People's Democratic Republic of Algeria
The Ministry of Higher Education and Scientific Research
University of Saida - Dr.MoulayTaher

Faculty of Natural and Life Sciences
Department: Biology

Memory presented for obtaining the Master's degree in: Biology

Specialty: Biochemistry
THEME:

Bioconversion of Potato Peels Waste into Starch, Bioplastic, Microbial Culture Media and Organic Fertilizer

A project submitted in part to meet the requirements for the Master's degree in Biological Sciences Startup Diploma, within the framework of the Ministerial Decree 1275.

مشروع لنيل شهادة مؤسسة ناشئة في إطار القرار الوزاري 1275

Presented by:

Miss. Sabah REGUIG

Miss. Abir TEMAR

Supervised by:

Dr. Abdelkrim RACHEDI

Board of Examiners

President	Pr. Mohamed TERRAS	University of Saida – Dr. MoulayTahar
Examiner	Dr. Abdelkrim KEFIFA	University of Saida – Dr. MoulayTahar
Examiner	Dr. AbdelkaderMeziane	University of Saida – Dr. MoulayTahar
Expert guest	Miss Abir YAHIAOUI	Environment House - Province of Saida
Supervisor	Dr. Abdelkrim RACHEDI	University of Saida – Dr. MoulayTahar

2022/2023

People's Democratic Republic of Algeria
The Ministry of Higher Education and Scientific Research
University of Saida - Dr.MoulayTaher

Faculty of Natural and Life Sciences
Department: Biology

Memory presented for obtaining the Master's degree in: Biology

Specialty: Biochemistry
THEME:

Bioconversion of Potato Peels Waste into Starch, Bioplastic, Microbial Culture Media and Organic Fertilizer

A project submitted in part to meet the requirements for the Master's degree in Biological Sciences Startup Diploma, within the framework of the Ministerial Decree 1275.

مشروع لنيل شهادة مؤسسة ناشئة في إطار القرار الوزاري 1275

Presented by:

Miss. Sabah REGUIG

Miss. Abir TEMAR

Supervised by:

Dr. Abdelkrim RACHEDI

Board of Examiners

President	Pr. Mohamed TERRAS	University of Saida – Dr. MoulayTahar
Examiner	Dr. Abdelkrim KEFIFA	University of Saida – Dr. MoulayTahar
Examiner	Dr. AbdelkaderMeziane	University of Saida – Dr. MoulayTahar
Expert guest	Miss Abir YAHIAOUI	Environment House - Province of Saida
Supervisor	Dr. Abdelkrim RACHEDI	University of Saida – Dr. MoulayTahar

2022/2023

Prayers and greetings be to Our Dear Master & Prophet "Mohammed" and his family and his faithful companions.I dedicate this modest work:

To my dear parents;

My sisters ***Yasmina, Fatima,Linda ,Khadidja*** , and my brother ***Abdelwahab*** and all my relatives from the "**Reguig**" family;

To all my close friends and colleagues at the University ofSaida,sincerily ***Nadjet*** and ***Zouaouia;***

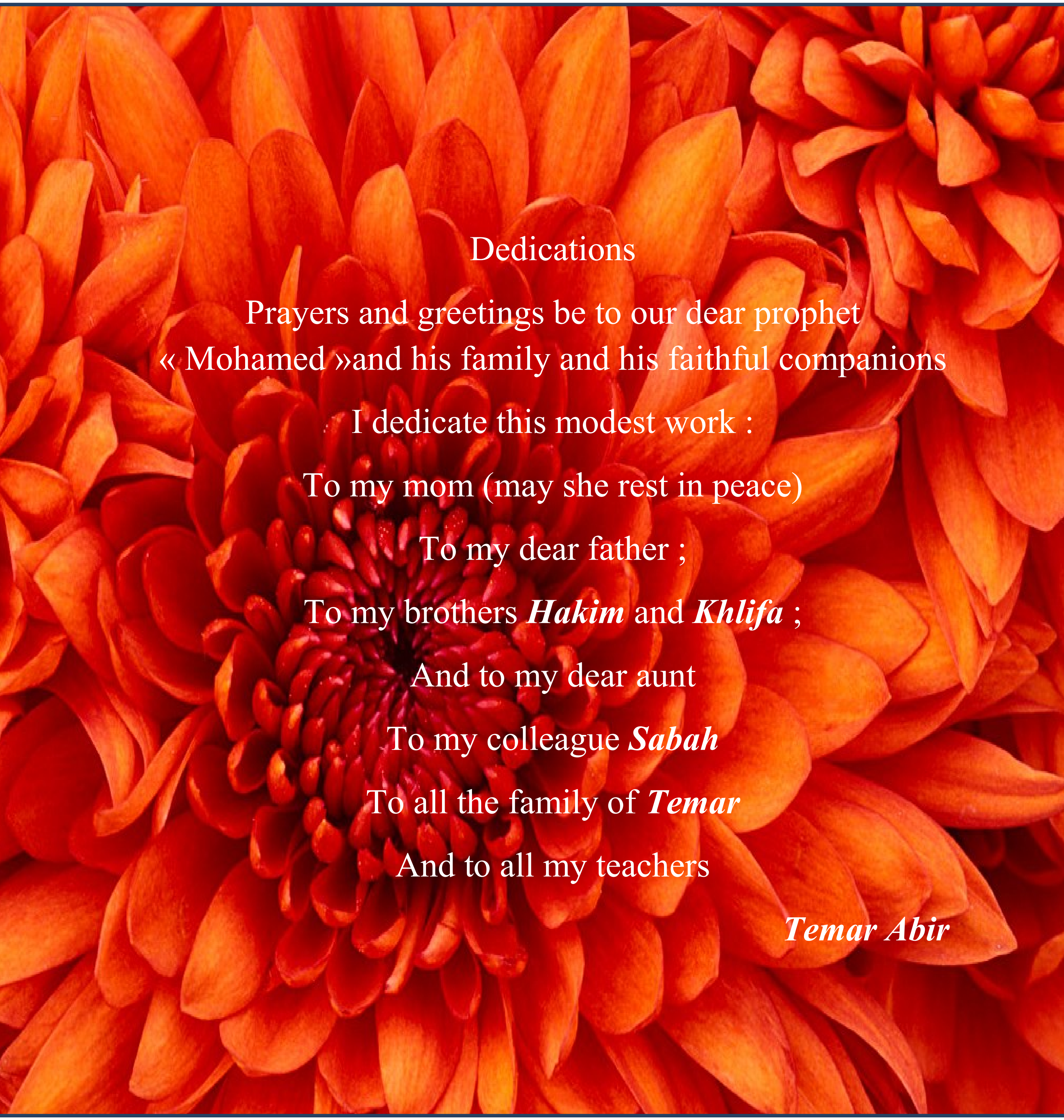
To my colleagues at work ***Billal*** and ***Setti***;

To the team laboratory ***MmeAmel***and ***Mr. Ahmed***

To my colleague and friend ***Abir***

and to all my teachers.

Reguig Sabah



Dedications

Prayers and greetings be to our dear prophet
« Mohamed »and his family and his faithful companions

I dedicate this modest work :

To my mom (may she rest in peace)

To my dear father ;

To my brothers ***Hakim*** and ***Khlifa*** ;

And to my dear aunt

To my colleague ***Sabah***

To all the family of ***Temar***

And to all my teachers

Temar Abir

Acknowledgements

First of all, we thank God, our creator for giving us the

Strength, Will and Courage to accomplish this modest work.

Our first words of gratitude are naturally addressed to the supervisor Dr. RACHEDI, professor at the University of Saida. He gave us access to the world of startups, it is a gesture that we do not forget.

We would like to deeply thank A. RACHEDI for the kindness and patience he showed towards us. We thank him also for having guided, encouraged, advised us throughout to the completion of this dissertation.

We would like to express our sincere thanks to the members of the jury for being interested in the subject and for agreeing to examine this thesis.

We would also like to thank all the laboratory members.

We would like to thank the head of incubator M***r.Benzai*** for his advices

List of Abbreviations

ANDI: Agence Nationale de Developpement de l'investissement

C°: Degré de Celsius

CM: Centimeter

DSP: Direction de la Santé et la Population

EPGPET: Entreprise Publique de Gestion collecte et l'enfuissement Téchnique

G: Gram

KG: Killogram

HCL: Chlorure d'Hydrogne

MCM: Microbial Culture Media

MIN: Minute

NACL: Chlorure de Sodium

PH: Hydrogen Potential

PNUE: Programme des Notions Unis pour L'environnement

S: Second

T°: Temperature

List of Figures

List of Tables

Abstract

This research project investigates the conversion of potato peels waste into a valuable resource, primarily focusing on starch production as a market-competitive alternative to corn-starch. The study explores the feasibility of utilising potato peels, often discarded as agricultural waste, to extract starch in quantities and qualities that rival traditional corn-starch. The findings indicate that the derived potato peel starch not only meets industry standards but presents an eco-friendly solution to waste management.

