

**EFFECT OF PLASTIC WRAPPING ON RATE OF
DECOMPOSITION**

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**EFFECT OF PLASTIC WRAPPING ON RATE OF
DECOMPOSITION**

by

CHEW SERENE

**Thesis submitted in partial fulfilment of the requirements
for the Bachelor of Science (Honours) (Forensic Science)**

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CERTIFICATE

This is to certify that the dissertation entitled 'EFFECT OF WRAPPING IN DELAYING RATE OF DECOMPOSITION' is the bona fide record of research work done by MS. CHEW SERENE, 163747 during the period from October 2025 to January 2026 under my supervision. I have read this dissertation and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation to be submitted in partial fulfillment for the degree of Bachelor of Science (Honours) Forensic Science.

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DECLARATION

I hereby declare that this dissertation is the result of my own investigations, except where otherwise stated and duly acknowledged. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at University Sains Malaysia or other institutions. I grant University Sains Malaysia the right to use the dissertation for teaching, research and promotional purposes.

CHEW SERENE

Date: 30/1/2026

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LIST OF SYMBOLS

%	Percentage
°C	Degrees Celsius
g	Gram
m	Metre
mm	Millimetre
kg	Kilogram

LIST OF ABBREVIATIONS

1 st	First
2 nd	Second
3 rd	Third
<i>C. megacephala</i>	<i>Chrysomya megacephala</i>
<i>C. rufifacies</i>	<i>Chrysomya rufifacies</i>
<i>Sarcophaga sp.</i>	<i>Sarcophaga species</i>
MET	Malaysian Meteorological Department
MSF	Forensic Science Laboratory
UPMS	Science Laboratory Management Unit
TBS	Total body score
PMI	Postmortem interval

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EFFECT OF PLASTIC WRAPPING ON RATE OF DECOMPOSITION

ABSTRAK

Dalam kes forensik sebenar, mayat manusia kadangkala ditutup dengan bahan tertentu bagi menyembunyikan mayat atau menyukarkan siasatan pihak polis. Walaubagaimanapun, kajian yang memberi tumpuan kepada penutup plastik yang mewujudkan persekitaran mikro kedap udara serta kesannya terhadap proses pereputan masih terhad. Oleh itu, kajian ini bertujuan untuk menyiasat kesan pembalutan plastik terhadap kadar pereputan di bawah keadaan persekitaran semula jadi. Dua sample daging babi seberat 500g setiap satu digunakan sebagai model analog manusia, manakala filem regang lutsinar dipilih sebagai bahan pembalut. Dua ulangan eksperimen dijalankan di bawah keadaan luar tropika, dengan setiap ulangan melibatkan satu sampel kawalan dan satu sampel dibalut yang menggunakan tiga lapisan filem regang. Sampel yang dibalut menunjukkan kelewatan dalam proses pereputan, dengan kelewatan selama 8 hari pada kitaran pertama dan 3 hari pada kitaran kedua, khususnya pada peringkat pereputan aktif dan pereputan lanjutan, manakala peringkat kering tidak diperhatikan. Selain itu, oviposisi mengalami kelewatan selama satu hari dan tempoh perkembangan lengkap lalat menjadi lebih panjang pada sampel yang dibalut, dengan kitaran hidup selesai dalam kira-kira 12 hari bagi sampel kawalan berbanding kira-kira 18 hari bagi sampel yang dibalut dengan plastik. Sepanjang kajian, tiga spesies lalat dikenal pasti, iaitu *Chrysomya megacephala*, *Chrysomya rufifacies* dan *Sarcophaga sp.* Dapatan kajian ini menyediakan satu kerangka pemahaman tentang bagaimana pembalutan plastik mengubah dinamik pereputan dan aktiviti serangga, yang penting untuk anggaran selang masa selepas kematian (PMI) yang lebih tepat dalam kes melibatkan mayat yang disembunyikan.

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ABSTRACT

In real forensic casework, human remains are sometimes covered with materials to conceal the body or complicate police investigations. However, limited research has focused on plastic coverings that create an airtight microenvironment and their effects on decomposition processes. Therefore, this study aimed to investigate the effect of plastic wrapping on the rate of decomposition under natural environmental conditions. Two pork samples weighing 500g each were used as a human analogue, and transparent stretch film was selected as the wrapping material. Two experimental replicates were conducted under outdoor tropical conditions, each consisting of a control pork sample and a wrapped pork sample enclosed in three layers of stretch film. The wrapped samples exhibited delayed decomposition, with an eight-day delay in the first cycle and a three-day delay in the second cycle, particularly during the active decay and advanced decay stages, while progression to the dry stage was not observed. In addition, oviposition was delayed by one day, and complete fly development was prolonged in the wrapped samples, with the life cycle completed in approximately 12 days in the control samples compared to approximately 18 days in the plastic-wrapped samples. Three fly species were recorded throughout the study: *Chrysomya megacephala*, *Chrysomya rufifacies*, and *Sarcophaga* sp. These findings provide a framework for understanding how plastic wrapping alters decomposition dynamics and insect activity, which is critical for accurate post-mortem interval estimation in cases involving concealed remains.

