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Shari'ah Compliance Safety for Malaysia Homestay *Muslim* Travellers

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Abstract

Muslim travellers are gradually showing interest in travelling to *Muslim*-friendly countries, specifically Malaysia. Malaysia is one of the few *Islamic*-viewing countries offering unique accommodation via the local homestay experience. However, the regulations set by the local authority are loosely enforced, especially regarding homestay guests' safety. Interpretations of safety are largely contributed only by each registered local homestay, with only minor guidelines provided by the local authority. It is also unclear whether the safety measures of homestays in Malaysia comply with *Shari'ah* principles. For example, under the official guidelines, insurance is to be adopted by homestays for the safety of the guest. However, *Muslim* travellers do not have a choice between *Shari'ah* and non-*Shari'ah* policies. When it comes to insurance policies, it is up to the homestay owner to provide *Shari'ah*-compliant or non-compliant coverage. Therefore, the article aims to explore whether the safety measures of homestays in Malaysia comply with *Shari'ah* principles and suggests ways to address these issues. Findings indicate that homestays' current level of safety and security in Malaysia is not standard since MOTAC's guidelines are too general and not curated for each homestay. Suggestions in the form of flow chart were put forward to address concerns about safety and security and to ensure compliance with *Shari'ah* principles.

1. Introduction

Muslim-friendly travel destinations are gradually emerging in Malaysia due to increased demand from tourists, particularly *Muslim*s, to satisfy their religious needs while in the country (Mohamed Battour, 2019; CrescentRating, 2019). *Muslim*-friendly standards include Halal food, *Shari'ah* compliance for ethical behaviour, family-friendly places, and a safe environment, among other things. (CrescentRating, 2019). Currently, *Muslim*s spent USD 2.02 trillion (RM 8.38 trillion) in 2019 on food, medications, cosmetics, modest fashion, media, and travel, according to the State of the Global *Islamic* Economy (SGIE) Report 2020/21. While the spending represents a 3.2% year-on-year increase, *Muslim* spending is decreasing in 2020 due to the pandemic's impact (Global *Islamic* Economy Report, 2021). However, spending on non-travel items rebounded by the end of 2021 and is expected to reach USD 3.3 trillion (RM 13.7 trillion) by 2024, growing at a cumulative annual rate of 3.1 per cent (Global *Islamic* Economy Report, 2021). Nevertheless, *Muslim* travellers are given a sense of security when their *Islamic* practises can be observed, especially in terms of their safety during their stay. *Muslim* travellers prioritise everything Halal, from food to accommodations and services, including *Shari'ah*-based safety applications, throughout their stay, reflecting *Islamic* practices.

One of the *Shari'ah*-based safety measures includes the option of *Takaful* Insurance, which objects to any unlawful transactions. *Islam* abhors any transactions that involve gambling (*maysir*), interests (*riba"*), and excessive uncertainty (*gharar kubra*) as mentioned in the *Qur'an* (*Al-Baqarah*: 275):

> *"Those who consume interest cannot stand (on the Day of Resurrection) except as one stands whom Satan is beating into insanity. That is because they say, 'Trade is (just) like interest.' However, Allah has permitted trade and has forbidden interest. So, whoever has received an admonition from his Lord and desists may have what is past, and his affair rests with Allah. However, whoever returns to (dealing in interest or usury) – those are the companions of the Fire; they will abide eternally therein."*

Takaful means that the insurance the insurer provides observes the religious recommendations and removes any elements that coincide with *Islamic* practices. Prohibitions of elements such as *Gharar, Maysir,* and *Riba'* are a requirement in the policy of *Takaful* Insurance for it to be permissible to be adopted by *Muslim*s. As *Muslim* travellers, religious practice observes food and their safety. One safety measure that the Ministry of Tourism (MOTAC) rules out is for all homestay

guests to adopt insurance. Insurance is a legally binding contract where the policyholder must pay a single premium upfront or a regular premium over time to the policy owner when the insured person is injured, lost limbs, warded, or even dies (Birds, J., 2019). *Takaful* Insurance promotes the same concept but with the elimination of non-permissible elements which may coincide with *Islamic* practices. Currently, there are no required guidelines by MOTAC to promote *Takaful*-based insurance to homestay owners for guests, not even *Muslim*s.

During a guest's stay at a homestay, various measures are taken to ensure their safety, such as the food provided and the condition of the surrounding areas. Activities that promote social interaction and unity are also included as part of the homestay experience. Homestays are primarily located in rural areas, and the registered homestay is to observe the sets of activities for the guests, including local *'kampung'* activities such *kayak*, boat riding, local food-making activities, and so on (MOTAC, 2019). Activities such as kayak, boat riding, and food preparations need some form of safety measures where insurance is necessary. *Muslim* guests can adopt a form of insurance that complies with the *Shari'ah* requirements as an option. So that they have a piece of mind knowing they are protected and able to observe *Islamic* practices throughout their stay and activities involvement.

A survey was done by Meimand (2013) on the expectations and experiences of Japanese tourists regarding various aspects - including safety, when visiting one of the homestays in Malaysia. His study demonstrates that safety ranks as the most concerning criterion for Japanese tourists. Concerns arising from guests on the safety and security aspects of homestay's overall systems, where the homeowner acting as guests' guardian for tourists should consider setting up (1) cupboard locks, (2) room locks, (3) proper parking spots, (4) appropriate room lighting, and (5) fix local's anxiety towards tourists (Meimand, 2013). In other parts of the world, Australia tackles the homestay safety aspects by getting police clearance of the area before the homestay can start operations (Ariff, 2015).

The safety and security aspect are considered one of the main themes highlighted in the *Qur'an*. *Islam* promotes the principle of human safety above everything else. *Muslim* Scholars agreed collectively on the relevance of *Maqasid Shari'ah*. *Shari'ah* can be exemplified as the road to watering-place, which signifies that water is vital for every living thing created by *Allah* to survive and improve the current state of society (Jasser Auda, 2014; Kamali, 1989). *Allah* mentions in *Surah An-Nur*, Verse 55:

> *"Allah hath promised such of you as believe and do good work that He will surely make them succeed in the earth even as He caused those who were before them to succeed; and that He will surely establish for them their religion which He hath approved for them, and will give them in exchange safety after their fear. They see Me. They ascribe no thing as partner unto Me. Those who disbelieve henceforth are the miscreants."*

2. Literature review

The homestay programme offers a one-of-a-kind experience of local activities to tourists and a means of generating GDP revenue for rural areas (Bavani *et al.*, 2015). Malaysia's homestay program offers local cultural activities for tourists. Activities by homestays are approved beforehand by the Ministry of Tourism and Cultural Affairs (MOTAC) (Jabar *et al.*, 2015; MOTAC, 2019).

The primary concept for homestay is to provide the tourist with a place to stay while shielding them from direct sunlight above and any other external elements, protecting the inhabitants (Districts and Guide, 2009). MOTAC's approach to registering the homestays are a mean to standardise the required facilities and activities in the homestays. Authorised homestay is a guaranteed place for Guests to enjoy the whole experience of what homestays should be with added security. Malaysian homestays are preferably located in a rural area, as suggested by MOTAC, to enhance the local's experience further. However, unregistered homestays are also still looming around and disguised as 'homestays', although they are not (Campbell, 2018).

The homestay placement requires a proper type of village, a small settlement, characterised agricultural areas, and a natural resources region (MOTAC, 2019). The village area may comprise different kinds of villages, a small settlements living in groups, parallel and scattered like a traditional village, FELDA village, FELCRA village, native villages, farm-like settlements and new villages. Communal activities that emphasise social cohesion are included as part of homestay activities. These activities involve cleaning the village, catching catfish, harvesting *paddy* fields, mock weddings, and others suited to specific homestay locations (Mapjabil *et al.*, 2017). Also, the homestay provides added benefits of hands-on experience of local activities close to Malaysian diverse cultures for all guests where it involves vast historical values and cultures intertwined with *Islamic* traditions since hundreds of years (MOTAC, 2019). Activities held however require some form of safety from homestay owners. Different sets of activities require certain safety measures, which are stated in the Guidelines (MOTAC, 2019). Current MOTAC guidelines only briefly mentions on safety guidelines. The scarcity of safety information left the owners to interpret their own safety standards from the Guidelines and posed an uncertain state of safety and security measures for the guest (MOTAC, 2019).

Most homestay operators are mainly *Muslim*, and local activities are knotted with *Islam*, emphasising the concept of Halalan-*Toyyiban* in daily life (Fatin Mazelan, 2019; Jabar, 2018; Rosie, 2014). This is where *Shari'ah* comes in to see whether the current safety implementations by MOTAC and homestay owners reflect as *Islam* requires or otherwise. The context of this study was to investigate the current safety standard for *Muslim*-friendly homestays in Malaysia.

Figure 1 shows the guest's current safety standard by MOTAC and the homestay owner. This study explores the application of safety in *Muslim*-friendly Homestays involving *Maqasid Shari'ah* of good practice (*Toyyib*) in the industry. The application of safety via the element of *Islam* in *Muslim*-friendly Homestays is one way to improve the current level of safety or otherwise.

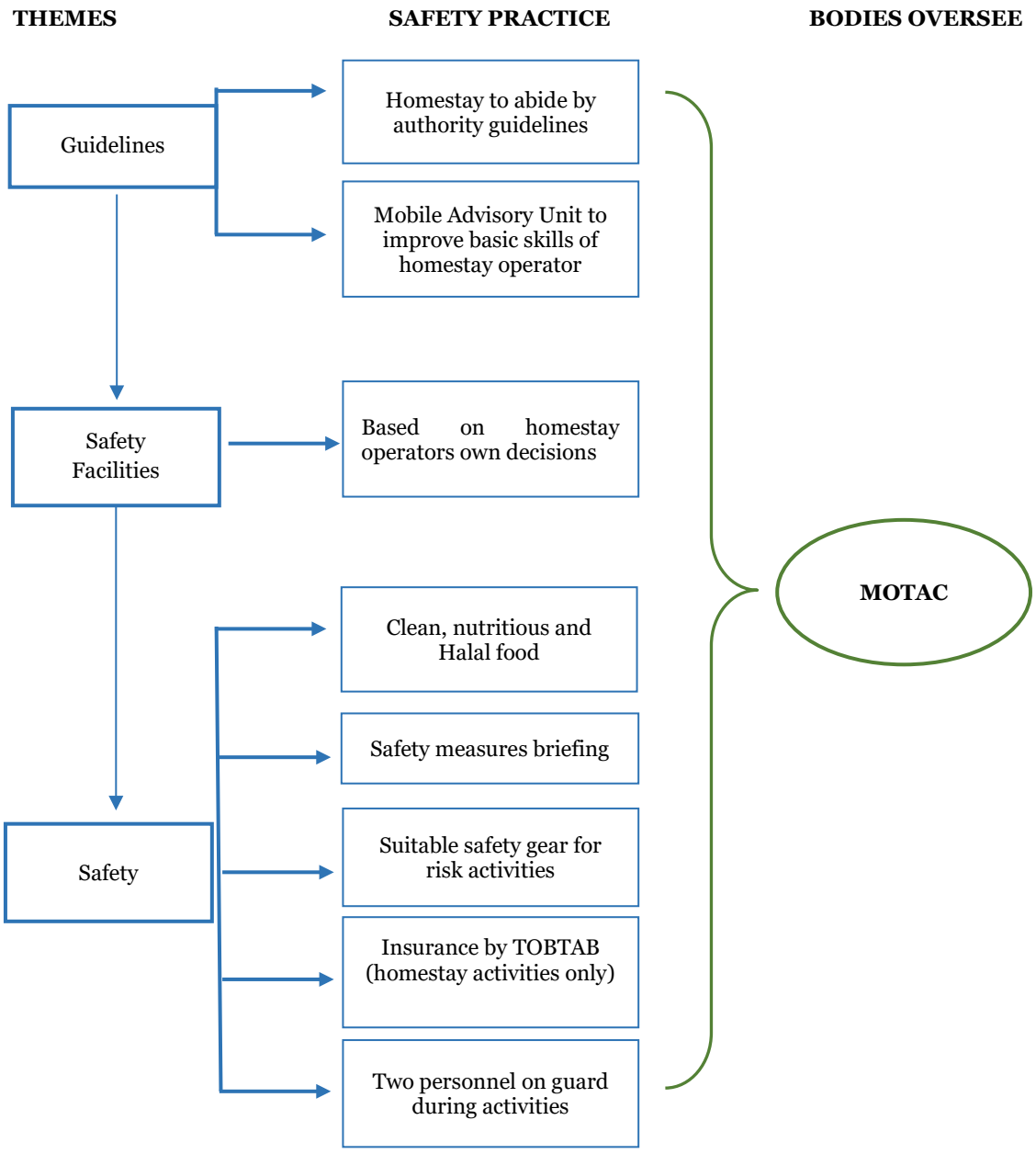

Figure 1: Current MOTAC'S safety standards

3. Methods

This study explores whether the safety measures of homestays in Malaysia comply with *Shari'ah*. The study employed a variety of data, including both primary and secondary sources. These included guidelines for homestay agreements, academic journals, books and reports, as well as interviews with relevant stakeholders. The study interviewed a representative from the Ministry of Tourism, Arts, and Culture (MOTAC) and *Shari'ah* experts. The data collection was conducted in stages. First, the study analysed various sources such as MOTAC's guidelines, ASEAN homestay standards, and homestay agreements to understand the current safety measures provided and their compliance with *Shari'ah*. The study then explored the authority's (one representative from MOTAC's) view on *Islamic* values of safety and investigated the effectiveness of the Mobile Advisory Unit (MAU) in improving homestay management skills on safety. A list of *Shari'ah* assumptions on homestay safety issues was then formulated based on the interview, homestay agreement, past studies, and guidelines. *Qur'an* and *hadith* were also referred to formulate the assumptions.

It should be noted that despite the efforts to gather a diverse homestay agreement sample, the study was limited because only two homestay contract agreements were obtained even after approaching hundreds of potential homestays. The list of *Shari'ah* assumptions is attached (Attachment 1). Finally,

the study verified its assumptions on homestay safety issues with *Shari'ah* experts to ensure they align with *Maqasid Shari'ah*. *Shari'ah* experts were given a list of assumptions containing 10 critical points about safety via a Google Form. This allows them to prepare and formulate the answers. The experts were then interviewed via phone calls. *Shari'ah* experts are only among the IIUM lecturers due to the global COVID-19 pandemic, which was spreading at the time of the interviews. Five experts are involved in this stage: two are from *Shari'ah* Law, two are from Qur'an and *Sunnah* Studies, and the last is from *Shari'ah* Humanisation.

4. Results and discussion

The results and discussion focus on the interview with MOTAC's Officer and the verification of assumptions on current safety practices to ensure they are in line or comply with *Shari'ah*.

4.1 Interview with MOTAC's officer

The interview first focused on the implementations of staying under one roof, the establishment of Village Development and Security Committees, or in Malay, *Jawatankuasa Kemajuan Keselamatan Kampung (JKKK)*, and whether ten houses nearby homestays are good safety measures in general. The importance of living together with the host is a safety measure in and of itself. For example, homestay Haji Dorani provides the option of living under the same roof or not (Fatin Mazelan, 2019; Rosie, 2014).

According to MOTAC, the safety and security of the guests are critical; the Guidelines state the need for insurance management by homestay operators for individuals. Group-based, it is handled by the Tour Operating Business and Travel Agency Business (TOBTAB) Agency. Establishing *JKKK* is essential to enhance the safety of the guests further. MOTAC's officer replied that insurance had been provided to ensure the safety of the guests. *JKKK* is also vital in ensuring safety and security measures are under control and curbing cases of fatal incidents.

MOTAC's officer states that they have provided guidelines for homestay implementation. Thus, it is up to individual homestays to determine how to implement such rules based on their locations, activities, and surrounding geography. In the author's opinion, homestay communities do not know how to implement the training they received before setting up the homestay. This is the primary reason MOTAC established MAU (Mobile Advisory Unit): to assist locals in effectively implementing what they learned during their training (Malaysia, 2017). Therefore, while the steps taken by MOTAC are considered good practice, they must be adequately documented in the guidelines to be mandatory.

However, MOTAC's officer did not answer the question about what would happen if Maqasid *Shari'ah* was combined with safety measures. A question was also raised regarding the formation of the MAU. MAU is a positive and beneficial solution developed by MOTAC to alleviate anxiety and skill disorientation in local homestay communities. Results from an interview with MOTAC on homestay safety measures align with previous studies (Jabar, 2018; Kasuma *et al.*, 2016; V. H. R. Kunjuraman, 2013; Malaysia, 2017; Meimand *et al.*, 2013; Tourism *et al.*, 2010)

4.2 Verification of assumptions

Shari'ah experts' views on the issues of locals' anxiety towards tourists were consulted (Table 1). According to this study, such practices violate *Shari'ah* because the following *Qur'an* verse in 49:13 emphasises the importance of equality in *Islamic* culture. Additionally, the Prophet's sermon mentions that all humans are descended from Adam. Thus, emphasise the equality of the needs of all humans. This study concluded the subject at hand, which concerned the locals' anxiety (local homestays emit a negative vibe in the presence of outside tourists). The tourists felt emotionally unsafe, contributing to negative perceptions of Malaysian homestays. All experts agree with the study's assumptions, and the majority make no additional contributions other than expressing the study's viewpoints.

Table 1: Local anxiety towards tourist

Local anxiety towards tourist	***Shari'ah* compliance**		**Non-*Shari'ah* compliance**	
Expert 1			✓	
Expert 2			✓	
Expert 3			✓	
Expert 4			✓	
Expert 5			✓	
Total and percentage	**0**	**0%**	**5**	**100%**

Experts were consulted on the issues of safety features in guest rooms (Table 2). This study's assumptions are based on current standards, which do not specifically mention safety features in homestays per MOTAC's Guidelines. According to this study, this is not *Shari'ah* compliance simply because the guidelines are too broad. Furthermore, the broadness of the guidelines reflects the element of *gharar*, which *Islam* forbids. The concerning aspect is that it is up to homestays to implement the safety features, which vary in how they are implemented. According to an interview with a MOTAC officer, *JKKK* was formed to bolster safety measures to avert unwanted crimes such as house robbery, fighting, violence, noise pollution, and a rare case of sexual assault (Awani, 2019; Bernama, 2020b).

Further, Experts 1 and 5 corroborate this study's assumptions. Additionally, this study's assumptions specified the importance of having proper guidelines, which experts 2 and 3 concurred with, with the former stating, "Guidelines are necessary to ensure that homestays adhere to the same set of rules" and the latter adding, "Specific safety measures must be established, avoiding future confusions." Expert 4, however, concurs with this study's assumptions and adds, "... budget constraints may cause it." That is why there are insufficient security features".

Table 2: Safety features in guest's room

Safety features in guest's room	***Shari'ah* compliance**		**Non-*Shari'ah* compliance**	
Expert 1			✓	
Expert 2			✓	
Expert 3			✓	
Expert 4			✓	
Expert 5			✓	
Total and percentage	**0**	**0%**	**5**	**100%**

On Question 3, experts were consulted. This study and experts agreed that MOTAC's Guidelines are adequate. However, expert four concurs with this study but adds that this is not always the case, as expert four has previously encountered uncleanliness in one homestay. Additionally, expert five states,

"*Islam* contains guidelines on which foods we may or may not consume, and even the source of the food was mentioned, as it is critical to ensure the food's hygiene."

