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## **Agro-waste research and augmentation (AWRA): development of animal-based gelatin edible bioplastic**

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### **Abstract**

The introduction plastic wrappers were considered as a big milestone for modern man but it comes with a cost of serious environmental disruption. This study used experimental approach in producing animal-based materials for bioplastic as alternative. Focusing on the notion of nose-to-tail consumption, the study honors the animal by using thrown-parts such as chicken feet and pork lard. Strict and meticulous hygienic practices were used in developing gelatin and glycerin by-products, followed by neutralization of the flavor and creation of thin biofilms. Created biofilms were subjected to spoilage detection test that focused on monitoring flavor and smell changes, color changes, texture damage, and taste changes. Biofilms lasted for three (3) weeks on very humid and hot environment, two (2) months on cold environment, and four (4) months in the freezer with no observable spoilage and did not affect the flavor of the food enclosed in it. The results were very promising considering that the material sources are economical, not chemically synthesized, and would minimize the waste from discarded animal remains. It is recommended to conduct characterization study of the bioplastic in order to support high animal welfare standard and further increase its sustainability.

**Keywords:** biodegradable, healthy, food wrapper, compostable, non-toxic

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### **Introduction**

Agricultural waste management has recently received attention among researchers who are interested in understanding its nature and sustainability (Foley et al., 2011) [18]. In the past, agricultural waste management researchers focused on the facet of this management variable in areas of understanding the concept (Obi et al., 2016) [20], generation (Giroto et al., 2015) [12], production (Chandra et al., 2012) [5], food bioconversion (Uçkun Kiran et al., 2014) [25], utilization (Väisänen et al., 2016), biodegradation (Emadian et al., 2017) [6], valorization (Tuck et al., 2012) [24], and profitability (Mel et al., 2015).

Globally, humans generate 998 million tons of agro-waste annually which makes up 15% of the total waste generation (André et al., 2018) [20]. The Philippines, in particular, is generating agricultural waste of 0.078 kg/cap/day or 780,000 tons of agro-waste in a year (Agamuthu, 2009). The country is looking into zero waste initiative (Sapuy, 2016) that could lessen the production thus doing less damage to the environment.

Back in 2019, a scientist, Denxybel Montinol from the University of San Carlos in Cebu, Philippines was able to develop bioplastics from mango and seaweed by utilizing carrageenan and pectin derived from the plant sources. Moreover, most of the researches on gelatin production were focused on non-waste products and plant-based resources (E.C. Agwamba, 2020; E C Agwamba et al., 2019; Ernest C. Agwamba et al., 2020; Lubis et al., 2020; Mascarenhas Joyline and Aruna K, 2019; Maulida et al., 2018; Pieja et al., 2016) [1, 2, 3, 16, 17, 18, 22].

With limited to no researches on synthesizing bioplastics from animal-based products, primarily animal carcasses and other agricultural waste derived from them, existing in most recent endeavors prompted the need for this study to actualized. With all of the information given, it bounces back to the question, why there are so much animal agro-waste generated? Are there necessary steps taken to solve it? Is there a way to convert animal agro-waste into something useful? Is bioconversion even possible?

The questions presented motivated the researcher to focus on agricultural waste, animal bones and fats as source of gelatin and glycerin for bioplastics production. There is a need to look into the acceptability of these materials and how it would fare with the traditional and widely-used plant-based gelatin, hence the conduct of this study.

### **Objectives**

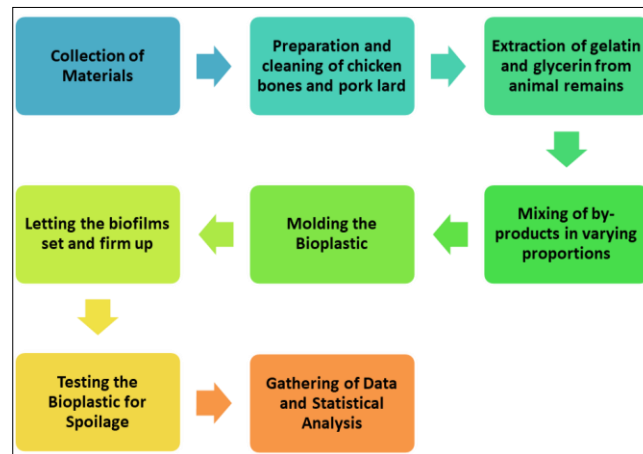
This study opted to synthesize gelatin from chicken bones and glycerin from pork fat as biomass converted to biologic films or bioplastics;

1. Find out the potential of animal agricultural waste from the utilization of chicken bones for gelatin and pork fat for glycerin as raw materials for bioplastics in terms of its spoilage;
2. Compared spoilage rate of varying proportions of bioplastics in a controlled environment mimicking average tropical temperature (25°C); and

- Find out spoilage rate of ideal material proportion of bioplastic across three distinct temperature, namely average tropical (25°C), cold environment (4°C), and freezing environment (-18°C).

