

OP-220 [Beekeeping Technology and Quality]

Honey Fraud: What Should We Know?

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BACKGROUND: Globally, the Food Fraud Database ranks honey as the third most counterfeit food. While some perceive this issue merely as a matter of consumer rights and trade, the profound implications on human health and beekeeping sustainability are often overlooked. Our study investigates the complex impacts of honey's authenticity beyond consumer rights and market dynamics using several research models. **METHODOLOGY:** We collected honey samples from wild bees in the jungle and local apiary farms and purchased honey from the local market. These samples underwent authenticity analyses encompassing physicochemical and antioxidant assessments and metabolomic analysis prior to conducting cell culture and animal study. **RESULTS:** All jungle and farm-sourced honey (pure honey) met international standards from the Honey Commission and Codex. In contrast, 90% of honey from the market failed to meet these standards, indicating widespread counterfeit honey. Pure honey exhibited significant benefits in cellular and animal models, including inhibiting cancer cell growth, stimulating normal cell viability, controlling adipocyte size and lipid volume and reducing blood sugar, cholesterol, and triglyceride levels. Conversely, fake honey stimulated cancer cell growth, decreased the viability of the normal cells, increased glucose and lipid levels and induced toxicity in rat livers and kidneys over four weeks of consumption. Data from metabolomics also supported the discrepancy effects of pure and fake honey samples. **CONCLUSION:** The medicinal benefits of honey are solely derived from pure sources, while fake honey leads to numerous health risks. Intriguingly, data from our study has been used as one of the guidelines for the authority's enforcement in preventing fake honey trading and systematically increasing pure honey production. However, more advanced methods and prompt actions are required to combat the honey fraud issue worldwide. **IMPLICATION:** The authenticity of honey not only affects consumer health and rights but also reverberates through food security and environmental sustainability. Preserving bee populations and ensuring the authenticity of honey is imperative for safeguarding our future well-being and ecological balance. Thus, prompt actions need to be taken to overcome the honey fraud throughout the world for the sake of all life on this planet!



Honey Fraud: What Should We Know?

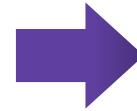
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Introduction

Beekeeping History

Human – Bee relationship has evolved over time 40,000 year ago



It has transitioned from simple honey-hunting to sophisticated beekeeping techniques