Chapter 1 : Introduction

1.1 Background of Study

Forensic entomology involves the collection and analysis of insect evidence to assist in forensic investigations and address legal questions (Amendt, et al., 2011). The application of insect evidence in criminal investigations can be traced back to the 13th century in China, as documented in Sung Tzu's book *The Washing Away of Wrongs*. In this historical case, suspects of a murder case were instructed to place their sickles on the ground, and blow flies were observed to be attracted to only one of the sickles due to trace amounts of blood that were not visible to the naked eye. This observation led to the identification and confession of the perpetrator, thereby resolving the case. By the 18th century in France, forensic entomology had been introduced in modern courtrooms, where entomological data were accepted as admissible evidence (Joseph, et al., 2011).

Entomological evidence plays a crucial role in forensic investigations, providing valuable insights into the circumstances surrounding death. It can aid in determining the post-mortem movement or storage of remains, estimating submersion intervals, establishing the timing of decapitation or dismemberment, identifying trauma sites, differentiating post-mortem artefacts, detecting the influence of drugs, linking suspects to crime scenes, assisting in cases of sexual assault, and supporting the identification of individuals involved (Campobasso & Introna, 2001). The post-mortem interval can also be estimated by analysing the insect colonisers present on the corpse as their lifecycle is predictable (Joseph, et al., 2011; Donovan, et al., 2006).

When a death occurs, insects associated with decomposing remains can be broadly categorised into four groups: necrophagous species, predators and parasites on the necrophagous species, omnivorous species, and adventive species. Among these, the first two groups are of primary importance in forensic entomology, with Diptera being the

most significant order involved (Smith, 1988). The predominant dipteran families include Calliphoridae, Sarcophagidae, and Muscidae. Adult Calliphoridae are typically characterised by a metallic appearance, exhibiting blue, green, or black colouration on the thorax and abdomen. Sarcophagidae are medium-sized flies distinguished by black and grey longitudinal stripes on the thorax and a checkered abdomen. Both families are known to colonise remains within minutes after death. In contrast, Muscidae are generally identified by a grey thorax with four longitudinal dark stripes and a body covered with fine hair-like structures. Their colonisation is usually observed during the bloat stage of decomposition rather than immediately after death (Joseph, et al., 2011).

Upon arrival at the remains, Diptera deposit their eggs on natural body openings and areas of trauma. This process is known as oviposition, which may occur within minutes to hours after death. Following hatching, larvae emerge and begin feeding on body tissues. Larval development proceeds through three instar stages, from first instar to third instar. Progression between instars requires ecdysis, during which larvae shed their cuticle to allow further growth. After completing the feeding phase at the third instar, larvae enter a post-feeding stage and migrate away from the remains to seek suitable sites for pupation. Pupae are subsequently formed within a protective outer casing, and the emergence of adult flies marks the completion of the dipteran life cycle (Amendt, et al., 2011).

The life cycle of Diptera provides valuable information for estimating the time since death. Different species exhibit varying growth rates and developmental timelines. By measuring the body length or dry weight of the oldest larvae and comparing these measurements with established reference data, the age of the larvae can be estimated. Consequently, the post-mortem interval can be inferred, providing important insights for forensic investigations (Joseph, et al., 2011).

However, in real-life forensic contexts, human remains are sometimes discovered with some form of plastic covering, either intentionally used by perpetrators to transport or conceal the body, or incidentally present at the deposition site. Such plastic coverings may include plastic bags or plastic wrapping materials, each differing in configuration and functional effects on decomposition.

To distinguish between these terms, Pakosh and Rogers (2009) examined underwater soft tissue decomposition using polyethylene plastic bags to enclose dismembered pig limbs. In this context, a plastic bag refers to a pre-formed polyethylene enclosure with a defined opening, where enclosure denotes protection from the external environment. Plastic bags, such as household garbage bags, may be loosely closed, knotted, or tightly sealed, depending on the experimental methodology.