Table 3: Food safety and security

Food Safety and Security	***Shari'ah* compliance**		**Non-*Shari'ah* compliance**	
Expert 1			✓	
Expert 2			✓	
Expert 3			✓	
Expert 4			✓	
Expert 5			✓	
Total and percentage	**0**	**0%**	**5**	**100%**

Experts were consulted on safety features for activity facilities. This study concurred that MOTAC's guidelines are comprehensive. Experts 1–3 agrees with this study that the released guidelines are general. Experts 4 and 5 emphasise the importance of curated guidelines for each homestay.

"We are exposed to the public when we are outside." "It is critical to feeling safe while participating in outdoor activities."

Table 4: Safety features for activity facilities

Safety features for activity facilities	***Shari'ah* compliance**		**Non-*Shari'ah* compliance**	
Expert 1			✓	
Expert 2			✓	
Expert 3			✓	
Expert 4			✓	
Expert 5			✓	
Total and percentage	**0**	**0%**	**5**	**100%**

Experts were consulted on safety and security before homestay activities (Table 5). This study agreed that the guidelines provided by MOTAC are sufficient. Expert Four further elaborates that "being safe is critical for providing a sense of security." Also, expert five adds "so that the guest is aware of their actions and is accountable for them."

Table 5: Safety and security before homestay activity

Safety and security before homestay activity	***Shari'ah* compliance**		**Non-*Shari'ah* compliance**	
Expert 1	✓			
Expert 2	✓			
Expert 3	✓			
Expert 4	✓			
Expert 5	✓			
Total and percentage	**5**	**100%**	**0**	**0%**

Experts were consulted on safety and security during homestay activities (Table 6). This study agreed that MOTAC's emphasis on having insurance is sufficient. Insurance is clearly stated in the MOTAC's official guidelines. Management handles individual insurance, while TOBTAB manages group-based insurance. According to the assumptions of this study, it is *Shari'ah* compliance and a good practice adopted by MOTAC. All of the experts echo this study's assumptions. Expert 3 asserts that "opting for insurance is a good safety measure."

Expert 5 also agrees but with conditions "need to have an agreement from both parties. Accident happens. This is to make sure both are responsible for anything that might happen". "expert five" means that insurance should be included in the agreement or arranged separately if both parties agree. Expert 2 asserts, "Insurance is a form of protection in and of itself. As a result, adhere to the rules of safety measures." However, expert two adds that, while life insurance is a safety measure, responsible parties must ensure that insurance policies are *Shari'ah* compliant.

Table 6: Safety and security during homestay activity

Safety and security during homestay activity	***Shari'ah* compliance**		**Non-*Shari'ah* compliance**	
Expert 1	✓			
Expert 2	✓			
Expert 3	✓			
Expert 4	✓			
Expert 5	✓			
Total and percentage	**5**	**100%**	**0**	**0%**

Experts were consulted on homestay's Standard of Operating Procedure (SOP) during the pandemic. The findings of this study are that the SOP for homestays during the Covid-19 pandemic is on point and considered *Shari'ah* compliance

because it follows per teachings by Prophet Muhammad in a *Hadith* stating people should avoid visiting a place of plague and quarantining themselves (*Sahih Bukhari* – Volume 7, Book 71, Number 625-626). Expert 2 further adds that it is a must for MOTAC to release Guidelines for all homestays to abide by Government's SOP since homestays provide accommodations and hands-on experience with locals.

This study agreed that MOTAC's emphasis on having insurance is sufficient. Experts 4 and 3 also agree it is *Shari'ah* compliance because the former asserts that Government's regulations complied with what has been practised during Prophet Muhammad's time. Further, the needs of SOP by restricting activities between guests and locals help reduce the

"escalation of the pandemic cases. Preventative measures should be implemented." (Expert 5).

Table 7: Homestay's SOP during the pandemic

Homestay's SOP during the Pandemic	***Shari'ah* compliance**		**Non-*Shari'ah* compliance**	
Expert 1	✓			
Expert 2	✓			
Expert 3	✓			
Expert 4	✓			
Expert 5	✓			
Total and percentage	**5**	**100%**	**0**	**0%**

When asked about separate safety and security guidelines for each homestay (Table 8), the study discovered that SOPs for homestay activities that adhered to the current MOTAC Guidelines for safety and security could not be implemented at all 206 registered homestays in Malaysia. The issue argues that since each homestay offers a unique set of activities and experiences owing to its rural setting, MOTAC's guidelines should be curated accordingly. According to this study, the currently published guidelines on this subject are not *Shari'ah*-compliant due to the existence of *gharar*.

Experts one and two agree with this study and add that "…the risks and situations that the guest will face are different…." The latter asserts that "different locations correspond to varying degrees of safety precautions." However, it is subject to further discussions and determined on a case-by-case basis (Expert 3). Finally, this study suggests that MOTAC emphasise the nature of each homestay's activity in detail. "…It is necessary to establish separate guidelines."(Expert 2).

Experts were interviewed on safety and security responsibilities (Table 9). According to this study, safety responsibilities are non-*Shari'ah* compliant because the agreement's element outweighs homestay owners more than guests. The guests' rights were violated, and they were oppressed. Protecting human rights and justice in *Islam* is mandatory, and no one shall be oppressed. All experts, however, disagreed with the study's assumptions and maintained that the issue is *Shari'ah* compliance. In their argument, before signing the agreement, homestay operators ensure that guests are adequately informed and aware of their circumstances (Experts 1, 2, and 3). Additionally, Expert 4 asserts that a shared understanding is deemed sufficient. Finally, the practice in this homestay is good, and Expert 5 encourages other hosts to emulate it and be more aware of this issue. As a result, safety and security responsibilities were deemed *Shari'ah*-compliant.

Table 7: Separate safety and security guidelines for each homestay

Separate safety and security Guidelines for each homestay	***Shari'ah* compliance**		**Non-*Shari'ah* compliance**	
Expert 1			✓	
Expert 2			✓	
Expert 3			✓	
Expert 4			✓	
Expert 5			✓	
Total and percentage	**0**	**0%**	**5**	**100%**

Table 8: Safety and security responsibilities

Safety and Security responsibilities	***Shari'ah* compliance**		**Non-*Shari'ah* compliance**	
Expert 1	✓			
Expert 2	✓			
Expert 3	✓			
Expert 4	✓			
Expert 5	✓			
Total and percentage	**0**	**0%**	**5**	**100%**

This study's findings regarding agreement changes (Table 9) without notifying guests are inconsistent with *Shari'ah* and do not constitute good practice (*Toyyib*). This study made these assumptions based on *gharar* terms and requires no new mutual consent in the event of recent changes from the homestay's side. Experts 2, 3, 4, and 5 agree with this study's assumptions but disagree that no changes can be made. All four experts agreed that amending the agreement is permissible but that new mutual consent is required (experts 2, 3, 4, and 5). Homestay can assert its rights under the agreement, but only with mutual consent and in a fair manner to both parties (Experts 3 and 4). However, only Expert 1 disagreed with this study's assumptions and maintained that changes made without informing others are valid. A new mutual consent is not required if both parties agree on the initial contract.

Although Expert 1 comes from an *Islamic* background, his agreement lacks a strong point, particularly in comparison to the views of Expert 2, a *Shari'ah* law specialist. Expert 2's opinion can supersede Expert 1's argument. According to Expert 2, amending the agreement is permissible based on the *Shari'ah* legal maxim *Al-Mashaqqah Taljub Al-Taysir* (hardship begets facility). According to the *Shari'ah* legal maxim, if the host's agreement changes, it can prevent a greater harm from occurring. Further, Expert 2 concludes that changes of agreement without prior notice if they only affect minor changes are allowed. As a result, if the changes are significant, a new mutual agreement must be established

(Expert 2).

Locals' anxiety was not addressed in the guidelines, but both the authority and homestay hosts understand that it is up to the homestay hosts to educate and send their staff for proper training. Anxiety portrayed by the current locale towards foreign guests sparks uneasiness and lowers their expectations for future visits to Malaysia. Equality towards all humankind is stressed in the *Qur'an*, chapter 49:13, which states:

> *"O people, we created you from the same male and female and rendered you distinct peoples and tribes that you may recognise one another. The best among you in the sight of GOD is the most righteous. GOD is Omniscient, Cognizant."*

According to the verse, all humans are descended from Adam and are thus brothers. Therefore, the current guest's (foreign) safety from the locals' anxiety is currently non-*Shari'ah*. Training and exposure for homestay staff are therefore required.

Table 9: Changes in agreement

Changes of Agreement	***Shari'ah* compliance**		**Non-*Shari'ah* compliance**	
Expert 1	✓			
Expert 2			✓	
Expert 3			✓	
Expert 4			✓	
Expert 5			✓	
Total and percentage	1	20%	4	80%

Safety and security features are not included in the current guidelines, and consequently, it is not *Shari'ah*-compliant. However, it is up to Homestay's initiative to provide those features for guests.

In terms of food safety and security, the guidelines provided by MOTAC are detailed and thorough in ensuring that the safety of food prepared for the guest is up to *Toyyib* standards. Therefore, it is *Shari'ah* compliance, and *Islam* emphasises the importance of consuming *Toyyib* food (*Qur'an* 2:168).

Regarding safety features for activity facilities and differences in implementations for each homestay. Due to geography, location, and cultural differences, the current guidelines are still general and cannot be implemented in all registered homestays in Malaysia. Therefore, according to experts, it is considered non-*Shari'ah* compliant and requires detailed guidelines to be explicitly released for each homestay. On the other hand, the aspects of safety and security before homestay activity, safety and security during homestay activity, and Standard Operating Procedure of homestay activity during the pandemic are *Shari'ah* compliance because they detail all requirements and what needs to be done to be safe and secure.

One of the initiatives is to provide insurance for the guests, which covers the damages inflicted upon them if anything unintended were to occur to them. However, it is worth noting here that only *Takaful* Insurance (cooperative) is considered in line with *Maqasid Shari'ah* on the protection of life. However, if a homestay adopts conventional insurance, it is non-*Shari'ah* because it involves *riba'* (interest), *gharar* (uncertainty on your life), and *maysir* (gambling). Therefore, removing the three aforementioned non-*Shari'ah* elements from current insurance for homestay guests will bring it into line with *Shari'ah*. The guidelines did not specify whether *Islamic* or conventional insurance would be used. Table 9 and 10 involve a contract agreement between the homestay host and the guest.

As indicated in table 9, the safety and security responsibilities in the agreement are regarded as complying with *Shari'ah* requirements as they mention everything for which the party would be responsible. Also, mutual consent was met, and it needs to be a valid agreement for a *Muslim*-friendly homestay. The practice of mutual consent mentioned by *Allah* in surah *An-Nisa* [4:29] "devour not the properties of one another unlawfully but let there be lawful trade by mutual consent".

Changes to the contract without prior notification are considered non-*Shari'ah* compliance. Part of the agreement that stated, "Homestay has rights to change this Contract Agreement from time to time without prior notice," is invalid. This part of the agreement removes the rights of another contracting party to agree or disagree with the changes in terms. In other words, the current homestay agreement removes the right to mutual consent. Thus, the host makes unilateral changes to the agreement. The changes, according to four out of five experts, are not *Shari'ah* compliant because they eliminate the right to mutual agreement. The current practice also contradicts the *Qur'an* surah *An-Nisa* [4:29]. Also, experts' opinions correspond to the *Hadith* of the Prophet, in which he said: "Transactions may only be done by mutual consent" [Sahih: Sunan Ibn Majah 2185]. Another *Hadith* also stipulated the prohibition of compulsion, in which the Prophet was reported to have said: "My people are forgiven for that which they have done through mistake, forgetfulness, and under coercion" [*Sahih: Sunan Ibu Majah* 2045]. Changes in the contract term are permitted and were practised by the Prophet's Companions.

> *`Umar b. al-Khattab adjudicated a case known as Hajariyyah, in which the deceased, a woman, was survived by her husband, mother, two consanguine, and two uterine brothers. 'Umar b. al-Khattab entitled all the brothers to a share in one-third of the estate. However, was told by one of the parties that the preceding year, 'Umar had not entitled all the brothers to share the portion of one-third. The Caliph replied, 'That was my decision then, but today I have decided it differently.' (Ibn al-Qayyim, I'lam, I, 177; Kassab, Adwa', p. 108; Badran, Usul, p. 485., in Hisham Kamali, 1989)*

Although the majority of the experts agree that new mutual consent is needed, they also gave their opinion that a unilateral agreement can also be *Shari'ah* compliant, subject to the discussions and situations at the time. Experts provided an example of how a unilateral agreement must be supported by evidence if the results are superior to a mutual agreement, which may result otherwise. *Shari'ah* experts' opinions align with M.H. Kamali, who states that a unilateral agreement is permissible if valid conditions and professional assumptions

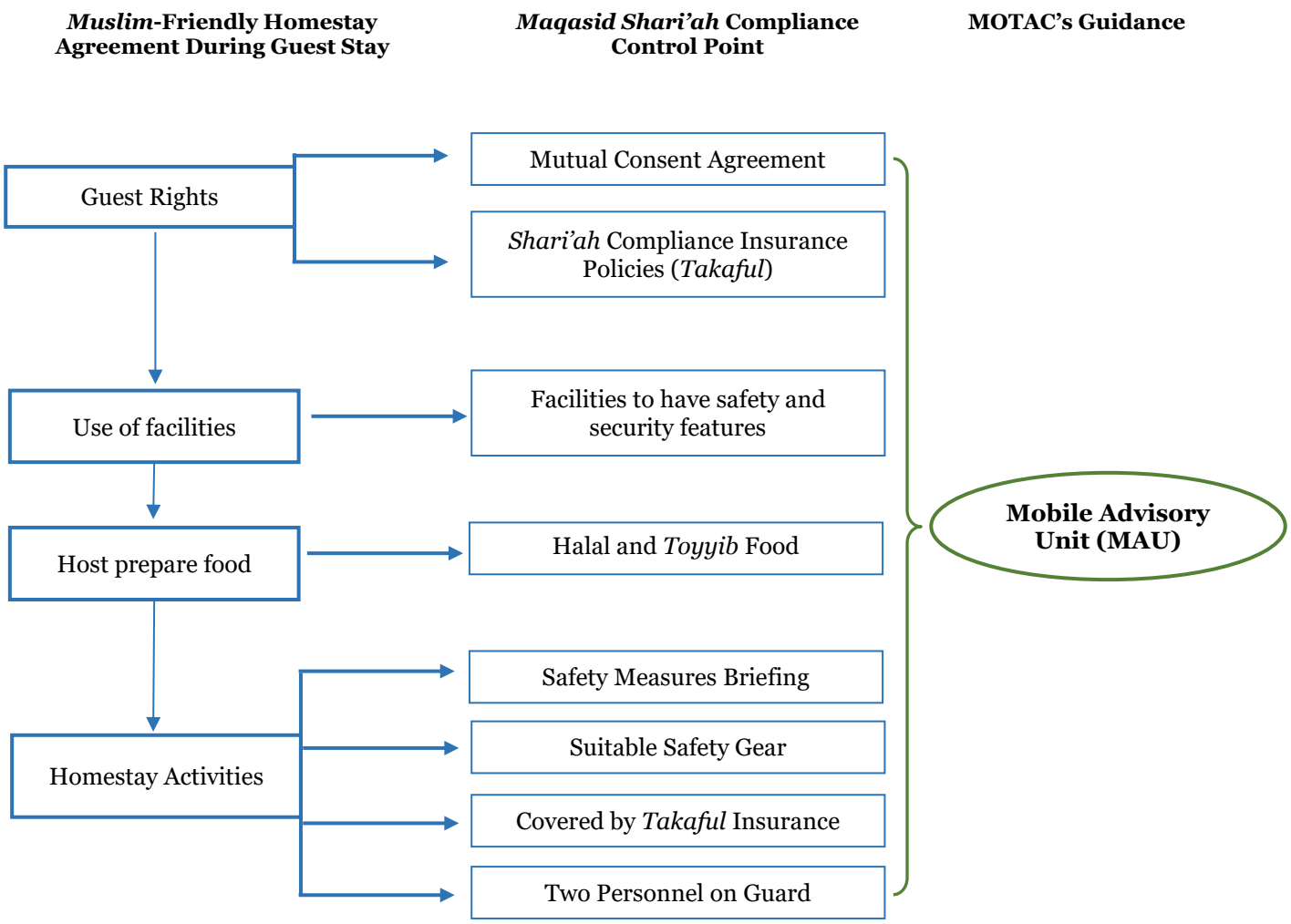

Figure 2: Safety and security of homestay according to *Shari'ah* and good practice (*Toyyib*)

have been exercised (Kamali, 1989). However, the permissibility does not supersede the established requirement of mutual consent; instead, it only allows the necessity for that specific time and situation (Mansour Z. Al-Mutairi, 1997).

4.3 Suggestion

Based on the research results, the author has proposed a safety and security process flow chart, as depicted in Figure 2. This flow chart is divided into three sections: *Muslim*-Friendly Homestay Agreement During Guest Stay, *Maqasid Shari'ah* Compliance, and MOTAC's Guidance. The middle section of the flow chart highlights the specific *Shari'ah* elements that must be implemented during the stay, making it a crucial section for ensuring *Maqasid Shari'ah* compliance. To ensure the efficient implementation of these *Shari'ah* elements, it is suggested that a MAU (Monitoring and Auditing Unit) be deployed. The role of the MAU would be to oversee the implementation of all safety and security-related procedures for every registered homestay. This approach is efficient as it encourages local homestay operators to address any issues related to safety and security. Furthermore, the deployment of the MAU ensures that all homestays comply with the *Maqasid Shari'ah* and meet the guidelines set by MOTAC.

5. Conclusions

In conclusion, this study found that homestays' current level of safety and security in Malaysia is not up to standard since the MOTAC's guidelines are too general and not curated for each homestay. Each homestay has its unique selling point, and one of its advantages is the kind of activity it offers. Not all homestays offer the same activities, food, and culture based on geography and location. Improvements, especially in these aspects, need to be made. In addition, the deployment of the MAU unit is an excellent effort by MOTAC to improve homestay further. However, MAU must also include the importance of safety and security on par with other flaws for each homestay. Homestay provides accommodation first, but their objective is highlighted in activities (MOTAC's officer). Therefore, safety and security measures during a guest's stay from the beginning until the end are not to be overlooked. This research has created a process flow for what it will be like to have a *Shari'ah*-compliant agreement. The agreement shall include the need to have *Shari'ah*-compliant insurance policies for guests during activities, rights, and a more detailed agreement to be added. Homestays differ from other types of accommodations, such as hotels, in that the former is typically located in rural areas and was designed to allow guests to learn more about local culture and language. The main attraction of a Malaysian homestay is that the guest gets to experience

firsthand the locale's way of life under the same roof.

