DEVELOPMENT OF BREADFRUIT [*Artocarpus altilis* (Parkinson) Fosberg] FLOUR-BASED EDIBLE SACHET INCORPORATED WITH BOVINE GELATINE

By

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Thesis Submitted to School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

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Chair : **Nur Hanani Zainal Abedin, PhD**
Faculty : **Food Science and Technology**

Breadfruit (*Artocarpus altilitis*) is an important source in many tropical countries, providing a reliable source of carbohydrates and nutrients. It plays a significant role in the diets of people in the Pacific islands, the Caribbean and parts of Southeast Asia. It is also rich in carbohydrates, ash, fibre, and protein. However, the breadfruit itself has several issues, including a short shelf life due to its highly perishable nature and rapid maturation. Therefore, processing breadfruit into flour is one of the techniques to reduce post-harvest losses and maximise utilisation. Unripe breadfruit (index 2) was often processed to flour to give a more stable storage form while also increasing the fruit's versatility. Breadfruit flour is more practical and easier to transport. Processed breadfruit's flour increases stability, yield and is more easily transported. Breadfruit flour also can be use to develop edible films. However, they do come with some drawbacks that need to be considered in their application and development such as high-water sensitivity leading to issues such as increased water vapour permeability fragility, hydrophilicity, poor resistance to external factors and mechanical properties. Therefore, the combination flour based edible film with other biopolymer such as protein allows to improve its properties and functionalities. Hence, the first objective of this study was to develop edible film from breadfruit flour (*Artocarpus altilitis*) (BEF) with the addition of gelatine (G) at different ratios. The proportion of BF: G were as follows: 5:0 (BEF), 5:1 (BEF-G2), 5:2 (BEF-G4), 5:3 (BEF-G6), 5:4 (BEF-G8), and 5:5 (BEF-G10). Another objective is to determine the shelf life and sensory evaluation of curry seasoning powder packed with breadfruit flour edible sachet for instant noodles in cup at ambient temperature for 9 months. For the first objective, the results showed that the concentration of gelatine did influence ($p<0.05$) the breadfruit flour film's thickness and water vapour permeability at 5:5 ratios (BEF-G10). The results also showed that the tensile strength (TS) and Young's modulus (YM) decreased significantly ($p<0.05$) while elongation at break (EAB) was increased as the increment of gelatine. In colour analysis, the addition of bovine gelatine has shown significantly reduced the lightness but increased the opacity of the films. In FTIR analysis, it was indicated that the addition of gelatine concentration resulted in a change from 1149.50 cm^{-1} on BEF films to 1152.12cm^{-1} BEF-G10 films, which confirmed the changes in breadfruit flour starch and its polysaccharide chains by the addition of gelatine. Scanning

electron microscopic (SEM) analysis also showed that BEF films had rough, slightly irregular, protruded surfaces compare with film added with gelatine BEF-G10 which had more smoother and homogenous surfaces. In the second objective, the physicochemical, microbiological and sensory evaluation of curry seasoning packed with breadfruit flour edible sachet edible films with the addition of gelatine at ratio of 5:5 (BEF-G10). The edible sachets were kept in sealed noodles cup and stored in and ambient room with controlled temperature of 27℃, with RH 70 in the pest-free stainless-steel cabinet for 9 months. The physicochemical properties of curry seasoning in BEFG-10 were investigated and compared with breadfruit edible film without the addition of gelatine (BEF), analysed one-month intervals. The results showed that the curry seasoning in the edible film sachet made from breadfruit flour with gelatine showed better shelf-life stability due to lower water activities and moisture being absorbed by the seasoning powder. Thus, PV and FFA values showed better properties as lower moisture was absorbed and less rancidity occurred. BEF-G10 film also shows low bacterial and yeast mould growth. All of the results on physicochemical properties indicated that film with gelatine (BEF-G10) has better protection against physical, chemical and microbiological deterioration on curry seasoning powder during the storage period. Generally, the sensory evaluation analysis indicated that films with gelatine addition (BEF-G10) gave better sensory acceptance scores on taste, aroma, texture (gravy concentration) and overall acceptability. In conclusion, breadfruit film added with bovine gelatine can be safely used as a curry seasoning sachet for instant noodles in a cup.