In addition to starch production, the research extends its innovation to the creation of bioplastics from potato peel waste, offering a sustainable alternative to petroleum-based plastics.

Additionally, this research showcases the versatile applications of the obtained starch. It has been successfully utilised in the creation of microbial culture media, expanding its utility beyond traditional industrial uses. Furthermore, through composting the residual potato peels, a natural fertilizer has been generated, contributing to sustainable agricultural practices.

The multi-purpose utilisation of potato peels for starch, bioplastic, microbial culture media, and natural fertilizer production represents a holistic approach to waste valorisation. In particular, the potential impact of incorporating potato peel-derived starch and bioplastics into various industries is significant, with implications for fostering a circular economy and reducing reliance on conventional resources.This research aligns with global initiatives for sustainable living, offering not only environmentally friendly alternatives but also multiple avenues for repurposing agricultural waste. As we address the challenges of waste management and environmental conservation, the outcomes of this study advocate for a comprehensive and sustainable transformation of agricultural byproducts into valuable resources, paving the way for a more resilient and eco-conscious future.

Keywords: Waste valorisation, Agricultural waste, Potato peels starch, Corn-starch, Bioplastics, Market-competitive alternative, Eco-friendly solutions, Environmental conservation.

ملخص

هذا المشروع البحثي يقوم على إستقصاء تحويل نفايات قشور البطاطا إلى مورد قيم، مركزا بشكل رئيسي على إنتاج النشا كبديل تنافسي في السوق لنشا الذرة. تستكشف الدراسة إمكانية استخدام قشور البطاطا، التي في كثير من الأحيان يتم التخلص منها كنفايات زراعية، لاستخراج النشا بكميات وجودة تنافسنشا الذرةالتقليدي. تشير النتائج إلى أن النشا المستمد من قشور البطاطا لا يناسب معايير الصناعة فقط، بل يقدم أيضا حلا صديقا للبيئة لإدارة النفايات.

بالإضافة إلى إنتاج النشا، يوسع البحث ابتكاره إلى صناعةالبلاستيك_الحيوي من نفايات قشور البطاطا، مقدما بذلك بديلا مستداما للبلاستيك المنتجمن البترول. يعالج استخدام قشور البطاطا في إنتاج النشا والبلاستيك_الحيوي بشكل مزدوج تحديات التقليل من رمي النفايات وتأثير التلوث البلاستيكي على البيئة.

بالإضافة إلى إنتاج النشا والبلاستيك_الحيوي، يظهر هذا البحث تطبيقات متعددة للنشا المحصل عليه حيث تم استخدامه بنجاح في إعداد وسائط زراعةالميكروبات، مما يوسع فائدته بما يتجاوز الاستخدامات الصناعية التقليدية. وعلاوة على ذلك، فإن المشروع قام تحويل الحثالة المتبقية من قشور البطاطا إلى سماد طبيعي، وهكذا تم الحصول على مساهمة في مجال الممارسات الزراعية المستدامة.

تمثل الاستفادة المتعددة الأبعاد لقشور البطاطا، أي في إنتاج النشا والبلاستيك_الحيوي ووسائط زراعة الميكروبات وسماد طبيعي، نهجا شاملا لتثمين قيمة النفايات. وهذا جلي بصورة خاصة عند إدراج النشا المستمد من قشور البطاطا والبلاستيك_الحيوي في مختلف الصناعات، مع تداول لتحقيق اقتصاد دائري والتقليل من الاعتماد على الموارد التقليدية. يتماشى هذا البحث مع المبادرات العالمية للعيش المستدام، مقدما ليس فقط بدائل صديقة للبيئة، ولكن أيضا طرقا متعددة لإعادة توجيه النفايات الزراعية. مع مواجهتنا لتحديات إدارة النفايات وحفظ البيئة، تؤيد نتائج هذه الدراسة لتحول شامل ومستدام للنواتج الزراعية إلى موارد قيمة، مما يمهد الطريق لمستقبل أكثر مرونة وصديق للبيئة.

كلمات مفتاحية: تثمين النفايات، نفايات زراعية، نشا قشورالبطاطا، نشا الذرة، البلاستيك الحيوي، بديل تنافسي في السوق، حلول صديقة للبيئة، الحفاظ على البيئة.

Résumé

Ce projet de recherche explore la conversion des déchets de pelures de pommes de terre en une ressource précieuse, se concentrant principalement sur la production d'amidon en tant qu'alternative compétitive sur le marché au maïs. L'étude examine la faisabilité d'utiliser les pelures de pommes de terre, souvent rejetées en tant que déchets agricoles, pour extraire de l'amidon en quantités et qualités rivalisant ou dépassant l'amidon traditionnel de maïs. Les résultats indiquent que l'amidon dérivé des pelures de pommes de terre non seulement répond aux normes de l'industrie, mais présente également une solution respectueuse de l'environnement pour la gestion des déchets.

En plus de la production d'amidon, la recherche étend son innovation à la création de bioplastiques à partir des déchets de pelures de pommes de terre, offrant une alternative durable aux plastiques à base de pétrole.

De plus, cette recherche présente les applications polyvalentes de l'amidon obtenu. Il a été utilisé avec succès dans la création de milieux de culture microbiens, élargissant son utilité au-delà des utilisations industrielles traditionnelles. De plus, en compostant les pelures de pommes de terre résiduelles, un engrais naturel a été généré, contribuant aux pratiques agricoles durables.

L'utilisation polyvalente des pelures de pommes de terre pour la production d'amidon, de bioplastiques, de milieux de culture microbiens et d'engrais naturels représente une approche holistique de la valorisation des déchets. En particulier, l'impact potentiel de l'incorporation d'amidon et de bioplastiques dérivés de pelures de pommes de terre dans diverses industries est significatif, avec des implications pour favoriser une économie circulaire et réduire la dépendance vis-à-vis des ressources conventionnelles. Cette recherche s'inscrit dans le cadre des initiatives mondiales en faveur d'un mode de vie durable, offrant non seulement des alternatives respectueuses de l'environnement, mais également plusieurs voies pour la réutilisation des déchets agricoles. En abordant les défis de la gestion des déchets et de la conservation de l'environnement, les résultats de cette étude plaident en faveur d'une transformation complète et durable des sous-produits agricoles en ressources précieuses, ouvrant la voie à un avenir plus résilient et respectueux de l'écosystème.

Mots-clés : Valorisation des déchets, Déchets agricoles, Amidon de pelures de pommes de terre, Amidon de maïs, Bioplastiques, Alternative compétitive sur le marché, Solutions respectueuses de l'environnement, Conservation de l'environnement.

Table of Contents

Introduction

Plastic is a synthetic material made up of macromolecules which are made from petroleum, the petroleum is refined, distilled, which makes it possible to obtain molecules called polymers, the word plastic is of Greek origin “plastikos” which means “mallrable, which can be shaped” (Kara. 2012;Laurent. 2013). The first plastic is of biomass origin, celluloid was developed by the HYETT brothers in1870 during a competition asking to find a material to replace ivory in the manufacture of billiard balls (Dorbane, Benslimane. 2014). Currently the world production is 311 million tons in 2014, of which china ranked the first producer in the world by 26 % of the world production (Pnue .2014).

Algeria and according to the national investment development agency, plastic consumption is one million tons per year, of which 2/3 of the primary materials are imported (ANDI, 2013). And according to the national statistics office, the plastics manufacturing sector experienced an increase of 1.5 % during the year 2012 compared to previous years (OMS, 2012).According to the direction of commerce of the city of Saida, the number of plastic recycling units is seven (7) units. The quantity of plastic to be recovered for the year 2015 is estimated at only 102 tonnes at the level of the technical landfill centre in level of the city of Saida, 10km capital of the city it considered as a minimal quantity (Epgcet, 2015). Despite the wide use of plastics in our daily lives, they are exposed to widespread criticism due to their harmful impact either on the environment or on human health (Dorbane*et al.* 2012; Laurant2013).

Plastic waste causes $13 billion in financial damage to marine ecosystems (PNUE, 2014), recent studies of Bisphenol A and pH Talates, chemicals in plastics, show they can cause diseases like cancer (Laurant 2013,Pnue. 2014).

According to the direction of health of the city of Saida, the number of cancer patients for period from 2011 to 2015, is 1041 patients and according to the same source that very large percentage resulting from chemical products and especially by the use of badly recycled plastic products (DSP .2015).

