A STUDY ON THE PHYSICAL INSULTS ON DRUGS FOR FORENSIC INVESTIGATION

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A STUDY ON THE PHYSICAL INSULTS ON DRUGS FOR FORENSIC INVESTIGATION

by

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for the degree
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CERTIFICATE

This is to certify that the dissertation entitled "A Study On The Physical Insults on Drugs For Forensic Investigation" is sincerely recorded of research work done by Mrs Nur Syafawati Binti Abu Bakar during the period from February 2020 to September 2020 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 fulfilment for the Master of Science (Forensic Science).

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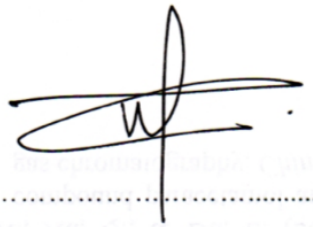
DECLARATION

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



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(NUR SYAFAWATI BINTI ABU BAKAR)

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LIST OF SYMBOLS

%	percen
±	plus and minus
µL	microliter
2D	two-dimensional
cm	centimeter
cm^{-1}	cubic centimeter
gm	gram
gsm	grams per square meter
ml	milliliter
mm	millimeter
n	number of samples (n=1,2,3…)
ºC	degree celsius

LIST OF ABBREVIATIONS

AADK	Agensi Anti Dadah Kebangsaan
ASTM	American Society for Testing and Materials
ATR	Attenuated total reflection
ATS	Amphetamine-type stimulants
CAF	Caffeine
CNPA	The Counter-Narcotics Police of Afghanistan
Covid-19	Coronavirus disease 2019
DAM	Diacetylmorphine
DDA	Dangerous Drug Act
DNA	Deoxyribonucleic Acid
DPH	Diphenhydramine hydrochloride
EPD	Ephedrine hydrochloride
FID	Flame Ionisation Detection
FTIR	Fourier Transform Infrared Spectroscopy
GC	Gas Chromatography
HCA	Hierarchic cluster analysis
HS-SPME	Headspace solid phase microextraction
LC-QTOF	Liquid chromatography quadrupole time-of-flight
LSD	Lysergic Acid Diethylamide
MCO	Movement control order
MDMA	3,4-Methylenedioxymethamphetamine
MS	Mass spectrometer
NADA	National Anti-Drug Agency
NPS	New Psychoactive Substances
PCA	Principal component analysis
PCM	Paracetamol
PCP	Phenylcyclohexyl piperidine
RMP	Royal Malaysia Police
RMPC	Royal Malaysia Police College
SWGDRUG	Scientific Working Group for the Analysis of Seized Drugs
UNODC	United Nations Office of Drug Crime

KAJIAN TERHADAP KESAN FIZIKAL KEPADA DADAH UNTUK SIASATAN FORENSIK

ABSTRAK

Dadah adalah ubat atau bahan yang mempunyai kesan tersendiri apabila ia dimsukkan ke dalam badan. Ia wujud dalam bahan semula jadi atau sintetik untuk menghasilkan kesan psikologi pada tubuh manusia atau haiwan. Dadah digunakan dalam bidang perubatan untuk merawat atau menyembuhkan penyakit kerana ia dianggap sebagai perangsang, narkotik dan halusinogen tetapi apabila disalahgunakan, ia menyalahi undang-undang. Laporan Dadah Dunia (2019) melaporkan gambaran keseluruhan dunia mengenai trend terkini pengedaran dadah, penggunaan dadah dan isu kesihatan akibat penggunaan dadah. Dadah haram merupakan kes terbesar yang dianalisa oleh makmal sains forensik. Tujuan kajian ini adalah untuk menentukan akibat kesan fizikal ke atas dadah dalam mengesan kehadiran dadah di dalam sampel. Paracetamol (PCM) adalah salah satu bahan tambahan yang terkandung di dalam dadah seperti kokain dan heroin, jadi dalam kajian ini, tujuh puluh dua sampel dari dua jenama parasetamol dianalisa secara fizikal untuk menentukan warna, berat dan dimensi mereka. Masing-masing dibungkus dengan menggunakan bekas kaca, beg plastik dan bungkusan kertas, dan dikenakan empat jenis kesan fizikal iaitu menggoncang, disimpan di dalam kereta, di dalam beg tangan dan poket seluar selama satu minggu. Sebarang perubahan fizikal kerana kesan fizikal telah ditentukan. Semua bahan pembungkusan juga diekstrak dan dianalisa menggunakan kromatografi gas - pengesanan pengionan api (GC-FID) untuk mengesan kehadiran parasetamol. Hasil kajian ini, menunjukkan bahawa jenis bungkusan dan kesan fizikal dapat mengubah ciri fizikal dadah. Pembungkusan dadah di dalam bekas kaca memberikan lebih

banyak kesan kepada sampel dadah tersebut berbanding dengan jenis pembungkusan lain. Dari segi kesan fizikal, kehadiran dadah mempunyai kemungkinan besar untuk dikesan pada bekas yang digunakan untuk menyimpan dadah tersebut, oleh itu maklumat ini sangat penting dalam siasatan forensik. Selain itu, bekas kaca juga tidak bagus untuk pembungkusan dadah kerana akan menyebabkan kerosakan pada sampel dadah. Selain itu, kertas yang digunakan untuk membungkus dadah juga dikesan dengan dadah ketika disimpan di dalam poket seluar untuk jangka waktu tertentu dibandingkan dengan plastik yang memberi kesan minima kepada sampel. Maklumat ini telah memberikan manfaat kepada penyelidikan forensik untuk mengenal pasti bukti forensik yang berpotensi tinggi untuk memberi petunjuk positif terhadap dadah, serta prosedur yang paling tepat digunakan dalam pengendalian dadah bagi memaksimumkan pengesanan dadah di dalam sampel.

A STUDY ON THE PHYSICAL INSULTS ON DRUGS FOR FORENSIC INVESTIGATION

ABSTRACT

Drug is medicine or substance which have its effect when it introduced to the body. It was designed in natural or synthetic substance to produce a specific set of psychological effects on the human body or animals but when it misused, it's become unlawful which called an illicit drug. The World Drug Report (2019) was reported a global overview of the latest estimates and trends in the supply, use and health consequences of illicit drugs. It represents the largest volume of criminal cases examined by forensic science laboratories. This study was aimed at determining the effect of physical insults on the detection of drugs. Paracetamol (PCM) is one of the possible adulterants in illicit drugs such as cocaine and heroin. In this study, seventy-two samples from two brands of paracetamol were examined physically to determine their colours, weight and dimension. Packaged using respective glass containers, plastic bag and paper wrap, and were exposed to four types of physical insults including shaking, putting in the car, handbag and pocket pants. Any physical changes due to physical insults were determined. All packaging materials were also extracted and analysed using gas chromatography - flame ionisation detection (GC-FID) to detect the presence of paracetamol. From this study, it was shown that the types of packaging and the physical insult could change the physical characteristics of the tablets drugs. Packaging the drugs in glass containers introduced more insults to the drug samples as compared to other types of packaging. In terms of physical insults, the presence of drugs possessed a high possibility to be detected on those containers used to keep the drugs. On the other side, it is not good for drug packaging because it

introduces to sample damage. Besides, the paper used to wrap the tablet drugs were detected with drugs when they are kept in the pocket pants for a duration of time compared to the plastic bag which introduces less in physical insult. Plastic bag is the best type of packaging for a drug. This comparative information had offered beneficial information in forensic investigation to identify the forensic evidence with high potential to give a positive indication of drugs, as well as the most appropriate procedure in drug handling to maximise the detection of drugs.

CHAPTER 1

INTRODUCTION

1.1 Drugs

Drugs are a natural or synthetic substance that is designed to produce a specific set of psychological effects on the human body or animals (Houck *et al*.,2015). The producers of drugs by legitimately drug manufacturers and prescribed for particular illnesses, injuries, or other medical problems. These drugs are often taken and used for the intended purpose. However, if they are taken other than their intended purposes, it could introduce other adverse effects leading to drug abuse. Drug abuse has been a serious public health problem worldwide (Mazlan *et al.*,2006).

Illicit drug is important forensic evidence that could be linked to heavy punishments as stated in section 39A(1) DDA, 39A(2) DDA, and 39B(2) DDA (Dangerous Drug Act, 1952). In Malaysia, the capital punishment for drug trafficking is imprisonment for life or for a term which shall not be less than 5 years, in addition to punished with whipping. The law includes also the traffic of dangerous drugs, offer to traffic of dangerous drug or offer to do an act preparatory or for trafficking in a dangerous drug under section 12 (2) DDA, 39A DDA and 39B DDA, depending on the weight of the seized drug (Dangerous Drug Act, 1952). Examples of illegal drugs are heroin, methadone, cocaine, and others as mentioned under the First Schedule in the Act.

United Nations Office of Drug Crime (UNODC) published the background and concepts of drug characterisation and profiling (UNODC, 2001). Characterisation and profiling of illicit drugs are important in helping forensic scientists and law enforcement authorities to answer a variety of questions including the dealer-user

relationship, drug source, distribution networks, and trafficking routes to manufacturing methods and precursors used (UNODC, 2001).

Analysis of drugs in Malaysia is carried by the Centre of Forensic Science Department of Chemistry Malaysia located at Petaling Jaya in supported by the branches in other states of Malaysia. According to *Kimia Malaysia* Annual Report 2018, the number of cases and samples received in 2018 on forensic science analysis discipline are as shown in Figure 1.1 and Figure 1.2. Narcotics section had covered the majority of the forensic cases in Malaysia (*Kimia Malaysia* Annual Report, 2018).

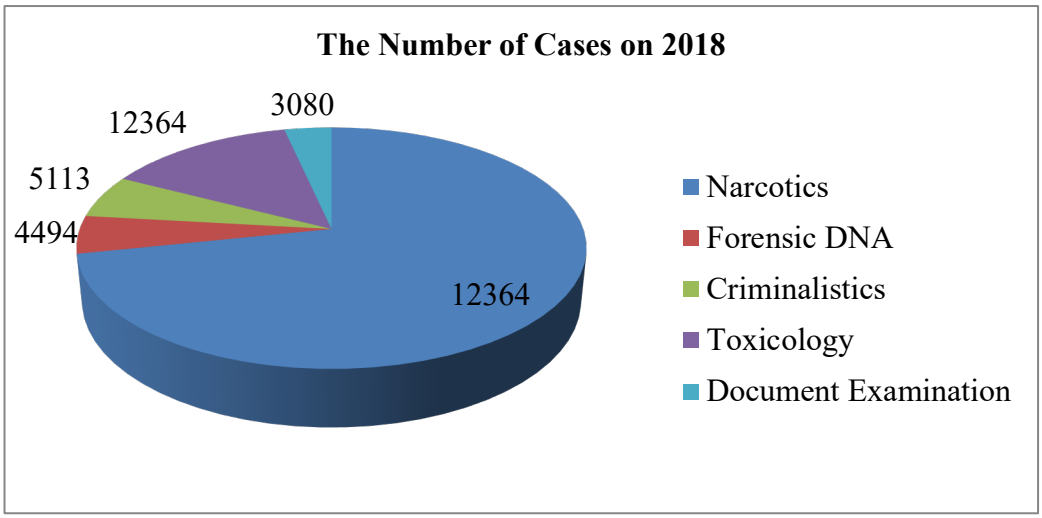


Figure 1.1 Total number of cases received according to forensic science analysis discipline on 2018

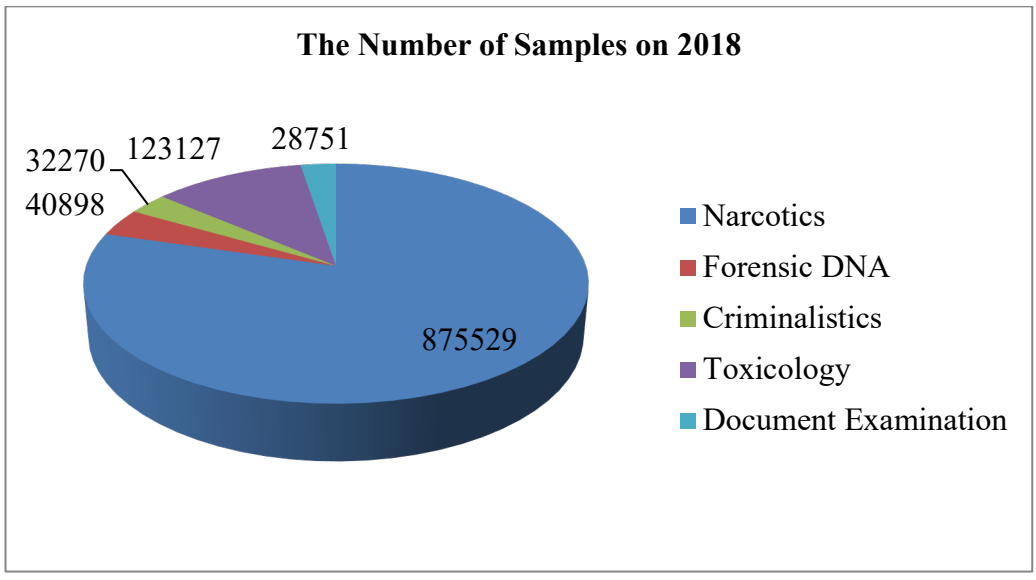


Figure 1.2 Total number of samples received according to forensic science analysis discipline on 2018

The variety of physical effect to the sample of a drug could contribute to the change of physical characteristic of drug including the colour, weight and dimension. It also related to the types of packaging of the drugs. In this study, as paracetamol is might one of the adulterants in the certain illicit drug so that it used as a representative sample to found the effect of physical insult to the sample.

1.2 Problem Statement

Among the many different types of forensic evidence, drug samples need careful examination to reach a defensible conclusion at the end of forensic investigation or forensic laboratory analyses. Due to the various types of drugs such as stimulant, depression, in the term of tablets, capsules, liquid and powder. Their sources could be natural, semi-synthetic, or synthetic drugs. Therefore, for evidential purpose or intelligence use, the drug analyses shall follow proper procedures, from their seizure at the crime scene, sample packaging for laboratory analysis, sample handling along the transportation chain, sample preservation prior to and post-analysis sampling strategies during analysis and sample analysis to reach the final conclusion.

In forensic analysis, care must be demonstrated to ensure the chain of custody of the drug sample from the crime scene to the court. Successful drug characterisation is important to provide information on the identity of drugs and, more importantly, to answer if the sample is connected to other samples through the linkage between the drug suppliers and the users. To a wider scope, it could relate the sample linked to local, national, or regional drug supply chain, or to a particular clandestine drug production groups.

