2016).** The medical importance of *Cydoniaoblonga*-A review. *IOSR Journal of Pharmacy*, 6(6), 87-99.
- Alzamora, S. M., Cerruti, P., Guerrero, N. S., Nieto, A. B., et Vidales, S. (2004).** Technologies combinées de conservation des fruits et légumes. Manuel de formation, FAO, Rome, 18p.
- Antolín-Amérigo, D., J. Barbarroja-Escudero, M. J. Sánchez-González, M. RodríguezRodríguez, F. Pineda and M. Alvarez-Mon, 2015:** Allergy to quince. *Allergologia et Immunopathologia*. 43, 101-103.
- AOAC. (2000).** Official Methods of Analysis. 17th Ed. Maryland. U.S.A. 360 p.
- AOAC. (2002).** Official Methods of Analysis.17th Ed. Gaithersburg, USA. 480 p.
- Aslanova D., Bakkalbasi E., et Artik N. (2010).** Effect of storage on 5 hydroxymethylfurfural (HMF) formation and color change in jams. *InternationalJournal of Food Properties*.13: 904-912.

- Audigie, L., Figarella J., et Zonszain F.(1978).** Manipulation biochimique. Ed. Doin. Paris.. 274p.
- Azad A. K. M., Ali M. A., Akter M. S., Rahman M. J., Ahmed M., (2014).** Isolation and characterization of pectin extracted from lemon pomace during ripening. Journal of Food and Nutrition Sciences,2(2), 30-35.
- Bartkiene, E. (2018)..**Sea buckthorn (*Hippophae rhamnoides* L.) and quince (*Cydonia oblonga* L.) juices and their by-products as ingredients showing antimicrobial and antioxidant properties for chewing candy: nutraceutical formulations, J. Food Qual. Article ID 3474202, 8 pages.
- Barrera A.M., Ramirez J.A., Gonzalez-Cabriaes J.J. & Vazquez M., (2002).** Effect of pectins on the gelling propertis of surimi from silver carp. Food Hydrocolloids, 16 (5), 441-447.
- Bauer, W.J., Badoud, R., Loliger, J. & Etaurnaud, A. (2010).** Science et Technologie des Aliments. Ed. Presses polytechniques et universitaires, Italie. pp 1-754.
- Benamara. S et Agougou. A., (2003) :** Production des jus alimentaires. Edition Office des publications universitaire.
- Besbes, S., Drira, L., Blecker, C., Deroanne, C & Attia, H. 2009.** Adding value to hard date (*Phoenix dactylifera* L.): Compositional, functional and sensory characteristics of date jam. Food Chemistry. 112: 406–411.
- Bonnin E., Le Goff A., Körner R., Vigouroux J., Roepstorff P. & Thibault J.-F., (2002).** Hydrolysis of pectins with deferent degrees and patterns of methylation by the endopolygalacturonase of *Fusarium moniliforme*. Biochimica et Biophysica Acta (BBA) - Protein Structure and Molecular Enzymology, 1596 (1): 83-94.
- Brissonnet , F., Bouix, M., Loiseau , G., Russel. A., and Leveauj, Y. (1994).** Le stress bactérien et ses conséquences en génie de l’hygiène.IAA .3, 106-114.
- Brown, V.A., Lozano, J.E., Genovese, D.B. (2014).** Pectin extraction from quince (*Cydonia oblonga*) pomace applying alternative methods: effect of process variables and preliminary optimization, Food Sci. Technol. Int. 20, 83–98.
- Çam, M., Hışıl, Y. &Durmaz, G. (2009).**Classification of eight pomegranate juices based on antioxidant capacity measured by four methods. Food chemistry. 112(3): 721-726.
- Codex Alimentarius (FAO/OMS). (1995).** Fruits et légumes traités et surgelés. 2e Eds. Vol 5. Rome. P 518.
- CODEX STAN 296-2009.** Norme du codex alimentarius pour les confitures, gelées et marmelades.