Cave painting from Spain, around 6000 BC



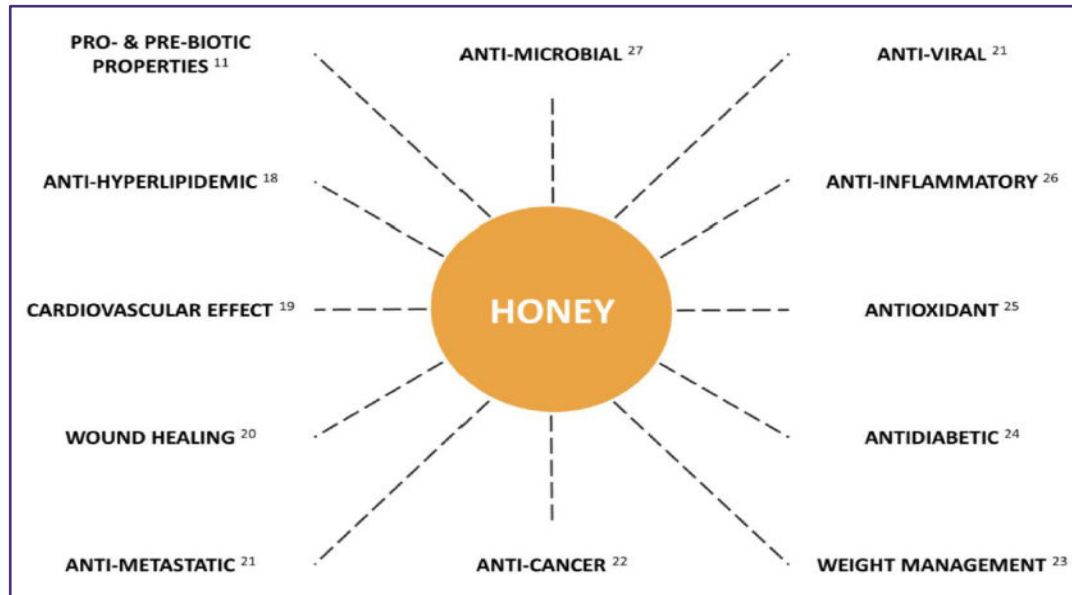
Traditional honey-hunting in Malaysia



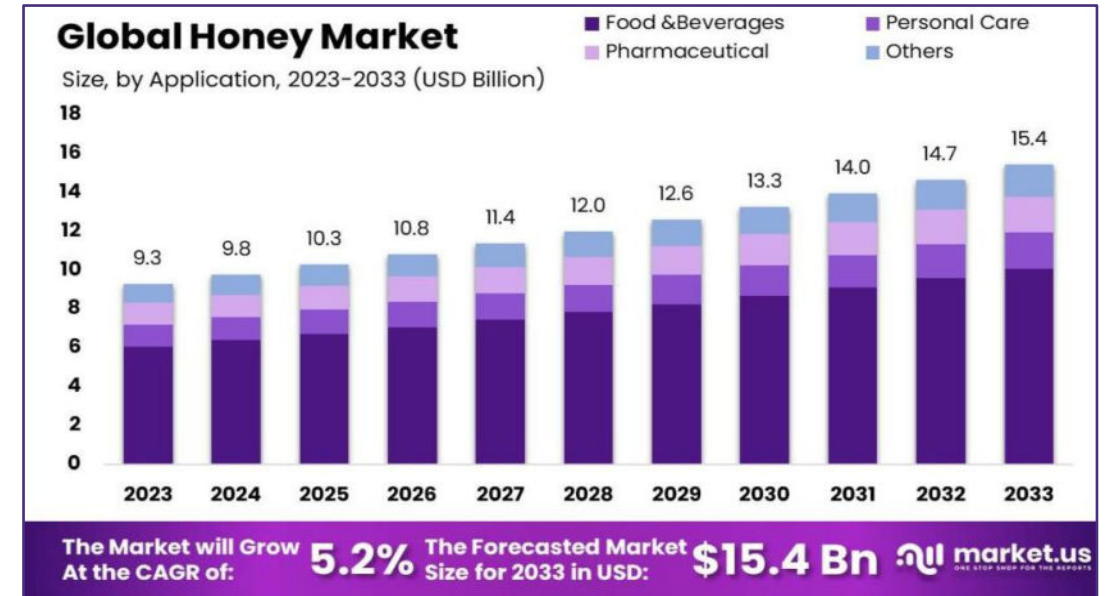
Modern beekeeping in Malaysia

Introduction

Global Trends & Health Benefits



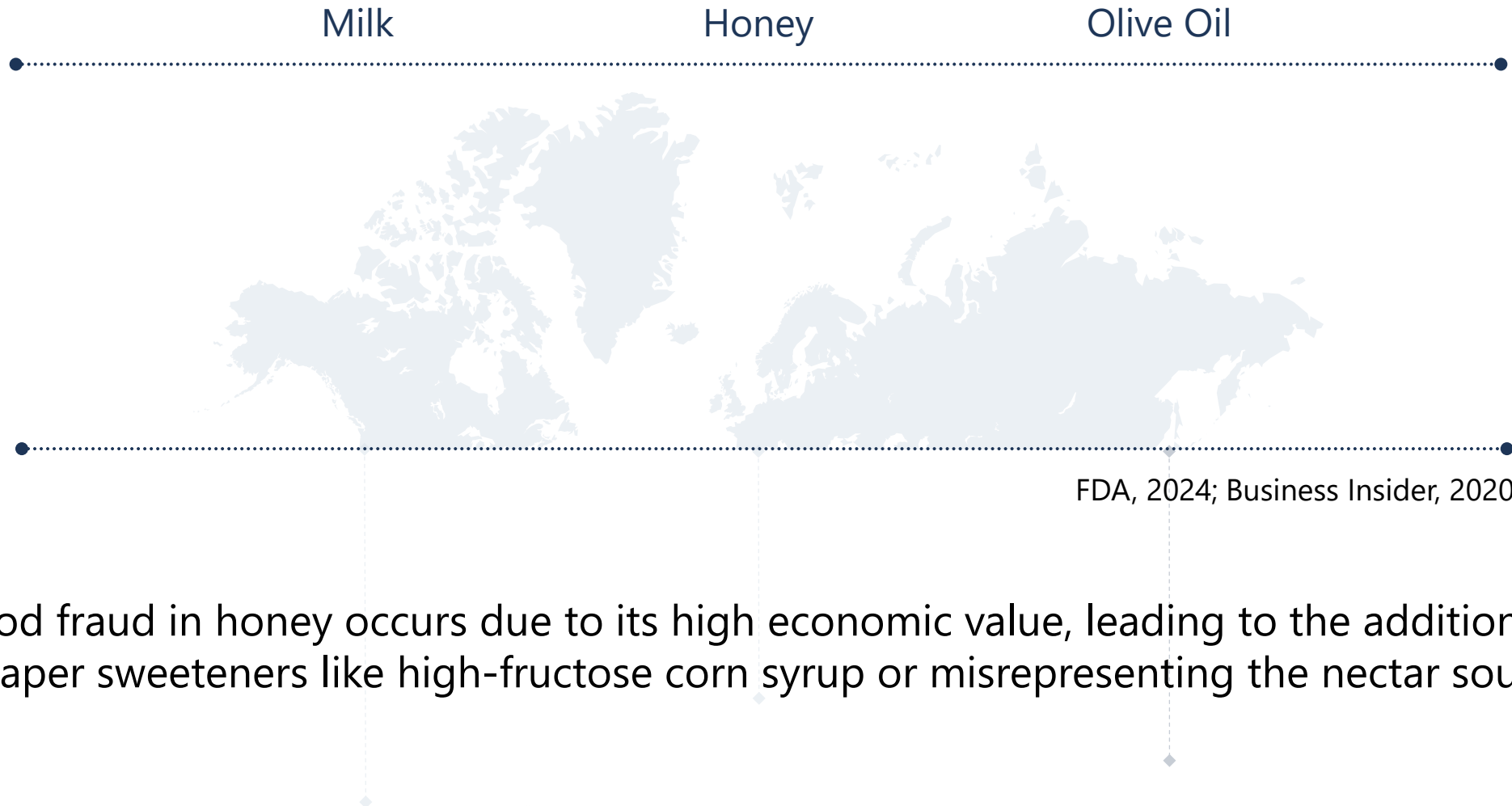
Honey offers **various health benefits** and is classified as a **functional food** (Ismail, 2016; Zulkifli et al., 2022)



The honey market demand is increasing from time to time, from **USD 9.3 billion in 2023 up to USD 15.4 billion in 2033** (Market.us, 2023)

Introduction

Honey is world third most faked food



Introduction

Honey is world third most faked food



Honey Authenticity Network, 2018

Honey is **highly counterfeited**, with reports in 2018 showing that about **1/3** of globally traded honey is **adulterated**

90% of samples failed authenticity tests in the UK
(9th November 2024, The Guardian)



Research using Honey

STUDY 1 Honey Bee Honey

1

Physicochemical &
phytochemical
analysis

2

In vitro & *in vivo*
obesity studies

STUDY 2 Stingless Bee Honey

1

Screening honey's
authenticity using
RapidRAW™

2

Physicochemical
analysis

3

Metabolomic
analysis

4

In vitro cancer
studies

STUDY 1

Research using **Honey Bee Honey**

A Study Comparing **Pure Pineapple Honey** with **Fake Honey**

- ① *Physico- & phytochemical analysis*
- ② *in vitro obesity analysis*



Pure Pineapple Honey

A. mellifera
Pineapple Plantation
Johor, Malaysia



Fake Honey

Purchased at local
market

STUDY 1

Research using **Honey Bee Honey**

1 Physicochemical & phytochemical analysis of **Pure Pineapple Honey** and **Fake Honey**

Table 1: Physicochemical data of pure pineapple honey and fake honey

Parameter (Codex)	Pure Pineapple Honey	Fake Honey
Moisture Content, % (<21%)	22.3	18.7
pH	3.50	3.79
Free Acidity, meq/kg	85.2	24
Ash Content, g (<0.6g)	0.18	ND
HMF, mg/kg (<80mg/kg)	0.68	195.4
Glucose Oxidase	Active	ND

STUDY 1

Research using **Honey Bee Honey**

1 Physicochemical & phytochemical analysis of **Pure Pineapple Honey** and **Fake Honey**

Table 2: Sugar composition in pure pineapple honey and fake honey

Parameter (Codex)	Pure Pineapple Honey	Fake Honey
Reducing Sugar, % (>60%)	70.43	49.29
Fructose/Glucose Ratio (1)	1.55	0.75
Sucrose, % (<5%)	2.63	5.75

Table 3: Antioxidant content in pure pineapple honey and fake honey

Parameter	Pure Pineapple Honey	Fake Honey
Total Phenolic Content, mg GAE/kg	186.56	40.93
Total Flavonoid Content, mg CA/kg	36.66	14.75

STUDY 1

Research using **Honey Bee Honey**

2

Effects of **Pure Pineapple Honey** and **Fake Honey** on Obesity Study: *in vitro* Analysis