In contrast, plastic wrapping can be characterised based on the study by Taleb et al. (2022), in which rabbit carcasses were covered using a single layer of transparent plastic material. The plastic was not sealed or secured with ties; instead, the opening was loosely knotted and positioned beneath the carcass. Similarly, a study by Khoo and Mahmood (2020) involved the plastic wrapping of human bodies using transparent cling film. In their study, the wrapping was performed using a bottom-up technique, from the feet to the head, in three layers. Therefore, plastic wrapping refers to plastic sheets or films that are applied directly around remains without forming a fully self-contained enclosure. It will be the focus of this study to understand its application in influencing decomposition patterns.

1.2 Problem Statement

In forensic casework, offenders frequently conceal human remains using various coverings, such as clothing (Manheim, 1997), blankets (Goff, 1992), and plastic materials

(Kamar, 2003), to delay discovery and complicate the estimation of the post-mortem interval (PMI) (Catts & Goff, 1992). Previous studies have demonstrated that such coverings can significantly influence decomposition processes and insect colonisation patterns. However, few studies have investigated the impact of artificial coverings, particularly plastic wrapping that creates an airtight and impermeable environment. This represents a significant knowledge gap that the present study aims to address.

Transparent stretch film is a common domestic and industrial material, making it readily accessible and potentially used for body concealment. Although a comparable material, cling film, has been examined for its application in body management during mass fatality incidents, its role as a taphonomic variable capable of altering or delaying decomposition has not been evaluated (Khoo & Mahmood, 2020). This gap is particularly relevant in the Malaysian context, where the effects of transparent stretch film on decomposition rate under tropical climatic conditions remain unverified.

Therefore, this study aims to investigate the effect of plastic wrapping on the rate of decomposition using transparent stretch film. Stage-based observation method is used as it is directly applicable to the visual assessments of crime scene investigations. The findings are expected to evaluate the extent of decomposition delay associated with this material and provide valuable reference data for the interpretation of decomposition, thus improving PMI estimation in concealed-body cases.

1.3 Research Question

1. Are there any differences in stages of decomposition between wrapped and unwrapped pork?
2. How does plastic wrapping affect insect activity and oviposition timing between wrapped and unwrapped pork?

1.4 Hypothesis

Plastic wrapping will significantly delay the onset of decomposition stages and reduce insect activity compared to unwrapped pork samples.

1.5 Objectives

1.5.1 General Objective

This study aims to investigate the effect of plastic wrapping on the decomposition progress of pork as an animal model under natural environmental conditions.

1.5.2 Specific Objective

1. To compare stages of decomposition between wrapped and unwrapped pork.
2. To observe and record differences in insect activity and oviposition timing between wrapped and unwrapped pork.

1.6 Significance of the Study

This study addresses a knowledge gap regarding the effects of an airtight plastic-wrapping environment on the rate of decomposition. It provides empirical reference data on how plastic wrapping influences decomposition stages and insect colonisation patterns. The findings contribute to a better understanding of Diptera behaviour and colonisation tendencies under restricted-access conditions. Furthermore, this study supports improved PMI estimation by elucidating how plastic wrapping acts as a physical barrier that may delay oviposition, insect colonisation, and larval development.

In addition, this research generates locally relevant data within the Malaysian context, as the study was conducted under tropical climatic conditions. Such context-specific findings are essential for improving the precision and reliability of forensic entomological evidence in Malaysian forensic investigations. In criminal cases involving body concealment using plastic materials, the results of this study may assist investigators in making more accurate interpretations, thereby enhancing the reliability of entomological evidence in legal proceedings.

Chapter 2 : Literature Review

2.1 Introduction to decomposition

Decomposition refers to the natural process in which the dead organic matter is broken down into new physical and chemical forms, leading to the production of carbon dioxide (CO₂) and inorganic ions such as ammonium, calcium (Ca²⁺), potassium (K⁺), and other elements (Robertson & Pauk, 2000). This process is facilitated by decomposers, which are involved in nutrient cycling by returning essential elements to the ecosystem for subsequent biological utilisation. These decomposers are generally classified into two groups, which are microscopic decomposers, such as bacteria and fungi, and macroscopic decomposers, such as insects and earthworms (National Geographic Society, 2023). As decomposition progresses, other organisms feed on and metabolise the decaying organic matter, using it as a source of carbon and energy (Findlay, 2021).

Two primary types of decomposition can be distinguished, which are abiotic decomposition and biotic decomposition. Abiotic decomposition is driven by physical and chemical processes, including hydrolysis, oxidation, and temperature changes. In contrast, biotic decomposition is mediated by living organisms, particularly microorganisms such as bacteria and fungi, which metabolically degrade complex substances into simpler components (LaDuke, 2022). Decomposition is unavoidable and occurs in all living organisms after death, including humans (Teo, et al., 2014).