During the drug characterisation, two main sources of information could be obtained through physical examination and chemical examination. For common drugs, the visual examination would be the first step, followed by measurement of weight, size, and probably microscopic features. The chemical examination focused on determining the chemical components of the drug sample.

In the real case scenario, the physical form of seized drugs both in a tablet or powder might change or remain unchanged along the way from seizure until laboratory analysis. If certain drugs in a certain form are prone to physical insults, the most appropriate way to preserve the samples from the crime scene to the laboratory and the court must be established. Any method of storage and physical insult which could introduce effect onto the drugs must be determined. The possibility to detect the presence of drugs on any packaging material should be determined to maximize the positive identification.

1.3 Aim and Objectives

The general objective of this study is to investigate the effect of physical insults towards the physical characteristics and detection of drugs. Three specific objectives are set as follows:

i. To investigate the physical characteristics of selected drug upon different physical insults.

ii. To investigate the possibility to detect the drug on different packaging materials upon physical insults.

iii. To establish sample and packaging procedures for handling of tablet drugs for forensic drug analysis.

1.4 Significance of Study

The outcome of study would provide the choice on the influence of physical insults toward the physical appearance of illicit drug in tablet form that had been packaged in different types of packaging methods. In addition, the determination of the impact of physical insults that could affect the detection of tablet on the packaging materials would aid the forensic investigating team to identify the evidence carrying the maximum possibility in giving positive results. Information from this study would suggest the appropriate packaging procedure to avoid the possible temper against the forensic evidence. Other than that, it also give information in crime scene investigation related to the drug container which will be found in crime scene.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Controlled substances are drugs and drug products scheduled under the Controlled Substances Act stated in the Title II of the Comprehensive Drug Abuse Prevention and Control Act of 1970. These substances can be varied from the plant-based substances to the synthetic substances in clandestine drug laboratories. Controlled substances had severely permeated the modern society. The substances are illegal if they could cause addiction, habituation, observable change in consciousness, and with the limited or no medical use. In some instances, prescription medication had also been treated as illicit drugs when they are sold or given to someone not for medicinal purposes. More recently, numerous new psychoactive substances (NPS) have entered the global black market. These NPS are more difficult to be detected by the law enforcement authorities due to the possibility to continuously changing the chemical composition of these substances. The issues arisen from illicit drugs had put the public in risks, not only from the distribution and sales of the substances, but also the subsequently criminal activities by the users, traffickers, manufacturers and the drug syndicates (National Forensic Science Technology Center, 2013).

2.2 Drugs and the Type of Drugs

Drugs can be classified by their origin as natural, semi-synthetic, or synthetic. Natural and semi-synthetic drugs are made from compounds found in nature and the most prevalent natural drug sources are planted while semi-synthetic drugs are hybrid either completely nature or completely synthetic. Synthetic drugs are synthesis from materials that are not found in nature. It made by using man-made chemicals and

products in the laboratory (Person *et al.,* 2013). Classification according to their ways of affecting human body and brain had helped law enforcement authorities to understand a drug and the drug that a person may have been taken based on the physical appearance and chemical behaviours (National Forensic Science Technology Center, 2013). The different categories of illicit drugs and their respective examples are as follows :

i. Marijuana (*e.g.* marijuana and hashish)
ii. Narcotics (*e.g.* opium, heroin, morphine, methadone, and oxycodone)
iii. Stimulants (*e.g.* amphetamines, methamphetamines, and cocaine)
iv. Depressants (*e.g.*barbiturates, benzodiazepines, and gamma hydroxybutyrate)
v. Hallucinogens (*e.g.*Lysergic acid diethylamide, Methylenedioxy methamphetamine, phenylcyclohexyl piperidine, ketamine, mescaline/peyote, and psilocybin)
vi. Synthetic drugs (*e.g.* synthetic cathinone, synthetic cannabinoid, and salvia)
vii. Steroids (*e.g.* human growth steroids and testosterone)
viii. Inhalants (*e.g.* ether, nitrous oxide, toluene, and butane)

United Nations Office on Drugs and Crimes (UNODC), in the World Drug Report 2019, reported a global overview of the latest estimates of and trends in the supply, use and health consequences of illicit drugs. Usage of amphetamine, especially methamphetamine, is increasing in parts of Asia and North America, with different forms of amphetamine was evident based on the varying countries. The non-medical use of prescription stimulants and methamphetamine is greatly used in North America while crystalline methamphetamine is prominent in East and South-East Asia, as well as the Oceania. In Western and Central Europe, as well as the Near Middle East, the most used illicit drug is amphetamine. In fact, the use of amphetamine and

methamphetamine continuously to be reported increasing in the world (UNODC, World Drug Report 2019).

According to the National Anti-Drug Agency (NADA), which is one of the organisations under the Ministry of Home Affair was published their findings in the form of annual report and is available at http://www.adk.gov.my/ show the statistics of drug types abused in Malaysia within the five years duration from 2014 to 2019 showed the records of opiate, methamphetamine (both crystalline and tablet), marijuana, Amphetamine-type stimulants, others (includes kratom leaves, depressant, dissociative, hallucinogens, inhalant), and psychotropic pills (includes benzodiazepine, psychotropic pill and Eramin-5). Table 2.1 demonstrates the statistics, clearly indicating the number of cases and individuals involving in illicit drugs.

Table 2.1 Statistics of drug types use 2014 – 2019 in Malaysia (Source: AADK, 2019)

Category	Per case / Per head	2014	2015	2016	2017	2018	2019
Opiate	**Per Case**	14,502	16,616	16,985	10,154	7,746	7,938
	Per Head	13,959	13,959	14,579	7,580	5,773	5,301
Methamphetamine (Crystalline)	**Per Case**	4,117	8,133	10,107	10,419	11,531	13,768
	Per Head	4,124	7,457	8,624	8,392	8,698	10,559
Methamphetamine (Tablet)	**Per Case**	1,919	1,389	1,236	1,066	4,853	2,386
	Per Head	1,221	861	2,310	3,697	3,822	1,760
Marijuana	**Per Case**	1,239	674	2,631	4,366	1,122	7,555
	Per Head	1,762	1,354	1,192	974	944	630
AAmphetamine – Type Stimulants (Excludes Methamphetamine)	**Per Case**	535	635	764	764	1,152	2,872
	Per Head	478	604	726	695	954	1,832
Others	**Per Case**	8	7	18	9	19	78
	Per Head	24	19	19	11	17	66
Psychotropic Pills	**Per Case**	35	25	23	13	26	14
	Per Head	7	7	12	5	15	9
Total	**Per Case**	**21,777**	**26,668**	**30,844**	**25,922**	**25,267**	**27,811**
	Per Head	**21,575**	**25,590**	**27,462**	**21,354**	**20,223**	**20,157**

The trend in drug abuse had changed lately, with drug users moving from plant-based drugs such as marijuana and heroin, to more harmful synthetic drugs such as syabu and ecstasy. Methamphetamine drugs such as shabu and ‘pil kuda’, as well as heroin,are still the drugs of choice among drug abusers in Malaysia. Various factors have had increased the prevalence of drug abusers, smugglers, and traffickers, especially at the high-risk areas. Moreover, the drug syndicates are becoming broader and are willing to do whatever it takes to gain profit, without concerning about the law

and the effects of drugs to the country. A high proportion of other violent crimes in the country, such as murder, could also be related to the drug issues. Therefore, drug addiction and drug abuse are serious concerns affecting society and public policy in multiple arenas, including loss of productive manpower and a taxation on the criminal justice administration and system.

Beside the active ingredient in illicit substances, other additives are also added to the composition, frequently the adulterants and diluents. These additives, often called cutting agents, could help a drug dealer to stretch purchasing power by increasing the profit or to harm consumer's health (Broseus *et al*., 2016), and some could cause illness and death (Houck *et al*., 2015). Besides, it also makes the drug appear in a larger amount of drug than is present so that to increase the dealer's profit (Andreasen *et al*., 2009). For intelligence purpose, the determinations of basic impurities in illicit drugs are useful (Lurie *et al*., 2013). In fact, illicit drugs obtained on the street are always mixed with cutting "substance" in the ratio of 20:1 to 100:1.

Adulterants are substances which are readily available, referring to pharmacological ingredients. The common examples of adulterants are caffeine, procaine, paracetamol, and sugars. They are likely to have minimal impact on user's health at low dosages and some of it, in injectable drugs, have the potential to cause serious health issues (Cole *et al.*, 2011). Fiorentin *et al*. (2019) in their study concluded that cutting agents are important in criminal investigation and management of acute intoxications to identify and to determine drug trafficking routes. UNODC (2005) had provided the reference for possible heroin adulterants as show in Table 2.2 and cocaine adulterants as show in Table 2.3. It gives an information that, paracetamol is one of the adulterants in heroin and cocaine.

Table 2.2 Adulterants in illicit heroin (Source: UNODC, 2005)

List of adulterants in illicit heroin		
Acetylsalicylic acid	Gluthetimide	N-Phenyl-2-Naphthylamine
Allobarbital	Griseofulvin	Procaine
Aminophenazon	Lidocaine (lignocaine)	Quinine
Antipyrine	Methaqualone	Salicylamide
Ascorbic acid	Methylphenobarbitone	Salicylic acid
Barbital	Nicotinamide	Strychnine
Benzocaine	Paracetamol (acetaminophen)	Theophylline
Bisphenol-A	(+ acetyl-paracetamol)	Thiamine
Caffeine	Phenacetin	Xylazine
Chloroquine	Phenazon	
Cocaine	Phenobarbitone (phenobarbital)	
Diazepam	Phenolphthalein	
Diphenhydramine	N-Phenyl-2-Naphthalene	

Table 2.3 Cocaine adulterants (Source : UNODC, 2005)

List of adulterants in cocaine		
Allobarbital	Ephedrine	Nicotinamide
Amphetamine	Fentanyl	Nitrazepam
Antipyrine	Flunitrazepam	Paracetamol (acetaminophen)
Aspirin	Flurazepam	Phenacetin
Atropine	Lidocaine (lignocaine)	Phenobarbital
Benzocaine	MDEAa	Piracetam
Benzoic acid	MDMAb	Procaine
Caffeine	Methadone	Quinine
Diazepam	Methamphetamine	Tetracaine
Dipyrone	Methaqualone	Theophylline

a 3,4-Methylenedioxyethylamphetamine.
b 3,4-Methylenedioxymethamphetamine

Diluents are a part of the component in illicit drugs. Sugars (*e.g.* glucose, lactose, sucrose) were added as diluents in heroin and cocaine (UNODC, 2005). According to El-Haj *et al*. (2004), mannitol hexaacetate had been found in brown heroin seizures. In the production of heroin, mannitol is added before the acetylating step (El-Haj *et al*., 2004), providing forensic intelligence in heroin profiling. The study of Andreasen *et al.* (2009) on heroin, amphetamine, and cocaine in Aarhus, Denmark showed that the drug

purity had decreased over time, making the illicit drugs more adulterated and diluted. Concentrations of diluents could be different based on the types of drugs. The presence of sugar in heroin is low because heroin is not suitable to smoke substances containing sugar. Lactose and sucrose were common diluents in amphetamine samples seized in 2002-2003 (n=140), with a frequency of 65% and 39%, respectively while cocaine samples seized in 2002-2003 (n=147) with the frequencies of 38% and 31% of the samples containing inositol and sucrose, respectively (Andreasen *et al.* 2009). Tables 2.4 and 2.5 demonstrate the diluents detection illicit heroin and illicit cocaine, respectively.

Table 2.4 Diluents in illicit heroin

List of diluents in illicit heroin		
Calcium carbonatea	Iditol hexa-acetate	Sodium chloride
Calcium chloride	Lactose/saccharose	Starch (usually corn)
Citric acid	Mannitol/mannit/sorbit	Sucrose
Fructose	Phthalic acid	Sucrose octa-acetate
Glucose	Potassium chloride	Tartaric acid
Glycine	Sodium carbonate	

Table 2.5 Diluents in illicit cocaine

List of diluents in illicit cocaine		
Ascorbic acid	Inositol	Mannitol
Citric acid	Lactose	Mannose
Fructose	Lysine	Sorbitol
Glucose	Maltose	Sucrose

Both qualitative and quantitative drug analyses are important. Broséus *et al.* (2015) analysed two types of illicit drug from western Switzerland, namely 6,586 cocaine specimens and 3,054 heroin specimens, seized from 2006 to 2014. From the analysis, they found that the composition in cutting agents was more heterogeneous for cocaine than for heroin. Frequently detected in cocaine are phenacetin, levamisole, lidocaine, and caffeine while heroin contained paracetamol and caffeine. Both heroin

and cocaine used sugars such as lactose and glucose as diluents. However, the dilution rate is relatively low for heroin and more important for cocaine. Cutting agents could help in discovering the structure of production and distribution of heroin and cocaine (Broséus *et al*., 2015).

The Counter-Narcotics Police of Afghanistan (CNPA) had also presented the finding of their analysis of cutting agents in the World Drug Report 2009. Every cutting agent was noted with their respective function. Caffeine can cause heroin to vapourise at a lower temperature for heroin users to smoke or inhale heroin. Chloroquine does not alter the effects of heroin or influence how it is consumed, supported by its widespread availability, low price, colour, and the crystalline structure. While the use of paracetamol as a cutting agent is for hiding the taste of poor-quality heroin because of its bitter taste. However, the findings of the CNPA laboratory suggested that heroin cutting takes place at source and that heroin produced in Afghanistan may be customised for different black markets and consumer groups (UNODC, 2009).

2.3 Law and Legislations in Malaysia

Heroin is an illegal and highly addictive drug in the United States. It was classified under Schedule 1 drug in The Control Substance Act of 1970. The possession, sale and trafficking of heroin bring stiff penalties in the United States. The typical sentencing is imprisonment for life and large fines but it may vary between different state. In Malaysia, the Dangerous Drug Act 1952 regulates the importation, exportation, manufacture, sale, as well as the use of opium and certain other dangerous drugs and substances. The capital punishment for drug trafficking includes imprisonment for life or for a term which shall not be less than 5 years and punished with whipping. For example, possession of 15 g or more heroin and morphine will receive the mandatory

death sentence under section 39B, (ACT 234, 1952). The drug is important for forensic evidence in a drug investigation because it for prosecution purposes in court to the identity of the exhibit.