Considering the environmental impacts, and the health impact; the large amount of residual material from packaging made from ordinary plastic; in face of this critical situation, certain. Measures are taken into consideration such as the ban the use of single –use plastic bags, for example France ban the use of single-use bags from January 1,2016 (energy transition law article n°75 of August 18.2015).In addition the encouragement of manufacture and use of plastic from renewable resources or bio-plastics (Kara S. 2012).

Chapter 1

Literature review

1 What is waste?

Waste is any unwanted or non-useful material because it no longer has a specific use. It can be solid, liquid, or gas, or it can be waste heat. There are many different kinds of waste(Hoornwey.D,&Bhada-Tata P. 2012), Figure1.

Figure1. World waste representation.

1.1 Waste types:

1.1.1 Plastic waste

Pollution resulting from plastic is one of the major environmental challenges we face in the modern age. Plastic is manufactured from materials derived from crude oil and is a non-biodegradable substance.

When plastic is improperly disposed of, it ends up in oceans, lakes, rivers, and landfills, causing environmental pollution and impacting wildlife and humans.

Plastic pollution particularly affects marine life, as aquatic animals ingest small or large plastic pieces, leading to injury and premature death. Moreover, plastic ends up in the food chain and reaches our meals, posing a risk to our health as well (Zhang.R, Su.J,Liu.H.2020).

We must address this challenge by promoting recycling, reducing the use of single-use plastics, and raising awareness about the harms of plastic pollution. Additionally, encouraging innovation in alternative materials and eco-friendly solutions is crucial, Figure2.

Figure 2. Plastic waste

1.1.2 Bio-waste

Bio-waste can be defined as any waste material that is organic or that is capable of undergoing anaerobic or aerobic decomposition such as commercial food waste and kitchen scraps, manure, animal and garden waste, forestry and agricultural residues, sewage sludge, paper and cardboard waste, and natural textiles (Van wyk JPH.2005), Figure3.

Figure 3. Bio-waste compilation.

1.2 Effects of waste on health and environment

Improper waste disposal can have significant negative impacts on both human health and the environment. Waste that is not properly managed can use air, water and soil pollution, leading to a range of health problems such as respiratory illnesses, neurological damage, and cancer. Exposure to hazardous waste can also cause reproductive and developmental problems, as Well as damage to the immune system.

In addition to the health impacts, waste can also have negative effects on the environment. When waste is not disposed of properly, it can contaminate the soil and water, harming plants and animals. Waste can also contribute to climate change by releasing greenhouse gases into the atmosphere, particularly when organic waste is not properly composted or recycled.

It is important to properly manage waste to minimize these negative effects on human health and the environment. This can be done through strategies such as reducing waste generation, recycling, composting, and proper disposal of hazardous waste (Rautela. R, Arya. S,Vishwakarma.S, Lee. J.2021).

2 Waste recycling

2.1 Plastic recycling

Recycling plastic is the process of converting plastic waste into new products in order to conserve natural resources and reduce negative environmental impacts. The consumed plastic is collected and processed for recycling by sorting and purifying it according to its type and removing impurities. The plastic is then transformed into small pellet, which can be used to manufacture new products such as plastic packaging, pipes, furniture, toys, and more(Shen. L,Worell.E.2014).

2.2 Bio-waste recycling

Organic waste recycling is the process of converting decomposable organic materials, such as food and plants, into useful and usable materials. Organic waste is collected and deposited at dedicated recycling facilities where it undergoes biological decomposition or fermentation processes. Bacteria and fungi are used to convert organic waste into methane gas and organic fertilizer, which can be utilized in alternative energy production and sustainable agriculture(Rai.I,Ahirwar, Rai. A,Svarjani,Vinayak. V.2022).

2.2.1 Importance of waste recycling

2.2.1.1 Environmental Protection:

Bio-waste recycling contributes to the reduction of environmental pollution. Improper disposal of bio-waste leads to the decomposition of organic matter and the production of greenhouse gases such as carbon dioxide and methane, which are major contributors to climate change .By recycling bio-waste, we can reduce greenhouse gas emissions and mitigate the effects of climate change.

2.2.1.2 Resource Utilization:

Bio-waste represents a valuable source of natural resources. Instead of being discarded, bio-waste can be utilized to produce organic fertilizers that enhance soil health and support crop cultivation.

3 Bioconversion of Bio-waste

Bio-waste recycling is a key strategy in transitioning towards a sustainable society and preserving the environment.

The biological decomposition and conversion of organic waste into environmentally and economically valuable products have a positive impact on both the environment and society.

3.1 Importance of Recycling Organic Waste into Bio-Plastics

Recycling organic waste into bio-plastics is a significant and innovative process in waste management and sustainable development. Bio-plastics are sustainable products derived from renewable organic materials, replacing traditional plastics derived from non-renewable fossil fuels. This technology allows for the utilization of organic waste, transforming it into a value-added product, thus contributing to environmental preservation and achieving sustainable development goals (Bayram. B, Greiff. K.2023).

3.2 Scientific Benefits

3.2.1 Reducing reliance on fossil resources:

Recycling organic waste into bioplastic helps reduce dependence on fossil resources such as oil and natural gas. In the production of traditional plastics, oil is a major source of raw materials. Therefore, promoting the use of bio-plastics works towards reducing environmental pollution associated with the extraction and use of fossil resources.

3.2.2 Mitigating greenhouse gas emissions:

Bio-plastics offer a more sustainable option compared to traditional plastics due to their renewable nature and biodegradability. Proper disposal of bio-plastics can help reduce greenhouse gas emissions.

When disposed of in appropriate ways, the organic materials in bio-plastics undergo decomposition, leading to a lower environmental impact compared to non-biodegradable plastics(Razza.F,Degli. F.2012).

4 Bioconversion of Potato Peels into Bio-plastics

Potato peels are considered a rich source of starch and possess unique mechanical and physical properties.

They contain a group of chemical compounds that make them an ideal material for producing bio-plastic.

Potato peels are generally composed of starch, plant fibers, and woody cells, and they also contain a variety of other organic compounds such as organic acids, flavonoids, and carotenoids (Shrestha. S, Khatiwada. J.R, Sharma. H.K, Qin. W.2021) .

4.1 Why we chose potato peels over other organic waste

Potato peels were chosen for recycling into bio-plastic due to their high starch content, which can be converted into biodegradable polymers.

Polymers made from starch are known to degrade quickly and transform into organic materials that are not harmful to the environment, making them an ideal alternative to petroleum-based polymers that are difficult to degrade and cause significant environmental damage.

In addition to this, using potato peels in bio-plastic production can help reduce the amount of plastic waste and improve environmental sustainability.

This can have a positive impact on public health and the environment (Tassinari G., Bassani A, Spigno G, Soregaroli C., 2023), Figure4.

Figure 4. Potatoes and peels waste.

4.2 Potato Peel Starch

The starch extracted from potato peels is a highly valuable product in the food and biotechnology industries. The process of extracting starch from potato peels is carried out using various technological methods, such as fermentation, settling, and purification. The extracted starch posseses unique properties that make it suitable for diverse applications (Hasama. M.S.2021),Figure 5.

Figure 5. Potato peel starch

4.2.1 Nutritional value and Various Health Benefits

The nutritional value of starch extracted from potato peels primarily stems from its chemical composition. Starch consists of long chains of glucose, a type of carbohydrate that serves as a major source of energy in the diet. The extracted starch from potato peels is rich in dietary fibers, non-digestible components that play a crucial role in supporting digestive health and improving bowel movement (Smith. J*et al.*2017).

Additionally, the extracted starch from potato peels includes a range of essential vitamins and minerals. It contains vitamin C, which boosts the immune system and acts as an antioxidant, and vitamin B6, which contributes to energy conversion processes within the body. Moreover, the starch contains minerals such as potassium, iron, and magnesium, which play important roles in heart health, muscle functions, and bodily functions (Johnson E.*et al.*2020).

Numerous scientific studies have shed light on the benefits of starch extracted from potato peels. Some studies suggest that dietary starch consumption may help reduce cholesterol levels in the blood and maintain heart health. Additionally, research indicates that starch may aid in improving the immune system and strengthening the digestive system (Gonzalez-Montoya M,*et al.*2015).

4.2.2 Applications of Starch Extracted from Potato Peels

The starch extracted from potato peels is used in various fields. Here are some main areas of using starch extracted from potato peels:

4.2.2.1 Food industry:

The starch extracted from potato-peels isused in the food industry as a thickening and binding agent. It is added to sauces, soups and creams to improve their texture and stability. It is also used as an anti-caking and separating agent in liquid products (Shogren. R.L, Willett .J.L,Deschamps. A.M.2007).