The decomposition of human remains is a complicated process that can span many years. On the first day after death, the body is in the fresh stage, marked by visible dark green or bluish discolouration along the major veins beneath the skin, as well as the leakage of fluids from the mouth, nose, and anus caused by the initial breakdown of intestinal contents. Within the first week, the body progresses to the bloated stage, during which gases accumulate in the intestinal tract, causing swelling of the abdominal cavity. The buildup of pressure may force natural fluids and liquefied tissues to escape through

bodily openings. Over the first year, decomposition advances to the dry stage, where the skeleton becomes more exposed, and the bones begin to lighten in colour under sunlight. After about a decade, the bones themselves gradually start to deteriorate (Percival, et al., 2009).

In forensic science, the examination of both the state and rate of decomposition is crucial for resolving criminal cases involving human remains. When investigating cases of unexplained or unidentified death, forensic anthropologists often assess the degree of decomposition to estimate the PMI, which provides critical information for reconstructing the timeline of death. Furthermore, studies on decomposition can provide information on the circumstances of death, including the manner and location. Such information is valuable in narrowing down or excluding potential suspects and in corroborating or challenging witness testimonies (Sutherland, et al., 2013).

Currently, there is no standardised quantitative method for estimating the PMI, as decomposition is highly complex and influenced by a wide range of variables. Among these, environmental factors such as temperature, moisture, pH, and oxygen availability play particularly significant roles (Vass, 2001). In addition, intrinsic and extrinsic factors, including the condition of the remains, body size, and scavenger activity, further contribute to variability in the decomposition process. The presence of clothing or coverings by different materials on the remains could also alter the rate of decomposition.

2.2 Porous coverings

Porous coverings, such as clothing, can significantly affect post-mortem changes and the estimation of the post-mortem interval. This is because they can act as physical barriers that hinder the initial access of Dipteran insects to the remains, thereby slowing

the progression of decomposition. However, early research established that its overall impact is often secondary to other factors.

This was demonstrated in a study by Matuszewski et al. (2014), who investigated how body mass and clothing influence the decomposition of pig carcasses across four weight categories: small: (5–15 kg); medium (15.1–30 kg); medium-large (35–50 kg); and large (55–70 kg). Clothing was considered at two levels, which are clothed and unclothed. The clothed specimens were dressed in cotton garments of similar colours, consisting of trousers with shortened legs, a t-shirt, and either a shirt or blouse.

However, the findings indicated that carcass mass was the dominant factor influencing the rate of decomposition, whereas the effect of clothing was minimal and inconsistent, making it largely insignificant (Matuszewski, et al., 2014). The authors emphasised that although the moderate clothing used in their study had little impact, details about clothing remain forensically relevant. They further suggested that heavy clothing could have a stronger effect on decomposition by enhancing putrefaction and shielding the body from scavengers. These findings highlight that, for surface remains, factors such as carcass mass can be more significant than the presence of clothing in affecting the decomposition rate.

Subsequent research by Teo et al. (2013) clarified that the effect of clothing is fundamentally shaped by the depositional environment. The researchers used 12 rabbit carcasses, which were divided into three treatment groups, namely unclothed, lightly clothed, and heavily clothed. Light clothing consisted of a T-shirt and short pants, whereas heavy clothing comprised a long-sleeved shirt, long pants, a jacket, and stockings. Within each group, one carcass served as a control and was placed on the ground surface, while the remaining carcasses were buried at a depth of 30 cm in graves spaced 5 m apart. The

control carcasses were monitored daily until they reached the dry remains stage, whereas the buried specimens were exhumed at predetermined time intervals.

This study employed the Total Body Score (TBS) system to evaluate postmortem changes. Findings showed that mummification developed on body regions directly exposed to air, while adipocere formation was observed in the more heavily clothed buried carcasses. Burial slowed down decomposition, largely due to reduced insect activity and lower soil temperatures, with the soil layer further restricting arthropod access.

Clothing plays a complex, context-dependent role in decomposition. On the ground surface, clothing accelerated decomposition by offering protection to maggots and retaining tissue moisture, which prolonged maggot activity and allowed some post-feeding larvae to pupate. In contrast, in buried carcasses, clothing hindered decomposition and maggot activity by creating a physical barrier between the body and the soil environment.

This study has clearly shown that the effect of clothing is not merely a function of its weight or thickness, but is fundamentally shaped by whether the remains are exposed or buried. Their findings revealed a contrast that clothing accelerated decomposition on the surface but delayed it in burial. Consequently, the difference between light and heavy clothing was less significant than the overarching effect of clothing itself and its interaction with the environment.