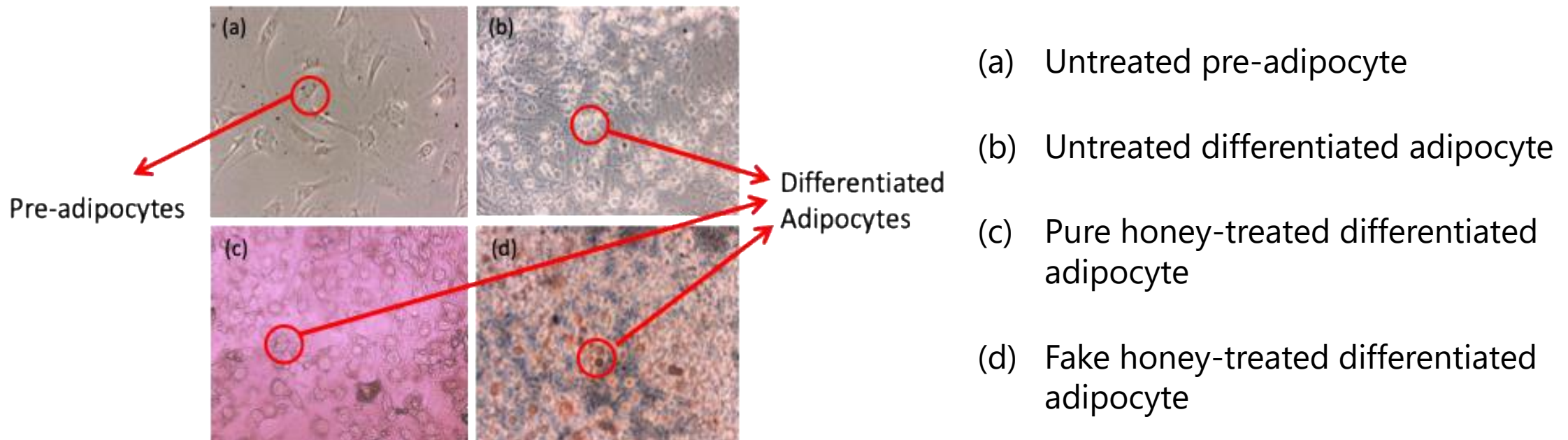


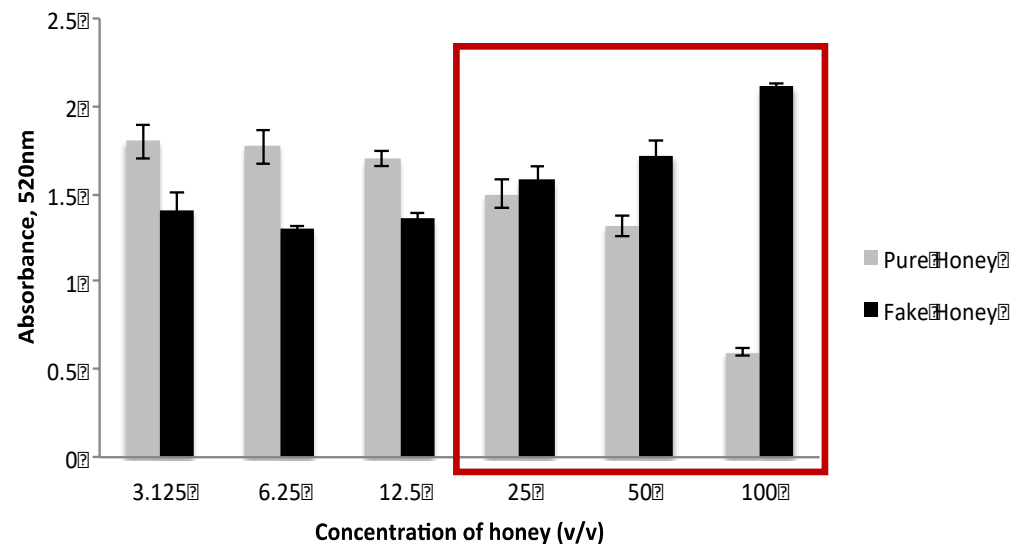
Figure: **Lipid accumulation** of (a) pre-adipocyte **3T3-L1 cells**, (b) differentiated adipocyte 3T3-L1 cells and differentiated adipocyte after being treated with pure (c) and fake (d) honey for 72h

STUDY 1

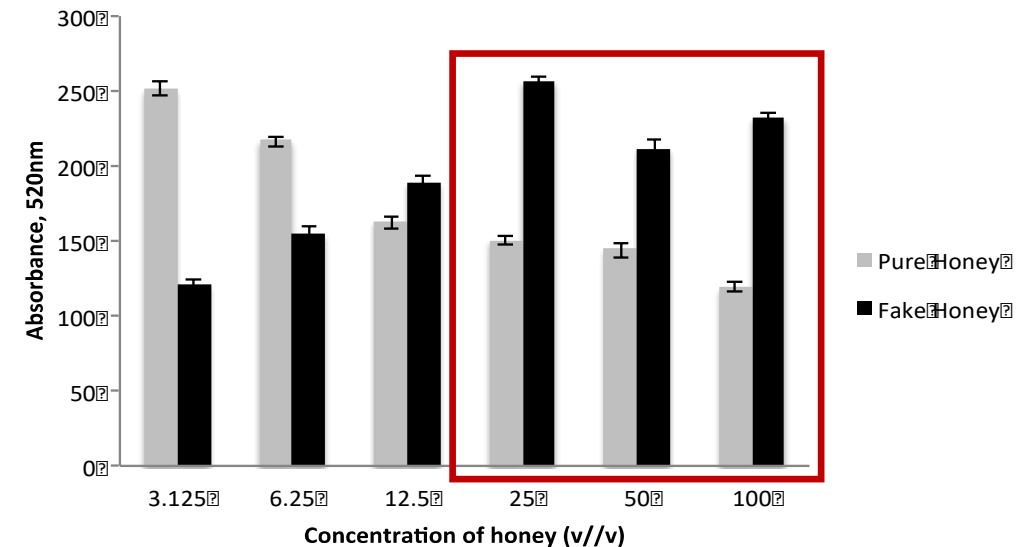
Research using **Honey Bee Honey**

2

Effects of **Pure Pineapple Honey** and **Fake Honey** on Obesity Study: *in vitro* Analysis



(a)



(b)

Figure: **Lipid accumulation** (a) and **triglyceride level** (b) in differentiated **3T3-L1** adipocytes treated with pure pineapple and fake honey. The accumulation was measured spectrophotometrically after being treated with several concentrations of the honey (0 – 100 % v/v). Results were presented in mean $\pm$ SD (n=4).

STUDY 1

Research using **Honey Bee Honey**

2

Effects of **Pure Pineapple Honey** and **Fake Honey** on Obesity Study: *in vitro* Analysis

- **Physicochemical and phytochemical data** from pure pineapple honey are **significantly different** from **fake honey**, especially free acidity, HMF, sugar parameter and antioxidant levels.
- **Fake honey significantly increased the lipid accumulation and triglyceride levels** in the fat cells (adipocytes) **compared to the pure pineapple honey**.

STUDY 1

Research using **Honey Bee Honey**

A Study Comparing **Pure Pineapple Honey** with **Fake Honey**

- ① *Physico- & phytochemical analysis*
- ② *in vivo obesity analysis*



Pineapple
Honey

A. mellifera
Acacia Forest
Johor, Malaysia



Acacia
Honey

A. mellifera
Acacia Forest
Johor, Malaysia



Gelam
Honey

A. dorsata
Setiu Forest
Terengganu, Malaysia



Fake Honey

Purchased at local
market

STUDY 1

Research using **Honey Bee Honey**

1 Physicochemical & phytochemical analysis of **Pure Pineapple, Acacia, Gelam** and **Fake Honey**

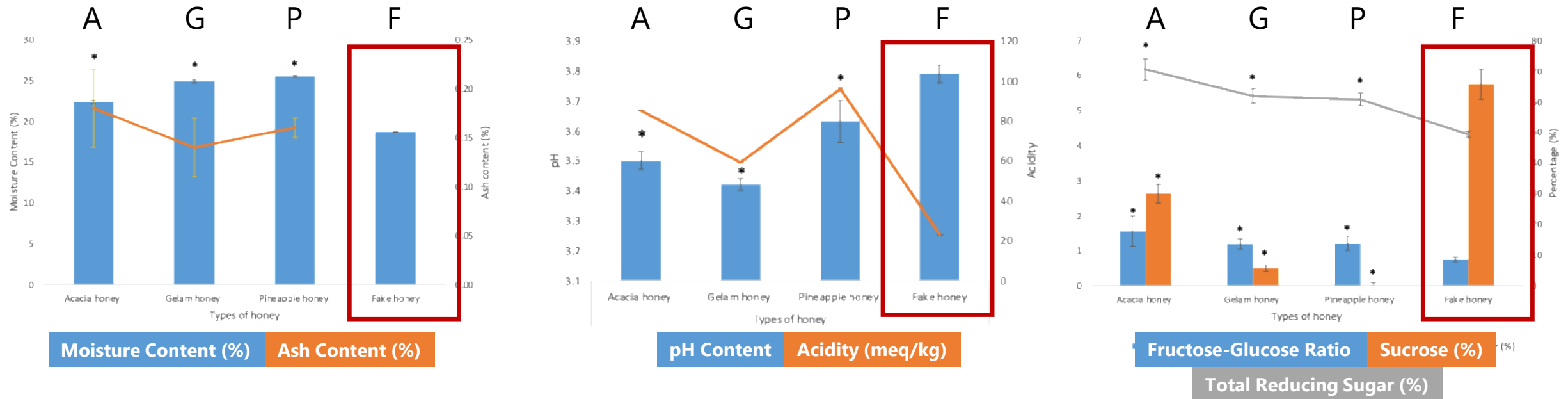


Figure: Physicochemical (moisture & ash content, pH & acidity) and sugar analysis of Acacia (A), Gelam (G), Pineapple (P) and fake (F) honey (Samat, Ismail et al., 2018; Samat, Ismail et al., 2017).