2.4 Forensic Drug Testing

Drug characterisation of seized drugs is important for law enforcement to provide investigative information and intelligence in operational works (UNODC, 2001). Forensic drug testing involves a series of procedures to be carried out in the field or laboratories to detect the presence of controlled substances. A part of drug testing procedure, usually screening test, could be applied directly at the crime scene. A forensic investigator, whenever an individual is suspected to in possession of an illegal substance, may carry out a presumptive test at the scene. Majority of the procedures are performed in the forensic laboratories, analysing the submitted evidence. The determination of illicit drug substance in the sample would help the law enforcement authorities to prosecute the offenders. Collectively, the practice uses a variety of analytical methods to conduct both the presumptive and confirmatory tests on the seized materials suspected to have contained the illegal substances. The experimental results from the analyses would serve as the basis for criminal proceedings and conviction of offenders, given that the result is possible (National Forensic Science Technology Center, 2013).

Under the national and international law and legislations, the successfully conviction of forensic cases involving controlled substances requires analytical confirmation through drug testing. In fact, an analytical scheme for the identification of drugs or chemicals combines a series of appropriate analytical techniques on the forensic evidence to reach scientifically supported conclusion. In general, such scheme

shall involve three different categories based on the achievable selectivity levels, as demonstrate in Figure 2.1 (SWGDRUG, 2019).

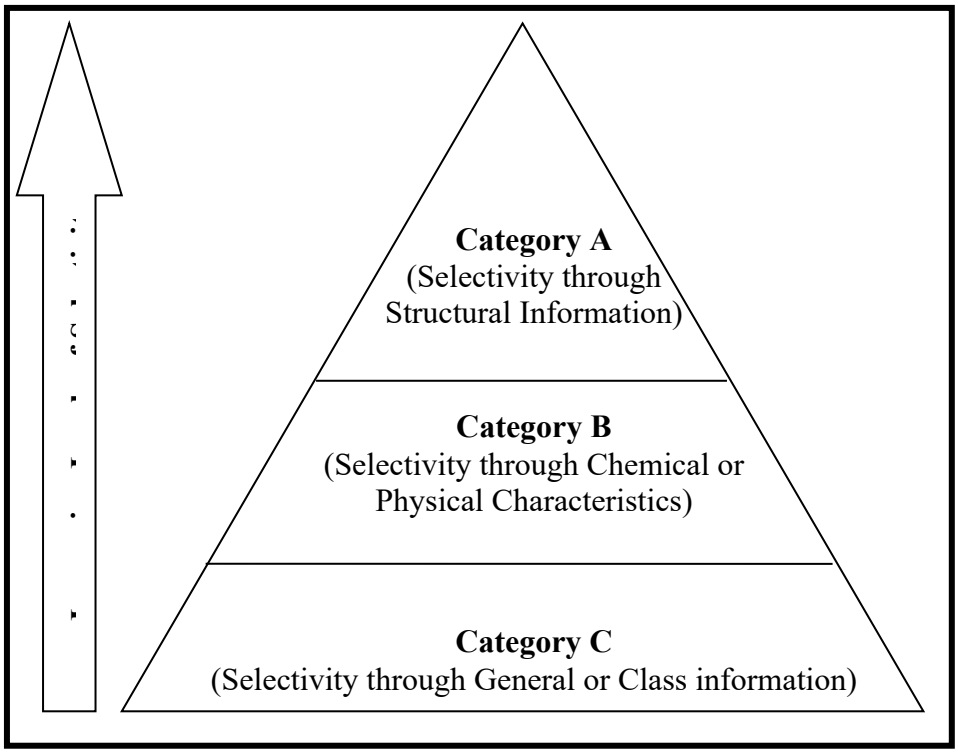


Figure 2.1 Level of selectivity in analytical scheme for forensic drug testing (SWGDRUG,2019)

Category A provides the highest level of selectively through the structural information, including techniques such as infrared spectroscopy, mass spectrometry, nuclear magnetic resonance spectroscopy, and Raman spectroscopy. Various chromatography techniques, capillary electrophoresis, microcrystalline tests, and ultraviolet-visible spectroscopy are included in Category B, suggesting an intermediate selectivity through physical and / or chemical characteristics without structural information. Lastly, the selectivity level through general or class information is classified into Category C, including colour tests, immunoassay, as well as melting point determination (SWGDRUG, 2019). In view of this, identification of a drug or

chemical could be achieved through a variety of techniques in different combinations to fulfil the requirements of the jurisdiction and criminal justice system.

Scientific Working Group for the Analysis of Seized Drugs (SWGDRUG) had also published a standard guide to improve the quality of forensic examination of seized drugs (SWGDRUG, 2019). The scientific working groups are member by scientific subject-matter experts, covering the needs of the forensic community through development of internationally accepted minimum standards, determination of best practices, and support of laboratories to meet the standards (National Forensic Science Technology Center, 2013; SWGDRUG, 2019).

As the drug related evidence could provide important information in solving a crime, appropriate and accurate forensic drug testing must be conducted on such evidence. American Society for Testing and Materials (ASTM) International had also published seven standard guidelines for the purposes, namely:

i. Standard Practice for Education and Training for Seized-Drug Analysts (ASTM E2326)
ii. Standard Practice for Quality Assurance of Laboratories Performing Seized-Drug Analysis (ASTM E2327)
iii. Standard Practice for Identification of Seized Drugs (ASTM E2329)
iv. Standard Guide for Sampling Seized Drugs for Qualitative and Quantitative Analysis (ASTM E2548)
v. Standard Practice for Validation of Seized-Drug Analytical Methods (ASTM E2549)
vi. Standard Practice for Uncertainty Assessment in the Context of Seized-Drug Analysis (ASTM E2764)

vii. Standard Guide for Analysis of Clandestine Drug Laboratory Evidence (ASTM E2882)

2.4.1 Gas Chromatographic Method

Gas chromatography (GC) coupled to an adequate detector is an established analytical technique for the analysis of volatile and semi-volatile organic compounds in gaseous, liquid, or solid samples. The technique is a common separation method in the analysis of drugs. GC coupled with flame ionisation detector (FID) and mass spectrometer (MS) is the great method used in narcotics laboratories. According to Groger *et al*. (2008), two-dimensional (2D) gas chromatography (GC × GC) combined with pixel-based chemometric processing was useful for chemical profiling of illicit drugs, namely the heroin and cannabis. Such analyses allowed the groupings of sample according to their chemical profiles. Subsequent calculation of Fisher criteria enabled the identification of discriminating compounds which can be used as markers for analysis in future illicit drug seizures.

An analysis of illicit heroin seizures by the Swiss Police in 1999 and 2000 by Esseiva *et al*. (2003) used gas chromatographic method which gives high resolution in the separation of impurities in addition to good sensitivity and reproducibility. The major impurities could be detected in one single analysis along with an amount of diacetylmorphine (DAM) and the identification of both adulterants and diluents in the matrix. They concluded that the method appeared to be robust, reliable, and simple for heroin samples comparison, allowing the establishment of linkages among the samples and to be used in routine drug profiling.

Fiorentin *et al.* (2019) detected cutting agents in illicit drugs using GC-MS method followed by liquid chromatography quadrupole time-of-flight mass

spectrometry (LC-QTOF). The presence of adulterants and diluents in seized drug exhibited from Kentucky (n = 200) and Vermont (n = 315) was investigated and the prevalence of cutting agents and drug-cutting agent combinations within the United States street drug supply chain was evaluated. Active compounds detected included caffeine (31.0%), quinine/quinidine (24.7%), levamisole (11.6%), acetaminophen, (8.2%) and procaine (8.2%). These compounds were found with several drugs of abuse, such as heroin, fentanyl, methamphetamine, and cocaine.

Inoue *et al.* (2008) have developed a method for impurity profiling of methamphetamine hydrochloride. They found that the applicability of headspace solid phase microextraction (HS-SPME) coupled with GC-MS allowed the profiling of these illicit substances. Methamphetamine samples were extracted with ethyl acetate containing four internal standards, namely n-decane, n-pentadecane, neicosane and n-octacosane under alkaline conditions. The author concluded the relative intensity of impurities in the samples determined was much greater than that by liquid-liquid extraction. Trace levels of impurities could exist in the crystals or powders even the purity of sample seizures could be higher than 99% (Inoue *et al*., 2008).

Chan *et al.* (2012) in their study used gas chromatographic method for analysis of major component in illicit heroin seized in Malaysia to quantify the various cutting agents in addition to alkaloids. Eight target analytes commonly in illicit heroin seized in Malaysia in 2010 were quantified. Quantitative analysis of cutting agents and alkaloids were obtained through two options of GC parameters for partial method validation. The established method was found to be simple, accurate and precise, successfully in quantifying the major components in illicit heroin samples (Chan *et al*., 2012).

2.4.2 Fourier Transform Infrared Spectroscopy

The Fourier Transform Infrared (FTIR) Spectroscopy is one of the tools which are commonly used in narcotics laboratories. Ravreby (1987) performed a research for the quantitative determination of cocaine and heroin using FTIR. The heroin hydrochloride was analysed and quantified by observing the carbonyl absorption peak as the analytical peak. The result found that the mixed samples of heroin free base and hydrochloride could be better quantified through area integration of two carbonyl peaks at the region in the range of 1720 to 1770 cm^{-1} (Ravreby, 1987).

FTIR method was chosen by Marcelo *et al.* (2015) in their study in profiling 513 cocaine samples which are 217 salt samples and 236 base samples from the State of Rio Grande do Sul (Brazil) seized between 2011 and 2012. The author concluded that the classification of cocaine seized was possible using ATR–FTIR spectra and chemometrics according to cocaine, both in salt and base form. The grouping of the samples into cocaine base and cocaine salt was possible utilising the fingerprint region in the FTIR spectra of cocaine sample, as well as the adulterants contained in the samples. Principal component analysis (PCA) and hierarchic cluster analysis (HCA) were used for sample clustering in the study (Marcelo *et al*., 2015).

2.5 Forensic Significance of Forensic Drug Testing

2.5.1 Determination of Identity and Quantity of Illicit Drug Substances

As described in the previous section, forensic drug testing is applied to identify the illicit drug substance using scientific method within the criminal justice system. In general, the analysts in the forensic laboratory would have to answer several questions regarding the forensic sample submitted (National Forensic Science Technology Center, 2013), including :

- What are the substances that present within the sample?
- Is any component within the sample an illegal substance?
- What is the amount of illegal substance that present within the sample?

The sample submitted to the forensic laboratory can contain a mixture of many compounds. For instance, cocaine powder is frequently cut with caffeine or lidocaine. The forensic sample needs to be separated out all the individual components and detected by the instrument. To confirm the identity of the compound(s), the chemical characteristics of each component can be compared with those characteristics to the certified reference material or with the library. Subsequently, the laboratory results are presented in court (National Forensic Science Technology Center, 2013).

2.5.2 Determination of Traces of Drug Substances

During forensic investigation, not only the substance itself is submitted to the forensic laboratory for analysis. In some instances, containers used to transport or smuggle the substance, utensils used to manufacture or had been used to contain the substance, as well as the samples recovered from any surface at the crime scene can also be collected and submitted. Besides, if a smuggling or trafficking activity is detected, traces of illicit drugs may be found on the materials or containers used for such activity, such as in the form of canned or boxed items, garments or fabrics, and etc. since there are unlimited channels for smuggling illicit drugs, the types of evidence submitted to the laboratories are also varied (UNODC, 2001). In view of this, the successfully detection of illicit drugs on such forensic evidence could aid in investigating the smuggling and trafficking activities. Furthermore, determination of the presence of illicit drugs or the raw materials to make the target drug on the forensic

samples recovered from any surfaces could also conclude whether the chemical structure could have been used as a clandestine laboratory (UNODC, 2001).

2.5.3 Drug Profiling and Forensic Intelligence

Chemical profiling of illicit drug could provide another interpretation of chemical information covering the purity, cutting agents, the presence of minor and major alkaloids, as well as the chemical class (Rhumorbarbe *et al*., 2016). Classification of physical and chemical characteristics of illicit drug substances possesses the potential of describing the phenomena and series of the forensic evidence (Ribaux & Margot, 1998). It could provide distribution networks of illicit drugs and the sellers. With the profiles of illicit drugs, the different levels of production in relation to the cultivation, manufacturing, trafficking and smuggling, adulteration and cutting, distribution, supply and sales to the end users could be determined (UNODC, 2006). The chemical and/or physical link between the two illicit drug samples could also be useful in establishing the association between the two samples, and in some instances, to link to the distribution chain or to trace the manufacturer (UNODC, 2006; Morelato *et al*., 2015; Esseiva *et al*., 2007).

In such regards, the analytical procedure does not solely focus on the identification of the illicit drug substance and its quantity, but also establishing the linkage between the forensic evidence (Ribaux *et al*., 2003). A database compiling the illicit drug profiles can be developed, allowing the extraction of important information regarding the source of a sample. According to Collins *et al.* (2007), Australia had built its illicit drug profiling based on two major arms which are chemical profiling and physical profiling. Additionally, Australia also manages a programme to establish chemical and profiling data on illicit drugs which are under The Australian Illicit Drug

Intelligence Program, in collaboration between the Australian Federal Police and the Australian National Measurement Institute (Collins *et al.,* 2007). Tactical intelligence is a type of information that can be linked drug seizure and law enforcement.

At international level, the UNODC had published the background and concepts of drug characterization and profiling (UNODC, 2001). Characterisation and profiling of drugs could help forensic scientists and law enforcement to answer a variety of questions including dealer-user relationship, drug source, distribution networks, and trafficking routes to manufacturing methods and precursors used (UNODC, 2001). According to Broseus *et al.* (2016), the combination of analysis forensic data and other sources could build intelligence information on drug trafficking and smuggling activities. The analysis of the drug market based on the chemical profiling of drug seizures may be used by law enforcement officials, criminologists, and policy makers. The objective of this study is to investigate the effects of physical insults towards the detection of pharmaceutical drugs that was used on adulterants packaged with different methods.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter describes the materials and chemicals used in this study, as well as the methodology to analyse the insulted samples. As mention in Table 2.2 and Table 2.3, paracetamol is possible adultrent in illicit drug, two types of paracetamol (PCM) samples were used, packaged in three different methods, and subjected to four different physical insults.

3.2 Materials and Apparatus

Two brands of paracetamol (Paracil and Panadol Menstrual) were purchased from the market. Paracil was manufactured by SM Pharmaceuticals Sdn Bhd, Sungai Petani, Kedah, Malaysia with batch number PA16J217 while Panadol Menstrual manufactured by Glaxo Smith Kline (GSK) Pharmaceutical Sdn Bhd, Petaling Jaya, Selangor, Malaysia with batch number JY4F. This two brands of paracetamol were chosen because these two brands have similarity in shape and colour with commonly seized drug and easy to observe any colour transfer to the container. Glass containers for Panadol Menstrual were provided by Forensic Laboratory School of Health Science University Sains Malaysia but because of Paracil cannot fit in with that glass container, the other types of glass container for Paracil were purchased from the market. Clear plastic bags and white A4 paper 80 gsm brand IK Yellow were acquired from the local market.