Keywords: Breadfruit flour; Edible film; Gelatine; Shelf-life stability

SDG: GOAL 3: Good Health and Well-being; GOAL 9: Industry, Innovation, and Infrastructure; GOAL 12: Responsible Consumption and Production

Abstrak tesis yang dikemukakan kepada Senat of Universiti Putra Malaysia sebagai memenuhi keperluan untuk Master Sains

PEMBANGUNAN SACHET BOLEH DIMAKAN DARI TEPUNG SUKUN [*Artocarpus altilitis* (Parkinson) Fosberg] YANG DITAMBAH GELATIN BOVIN

Oleh

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Buah sukun *(Artocarpus altilitis)* kaya dengan kandungan karbohidrat, abu, fiber dan protein. Ia dikenali sebagai pengganti sumber karbohidrat di sesetengah negara. Namun begitu, penghasilan buah mempunyai beberapa masalah termasuk jangkahayat pendek yang disebabkan oleh daya kerosakan yang tinggi dan tahap keranuman yang cepat. Oleh itu, pemprosesan buah sukun kepada tepung adalah salah satu teknik untuk melanjutkan jangkahayat dan kestabilan serta mengurangkan kerugian hasil lepastuai. Penghasilan filem boleh dimakan menggunakan tepung sukun merupakan satu cubaan untuk memaksimumkan penggunaan buah sukun dan dipercayai akan menghasilkan filem yang mempunyai ciri fizikal yang baik. Objektif pertama ialah untuk menghasilkan bahan pembungkus filem boleh dimakan dari tepung sukun (BF) dengan konsentrasi gelatin (G) yang berbeza. Formulasi campuran bahan filem boleh dimakan dengan kadar nisbah tepung sukun kepada gelatin adalah seperti berikut (BF: G) 5:0 (G0), 5:1 (G1), 5:2 (G2), 5:3(G3), 5:4 (G4) and 5:5 (G5). Objektif lain adalah untuk menentukan jangka hayat dan penilaian sensori serbuk perasa kari yang dibungkus dengan sachet tepung sukun pada mi segera dalam cawan pada suhu bilik selama 9 bulan. Bagi objektif pertama, kajian mendapati bahawa konsentrasi gelatin mempengaruhi ($p<0.05$) ketebalan dan kebolehtelapan wap air filem tepung sukun pada nisbah 5:5 (BEF-G10). Kajian juga mendapati bahawa kekuatan regangan (TS) dan kelenturan (YM) berkurangan secara signifikan ($p<0.05$) namun elastisiti takat putus (EAB) semakin meningkat seiring dengan pertambahan kosentrasi gelatin. Dalam analisis warna, pertambahan gelatin mengurangkan kecerahan tetapi meningkatkan kelegapan filem. Dalam analisis FTIR, pertambahan gelatin menunjukkan perubahan nilai gelombang dari 1149.50 cm^{-1} untuk filem BEF kepada 1152.12cm^{-1} bagi filem BEF-G10, yang menunjukkan perubahan kanji tepung sukun dan polisakaridanya dengan penambahan gelatin. Analisis mikroskopik elektron menunjukkan filem BEF mempunyai permukaan yang kasar, tidak sekata dan permukaan yang berbintil berbanding filem yang telah ditambah dengan gelatin BEF-G10 dimana filem tersebut lebih licin dan sekata. Dalam objektif kedua, penilaian fizikokimia, mikrobiologi dan deria bagi perencah kari yang dibungkus dengan sachet filem tepung sukun boleh dimakan dengan penambahan pada nisbah 5:5 (BEF-G10) dibandingkan dengan perencah kari yang dibungkus dengan filem tepung sukun yang boleh dimakan tanpa penambahan gelatin (BEF), disimpan pada suhu bilik selama 9 bulan dan dianalisis selang satu bulan. Kajian mendapati serbuk perencah kari yang dibungkus dengan peket filem boleh dimakan daripada tepung sukun dengan penambahan gelatin menunjukkan jangka hayat yang lebih stabil disebabkan oleh aktiviti air dan serapan kelembapan serbuk perencah yang lebih rendah. Oleh itu, nilai PV dan FFA menunjukkan sifat yang lebih baik kerana kelembapan yang diserap lebih rendah dan kurang ketengikan berlaku. Filem BEF-G10 juga menunjukkan pertumbuhan yis dan kulat yang rendah. Kesemua keputusan penilaian fizikokimia menunjukkan bahawa filem dengan gelatin (BEF-G10) mempunyai perlindungan yang lebih baik terhadap kemerosotan fizikal, kimia dan mikrobiologi pada serbuk perencah kari semasa tempoh penyimpanan. Secara umumnya, filem dengan penambahan gelatin memberikan skor penerimaan yang lebih baik dari segi rasa, aroma, tekstur (kepekatan kuah) , dan penerimaan keseluruhan. Secara kesimpulannya filem dari tepung sukun yang ditambah dengan gelatin boleh digunakan secara selamat sebagai peket perencah kari untuk mi segera dalam cawan.