- Constenla D., Lozano J. E. (2003).** Kinetic model of pectin demethylation. *Latin American Applied Research*, 33:91-96.
- Cordenunsi, B. R., Nascimento, J. D., & Lajolo, F. M. (2003).** Physico-chemical changes related to quality of five strawberry fruit cultivars during cool-storage. *Food Chemistry*, 83(2), 167-173.
- Cortés-Camargo, S., Román-Guerrero, A., Alpizar-Reyes, E., Pérez-Alonso, C., 2023.** New Sources of Pectin: Extraction, Processing, and Industrial Applications, in: *Utilization of Pectin in the Food and Drug Industries*. IntechOpen. <https://doi.org/10.5772/intechopen.109579>
- Couplan, F. (2012).** Les plantes et leurs noms : Histoires insolites. *Les plantes et leurs noms*. 65.
- Crespo, P., Bordonaba, J. G., Terry, L. A., & Carlen, C. (2010).** Characterisation of major taste and health-related compounds of four strawberry genotypes grown at different Swiss production sites. *Food Chemistry*, 122(1), 16-24.
- De Moura, S. C. S. R., da Tavares, P. E. R., Germer, S. P. M., Nisida, A. L. A. C., Alves, A. B., & Kanaan, A. S. (2012).** Degradation kinetics of anthocyanin of traditional and low-sugar blackberry Jam. *Food and Bioprocess Technology*, 5(6), 2488–2496. <https://doi.org/10.1007/s11947-011-0578-7>
- Degmara. N, Samah. H, Zoghba. N ,** Mémoire de Master : Essai d'élaboration d'une formulation de confiture à base de fraise et l'évaluation des paramètres physicochimiques, microbiologiques et sensoriels. Université Mohamed sedik ben yahya Jijel. **2018-2019.**
- Delacharlerie, S., De Biourge, S., Chene, C., Sindic, M. & Deroanne, C. 2008.** Les Méthodes d'Analyse. In « HACCP Organoleptique: Guide Pratique ». Ed. Les Presses Agronomiques de Gembloux, Belgique. pp72-73.
- Deng, Y., Huang, L., Zhang, C., Xie, P., Cheng, J., Wang, X., & Li, S. (2019).** Physicochemical and functional properties of Chinese quince seed protein isolate. *Food Chemistry*, 283(16), 539–548. <https://doi.org/10.1016/j.foodchem.2019.01.083>
- Dennapa B., Kamonrad R. & Hataichanoke N., (2006).** Extraction and Physicochemical Characteristics of Acid-Soluble Pectin from Raw Papaya (*Carica papaya*) Peel. *Chiang Mai J. Sci.*, 33 (1) : 129-135.
- Devi, W.E., Kumar, R.S.K.B.A. and Mishra, A.A. (2014).** Extraction of Pectin from citrus fruit peel and its utilization in preparation of jelly. *Int. J. Eng. Res.* 3(5): 1-5
- Donato L. (2004).** Gélification et séparation de phase dans les mélanges protéines globulaires/pectines faiblement méthylées selon les conditions ioniques. Thèse de doctorat, France.

- Elleuch, M.; Bedigian, D.; Roiseux, O.; Besbes, S.; Blecker, C.; Attia, H. (2011).** Dietary fibre and fibre-rich by-products of food processing: Characterisation, technological functionality and commercial applications: A review. *Food Chem.*, 124, 411–421.
- Elmizadeh, A., M. Shahedi and N. Hamdami, 2017:** Comparison of electrohydrodynamic and hot-air drying of the quince slices. *Innovative Food Science & Emerging Technologies*, 43, 130-135.
- Ercisli, S., M. G. Boydas, F. Kalkan, I. Ozturk and Kara, M. (2015).** Dimensional, Frictional, and Color Properties of Four Quince Cultivars (*Cydonia oblonga* Miller). *ErwerbsObstbau*, 57, 113-118.
- Escalada Pla, M.F., Uribe, M., Fissore, E.N., Gerschenson, L.N., Rojas, A.M. (2010)** Influence of the isolation procedure on the characteristics of fiber-rich products obtained from quince wastes. *J. Food Eng.* 2010, 96, 239–248.
- Essafi-Benkhadir, K., Refai, A., Riahi, I., Fattouch S., Karoui, H., Essafi M. (2012).** Quince (*Cydonia oblonga* Miller) peel polyphenols modulate LPS-induced inflammation in human THP-1- derived macrophages through NF- $\kappa$ B, p38MAPK and Akt inhibition, *Biochem. Biophys. Res. Commun.* 418, 180–185.
- Fattouch, S., Caboni, P., Coroneo, V., Tuberoso, C.I.G., Angioni, A., Dessi, S., Marzouki, N., Cabras, P. (2007),** Antimicrobial activity of tunisian quince (*Cydonia oblonga* Miller) pulp and peel polyphenols extracts, *J. Agric. Food Chem.* 55, 963–969
- Fishman, M. L., Pepper, L., Damert, W. C., Baford, R. A. (1986).** Chemistry and function of pectins, (Fishman M. L and JEN JJ eds.), ACS symposium series 310, Washington.33p.
- Food Chemical Codex. (1996).** IV monographs. Washington DC: National Academy Press, pp : 283
- García-Viguera C., Zafrilla P., Romero F., Abellán P., Artés F. et Tomás-Barberán F.A. (1999).** Color stability of strawberry jam as affected by cultivar and storage temperature. *Journal of Food Science.* 64( 2), 243-247.
- Gheisari H R. and Abhari K. H. (2014).** Drying method effects on the antioxidant activity of quince (*Cydonia oblonga* Miller) tea. *Acta Scientiarumpolonorum. Technologiaalimentaria* 13(2). 129-13
- Giampieri, F., Alvarez-Suarez, J. M., Mazzoni, L., Romandini, S., Bompadre, S., Diamanti, J., Tulipani, S. (2013).** The potential impact of strawberry on human health. *Natural productresearch*, 27(4-5), 448-455.