STUDY 1

Research using **Honey Bee Honey**

1

Physicochemical & phytochemical analysis of **Pure Pineapple, Acacia, Gelam** and **Fake Honey**

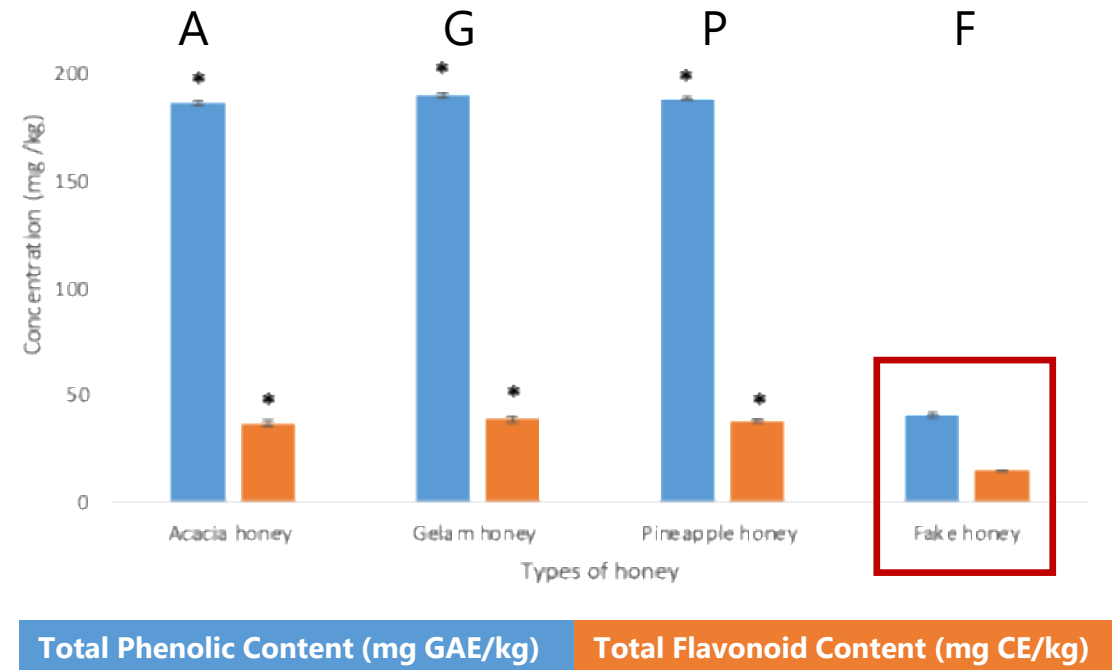
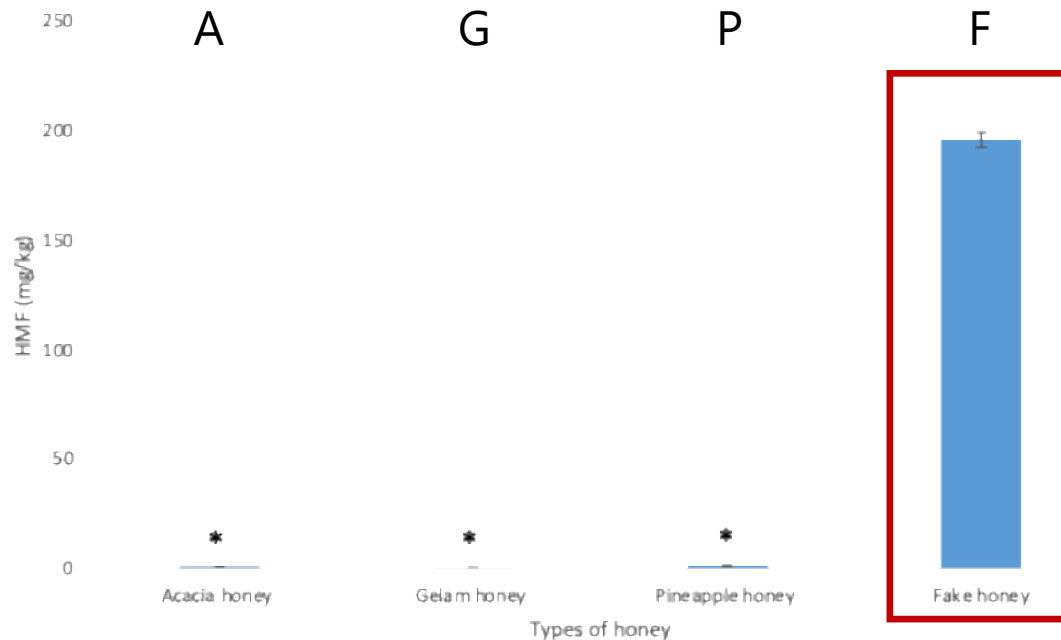


Figure: HMF and antioxidant analysis of Acacia, Gelam, Pineapple and fake honey (Samat, Ismail et al., 2018; Samat, Ismail et al., 2017).