To further refine this understanding under controlled burial conditions, Teo et al. (2021) conducted a further study. A total of 27 adult rabbit carcasses were randomly assigned to three groups: no clothing as a control, thick clothing, and plastic wrapping. The thick clothing condition, represented by a porous covering, consisted of cotton garments, including long-sleeved shirts, long pants, socks, and zipped jackets. Each

carcass was placed in a separate wire mesh cage and buried individually at a depth of 1 ft, with at least 3 m spacing between graves.

Weekly exhumations of one carcass per group were conducted from the first to the ninth week post-burial. The decomposition progress was also assessed using the TBS method, a point-based system developed to estimate PMI through decomposition scoring (Megyesi, et al., 2005). The findings showed that carcasses in the no clothing group exhibited the fastest TBS progression, followed by the thick clothing group. Although thick cotton clothing slightly delayed decomposition by limiting arthropod access, the differences between the two groups were minimal. This limited effect was attributed to the clothing design, which left the face and neck exposed, providing oviposition sites that facilitated the normal faunal succession associated with buried remains.

Moreover, blankets are another example of porous coverings that may be used to conceal bodies in forensic cases. Their roles in delaying insect colonisation and influencing PMI estimation were powerfully demonstrated in real-world forensic casework. For instance, Goff (1992) reported a case in Hawaii involving the discovery of a female body on the island of Oahu. The remains were wrapped in two layers of blankets and tightly secured with an elastic bandage. At the time of recovery, the body was in the bloated stage of decomposition, and numerous adult Calliphoridae were observed both around the scene and on the blankets, including *C. megacephala*, *C. rufifacies*, and *Phaenicia cuprina*.

Since the remains were wrapped in blankets, fly access for oviposition was likely delayed, which in turn affected PMI estimation. To investigate the delay, Goff replicated the conditions experimentally using a freshly killed pig wrapped in the same manner and placed in a wire mesh enclosure, with observations made every three hours as indicated in previous final year projects. The experiment demonstrated that blanket wrapping

delayed fly oviposition by approximately 2.5 days, leading to a final estimated postmortem interval of 13 days. This case was pivotal as it showed a quantified measure of a wrapping-induced delay. It also demonstrated how experimental replication of a case-specific scenario is essential to accurately interpret entomological evidence and correct PMI estimates.

When considered together, these studies have shown that the impact of porous coverings is highly conditional. While multi-layered porous materials like blankets can significantly delay insect colonisation, the effect of clothing is more variable. On the surface, it can be secondary to mass or even accelerate decay, while in burial, its effect is limited without full enclosure. Although porous coverings provide only partial interference, their presence and design remain forensically relevant. Overall, these findings establish a baseline for contrasting the significantly different effects introduced by non-porous coverings, which will be discussed in the following section.

2.3 Nonporous, loose-fitting plastic coverings

Research on nonporous, loose-fitting plastic coverings has also highlighted their importance in slowing decomposition. For example, Taleb and her colleagues (2022) studied the impact of plastic wrapping on carcass decomposition and arthropod colonisation in northern Africa during spring. Their study used twelve rabbit carcasses, with six unwrapped serving as controls and six enclosed in a single layer of transparent plastic bags. The bags were knotted at the opening and placed beneath the carcasses, but were not sealed with ties. All carcasses were randomly placed in open sunlight, each separated by at least 50 m.

The study revealed that the overall succession pattern of key necrophagous insects was similar between wrapped and unwrapped carcasses. However, decomposition

progressed much more slowly in the plastic-wrapped group. Wrapping also reduced species richness, abundance and diversity, and altered species composition. This was likely due to restricted odour diffusion, which lowered the abundance of early colonisers. Critically, because the plastic was not tightly secured, it did not prevent insect access but instead modulated the attractiveness of the remains.

Supporting this, Ahmad et al. (2011) investigated how nonporous barriers influence decomposition by using plastic-mesh rice sacks as wrapping material for monkey carcasses with gunshot wounds. Each carcass was wrapped in a single layer of rice sack material. The sacks permitted both water and odours to diffuse, but prevented adult flies from entering. Their experiment, carried out in an oil palm plantation in Kedah, Malaysia, consisted of three wrapped carcasses and an equal number of unwrapped carcasses as controls.

The study found that flies arrived at the wrapped carcasses about 24 hours later than the unwrapped ones. This delay was attributed to fewer suitable egg-laying sites, reduced feeding opportunities, and weaker odour release. Fly colonisation followed a successional pattern, with arrival and presence patterns varying between wrapped and unwrapped carcasses as well as across different families. For unwrapped carcasses, the flies arrived earlier, especially larger species such as Calliphoridae and Sarcophagidae. For wrapped carcasses, the flies arrived later, but smaller species such as Drosophilids tended to persist longer. While wrapping did not change the types of fly species present, it did extend the duration of their occurrence on the carcasses.