- Gil, M., Tomas-Barberan, F. (2000).** Antioxydant activity of pomegranate juice and its relationship with phenolic composition and processing. *Journal of Agricultural and Food Chemistry*. 48, 4581-4589.
- Guillotin S.E., Van Loey A., Boulenguer P., Schols H.A. & Voragen A.G.J., (2007).** Rapid HPLC method to screen pectins for heterogeneity in methyl-esterification and amidation. *Food Hydrocolloids*, 21 (1), 85–91.
- Hebbache.I. and Sebkhil .S, (2013).** Mémoire en vue d'obtention du diplôme de Master en Biochimie Appliquée : Teneurs en antioxydants et activités antioxydantes de quelques variétés de confitures industrielles. Université Abderrahmane Mira Bejaia.
- Herrera-Rocha, K.M., Rocha-Guzmán, N.E., Gallegos-Infante, J.A., González-Laredo, R.F., Larrosa-Pérez, M., Moreno-Jiménez, M.R. (2022).** Phenolic Acids and Flavonoids in Acetonic Extract from Quince (*Cydonia oblonga* Mill.): Nutraceuticals with Antioxidant and Anti-Inflammatory Potential. *Molecules*. 27(8), 2462; <https://doi.org/10.3390/molecules27082462>
- Hussain, I., and Chakir, I. (2010).** Chemical and organoleptic characteristics of jam prepared from indigenous varieties of apricot and apple. *World Journal of Dairy and Food Sciences*, 5(1) ,73-78.
- Hussain, S.Z., Naseer, B., Qadri, T., Fatima, T., Bhat, T.A., (2021).** Quince (*Cydonia oblonga*)—Morphology, Taxonomy, Composition and Health Benefits, in: Hussain, S.Z., Naseer, B., Qadri, T., Fatima, T., Bhat, T.A. (Eds.), *Fruits Grown in Highland Regions of the Himalayas: Nutritional and Health Benefits*. Springer International Publishing, Cham, pp. 49–62. [https://doi.org/10.1007/978-3-030-75502-7\\_4](https://doi.org/10.1007/978-3-030-75502-7_4)
- Ismail, N.S.M., Ramli, N., Hani, N.M. and Meon, Z. (2012).** Extraction and characterization of pectin from dragon fruit (*Hylocereus polyrhizus*) using various extraction conditions. *Malaysiana Science (In Malay)*. 41(1), 41-45.
- Jayaprakasha G.K., Girenavar B. and Patil B.S. (2008).** Antioxidant capacity of pummel and navel oranges: Extraction efficiency of solvents in sequence. *Food Science and Technology*, 41, 376-384.
- Jellinek, G. (1985).** Sensory evaluation of food-Theory and practice. Ed. Ellis Horwood Series in Food Science and Technology, Chichester (England). 429.
- Kar F. & Arslan N., (1999).** Effect of temperature and concentration on viscosity of orange peel pectin solutions and intrinsic viscosity–molecular weight relationship. *Carbohydrate Polymers*. 40 (4), 277–284.