4.2.2.2 Paper industry:

Potato peel extracts are used to obtain starch in the paper industry. Starch acts as a bending agent, enhancing the strength and tear resistance of the paper. The use of starch in the paper industry is considered an environmentally friendly alternative compared to other harmful chemicals (Shogren.R.L, Willett .J.L,Deschamps. A.M.2007).

4.2.2.3 Plastic industry:

The starch extracted from potato peels is utilized in the production of biodegradable plastics. The starch can be converted into a biodegradable plastic material used in manufacturing of packaging films, bags, and compostable plastic containers (Shogren.R.L, Willett .J.L,Deschamps. A.M.2007).

4.2.2.4 Pharmaceutical industry:

The starch extracted from potato peels is used in the pharmaceutical and pharmaceutical preparations industry. Starch acts as a binding agent in the production of tablets and capsules, helping to maintain the required dose of the active pharmaceutical ingredient (Shogren.R.L, Willett .J.L,Deschamps. A.M.2007).

4.2.2.5 Agricultural applications:

The starch extracted from potato peels finds application in the production of agricultural pesticides and bio-stimulants. It can be used as a stabilizer and enhancer for the properties of pesticides and fertilizers, improving their effectiveness and stability (shogren. R.L, Willett .J.L,Deschamps.A.M.2007).

These are some of the main areas of using starch extracted from potato peels. Ongoing studies aim to explore additional potential applications for this valuable compound.

5 Conventional Plastic

Conventional plastic, also known as traditional or ordinary plastic, is a synthetic material widely used in various industries. It is derived from petroleum-based substances such as crude oil and natural gas. These raw materials are converted into chemical compounds called polymers, which are long chains of interconnected molecules (Plastics Europe.2020).

The polymers used in conventional plastic primarily consist of ethylene, propylene, and polyvinyl chloride. These chemical compounds are obtained from different sources of crude oil and natural gas, requiring processes such as refining, distillation, and conversion to obtain the final components (Andrady.A.L.2015)

Conventional plastic is a commonly used material in industrial and commercial applications due to its lightweight, strength, and flexibility. It forms the basis for manufacturing plastic utensils, packaging materials, automotive and electronic components, and much more(European Commission, 2020), Figure 6.

Figure 6. Conventional petrol based plastic

6 Bio-plastic

Biodegradable plastic is a type of sustainable plastic material that is produced from renewable sources, such as bio-based plants and organic waste. Biodegradable plastic is manufactured using biological processes, including bacterial fermentation or fermentation of sugars and other organic materials.

The origin of biodegradable plastic can be traced back to the desire to create sustainable and compostable alternatives to traditional petroleum-derived plastics. The goal of biodegradable plastic is to reduce the environmental impact of plastic materials and minimize the pollution caused by the accumulation of conventional plastic waste (Stevenes.E.S.2002).

The components of biodegradable plastic consist of organic materials that are capable of naturally decomposing. These essential components include starch, cellulose, and poly-lactic acid, which are extracted from sources such as wood chips, sugarcane, corn, and other sugars.

Biodegradable plastic shares similar properties to traditional plastic in terms of moldability and durability, but it degrades faster in the environment and is considered more sustainable (Mohanty.A. K,Misra. M &Drzal. L.T.2002).

Biodegradable plastic is used in a wide range of applications, including packaging, bags, disposal utensils, and food containers, Figure 7.

Figure 7. Bioplastic decay over time.

6.1 Bio-plastic Polymerisation

The process of bio-plastic polymerization is a biological and sustainable process used to convert bio-based raw materials into plastic. This process aims to produce plastic materials that are biodegradable and reduce the environmental impact of traditional plastic materials derived from fossil fuels (Auras. R, Harte. B& Selke.S.2004).

The bio-plastic polymerization process involves several key steps. Firstly, bio-based raw materials such as starch, sugars, and plant oils are collected from diverse sources such as plants and renewable crops. These raw materials are then processed to obtain their basic components, often monomers or short polymer chains (AlbertssonA. C. &HakkarainenM., 2017).

Next, the monomers or short chains are activated using biological or chemical catalysts, which results in their linkage to form long chains of the desired polymer. This polymerization process can be conducted at specific temperatures and under defined conditions that help accelerate the polymerization reaction (Albertsson. A.C, Hakkarainen. M. 2017).

Once the polymerization process is complete, the polymer is shaped into final products such as biodegradable shopping bags or compostable containers. The properties of the bio-plastic polymer can be customized by adjusting the raw materials and process conditions, allowing for the production of products with specific performance characteristics (Chen. G.Q. 2009).

The bioplastic polymerization process is an integral part of research and development in the field of bioplastics and has witnessed continuous advancements in recent years. These technologies aim to improve process efficiency, enhance the quality of the final product, and expand the range of raw materials used and application possibilities (Chen. G.Q. 2009).

6.2 Use of Bio-plastics

6.2.1 Food Packaging and Films:

Bio-plastics are used in the production of biodegradable food packaging and films. This helps maintain the quality of food products while reducing plastic waste (Narayan .R. 2019).

6.2.2 Biodegradable Plastic Utensils:

Bio-plastics are used in the manufacturing of biodegradable plastic utensils that can be disposed of in an environmentally friendly manner, such as cups, plates, and cutlery (SelkeS., 2012).

6.2.3 Fibers and Clothing:

Bio-plastics are utilized in the production of biodegradable fibers and sustainable plastic clothing, serving as alternatives to conventional synthetic fibers (Roy. P., Chaudhuri S, Mondal. P. 2010).

6.2.4 Agricultural Applications:

Bio-plastics are employed in the manufacturing of greenhouse films and biodegradable mulch covers, enhancing agricultural efficiency and reducing the use of pesticides (Hopewell J, Dvorak. R., Kosior. E. 2009).

6.2.5 Packaging and Wrapping:

Bio-plastics are used in the production of biodegradable packaging and wrapping materials for consumer products, such as water bottles and shopping bags, reducing the environmental impact of plastic (Hopewell J., Dvorak R., Kosior E., 2009).

6.2.6 Medical Applications:

Bio-plastics are utilized in the manufacturing of medical materials, including prosthetics and biodegradable medical devices, offering a sustainable solution for patients (Chiellini. E. 2003).

7 Biodegradable Plastics

7.1 Assessing Degradation Capability

One of the key advantages of bio-plastics is their ability to naturally degrade under certain conditions, reducing the negative environmental impact associated with conventional plastics. To assess the degradation capability of biodegradable plastics, several factors need to be considered

7.1.1 Biodegradation:

Biodegradation refers to the ability of bio-plastic materials to decompose through the action of microorganisms or biological enzymes. The rate of degradation is influenced by factors such as the chemical composition of the plastic, temperature, moisture, and the concentration of surrounding microorganisms. Degradation rates are typically measured using standardized laboratory tests.

7.1.2 Physical degradation:

Physical degradation involves the mechanical breakdown of plastic without affecting its chemical composition. This type of degradation can occur through processes such as heat, ultraviolet radiation, oxygen, and other environmental factors. The rate of physical degradation depends on the type of plastic and the conditions of exposure.

Studies have shown that biodegradable plastics can degrade through various biological factors such as bacteria, fungi, algae, worms, water, and ultraviolet radiation. Biodegradable plastics generally break down into harmless substances like water, carbon dioxide, and biomass, which contributes to reducing the negative impact on the environment.

8 Current Developments

Research efforts have continued to understand and improve the biodegradability of bio-plastics, leading to significant discoveries and intriguing advancements. In a recent study conducted by Smith *et al. (*2022), a new bio-based polymer with enhanced biodegradability and improved mechanical performance was developed. This improvement was achieved through the use of polymer structure modification techniques and enhancing its degradation properties. The researchers indicate that these promising results pave the way for the use of biodegradable plastics in a wide range of applications (Smith. A.,*et. al*.2022).

Furthermore, in another study by Garcia et al.(2023), biotechnology techniques were employed to enhance the biodegradability of bio-plastics. A novel bioprocess was developed, utilizing optimized microorganisms and enzymes to accelerate the degradation process. The results demonstrated impressive performance, achieving complete degradation of biodegradable plastics in a shorter timeframe compared to traditional techniques (Garcia. B., *et. al*.2023).

9 Factors contributing to the Spread and Support of Bio-plastics in the Market

9.1 Focus on Sustainability:

The growing concern for environmental preservation and mitigating the impact of pollution is a major factor in supporting the spread of bio-plastics. Bio-plastics help reduce carbon dioxide emissions and the harmful environmental effects associated with the production and manufacturing of conventional plastics (Kijchavengkul T., Auras R.,Rubino M., Selke S., 2008).