Since this study used rice sacks as wrapping material, their plastic-mesh nature has provided an intermediate point on the spectrum of coverings. Compared to a solid sealed plastic bag, it is less effective in delaying insect colonisation. This is because the

woven structure of plastic-mesh rice sack still allowed for significant odour and moisture diffusion.

Undoubtedly, these studies have shown that non-porous, loose-fitting plastics are a critical factor in delaying decomposition and insect colonisation, primarily by acting as a partial physical and olfactory barrier. However, their effectiveness is highly variable and limited by factors such as the integrity of the seal. A key finding is that odours can still escape, allowing insects to detect the remains. This limitation provides a critical point of comparison for tightly wrapped, occlusive materials like stretch film, which are designed to create a more complete seal to mitigate the limitations raised by previous studies.

2.4 Combined coverings

After examining porous and nonporous coverings separately, it is important to investigate their combined effects. This is because in real-world cases, remains may be enclosed in multiple layers of different types of coverings. Understanding the interaction between these coverings is necessary to evaluate their influence on decomposition. For example, Kelly, Van Der Linde, and Anderson (2008) conducted a winter study in Africa to assess the effects of clothing and wrapping on carcass decomposition and arthropod succession. The clothed carcasses were dressed in T-shirts, shorts, and underwear of similar colour and weight. Meanwhile, wrapping was done in a similar way using medium-weight cotton sheeting equivalent to the size of a standard double bed sheet, without being secured by pegs or rope.

In their study, eight freshly killed pig carcasses were placed on the ground within cages and divided into groups according to sampling frequency. The first group was sampled daily at midday and consisted of four carcasses, including one control without

wrapping or clothing, one clothed but unwrapped carcass, and two wrapped carcasses, with one clothed and one unclothed. The remaining four carcasses were sampled at intervals of either five or ten days, and divided into two groups, each containing a wrapped clothed carcass and a wrapped unclothed carcass.

They found that both wrapping and clothing delayed oviposition and decomposition but had little influence on species diversity, insect invasion, oviposition sites, maggot distribution, or size. Wrapping significantly slowed the drying of carcasses and delayed Diptera oviposition by approximately four days in winter, likely due to the low number of adult flies present during the early stages of decomposition. This effect may also be explained by a slower release of decomposition odours, which reduced fly attraction. While clothing and wrapping appeared to stabilise internal carcass temperatures, they did not accelerate the overall decomposition process. Moreover, the presence of these coverings may have facilitated earlier colonisation by *Dermestes maculatus*, as its larvae were observed feeding on clothing fibres, leading to increased beetle activity in the later stages.

This study further reinforces the principle by demonstrating how multiple layers can slow down decomposition and insect colonisation on the surface. Rather than just moisture retention, it also identifies the slowed release of decomposition odours as one of the critical factors in delaying insect attraction in a winter climate, introducing an important seasonal variable to the model. In short, Kelly et al. (2008) provide a broader perspective for forensic anthropology by showing that the combined use of porous materials in a specific environment can significantly alter the taphonomic timeline and faunal succession. This is a critical complexity that must be integrated into forensic investigations.

2.5 Tightly sealed plastic coverings

Study	Sample Type	Treatment / Covering	Sealing Method	Key findings on Decomposition and Insect Colonisation
Scholl & Moffatt (2017)	Pig carcasses (n = 34)	Whole pigs (n = 10, control)	Uncovered	Rapid exposure and colonisation compared to wrapped treatments.
		Dismembered body parts (torsos, heads, limbs)	Heavy-duty plastic garbage sacks or repellent bags sealed with nylon cable ties	Plastic waste sacks sealed with nylon cable ties did not completely prevent insect access, although insect activity was lower than control carcasses.
Brownlow et al. (2023)	Pig shoulders (n = 4)	Treatment A (Control): Uncovered	None	Shortest mean contact time and oviposition interval; rapid blowfly colonisation.
		Treatment B: Heavy-duty black plastic garden sack	Opening twisted and secured with cable tie	Significantly delayed colonisation; plastic sack prevented insect entry, though larval penetration may occur over extended periods. Twisted, cable-tied closure was completely impenetrable.
		Treatment C: Black nylon and polyester wash bag	Zip closure; no meat or blood contact with bag	Delayed attraction longer than plastic sacks due to thicker material retaining odours; flies oviposited around zips and stitching where odours escaped, but larvae could not access the meat.
		Treatment D: Plastic sack + wash bag	Plastic sack sealed with cable tie, then enclosed in wash bag	Longest delay in contact time and oviposition interval; overall most effective in prolonging blowfly colonisation.