Kata kunci: Filem boleh dimakan; Gelatin; Kestabilan jangka hayat; Tepung sukun

SDG: GOAL 3: Good Health and Well-being; GOAL 9: Industry, Innovation, and Infrastructure; GOAL 12: Responsible Consumption and Production

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a *	redness/yellowness
AOAC	Association of official analysis chemists
ANOVA	Analysis of variance
ASTM	American standard test method
ATR	Attenuated reflection wavelength
°C	Degree celsius
A_{600nm}	Optical density at wavelength 600 nanometer
^{0}Brix	Measure of the dissolved solids
b*	Blueness/ greenes
B.C	Before centuries
BF	Breadfruit flour
BEF	Breadfruit flour edible film
BEFG	Breadfruit flour edible film with gelatine
cfu	colony forming unit
cm	centimeter
cm^{-1}	Inverse centimeter
$C_3H_8O_3$	Trihydroxyl alcohol
EAB	Elongation at break
E. coli	*Escherichia coli*
EtOH	Ethanol
FFA	Free fatty acid
FS %	Percentage of film solubility
FTIR	Fourier transform infra red
g	Gram
G	Gelatine
H	Height
KI	Kalium iodide
Kg	Kilogram
kPa	Kilopascal
L	Litre
LDPE	Linear density polyethylene
LLDPE	Linear low-density polyethylene
L*	Lightness
l_{max}	Film elongation
M	Molar
m	meter
m^2	meter square
mEq	Miliequivalent
mL	Mililitre
mm	Milimeter
mw	wet mass
md	Dry mass
µm	Micrometer
MPa	Megapascal
N	Load
NaOH	Natrium hidroksida
nm	nanometer

No.	Number
OH	Hydroxyl group
PE	polyethylene
pH	figure expressing the acidity or alkalinity
PV	Peroxide Value
RH	Relative humidity
S	Second
SEM	Scanning Electron Microscopy
T	Transparency
Tg	Glass transition
TS	Tensile Strength
TSS	Total soluble solid
UV	Ultraviolet
W	Width
WVP	Water Vapour Permeability
YM	Young's modulus

CHAPTER 1

INTRODUCTION

1.1 Background

The main function of food packaging is to preserve the quality and ensure food product is safe to eat from the time it is produced until reaching the hands of consumers. Although petrochemical-based plastic packaging can meet those requirements, plastic packaging is rarely recycled. This condition results in environmental problems due to undegradable plastic characteristics even after hundreds of years (Liu et al., 2021). The food industry uses many packaging materials, therefore, the most effective way to protect the environment from packaging waste is to reduce the use of petrochemical-based plastic packaging materials.

In line with the increasing consumer awareness of environmental conservation, the demand for packaging made from materials which easily recycled or environmentally friendly such as biodegradable or edible substances is also increasing. Recognizing this fact, the food packaging industry needs to understand the interaction between food, packaging, and the environment to produce efficient food packaging. Biodegradable or bio-polymer packaging products can be made from raw materials derived from agricultural or marine sources (George et al., 2021). Early research has demonstrated that starch-based edible film production can result in high-quality, cost-effective films. Therefore, this study has focused on the development of edible films as food packaging materials based on flour from unripe breadfruit fruits.