- Karar, M. G. Pletzer, E., D., Jaiswal, R., Weingart H., AND Kuhnert, N.(2014).** Identification, characterization, isolation and activity against *Escherichia coli* of quince (*Cydonia oblonga*) fruit polyphenols. *Food Research International*, 65, 121-129.
- Kemp, S.E., Hollowood, T., & Hort J. 2011.** *Sensory Evaluation, a practical handbook: Sensory perceptions*, Ed. willy-blackwell pp 96.
- Koubala BB, Kansci G, Mbome LI, Crépeau MJ, Thibault JF, Ralet MC. (2008).** Effect of extraction conditions on some physicochemical characteristics of pectins from “Améliorée” and “Mango” peels. *Food Hydrocolloids*, 22:1345-1351.
- Koubala BB, Mbome LI, Kansci G, Tchouanguép Mbiapo F, Crépeau MJ, Thibault JF, Ralet. M.C., (2008).** Physicochemical properties of pectins from ambarella peels (*Spondias cytherea*) obtained using different extraction conditions. *Food Chemistry*, 106: 1202–1207
- Lago-Vanzela, E.S., Santos, G.V., Lima, F.A., Gomes, E. & Da-Silva, R., (2011).** Physicalchemical, caloric and sensory characterization of light jambolan (*Syzygium cumini* Lamarck) jelly. *Ciênc. Tecnol. Aliment.* 31(3): 666-673.
- Legua, P., Serrano, M., Melgarejo, P., Valero, D., Martínez, J. J., Martínez, R., & Hernández, F. (2013).** Quality parameters, biocompounds and antioxidant activity in fruits of nine quinces (*Cydonia oblonga* Miller) accessions. *Scientia horticulturae*. 154- 165.
- Lekhuleni, I.L.G., Kgatla, T.E., Mashau, M.E., Jideani, A.I.O., (2021).** Physicochemical properties of South African prickly pear fruit and peel: Extraction and characterisation of pectin from the peel. *Open Agriculture* 6, 178–191. <https://doi.org/10.1515/opag-2021-0216>
- Lele, V., Monstavičiute, E., Varinauskaite, I, Peckaityte, G., Paskeviciute, L., Plytnikaite, M., Tamosiunaite, V., Pikunaite, M., Ruzauskas, M., Stankevicius, R.,**
- Levigne S., Thomas M., Ralet M.-C., Quemner B. & Thibault J.-F., (2002).** Determination of the degrees of methylation and acetylation of pectins using a C18 column and internal standards. *Food Hydrocolloids*, 16 (6), 547-550.
- Liu L., Fishman M. L., Kost J., Hicks K. B. (2003).** Pectin-based systems for colon-specific drug delivery via oral route. *Biomaterials*, 24(19), 3333-3343.
- Lopes da Silva J.A. & Rao M.A., (2006).** Pectin: Structure, Functionality, and Uses. In *Food Polysaccharides and Their Applications*, Second Edition. Edition: Stephen, CRC Press Taylor & Francis Group. Chapter 11 : pp 353-412.
- Magalhaes, A.S., Silva, B.M., Pereira, J.A., Andrade, P.B., Valentao, P., Carvalho, M., (2009).** Protective effect of quince (*Cydonia oblonga* Miller) fruit against oxidative hemolysis of human erythrocytes, *Food Chem. Toxicol.* 47,1372–1377.