Vernier Calipers (0-125 mm x 0.02) brand A 1476 was provided from Forensic Laboratory. An analytical balance Sartorius BSA224S-CW (Gottingen, Germany) was used to measure the weight of the samples before and after the physical insults. A7890A

Gas Chromatography – Flame Ionisation Detection System was equipped with 7893 Autosampler was used to analyse and detect the target compound.

3.3 Procedure

3.3.1 Physical Observation Prior to Physical Insults

Prior to the physical insults, the weight, shape, dimension and size of each sample were measured, determined and recorded. The diameter and thickness of the samples were measured using Vernier Caliper, while the weight was determined using an analytical balance. Every sample was kept in three different packaging methods, which were glass container, plastic bag and paper wrapped as shown on Figure 3.1 and Figure 3.2 packaging for Paracil and Panadol Menstrual respectively. All samples were packaged properly and labeled accordingly.

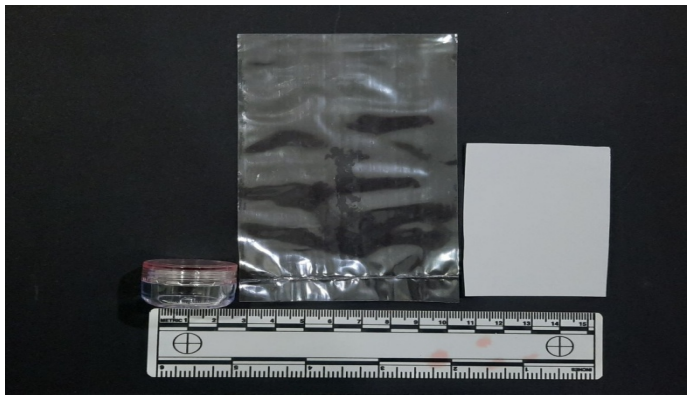


Figure 3.1 Packaging materials for samples brand of Paracil

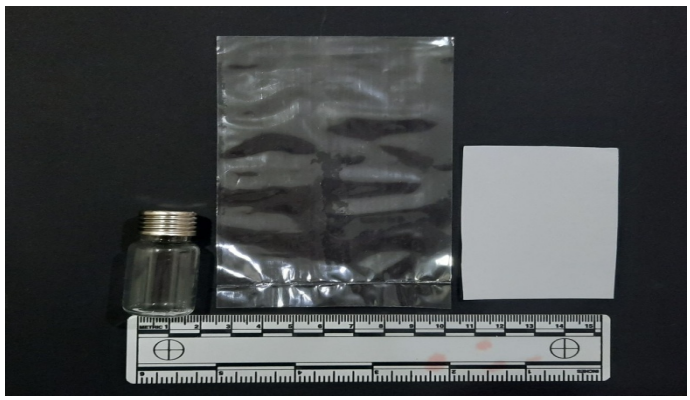


Figure 3.2 Packaging materials for samples brand of Panadol Menstrual

3.3.2 Physical Insults

All the samples kept with different packaging methods were subjected to four different physical insults for a duration of one week. The four physical insults included in this study were shaking for 3 minutes each day for one week, shaking by put inside the car for one week, handling by putting in the handbag for one week and handling by putting in pockets of pants for one week. These physical insults could be encountered during the forensic investigation and caused by the criminals during daily activities. The storage condition and physical insults were shown in Table 3.1. for each combination of storage condition and physical insult, three samples were prepared, making a total of 36 samples for each types of paracetamol.

Table 3.1 Storage condition and physical insult

Physical insults	**Glass container**	**Plastic bags**	**Wrapped in paper**
Shaking	3 samples	3 samples	3 samples
Shaking- put in car for one week	3 samples	3 samples	3 samples
Handling- put in handbag for one week	3 samples	3 samples	3 samples
Handling- put in pocket in pants for one week	3 samples	3 samples	3 samples

3.3.3 Physical Observation After Physical Insults

After one week, all samples were measured again to determine any change in term of the colour, shape, size and the dimension. Any change identified through the physical observation was recorded. All the containers, plastic bags, and papers were used to wrap the samples were kept properly and used for subsequent analysis.

3.4 Gas Chromatography with Flame Ionization Detector (GC-FID) Analysis

3.4.1 Sample Preparation

The packaging materials used in this study were prepared differently prior to GC analysis to extract or transfer any drug residues from each packaging material to the vial. For glass container packaging method, 1 mL of methanol was added into glass container using pipette and swirled evenly. The solution with potential drug residue was then transferred into GC vial using pipette carefully. The GC vial with the sample was properly labeled. For the preparation of samples wrapped with plastic bags and papers, 1 cm x 1 cm of the packaging materials contacted with the sample was cut and soaked in 1 mL of methanol in GC vial for one hour. After the set time duration, the cut packaging material was removed and filtered from the GC vial and labeled accordingly.

3.4.2 Instrumental Parameters

Analyses were performed using GC-FID. Analyses were conducted on a HP-5 capillary column (30 m length, 0.32 mm i.d. and 0.25 μm film thickness), (Agilent Technologies, Santa Clara, CA). Injections were carried out in the splitless mode, where 1μL of each sample together with 500 ug/mL paracetamol standard was injected with purified nitrogen gas used as the carrier gas at a flow rate of 1.0 mL/minute. The oven temperature programme started at 70 ºC and hold for 1 minute, ramped 30 ºC/minute to 280 ºC, and lastly hold for 1 minute to complete the analysis. Injection temperature was maintained at 280 ºC and detector temperature was set at 300 ºC. The detector was supplied with hydrogen gas (30 mL/minute), purified air (300 mL/minute) and nitrogen as the make up gas (15 mL/minute). Chemstation software (Rev. B.04.02) (Santa Clara, CA) was used to automate the GC system and analyse the chromatographic outputs. The resulting peaks in the chromatograms were identified.

To investigate the effects on physical insults towards the detection of paracetamol on the packaging materials. In this study, four different groups of independent physical insults were tested with categorical data output, either detected or non-detected. The physical insults which could lead change in the physical characteristics of the tablet samples were determined. The possibility to extract and detect the presence of drug for the packaging materials was also evaluated.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter describes the results on the detection of paracetamol upon four different physical insults. Physical characteristics of the paracetamol samples before and after one week of the physical insults were observed and recorded. Samples with brand of Paracil is round in shape with white colour and while the sample brand Panadol Menstrual is oval in shape with pink colour. For detection of drugs on the packaging materials, the prepared samples were analysed using GC-FID.

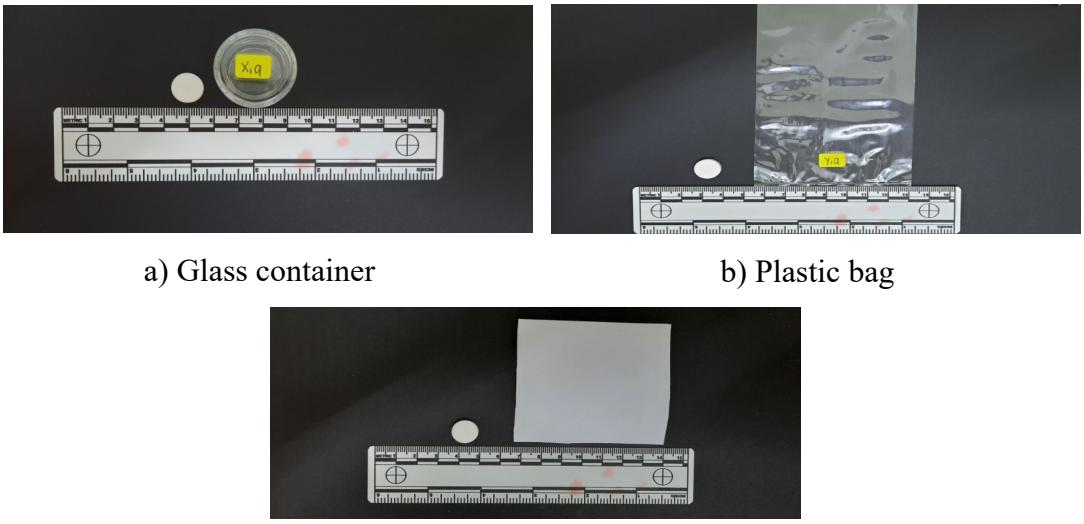
4.2 Physical Characteristics Examination Before and After Physical Insult

4.2.1 Control Samples

All the paracetamol samples were measured and observed before packaging and insulting by varying physical assaults. Table 4.1 shows the measurement of the Paracil tablets and the physical observation for Paracil. Since the tablets appeared as round shape; the dimension of the samples was measured in diameter and thickness. Diameter of Paracetamol with the brand of Paracil was measured at 12.56 ± 0.00 mm while the thickness was measured at 4.29 ± 0.11 mm. It was found that the thickness of the tablet slightly varied among the samples. Figure 4.1 illustrated the physical appearance of the tablet drugs with respective packaging materials before the physical insults.

Table 4.1 The physical observation and measurement sample brand of Paracil (n=36)

Colour	White
Diameter (mm)	12.56 ± 0.00
Thickness (mm)	4.29 ± 0.11
Weight (gm)	5.79 ± 0.11



a) Glass container b) Plastic bag

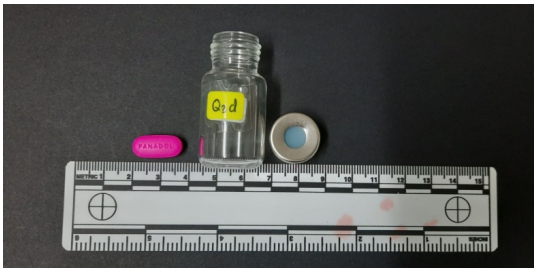
c) Paper

Figure 4.1 The physical appearance of the sample brands of Paracil with respective packaging materials

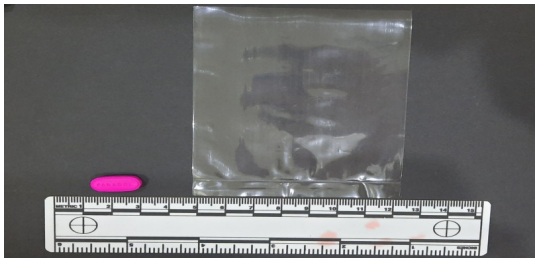
Table 4.2 shows the physical observations and measurements of sample Panadol Menstrual before being subjected to storage and insults. Based on the physical observations, the tablets appear differently as compared to the samples from the brand of Paracil. The samples of the brand of Panadol Menstrual were pink in colour, allowing their differentiation from other samples. As the target groups of the consumer for this kind of tablets are specific to women, the choice of pink colour could aid in discriminating the tablets from other drugs commonly used by the general public. In term of the shape, the tablets appear in an oval shape, therefore the dimension was measured in length x width x thickness.

Table 4.2 The physical observation and measurement of sample brand Panadol Menstrual (n=36)

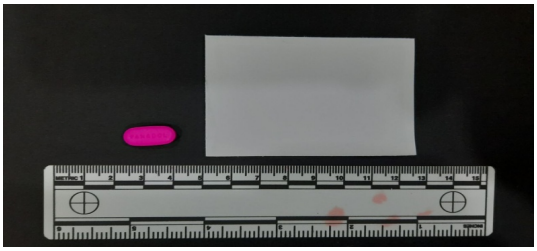
Colour	Pink
Length (mm)	17.20 ± 0.00
Width (mm)	8.20 ± 0.00
Thickness (mm)	5.40 ± 0.00
Weight (gm)	6.51 ± 0.10



a) Glass container



b) Plastic bag



c) Paper

Figure 4.2 The physical appearance of the sample brands of Panadol Menstrual with respective packaging materials

4.2.2 Insult by Shaking

Upon insult through shaking, the shape for each sample for both brands did have change in measurement. Physical observation of the samples brand Paracil upon physical insult on shaking was shown in Table 4.3 and the measurement was shown in Table 4.4. The observation and measurement of the samples brand Panadol Menstrual was tabulated in Table 4.5 and Table 4.6 respectively. Figure 4.3 shows the packaging and sample brand of Paracil after insulted by shaking. However, it was noted that stored in glass container showed change on sample physical condition. In fact, the majority of the sample crack and become powder due to the physical movement and

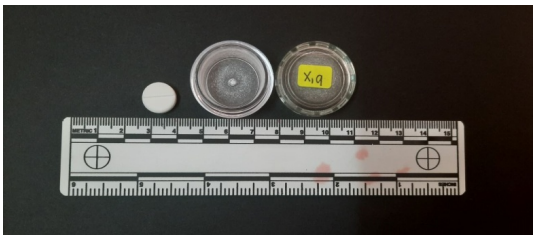
collision of the sample onto the glass walls during shaking. On the other hand, samples kept in plastic bag and wrapping paper did not show much changes and did not leave any observable trace on packaging through visual observation except for brand Panadol Menstrual in wrapping paper due to the pink colour appearance. Although those samples did not show any observable trace, the percentage of weight changes for both brand in all types of packaging reduced. On the paper used to keep the Panadol Menstrual tablets, a slight pink stain was observed as shown in Figure 4.4. This indicated that a minor portion of the tablets had been successfully transferred onto the paper materials used to wrap the samples.