5.1 Limitations and recommendations

This study is constrained by time and resources. It is, therefore, necessary to highlight the following limitations of this study where things should be evaluated under these boundaries:

i. The scope of this research is limited to the safety and security of current *Muslim*-Friendly homestays in Malaysia.
ii. The findings of this study are not the final and conclusive answers for a *Muslim*-friendly contract agreement for all homestays here in Malaysia.
iii. Further research and in-depth study on this or part of the topic are much needed.
iv. Some sources used were the primary sources from the *Qur'an* and *hadith*, which require excellent knowledge to better present the points made.
v. This study does not have the resources or time to go to each homestay and ask for their agreement for comparison.
vi. This study only obtained one homestay contract agreement sample after approaching hundreds of homestays. Most of them do not reply due to Malaysia's current pandemic situation.
vii. Lastly, this study did not gather any extra material since the pandemic occurred.

Recommendations for future research include:

i. An in-depth study on necessity limits the permissibility to change the contract agreement terms unilaterally.
ii. Further study on *Shari'ah* safety and security compliance via other means, such as for each homestay other than what studies have pursued through MOTAC's Guidelines.
iii. Lastly, different and in-depth study type of life insurance involves homestays in the light of *Maqasid Shari'ah* for homestays to become 'true' *Muslim*-friendly homestays.

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Egg and Broiler Supply in Malaysia: Issues, Challenges and Recommendations

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Abstract

The Malaysian poultry industry, particularly the broiler and egg supply, was greatly affected due to recent global challenges such as COVID-19, the Russia-Ukraine conflict, global logistic strains, and the overall deceleration of economies. Being self-sustainable for poultry, the crisis throughout 2022 has shown how fragile the industry is in Malaysia. Based on the above perspectives, the dependency of the poultry industry on imported feed materials and its stability from external factors that support the industry needs to be considered to sustain food security. Therefore the concept of food security in a country might need to be further evaluated as a sustainable value chain rather than individual components. Understanding the value chain involved in the poultry industry is important to conclude the decisions to attain supply stability in Malaysia.

1. Introduction

In order to contribute to the existing body of literature on this topic, we must first ask ourselves: what is food security? At its most basic level, it refers to having enough food to eat on a regular basis. This means having enough food for today or tomorrow, next month and next year. Though this may seem like a straightforward concept, there is still a great deal of confusion surrounding it. To help answer this question, we must consider the various factors contributing to food security. The Food and Agriculture Organization of the United Nations suggests that food security is the result of food availability, food access, stability of supplies, and biological utilisation (Clapp *et al.*, 2021).

1.1 Availability

The availability of food is determined by a combination of factors, including domestic production and imports, such as well-functioning market infrastructure, adequate transportation, and storage and processing technologies (Riely *et al.*, 1999)

1.2 Access

Food access refers to the ability of individuals to obtain and maintain adequate supplies of food for a nutritious diet. This may involve direct access to food, such as growing, purchasing, and bartering, and indirect access through social arrangements such as family, welfare systems, and emergency food aid (O'Hara and Toussaint, 2021).

1.3 Stability

The idea that food security can be lost and gained is of increasing concern within the food security debate. As a result, risk management is gaining much credibility as a tool in the fight against hunger. Such consideration involves issues of stability and vulnerability; this can be of the wider economy in general, of livelihoods in particular, incomes, or even of food supplies themselves, concentrating on shocks, sudden or otherwise, such as floods, droughts or pests (Béné, 2020).

1.4 Utilisation

The concept of biological utilisation refers to a person's ability to absorb the nutrients in the food they eat. Research has shown that this ability is closely related to a person's overall health. Optimum biological utilisation requires access to

proper health care, clean water and sanitation, and adequate knowledge of nutrition and physiology.

Although the above provides a more detailed overview of food security, it only scratches the surface of this complex concept. There are many definitions of food security, each with nuances. For example, the United Nations have different definitions of food security. This can make it difficult to clearly understand what food security means.

The Food and Agriculture Organization (FAO) of the United Nations' definition of food security has had many incarnations over the years and is still being widely debated. In October 2012, the Committee on World Food Security attempted to revise the terminology of their current definition to reflect popular progressive thinking, but most have used the following definitions.

> *"Food and nutrition security exists when all people at all times have physical, social and economic access to food, which is safe and consumed in sufficient quantity and quality to meet their dietary needs and food preferences and is supported by an environment of adequate sanitation, health services and care, allowing for a healthy and active life."*
>
> (FAO, 2001)

It is not necessarily the case that a country with a lot of food is also a food secure country. Following the definition of food security by the FAO strictly, food security does not readily exist in Malaysia since it would require all people to have access to sufficient, safe, and nutritious food at all times. Malaysia was previously reported as having quite an obese population (Verma *et al.*, 2013). Various efforts by the government to ensure malnutrition is not undermined and the ability to have access to subsidies and support systems for the underprivileged for access to food is commendable (Muda, 2020). Furthermore, anecdotal evidence suggests that food wastage is still prevalent in Malaysia (Papargyropoulou *et al.*, 2019; Zainal *et al.*, 2019). Thus the current status of compromised food security may be wrongly defined, but rather can be arguably applied to having an issue of stability towards food security in the event of a crisis (Béné, 2020; Jamaludin *et al.*, 2022;). To fulfil the aspects of food availability, food access, food utilisation and food stability, which are essential for food security, remains elusive and maybe unlikely achievable in practice by a singular country if the definition was to be extended to the ability to reach all individuals within that particular country.

2. Malaysia self sustainability for food status

According to The Department of Statistics Malaysia (2022), from 50 identified commodities, Malaysia was considered self sustainable for 26 items. While most fish supplies are within very favourable self-sustainable levels, protein sources from cattle, goats and sheep are still struggling to reach a reasonable level (Jamaludin *et al.*, 2014; Zayadi, 2021). Meanwhile, Malaysian broilers and eggs are abundant in Malaysia (Firdaus *et al.*, 2020; Sulaiman *et al.*, 2021). The ability of Malaysia to import to cover for the insufficiency shows very little issues of food security, although shortages of food materials during certain periods of the year or during major events do happen, but are not catastrophic. The implication of dependence on imports can be vulnerable on an economic aspect in fluctuations of costs (Mohamed and Hameed, 2010; Luo and Tanaka, 2021). Yet major events such as the COVID-19 pandemic, which resulted in supply instability, can be detrimental to a country that is reliant on imports, such as what was faced by Malaysia shows how fragile a country's food supply chain can be (Chin, 2020).

2.1 Poultry in Malaysia

The poultry and egg industry can be a typical case study of how a country relates the basis of food security. Eggs and poultry are considered cheap protein sources and are widely consumed by Malaysian consumers. The growth of the Malaysian economy saw the diet shifting to more meat, particularly poultry products such as chicken (Drewnowski *et al.*, 2020). The consumption of chicken in Malaysia stands at 49.7kg per person is considered one of the highest in the world (Zayadi, 2021) and is expected to increase further in the future. Malaysia's poultry and eggs industry is privately driven (Jamaludin, 2013; Jamaludin *et al.*, 2022) but imposed ceiling prices as part of government initiatives to ensure a relatively affordable protein supply to the general public. Profit margins for poultry and egg producers are considered small; thus, mass production via intensive farming practices is the typical approach to ensure that revenue is sufficient to support future production cycles. The production of poultry for broilers and eggs can be considered stable for the last 5 years, as shown in Table 1 and is expected to maintain steady growth for years to come.

Although broilers and eggs in Malaysia are considered commodities with a favourable self-sustainable ratio, feed inputs are still dependent on imports (Rae *et al.*, 2019; Abdullah *et al.*, 2020), mainly maise and grains. For example, the value of grain corn used in animal feed has increased by over 2 times in the last 5 years (Figure 1), which can be related to the event of the COVID-19 pandemic (Elleby *et al.*, 2020).

Table 1: Number of poultry output (broiler and eggs) from 2016 until 2021 (Federation of Livestock Farmers' Association of Malaysia, n.d.)

Year	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Number of broiler (millions)	818	767	717	787	799	756*
Number of eggs (millions)	12,113	12,502	11,943	9,624	11,743	12,372*

*estimated

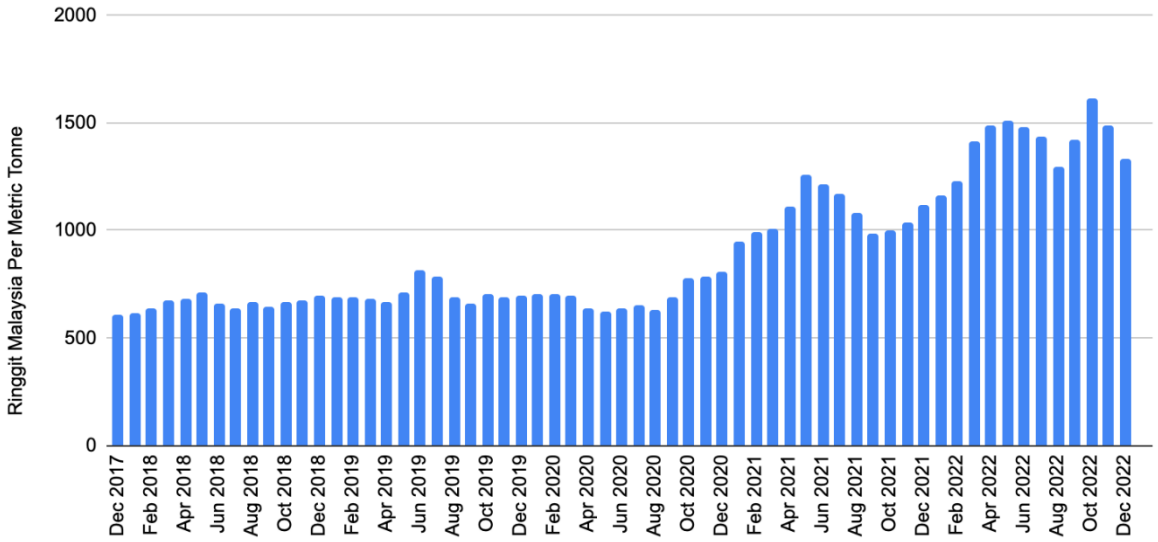

Figure 1: Corn grain prices in Ringgit Malaysia (Indexmundi, 2023).

Further global instability, such as the Russia-Ukraine conflict, further adds to the instability in the global farming system supply chain (Behnassi & Haiba, 2022; Ben Hassen & El Bilali, 2022). Ukraine is a major exporter of wheat, soybean and maise, which are heavily used as material for animal feed and were greatly affected by the conflict (Nasir *et al.*, 2022). On the one hand, the implication of Russia, a major producer of fertiliser, did, to some extent, destabilise accessibility by countries that focus on intensive arable farming practices (Lin *et al.*, 2023).

Due to the various global events, the domino effect has led to increased broiler and egg prices, which end users bear. The rise in poultry production costs was inevitable, but the industry has maintained its production to meet demand. Despite the price hike, poultry was still one of the cheapest protein sources, at an average of RM9.35 per kg, compared to beef (RM38.47 per kg) or fish (Cencaru or *Megalaspis cordyla* at RM10.35 kg) (Department of Statistic Malaysia, 2022).

2.2 Management of poultry crisis

Poultry production in Malaysia was considered one of the cheapest due to its industrial approach (Bahri, 2019; Zayadi, 2021). The policy by the Malaysian government to ban export on 1st June 2022 (Kementerian Pertanian dan Industri Makanan, 2022) was to ensure poultry was sufficient within the country, and the decision to import poultry was initially expected to cushion local supply stability. This policy did not go down well with some local farmers and poultry integrators, suggesting the effect it will bring on the export market to Singapore (Nordin, 2022). The 3.6 million birds produced monthly for the export market were banned from leaving the country, accounting for just 2% of monthly broiler production in Malaysia. Meanwhile, the suggested import of frozen chicken created uncertainty leading to reduced production in the advent of a potential stockpile of chicken in the market, which can potentially push down the selling price, affecting revenue on the already high cost of production. Concerns by integrators and also farmers on the possible influx of imported chicken led to the decision to reduce output into the market by extending harvesting time and reduced poultry stocking numbers. In this effect, the insufficient market supply of chicken was evident for 2 to 3 months, followed by oversupply from August 2022. The supply crises did not last long, as supply and prices stabilised (Ong, 2022), although at a slightly higher retail value.

A recent egg crisis in late 2022 saw Malaysia importing 2 million to 10 million units per day from India in December 2022 (Yunus *et al.*, 2022). The production of eggs is expected to take slightly longer to stabilise than broilers. This reason is expected because layer hens will take 6 months to consistently produce eggs (Hamilton and Bryden, 2021), compared to broilers which can be harvested after an average of 35 days (Indi *et al.*, 2022). The outcome to import is an indication that policymakers need to understand the economic consequences on the stability of the production ecosystem and its domino effect.

The issuance of cartels in the poultry industry shows the country's lack of preparedness to manage the crisis. The industrialisation of poultry production takes on many risks, from the potential wipeout of flocks from diseases to absorbing potential price hikes from the external market. Creating anti-monopoly regulation tools (Anisimova *et al.*, 2021) and supporting the growth of smaller farmers requires developing a long-term support system to democratise the poultry industry. With subsidies for broiler breeders and egg, producers extended until the end of 2022 (Bernama, 2022), a negative impact on commercial farmers is not expected, and production is presumed to maintain a subtle growth.

2.3 *Halalan Toyyiban* and poultry

Being a Muslim majority country, poultry is an important source of food products that can be consumed. The *Halalan Toyyiban* concept in poultry consumption is important to create upright and righteous individuals and has been stressed by the prophetic tradition.

أَيُّهَا النَّاسُ إِنَّ اللَّهَ طَيِّبٌ لاَ يَقْبَلُ إِلاَّ طَيِّبًا

"*O people ! Allah is toyyib (pure) and, therefore, accepts only that which is pure.*" (*Sahih Muslim*, *Hadith* no.1015)

The Islamic prophetic tradition in food consumption was also highly regarded and mentioned in the Islamic scriptures of the *Qur'an*,

يَٰٓأَيُّهَا ٱلرُّسُلُ كُلُواْ مِنَ ٱلطَّيِّبَٰتِ وَٱعۡمَلُواْ صَٰلِحًاۖ إِنِّي بِمَا تَعۡمَلُونَ عَلِيمٞ ٥١

"O Messenger! Partake of the things that are toyyib (pure, clean, wholesome) and act righteously. I know well all that you do" (*Qur'an*, 23:51)

يَٰٓأَيُّهَا ٱلنَّاسُ كُلُواْ مِمَّا فِي ٱلۡأَرۡضِ حَلَٰلٗا طَيِّبٗا وَلَا تَتَّبِعُواْ خُطُوَٰتِ ٱلشَّيۡطَٰنِۚ إِنَّهُۥ لَكُمۡ عَدُوّٞ مُّبِينٌ ١٦٨

"*O you who believe, eat from the good things which have provided for you*" (*Qur'an*, 2:172)

In the poultry industry for food consumption, it is clear that avoiding suspicious things safeguards one's religion, honour and company dignity. It is related to what has been mentioned in *Hadith*

الْحَلاَلُ بَيِّنٌ وَالْحَرَامُ بَيِّنٌ، وَبَيْنَهُمَا مُشَبَّهَاتٌ لاَ يَعْلَمُهَا كَثِيرٌ مِنَ النَّاسِ، فَمَنِ اتَّقَى الْمُشَبَّهَاتِ اسْتَبْرَأَ لِدِينِهِ وَعِرْضِهِ

"*Both legal and illegal things are evident, but in between them, there are doubtful (suspicious) things, and most people have no knowledge about them. So whoever saves himself from these suspicious things saves his religion and honour.*"(*Sahih Bukhari*, *Hadith* no.5)

The responsibility of the authority is to ensure a stable poultry supply, making sure consumers, particularly the Muslim community, have access to *Halalan Toyyiban*.

2.4 Misconception of food security?

Poultry is a cost effective and reliable protein material important for food security. In light of the situation faced in Malaysia, the question arises whether it is food security or food instability. The management and coordination of producers and storage capability will be important in ensuring stable supply demand equilibrium. The instability being mostly due to external factors; Malaysia may need to identify long term measures to manage a similar crisis before it occurs.

The rise in the cost of production cannot run from the fact that the feed materials required are dependent on imports. With feed cost accounting for almost 70% of the production of most livestock, controlling its availability and costs is important to ensure a much more stable price for end products. One of the main important factors in the price hike can be attributed to rising feed costs. Food security should not negate the decision to import a commodity for short term measures. Two main aspects of food security that should be focused on are the ability to ensure localised end-to-end supply and the ability to have access to supply during times of crisis. Taking the issue surrounding poultry in Malaysia, using the context of food security may need to be redefined, and measurement used to justify its use should also be scrutinised (Jamaludin *et al.*, 2022).

3. Tackling the poultry crisis

The poultry crisis shows the vulnerability of an industrial production that was proclaimed as being self sufficient. If evaluating a stable ability to be self sufficient, many factors may need to be looked into to understand the capacity to withstand a crisis if it does occur. For the poultry industry in Malaysia, a strong scientific understanding of animal science is impeccable and must be developed and sustained, particularly on feed and nutrition, breeding and genetics, and innovative housing systems. The infrastructure and support system that ensures supply can be made available during a crisis should also not be overlooked, covering management of the product, its storage and stocking, logistics, and fluctuating Malaysian Ringgit. Consumers are also important to ensure the stability of the food production system, and encouraging diversification in diets can ease dependency on a singular item. As Malaysians become more conscious of the food they take, the industry must also be prepared to face consumer perception of animal welfare and its possible effect on poultry operations. The following list some of the above challenges that can be further evaluated to successfully manage towards achieving much more sustainable poultry stability for Malaysia.

3.1 Feed and nutrition

Identifying alternative raw materials to reduce dependence on imports. The inability to produce sufficient corn and maise should also get local researchers to identify readily available raw materials. Oil palm is an example of readily available material that can be utilised and has shown to be potential for not just poultry but also other livestock such as cattle (Zahari & Alimon, 2005; Zahari *et al.*, 2012; Halim *et al.*, 2021; Alshelmani *et al.* 2021; Azizi *et al.* 2021; Boateng *et al.*, 2008). New approach to utilising waste material by fermentation can reduce or replace dependency on raw feed materials (Vandenberghe *et al.*, 2021; Kari *et al.*, 2022; Zhang *et al.*, 2022). The potential of plant-based material as a source of protein can support the need to maintain the Halal integrity status of poultry produced in Malaysia (Zainuddin *et al.*, 2020; Ashraf and Rahman, 2022).

3.2 Breeding and genetics

Poultry is bred for its meat (termed as broilers) or for the eggs produced (from layers). Breed improvement strategy is a long process of pedigree improvement and maintenance of quality traits for mass production (Kumar *et al.*, 2021; Portilo-salgado *et al.*, 2022). Quicker growth does not necessarily be the only option. Alternative breeds giving different qualities or types of chicken can allow different target traits such as better nutritive values, specific meat quality, better resistance to disease, and adaptability to specific housing conditions (Pius *et al.*, 2021). Poultry research on new breeds, both exotic and industry use, should be part of Malaysia's research initiative since the industry is mature and a major producer of a good protein diet

for local consumers. Currently, it is reported that only 4 Grand Parent stocks are managed in Malaysia (Ferlito, 2020), and very limited information can be found on Great GrandParent or pureline maintenance in the country. The maintenance of pure lines and pedigree selection, such as in figure 2, should also be considered part of good food security practices (Lisanty *et al.*, 2021). Apart from the common commercialised chicken such as Legohorn, Rhode Island Reds, Cobbs Chicken and White Recessive Rocks (Wang *et al.*, 2021), a good example is the development of the Haebara Breed of Chicken, which was developed to support the supply of halal non-Genetically Modified Organism (GMO) poultry breeds without antibiotics nor vaccination, currently in its prototype and implemented in Myanmar (Exclusive Interview With Mr Zuraimi Jumaat, 2022).