9.2 Legislation and Regulations:

Environmental laws and regulations play a significant role in driving the use of bio-plastics in the market. These regulations may include incentives for manufacturers and companies to use biodegradable materials, such as tax benefits or financial advantages for companies committed to using bio-based materials (Narayan R., 2018).

9.3 Technological Innovation:

Technological advancements play a crucial role in the development and improvement of bio-plastics, whether in terms of their physical properties or their ability to naturally degrades. Innovative technologies contribute to enhancing the quality and performance of bio-plastics, making them more suitable for a wide range of applications (Niaounakis. M.2013).

9.4 Public Awareness and Education:

Public awareness and education regarding the environmental challenges associated with conventional plastics play a vital role in promoting the use of bio-plastics. As awareness of plastic pollution increases, consumers are shifting towards choosing eco-friendly alternatives (European Bio-plastics.2020).

9.5 Cost and Economic Sustainability:

Improving the efficiency of bio-plastic production and distribution is a key factor in expanding its use in the market. With advancements in technology and production processes, the cost of producing bio-plastics decreases, making it a more economically attractive option for companies and manufacturers (European Bio-plastics.2020).

In conclusion, overcoming the issue of plastic pollution and achieving environmental sustainability requires collaboration among governments, companies, and consumers. By supporting and expanding the use of bio-plastics in the market, we can work towards a cleaner and more environmentally sustainable future.

10 Bioconversion into Organic Fertilizer

Organic fertilizer consists of a diverse range of organic components, including decomposed organic matter, organic microorganisms, fatty and proteinaceous substances, organic acids, sugars, vitamins, and mineral salts. These components play a vital role in improving soil structure, enhancing nutrient availability, and promoting plant growth.

10.1 Importance of Organic Fertilizers in Agriculture

10.1.1 Soil Health Enhancement:

Organic fertilizers promote soil fertility and improve its physical and chemical composition. They increase the organic matter content in the soil, enhancing soil aeration, water retention, and nutrient availability (Ahti. E.1984).

10.1.2 Supply of Essential Nutrients:

Organic fertilizers contain a wide range of essential nutrients for plant growth, such as nitrogen, phosphorus, potassium, and micronutrients. They contribute to the sustainable availability of these nutrients to plants over the long term (Ahti. E.1984).

10.1.3 Improvement in Crop Quality:

The use of organic fertilizers leads to improved crop quality, including flavor, nutritional value, and appearance. They enhance the formation of important organic substances, such as proteins, amino acids, and vitamins, in crops (Ahti. E.1984).

10.1.4 Environmental Preservation:

Organic fertilizers serve as an environmentally friendly alternative to chemical fertilizers, which can cause soil and groundwater pollution. They contribute to maintaining the ecological balance of the soil and minimizing negative impacts on the natural environment (Ahti. E.1984).

10.1.5 Promotion of Biodiversity:

Through the use of organic fertilizers, biological diversity in the soil and agricultural systems is enhanced. The organic components stimulate the growth of beneficial organisms in the soil, thereby improving plant health and disease resistance (Ahti. E.1984).

10.2 The Difference between Organic and Chemical Fertilizers

Table 01. The Difference between Organic and Chemical Fertilizers

	Organic Fertilizer	Chemical Fertilizer
Composition	They consist of natural organic materials such as animal manure, plant residues, and organic waste. They contain balanced proportions of essential nutrients like nitrogen, phosphorus, and potassium, along with beneficial organic matter	They are synthetic and typically composed of chemical compounds with high concentrations of specific nutrients like nitrogen, phosphorus, and potassium. They are manufactured through various chemical processes and may have different sources
Source	They come from natural sources such as plants, animals, and organic waste. Examples include animal manure, compost from plant residues, and food waste	They are produced synthetically using inorganic sources such as phosphates, ammonia, and potassium. They can be derived from petroleum or mineral resources

Impact on Soil and Crops	They contribute to improving soil structure, enhancing its water-holding capacity, and increasing nutrient retention. They promote the activity of beneficial microorganisms in the soil, improving soil aeration and nutrient availability. Organic fertilizers provide balanced and sustainable nutrition to crops, enhancing their growth and productivity naturally	They provide high and rapid concentrations of specific nutrient to crops. However, they can lead to salt accumulation in the soil and contamination of groundwater.Chemical fertilizers may have short-term effectiveness and require frequent applications to maintain their impact

11 Bioconversion of Potato Peel Starch into Growth Media for Bacteria

Utilizing the starch extracted from potato peels to create growth media for bacteria is an important innovative step aimed at achieving environmental sustainability and maximizing the utilization of organic materials, Figure8.

Figure8. Bacteria culture media

11.1 Potential Benefits

11.1.1 Waste Reduction:

By using potato peel starch to create growth media for bacteria, neglected organic materials are converted into a secondary resource that can be utilized effectively (Navarrate-Bolanos. J.L,Lizardi-Mondosa. J*et al*.2020).

11.1.2 Promotion of Environmental Sustainability:

As a natural and renewable resource, starch extracted from potato peels provides a suitable environment for bacterial growth, enhancing biodiversity and reducing reliance on other synthetic resources (Navarrate-Bolanos J.L., Lizardi-MondosaJ.*et al*., 2020)..

11.1.3 Enhancement of Sustainability Economy:

The media cultured with potato peel starch can be used to cultivate beneficial bacteria in various fields such as food production, agriculture, and microbiology. This enables the provision of alternative and sustainable food sources for bacteria, fostering local economic development (Navarrate-Bolanos J.L., Lizardi-MondosaJ.*et al*., 2020)..

11.1.4 Improved Fermentation Process:

The starch extracted from potato peels serves as an excellent source of readily available sugars for bacteria in fermentation processes, enhancing their activity and production of desired products such as organic acids and enzymes (Navarrate-Bolanos J.L., Lizardi-MondosaJ.*et al*., 2020)..

11.1.5 Provision of Natural and Eco-Friendly Materials:

The media cultured with potato peel starch can be utilized as a substitute for traditional industrial media used in bacterial cultivation, reducing environmental impact and costs associated with synthetic materials (Navarrate-Bolanos J.L., Lizardi-MondosaJ.*et al*., 2020).

11.1.6 Development of Value Added Products:

The media cultured with potato peel starch can be used to cultivate bacteria that produce pharmaceuticals and other bioactive substances, opening avenues for the development of economically and health-wise valuable products (Navarrate-Bolanos J.L., Lizardi-Mondosa. J.*et al*., 2020).

Chapter 2

Materials and methods

Introduction:

The main product that has been produced by this project is a cheaper **potato peels**' based **starch** product that has been given the commercial-name "**PeelGold**". This is proposed as a food product alternative to the **corn-starch** product available in the market known as "**Maizena**" imported from the main corn-growing countries including the United States, China, Brazil and India.

The project undertakes this bioconversion production using the available household potatoes (*Solanum tuberosum* L.) waste, mainly potato peels, thrown in waste landfills (dumps or disposal areas). Thus, this project makes a significant contribution in bio-waste recycling and waste management and in environment protection.

Additionally, this project worked on the creation of important commercial and environment-friendly products such as bioplastic, organic fertiliser (compost), bacterial culture/growth media.

12 Collection of the potato peels:

This project reflects the interest in sustainability and highlights the valorising potential of food waste which shouldn't be seen as just useless waste but rather a resource of raw material that can be transformed into a variety of commerciallyimportant products, Figure 9.

Figure 9. Small part of the Doui-Thabet landfill, Saida, a variety mixture of different types of waste including food waste.

A quantify of 5 kg of potato peels was used in our the project. To collect potato peelings we needed to collect potato peels from homes, order them from restaurants and procuring from municipal waste landfills, Figure 10.

Figure 10. Sample of collected potato peels

13 The extraction of the Starch material:

The method employed in the extraction is outlined below is modified version of a widely recognized starch extraction protocol (Mueez S. A. *et al.*, 2023).

13.1 Material:

To extract starch from potato peels, we need the following materials:

1. Potato peels and/or potatoes leftovers
2. Water
3. Blender
4. Large pot
5. Fine mesh strainer
6. Bowl
7. Spoon.

It's important to ensure that all equipment and materials used in the extraction process are clean and free from contaminants to obtain high-quality starch. The final product is sterilised using autoclave.