Table 4.3 The physical observation of sample brand of Paracil after insulted by shaking

Packaging	**Glass container**	**Plastic bag**	**Paper wrapping**
Colour	white	white	white
Sample condition	white dusty / crack	no changes	no changes
Packaging	white powder	no visible trace	no visible trace

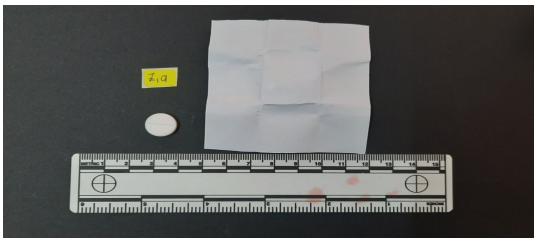
Table 4.4 The measurement of sample brand of Paracil after insulted by shaking

Packaging	**Glass container**	**Plastic bag**	**Paper wrapping**
Diameter (mm)	12.56 ± 0.00	12.56 ± 0.00	12.56 ± 0.00
Thickness (mm)	4.35 ± 0.14	4.23 ± 0.01	4.27 ± 0.22
Weight (gm)	5.80 ± 0.15	5.74 ± 0.13	5.74 ± 0.32
Percent of weight changes (%)	(-) 0.17	(-) 1.20	(-) 1.20



a) Glass container

b) Plastic bag



c) Paper

Figure 4.3 Packaging and sample brand of Paracil after insulted by shaking

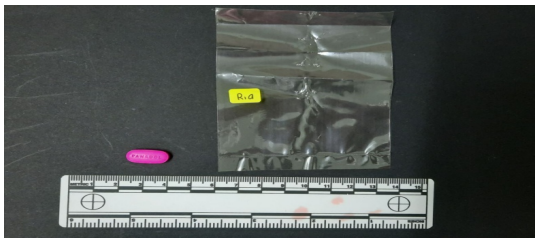
Table 4.5 The physical observation of sample brand of Panadol Menstrual after insulted by shaking

Packaging	**Glass container**	**Plastic bag**	**Paper wrapping**
Colour	pink / white	pink	pink
Sample condition	crack / powdering	no changes	no changes
Packaging	pink / white powder	no visible trace	pink stain

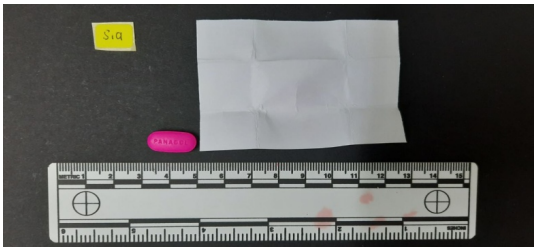
Table 4.6 The measurement of sample brand of Panadol Menstrual after insulted by shaking

Packaging	**Glass container**	**Plastic bag**	**Paper wrapping**
Length (mm)	17.07 ± 0.11	17.20 ± 0.00	17.20 ± 0.00
Width (mm)	8.19 ± 0.01	8.19 ± 0.00	8.20 ± 0.00
Thickness (mm)	5.32 ± 0.07	5.30 ± 0.00	5.33 ± 0.06
Weight (gm)	6.36 ± 0.19	6.43 ± 0.03	6.37 ± 0.07
Percent of weight changes (%)	(-) 2.3	(-) 1.22	(-) 2.15

a) Glass container



b) Plastic bag



c) Paper

Figure 4.4 Packaging and sample brand of Panadol Menstrual after insulted by shaking

4.2.3 Insult by Shaking Inside Car

When the samples were placed in the car for one week, they were subjected to physical insults including the shaking or the movement of the car and also the extreme weather and temperature. In this case, the weather was hot for the whole week during the day and rain for one night. The car was parked under the shade and also have certain movement almost everyday. Tables 4.7 and Table 4.8 shows the physical observation and measurement of sample brand Paracil respectively. The physical observation and measurement after physical insult for Panadol Menstrual as shown in Table 4.9 and Table 4.10. The measurement samples for Paracil were reduced in all types of the container but for Panadol Menstrual, the percentage of weight changes were increase for samples in a glass container and plastic bag. It may due to contamination or others factor. It was found that for brand Paracil a small amount of white powders was detected inside glass container as shown on Figure 4.5 as compared to brand Panadol Menstrual where light pink colour spot was noticed on paper

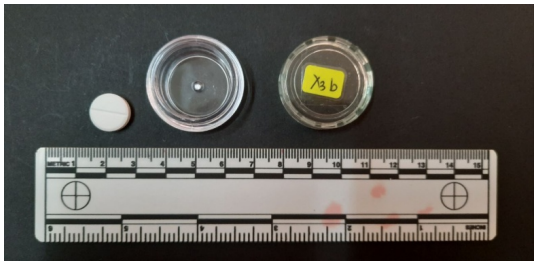
wrapping as shown on Figure 4.6. No visible trace was found in the plastic bags contained the samples.

Table 4.7 The physical observation of sample brand of Paracil after insulted by shaking inside car

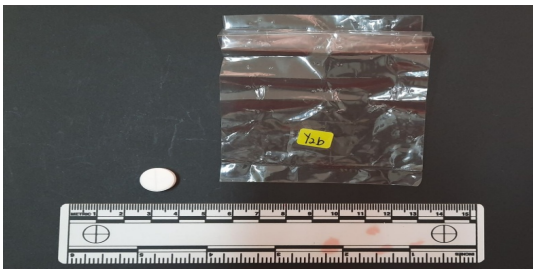
Packaging	**Glass container**	**Plastic bag**	**Paper wrapping**
Colour	white	white	white
Sample condition	no changes	no changes	no changes
Packaging	white powder	no visible trace	no visible trace

Table 4.8 The measurement of sample brand of Paracil after insulted by shaking inside car

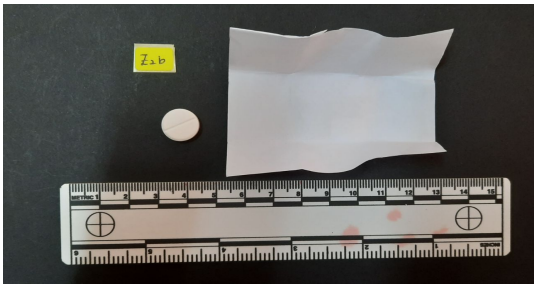
Packaging	**Glass container**	**Plastic bag**	**Paper wrapping**
Diameter (mm)	12.56 ± 0.00	12.56 ± 0.00	12.56 ± 0.00
Thickness (mm)	4.23 ± 0.08	4.22 ± 0.10	4.19 ± 0.12
Weight (gm)	5.75 ± 0.18	5.72 ± 0.14	5.66 ± 0.19
Percent of weight changes (%)	(-) 1.03%	(-) 1.55%	(-) 2.58%



a) Glass container



b) Plastic bag



c) Paper

Figure 4.5 Packaging and sample brand of Paracil after insulted by shaking inside car

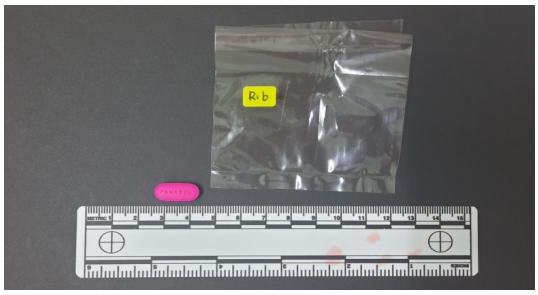
Table 4.9 The physical observation of sample brand of Panadol Menstrual after insulted by shaking inside car

Packaging	**Glass container**	**Plastic bag**	**Paper wrapping**
Colour	pink	pink	pink
Sample condition	no changes	no changes	no changes
Packaging	no visible trace	no visible trace	light pink stain

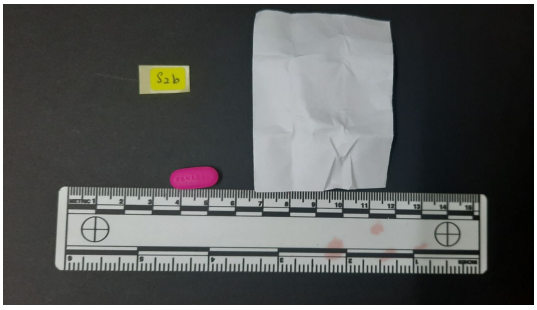
Table 4.10 The measurement of sample brand Panadol Menstrual after insulted by shaking inside car

Packaging	**Glass container**	**Plastic bag**	**Paper wrapping**
Length (mm)	17.20 ± 0.00	17.20 ± 0.00	17.20 ± 0.00
Width (mm)	8.20 ± 0.00	8.20 ± 0.00	8.20 ± 0.00
Thickness (mm)	5.40 ± 0.00	5.40 ± 0.00	5.30 ± 0.00
Weight (gm)	6.54 ± 0.01	6.57 ± 0.04	6.46 ± 0.06
Percent of weight changes (%)	(+) 0.46	(+) 0.9	(-) 0.77

a) Glass container



b) Plastic bag



c) Paper

Figure 4.6 Packaging and sample brand of Panadol Menstrual after insulted by shaking inside car

4.2.4 Insult by Handling in Handbag

In this study, samples were placed in handbag and the movement of the person carrying the bag introduced physical insult to the sample. Tables 4.11 and Table 4.12 demonstrate the physical observation and measurement of sample brand Paracil while Table 4.13 and Table 4.14 for Panadol Menstrual after insulted by handling in a handbag. Throughout the week of study, the samples were placed in the same handbag in a different compartment of the handbag. The movements were through walking, riding with the motorcycle and without being removed from handbag when at home. The experimental results showed that the level of residue transfer and modification on the original form of tablets depends on the type of packaging materials used to keep the samples. The change on the samples subjected to insult was minimum, as they appeared very similar to their physical appearance before any insult. For Paracil sample in a plastic bag and paper wrapping, the percentage of weight changes were (-

2.07%) compared to the sample in a glass container but through visual examination, no visible trace was detected in plastic bag and paper wrapping. The reduced of weight may due to the location where the samples were placed and may be effected with other things in a handbag but the percentage of weight for sample Panadol Menstrual in plastic was increased in small percentage at (0.31%). It may due to contamination or other factors. In fact, only a small amount of white powder was detected in the glass container as shown in Figure 4.7. Similar to Panadol Menstrual sample, the size and dimension were less likely to change but the pink spot of residue transfer was noticed in one of the wrapped papers as shown in Figure 4.8.

Table 4.11 The physical observation of sample brand of Paracil after insulted by shaking in handbag

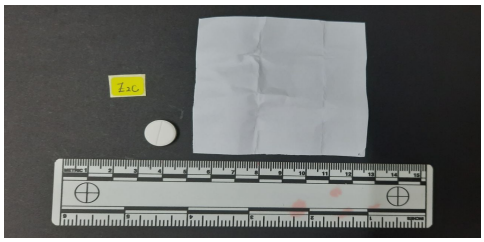
Packaging	**Glass container**	**Plastic bag**	**Paper wrapping**
Colour	white	white	white
Sample condition	No changes	No changes	No changes
Packaging	White powder	No visible trace	No visible trace

Table 4. 12 The measurement of sample brand of Paracil after insulted by shaking in handbag

Packaging	**Glass container**	**Plastic bag**	**Paper wrapping**
Diameter (mm)	12.56 ± 0.00	12.56 ± 0.00	12.56 ± 0.00
Thickness (mm)	4.29 ± 0.14	4.28 ± 0.14	4.23 ± 0.10
Weight (gm)	5.78 ± 0.20	5.69 ± 0.24	5.69 ±0.21
Percent of weight changes (%)	(-) 0.52	(-) 2.07	(-) 2.07

a) Glass container

b) Plastic bag



c) Paper

Figure 4.7 Packaging and sample brand of Paracil after insulted by shaking in handbag

Table 4.13 The physical observation of sample brand of Panadol Menstrual after insulted by shaking in handbag

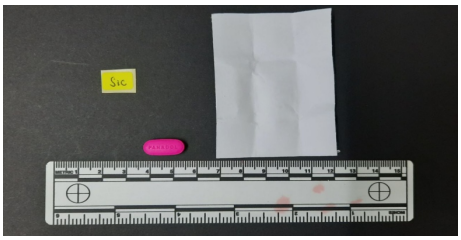
Packaging	**Glass container**	**Plastic bag**	**Paper wrapping**
Colour	pink	pink	pink
Sample condition	No changes	No changes	No changes
Packaging	No visible trace	No visible trace	Pink stain

Table 4.14 The measurement of sample brand of Panadol Menstrual after insulted by shaking in handbag

Packaging	**Glass container**	**Plastic bag**	**Paper wrapping**
Length (mm)	17.20 ± 0.00	17.20 ± 0.00	17.20 ± 0.01
Width (mm)	8.20 ± 0.00	8.20 ± 0.00	8.20 ± 0.01
Thickness (mm)	5.33 ± 0.00	5.4 ± 0.00	5.37 ± 0.06
Weight (gm)	6.42 ± 0.00	6.53 ± 0.05	6.49 ± 0.10
Percent of weight changes (%)	(-) 1.38	(+) 0.31	(-) 0.31

a) Glass container

b) Plastic bag



c) Paper

Figure 4.8 Packaging and sample brand of Panadol Menstrual after insulted by shaking in handbag

4.2.5 Insult by Handling in Pocket in Pants

In this experimental setting, all samples were placed in different containers or packaging materials and put in pocket pants for one week. The insult was due to the movement of the individual, the friction between the pants and samples, and also activities conducted by the person. The mentioned activities included walking around the shopping complex, doing housework, jogging, driving and riding. Tables 4.15 and Table 4.16 shows the physical observation and measurement of sample brand Paracil respectively while Table 4.17 and Table 4.18 shows the physical observation and measurement of sample Panadol Menstrual after insulted by handling in the pocket in pants. Through visual observation, a small amount of white powder was detected in the glass container sample brand of Paracil after this insult. In the respective glass containers, traces of white powder were evident which had been absent in other packaging materials as shown in Figure 4.9. The measurement and the weight of Paracil samples in all types of container reduced significantly. In samples with the brand of Panadol Menstrual, obvious changes were observed by visual examination,

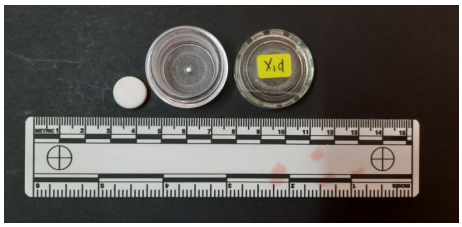
especially those wrapped with paper as shown in Figure 4.10. The paper was found attached to the samples which cause the measurement of length and width increase. This caused the packaging paper was noticed with pink colour stain. However, such observation was not evident in other types of packaging materials. Additionally, the thickness of the tablets was greatly reduced after the physical insult in which a portion of the drug tablet had been insulted. This could be due to the introduction of moisture into the packaging paper, leading to the stickness of the tablet. Subsequently, the tablet was attached onto the paper itself.