STUDY 1

Research using **Honey Bee Honey**

2 Effects of Acaria, Gelam, Pineapple and Fake Honey on **O**besity: An **A**nimal **S**tudy

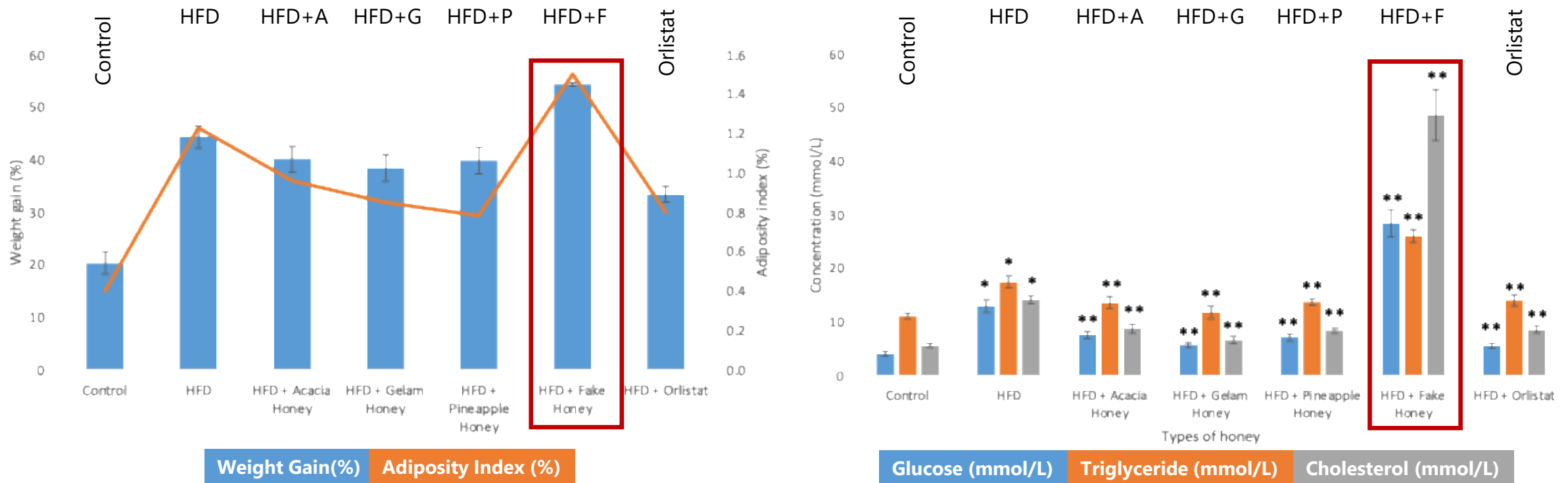
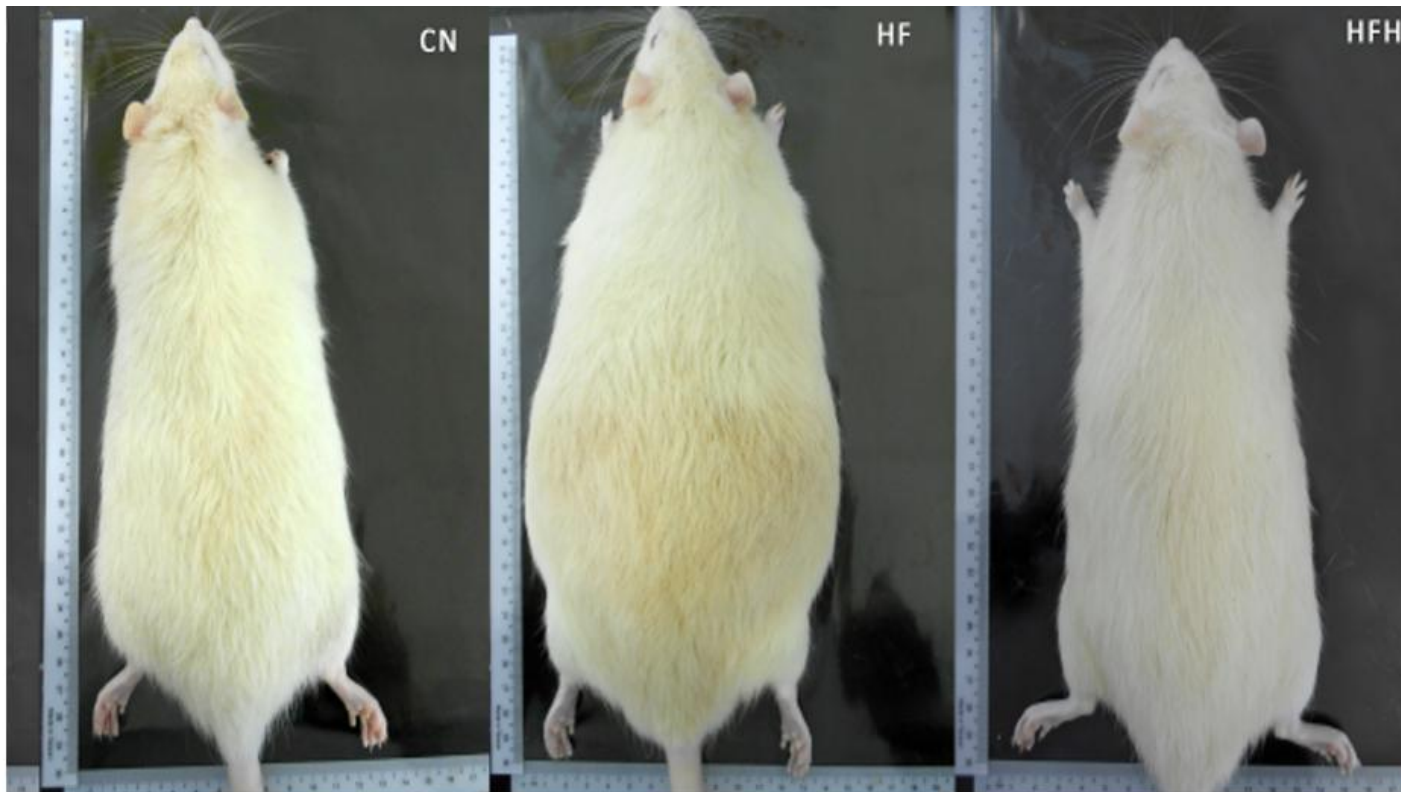


Figure: HMF and antioxidant analysis of Acacia, Gelam, Pineapple and fake honey. (Samat, Ismail et al., 2018; Samat, Ismail et al., 2017)

STUDY 1

Research using **Honey Bee Honey**

2 Effects of **Acacia, Gelam, Pineapple** and **Fake** Honey on **Obesity**: An **Animal Study**



Left: Control rat

Middle: Obese-induced rat +
fake honey (2g/kg for 16 weeks)

Right: Obese-induced rats +
pure honey (2g/kg for 16 weeks)

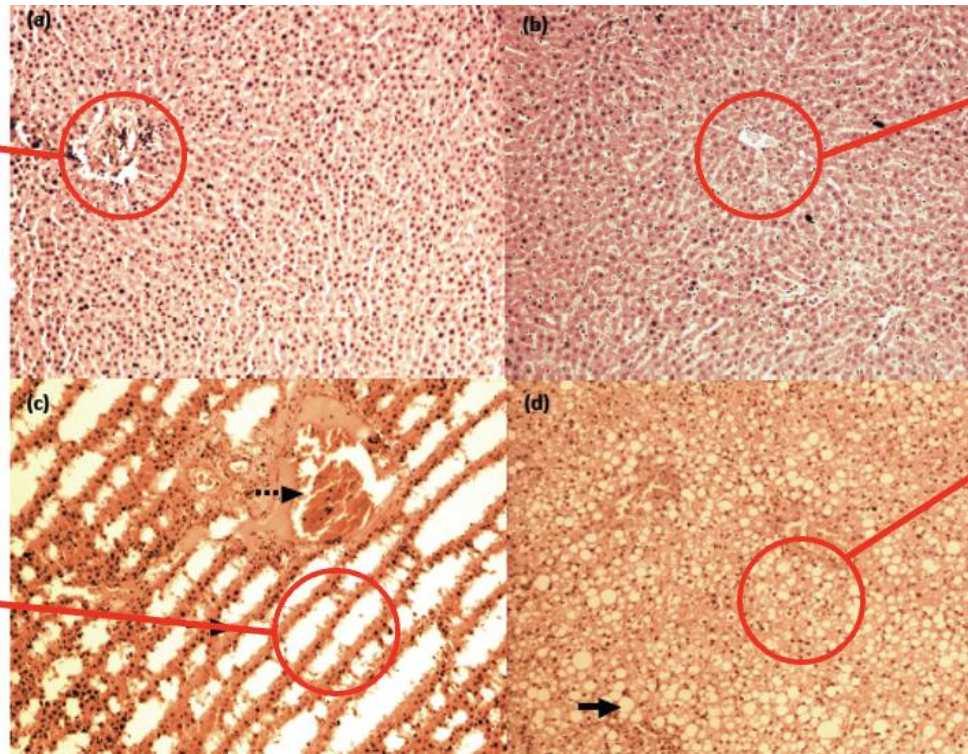
STUDY 1

Research using **Honey Bee Honey**

2

Effects of **Acacia, Gelam, Pineapple** and **Fake** Honey on **Obesity**: An **Animal Study**

- Normal histology
- Sinusoidal cords of hepatocytes with central vein & portal tracts



- Sinusoidal cords of hepatocytes with central vein & portal tracts
- Normal lobular architecture
- No pathologies changes

- Distortion in the cell arrangement around the central vein
- Development of fibrosis with necrosis of hepatocytes

- Moderate to severe steatosis & hepatocytes ballooning
- Development of Mild to moderate intrahepatic hemorrhage & erythrocytes in central vein

Figure: Photomicrograph of rats liver fed with normal diet (a), pure honey (b) and fake honey (c, d) for 16 weeks (Samat, Ismail et al., 2018; Samat, Ismail et al., 2017).