13.2 Method:

There are several methods for extracting starch from potato peels. The following simple method is used:

1. Collect and wash the potato peels to remove any dirt impurities, Figure 11.
2. Cut and shred the raw material into small pieces, roughly the same size, Figure 12.
3. Pieces of the peels are placed in a large pot and add enough water to cover theme completely.
4. The mixture is mashed thoroughly with the blender until they are completely smooth and free of lumps. Figure 13.
5. Line the fine mesh strainer over another bowl and pour the mixture into the strainer,Figure 14.
6. Use a spoon to press down the mixture to help extract the starch.
7. The potato starch liquid will filter through the strainer and collect in the bowl underneath.
8. Let the potato starch settle for few hours, or until it forms a thick layer at the bottom of bowl, Figure 15.
9. Carefully pour off the clear liquid on top of the starch layer, being careful not to disturb it.
10. Once the liquid has been poured off, use a spoon to scrape the starch from the bottom of the bowl and transfer it to a clean, dry container, Figure 16.

11. Wash the resulted active-ingredient in airtight container in a cool, dry place until ready to use.

Figure 11. Potato peels after collection and washing

.

Figure 12. Shredding the quantity of the potato peels

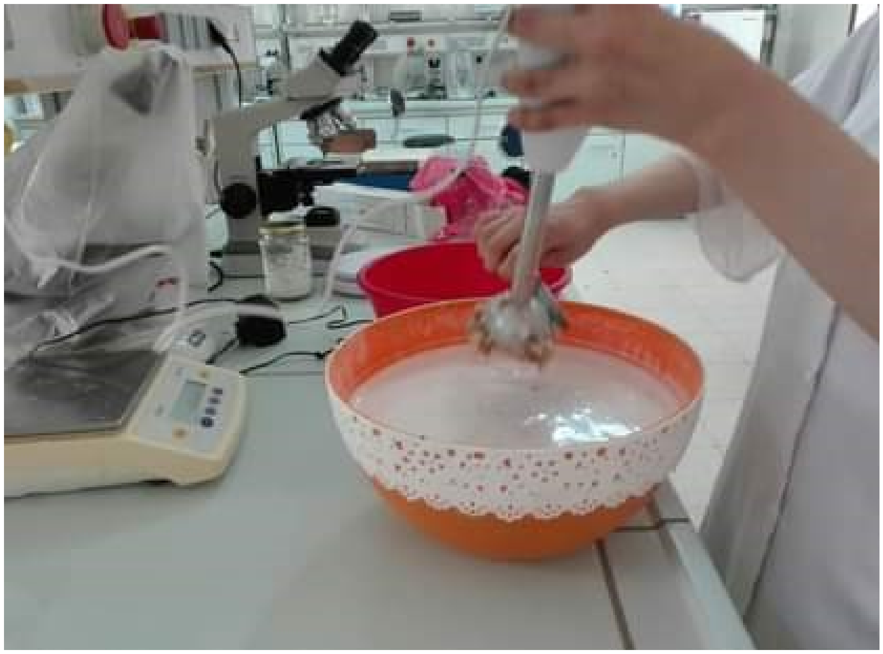


Figure 13. Potato peels mashing using a hand-held electric blender

Figure 14. Straining the mashed potato peels for starch extraction in bowl.

Figure 15. Strained starch left to settle to the bottom of bowls.

.

Figure 16. Sample of extracted and spoon collected starch after straining

14 Starch Drying and Weighing

14.1 Starch drying conditions:

The obtained starch, still wet at this stage, was dried using the laboratory drying tool ETUVE (Figure 17) set to the temperature of 30°C and fan, monitoring air circulation, set to 20% for 15 minutes, as shown below.

Figure 17. ETUVE drying machine

The process underwent two stages until drying state was achieved, Figure 18.

Stage 1:

Time → 15 min
Temp → 30°C
Fan → 20%

} semi-dried = 155 g starch

Stage 2:

Time → 15 min
Temp → 30°C
Fan → 20%

} dried = 75 g starch

Figure 18. Dried and bottle collected starch

15 Bioplastic production:

In this project, a certain percentage of the starch produced in the process described above is converted to bioplastic. Below descriptions and details are provided for materials and methodology adopted from a widely recognized protocol for making bioplastic from starch (Navasingh R.J.H., *et al.* 2023).

15.1 Material:

1. Potato starch: one quantity of starch.
2. Water: four quantity of water.
3. 15 mils of acetic acid for each 50g of starch quantity.
4. 15 mils of glycerol for each 50g of starch quantity, as per need.
5. Few drop of colours (if desired).
6. Heating equipment: A stove or heating plate will be required to heat and mix the starch, acetic acid, and water.
7. Mixing utensils: Utensils such as spoon or spatulas will be needed to mix the ingredients thoroughly.

15.2 Method:

To produce bio-plastic from potato starch, the following stepshave been followed:

1. Mix well the quantity of starch with the quantity of water and let it rest for few minutes around 5 min.
2. Add the acetic acid and the glycerol (when needed) and mix well.
3. Add some colour (optional) and mix, Figure 19.
4. Heat up the mixture with continuous mixing, Figure 20.
5. Cook it well until a malleable massis obtained, Figure 21.
6. Leave to cool (to touch)for few minutes.
7. Store and/or mould the mass of bio-plastic to desired shape, Figure 22.

Figure 19: Mixing the ingredients including the colour, red colour is used in this case.

Figure 20. Heat application to the mixture

.

Figure 21. Malleable masses of bio-plastic coloured in red and green

.

Figure22. Example of moulding a mass of bio-plastic into a beaker shape, see also **Results and Discussion** chapter.

The work in this project involved creating hard and flexible types of bio-plastic on the following procedural bases:

- Production of hard (not flexible) bioplastic: Use of 25 g of starch +10 mils of acetic acid 9% +100 mils of water +colour; red mass in Figure 21.
- Production of flexible bioplastic: Use 25 g of starch +10 mils of acetic acid +10 mils of glycerol +100 mils of water + colour; green mass in Figure 21.

See **Results and Discussion** chapter for more about the types of bioplastic produced in the project.

16 Production of Microbial Culture Medium:

For making a medium to culture microorganisms from the potatoes-peels starch produced above, the needed material and method employed are as follows as a modified version based on Starch Agar Protocol (Lal A. and Cheeptham N., 2012):

16.1 Material:

1. 10 g Extracted product.
2. 10 g Tryptone.
3. 5 g Yeast extract.
4. 5 g Salt (NaCl).
5. 15 g Agar
6. 1litter distilled water.
7. Autoclave or pressure cooker
8. Sterile Petri dishes

16.2 Method:

1. Stir the mixture well to ensure that all the ingredients are thoroughly mixed, Figure 23.
2. Autoclave or pressure cook the mixture at 121°C for 150minutes to sterilize it, Figure 24.
3. Allow the mixture to cool to about 50°C before pouring it into sterile Petri dishes.
4. Let the mixture cool and solidify in Petri dishes, see next chapter.

5. Store the plates or slants in a cool, dry place until ready to use.

Figure 23. Heating andmixing the culture media.

Figure 24. Pressure cook used to sterilize the culture media

17 Composting and Production of Organic Fertiliser:

The compost is a mixture of ingredients used as plant fertilizer and to improve soil's physical, chemical, and biological properties. It is commonly prepared by decomposing plant and food waste, recycling organic material and manure.

The procedure for the production of compost is summarized in the following:

- Useof the residuesleft from the potato peels after starch extraction, Figure 25.This is after blending withadditional mixture of kitchen waste like vegetable and fruit left overs, Figure 26.
- The mixture if left to decompose, in aerobic condition,with regulardaily flip over to avoid the anaerobic degradability.

The compost takes around 30 days for degradability and be ready to use.

Figure 25. Residue of potato peels after starch extraction

Figure 26. Compost obtained from the potato peels residues

Chapter 3

Results and Discussion

Four products have come out of the conversion and recycling of a major household waste the potato peels used in this project. These are potato-starch, bio-plastic, microbial culture medium (MCM) and natural fertilizer (compost). Both the bio-plastic and MCM are products based on the starch product, however, the compost is created from the aerobic decomposition of the potato peels remains after the starch extraction.

In this chapter, results are detailed for two of the four products: the potato-starch and the bio-plastic. However, due to time restrictions, the details of the MCM and the fertilizer are not included in this version of this thesis.

18 Results of the starch production

The final obtained quantities, summarised in Table 02 below, are the results of potato peels starch extraction from three experiments carried out in this project, Chapter 2. Each process represents the grinding of 1 kg of potato peels and the average obtained amount of totally dried potato starch extracted from 1 kg of potato peel is 80g.Theseresults fall within the average value reported in literature of 14 ± 2% (Alrefai R.*et. al.* 2020) and of 13.5 – 15 % (Khanal S. *et al.* 2023). However, the quantity of starch can be extracted from potato peels may vary depending on the type of potatoes the peels come from.