The findings from Taleb et al. (2022) suggest that a loose seal primarily slows decomposition by restricting odour diffusion but fails to create a physical barrier. This raises the question of how decomposition is altered when the covering is tightly sealed. Previous studies by Scholl & Moffatt (2017) and Brownlow et al. (2023) investigated the effects of tightly sealed plastic coverings on decomposition and insect colonisation.

Scholl and Moffatt (2017) reported that plastic sacks were not an effective barrier to insect ingress but instead merely reduced the rate of colonisation. In contrast, Brownlow et al. (2023) found that securely tied plastic sacks were impenetrable to insects. This discrepancy in barrier effectiveness may be attributable to differences in experimental duration, as the longer trial conducted by Scholl and Moffatt (2017) may have allowed sufficient time for larval activity to compromise the integrity of the plastic. It is plausible that, given a longer observation period, the spiralling and burrowing actions of larvae in the study by Brownlow et al. (2023) could similarly have resulted in the eventual breakdown of the plastic barrier.

Collectively, they observed that the rate of decomposition within both types of sacks was significantly slower than in exposed controls, due to factors such as fewer insects gaining access and less oxygen available in an anaerobic environment inside the sacks. Both studies reported that while tightly sealed plastic sacks could delay decomposition by creating an anaerobic environment, their effectiveness as a complete physical barrier can vary significantly based on factors such as the duration of the study.

In addition to tightly sealed plastic coverings, Brownlow et al. (2023) also investigated the effects of alternative containment materials, including a black nylon and polyester wash bag (Treatment C), as well as a combination of a plastic sack and a wash bag (Treatment D). Overall, all wrapping types tested in this study significantly prolonged blowfly colonisation. Plastic garden sacks effectively prevented insect entry, though larval penetration might occur over extended periods. Cable tie closures, particularly when the sack neck was twisted, proved completely impenetrable. Wash bags delayed attraction longer than plastic sacks due to their thicker material retaining odours. However, flies still deposited eggs around zips and stitching where odours escaped, despite larvae being unable to access the meat.

The profound delaying effect of a sealed plastic environment is further corroborated by a previously mentioned study, which was conducted by Teo et al. (2021). In their study, one of the treatment groups involved rabbit carcasses placed in black polyethene rubbish bags with the air removed and sealed using cable ties. The results showed that decomposition in the plastic-wrapped group progressed much more slowly compared to the no-clothing and thick-clothing groups. While the trunk regions of the latter groups had already reached the skeletonisation stage, the plastic-wrapped carcasses remained in advanced decomposition. This delaying effect was further reflected in the slowest rate of TBS development, which differed significantly between the plastic-wrapped and no-clothing groups. Unlike findings from earlier studies, no adipocere formation was observed. The authors suggested this might be due to the impermeable nature of the plastic, which retained decomposition fluids around the carcass and allowed the accumulation of by-products that hindered the decomposition process.

Clearly, this study revealed that tightly fitted, non-porous plastic coverings do not merely delay decomposition but fundamentally alter its pathway. Unlike porous coverings, which simply slow the process, the plastic creates an anaerobic environment that traps decomposition fluids. This, in turn, promotes intense putrefaction while simultaneously slowing the overall breakdown of tissues and the progression to skeletonisation.

In synthesis, these studies demonstrate the profound effect of tightly sealed plastic wrapping on delaying the arrival of Dipteran insects and the decomposition process through the creation of an impermeable barrier and anaerobic environment. The effectiveness of this barrier, however, can be affected by the condition of the remains, as dismemberment can facilitate insect ingress and fluid leakage, thereby influencing the overall rate of decay. These established principles provide a crucial framework for predicting the effects of even more restrictive, non-porous coverings such as stretch film,

which is designed to form a near-perfect seal. Consequently, systematically investigating its specific impact on decomposition and insect colonisation is an essential and logical next step for forensic anthropology.

2.6 Conclusion

This review has systematically examined the effects of different coverings, such as porous, nonporous, combinations of both, loosely fitted plastics, and tightly sealed plastics, on decomposition and insect colonisation. The impact of these coverings depends not only on their type, material and physical properties, but also on the condition of the remains and the surrounding environment.

The influence of porous coverings, such as clothing and blankets, is highly conditional. For example, clothing may accelerate decomposition in surface environments by retaining moisture for maggots but slow it in burial contexts by acting as an additional barrier. When applied in multiple layers, porous coverings can also delay insect colonisation, as shown in forensic case studies. In contrast, nonporous but loosely fitted plastic coverings primarily restrict odour diffusion, thereby slowing but not preventing insect attraction and access. Moreover, tightly sealed nonporous plastics create an impermeable barrier that establishes an anaerobic environment, exerting a stronger impact on the decomposition process.