STUDY 1

Research using **Honey Bee Honey**

2 Effects of **Acacia, Gelam, Pineapple** and **Fake** Honey on **Obesity**: An **Animal Study**

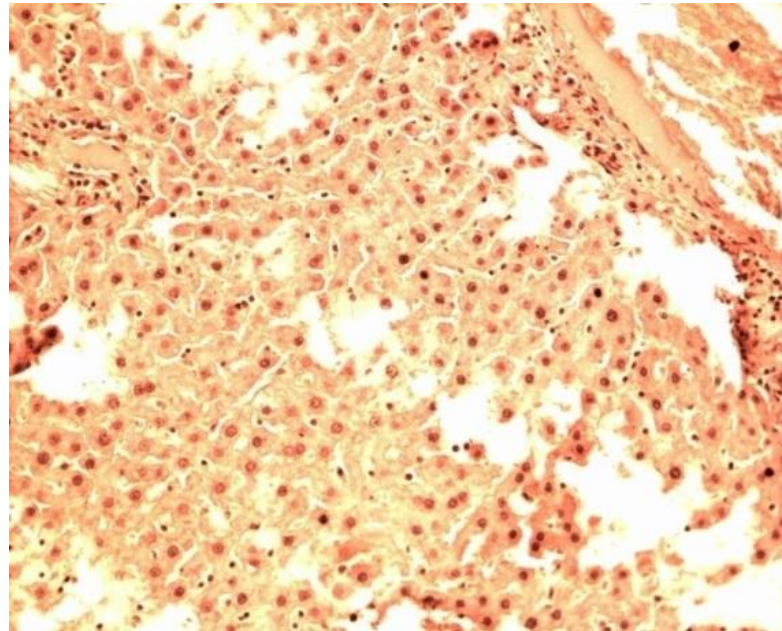


Figure: Photomicrograph of rats liver fed with commercial drug (orlistat) for 16 weeks (Samat, Ismail et al., 2018; Samat, Ismail et al., 2017)

STUDY 1

Research using **Honey Bee Honey**

2 Effects of **Acacia, Gelam, Pineapple** and **Fake** Honey on **Obesity**: An **Animal Study**

Acacia, Gelam & Pineapple honey showed similar results (obese-induce rats with high fat diet) compared to fake honey:

- **Reduce** weight gain & adiposity index
- **Reduce** glucose, triglyceride & cholesterol
- **Increase** adiponectin but reduce leptin
- **No toxicity effects** were observed (levels of AST & ALT and histological analysis)

Fake honey

- **Increase** weight gain & adiposity index
- **Increase** glucose, triglycerides & cholesterol
- **Increase** leptin but reduce the adiponectin level
- **Toxicity effects** observed (levels of AST & ALT-not shown and histological analysis)

STUDY 1

Research using **Honey Bee Honey**

2 Effects of **Acacia, Gelam, Pineapple** and **Fake** Honey on **Obesity**: An **Animal Study**

Meanwhile, orlistat (commercial anti-obesity drug)

- **Reduce** weight gain & adiposity index
- **Reduce** glucose, triglyceride & cholesterol
- **Increase** adiponectin but reduce level of leptin
- **Toxicity effects** were observed (levels of AST & ALT and histological analysis)

Research using Honey

STUDY 1 Honey Bee Honey

1

Physicochemical & phytochemical analysis

2

In vitro & *in vivo* obesity studies

STUDY 2 Stingless Bee Honey

1

Screening honey's authenticity using RapidRAW™

2

Physicochemical analysis

3

Metabolomic analysis

4

In vitro cancer studies

STUDY 2

Research using **Stingless Bee (Kelulut) Honey**

A Study Comparing **Pure Kelulut Honey** with **Adulterated** and **Fake Kelulut Honey**

- ① *Authenticity analysis*
- ② *Physicochemical analysis*
- ③ *Metabolomic analysis*
- ④ *in vitro cancer cell analysis*



Pure Kelulut Honey

H. Itama
Acacia Forest
Terengganu, Malaysia



Adulterated Kelulut Honey

Pure Kelulut Honey + 100%
glucose solution

+



Fake Kelulut Honey

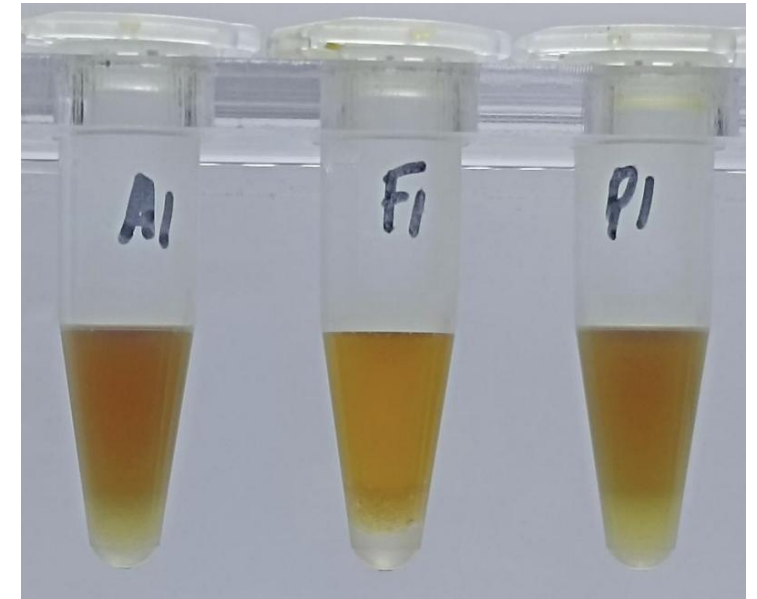
Supplied by MGVI,
Malaysia

STUDY 2

Research using **Stingless Bee (Kelulut) Honey**

1 Screening **Pure, Adulterated** and **Fake Kelulut Honey's** Authenticity using RapidRAW™

- RapidRAW™ is a patented method that quickly detects substances found in raw honey.
- It forms a precipitate of lipids and proteins in raw honey samples but not in sugar concoctions.
- While RapidRAW™ is a preliminary screening test for raw honey, it should not be used alone to determine authenticity or quality.