- Marcon, M.V., Vriesmann, L.C., Wosiacki, G., Beleski-Carneiro, E., Petkowicz, C.L.O (2005).** Pectins from apple pomace, *Ciência e Tecnologia*, 15(2), 127- 129.
- Meenaks, hisundaram S. & Farhath K. (2014).** Processing seabuckthorn fruit for antioxidant rich jam development and shelf stability assessment. *Indian journal traditional knowledge*, 13 (2), 335-346.
- Mesbahi G., Jamalian J. & Farahnaky A., (2005).** A comparative study on functional properties of beet and citrus pectins in food systems. *Food Hydrocolloids*, 19, 731-738.
- Michel B., (2002).** Conservation par les sucres : confitures, gelées, fruits sur sucre. In : *Technologies de transformation des fruits. Technique et documentation-Lavoisier (Ed). Paris*, pp 421-425.
- Mohamadzaheh J., Sadeghi-mahoonak A.R., Yaghbani M., Aalami M., (2010).**Extraction of pectine from sunflower head residues of selected Iranian cultivars.*World Applied Sciences Journal*, 8 (1): 21-24.
- Morris, G.A., Foster, T.J. Harding, S.E. (2002).** A hydrodynamic study of the depolymerisation of a high methoxyl pectin at elevated temperature. *Carbohydrate Polymers*. 48, 361-367.
- N’BeMiller J., (2001).** Plant Gums. *Encyclopedia of Life Sciences*, John Wiley & Sons, Ltd. pp 1-5.
- Nachtigall, A.M. and Zambiazzi, R.C. (2006),** “Geléias de hibisco com reduzido valor calórico: características sensoriais”,*Boletim do Centro de Pesquisa e Processamento de Alimentos*. 24 (1), 47-58.
- Nan-Jung Jung and Yoon-Han Kang (2012).** Comparison of the Physicochemical Quality Characteristics of Strawberry Jams by Processing Methods. *Korean J Food Preserv* 19(3), 337-343.
- Nielsen. S.S. (2010).** *Food Analysis*.4<sup>ème</sup>Ed. Springer. USA. 602 p.
- Nimitula A, Mamatjan M and Mutallip A (2005)** Uighur medicine commonly used herbs; Xinjiang People’s Health Publishing House: Urumqi,China pp.133.
- O’Neill A.M., Darvill A.G. & Albersheim P., (2001).** Pectic Substances. *Encyclopedia of Life Sciences*, John Wiley & Sons (Ed), pp 1-11.
- O’neill, M., Albersheim, P., Darvill, A., (1990).** The Pectic Polysaccharides of Primary Cell Walls, in: Dey, P.M. (Ed.), *Methods in Plant Biochemistry, Carbohydrates*. Academic Press, 415–441.
- Oliveira. A .P, Pereira J M, Andrade P B, Valentão P, Seabra R M and Silva B M (2007)** Phenolic profile of *Cydoniaoblonga* Miller leaves. *J. Agricult. Food Chem*. 55(19), 7926-

7930.

**Oosterveld A., Beldman G. B., Schols H. A., Voragen A. J. (1996).** Arabinose and ferulic acid rich pectic polysaccharides extracted from sugar beet pulp. *Carbohydrate Research*, 288(19),143-153.

**Othman, S.; Añibarro-Ortega, M.; Dias, M.I.; Cirić, A.; Mandim, F.; Soković, M.; Ferreira, I.C.F.R.; Pinela, J.; Barros, L. (2022).** Valorization of quince peel into functional food ingredients: A path towards “zero waste” and sustainable food systems. *Heliyon*, 8, e11042.

**Panouillé M., Thibault J-F. & Bonnin E., (2006).** Cellulase and Protease Preparations Can Extract Pectins from Various Plant Byproducts. *Journal of Agricultural and Food Chemistry*. American Chemical Society, 54 , 8926-8935.

**Pereira, A., Añibarro-Ortega, M., Nogueira, A., Barros, L, Pinela, J. (2023).** Optimization of Dietary Fiber Extraction from Quince Peel. *Eng. Proc.*, 37, 78.

**Postman, J. (2009).** *Cydonia oblonga*: The unappreciated quince. *Arnoldia* 67(1), 2-9.

**Pranati S., Rishabha M. (2011).** Sources of pectin, extraction and its applications in pharmaceutical industry– an overview. *Indian Journal of Natural Products and Resources*. 2(1), 10-18.

**Prieto, P., Pineda, M., & Aguilar, M. (1999).** Spectrophotometric quantitation of antioxidant capacity through the formation of a phosphomolybdenum complex, Specific application to the determination of vitamin E. *Analytical Biochemistry*. 269, 337-341.

**Renard C., (2010).** "Les pectines dans la paroi végétale", Université Avignon. France.

**Ridley, B.L., Malcolm A, O., Mohnen, D., (2001).** Pectins: structure, biosynthesis, and oligogalacturonide-related signaling. *Phytochemistry* 57, 929–967.

**Rihani N., (1991).** Valeur alimentaire des sous-produits des agrumes en alimentation animale. *Options méditerranéennes. Série séminaires*, 16,113-117.

**Schols H.A. & Voragen A.G.J. (2002).** The chemical structure of pectins. In: *Pectins and their Manipulation*. Blackwell Publishing Ltd, 1-29.