3.3 Housing system

Malaysia is considered a user of technology (Mustafa, 2021). Production and housing systems are still dependent on foreign technology. Such a system focuses on providing the most appropriate environment for optimal growth and biosecurity practices. Improvements that can be considered, such as cost effective building materials, improved biosecurity application, and automation (Li *et al.*, 2022), should take a localised approach to fit Malaysia. Local research institutions may play a crucial role in applying technological solutions to improve housing systems that are efficient and cost effective.

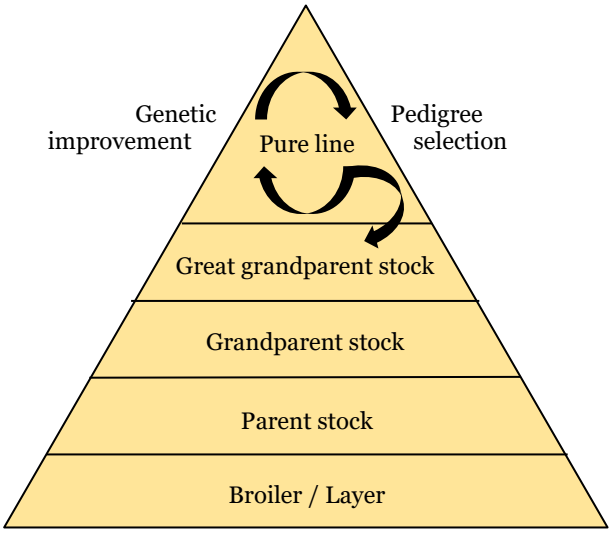

Figure 2: Management strategy for breed used in production of broilers and layers.

3.4 Production, storage and stocking

Production is driven by demand, and the industry has been quite stable and grew with little government support. With regards to ensuring supply availability, government intervention is required to focus on storage and stocking capability making sure readily available supply can be made available when needed (Gundersen *et al.*, 2021). Improve stocking approaches, such as energy efficient freezing strategy, strategic frozen storage facility, or stock in stock out a strategy to ensure food safety and quality.

3.5 Increased logistic cost

Logistics costs, both within the country and between countries, saw a sharp rise in the last decade, which was most prominent from the effect of the COVID-19 pandemic. Congestion and delays at ports, airports, and highways can lead to delays, increasing logistics costs by causing additional fuel consumption and driver overtime (Liu *et al.*, 2020; Barbosa *et al.*, 2022). Government regulations such as import or export restrictions further increase demand and supply instability (Aday and Aday 2020). Malaysia's logistic activities were not spared from the pandemic (Shin *et al.*, 2020) and numerous suggestions to improve these activities, such as automation and better management, as possible strategies to reduce costs (Sudan and Taggar, 2021).

3.6 Fluctuating Malaysian ringgit

The fluctuation of the Malaysian ringgit can lead to an increase in the cost of imported animal feed, leading to higher costs for farmers and potentially higher prices for consumers. This is because a weaker ringgit makes imported goods, such as animal feed, more expensive. Additionally, if domestic animal feed production is unable to keep up with demand, farmers may have to rely more heavily on imports, exacerbating the impact of a weaker currency on feed costs (Erokhin and Gao, 2020). With the main cost of production for poultry coming from feed, instability in the price of imported material will lead to the need to transfer these extra costs to consumers. The need to not be dependent on importing materials that go towards poultry production can ease sudden hikes in costs and ensure the stability of poultry prices.

3.7 Diversifying consumer diets

Malaysians are large consumers of chicken and eggs, and reducing intake of these protein materials can be an option to justify the relevance of a major crisis issue. While industrial needs can affect economic activities, consumers can always adapt to alternatives such as plant based protein resembling either chicken or eggs (Rubio, 2020; Will, 2022). In reality, eggs and chicken are protein products that Malaysians are custom too, and should not be negated to food security but rather production and supply stability. In this aspect, consumer adaptability to diversified protein sources should also be taken as an internal strategy for stabilising food security issues. Many countries have shifted to diversifying food production (Kerr *et al.*, 2021) towards preparing and understanding consumers to accept such diversity in diets (Aliabadi *et al.*, 2021). The use of motivation theory to understand consumer perception and practice (Soon *et al.*, 2020; Soon *et al.*, 2022) can further develop an approach to encourage understanding diets among communities. Diversifying diet can ease the burden to produce food materials, encouraging consumers to try new food materials, thus creating a much more resilient and adaptable individual if a crisis does occur.

3.8 The rise of consumerism

As poultry production becomes more industrialised, farmers aim to produce broilers and eggs at cost effective measures. Various production systems create different perceptions of the rearing and management of poultry animals. Animal welfare has been mainly expressed in industrialised countries (Bessei, 2018). However, can be anticipated to occur in Malaysia as consumer perception and awareness are made known. Currently, certification practices such as Halal have been the current perception of food quality awareness among Malaysians (Ramli *et al.*, 2020; Al-Shammari, 2021) rather than overall animal welfare.

4. Conclusion

Broiler and egg production stability in Malaysia is highly dependent on imports. Fluctuation of the Malaysian ringgit, rising logistics costs, and import of raw materials for feed is passed down to the initial cost of production. The poultry industry, in general, is also technologically dependent on foreign expertise and would need to reassess its capability to be highly well versed. Research and innovation in poultry production should be enhanced to reduce dependency on imported raw materials by focusing on alternative natural resources. Breed improvement and diversification of breed type to create market segments can be more beneficial than existing ones. The engineering aspect, for example, building materials, design and technological inputs and automation, will be required to reduce loss and increase productivity. Infrastructure capacity to create stock for emergencies of a real food security threat should also be efficiently developed. However, sustainable progress could be industrialised by utilising competent inhouse expertise along the value chain within the matured poultry industry in Malaysia.

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HALALSPHERE
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Mini Review on *Halal* Food Colourants and Potential Sources

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Abstract

According to *Qur'an*, every *Muslim* must ensure that their food comes from *Halal* sources. In addition, being taught to be conscious that food and goods must be *Halal*, *Muslim*s must also be cognizant of the quality. The rest of the world is gradually beginning to see the significance of the *Muslim* need for *Halal* food and other consumables. For example, Malaysia, a diverse *Muslim* country, has a broad selection of *Halal* products and services and a high standard for food quality. As a result of the expansion of the food industry, societies now have access to a wide range of food products, including common foods, confections, desserts, and snacks. Despite the recent reduction in the permissible amount of synthetic colourants for consumer health reasons, many distinct synthetic food dyes continue to be widely utilised due to their low cost, high efficiency, and outstanding stability. Industry and customer awareness of *Halal* food and its quality should be evident. Hence, this paper aims to understand the issue and *Halal* concept in food. Focusing on food colourants sources and acknowledging the *Halal* standard in Malaysia. Based on the finding from this study, the concept of *Halal* should be combined with safety and health for consumer health, and there is a need for research into new resources for *Halal* colourants, particularly from natural colourant pigments compared to synthetic colourants.

1. Introduction

The world community has just begun to recognise the significance of *Halal*, a *Muslim* requirement for food and other consumables. The *Halal*-certified food and products market is booming (Majid *et al.*, 2015). Although the term *Halal* has never received as much attention as in recent years, a *Halal* food market exists wherever there are *Muslim* consumers whose food preferences are governed by *Halal* laws. The Economic Planning Unit of the Prime Minister's Department reported that the *Halal* market would contribute 8.1% of GDP by generating exports of RM56 billion by 2025. The *Halal* industry contributed RM9.7 billion to the country's gross domestic product in 2020 alone. According to Datuk Tan Tian Meng, secretary general of the Associated Chinese Chambers of Commerce and Industry of Malaysia (ACCCIM), this is due to non-*Muslim* consumers realising the importance of *Halal* certification for their trend of healthy eating and safe consumption compared to non-halal products. He added that the recent development and expansion of the *Halal* market had altered the perception and acceptability of non-*Muslim* consumers towards *Halal* consumption. Even non-*Muslim*s now realise and appreciate that *Halal* and *Toyyib* products are not limited to pork lard and alcohol but cover the whole process of producing the product of the highest quality benefits all consumers. Consequently, this explains why demand continues to rise year after year.

As a result of *Shari'ah* law, the *Islamic* dietary and consumption system is different and unique compared to other ethnic dietary systems. In a previous address, the former deputy minister in charge of *Islamic* Affairs stated that *Muslim*s worry more about *Halal* food than *Halal* income. This statement is consistent with the findings reported by Abdullah and Ireland in 2012, in which 49% of the respondents were highly concerned about the presence of alcohol in their perfume, makeup, and cosmetics, as well as the contamination of these goods with pig and other animal derivatives. Meanwhile, according to Jalil *et al.* (2018), *Muslim*s are more likely than other religious groups to view the humane and respectful treatment of animals in *Halal* as significant, as the *Qur'an* prohibits animal cruelty. Every *Muslim* must ensure that the food and drink they consume comes from *Halal* sources. This entails checking the ingredients and ensuring that the process adheres to *Shari'ah* principles. Due to the difficulty of tracking the source of various ingredients used to make food, drink, or other consumable items, many *Muslim* consumers rely on the ingredients on the exterior package to facilitate selecting *Halal* items. Since so many products are on the market nowadays, the issue becomes more complicated when numerous ingredients are listed in their scientific nomenclature. Especially considering that only some buyers comprehend technical phrases, the need for more comprehension of the employed codes is even worse. *Muslim*s are required to consume *Halal* food and avoid *Shubhah*.

According to MS1500: 2019 third revision, synthetic food colourants should be declared *Halal* because they comply with all the requirements for food or ingredient to be considered *Halal*. However, *Halal* food does not necessarily be *Toyyib*. We are all aware that the *Halalan Toyyiban* concept requires more than merely *Halal* and must include safety and not harm. Since synthetic food colourants cause more harm than good, it is time to find safe alternatives. Generally, synthetic colourants can be classified into water-soluble and fat-soluble colourants based on their solubility. Consumers concerned about synthetic colourants' safety urge food manufacturers to substitute synthetic colourants with natural colouring. Recently, The European Union (EU) required that all food manufacturers put a warning label on products containing the 'Southampton six colourant' (Munawar & Jamil, 2014). These colourants, known as tartrazine, quinoline yellow, sunset yellow, carmoisine, ponceau red, and Allura red, may cause intolerance reactions in sensitive individuals and adverse effects on children's behaviour, although robust scientific evidence is still lacking (Abbey, 2014). Thus, the nutritional value of the food must also be emphasised in the *Halalan Toyyiban* concept, and *Halal* food that can cause health problems should be avoided.

2. The *Halal* concept in food production

Halal food does not contain any ingredients that *Muslim*s are forbidden to consume. In today's modern age, the definition of *Halal* must go beyond simply designating "pork-free" food in its physical form. Instead, it encompasses various elements, including emulsifiers, additional food components such as gelatin, enzymes, lecithin, and glycerin, and additives such as stabilisers, flavouring, and colouring (Khan *et al*., 2016). In *surah al-Baqarah* verses 168, *Islam* establishes two fundamental standards for food consumption:

> *"O humanity! Eat from what is lawful and good on the earth and do not follow Satan's footsteps. He is truly your sworn enemy."* (2:168)

... meaning *Halal* (permitted by the *Shari'ah*) and *Toyyib* (of good quality), whereas *surah al-Baqarah* verses 172 to 173 "O believers! Eat from the good things We have provided for you. And give thanks to *Allah* if you ˹truly˺ worship Him ˹alone˺. He has only forbidden you ˹to eat˺ carrion, blood, swine, and what is slaughtered in the name of any other than *Allah*. However, if someone is compelled by necessity—neither driven by desire nor exceeding immediate need—they will not be sinful. Surely *Allah* is All-Forgiving, Most Merciful." These verses (2:172-173) state that every *Muslim* is obligated to eat *Halal* food and avoid what has already been forbidden (Md Shariff *et al*., 2021). In addition to being instructed to be conscious that food and items must be *Halal*, *Muslim*s must also be aware of what pertains to the quality. The Prophet Muhammad (PBUH) also emphasised this issue in many traditions (*Hadith*s). The Prophet's guidelines show that Islam stresses the quality of food (*Toyyib*) consumed by its believers. Every law in the *Qur'an* is understood to have a rationale and should not be taken for granted (Zakaria, 2008).

3. *Halal* recognition in Malaysia and futures

Malaysia is increasingly acknowledged as the global centre of the *Halal* industry. Despite being a multi-religious and multiracial nation, the objective of making the country's *Halal* industry a role model for other countries is highly ambitious (Md Shariff *et al*., 2021). Malaysia is striving to reach the goal to accomplish the stated objective. This is demonstrated by the annual budget, which is presented annually and allocates a specific amount of money towards *Halal* development. This demonstrates that the government has deliberately provided incentives for planning and achieving this goal. In Malaysia, a multiracial *Muslim* nation, *Halal* goods and services are easily accessible and widely available. However, the authority must also supervise and enforce guidelines to ensure the authenticity of *Halal*, particularly when the goods or services are produced, distributed, prepared, or offered by non-*Muslim*s (Dollah *et al*., 2012). Several certifications or *Halal* labelling regulations have been implemented in Malaysia. According to Ismail, Othman, Rahman, Kamarulzaman, & Rahman (2016), *Halal* certification examines every element of the production, not only its materials or components. This is consistent with *Toyyib*an, which is wholesomeness as a strength of *Halal* in food production to provide sanitation and safety products that all customers, including non–*Muslim*s, can appreciate. These characteristics are crucial marketing features for the entire consumer population. Malaysia's *Halal* laws are rapidly evolving to keep up with the country's booming *Halal* market, as seen by the following list of guidelines pertinent to *Halal* regulations in Malaysia (Azis Jakfar Soraji, Mohd Daud Awang, & Ahmad Nasir Mohd Yusoff, 2017):

i. The Trade Descriptions (Certification and Marking of *Halal*) 2011,
ii. The Trade Descriptions (Definition of *Halal*) 2011,
iii. The Rules of the Trade Descriptions (Fi Certification and Marking of *Halal*) 2011,
iv. The Food Act 1983,
v. The Regulation Food 1985,
vi. The Animal Act 1953 (Revised 2006),
vii. The Animals, 1962, the Order of Animals (Importation),
viii. The Abattoirs (Privatisation) Act 1993,
ix. State Syariah Criminal Offences Enactment and
x. The National Livestock Act

The current Malaysian Standard, MS 1500, "General Guidelines on the Production, Preparation, Handling, and Storage of *Halal* Food," which is a fundamental requirement for food products and food trade or business in Malaysia, prescribes the practical guidelines for the food industry regarding the preparation and handling of *Halal* food (Zakaria, 2008). Aside from that, food producers and manufacturers must adhere to the benchmark standards of Hazard Analysis Critical Control Point (HACCP), Good Manufacturing Practices (GMP), Good Hygienic Practice (GHP), and ISO9000 to achieve *Halal* requirements (Aziz & Chok, 2013). In certain ways, implementing food safety and cleanliness requirements assures that the food consumed is not only *Halal* but also safe. Other than that, the HDC, or *Halal* Development Corporation, is an entity wholly responsible for the administration of *Halal* and a sign of government initiatives put in place to strengthen Malaysia's position as a significant player in the global *Halal* market with good references by JAKIM's (Department of *Islamic* Development of Malaysia) on the management of *Halal* (Zakaria, 2008). HDC will also improve coordination, expedite the *Halal* certification procedures, and eliminate international complications to position Malaysia as a significant centre for *Halal* trade (Noordin, Md Noor, Hashim, & Samicho, 2009). Understanding *Halal* recognition, certification, and marketing-related components has determined the customer's purchasing intent for the product. According to Che Mohd Zulkifli (2013), the increased demand for *Halal* food, estimated

to be worth USD 346.7 billion or RM1317 billion annually, is associated with an increase in the number of *Muslim*s, a higher level of education, and greater purchasing power. Innovative food businesses have been surpassing the growing global market by establishing competitive advantages in the relevant market segments. Besides, the demand for *Halal* products is anticipated to rise because the world's population has topped two billion, and 57 nations have *Muslim* populations. Aside from this, *Halal* food sales in Malaysia account for RM36.63 billion, or 6.3% of nominal GDP (2009 prices), as Malaysian SMEs are now on par with the world's most influential businesses. Their products are widely available and considered high quality (Said, Hassan, Musa, & Rahman, 2014). On top of that, one of the most significant considerations in providing *Halal* food is to recognise that the *Islamic* dietary and consumption system is distinct from other ethnic groups. This is because the concept of *Halal* is not only related to food or food products but also goes beyond food to cover all aspects of *Muslim* life (Khan *et al.*, 2016).

Malaysia is among the nations whose government completely supports efforts to promote *Halal* certification for goods and services (Aziz & Chok, 2013). Malaysia aspires to be the global reference point for *Halal* integrity. The Malaysian government anticipates that by 2008, Malaysia will be the epicentre for the production and distribution of *Halal* products, *Halal* service providers, references to *Halal* standards, and *Halal* R&D. This is in line with the *Halal* Industry Mater Plan 2030, which is to strengthen the development of the *Halal* industry (HIMP 2030). The Malaysian government has also implemented a plan to make Malaysia the world leader in innovation, production, and trade in several *Halal*-related industries, including speciality processed foods, cosmetics and personal care, pharmaceutical ingredients, livestock, and the services sector, particularly logistics, tourism, and healthcare (Tsang, n.d). As a result, the *Halal* Hub Master Plan correctly identifies two development goals for Malaysia. Prioritise R&D and lead best practices in products, procedures, standards, and certification. Malaysia also possesses a well-rounded understanding of *Islamic* principles and other subjects, such as technological advancement, the sciences—particularly food, biochemistry, and microbiology—and business management (Said *et al.*, 2014).

4. Food colourant and its sources

Food is frequently coloured to improve its appearance and to boost sales (Spence, 2015). Despite the recent reduction in the permissible amount of synthetic colourants for consumer health reasons, a wide variety of synthetic food dyes are still used extensively around the world due to their low cost, high effectiveness, and excellent stability. Colourants are manufactured to boost their stability and appropriateness for various meals and beverages. Food is coloured for various reasons, including to restore colour lost during processing, to enhance colour that is already present, to reduce batch-to-batch variations, and to colour food that is otherwise uncoloured (Aberoumand, 2011). Consumers' avoidance of artificially coloured foods has encouraged the food sector to move to natural colours. According to Aberoumand (2011), food colourants can be categorised into natural, nature-identical, inorganic, and synthetic. Renewable resources are used to create natural food colourings. Natural colourants are derived from animals, plants, fruits, minerals, and spices. Most plant-based food colouring is sourced from fruits and vegetables and can be found in nearly every part of a plant, including the fruit, leaves, stalk, seeds, roots, and flowers (Rodriguez-Amaya, 2016).