STUDY 2

Research using **Stingless Bee (Kelulut) Honey**

2 Physicochemical Analysis of **Pure, Adulterated** and **Fake Kelulut Honey**

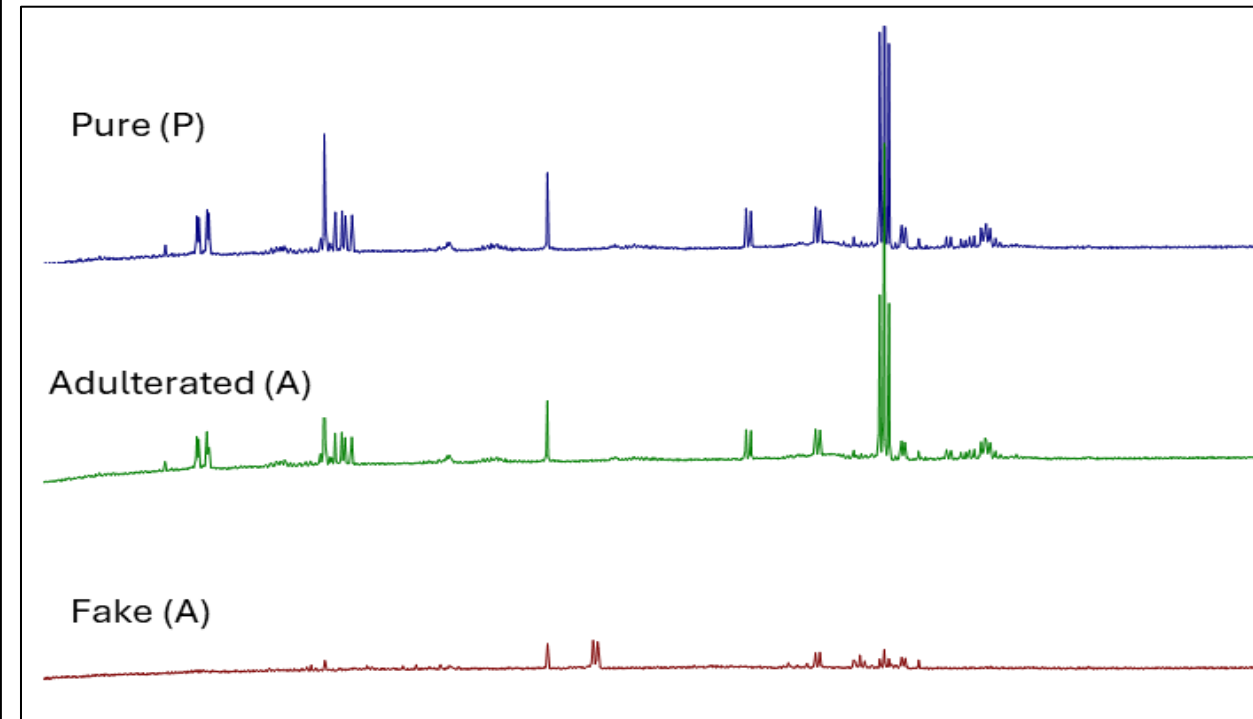
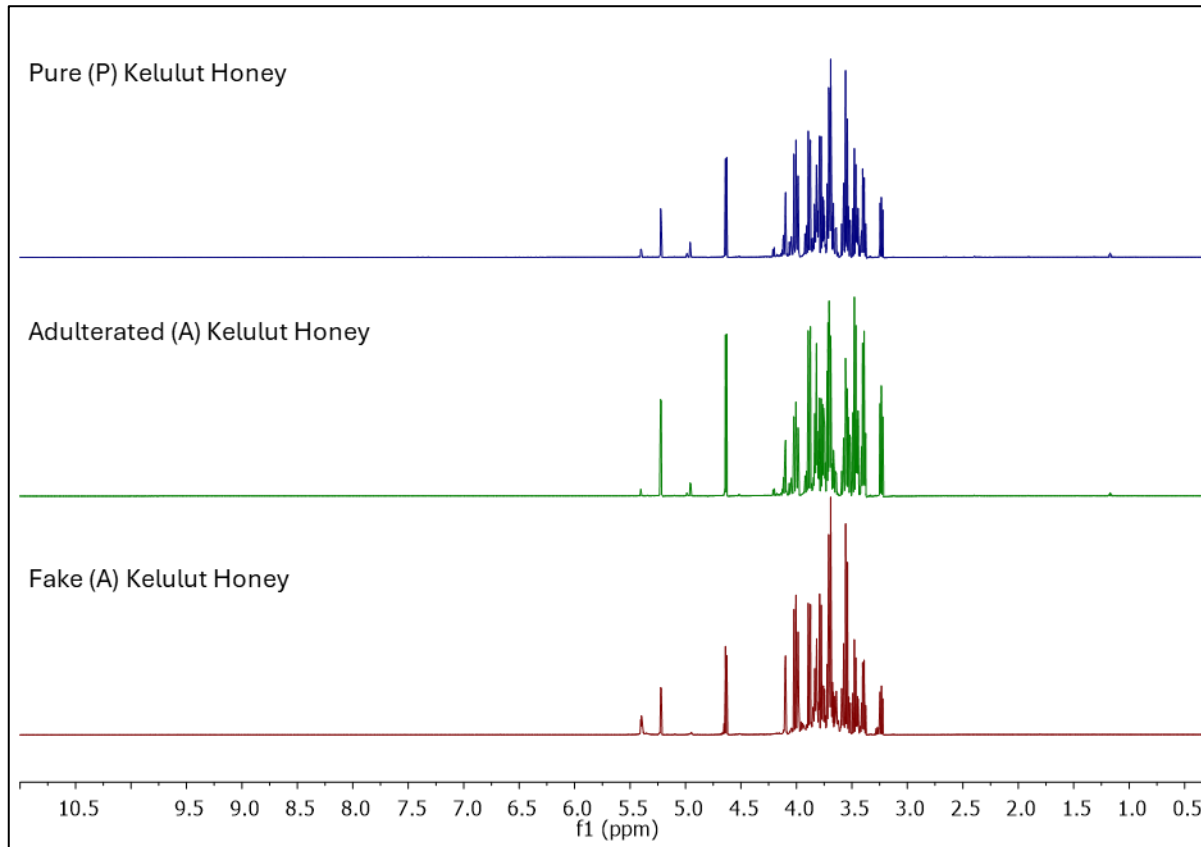
Table 1: Physicochemical data of Pure, Adulterated and Fake Kelulut honey

Parameter	Pure Kelulut Honey	Adulterated Kelulut Honey	Fake Kelulut Honey
Moisture Content, % (<21%)	28.1	26.0	>30
pH	3.42	3.57	3.02
Free Acidity, meq/kg	52	42	145
HMF, mg/kg (<80mg/kg)	0.427	111.042	300.226
Total Phenolic Content, mg GAE/kg	50.365	46.008	28.907
Total Flavonoid Content, mg CA/kg	65.104	55.688	16.01

STUDY 2

Research using *Stingless Bee (Kelulut) Honey*

3 ^1H NMR Metabolomic Analysis of **Pure, Adulterated** and **Fake Kelulut Honey**



STUDY 2

Research using **Stingless Bee (Kelulut) Honey**

3 ¹H NMR Metabolomic Analysis of **Pure, Adulterated** and **Fake Kelulut Honey**

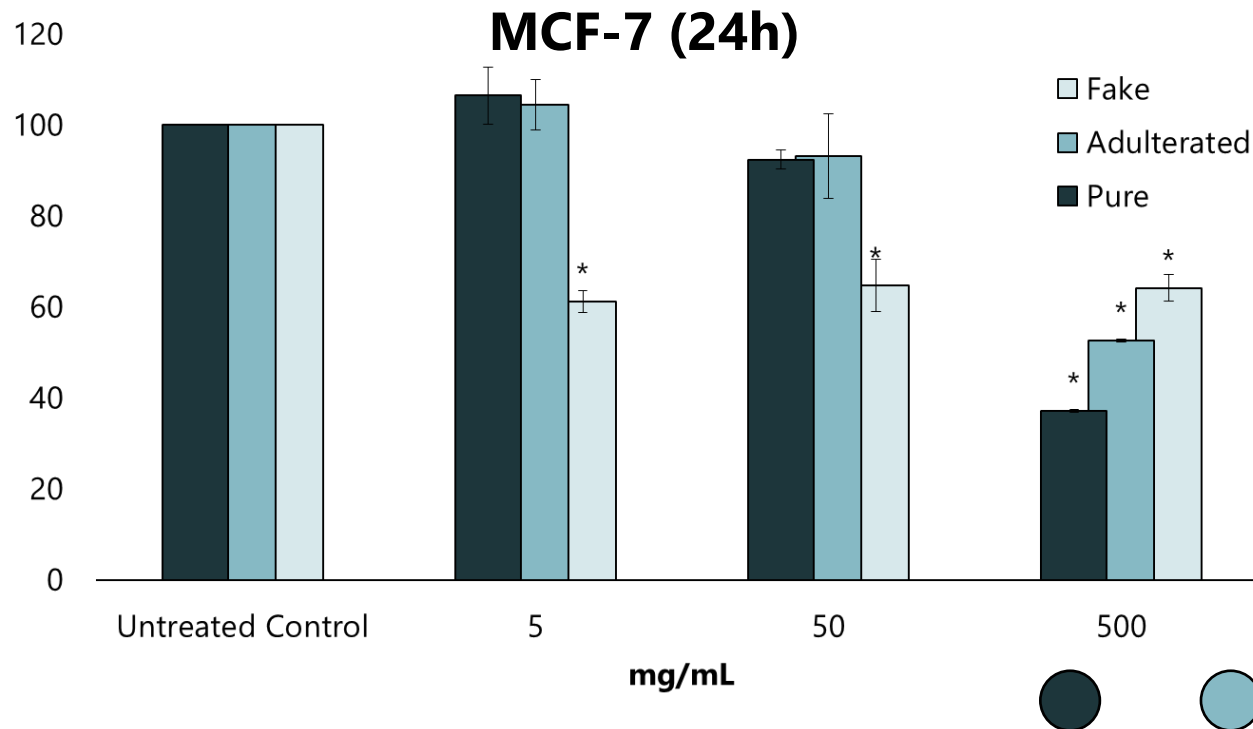
Table 2: Identified metabolites of pure (P), adulterated (A), and fake (F) kelulut honey based on ¹H NMR analysis