Table 02: Summary of the three experiments and obtained results

Experiments using 1kg of potato peels	Obtained Starch Semi-dried/ grams	Obtained Starch Dried/grams
1	155	73
2	182	88
3	164	79
Mean values	167	80

This average quantity of starch extracted from potato peels is obviously competitive to the imported corn-starch currently heavily consumed by our society which burdens the central bank large amounts of foreign currency. The potato-peels starch thus constitutes a primary product result of this project, Figure 27, and can potential be packaged and sold to the local market as a competitive product.

Figure 27. Example of starch extracted from potato peels.

18.1 Potato peels sources and availability:

Large quantity and uninterrupted supply of potato peel raw material are abundantly available since potatoes are a staple crop with well-established supply chains, contributing to the reliability of sourcing potato peels. Potatoes constitute an important part of daily life consumption habit of most societies not only in Algeria but worldwide. The availability is present all year around independently of season movements and main sources can be listed below, next page:

18.1.1 House hold bio-waste:

Households generate a significant amount of potato peels through everyday cooking practices.

18.1.2 Restaurant and Food Service Industry:

Large-Scale potatoes consumption restaurants and food service establishments, especially those specializing in potato-based dishes, generate substantial quantities of potato peels on a daily basis.

18.1.3 Potato Processing Industry:

Potato processing industry such chips producing companies generate vast quantities of potato peels.

18.1.4 Potatoes farms:

In addition to the potatoes themselves being the source of the potato peels waste as shown above, another source of large quantities potato waste that can be used in this project are the low quality and bad potatoes.

It is noted here that all these sources of the raw material mostly end up in the municipal landfills.

Although the exact total quantities of such types of waste in the landfill are not available, as estimation can be made based on statistics for the years 2018/2019 worked out by the Algerian National Waste Agency- **A**gent **N**ationale des **D**échets (AND**وون**) الوكالة الوطنية للنفايات- (AND, 2018/2019).

This government official documents states that the average quantity if waste of a verity of different types is **13.1 million tonnes** for the year 2018. The amount of biological type of waste is ~ **53.6%**, Figure 28, being the largest type of waste thrown in the landfills. This means that biological waste amounts to around **~ 7.02 million tonnes.**

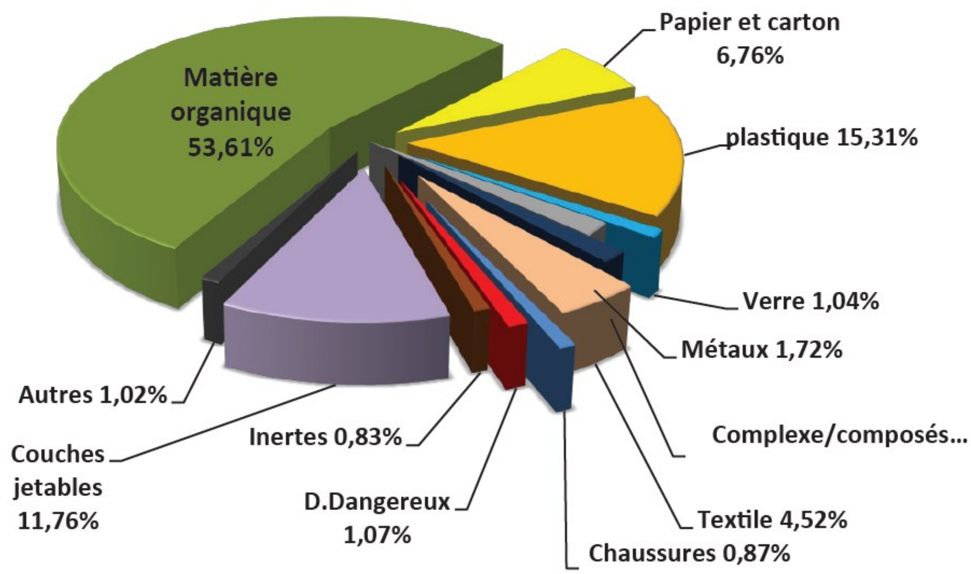


Figure 28. The average composition of household and similar wastein the 4 seasons, Algeria (AND, 2018/2019).

Though the statistics are limited, it is still possible to have a rough estimation based on the potato peels amounts and availability discussed above, it would be expected that potato peels would reach annual average quantities of the order of, at least, some **few hundred thousand tonnes** which still reflect a **potential for large-scale starch production business**.

To put this in perspective, perhaps its worth to notice that globally, it is estimated that around 8 million tonnes of potato peels waste alone could be generated in 2030 (Ebrahimian F. *et al.*, 2022).

It is, thus, safe to conclude that the obtained average quantity value of 80g/kg potato starch is very significant as it means that potato peels waste would **generate** an average of 80 kg/tonne of starch and for 1ktonne. This means that the potential amounts of generated starch would reach the order of thousands of tonnes yearly.

Such high potato based starch production expectations show significant market competition to the corn based starch thereby the project reflects a significant contribution to national economy in generating work opportunities, income and foreign currency savings.

19 Results of the production of bio-plastic

Small amounts of starch extracted from the potato peels as described in the methodology Chapter 2 have successfully been used to obtain bioplastic material types as described below:

19.1 Hard bio-plastic:

This type of bio-plastic has been produced without the use of glycerol and concentrations of 6% and 9% acetic acid. Two mould types of bio-plastic have been created a thick block and sheets. As the sheets dried showed cracks, see Figure 29. The used acetic acid concentrations showed no important impact though more investigation using other grades of acetic acid may show effects on the final characteristics of the bio-plastic.

Figure 29. Hard bioplastic coloured red; A 1cm thick block, B crackable sheet and C beaker shaped mould.

19.2 Shredded hard bio-plastic:

For practical commercial reasons, thehard bio-plastic is shreded to small pieces, Figure 30.This product form is used for moulding into a variety of mould patterns by heat application to manufacture, for example, of hard type of kitchenware such as cups, plates and spoons.

Figure 30. Shreds of hard bioplastic to be used in moulding process for the creation of hard type kitchenware like spoons and plates etc.

19.3 Flexible bio-plastic:

A. This type of bio-plastic has been produced with the use of glycerol and concentrations of 6% and 9% acetic acid. Two mould types of flexible bio-plastic have been obtained a shaped blob and sheet style. Both remained flexible after drying see Figure 31.Here also, the used acetic acid concentrations showed no important impact. More investigation using other grades of acetic acid may show effects on the final characteristics of the bio-plastic.

Figure 31. Flexible bioplastic coloured green; in sheet form A thin, B thicker and flower shaped blob C using a press mould.

19.3.1 Films of flexible bioplastic:

Quite a number of commercial applications such as food packaging and storing flexiblebioplastic can be used, Figure 32. Also shown in Figure 31 indicated A and B.

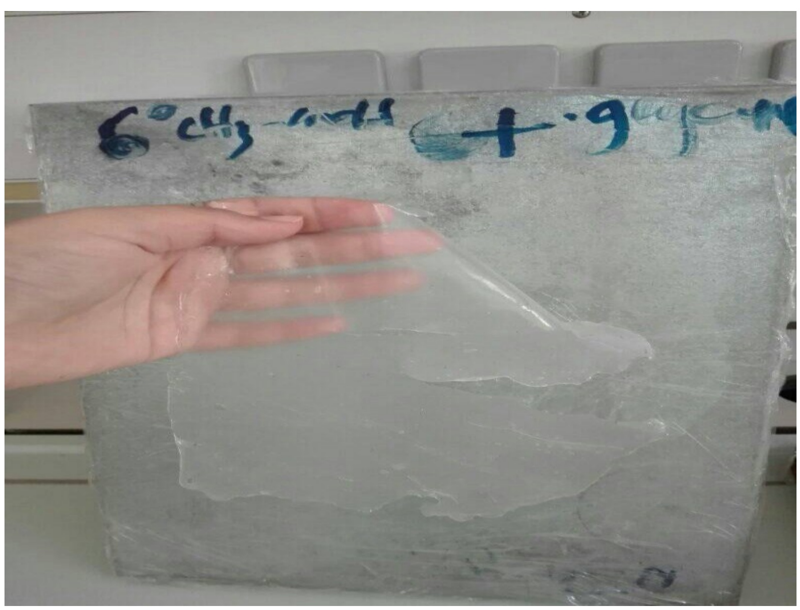


Figure 32. Transparent flexible bioplastic film can target packaging, storing food industry and be used as alternative to plastic bags.