Natural pigments such as carotenoids, myoglobin, chlorophyll, and anthocyanins may contribute to the natural colour (Khoo *et al.*, 2017). Carotenoids and anthocyanins are the two main classes of pigments responsible for the colouration of plants. Carotenoids are responsible for the orange and yellow lipid-soluble pigments in plastids, while anthocyanins are responsible for the pink, red, purple, and blue water-soluble vacuolar pigments in colourful plant pigments (Shrikant *et al.*, 2020). Annatto, paprika, saffron, caramel, chlorophyll, and turmeric are the most prevalent sources of carotenoids, followed by red pigment and caramels with a brown hue. Animal-derived food colouring is derived from insect bodily fluid. Cochineal, also known as carmine, is one of the most popular colours for animals. It is derived from the female cochineal insect. It is a native South American and Mexican insect that feeds on moisture and nutrients and inhabits the genus Opuntia of cacti (Dikshit & Tallapragada, 2018). The insect is dried and boiled to produce red food colouring. The body and eggs of the insect contain significant levels of carminic acid (Penang, 2015).

Mineral-based colourants include titanium oxide, calcium carbonate, iron oxide, and numerous others. Some of the most permanent and strong food colourings are made from mineral-based sources. Confectionery coatings, decorations, chocolates, calcium carbonate, bread, and gum are coloured with these substances (Rodriguez-Amaya, 2016). Natural colourants are typically extracted and concentrated using organic solvents for lipophilic pigments and water or lower alcohols for water-soluble pigments (Amchova *et al.*, 2015). The Muzakarah of the Fatwa Committee of the National Council for *Islamic* Religious Affairs Malaysia (1988) stated that cordial drinks containing added flavours which use alcohol as a stabiliser are permissible to drink and must comply with two conditions. Firstly, alcohol used as a stabiliser is not produced by making alcohol. Second, the quantity of alcohol in the flavours is a little, which is not intoxicating.

The law establishes limitations on the permissible colourants, the sources from which they may be derived, the solvents used to extract them, and the quality of the pigment. Nevertheless, several restrictions, including low resistance to heat, light, and pH, contribute to the limited usage of natural colouring. In addition to having a low tolerance for acidity and high temperatures, natural food colouring fades rapidly when exposed to light (Sezgin & Ayyilidz, 2017). Natural colouring is more expensive than artificial colouring, and natural colouring may impart an unwanted flavour (Sigurdson *et al.*, 2017).

Carotene, canthaxanthin, and riboflavin are some examples of synthetic pigments that closely resemble natural hues. The development of colour formulations has improved significantly over the past decades. Natural pigments originating from plant sources are unstable and sensitive to heat and pH, making them unsuitable for usage. As a result, in addition to stabilising them, researchers have formulated pigments identical to natural pigments (Dikshit and Tallapragada, 2018). These formulations emphasise the following criteria, as reported by Enaru *et al.* (2021). The first methods involve stabilisers, emulsifiers, and antioxidants to make them water-soluble. To improve the stability of pigments, oxidation is avoided. Efforts are being made to employ them in soft drinks, jellies, and other

products to increase their acidity. Work is underway to remove the allergens in natural pigments (peanut oil, maise, and soya derivatives).

Unlike natural colours, synthetic colours are created by humans (Aberoumand, 2011). These colours are created using chemical synthesis to resemble natural hues. Various synthetic dyes have been developed and used due to their lower production costs, longer shelf life, colour stability, and ease of blending to generate a vast array of hues (Sezgin & Ayyilidz, 2017). Tartrazine (E102), also known as an azo dye, is a petroleum-based artificial food colouring. In addition to producing the colour yellow, tartrazine can also be mixed with blue to create different hues of green. Tartrazine is present in bread, cereals, ice cream, soft drinks, confections, and canned goods (Silva *et al.*, 2022). Another often utilised azo dye is ponceau 4R (E124). It is made from petroleum and coal tar and is frequently found in processed meat, jams, jellies, drinks, and marmalades (Chung, 2016).

Based on their solubility, synthetic colourants are often classed as water-soluble or fat-soluble. Most fat-soluble synthetic dyes sold commercially are azo compounds such as Sudan I, Sudan II, Sudan III, and Sudan IV. Today, the Food and Drug Administration (FDA) in the United States permits two main kinds of food colourants: certified (typically synthetic colourants) and exempt from certification (typically natural pigments). However, there is no clear definition of what "natural" implies in this context (Sigurdson *et al.*, 2017). It has been determined that several azo dyes are harmful to the genetic system (Chung, 2016), and structure-activity relationships have been evaluated (Silva *et al.*, 2022). The worldwide food regulation act prohibits the use of Sudan I in foods. The International Agency for Research on Cancer has categorised Sudan (I-IV) as a category three human carcinogen (DiDonna *et al.*, 2004). However, imported food products such as paprika, chilli powder and curry pastes continued to contain Sudan dyes (Nisa *et al.*, 2016).

5. Food colouring issue

As a result of the expansion of the food industry, societies now have access to a vast array of food products, including staple foods, confections, desserts, and snacks. Due to time constraints and busy schedules, consumers now prefer processed or ready-made food to those they prepare. Unknown additives may be present in ready-made foods, which consumers may need to be aware of (Md Shariff *et al.*, 2021). Food and Drug Association (FDA) states that food additives are compounds added to food during production, processing, preparation, packaging, wrapping, transportation, preservation, and storage processes (FDA, 2011). Artificial colourings such as tartrazine, carmoisine, sunset yellow, ponceau 4R, quinoline yellow, and Allura are potentially hazardous to your health. There is evidence that safety concerns over artificial food colourings are developing.

The International Codex Alimentarius Commission (CAC), founded by the World Health Organization (WHO) and the Food and Agriculture Organization (FAO), defines food additives as "any substance not normally consumed as a food by itself and not normally used as a typical ingredient of the food, whether or not it has nutritive value, but added to achieve a specific purpose, known for having safe dose levels, and subject to regulation." Food colouring in Malaysia is governed by Food Additive Regulation in The Food Act 1983 and the Food Regulations 1985. Some synthetic dyes may be used as food colouring agents if they do not exceed the authorised threshold. It has been determined that the two principal dye groups, known as azo-dyes and triphenylmethanes, are most likely to be put into food without authorisation (EFSA, 2005). Azo dyes are organic compounds with numerous industrial applications. The metabolism of these dyes is responsible for their toxicity (Oplatowska & Christopher, 2015). Because they are easily applied, readily available, and stable in foods throughout processing, synthetic dyes are most frequently utilised in food-related applications (Munawar & Jamil, 2014).

Several health risks are associated with food colouring intake (Md Shariff *et al.*, 2021). Tartrazine, quinoline yellow, sunset yellow, carmoisine, azorubine, ponceau 4R, and Allura red are the six most common synthetic food colourants associated with attention deficit and hyperactivity in children. These substances can be found in sweetened foods and beverages (Martins *et al.*, 2016). Sunset yellow and tartrazine are widely mixed to create colour mixes for ice cream cones (Chung, 2016), while sunset yellow and carmoisine are used to create yoghurt (Pandey & Upadhyay, 2012). Meat and fish products typically contain carmoisine, erythrocin, tartrazine, Allura red, and red as colouring additives. These substances contribute to children's behavioural disorders, hyperactivity, and attention deficits; however, individual susceptibility varies considerably (Amchova *et al.*, 2015). There have been reports of tartrazine-induced allergic, including skin rashes, swelling, eye redness, and runny nose. Both sunset yellow and tartrazine have carcinogenic potential. Carmoisine has been linked to cancer, food poisoning, and allergic reactions. In addition, a study done in Japan found that cochineal might produce allergic reactions such as rashes, swelling, and itching. Research has also associated food colouring with health problems such as hyperactivity, allergies, learning disabilities, aggression, and irritability in children. Miller *et al.* (2022) also reported that the consumption of sunset yellow caused changes in children's behaviours.

Apart from behavioural concerns and cancer risks, the most evident risk that dyes provide to children is that they entice them away from nutrient-rich foods in favour of brightly coloured processed items that are high in calories but low in nutrients, such as fruit-flavoured drinks and snacks. According to CBS News (1990), these foods significantly contribute to the obesity epidemic sweeping the United States. Allura red is a synthetic colourant that may induce cancer, chromosomal aberration, developmental toxicity, DNA damage, genotoxicity, hyperactivity in children, neurotoxicity, phytotoxicity, and reproductive toxicity (Sabnis *et al.*, 2010). In addition to health concerns, the *Halal* status of food colouring may also be called into question. Cochineal (E120) is an example used in food, particularly in red velvet cake and crab sticks (McCann *et al.*, 2007). Besides locusts, Islam prohibits animals like caterpillars, ants, cockroaches, scorpions, mosquitoes, flies, bees, and spiders. According to a fatwa given by the State Mufti of Brunei in June 2015, cochineal is prohibited in food because the insect is regarded as impure or *najs* (Pelita Brunei, 2015). Even if only an extract or very small amounts of the insect are used to produce the colouring, it is still deemed haram because the colouring is still derived from the insect. Unlike liquid colours are designated as *Shubhah* (doubtful) since the solvent may be derived from haram sources unless it is *Halal*. However, Muzakarah Jawatankuasa Fatwa Majlis Kebangsaan Bagi Hal Ehwal Ugama Islam Malaysia and Majelis Ulama Indonesia have issued a fatwa on the consumption of cochineal

in food as permissible (JAKIM, 2015 and Majelis Ulama Indonesia, (2011). Fatwas in Malaysia are more inclined towards the opinion of the majority of Hanafi, Maliki and Hanbali jurists who categorise insect carcasses of insects that do not bleed as pure (Salleh *et al*., 2020).

6. Conclusion

In conclusion, the *Halal* food industry has gained much public interest due to a significant rise in consumer awareness regarding substances such as food colourants. The *Halal* standard of Malaysia also recognises food safety as an indicator of food quality and the status of *Toyyib*an. Therefore, it is essential to research food colourants derived from *Halal* and *Toyyib*an substances to identify new sources of pigments and improve food safety and quality assurance in the sector. Due to the increasing demand for pigment, separated natural colourants now outnumber synthetic colours in terms of demand.

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Environmental Approach for Securing *Halalan Toyyiban* Concept in Food Safety - A Mini Review

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Abstract

The relationship between the *Halalan Toyyiban* concept and food safety has been well known and discussed among scholars since the early years. *Muslim*s are guided by the concept highlighted in the *Qur'an* to consume food. However, the widely occurring environmental pollution and contamination around the globe have threatened the status of natural food resources. One of the major threats to global food safety is the chemical contamination of the environment. Harnessing the ability of the microorganism in the environment to restore nature is one of the approaches used to ensure the concept of toyyiban is safely fulfilled. Using the Qur'an as a primary source and other published articles, this article connects the links between the wider *Halalan Toyyiban* concept and the environmental sciences related approaches and subsequently provides an alternative perspective to the *Halalan Toyyiban* concept, especially for the food safety issues.

1. Introduction

The word environment is first used in French as "Environ", which defines the surroundings and neighbourhood. Currently, the word environment is widely used globally which refer to the physical factors of the surroundings around human beings and also as the setting where humans, animals and plants stay and food and nutrition available to be consumed and to nourish the living things (Muhamad *et al.*, 2019). A good environment reassures the nourishment pathway will be attained and benefit the population. Many elements of an environment, including air, soil and water, are the basic elements. There are also referred to as interconnected systems comprised of the biosphere, atmosphere, hydrosphere and lithosphere (Haque & Talukder, 2021). Human activities and the other way around are always changing these four systems. The environment is the most crucial element for an organism to survive and function orderly and, most importantly, to perform its duty as a vicegerent of God on Earth.

2. Environmental pollution

In this modern era, continuous development has unintentionally caused environmental pollution and impacted the globe in many undesirable ways. Water, air and soil pollution are majorly contributed to the results of anthropogenic activities that cause changes in the environmental quality and destructively impact the environment, including its residents are human beings, animals, plants and microorganisms (Adam, 2018). It also included situations like unclean food sources, sudden climate changes and elevation of temperature.

These pollutants may consist of potentially toxic substances that can contaminate the foods consumed by other organisms, including humans. The pollutant can be organic and inorganic and may come from various sources of origin. Environmental clean-up strategies are usually implemented before the pollutants reach the environment (treatment) or after they are released to the environment (remediation) along the contamination pathways, as illustrated in Figure 1.

As the pollution continues, the natural nourishment and bounties provided earlier on the earth started to fade and consequently affected the human being. *Allah SWT* gave a reminder in *surah Ar-Rum*: verse 41 that a human being destroys this earth; therefore, He asked the doer to ponder upon the consequences of the actions and return to Him. He asked his servant to reflect upon their actions to improve the

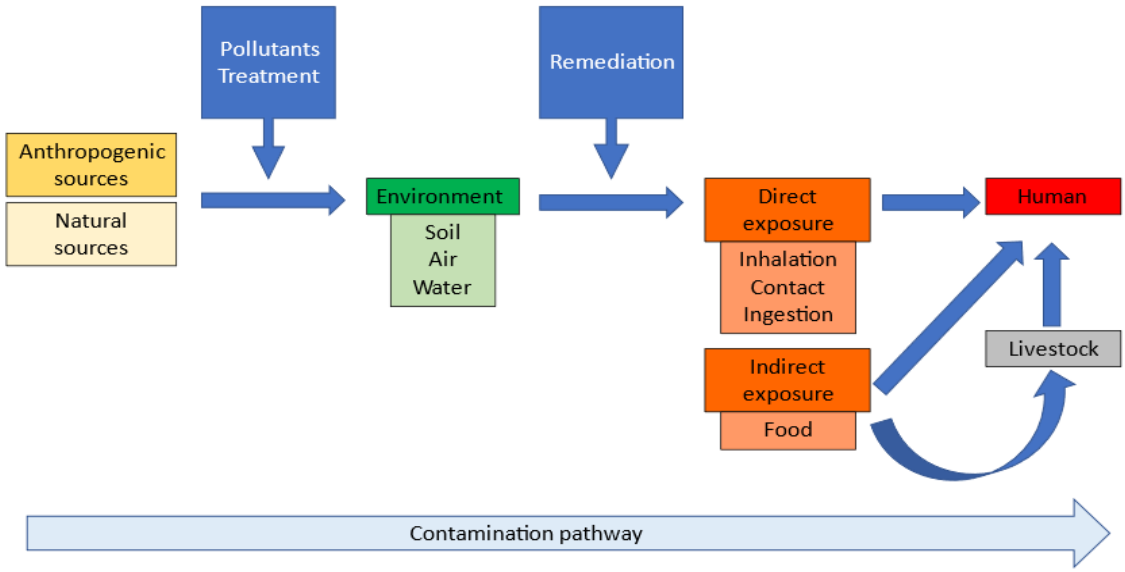

Figure 1: The fate of contaminants to human.

situation.

> *"Corruption has spread on land and sea as a result of what people's hands have done, so that Allah may cause them to taste 'the consequences of some of their deed and perhaps they might return to the Right Path'". (Qur'an ar-Rum 30:41)*

From the verse highlighted, it is certainly exposed that humans would cause corruption to the earth with their own dirty hands. However, humans can change the corruption to a better condition if they return to the right path.

Environmental preservation becomes the main agenda in protecting the natural environment from further destruction. At the same time, environmental restoration through remediation approaches was conducted everywhere to recover any damage caused by environmental pollutants. Today, it is become part of Fard al-Kifayah to treat the pollution so that all the Earth residents will have a better place to live and perform ibadah in a conducive sphere.

3. The clean-up of environmental contaminants

The environmental preservation concept is not only limited to avoiding the "corrupted" hands from destroying the atmosphere but also includes strategies to ensure the environment is free from harmful substances. A contaminated environment cannot supply good and pure raw materials. Many techniques are available to remediate the pollutants; however, cleaning up the environment using methods that will not harm the environment is crucial and could be very tricky at the same time.

Remediation is referred to as the process of eliminating pollutants from the sources. There are several types of remediation available such as chemical techniques, physical techniques and biological techniques. Each of the techniques is unique and available to be employed based on the condition of the polluted site and also the properties of contaminants. To successfully remove the contaminant, a comprehensive study of the contamination characteristics and properties is needed; hence an exact process could be chosen. Considerations must occur before employing the technique to ensure the benefits outweigh the harms. Remediation by traditional methods that employ physical and chemical methods is inefficient as it will always leave huge volumes of chemicals over (Tarekegn *et al.*, 2020).

Frequently, a combination of a few degradation strategies is being used to achieve fully degradation and remove toxic contaminants compounds. It is important to choose the right technique to clean up contaminants to ensure that the contaminants are fully removed and that no harm from the clean-up process is left in the environment.

One of the potential solutions for reducing and eliminating pollutants is by using bioremediation. According to Spellman (2021), bioremediation is any process that employs a living thing's potential to restore the polluted natural environment to its original state. Bioremediation is a technique that employs the special features of microorganisms to degrade pollutants to less toxic or even harmless substances for environmental clean-up. Studies on a microcosm of microorganisms and their ability have shown some hope for the bioremediation of toxic contaminants (Terzaghi *et al.*, 2020). These strategies were carried out by harnessing the ability of microorganisms, mainly bacteria. Those microorganisms will break down the organic pollutants into harmless metabolites or mineralise the pollutants into carbon dioxide and water (Zhao *et al.*, 2022). This technique is the most preferred to remediate the environment as it rarely leaves harmful traces after cleaning up.

4. Environmental preservation from a legal perspective

Environmental preservation from a legal mode took place in Malaysia when the Environmental Quality Act 1974 was introduced. It shows the effort of the country to conserve the environment. The objectives of the Environmental Quality Act are to promote self-regulatory on the part of the industrial sector and ensure direct participation in environmental protection (Environmental Quality Act, 1974). This act is an important action taken by the Malaysian government as part of the UN Conference on the Human Environment (Stockholm Conference) in 1972. Agenda 21 under the United Nations Environment Programme has outlined that integrated environment and development in decision making is needed by applying the economic instrument within the law.

Starting from that point, it can be seen that Malaysia has taken many actions from the perspective of law and economics in order to protect the environment. By virtue of section 34 Environmental Quality Act, Environment Impact Assessment is introduced. Regarding the section, Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987 has been enacted. Environmental Impact Assessment aimed to be implemented on a selected project to inspect and select the best form of project option offered, to recognise and incorporate mitigating measures, to predict the importance of residual environmental impact and to discover the cause and benefit of the project to the community. This can be seen in the Malaysian government's strategies to overcome the rapid development activities affecting the environment. Petroleum Development 1974 and Town and Country Planning Act 1976 are also among the acts that are being enacted in order to fight the effect of development on the environment. According to those acts, Malaysia still needs space to improve the environmental condition from the perspective of law.

From the economic perspective, Malaysia's Third Plan in 1976 introduced the concept of sustainable development. This concept is important to bring together economic and environmental strategies for Malaysia to be a developed country. It has been mentioned that environment-friendly business is more proficient since it can generate less pollution and benefit from the consumers' respect.

At present, Sustainable Development Goals (SDGs), introduced in 2016 by the United Nation (UN), has been referred to as the blueprint the ongoing development around the world so that development will align with the needs of people regardless of the economic status, race and religions (Bundschuh *et al*., 2022). The objectives included are eliminating poverty and preserving the earth, a home for all. Sustainable development can be defined as the development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It aims to bring together the conservation and development objectives so thus our present and future generations will home a better place.