Compound	P	A	F	Compound	P	A	F
HMF			✓	Glutamic acid	✓	✓	
Formic acid	✓	✓	✓	Acetic acid	✓	✓	✓
2'-Deoxyguanosine	✓	✓		Lactic acid	✓	✓	✓
Phenylalanine	✓	✓		Alanine	✓	✓	
Tyrosine	✓	✓		Ethanol	✓	✓	✓
Maltose	✓	✓		Propylene glycol	✓	✓	✓
Sucrose	✓	✓	✓	Valine	✓	✓	
Tri- & Oligo-saccarrides			✓	Isoleucine	✓	✓	
Glucose	✓	✓	✓	Leucine	✓	✓	
Fructose	✓	✓	✓	Unknown			✓
Malic acid	✓	✓					

STUDY 2

Research using **Stingless Bee (Kelulut) Honey**

4 In Vitro Analysis of **Pure, Adulterated** and **Fake Kelulut Honey** using MCF-7 Cancer Cells



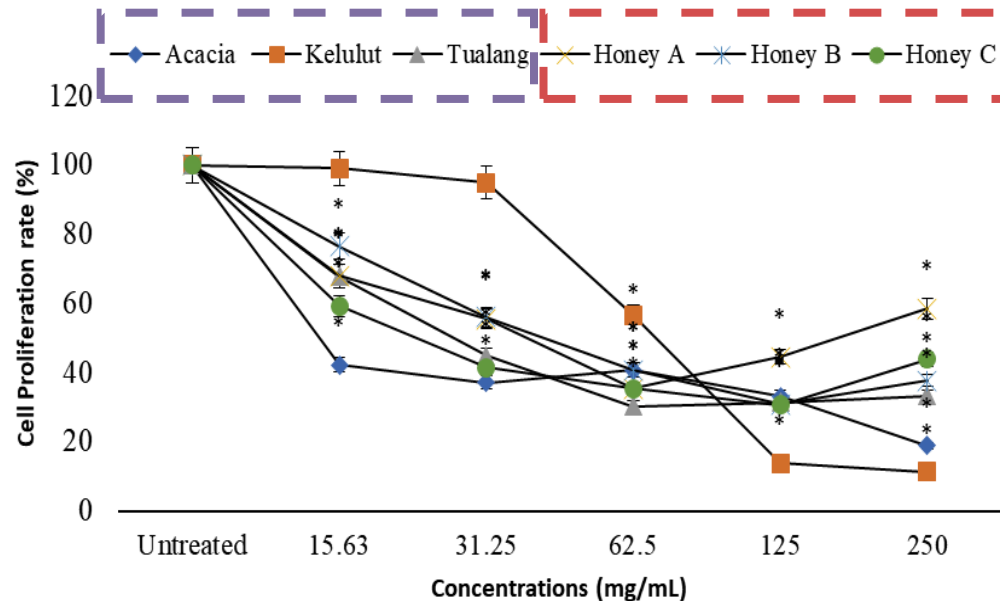
Pure honey shows higher cytotoxicity activity towards MCF-7 cells at high concentration (500 mg/mL) when compared to adulterated and fake Kelulut honey.

Figure: **Cell viability** of **MCF-7 cancer cell** after treated with **pure, adulterated** and **fake kelulut honey** for 24 hours.

STUDY 2

Research using **Honey Bee Honey**

Effects of **Pure Kelulut, Acacia, Tualang**, and **Fake Honey** on Cancer Study: *in vitro* Analysis



- Higher pure honey concentration = Lower MCF-7 cancer cell proliferation
- Low fake honey concentration = Low MCF-7 cancer cell proliferation
- High fake honey concentration = higher MCF-7 cancer cell proliferation

Figure: Effects of six types of honey at concentrations ranging from 15.63 mg/mL to 250 mg/mL on the proliferation of **MCF-7 cancer cells** after 72 hours. The results are presented in mean $\pm$ SEM (standard error mean).

Honey Fraud: What Should We Do?

Pure Honey
with health benefits

VS

Fake Honey
with health problems

----- Share the findings to all authorities, public etc. -----



Honey Fraud: What Should We Do?



Produced the first Malaysian Standard & MyGAP on the Stingless Bee Specification & Good Meliponiculture & Apiculture Practices

Honey Fraud: What Should We Do?



Holistic approach to supply pure honey = Developed 10-year Strategic Plan for Malaysian Beekeeping to help beekeepers (esp. from underprivileged people), entrepreneurs, scientists, policy makers, government & private sectors, NGOs to work together

Honey Fraud: What Should We Do?



Train more beekeepers, organize workshops, seminars, conferences, discussions etc.

Honey Fraud: What Should We Know?

Conclusion

- Honey fraud is getting more complicated.
- Fake honey production → sophisticated methods
- **Health benefits only from pure/natural honey.**
- **Fake honey = Major health problems & many other problems**
 - Honey consumers – consumer's right
 - Negative perceptions on honey
 - Beekeeping industry – may collapse
 - World ecosystem – food security etc.



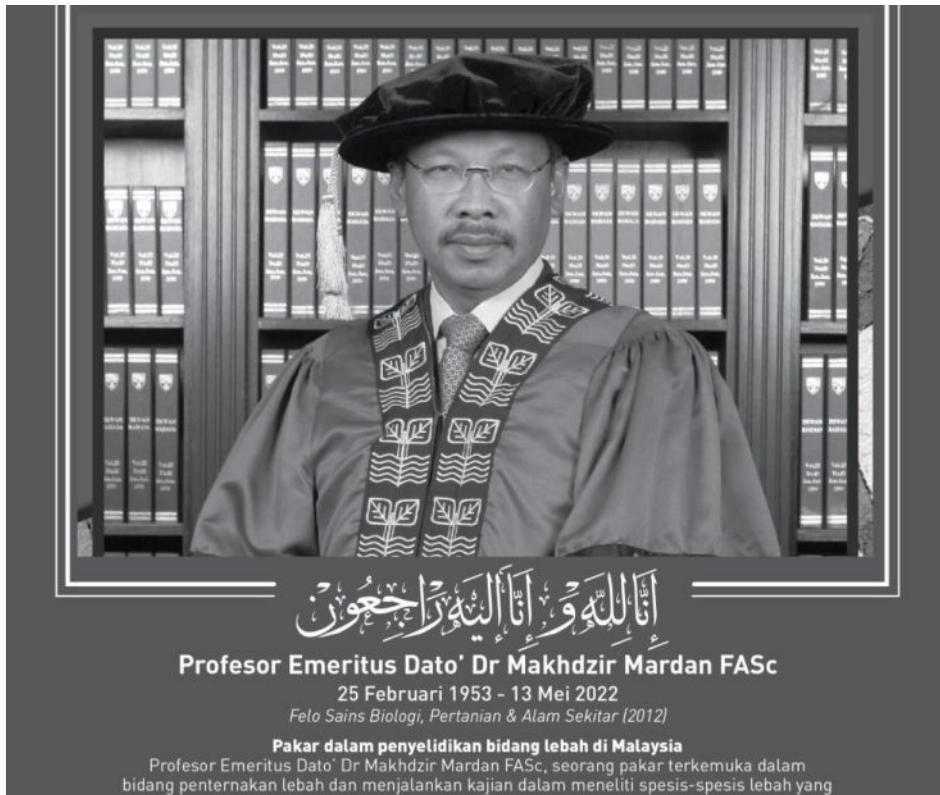
What can we do to solve the problems at the international level?

- Honey fraud is a global issue which has significant impacts to human being.
- Honey study **must** include **honey analysis (authenticity test)** to confirm the results/outcomes of the study.
- Develop robust **honey testing & honey standard**.
- **Looking for collaboration: From various sectors and expertise to overcome this issue effectively at the international level.**



Together
WE'RE
strong

Acknowledgement



- Late Mentor Prof. Emeritus Dato' Dr. Makhdzir Mardan, UPM (RIP)
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