### Methodology

This study utilized a controlled experimental design, specifically quasi-experimental design, of which isolation, augmentation, control, as well as data analysis are conducted under laboratory conditions (Fraenkel & Wallen, 2006).



**Fig 1:** Process Flowchart

Strict and meticulous hygienic practices were used in developing gelatin and glycerin by-products, followed by neutralization of the flavor and creation of thin biofilms. Created biofilms were subjected to spoilage detection test that focused on monitoring flavor and smell changes, color changes, texture damage, and taste changes.

**Table 1:** Composition of Biofilms

Material	Proportion		
	Biofilm A	Biofilm B	Biofilm C
Neutralized Gelatin	48g	48g	48g
Neutralized Glycerol	12g	18g	24g
Cold Filtered Water	240ml	240ml	240ml

The ideal created biofilm, which has a gelatin to glycerol ratio of 48:18 was further subjected to spoilage detection test against three distinct environmental conditions: average tropical temperature, cold temperature, and freezing temperature. The variation in time for the two tests were subjected to statistical analysis, both descriptive and inferential statistics, with the aid of Microsoft Excel Data Analysis and SPSS.

### Results and Discussion

The technology generated in the study centers around the utilization of animal agricultural waste, bioconversion in the form of bio-extraction and tackling the issues on agricultural waste management, advocating nose-to-tail consumption, threats of pollution from over dependence to plastics, and alternative gelatin and glycerin sources. This study is brainchild of the Agro-Waste Research and Augmentation (AWRA) Phase 1 study with the same aim of farmer empowerment and agricultural innovation. It is looking into reusing animal agricultural waste and turning it for potential food packaging. It could lessen the demand for plastic wrappers thus minimizing the threat for pollution. Bio-extraction and conversion creates by-products in the production of non-toxic, safe for human consumption, and all-natural materials that can easily decomposed.

#### a. Spoilage Rate of Varying Proportions of Bioplastics

Table showed the result of spoilage detection test under a controlled tropical temperature of 25°C which highlighted that the proportion with the longest freshness duration or does not spoil easily was that of Biofilm B with 21 days.

**Table 2:** Spoilage Rate per Biofilm Proportions

Proportion	Spoilage Rate (Day)			Average (Day)
	1	2	3	
Biofilm A	14	15	16	15
Biofilm B	22	20	21	21
Biofilm C	18	19	17	18

Likewise, it can be gleaned that the biofilm with a gelatin to glycerin ratio of 48:18 grams have no flavor and smell changes, color changes, texture damage, and taste changes within 21 days. Further observation showed that the right amount of glycerol contributed to the integrity of the biofilms, while putting too much could make it flexible penetrating to the food item thus introducing spoilage while putting too little could make the film hard and brittle prone to breakage that could allow air into the food item and causing early spoilage.

Glycerin and gelatin, if used on intended doses, have been seen to reduce food spoilage by inhibiting microbial activity penetration (Perna et al., 2015). Gelatin coating decreases the microbial spoilage as well as oxidative spoilage by increasing the phenol content and introducing an additional antioxidant activity on the food surface (Feng et al., 2017; Ganiari et al., 2017; Kakaei & Shahbazi, 2016).

#### ***b. Difference in Spoilage Rate of Varying Proportions of Bioplastics***

Upon subjecting the results of spoilage detection test to statistical analysis, it was found that there was a significant difference in the spoilage rate of various proportions of bioplastics.

#### ***c. Spoilage Rate of Ideal Biofilm Proportion of Varying Temperature***

Table showed the result of spoilage detection test for an ideal biofilm with a gelatin to glycerin ration of 48:18 grams across three distinct temperature, namely average tropical (25°C), cold environment (4°C), and freezing environment (-18°C).

**Table 3:** Spoilage Rate per Temperature

Temperature	Spoilage Rate (Day)			Average (Day)
	1	2	3	
Average Tropical (25°C)	22	20	21	21
Cold (4°C)	59	63	58	60
Freezing (-18°C)	123	121	120	121

Food grade items are expected to last more if not exposed to humid environment. It is observed as well it can be stored longer at freezing temperatures which is expected as well in food items to retain freshness more and make it more available at any time of the year (Giannakourou, 2015; Kaale et al., 2011; Khan & Mittal, 2017; Velioğlu et al., 2015).

#### **Conclusion and Recommendation**

The ideal biofilm has a good gelatin to glycerin ratio of 48:18 grams which proved to work and last well in an ideal tropical climate. Showing adaptability to a fickle and often tricky temperature ranges showcases a promising considering that the material sources are economical, not chemically synthesized, and would minimize the waste from discarded animal remains.

The era of a zero-waste future is not far from distant and honoring the animal by focusing on the notion of nose-to-tail consumption by utilizing thrown bits and pieces of animal carcasses resonates to a sustainable upcoming. It is recommended to conduct characterization study of the bioplastic in order to support high animal welfare standard and further increase its sustainability.

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