Table 4.15 The physical observation of sample brand of Paracil after insulted by handling in pocket pants

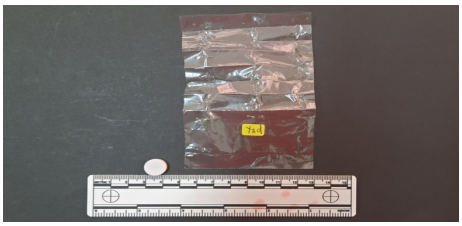
Packaging	**Glass container**	**Plastic bag**	**Paper wrapping**
Colour	white	white	white
Sample Condition	no changes	no changes	no changes
Packaging	white powder	no visible trace	no visible trace

Table 4. 16 The measurement of sample brand of Paracil after insulted by handling in pocket pants

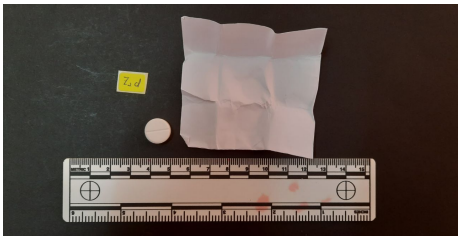
Packaging	**Glass container**	**Plastic bag**	**Paper wrapping**
Diameter (mm)	12.56 ± 0.00	12.56 ± 0.00	12.56 ± 0.00
Thickness (mm)	4.17 ± 0.05	4.25 ± 0.08	4.14 ± 0.00
Weight (gm)	5.65 ± 0.14	5.74 ± 0.18	5.61 ± 0.06
Percent of weight changes (%)	(-) 2.42%	(-) 0.86%	(-) 3.11%



a) Glass container



b) Plastic bag



c) Paper

Figure 4.9 Packaging and sample brand of Paracil after insulted by handling in pocket pants

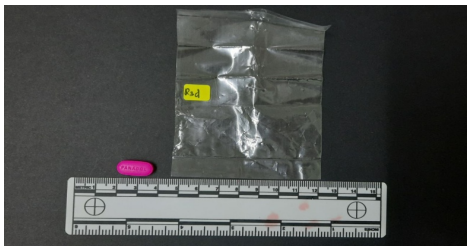
Table 4.17 The physical observation of sample brand of Panadol Menstrual after insulted by handling in pocket pants

Packaging	**Glass container**	**Plastic bag**	**Paper wrapping**
Colour	pink	pink	pink
Sample condition	no changes	no changes	tablet stick with paper
Packaging	no visible trace	no visible trace	pink stain / torn

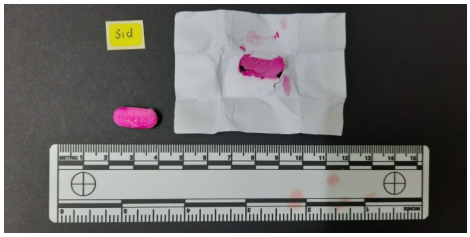
Table 4. 18 The measurement of sample brand of Panadol Menstrual after insulted by handling in pocket pants

Packaging	**Glass container**	**Plastic bag**	**Paper wrapping**
Length (mm)	17.20 ± 0.00	17.20 ± 0.00	17.22 ± 0.03
Width (mm)	8.21 ± 0.02	8.24 ± 0.00	8.22 ± 0.03
Thickness (mm)	5.40 ± 0.01	5.27 ± 0.06	5.37 ± 0.06
Weight (gm)	6.49 ± 0.04	6.50 ± 0.15	6.38 ± 0.01
Percent of weight changes (%)	(-) 0.31	(-) 0.15	(-) 2.00

a) Glass container



b) Plastic bag



c) Paper

Figure 4.10 Packaging and sample brand of Panadol Menstrual after insulted by handling in pocket pants

4.3 Gas Chromatography – Flame Ionisation Detector Analysis

GC-FID provides good detection and sensitivity in chemical analysis, particularly the organic compounds. In this study, the GC-FID method was adapted from an in-house method was found suitable to detect the presence of paracetamol. The method was aimed to detect the presence of paracetamol on packaging materials which had been used to contain and store the samples during the physical insult. The peak of paracetamol was shown at a retention time of 7.5 minutes as shown in Figure 4.11. From the GC result, it showed that certain packaging of drugs samples could give the information on the presence of drugs, depending on the degree and types of physical insult to the drugs. Yao *et al*. (2007) in their studying had developed a gas chromatographic method in determining paracetamol (PCM), caffeine (CAF), diphenhydramine hydrochloride (DPH) and ephedrine hydrochloride (EPD) in compound paracetamol and diphenhydramine tablet. This method successfully determines of the fourfold mixture of PCM, CAF, DPH and EPD in pharmaceutical

preparation. It was shown that paracetamol could be detected by the gas chromatographic method, which was also demonstrated in this study.

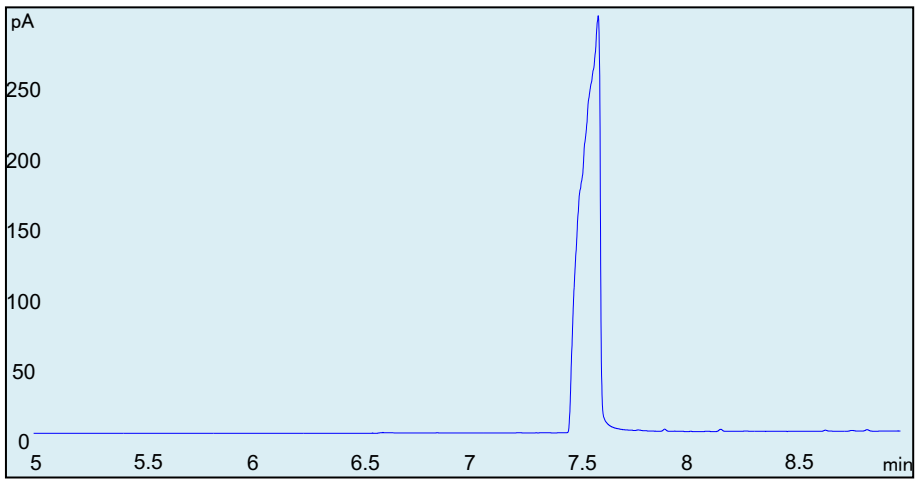


Figure 4.11 The chromatogram of 500 ug/mL paracetamol standard

Due to the introduction of other additives during the manufacturing of drugs, several small peaks were also detected along with the paracetamol. These additives could be colourants, binders or stabilisers added to give colour, bind all the composition together and to increase the shelf life of the tablets, respectively. From this study, not all the packaging materials tested detected the presence of paracetamol. Tables 4.19 and 4.20 demonstrate the detection of drugs from the packaging materials upon exposure to different physical insults for samples of the brand of Paracil and Panadol Menstrual, respectively. The result was identified by referring to the chromatogram of paracetamol standard Six containers for the brand of Paracil was detected with Paracetamol. From this research, the glass container possessed the highest probability to detect paracetamol as compared to other packaging methods. Almost all the four types of insults in this study cause the transfer of traces of white powder for brand Paracil. It could be due to the relatively softer nature of the brand Paracil which is less susceptible to the physical insult and easy to break the sample.

Besides that, the plastic bags that contained sample brand of Paracil which insulted by handling inside handbag also shows the presence of paracetamol. Same goes to the paper wrapping for the sample which was insulted by handling in the pocket in pants. Figure 4.12 – Figure 4.23 show the chromatogram of detection paracetamol in container sample brand of Paracil and Figure 4.24 – Figure 4.35 show the chromatogram of detection paracetamol in container sample brand of Panadol Menstrual. By comparison with Panadol Menstrual, only four types of insult were trace with paracetamol. Only the shaking insult left traces in a glass container for sample brand of Panadol Menstrual. Panadol Menstrual also left the trace in paper wrapping with was insulted by shaking inside the car, in handbag and in the pocket in pants. The successful detection of paracetamol in certain container or packaging material depends on the type of packaging as well as the degree of physical insults.

Table 4.19 Detection of paracetamol in container sample brand of Paracil

Physical Insult	**Glass Container**	**Plastic Bags**	**Wrapped in paper**
Shaking	Yes	No	No
Shaking - put in car for one week	Yes	No	No
Handling - put in handbag for one week	Yes	Yes	No
Handling – put in pocket in pants for one week	Yes	No	Yes

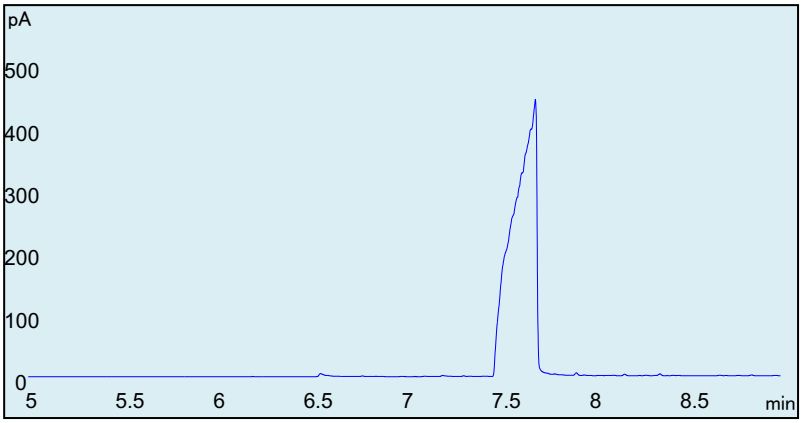


Figure 4.12 The chromatogram of the glass container was insulted by shaking the sample brand of Paracil

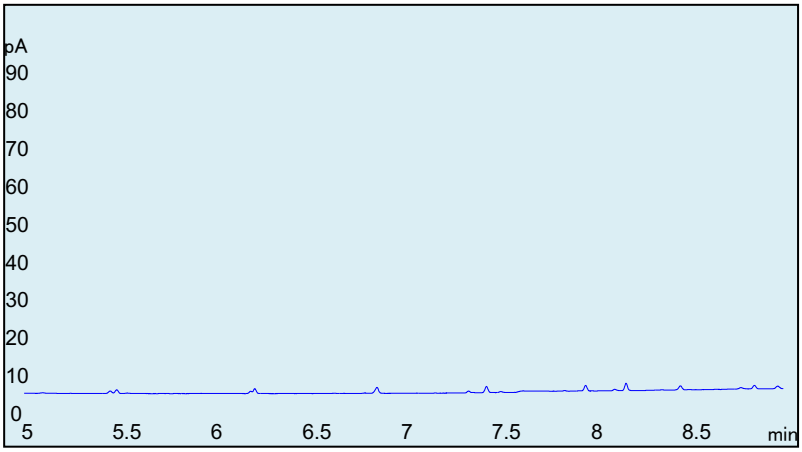


Figure 4.13 The chromatogram of the plastic bag was insulted by shaking the sample brand of Paracil

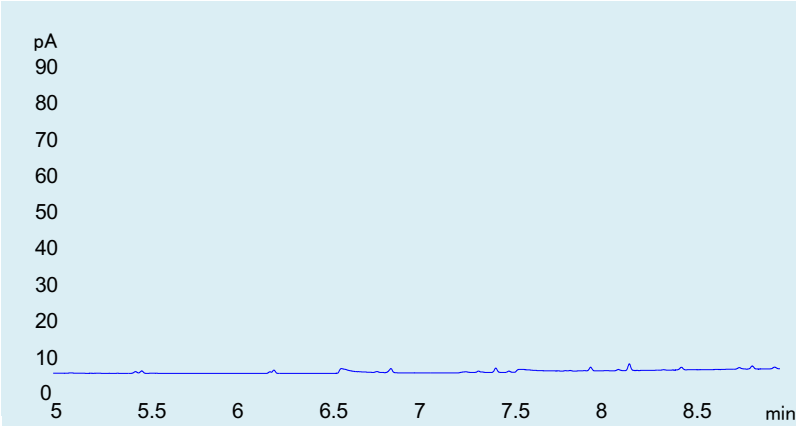


Figure 4.14 The chromatogram of the paper wrapping was insulted by shaking the sample brand of Paracil

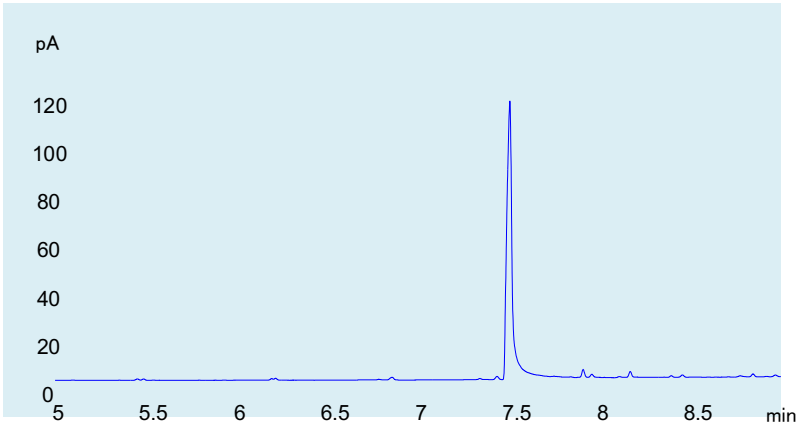


Figure 4.15 The chromatogram of the glass container was insulted by shaking inside the car for the sample brand of Paracil

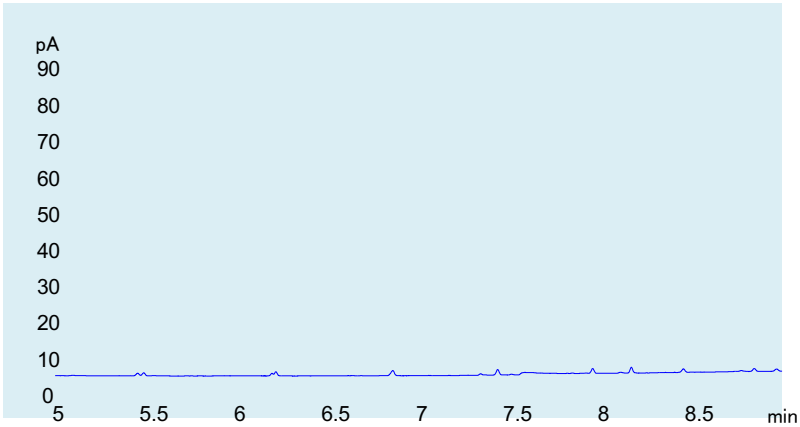


Figure 4.16 The chromatogram of the plastic bag was insulted by shaking inside the car for the sample brand of Paracil

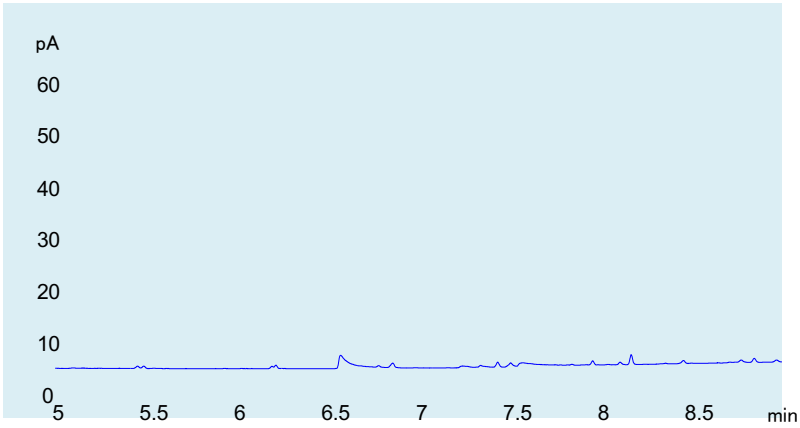


Figure 4.17 The chromatogram of the paper wrapping was insulted by shaking inside the car for the sample brand of Paracil