5. *Maqasid al-shari'ah* concept of environmental preservation

From the *Islam*ic perspective, the *Maqasid al-shari'ah* concept is defined as choosing a way of living perception in everyday life. According to (Auda, 2018), *Maqasid al-shari'ah* is a term that refers to order preservation, benefit achievement and harm prevention, equality among people formation, and law establishment. Allowing the clarification for decision making process to be easier will assist the *ummah* to become more powerful, respected, and confident among others.

There are three main objectives in *Maqasid al-shari'ah*, that is *Darrruriyyah* (Necessity), *Hajiyyat* (Requirement) and *Tahsiniyyat* (Embellishment). After protecting religion in the first group of *Daruriyyah*, the second point is protecting one's life. To protect life conveys many definitions that vary from one circumstance to another circumstance. One of the ways to protect one life is to be aware of nutrient intake in everyday life. Nutrient intake is commonly referred to as food intake and is the daily life activities of all living things to survive.

The environment needs to be well taken care of; thus, it will provide nutritious food. A previous study has proved that pollutants in the environment have altered the nutrients in foods that caused negative impacts on human beings as well as animals (Eskenazi *et al*., 2018; Pavuk *et al*., 2019; Tarekegn *et al*., 2020). Hence, to ensure the well-being of the *ummah*, it is needed for someone to take responsibility for clearing up the pollutants

6. *Halalan Toyyiban* concept in food safety

Allah SWT has made it obligatory for every *Muslim* to consume food that is *Halal* (lawful) and of good quality with sufficient minerals and vitamins as needed (Mokti *et al*., 2022). In *Islam*, daily food intake is guided to ensure the meals taken will help the *Muslim* to perform ibadah spiritually with a good state of physical and intellectual (Elgharbawy & Azmi, 2022). Not only to ensure physical health and alertness, but these two factors, *Halal* and of the best quality, will also be a factor that will help to increase the quality of one *Taqwa* (God-fearing) and *Syukur* (Gratefulness) towards *Allah SWT*.

This matter has been mentioned in *Qur'an*

> *"O ye who believe! Eat the good things that We have provided for you, and be grateful to God, if it is Him ye worship." (Qur'an al-Baqarah 2:172*)

In verse, the presence of the word *Toyyib* which means good and pure has made the *Halalan Toyyiban* concept a complete guideline. *Toyyib* is one exhibition of Ihsan and Itqan concepts (competent and orderly manner). Due to this reason, the quality or estimated value of the lawfulness or the unlawfulness (*Halal* or *Haram*) of a matter cannot be judged separately without taking into consideration the process of production, manners, and ways of consumption and also its effect (Mokti *et al*., 2022).

This concept is a complete guideline for preparing wholesome food from the farm to the table. Food prepared must be from the permissible ingredients that are clean and hygienic. If the ingredients are already contaminated with pollutants, they will not be safe for human consumption and have bad effects on humans. These conditions somehow contradict the concept of *Halalan Toyyiban* that has been mentioned in the *Qur'an*. The *Halalan Toyyiban* concept is aligned with the food safety requirements that bring all people, not only those limited to *Muslim*s, to attract the application of this concept in their food preparation process.

6. Conclusion

To tackle the food safety issues, the preservation of the environment as the largest part covering the food chain needs to be considered. The environment needs to be clean to supply nutritious and free pollutant food to humans and animals. To ensure the nourishing food is of the best quality, pay attention to the food preparation process and from the initial stage at the source of origins of the raw materials. This is where environmental preservation takes place, contributing to and ensuring *Halalan Toyyiban* and food safety issues meet the necessity, thus guaranteeing the food arrives on the plates is only from the good and pure sources of the raw materials. The current best strategy to avoid further damage to the environment is by implementing sustainable development goals, both potential for environmental protection and economic sustainability. Apart from that, the environment must be well taken care of to achieve sustainable development by fulfilling all of its requirements, including a proper strategy to balance the ecological system by ensuring the endangered species are not threatened and urbanisation with forest destruction are well planned. Pollution and contamination of the environment should be avoided at all costs, as all the elements play a role in providing a well-balanced network (Fahad *et al.*, 2020). Furthermore, these contribute to the well-balanced biogeochemical cycle of an ecological system that provides the earth's residents with good sources of nutrients.

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Physicochemicals Properties for *Toyyib* Environmental Assessment on Lake Water Quality: A Mini Review

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Abstract

As Malaysia strives to become industrialised, numerous water bodies are increasingly dumping grounds for chemicals, sewage, and pollutants. It is considered that pollutant substances are continuously channelled into water bodies and then transferred into organic and inorganic particles, nutrients, pesticides, and herbicides that directly affect the aquatic ecosystem. This paper aims to study the overview of physicochemicals properties for lake water quality in relation to *Toyyib* environmental assessment. Malaysian water quality assessments are based on several rules, including the National Lake Water Quality Criteria and Standard, Urban Storm Water Management Manual for Malaysia, and National Water Quality Index Standard. As a result of the transmission of physicochemical qualities, water contaminants inflict harm not only on aquatic ecosystems but also on the safe water for human use. These studies indicate the water quality measurements or parameters for assessing the water quality for the *Toyyib* environment and establish the list of physicochemical properties for water quality assessment on the lake. On the other hand, the methodology applied for each parameter was also studied and presented.

1. Introduction

The National Institute of Hydraulic Research Malaysia reported that more than 60% of the ninety lakes examined were eutrophic (Sharip, Zaki, Shapai, Suratman, & Shaaban, 2014). The source of pollution in urban areas includes artificial and natural surface runoff, such as soil, which acts as a medium for the pollutants to enter the water body. Besides, according to the Malaysia Environmental Quality Report, the most influential sources of water pollution in Malaysia were anthropogenic: suspended solid (SS), ammoniacal nitrogen (NHO3) and biochemical oxygen demand (BOD). Typically, a water supply's physical, chemical and biological characteristics are utilised to evaluate its quality (Danjuma, 2019). In tropical developing nations where treating effluents before discharging them into water bodies is not a priority, the deterioration of water quality has been a troubling problem. According to Environmental Report (2022), studies on this particular category for Malaysia currently need to be made available. Hence, *Islam* clarifies that Muslims must be earth stewards (*Khalifah*). Therefore, the discussion has brought together the *Islam*ic perspective on the importance of water in *Islam*, the religious duty for water management, and the relationship to the *Toyyib* environment in water issues.

Manufacturing Practices (GMP) (Mansor *et al.*, 2020). So, in *Halal* cosmetics, the *Halalan Toyyiban* concept covers critical aspects of product preparation, including selecting ingredients, processing, packaging, storing, and delivering to consumers (Mansor *et al.*, 2017).

In Malaysia, the production of *Halal* cosmetics has become a trend among local cosmetic manufacturers as they are keen to dominate the market and come out with a wide range of product types to seek and satisfy clients (Abdullah *et al.*, 2020). Therefore, the growing knowledge and awareness regarding *Halal* cosmetic products are drastically changed to meet the local market's demand and supply. However, international companies unsurprisingly rule Malaysia's cosmetics and beauty items (Zakaria *et al.*, 2019; Kaur *et al.*, 2018). Hence, despite the understanding of *Halal* products, many Muslim consumers remain loyal to uncertified *Halal* cosmetic products because many products are imported and do not have *Halal* certification (Ngah *et al.*, 2021).

In short, as soap consumption has increased due to the Covid-19 pandemic, it is essential to know the *Halalan Toyyiban* concept in soap production to ensure the quality and safety of the product. Thus, this paper was written to study the concept of *Halalan Toyyiban* in soap production. This paper focuses on the soap for cosmetic uses, not for general uses. This paper adopts qualitative methods to collect information from articles and journal sources. This paper discusses three main topics: the overview of soap, the *Halalan Toyyiban* concept in soap production, and *Halal* cosmetics in Malaysia.

2. *Toyyib* environment towards water quality

Toyyib environments are not often used in environmental quality status, but they represent a safe and healthy environment based on risk assessment. As stated in *surah al-Mukminun*, verse 51, *Toyyib* means clean and pure. *Islam* recognised water as the source of life for the entire universe. This conclusion is supported by information highlighted in the *Qur'an* regarding the significance of water. *Allah SWT* created all living things entirely, as mentioned in the *Qur'an* in *surah al-Anbiya,* verses 30:

> *"Do not the unbelievers see that the heavens and the earth were joined together before we clove them asunder? We made from water every living thing. Will they not then believe?" (Qur'an,* 21:30*)*

Water is a medium of understanding, faith, and wisdom essential to *Islam*'s physical and spiritual practice. It is important to show how our *Islam*ic faith protects and cherishes the planet (Abdul Matin & Elisson, 2010). Water transfixes us with its beauty and frightens us with its awesome destructive force, serving as a constant and reliable sign of the creator. In *Islam*ic Jurisprudence, water is a vital element that bestows privileges on all living things. *Al-Qaradawi* has elucidated the principles of *Islam*ic Jurisprudence regarding the environment associated with water by the *Qur'an*, which includes five components; *Tashjir and Takhdir* (Planting and Greening),' *Imarah and Tathmir* (Sustainable Development), *Nazafah and Tathir* (Cleanliness and purification), natural resources and biodiversity conservation and health sustenance, as cited in Istajib & Abdullah (2014).

As evidenced by *Allah SWT* repeated reminders in the Qur'an, these elements constitute a critical relationship to the human's religious obligation regarding water. For instance, in *surah al-Annam,* verse 66 states:

> *"And it is He who sends down rain from the sky, and we produce vegetation of all kinds. We produce from it greenery from which We produce grains at harvest, And from the palm tree of its emerging fruit are clusters hanging low. Moreover, We produce a garden of grape vines, olives and pomegranates, similar yet different. When they begin to bear fruit, feast your eyes with the fruit and the ripeness thereof. Behold, in that, are signs for a people who believe." (Qur'an,* 6:99*)*

At the end of the verse, *Allah SWT* emphasised that all creatures are a sign for those who owe him obedience. As mentioned in *surah Hud*, verse 6, when *Allah SWT* had created all the things that are necessary for humans to ensure the safe and sustainable management and development of the environment:

> *"And to Thamud, We sent their brother Salih. He said, "O, my people, worship Allah; you have no deity other than Him. He has produced you from the earth and settled you in it, so ask forgiveness of Him and then repent to Him. Indeed, my Lord is near and ready to answer." (Qur'an,* 11:61*)*

As *Allah SWT* created all creatures on the earth for the benefit of humanity, people should show their gratitude to *Allah SWT* by managing the environment following the rules and regulations in the *Qur'an* and to please *Allah SWT*. The destruction of the environment is not a natural occurrence unrelated to human activities, as justified in *surah ar-Rum* verse 41:

> *"Mischief has appeared throughout the land and sea by reason of what the hands of men have earned so Allah may give them a taste of some of their deed in order that they may turn back from evil."* (*Qur'an*, 30:41)

The verse shows that human activities will lead to the effect of corruption. Thus, the subject of cleanliness and purification, natural resources and biodiversity conservation, and health sustenance is relevant to be emphasised in the *Toyyib* environment regarding the religious duty on environmental management, including water safety and health risk.

3. Water issues

Water is a part of the environment that provides many benefits to humans, society, and the earth system to support the living environment. It is a basic unit of life, and it has a complex and multidimensional concept, ranging from the global circulation system to a single human cell. In the new globalisation era, however, everyone is engaged in a battle to control water resources. Only a few categories of water usage contribute to water challenges, such as domestic use, industrial, agriculture, food production, etc. Water is a fundamental substance for human life. The ever-increasing water crisis compels humans to develop many innovative methods for predicting future environmental conditions and preventing the loss or depletion of natural resources. In the first half of the 20th century, the world begins to pay attention to the scarcity of natural resources due to the rise in global populations and resource consumption (Schmidt, 2019).

Moreover, the various activities in high population areas, such as urban areas, determine the social and economic impact on the environment, including the water bodies. Urbanisation is growing as a result of the population rising. The site has been employed for economic advantage based on the potential natural features ideal for any physical development, such as dwelling, business area, institution, public park, and public transportation route, to satisfy human requirements. This kind of land use, which will transform into an urban area, will influence the source of water pollution.

3.1 Point sources of pollution and nonpoint sources of pollution

Most point source contamination originates from industrial wastewater and municipal sewage discharges from urban or densely populated regions (from various manufacturers)

(Kèm, Nhơn, Ahmad, Gang, & Sakib, 2018). This definition was supported by Singh & Gupta (2017), who described point source pollution as a source that can be directly identified. As described in Environmental Quality Report 2022, point sources are defined as sources of pollution with definite, recognisable discharge sites that remain fixed over time. These sources include industries, agriculture, and sewage treatment systems.

Wu *et al.* (2015) have described nonpoint source pollution as originating from diffuse sources such as urban runoff and soil erosion, which affect receiving waters such as lakes, rivers or reservoirs caused by leaching and erosion of rainfall runoff, agricultural as well as anthropogenic activities (Ridolfi, 2016). Wang *et al.* (2015) found that agricultural nonpoint source pollution contributed between 68% to 83% of the total pollution, including nitrogen, phosphorus, nutrients, and organic and inorganic pollutants exposed to surface runoff. According to Zhang *et al.* (2013), another factor affecting nonpoint sources is improper land use structure and management, leading to soil erosion and pollutant-induced water eutrophication.

3.2 Source of water pollution in Malaysia

Water pollution load is one of the most critical factors that must be considered when prioritising and planning pollution prevention and control strategies. The sources of pollution come from natural sources, most of which are the result of human activity (Afroz, Masud, Akhtar, & Duasa, 2014).

According to Environmental Quality Report (2020), there are three significant effects of environmental pollution load in water sources Biochemical Oxygen Demand (BOD), Ammoniacal Nitrogen (NH3N), and Suspended Solid (SS). On top of that, the findings by (Camara, Jamil, & Abdullah, 2019) showed that 87% of the studies that were analysed identified urban land use as a significant cause of water pollution, compared to 82% that identified agricultural land use, 77% that identified forestry use, and 44% that identified other land uses. All of these are a result of human activities.

4. Lake water quality in Malaysia

Due to its climate, Malaysia is one of the countries that receive high levels of rainfall every year. As part of water management, lake catchments are necessary to balance the ecosystem in a region, state, rural, and urban area. However, rapid development has significantly affected the quality standard of the lake in Malaysia.

4.1 National lake water quality criteria and standards

The National Hydraulic Research Institute of Malaysia (NAHRIM) and the Ministry of Natural Resources and Environment of Malaysia has developed the National Lake Water Quality Criteria and Standard (NRE). This standard is intended to establish specific water quality criteria and provide the information necessary for the lake quality assessment prior to lake categorisation, such as recreational activities or ecosystem health. In addition, this standard serves as a basis for conducting lake research in Malaysia in a manner that is non-deteriorating and yet improves the environmental quality. According to National Lake Water Quality Criteria and Standard (2015), the classification of lakes is based on four monitoring parameters: physical, nutrients, biological, and microbiological measurements and other measurements such as heavy metal. Besides, the categorisation of the lakes is divided into four, as shown in Table 1.

For category A, the lake water quality is managed for the primary body contact recreation such as swimming and must be free from water-borne diseases; hence, additional microbiological parameters must be measured. In category B lakes, however, the water quality is managed for secondary body contact recreation, such as cruising, and direct body contact activities are prohibited, as microbiological and water-borne diseases measurement is not required. A category C lake is managed to preserve aquatic life and biodiversity as part of a healthy lake and ecosystem. The main parameter measured is physical parameters, nutrients, and heavy metals. Category D requires the minimum preservation for aquatic life, as all possible pollutants must be removed. The parameters are listed in Tables 2 and 3. Other optional parameters for measuring the lake water quality include calcium ion, chloride, fluorine, nitrite, sulphate, etc. The required values are varied depending on the category of the lake. In addition, the concentration of heavy metals is an essential criterion for determining the toxicity of water, as shown in Table 2.

Table 1: Description of lake categories

NO.	CATEGORIES	DESCRIPTION
1	CATEGORY A	Lakes are managed where the water is used for recreational purposes - primary body contacts such as swimming, diving and kayaking.
2	CATEGORY B	Lakes are used for recreational purposes - secondary body contacts such as boating and cruising. Swimming is not allowed in this category of lakes.
3	CATEGORY C	The lakes are meant for the preservation of aquatic life and biodiversity.
4	CATEGORY D	Lakes are managed for the minimum preservation of good aquatic life in the lakes.

4.2 National water quality standard for Malaysia

Furthermore, the National Water Quality Standard for Malaysia also consider the same parameters as the lake quality assessment, as shown in Table 4, and a few additional parameters, such as heavy metals, as shown in Table 5.