20 General conclusion

The research project focused on recycling potato peels waste to produce starch has demonstrated significant potential for creating a sustainable and market-competitive alternative to corn-starch. The quantity and quality of the starch obtained from potato peels not only meet but exceed the standards set by traditional corn-starch. This breakthrough not only addresses the issue of waste management by utilizing potato peels but also offers an environmentally friendly alternative to a widely used agricultural product.

The positive impact of this project on environment and reduction of global warming can be seen if we consider the global 2030 projected generation of the quantity of 8 million tonnes of potato peels waste, as reported above, with greenhouse gas emissions of 5 million tons of CO_2 equivalent associated with its disposal (Ebrahimian F. et al., 2022).

Furthermore, the project's innovation extends beyond starch production, as the development of bioplastics from the same potato peel starch, produced in the project, presents a viable alternative to petroleum-based plastics. This dual-pronged approach not only tackles the challenges associated with waste reduction but also contributes to mitigating the environmental impact of plastic pollution.

Although more analysis and further studies are still need to refine the quality of the starch and define the degradability time of the bioplastic produced in the project, the successful integration of these findings into various industries could mark a crucial step towards a more sustainable and circular economy. The adoption of potato peel-derived starch and bio-plastics has the potential to reduce dependency on conventional resources, decrease environmental degradation, and foster a more eco-friendly approach to industrial processes.

In the broader context, this research not only adds value to a commonly discarded agricultural by product but also aligns with global efforts to develop innovative solutions for sustainable living. As we navigate the complexities of modern waste management and environmental conservation, the findings from this study offer a promising avenue for creating a more sustainable and competitive market, with the added benefit of reducing our reliance on non-renewable resources.

References

Albertsson A. C. & HakkarainenM. (2017). Designed to degrade-Towards advanced sustainable polymers. Advanced Drug Delivery Reviews,107,223-240

Alrefai R, Alrefai A, BenyounisK. Y., Stokes J.(2020). An evaluation of the Effects of the Potato Starch on the Biogas Produced from the Anaerobic Digestion of Potato Wastes

Andi (2013). Agence Nationale de Developpement de l'investissement Données statistiques Alger

AND (2019). Caractérisation des déchets ménagers et assimilés campagne nationale 2018/2019. https://and.dz/caracterisation-des-dechets-menagers-et-assimiles-campagne-nationale-2018-2019/.

Andrady, A.L.(2015).Plastics and environmental sustainability. John Wiley and Sons

Ahti.E.(1984). Fertilier-induced leaching of phosphorus and potassium from peatlands drained for forestry. Proceedings of the 7th International Peat Congress, Dublin 3:153-163

Auras R., Harte B. & Selke S.(2004). An overview of polylactides as packaging materials. Macromolecular bioscience,835-864

Bayram B, Greiff K.(2023) Life cycle assessement on construction and demolition waste recycling: A systematic review analyzing three important quality aspects

Chen G.Q.(2009). A microbial polyhydroxyalkanoates(PHA) based bio and materials industry. Chemical Society Reviews,2434-2446

Chiellini E, (2003). Biodegradable polymers: Market trends and new perspectives. Emerging technologies in plastics recycling,28-45

Dorbane N.(2004). Gestion des dèshets solides urbains dans le cadre du dèveloppement durable cas de la ville TisiOuzou (Doctoral dissertation, Universitè de Tizi Ouzou-Mouloud Mammeri)

DSP, (2015). Direction de la santé et la population de la wilaya de Saida. Bilan des activitès du registre cancer de l'annèe 2015

Ebrahimian F., Denayer J.F.M., Karimi K. (2022) Potato peel waste biorefinery for the sustainable production of biofuels, bioplastics, and biosorbents. Bioresour Tech 360:127609. https://doi.org/10.1016/j.biortech.2022.127609

EPGCET, (2015). Entreprise publique de gestion et controle et l'enfouissement technique de la wilaya de Saida

European Bio-plastics, (2020). Bioplastics in the circular economy

European Bio-plastics, (2020). Environmental benefits of bio-based plastics

European Commission.(2020). Plastics Strategy. https://ec.europa.eu/environment/circular-ecoomy/plastics-strategy-en

Mueez S. A., Siddique Y., Mehnaz S., Bilal Sadiq M. (2023). Extraction and characterization of starch from low-grade potatoes and formulation of gluten-free cookies containing modified potato starch. Heliyon, 9 (9). e19581. https://doi.org/10.1016/j.heliyon.2023.e19581

Garcia; B. and al.(2023). Advances in Biotechnology for Improved Biodegradability of Bioplastics. Biotechnology Advances, 41, 107804

Hoornwey D, Bhada-Tata P. (2012). WHAT A WASTE: A Global Review of Solid Waste Management. Urban Development Series Produced by the World Bank's Urban Development and Local Government Unit of the Sustainable Development Network, No. 15.

Hopewell J., Dvorak R & Kosior E.(2009). Plastics recycling: Challenges and opportunities. Philosophical Transactions of the Royal Society B: Biological Sciences,364(1526),2115-2126

Johnson E. and al. (2020). Dietary Fiber Intake and Cardiovascular Disease Risk: A Systematic Review and Meta-Analysis of Prospective Cohort Studies. Critical Reviews in Food Science and Nutrition,,pp.1680-1690

Kara S. (2012). Prèparation des copolymers hydrosolubles à base d'amidon, Modification et controle des proprieties. Thèse magister en chimie, universitè Abou Baker BELKAID, Telemcen

Khanal S., Karimi K., Majumdar S., Kumar V., Verma R., Bhatia S.K., Kuca K., Esteban J. & Kumar D. (2023). Sustainable utilization and valorization of potato waste: state of the art, challenges, and perspectives. BiomassConv. Bioref. https://doi.org/10.1007/s13399-023-04521-1

Lal A. and Cheeptham N.(2012). Starch Agar Protocol. American Society for Microbiology; https://asm.org/ASM/media/Protocol-Images/Starch-Agar-Protocol.pdf?ext=.pdf

Laurent(2013). Etude sur la performance Environnementale comparativement aux plastique pètrochimiques, Universitè de Sherbrooke Canada

Kijchavengkul T. A. R., Rubino M. & Selke S. (2008). Improving the performance of polylactic acid for use in blends and composites. In Handbook of Bioplastics and Biocomposites Engineering Applications (65-98). John Wiley and Sons.

Mohanty, A. K.,Misra, M. & Drzal L.T. (2002). Green plastics: An introduction to the new science of biodegradable plastics. Princeton University Press.

Narayan R. (2018). Biopolymers: New materials for sustainable films and coatings. Wiley

Navarrate-Bolanos JL, Lizardi-Mondosa J. (2020). Bioactive compounds from potato peel ad their health benefits: A review. Food Funct.

Niaounakis M. (2019). Biopolymers: Biobased Materials and Their Applications. CRC Press

PNUE (2014). Programme des Notions Unies pour l'environnement

Navasingh R. J. H., Gurunathan M. K., Nikolova M. P. and Królczyk J. B. (2023). Sustainable Bioplastics for Food Packaging Produced from Renewable Natural Sources, Polymers, 15(18), 3760; https://doi.org/10.3390/polym15183760

Roy A. (2019). Handbook ofBio-plastics and Bio-compositesEgineering Applications. Wiley

Selke S.(2012). Packaging and the environment. CRC Press

Shen L., Worell E. (2014). Plastic recycling. Handbook of Recycling. Boston: Elsevier, pp. 179-190

Shogren R.L., Willett J.L.,Deschamps A.M.(2007). Starch-based biodegradable plastics: synthesis, characterization, and industry outlook. Macromolecules,404-415

Shrestha S., Khatiwada JR, Sharma HK, Qin W. (2021). Bioconversion of fruits and vegetables wastes into value-added products, in advances in science, technology and innovation.(Switzerland: springer nature),145-163

Smith; A. and al. (2022). Enhancing Biodegradability and Mechanical Performance of Bio-based Polymers. Journal of Applied Polymer Science, 139(45), e53315

Smith; J. and al. (2017). Nutritional Value and Health Benefits of Potato Peel: A Review. Food Chemistry, pp. 494-501

Stevenes E.S. (2002). Green plastics: An introduction to the new science of biodegrdable plastics. Princeton University Press

Tassinari G; Bassani A; Spigno G; SoregaroliC. (2023). Do biodegradable food packaging films from agro-food waste pay off. A cost-benefit analysis in the continent of Europe, science of the total environment, 856 (September 2022). Doi:10.1016/j.scitotenv.2022.159101

Van wyk JPH.(2005). Aprofessional and developmental approach.Juta: cape town.second edition.pp.466-488

Zhang R., Su J., Liu H. (2020). Application of Biowaste to Energy Conversion Technologies: Current Status and Future Trends. Journal of Cleaner Production, 262, 121198