**Shivani et al. (2022).** Effect of varieties and storage on the quality parameters of nectarine (*Prunus persica*)-based intermediate moisture food (IMF) products. *Journal of Applied and Natural Science*, 14(1), 216 - 224. <https://doi.org/10.31018/jans.v14i1.3299>

**Silva B M, Andrade P B, Ferreres F, Seabra R M, Beatriz M, Oliveira P P and Ferreira M A (2005)** Composition of quince (*Cydonia oblonga* Miller) seeds: phenolics, organic acids and free amino acids. *Natural Product Res.* 19(3), 275-281.

**Silva B M, Andrade P B, Valentão P, Ferreres F, Seabra R and Ferreira M A (2004)**

- Quince (*Cydonia oblonga* Miller) fruit (pulp, peel, and seed) and jam: antioxidant activity. *J. Agricult. Food Chem.* 52(15), 4705-4712.
- Slusarczyk S., Hadjnos M., Skalicka-Wozniaak K. and Matkowski A. (2009).** Antioxidant activity of polyphenols from *lycopus lucidus* turcz. *Food chemistry*, 113, 134-138.
- Sriamornsak P. (2003).** Chemistry of Pectin and Its Pharmaceutical Uses, A Review,, *Silpakorn University International Journal.* 3, 206-228.
- Stojanovic, B.T., Mitic, S.S., Stojanovic, G.S., Mitic, M.N., Kostic, D.A., Paunovic, D., Arsic, B.B., Pavlovic, A.N. (2017).** Phenolic profiles and metal ions analyses of pulp and peel of fruits and seeds of quince (*Cydonia oblonga* Mill.), *Food Chem.* 232 466–475.
- Tang P. Y., Wong C. J., Woo K. K., (2011).** Optimization of pectin extraction from peel of dragon fruit (*Hylocereus polyrhizus*). "*Asian Journal of Biological Sciences.* 4(2), 189-195..
- Temagoult, A. (2017).** Caractérisation et Transformation de la Figue de Barbarie (*Opuntia Ficus Indica* L.), Elaboration d'une Confiture et d'une Gelée Extra. *Génie des Procédés Alimentaires. Mémoire de master, Université Hadj Lakhdar- Batna 1.* pp 1-71.
- Thakur B.R., Singh R.K. & Handa A.K., (1997).** Chemistry and uses of pectin: a review. *Crit. Rev. Food Sci. Nutr.*, 37(1), 47-73.
- Thibault, J.F. and Petit, R. (1980).** Les substances pectiques : Les polymères végétaux, polymères pariétaux et alimentaires non azotés. Ed. Bordas, Paris.
- Tillmann S., Roland W., Rob V. & Werner K., (2002).** Enzymatic modifications of pectins and the impact on their rheological properties. *Carbohydrate Polymers*, 47 (2), 99 -108.
- Tilly G. (2010).** Pectines. *Techniques de l'ingénieur Trends Plant Sci.* 1-11
- Tsoga A., Richardson R.K. & Morris E.R., (2004).** Role of cosolutes in gelation of highmethoxy pectin. Part 2. Anomalous behaviour of fructose: calorimetric evidence of sitebinding. *Food Hydrocolloids*, 18 (6), 921-932.
- Valizadeh, R., Sobhanirad, S. (2009).** The Potential of Agro-Industrial By-Products as Feed Sources for Livestock in Khorassan Razavi Province of Iran. *Journal of Animal and Veterinary Advances*, 8, (11), 2375-2379.
- Virk, B.S. and Sogi, D.S. (2004).** Extraction and Characterization of pectin from apple (*Malus pumila*. Cv Amri) peel waste. *Int. J. Food Prop.* 7(3), 693-703.
- Wakerlya Z., Fell J. T., Attwood D., et al.(1996),** " In Vitro Evaluation of PectinBased Colonic Drug Delivery Systems" .. *International Journal of Pharmaceutics*, 129, 73-77.
- Yamamoto, T., Kimura, T., Soejima, J., Sanada, T., Ban, Y., & Hayashi, T. (2004).**

## References

---

Identification of quince varieties using SSR markers developed from pear and apple. *Breeding Science*, 54(3), (239-244).

**Yara Paula de Oliveira Nishiyama-Hortense a,b , Maria Júlia de Paula Rossi a , Victoria Diniz Shimizu-Marina , Natália Soares Janzantti a , Sergio Gómez-Alonso b , Roberto Da- Silvaa , Ellen Silva Lago-Vanzela (2022)**, Jelly candy enriched with BRS Violeta grape juice: Anthocyanin retention and sensory evaluation, *Future Foods* 6, 100179.