4.3 Urban storm water management manual for Malaysia

Another initiative taken by the Government of Malaysia through Department of Irrigation and Drainage in controlling the adverse impact on the water bodies such as lake in the urban area is the Urban Storm Water Management Manual for Malaysia (MSMA 2nd Edition). This guideline is produced to minimize the adverse impact such as water pollution, ecological damage, erosion, etc. According to (Department of Irrigation and Drainage-DID, 2012), there were a list of pollutants estimation that come from the nonpoint source (NPS) and typically found in the urban area such as gross total suspended

Table 2: The measurement parameter for heavy metals concentration for lake water quality criteria and standard

PARAMETER	UNIT	CATEGORY A	CATEGORY B	CATEGORY C	CATEGORY D
Aluminium (Al)	mg/L	0.1	0.1	0.05	0.05
Antimony (Sb)	mg/L	0.03	0.03	0.03	0.03
Barium (Ba)	mg/L	0.1	0.1	1	1
Berylium (Be)	mg/L	0.004	0.004	0.004	0.004
Boron (B)	mg/L	1	1	1	1
Chromium (Cr)	mg/L	0.05	0.05	0.05	0.05
Cobalt (Co)	mg/L	0.05	0.05	0.05	0.05
Copper (Cu)	mg/L	0.02	0.02	0.02	0.02
Iron /Ferum (Fe)	mg/L	1	1	1	1
Magnesium (Mg)	mg/L	150	150	150	150
Manganese (Mn)	mg/L	0.1	0.1	0.1	0.1
Silver (Ag)	mg/L	0.05	0.05	0.05	0.05
Sodium (Na)	mg/L	200	200	200	200
Sulphur (S)	mg/L	0.05	0.05	0.05	0.05
Zink (Zn)	mg/L	3	3	5	5

Table 3: The measurement parameter for national lake water quality criteria and standards according to categories

PARAMETER	UNIT	CATEGORY A	CATEGORY B	CATEGORY C	CATEGORY D
PHYSICALS					
Colour	TCU	100 - 200	150 - 300	300	300.00
Conductivity	µS/cm	1000	1000	2000	5000.00
Salinity	ppt	nvd	nvd	<1	>1
Floatables	-	NV	NV	NV	NV
Dissolved oxygen	mg/L	6.3 - 7.8	5.5 - 8.7	4.5 - 10.3	3.3 - 10.3
DO percentage saturation	%	80 - 100	70 - 110	55 - 130	40 - 130
Odour	-	NOO	NOO	NOO	NOO
pH	-	6.5 - 8.5	6.5 - 8.5	s	5.5 - 9.0
Taste	-	NOT	NOT	NOT	NOT
Temperature	°C	28	28	28	28.00
Total Suspended Solid	mg/L	<100	100 - 500	200	> 200
Turbidity	NTU	40.0	40 - 170	70	250.00
Transparency (Secchi)	m	0.6	0.60	0.3	0.30
Oil & Grease	mg/L	1.5	1.50	1.5	1.50
NUTRIENTS					
Ammoniacal Nitrogen (NH3-N)	mg/L	0.1	0.3	1	2.70
Nitrate-N (NO3-N)	mg/L	7.0	7.0	10	10.0
Total Phosporus	mg/L	0.01	0.035	0.04	0.05
HEAVY METALS					
Arsenic (As)	mg/L	0.05	0.10	0.15	0.40
Cadmium (Cd)	mg/L	0.002	0.002	0.01	0.01
Lead (Pb)	mg/L	0.05	0.05	0.05	0.05
Mercury (Hg)	mg/L	<0.001	<0.001	<0.001	< 0.001
Nickle (Ni)	mg/L	0.02	0.02	0.05	0.05
Aluminium (Al)	mg/L	0.10	0.10	0.05	0.05
Antimony (Sb)	mg/L	0.03	0.03	0.03	0.03
Barium (Ba)	mg/L	0.10	0.10	1.00	1.00
Beryllium (Be)	mg/L	0.004	0.004	0.004	0.004

Boron (B)	mg/L	1.00	1.00	1.00	1.00
Chromium (Cr)	mg/L	0.05	0.05	0.05	0.05
Cobalt (Co)	mg/L	0.05	0.05	0.05	0.05
Copper (Cu)	mg/L	0.02	0.02	0.02	0.02
Iron/Ferum (Fe)	mg/L	1.00	1.00	1.00	1.00
Magnesium (Mg)	mg/L	150.00	150.00	150.00	150.00
Manganese (Mn)	mg/L	0.10	0.10	0.10	0.10
Silver (Ag)	mg/L	0.05	0.05	0.05	0.05
Sodium(Na)	mg/L	200.00	200.00	200.00	200.00
Sulphur (S)	mg/L	0.05	0.05	0.05	0.05
Zinc (Zn)	mg/L	3.00	3.00	5.00	5.00
BIOLOGICAL / MICROBIOLOGICAL					
Chlorophyll-a	µg/L	10	15	15	25
Biochemical Oxygen Demand (BOD)	mg/L	3	6	6	8

Table 4: Parameter used in national water quality standard for Malaysia (Environmental Quality Report,2020)

PARAMETER	**UNIT**	**CLASS**					
		I	**IIA**	**IIB**	**III**	**IV**	**V**
Ammoniacal Nitrogen	mg/L	0.1	0.3	0.3	0.9	2.7	> 2.7
Biochemical Oxygen Demand	mg/L	1	3	3	6	12	> 12
Chemical Oxygen Demand	mg/L	10	25	25	50	100	> 100
Dissolved Oxygen	mg/L	7	5 - 7	5 - 7	3 -5	< 3	< 1
pH	-	6.5 - 8.5	6 - 9	6 - 9	5 - 9	5 - 9	-
Colour	TCU	15	150	150	-	-	-
Electrical Conductivity	mS/cm	1000	1000	-	-	6000	-
Floatables	-	N	N	N	-	-	-
Odour	-	N	N	N	-	-	-
Salinity	%	0.5	1	-	-	2	-
Taste	-	N	N	N	-	-	-
Total Dissolved Solid	mg/L	500	1000	-	-	4000	-
Total Suspended Solid	mg/L	25	50	50	150	300	300
Total Suspended Solid	mg/L	25	50	50	150	300	300
Temperature	°C	-	Normal + 2 °C	-	Normal + 2 °C	-	-
Turbidity	NTU	5	50	50	-	-	-
Faecal Coliform	count/						
100 mL	10	100	400	5000			

Table 5: Additional parameter used in national water quality standard for Malaysia

PARAMETER	UNIT	CLASS				
		I	IIA/IIB	III	IV	V
Al	mg/L		-	-0.06	0.5	
As	mg/l		0.05	0.4 (0.05)	0.1	
Ba	mg/l		1	-	-	
Cd	mg/l		0.01	0.01* (0.001)	0.01	
Cr (IV)	mg/l		0.05	1.4 (0.05)	0.1	
Cr (III)	mg/l		-	2.5	-	
Cu	mg/l		0.02	-	-	
Hardness	mg/l		250	-	-	
Ca	mg/l		-	-	-	
Mg	mg/l		-	-	-	
Na	mg/l		-	-	3 SAR	
K	mg/l		-	-	-	
Fe	mg/l		1	1	1 (Leaf) 5 (Others)	
Pd	mg/l		0.05	0.02* (0.01)	5	
Mn	mg/l		0.1	0.1	0.2	
Hg	mg/l		0.001	0.004 (0.0001)	0.002	
Ni	mg/l		0.05	0.9*	0.2	
Se	mg/l		0.01	0.25 (0.04)	0.02	
Ag	mg/l		0.05	0.0002	-	
Sn	mg/l		-	0.004	-	
U	mg/l		-	-	-	
Sr-90	Bg/l		< 1	-	-	
CCE	µg/l		500	-	-	
MBAS/BAS	µg/l		500	5000 (200)	-	
O&G (Mineral)	µg/l		40 ; N	N	-	
O&G (Emulsified Edible)	µg/l		7000 ; N	N	-	
PCB	µg/l		0.1	6 (0.05)	-	
Phenol	µg/l		10	-	-	
Aldrin/Dieldrin	µg/l		0.02	0.2 (0.01)	-	
BHC	µg/l		2	9 (0.1)	-	
Chlordane	µg/l		0.08	2 (0.02)	-	
t-DDT	µg/l		0.1	-1	-	
Endoslufan	µg/l		10	-	-	
Heptachlor/Epoxide	µg/l		0.05	0.9 (0.06)	-	
Lindane	µg/l		2	3 (0.4)	-	
2,4-D	µg/l		70	450	-	
2,4,5-T	µg/l		10	160	-	
2,4,5-TP	µg/l		4	850	-	
Paraquat	µg/l		10	1800	-	
2,4,5-T	µg/l		10	160	-	
2,4,5-TP	µg/l		4	850	-	

Notes:
* = At hardness 50 mg/l $CaCO_3$
# = Maximum (unbracketed) and 24 – hour average (bracketed) concentrations
N = Free from visible film sheen, discolouration and deposits

solid (TSS), biochemical oxygen demand (BOD), chemicals oxygen demand (COD), total nitrogen (TN), total phosphorus (TP), Copper (Cu), Lead (Pb),Zinc (Zn), Oil and Grease (O & G) and Bacteria (E. coli). However, there are three pollutant generation potential that always take place in the urban area which were resulted from various landuse as presented in Table 6.

Additionally, accumulation of the pollutants was estimated based on the EMC method and it depends on the land activities and practices at the selected area. Table 7 is showing the example of estimated pollutants at four selected area which were in Malacca, Damansara, Penang and Kajang that was conducted by the authority.

5. Physico chemical for water assessment

To protect and restore water related ecosystem is in line with one of the United Nation Sustainable Development Goals,which is SDG 6, through the restoration and preservation of freshwater ecosystems (Wuijts, Driessen, & van Rijswick, 2018). Water Quality standard have been measured from numerous perspectives, and geology and other related factors influence the evaluation criteria such as type of soil (Wan Sulaiman,2019). Typically, a water source's physical, chemical, and biological compositions are used to determine its quality (Danjuma, 2019). Depending on the type of water body (lakes) and its various uses, a variety of physicochemical and biological characteristics are selected to evaluate the quality of lake water (or other surface sources)(Vasistha & Ganguly, 2020). Determining the existing properties of a water body will assist in identifying potential trends and aid in choosing the most effective methods for monitoring water pollution. Thus, Water Quality Index (WQI) is a crucial instrument for identifying the lake water quality.

The classification of water was identified based on the values of six main parameters, including dissolved oxygen (% saturation), biochemical oxygen demand, chemicals oxygen demand, ammoniacal nitrogen, total suspended solids, and pH, as shown in the equation in Figure 1. However, the surrounding environment affected the hydrological system, particularly soil as a water runoff medium. The 6 major parameters above have been briefly discussed.

5.1 Dissolved oxygen

Dissolved oxygen (DO) is is an essential indicator of water quality that can be easily measured in any body of water. According to Kannel & Lee (2007), dissolved oxygen is a key factor for aquatic life and plants as well as a barometer for measuring water health. Regarding the process of respiration from animals and plants in water bodies, the amount of dissolved oxygen can decrease, which will increase the photosynthetic activity of algae (Dominic, Murali, & Nisha, 2009). Without proper management and control, this mechanism affected the water quality.

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WQI = (0.22*SIDO) + (0.19*SIBOD) + (0.15* SIAN) + (0.16*SISS) + (0.12* SIpH)

where;
SIBOD = Subindex DO(% saturation
SIBOD = Subindex BOD
SICOD = Subindex COD
SIAN = Subindex NH3-N
SISS = Subindex SS
SIpH= Subindex pH
0 ≤ WQI ≤ 100

WQI SCORE
Class I = > 92.7
Class II = 76.5 – 92.7
Class III = 51.9 – 76.5
Class IV = 51.9 -76.5

Figure 1: Water quality index formula and calculation. (Malaysia Environmental Quality Report, 2020)

5.2 Biochemicals oxygen demand

In addition, the trend of biochemical oxygen demand (BOD) was found to be comparable to the value of chemical oxygen demand (COD) in term of being significantly correlated with the water quality status (Hossain, Sujaul, & Nasly, 2013). The value of dissolved oxygen decreases as biochemical oxygen demand increases (BOD) (Jodeh, Salim, & Haddad, 2013). A significant contributor to the increase in biochemical oxygen demand is the high proportion of organic pollution load in water (Muyibi, Ambali, & Eissa, 2007).

5.3 Chemicals oxygen demand

As mentioned previously, the biochemical oxygen demand (BOD) correlates with the value of chemicals oxygen demand (COD), and it is toxic to biological life (David Noel, Rajan, & Sivakumar, 2014). According to Mohamed & Othman (2015), the correlation between COD value and temperature and ammoniacal nitrogen is also positive (NH3N).

5.4 Ammoniacal Nitrogen

Besides, the amount of ammonical nitrogen (NH3N) that influences eutrophication and the high concentration of ammonical nitrogen (NH3N) generally supply from industrial activities such as vicinity of polymer, chemical, metal, gas ,wooden industries, agro-based industries that received their effluents contribute to the water quality degradation that has become a primary environmental concern (Hossain, Sujaul, & Nasly, 2013).

5.5 Suspended solid

A suspended solid load can harm the receiving water bodies (Burford, Costanzo, Dennison, Jackson, & Jones, 2003). According to Mohamed & Othman (2015), suspended solid (SS) are composed of both organic and inorganic material wastes. Sources of suspended solid (SS) include surrounding activities such as earthwork or land clearing.

5.6 pH

On top of that, pH is a significant indicator that affects chemicals and biological processes, and most organisms' survival depends on a particular range of pH (Kannel & Lee, 2007). pH was found to be positively correlated with the amount of biological oxygen demand (BOD) and chemicals oxygen demand (COD) (Hossain et al., 2013). By definition, pH

measures the hydrogen concentration in any substance, such as water or soil, and the value is typically associated with acidity or alkalinity (Rahmanian et al., 2015). According to Sujaul, Sobahan, Edriyana, Yahaya, & Yunus (2015), the atmosphere's temperature can impact the pH level.

5.7 Trace elements or heavy metals

Large quantities of pollutants are produced in urban environments, accumulating on surfaces such as roads and roofs. These contaminants enter the storm sewer system during rain events, where they are either transport to treatment facilities or discharged directly into receiving waterways. Numerous pollutants from stormwater such as heavy metals (lead, zinc, copper, cadmium, chromium and nickel), organic compounds, nutrients, solids, have accumulated in the bottom sediment, resulting in higher concentrations than in natural sediments (Karlsson, Viklander, Scholes, & Revitt, 2010). In particular, Soldatova et al. (2018) conducted a highly thorough health risk assessment study by considering the potential toxic effects of 11 drinking water contaminants, including lead, thallium, mercury, and the heavy metals, NO3-, NH4+, Fe, Mn, and As (Pb) (Li & Wu, 2019). According to Ashraf, Maah, & Yusoff (2011), high concentration of some of the heavy metals, such as Pb2+, Zn2+, Ni2+, Co2+, As3+, Cu2+, Fe2+, Mn2+, Sn2+ have direct effects on the growth of crops, while other heavy metals do not directly affect crop growth but may indirectly affect the animals that feed on the crops.

6. Conclusion

As a conclusion, lake water quality that affected by pollution from the activities surrounding will render the water unfit for human activities, particularly those involving bodily contact. This might be considered as risk management for the *Toyyiban* environment, as we should provide a safe and healthy space for halal lifestyle. All of the evaluated physicochemical properties can serve as a guideline for identifying or determining the risk to lake water quality and apart of *Toyyib* environmental assessment to provide a safe condition for human activities such as water recreation activities and also other ecosystem. The overview of few assessment from National Lake Water Quality Criteria and Standards, National Water Quality Standard for Malaysia and Urban Storm Water Management Manual for Malaysia had presented the indicator to ensure the quality of water for future lake water quality management for *Toyyib* environmental assessment.

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HALALSPHERE

International Islamic Univerity Malaysia - INHART

The Role of *Shari'ah* Principles in Guaranteeing *Halal* Logistics: A Review

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Abstract

Shari'ah principles play an important role in ensuring that the activities of the *Halal* industry are conducted in a way that conforms to Islamic principles. Processing *Halal* products requires logistics that adhere to *Shari'ah* principles, from the raw material to the products used by consumers. A *Shari'ah*-compliant approach ensures *Halal* is guaranteed throughout the *Halal* logistics process. This paper aims to uncover the *Shari'ah* principles as a basic reference in implementing the logistics activity process and protecting *Halal* products from elements that can tarnish their *Halal* status. A review of conference papers, scientific journals, and related scientific books was done to achieve the goal. It is concluded that the principles of *Shari'ah* are important in *Halal* logistics so that the product is always guaranteed to be *Halal*. Customers will have a greater sense of confidence in their *Halal* products.

1. Introduction

Shari'ah principles play an important role in maintaining *Halal* products so that *Halal* guarantees are well protected. All mobilisation activities involving the process of a product must refer to *Shari'ah* guidelines; this shows that Islam pays close attention to the issues that arise. Not to mention the issues related to the *Halal* industry that always exist from time to time. This *Shari'ah* principle is flexible in monitoring the *Halal* industry as a whole. *Shari'ah* principles used in resolving *Halal* industry issues, especially logistics, are general. Therefore, disclosing Shari'ah principles that can be used as a logistic guide is necessary.

In the millennium era, the development of *Halal* products and goods is very exciting and fast-paced. The need for these *Halal* products is very much in demand by people from both Muslim and non-Muslim countries. In selecting *Halal* products, one must consider Halal's status, be clean, and be good for Muslims to live on earth. *Allah* Almighty has said in the *Qur'an*, surah *al-Baqarah* 2: 168, which means:

"O mankind! Eat of that which is lawful (Halal) and clean on earth, and do not follow the footsteps of Shaitan (Satan). Verily, he is to you an open enemy."

Based on this verse, it is found that choosing *Halal* food and avoiding *Haram* food is an obligation for Muslims to observe. This selection is not limited to food only but to all consumer goods. In general, *Halalan Toyyiban* (*Halal* and Good/Clean) is a *Shari'ah* principle that is the basic tenet to maintain the sustainability of *Halal* status.

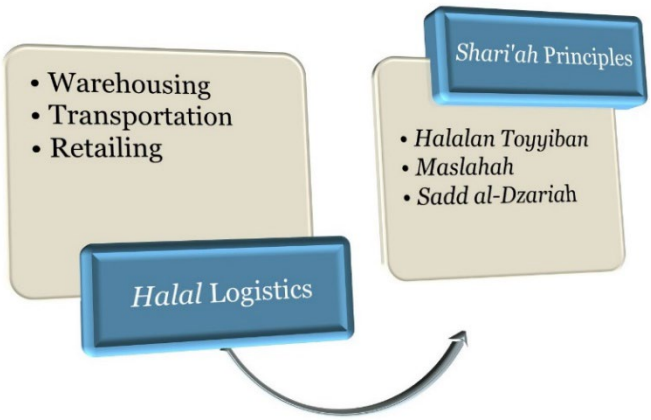
Malaysia is an Islamic country that plays an important role in developing the *Halal* industry at the global level. In the effort to market *Halal* products, it is necessary to use *Halal* logistics so that all *Halal* products can be guaranteed to be *Halal*. The Halal industry needs to use Halal logistics to conduct its business. Tieman (2013) says *Halal* logistics is managing the procurement, movement, storage, and handling of materials, livestock parts, and long-completed inventory, whether food or non-food, under organisational management through a supply chain that complies with *Shari'ah* principles. Omar *et al.* (2011) view that this logistic process also requires a *Halal* supply chain where both will consolidate business processes and activities, starting from the origin to the consumer by adhering to *Shari'ah* principles.

Halal logistics protects *Halal* products from *Haram* contamination so that *Halal* products will remain *Halal*. The logistics movement is divided into three main sectors: warehousing, transportation, and retail. These three sectors must adhere to *Shari'ah* principles to ensure the *Halal* status of products and prevent contamination. *Halal* industry players involved in running *Halal* product factories must follow *Shari'ah* guidelines in full on the part that involves logistics. Alam & Sayuti (2011) explained that if the handling and storage of food are not properly controlled, it will not be considered *Halal*.

Therefore, it is necessary to be exposed to *Shari'ah* principles

that can be used to guide *Halal* logistics, whether general principles or specific principles. This aims to protect all *Halal* products safely and get protection through the principle of *Halalan Toyyiban*, which is a general guide. Flow chart 1 shows that movement activities in *Halal* logistics, such as warehousing, transportation, and retailing, must follow the guidelines of *Shari'ah* principles, such as *Halalan Toyyiban*, *Maslahah* and *sadd al-dzariah* to maintain the *Halal* product guarantee status. The three principles of *Shari'ah* will be explained hereafter.

Figure 1: *Halal* logistics based on *Shari'ah* principles



2. Shari'ah principles

Shari'ah is universal and can be used to resolve all matters in accordance with the time and place. Islam has many principles that guide the activities of human life on this earth. These *Shari'ah* principles come from two sources, namely, the *Qur'an* and *Hadith*, which are the result of istiqra '(induction) of the Islamic scholars, both the former and the latter, comprehensively. Many *Shari'ah* principles can be used to guide logistics activities, but this study only provides exposure to relevant and selected principles.

2.1 Principle of *Halalan Toyyiban*

In the *Halal* industry, the word of *Allah* in surah *al-Baqarah*, verse 168, clearly contains the principle of *Halalan Toyyiban,* which is generally referred to. It is the basis for using *Halal* and *Toyyib* (good) consumer goods. In addition, it can be a guide to every activity in the logistics process involved in preparing and supplying consumer goods to the community.