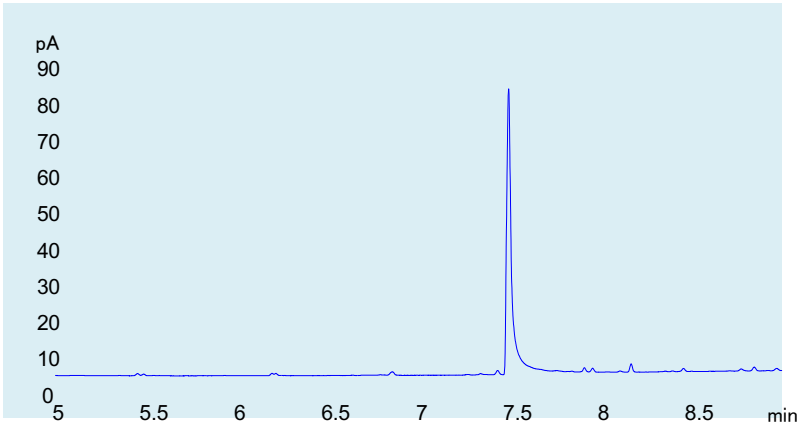


Figure 4.18 The chromatogram of the glass container was insulted by handling in the handbag for the sample brand of Paracil

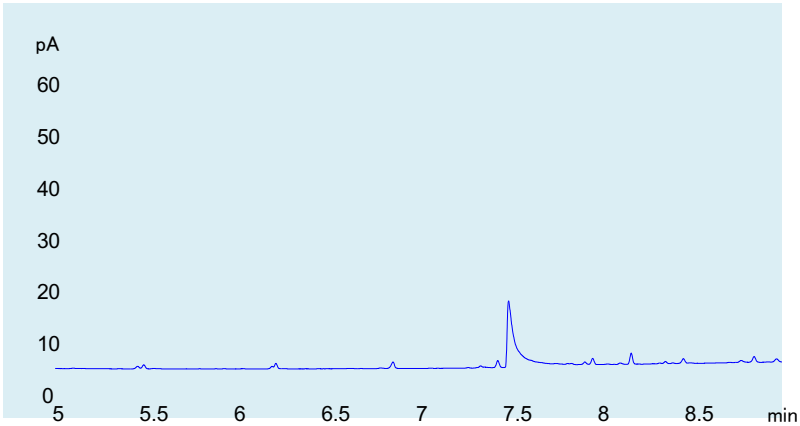


Figure 4.19 The chromatogram of the plastic bag was insulted by handling in the handbag for the sample brand of Paracil

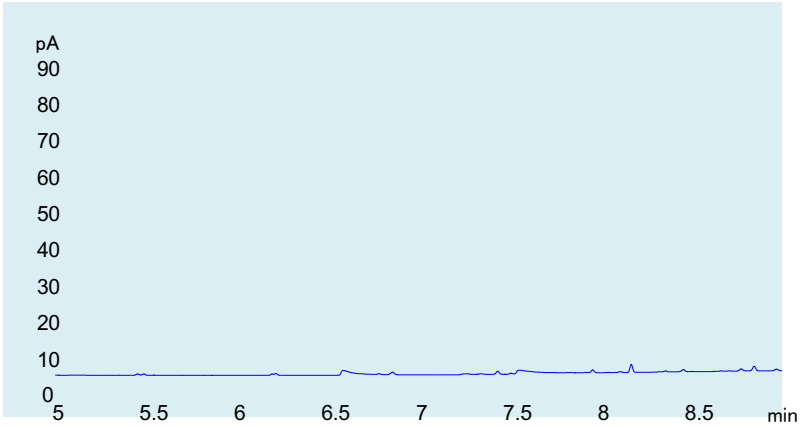


Figure 4. 20 The chromatogram of the paper wrapping was insulted by handling in the handbag for the sample brand of Paracil

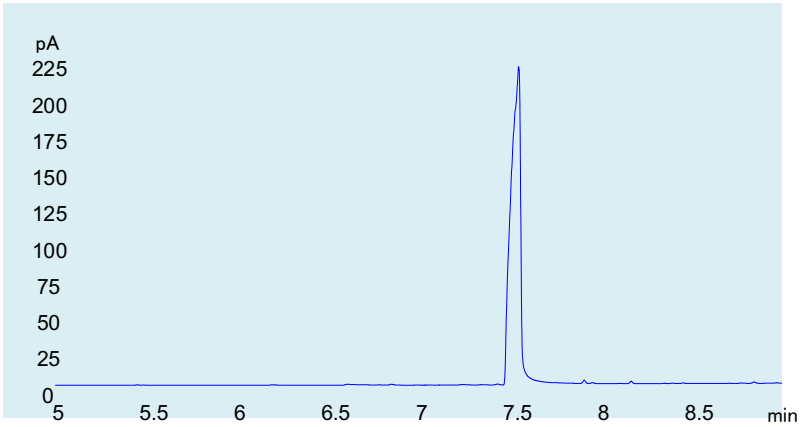


Figure 4.21 The chromatogram of the glass container was insulted by handling in the pocket pants for the sample brand of Paracil

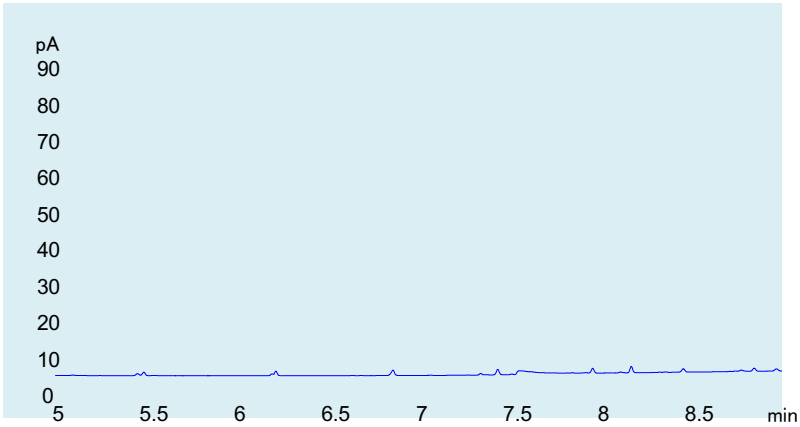


Figure 4.22 The chromatogram of the plastic bag was insulted by handling in the pocket pants for the sample brand of Paracil

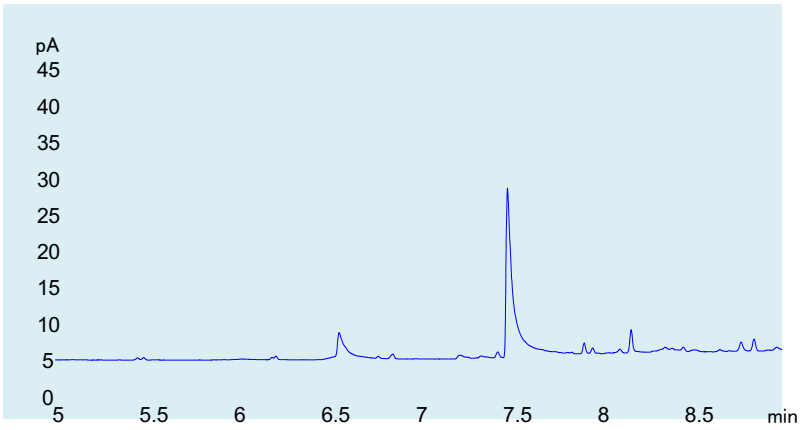


Figure 4.23 The chromatogram of the paper wrapping was insulted by handling in the pocket pants for the sample brand of Paracil

Table 4.20 Detection of paracetamol container brand of Panadol Menstrual

Physical Insult	Glass Container	Plastic Bags	Wrapped in paper
Shaking	Yes	No	No
Shaking - put in car for one week	No	No	Yes
Handling - put in handbag for one week	No	No	Yes
Handling – put in pocket in pants for one week	No	No	Yes

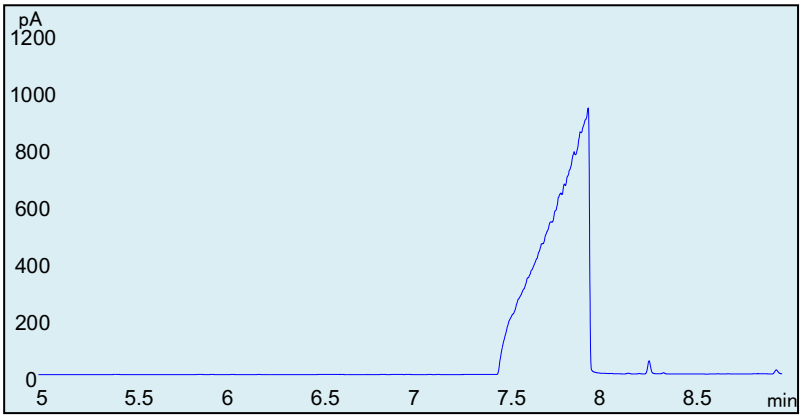


Figure 4. 24 The chromatogram of the glass container was insulted by shaking the sample brand of Panadol Menstrual

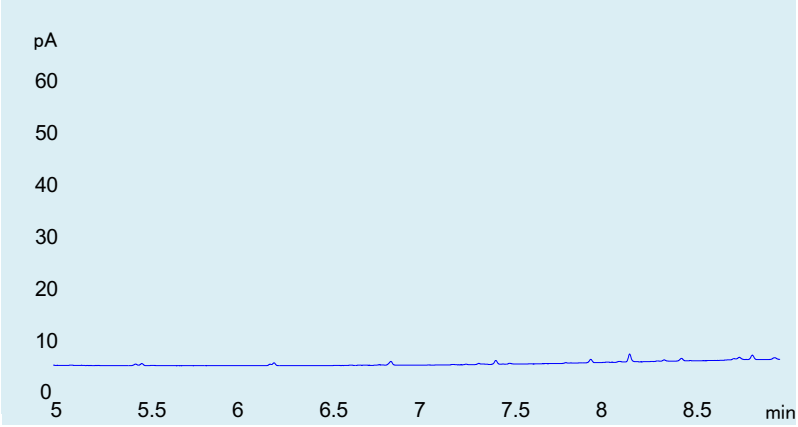


Figure 4. 25 The chromatogram of the plastic bag was insulted by shaking the sample brand of Panadol Menstrual

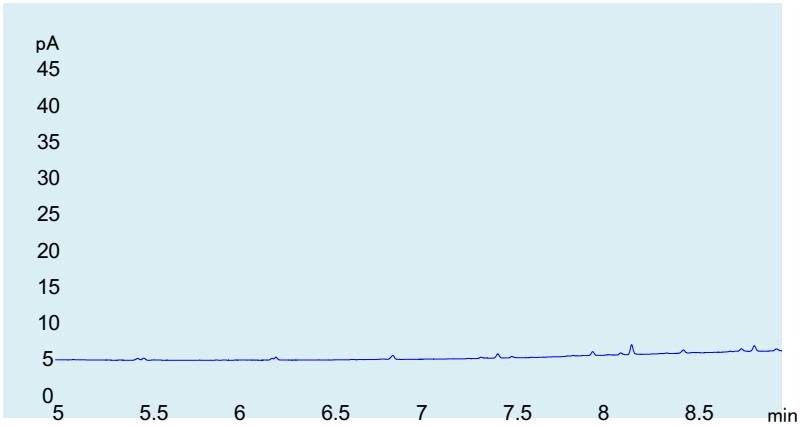


Figure 4.26 The chromatogram of the paper wrapping was insulted by shaking the sample brand of Panadol Menstrual

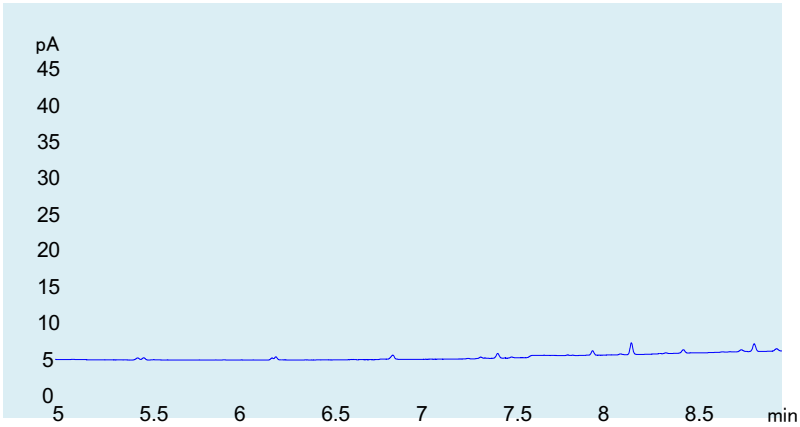


Figure 4.27 The chromatogram of the glass container was insulted by shaking inside the car for the sample brand of Panadol Menstrual

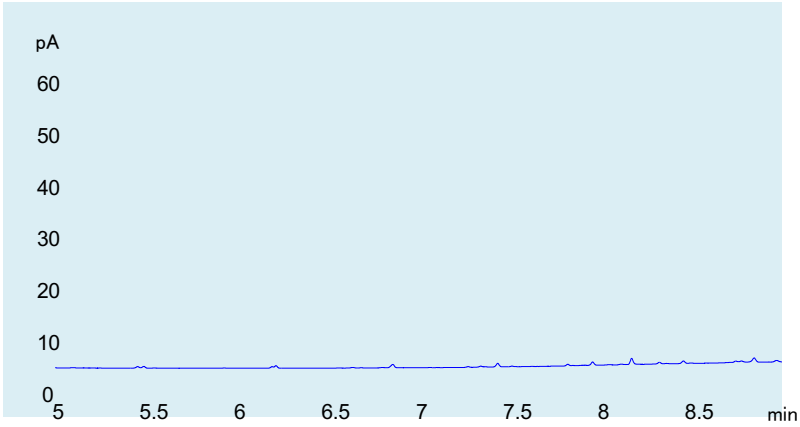


Figure 4.28 The chromatogram of the plastic bag was insulted by shaking inside the car for the sample brand of Panadol Menstrual