**Yokoi, H., Obita, T., Hirose, J., Hayashi, S. & Takasaki Y. (2002)**. Flocculation properties of pectin in various suspensions. *Bioresource Technology*, 84 (3), 287–290.





**Yurou Yun , Jian Li , Fei Pan , Yijun Zhou , Xiangqiao Feng , Jun Tian , Shengbao Cai , Junjie Yi , Linyan Zhou (2023)**. A novel strategy for producing low-sugar pomegranate jam with better anthocyanin stability: Combination of high-pressure processing and low methoxyl & amidated pectin. *LWT Volume* 179, (1), 114625.




**Zanella, K., and O. P. Taranto. (2015)**. Influence of the drying operating conditions on the chemical characteristics of citric acid extracted pectins from perasweet orange (*Citrus Sinensis* L. Osbeck) albedo and flavedo. *J. Food Eng.* 166, 111–118

**Zhong R, Ye ZH. (2003)**. Unraveling the functions of glycosyltransferase family 47 in plants. *Trends Plant Sci.*;8:565-8

## Appendix

**Table 01: Laboratory glassware**

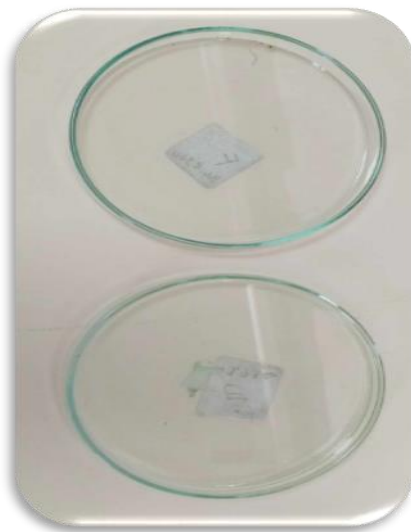
Glassware	Illustrations
Beakers	
Burette	
Erlenmeyer	
Funnel	

<p>Pipettes</p>	
<p>Mortar</p>	
<p>Volumetric flask</p>	
<p>Wach bottle</p>	

**Graduated cylinder**



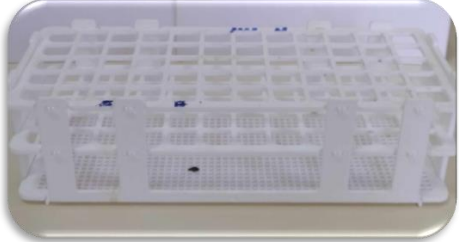


**Petri dish**



**Spatulas**



Pro-pipette	
Test tube	
Test tube holder	

**Table 02 : Laboratory Equipments**

<b>Equipments</b>	<b>Illustrations</b>
<b>pH meter</b>	
<b>Micropipette</b>	
<b>Spectrophotometer</b>	
<b>Magnetic stirrer</b>	

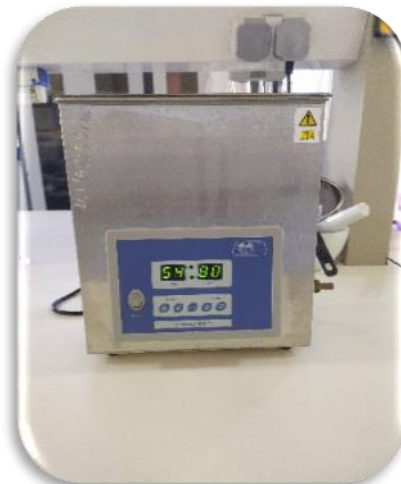
**Centrifuge**



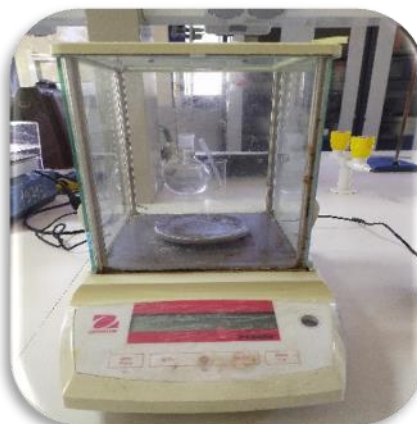
**Refractometer**



**Sonicator**



**Balance**



**Muffle oven**



**Oven**