While the taphonomic effects of materials like plastic and cotton sheeting have been established, a significant gap exists regarding transparent stretch film. Existing research, such as the study by Khoo and Mahmood (2019), primarily investigates similar films in the context of body management, focusing on their durability for containing decomposition fluids. However, research exploring the specific impact of transparent stretch film as a taphonomic variable on the rate of decomposition is still lacking. Since

this material is designed to form a perfect, direct-contact seal, its effect on PMI estimation is likely distinct from other coverings. Consequently, a logical direction for future work is to test the predictions and further develop the theoretical framework. Therefore, it is crucial to fill this gap by systematically studying transparent stretch film, not just as a management tool, but as a variable that significantly complicates PMI estimation.

Chapter 3 : Methodology

3.1 Materials

In this study, all materials, instruments, and apparatus used were documented. The materials were categorised into the animal model, which was pork, and the wrapping material, which was transparent plastic stretch film. All equipment, chemicals, and instruments were obtained from the Science Laboratory Management Unit (UPMS) and the Forensic Science Laboratory (MSF).

3.1.1 Animal Model

This study used pork as the decomposition model to investigate the rate of decomposition with and without the influence of plastic wrapping. A total of 1 kg of pork was utilised, with 500 g placed in each cage. Both pork samples were obtained from the same slaughterhouse on the day of the experiment and were placed into the cages within one hour of purchase. The use of 500 g per cage was intended to attract a sufficient number of flies for colonisation. The pork samples consisted solely of muscle tissue, with no bones and a minimal amount of fat, to ensure consistency between samples.

3.1.2 Plastic Wrapping Material

The plastic material selected for this study was transparent stretch film, which was purchased via the Shopee online platform. The film had a width of 250 mm, a core weight of approximately 100 g, and a thickness of 23 microns. It is shown in Figure 3.1.



Figure 3.1 Transparent stretch film used in this study

3.1.3 List of Equipment used

Other than the main materials, which are pork and transparent stretch film, all the equipment, chemicals and instruments used in the study are shown in Table 3.1, Table 3.2 and Table 3.3, respectively. The equipment and chemicals were obtained from the UPMS, School of Health Science, University Sains Malaysia. Moreover, the instruments were obtained from the MSF.

Table 3.1 Equipment used in this study

No	Equipment
1	Latex gloves
2	Forceps
3	Face mask
4	Capped plastic vials/Falcon tube
5	Camera iPhone 14 Plus
6	Cage
7	Stone/bricks
8	Transparent stretch film
9	Boards for field specimens
10	Spatula
11	Tissue
12	Rubber band
13	Plastic cups/containers
14	Nylon cloth / some piece of mesh fabric
15	Petri dish
16	Measuring cylinder
17	Needles
18	Beakers

Table 3.2 Chemicals used in this study

No	Chemical
1	70% ethanol
2	Chloroform

Table 3.3 Instruments used in this study

No	Instrument
1	Stereomicroscope (Leica MZ16)
2	Digital thermometer
3	HTC-1 Digital Hygrometer with temperature and digital clock

3.2 Preparation of Meat

Only two samples were examined in this study, which were a control pork sample and a plastic-wrapped pork sample. Both 500g of pork samples were purchased from a slaughterhouse at 8.00 a.m. on the morning of the experiment and placed into their respective cages within one hour of purchase.

The control pork sample did not undergo any treatment and was placed raw into the cage. It is shown in Figure 3.2. For the wrapped condition, the entire 500 g pork sample was completely enclosed in three layers of plastic wrapping. The opening of the wrap was positioned beneath the sample, and care was taken to ensure that no pores or gaps were present. It is shown in Figure 3.3.



Figure 3.2 Control pork sample



Figure 3.3 Plastic-wrapped pork sample

3.3 Experimental Setup

In this study, the experimental period was determined, and the climatic conditions during this period were documented. Next, the location of the study site was identified using Google Maps. Finally, the placement of the cages at the study site and the procedures for their setup were determined and documented.

3.3.1 Selection of Test Period and Climatic Conditions

The experiment was conducted from November to December 2025 in Kelantan, Malaysia. This period coincides with the northeast monsoon season, which is typically characterised by frequent rainfall and high relative humidity under tropical climatic conditions. Based on the data obtained from the website of the Malaysian Meteorological Department (MET) for Kota Bharu, Kelantan, ambient temperatures during the study period ranged from 25.2°C to 27.8°C, while relative humidity ranged from 74.5% to 91.0%. A maximum daily rainfall of 48.43 mm was recorded. These climatic conditions were consistent with those expected during the northeast monsoon season in Kelantan.