Breadfruit fruit is a beneficial plantation crop in various countries. However, the potential of the breadfruit fruit-based in food industry is not fully utilized. Breadfruit-based downstream products are also very limited, besides being sliced and fried, breadfruit-based products are not very well known in Malaysia, which contributes to the dumping of breadfruits, every time the tribal season arrives. Therefore, research and development on the usage of breadfruits are needed to support the development of breadfruits in industry. Beyond this study, the development of edible films based on breadfruit flour is one of the methods to diversify utilization and increase the value of breadfruit. This effort is crucial in supporting the government's aspiration to make Malaysia a high-income country from agricultural produce.

1.2 Problem Statement

Artocarpus altilis, or breadfruit, is a plant in the family *Moraceae*. The *Moraceae* family has more than 50 genera and more than 800 plant species, most of which live in tropical and subtropical areas. Breadfruit has long been an important staple crop of Polynesia and has grown widely in tropical, pacific, Caribbean and African countries (Ragone et al., 2014). In Malaysia, the production of breadfruit was 54.40 metric tonnes in 2021 (Department of Agriculture Malaysia, 2021). The fruits are considered a neglected and underutilized fruit plant species in Malaysia and it was included in the National Agricultural Policy (NAP3, 1998-2010) (Deivanai, S. and Bhore, 2010). The fruits provide a good amount of carbohydrates, vitamins and fiber while also being low in fat (Huang et al., 2019). Hundred gram of breadfruit flour (produced from breadfruit with Index 2) high in carbohydrates (77.09g/per), with the starch content ranging from 14.26 to 18% (Otemuyiwa et al., 2021). The starch has high content of amylopectin (77.48%) and amylose (22.52%). Also, it is a good source of fiber, calcium, copper, iron, magnesium, potassium, thiamine, and niacin. Although it's grown in almost 90 countries, breadfruit is still thought of as an underutilized crop and have poor shelf life (Nochera & Ragone, 2019; Fitriani et al., 2021).

The main issue with breadfruit is that it ripens in two to three days since it has a high post-harvest respiration rate (Nochera & Ragone, 2019). Due to the rapid ripening rate, it is rational to maximize this potential fruit by turning it into a variety of long-lasting food products. Modifying it to flour and starch would give it a more stable form and enhance its utility and versatility. Starch is useful in a wide variety of industries, including those that produce food, paper, and textiles because of its one-of-a-kind qualities, such as the capacity to form gels and thicken liquids. Because of its vast application and accessibility, starch has been the focus of a significant amount of academic investigation, notably in the field of biotechnology (Rostamzad, 2020).

Amylose and amylopectin play important roles in the formation and properties of edible films. So, instead of discarding and wasting the breadfruit, it would be wise to turn it into flour and then make edible films. However, starch-based edible films have certain disadvantages due to their high susceptibility to water which affects the film's mechanical properties (Mali et al., 2005; Chatli & Town, 2018)

Therefore, combination the starch with other materials such as gelatine can improved the properties of edible film. The inclusion of gelatine has proofed produced firmer films with improved extensibility and durability as well as increased resistance to rupture (Ulyarti et al., 2020; Malherbi et al., 2019; Acosta et al., 2015). The characteristics of gelatine include high gel strength, viscous and elastic moduli, high alpha-helix and β-sheet type structure, and strong hydrogen bonding (Sarbon et al., 2013) produces stronger films with better tensile strength, flexibility, and durability (Acosta et al., 2015). However, addition of gelatine on breadfruit edible film and its application as edible sachet film still not been explored.

1.3 Objectives

The aim of this study is to developed the breadfruit flour-gelatine blend edible films as well as the effectiveness of the films produced on food applications. There are two specific objectives in this study:

1. To develop edible film from breadfruit flour (*Artocarpus altilitis*) (BF) with the addition of gelatine (G) at different ratios (BEF:G); 5:0 (BEF), 5:1 (BEF-G2), 5:2 (BEF-G4), 5:3(BEF-G6), 5:4 (BEF-G8) and 5:5 (BEF-G10).

2. To determine the shelf life and sensory evaluation of curry seasoning powder packed with breadfruit flour edible sachet for instant noodle in cup at ambient temperature for 9 months.

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