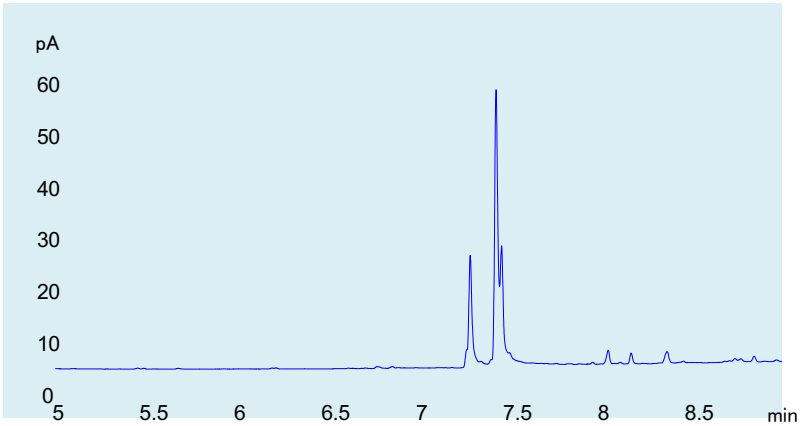


Figure 4.29 The chromatogram of the paper wrapping was insulted by shaking inside the car for the sample brand of Panadol Menstrual

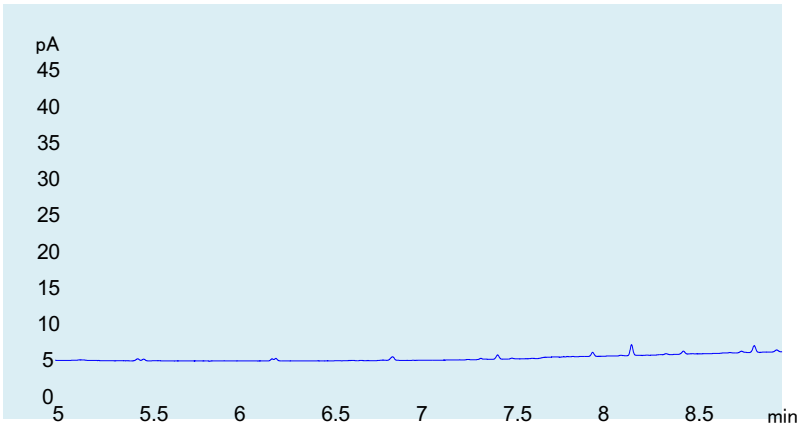


Figure 4. 30 The chromatogram of the glass container was insulted by handling in the handbag for the sample brand of Panadol Menstrual

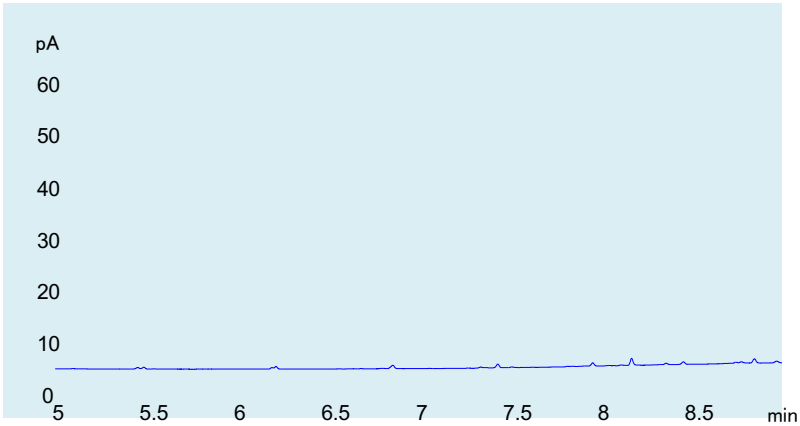


Figure 4.31 The chromatogram of the plastic bag was insulted by handling in the handbag for the sample brand of Panadol Menstrual

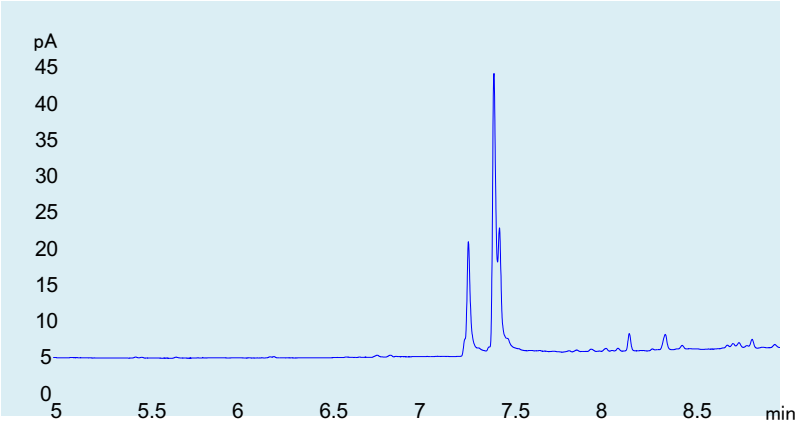


Figure 4.32 The chromatogram of the paper wrapping was insulted by handling in the handbag for the sample brand of Panadol Menstrual

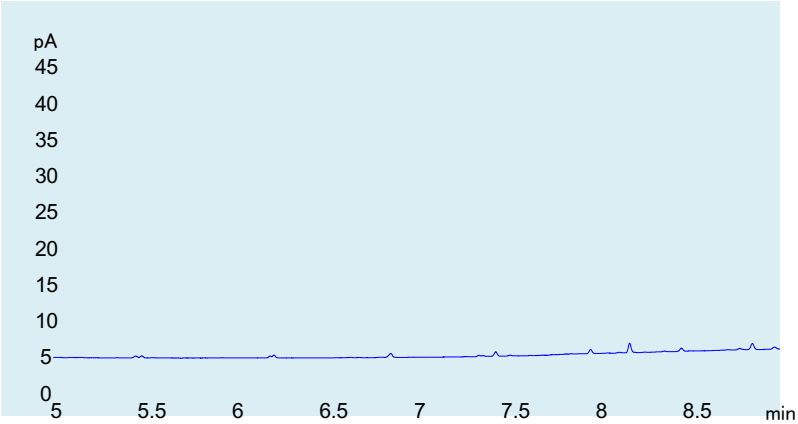


Figure 4.33 The chromatogram of the glass container was insulted by handling in the pocket pants for the sample brand of Panadol Menstrual

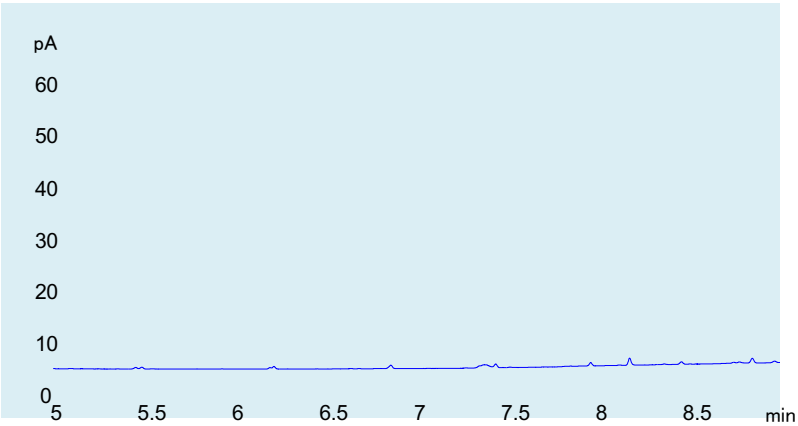


Figure 4.34 The chromatogram of the plastic bag was insulted by handling in the pocket pants for the sample brand of Panadol Menstrual

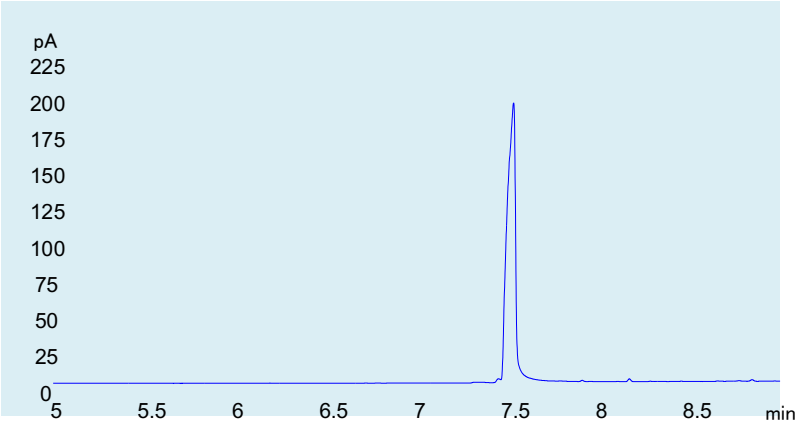


Figure 4.35 The chromatogram of the paper wrapping was insulted by handling in the pocket pants for the sample brand of Panadol Menstrual

In pharmaceutical industries, the glass container is the main choice in packaging because of their excellent gas and moisture barrier properties (Vilivalam *et al.,* 2016). However, glass might not be the best solution for all chemicals or biological drugs because it contains free alkali oxides and trace of metals. One disadvantage of the glass container is that it may break during processing or transportation and also when it is stored in low freezing temperature (Vilivalam *et al*., 2016). In other words, a glass container may cause the sample to be damaged, but in forensic analysis, the trace was left in the container can be important evidence.

Vilivalam *et al.* (2016) also mentioned plastic material was also chosen the most choice in global pharmaceutical packaging. In this study, showed that all the sample in plastic packaging were well preserved either in their physical characteristics or leaving any trace, note also that the plastic bag sample with the brand of Paracil which insulted by handling in the handbag, had given positive detection using GC-FID compared to the brand of Panadol Menstrual, all types of insult does not leave any trace. This could happen because the degree of insult to the sample had successfully transferred to residues or to the plastic bags.

Referring to the wrapped paper, sample brand of Paracil which appeared white in colour, no trace was detected using eye observation. However, the presence of paracetamol was detected on paper wrapping materials that insulted by putting in pocket pants. Other physical insults did not give any positive results. For the brand of Panadol Menstrual, due to its pink colour appearance, it was easy to observe using visual examination where the packaging paper was noticed with pink colour stain. Additionally, the positive detection of paracetamol insulted by shaking inside a car, in handbag and in pocket pants. In a forensic investigation, paper wrapping packaging might cause loss of samples as compared to others, as it could not preserve or protect the sample from degradation or humidity and temperature, as evident in this study.

All types of packaging have their own advantages and disadvantage. It was found to be dependent on what information the forensic analyst want to get from the evidence. The weight of drugs is an important element in investigation and legislation but for intelligence aspect, the small amount of drug detected could give a lot of information in the forensic investigation even in the empty container by using visual observation. Certain forensic evidence such as container or packaging materials could be tested for the presence of drugs if they are suspected to have contained drugs prior to removal by the criminals. Besides this study also stressed the importance of selecting an appropriate sampling and storage procedure of tablet drug-related evidence. Certain packaging method while subjected to physical insults could greatly change the physical properties of the forensic evidence, especially on the wrapped paper. The forensic investigator must carry out the most suitable sampling method and the analysis shall be performed as soon as possible to avoid the tampering or contamination of the samples and to maximise the recovery and detection of the target compound.

CHAPTER 5
CONCLUSION AND FUTURE RECOMMENDATIONS

5.1 Conclusion

From this study, different exposure and handling condition of drugs could affect their physical characteristics in terms of their weight, dimension and some drugs might easy to break with their fragile nature. Different drugs could carry different behaviours. Both types of brands of paracetamol show the changes of the in physical characteristic when insult by shaking in a glass container. It shows that glass container is not a good container for drug packaging but on the other hand, the glass container is a good exhibit for forensic investigation at the crime scene such as a clandestine lab. It proves by the trace of paracetamol in a glass container in this study by using GC-FID. Additionally, the types of container and packaging materials might also affect the physical characteristics of drugs added to physical insults. This study found that a certain combination of packaging material and physical insult could lead to positive detection of target drug-using instrumental analysis. This study was found the plastic bag container is a good type of drug container among others. However, the plastic bag is still can insult the sample but it depends on the degree of insult and the way of preserving the sample. To conclude, this study provided important information in handling of confiscated drugs and the significance in packaging evidence during a forensic investigation. Besides, any packaging materials suspected to have contained any drugs could be tested using the instrumental analysis to investigate the modus operandi of the forensic cases.

5.2 Limitations of Study

As we know this study was conducted during Covid-19 pandemic, limitations were encountered, including the preparation of samples. As the experiments for

physical insults were conducted outside the laboratory, others external factors could have been introduced especially during the transportation of sample prior to the instrumental analysis. The number of samples and the types of physical insults were limited in the current study. If possible using real illicit drugs such as amphetamine-type stimulants (ATS) and can be exposed to other physical insults to reflect the real case scenarios.

Beside that, there was limited of access to the previous research studies related on this topic. As this study conducted during Covid-19 pandemic and the movement control order (MCO), the access to the supervisor, documents, organisation such as Department of Chemistry Malaysia were limited. The others problem for this study was the limitation of the instrument during the data collection including the error when taking the measurement of the sample and the contamination during handling the sample which may affect the result.

Futhermore, the image quality that had been recorded was not good. Its may due to the types of the camera was used and the lighting of the image background. This is important to show the physical changes of the sample and the other's observation on the container especially the transferred colour to the container.

5.3 Future Recommendations

Mansour *et al*. (2018) have found that physical stability of certain drugs depends on the hardness, the friability and the chemical stability. The characteristics of a drug could be also affected by the environmental condition including temperature, pH, moisture, light, the exposure to oxygen and concentration of drugs. Therefore, the stability of sample should be tested to reflect the real case scenarios. Other than that, the variety of containers could be used for packaging purposes such as aluminium

container and foil, clothe or others types of packaging that might be used in drug packaging. The weather and humidity could the factor to be investigated in future research and determine to handle the appropriate ways wet drug exhibit.

The various range of time could be used in future study to observe more physical insult and the degradation of sample related to the real case scenario. The study of force degradation on drugs by Blessy *et al*. (2014) have found that the force degradation drug are potential to be degrade or not under relevant storage but it assist in developed method of stability. It is better to start with degradation studies so that it will gain information of drugs stability and the storage condition will determine (Blessy *et al*., 2014). The information or survey from forensic analyst and law enforcement department should be used for further research to found the real situation and problems in handling of drug investigation.

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