Ibn Kathir (1980) argues that *Halalan Toyyiban,* in this verse, explains the command of *Allah SWT* to take *Halal* food on this earth and *Toy*, which is good for personal use without any harm to the body or mind. Mohd Amri (2019) explained that verse 168 in surah *al-Baqarah* covers *Halal* products of food, beverages, slaughterhouses, consumer goods, cosmetics, pharmaceuticals, logistics, and other industries in the *Halal* industry. Alias *et al.* (2011) believe that *Halalan Toyyiban* is not only related to the status of *Halal* and *Toyyib* alone but also covers issues related to processing places and processing materials. This means that the principle of *Halalan Toyyiban* becomes the basis that must be carried out on all *Halal* products as a whole. Even in providing *Halalan Toyyiban* guarantees, this covers all logistical movements. Therefore, every part of the logistics requires constant monitoring that can ensure that all *Halal* products are both *Halal* and good. Of course, the principle of *Halalan Toyyiban* aims to avoid things that are *Haram* and bad in terms of the body, soul, and mind. The implication is also to get the blessings of *Allah* for human beings as His servants in living life on earth.

2.2 Principle of *Maslahah* (Interest)

Maslahah is also referred to as a benefit rather than a disadvantage or harm. One of the Shari'ah principles can be used as a reference and guide in running the *Halal* industry. Through surah *al-Baqarah* verse 168, which contains a call to mankind in general without specifying a particular party. Ibn Kathir (1980) argues that this verse points to the bounty of *Allah*, in which He is the Provider of sustenance to all His creatures, which, by the way, consume *Halal* yet good food. The word of *Allah*: "*Ya Ayyuha al-Naas* " (O mankind!), indicated that all human beings, whether Muslims or non-Muslims, show the existence of *Maslahah* for all His servants. *Allah*'s provision in food consumption is *Halalan Toyyiban* which provides mutual benefits to His creatures.

Setiyawan (2019) explained that *Maslahah* is the benefit provided by *Allah* for His servants in maintaining religion, soul, intellect, property, and lineage. Every affair that contains these five things is *Maslahah*, but on the other hand, if it expires from these five things or one of the five things, then it is *Mafsadah* (damage). Adopting this principle of *Maslahah* must follow the conditions required by Islamic *Shari'ah* to achieve a well-preserved common interest. Al-Zuhaili (1996) explains this as follows:

i. The taking of *Maslahah* must be in line with the *maqasid syar'iyyah* (objective of *Shari'ah*).

Taking *Maslahah* must not conflict with the *Shari'ah* of *Allah*, which is not contrary to the text or *Qat'i* (definitive) evidence such as the *Qur'an*, *Hadith* and *Ijma'*, but must be in line with the *Maslahah* that *Allah* wants to achieve.

ii. *Maslahah* used must be logical

The adoption of *Maslahah* as a law must be acceptable to the intellect. That is, *Maslahah* is used according to need and not according to conjecture to obtain benefits and avoid harm.

iii. *Maslahah* is used for public interest

Islamic law is revealed to all beings without exception, not for the benefit of certain individuals and groups. *Maslahah* is used comprehensively, covering all aspects and needs. So *Maslahah* taking is not reserved for some beings.

iv. Taking *Maslahah* for *Hifz Darurah wa Raf'u Haraj* (saving the necessity and raising the critical)

Its essence is that *Maslahah* is used for human life in religious and worldly affairs that involve preserving religion, soul, intellect, lineage, and property. At the same time, avoid difficulties to facilitate matters carried out following the purpose of *Shari'ah*.

Based on the conditions of taking *Maslahah* as a *Shari'ah* principle, there is a basis for building *Shari'ah* law on various new issues. This is also a series of legal sources produced by

scholars after referring to previous texts. Adopting this *Maslahah* principle is also a guide in conducting *Halal* logistics to provide *Maslahah* for all *Halal* industry players and consumers. In the context of the current industry, it is necessary to separate *Halal* and non-halal products because *Halal* industry players still use non-halal logistics services. Therefore, the system of separating *Halal* and non-halal goods is for the *Maslahah* of *Halal* products so that they are not contaminated with non-halal goods.

2.3 Principle of *Sadd al-dzariah*

Sadd al-dzariah is one of the *Shari'ah* principles that means blocking the lawful means to an unlawful end. The principle prevents in any way the possibility of damage because the damage is a prohibited thing. Preventing things that are broken and destructive before they happen will, in turn, lead to *Maslahah*. The application of the *sadd al-dzariah* must be based on the evidence of *nas* from the *Qur'an* and *Hadith*, meaning this principle is not to be used alone without strong evidence. Al-Zuhaili (1996) says that *al-dzariah* and *Maslahah* have similarities in principle, where both lead to mutual importance and benefit based on the evidence of *nas* and have a purpose for *Himayat al-Masalih al-Ammah wa Daf'u al-Mafasid al-Ammah* (protection of public interests and prevention of public corruption).

As it is known that *Halal* logistics and supply chain require chain movement activities that will, of course, be exposed to illegal things. This risk of mixing is very likely to occur, i.e. the exposure of *Halal* goods with illegal goods. Therefore, to avoid this mixture, it is necessary to the principle of *sadd al-dariah*. The application of this principle is believed that the guarantee of *Halalan Toyyiban* will be well maintained. Revealing non-halal products to be separated from *Halal* products is a good statement based on *sadd al-dzariah,* which is the antimony between both products.

3. Warehousing

In order to maintain *Halal* status, it is necessary to take care of warehousing and storage that stores certain items within a certain time frame. Therefore, it is necessary to take some action to maintain *Halal* status. The care of this storage warehouse aims to take the Maslahah (interest) principle as a *Shari'ah* principle in keeping the *Halalan Toyyiban,* especially so as not to be exposed to *Haram* elements. Al-Zuhaili (1996) views the *Maslahah* to lay down a law to achieve the public interest. The law preserves the common interest (Setiyawan, 2020). The principle of *Maslahah* is the basis in warehousing by doing some of the actions below.

3.1 Keep away straight touch from *Haram*

A warehouse is a place to store a product and goods before they are sent to retailers to market goods to consumers. This storage activity is to provide warehousing, which is one of the parts of processing *Halal* logistics and storing goods for a long period. Prolonged storage of goods will cause contamination with *Haram* goods. This risk of contamination always exists in the storage of goods due to the long time they spend in the warehouse. Therefore, the *Shari'ah* principle is a principle that needs to be referred to so that the warehouse mechanism can maintain *Halal* integrity on an ongoing basis. Every process in the warehouse must be implemented under the monitoring of *Shari'ah* principles, even as a reference for those who implement *Halal* logistics. The technique for protecting goods from contamination is to physically separate the *Halal* product from the *Haram* product while it is in the warehouse. If possible, these *Haram* products must be avoided. Azmin & Suhaiza (2017) say that Halal products should be stored in a special place or storage zone, and special shelves should also be away from *Haram* products. A special mark should be placed as a boundary that distinguishes two products that may cause contamination. This effort aims to ensure that *Halal* products stored are not mixed with *Haram* products in one warehouse.

The manufacturer must provide Halal parts with Halal facilities to protect *Halal* products from being exposed to *Haram* products. *Halal* products need to be stored in a special place, where special stores also need to provide a place safe from *Haram* elements. *Halal* guarantees on *Halal* products must be displayed on all items of *Halal* products guided by *Shari'ah* principles. A special feature should be given to food products such as meat, pharmaceutical, and cosmetic products to facilitate the selection of such items. Abdul Hafaz *et al.* (2013) view that placing varying special features on goods will point to guaranteed *Halal* integrity. This will ensure that *Halal* products are always identified as having *Halal* status and are guaranteed to be *Halal*.

Furthermore, Marco & Maznah (2012) say *Halal* goods and products should be given unique labels and codes and informed through the supply chain unanimously by putting the word "*Halal* Supply Chain" on these products. This word will explain that the supply chain has *Halal* status. Even the zones and shelves for placing all products need to be affixed with a clear *Halal* label to avoid mixing with *Haram* products/elements. In addition, *Halal* labels affixed to all products should be coded and marked in an orderly manner so that employees can see and understand the status of the goods. *Halal* and *Haram* products that use clear labels will distinguish the two products clearly; in fact, this practice is *Shari'ah*-compliant. The label on each product will provide a clear guarantee of safety.

3.2 Inscribing the risk of contamination

Avoiding contamination between *Halal* and *Haram* must be specially observed, as it can pose a risk that can fall to *Haram*. If there is cross-contamination of *Halal* products and something *Haram* even a little, the product can be non-halal. Even when there is doubt about whether this product has *Halal* and *Haram* elements, then the use of the product should be abandoned. This is based on the *Hadith*: From al-Nu'man ibn Basyir RA, who said:

> "*That which is Halal is clear, and that which is the act of avoiding contamination between Halal and Haram must be specially observed, as it can pose a risk that can fall under Haram. If there is cross-contamination between Halal products and something Haram, even a little, then the product can be non-halal. Even when there is doubt about whether this product has Halal and Haram elements, the use of the product should be abandoned. This can refer to the Hadith: From al-Nu'man ibn Basyir RA, who said:Haram is clear, and between the two them are doubtful matters about which many people do not know. Thus, he who avoids matters clear himself in regard to his religion and his honour, but he who falls into doubtful matters (eventually) falls into that which*

is Haram" (al-Bukhari no. 52 and Muslim no. 1599).

Therefore, according to Marco (2013), logistics should look at the doubtful factor; this is very important because it will determine the status of a product. The issue of cross-contamination needs to be addressed immediately, and progressive action must be taken. Continuous handling of cross-contamination will ensure lasting *Halal* status. It can also eliminate the doubtful factor to ensure its *Halal* status; if the product is *Halal*, then it will be guaranteed *Halal*, while if the product is *Haram*, it can be avoided.

3.3 Risks of possibilities contamination & solution

The warehousing carried out will face several issues related to contamination from the material aspect, including both *Haram* and dangerous elements. This will be explained as follows:

i. From *Haram* materials

a) "*Halal* Supply Chain" is a special label and code that needs to be placed on *Halal* goods when they leave the warehouse. Some non-Muslim countries have no dedicated warehouses to store *Halal* goods. Therefore, it is necessary to arrange certain zones and shelves to store *Halal* goods, so there is no vertical mixing between Halal and non-Halal products.

b) *Halal* and non-halal products must not be mixed on the pallet or cargo carrier.

c) *Halal* and *Haram* products, such as products containing pork and/or alcohol, should be stored separately. The "*Halal* Supply Chain" label should be affixed to *Halal* products to make it easier for employees to identify and sort the goods in the warehouse.

d) The warehouse must be in a safe and secure condition from contamination during the storage of *Halal* materials so that it can be used as a place to pack *Halal* products specifically. This means that the processing technique only needs to use *Halal* ingredients to maintain the *Halal* guarantee of the ingredients. Meanwhile, the process of storing materials involving *Haram* substances must be avoided, as it will harm human health.

e) The use of *Halal* food logistics (HFL) is relatively low in demand for services, such as warehouse services and storage space. This service is only offered by about 5 out of 9 logistics service providers (LSPs). In addition, less than 30% of the total existing capacity (for *Halal* warehousing) has been used for its services. There are also allegations from many LSPs stating that there is no obligation for the issuance of *Halal* (Food and Beverage Products (F&B) certificates, so this is the cause of very low demand for warehouse services (Norlila *et al.* 2017: 337-346).

HFL services have high operating costs, resulting in less response from F&B manufacturers. Typically, these logistic services are used over a long period by setting operating costs to carry out containers' cleaning ceremony (sertu) and renting a special place or freezer room.

ii. From dangerous materials

a) **Biological:** The food industry must be able to keep food safe from chemical, physical, or biological (viruses, parasites, fungi, bacteria, viruses, and other toxins) risks. In general, food conditions need to be safe, so a review is needed to ensure that the *Halal* guarantee is met in terms of quality.

b) **Chemical:** The entire production chain could be exposed to accidental contamination with chemicals. Foods produced by manufacturers will inevitably be exposed to chemicals potentially harmful to health. Not to mention the food will move from one place to another. Unintentional contaminated food items need to be considered strictly to protect food safety.

c) **Physical:** Physical mixing of *Halal* and non-halal meats is common in storage facilities. According to Norlila *et al.* (2017), transportation companies lack knowledge about *Halal* practices, thus being exposed to unintentional contamination through certain objects and activities of employees.

So, keeping *Halal* goods away from *Haram* goods is intended to avoid the interference that Halal goods can cause with illegal goods or the occurrence of suspicion about the *Halal* goods. To achieve the common good in storing goods risks that likely lead to contamination should be carefully avoided, such as mixing Halal and Halal elements and goods with hazardous substances. The act of separation between *Halal* goods and illegal goods in this warehouse needs to be observed and implemented comprehensively.

This can protect *Halal* products so that they always have *Halal* status. In practice, this warehousing arrangement leads to the principle of *Maslahah,* which is useful for the common good to maintain the *Halal* status of *Toyyiban* in the storage of goods. In addition, also based on the principle of *sadd al-dzariah*, to avoid mixing between *Halal* goods and illegal goods, the management should adopt this principle immediately and ensure adequate preparation, in addition to ensuring that *Halal* status is evident for the product that is considered to be *Halal.*

4. Transportation

Transportation is a critical area in ensuring safe and contamination-free *Halal* transportation. Zailani *et al.* (2017) argue that the integrity of *Halal* food is subject to a logistics system that plays a role in maintaining *Halal* quality by carrying out proper transportation management, control, and storage along the supply chain to safely reach the destination. Soon *et al.* (2017) argue that *Halal* integrity needs to be observed starting from the consumption of raw materials until they are ready for distribution and then reach the consumers, which means that it is not only discussing permitted and prohibited goods. Coyle *et al.* (2011) define transportation as an activity that transfers goods from raw materials to the place of destination by stating the time and place according to the context of logistics activities. Accordingly, goods move from producer to customer.

The transport must be clean before it is stuffed or loaded with Halal goods. As bulk transport is in direct contact with the container/transport vehicle, the container/transport must be

dedicated for *Halal* or ritually cleansed before use. Ritual cleansing is also critical for wet (chilled, frozen) environments. *Halal* livestock needs to be segregated from non-halal livestock (like pigs). For live animals, it has been agreed that *Halal* and non-halal livestock must be segregated. Extensive discussions were held on transporting *Halal* and non-halal slaughtered chicken in one container. It was argued that *Halal* and non-halal slaughtered meat of *Halal* livestock should be allowed to be shared in one container/transport if *Halal* meat has proper tertiary packaging.

Many studies propose the segregation of *Halal* and non-halal goods during transportation, storage, and (sea/air/rail/inland) terminal operations to avoid cross-contamination and mishandling, thus ensuring that operations are consistent with the expectations of Muslim consumers. In *Halal* logistics, it is important to know the segregation levels formulated as consumer requirements during transportation, warehousing, shipment, and in the supermarket (Tieman, 2012). Logistics activities from the transport sector often face various issues related to mixing *Halal* and *Haram* products throughout the operation. To protect this matter from mixing, special transportation needs to be performed by manufacturers and suppliers involved in this type of logistics activity. This action will reduce the risk of cross-contamination, and the delivery process will be simplified for customers and clients. Transportation, as defined by Coyle *et al.* (2011), is the activity of moving goods from a starting point to a planned destination by covering the place and utility, that is, the activity of moving goods performed by manufacturers to customers.

The issue related to the mixing between *Halal* and *Haram* goods is huge in terms of transportation. Therefore, it should adhere to the principle of *Maslahah*; then, it is necessary to segregate the two products to avoid the risk of cross-contamination. Setiyawan (2019) is of the view that the principle of *Maslahah* is very important to *Hifz Darurah wa Raf'u Haraj* (save the necessity and raise the critical). It is an obligation to keep things *Halal* and avoid *Haram*.

In the matter of transportation, indeed, the industry controls the movement of the transportation so that it does not mix between *Halal* and *Haram* goods. Of course, the *Halal* industry uses transportation specifically to carry *Halal* goods only so that the *Tayyiban Halalan* guarantee is well maintained and to safeguard the common interest based on the principle of *Maslahah*. The principle of *Maslahah* in maintaining the *Halalan Toyyiban* status is a priority in mobilising transportation. The principle of *sadd al-dzariah* is also a *Shari'ah* guide in taking transportation specifically for *Halal* goods only, transportation must be in a clean condition, and there is no mixing between *Halal* and *Haram*. The care of the vehicle is very important so as not to be exposed to harm, which is a Haram thing, so the *Halalan Toyyiban* guarantee remains throughout the time of transportation.

5. Retailing

Tieman & Barbara (2020) informed that the Department of Standards Malaysia published the world's first *Halal* refining standard in 2010, MS 2400-3: 2010: management system requirements for retailing. Zaidan (2011) & al-Ashqar (1984) say that the application of *Shari'ah* principles and *Shari'ah* objectives by considering the general *Maslahah* (public interest) is very appropriate for civil society involving Muslims and non-Muslims. This shows the comprehensiveness of Islam in protecting the rights of consumers.

This *Halal* retailing standard intends to assure the *Halal* integrity of products, goods and/or cargo at the retail stage. It specifies the framework a retailer should establish to meet regulatory *Halal* requirements. In implementing the standard, the retailer should address the handling and managing of *Halal* products and/or goods whenever there exist interfacing activities during receiving, loading and delivery. However, this management system is not prescriptive regarding how purchasing needs to be organised, what categories of Halal retailers are possible, the layout of retail outlets, and whether there should be segregation at retail outlets and logistics. It also leaves out considerations of consumer preferences and how this *Halal* retailing standard protects *Halal* integrity according to Islamic thought, including fatwas and the local customs of Muslim societies.

5.1 The concept of *Halal* retailing

Halal Tayyiban (*Halal* and good) is a principle that Islamic retail store players must hold in offering products produced by Muslims. Islamic grocery stores control all movements of *Halal* products so that the *Halal* guarantee remains as long as they are in the store. All products must be in good condition, safe to use, and protected from *Shari'ah* and science. The preparation of food produced by Muslims in the shop should also have Islamic values so that the business is blessed. An Islamic retail store with Islamic values , such as explaining the status of its business goods honestly, will lead to quality assurance of *Halalan Toyyiban* business. The *Shari'ah* principles practised by the grocery store are special features that serve as a guide in carrying out management; Muslim producers must produce the status of Halal products; Muslim entrepreneurs must give the status of Halal products priority; staff should wear clothing in accordance with *Shari'ah* requirements (Waida Irani *et al.* 2013)

Halal retail aims to guarantee Halal integrity by controlling the supply chain process of the *Halal* category at the point of consumer purchase (Tieman & Barbara, 2020). The differences in the *Halal* retail formula are as follows:

i. *Halal*-exclusive retailer. Where the outlet offers only Halal products. The design is made so that the local Muslim community's specific needs and Halal requirements can be met and included in the *Halal* category.

ii. *Halal*-segregated retailer. Halal products and Haram products are offered by an outlet that clearly identifies the product's status and physically separates the items on shelves and displays so that the risks involving contamination and perception can be easily addressed. The design of the *Halal* category can be multiplied and extended to mainstream Muslim consumers.

iii. *Halal*-mixed retailer. Where the outlet offers both Halal and illegal products, but there is no separation between these two products physically, so is not clear the status of the product. The retailer does not recognise a Halal category.

The *Halal*-exclusive retailer only carries products that are considered *Halal* according to governing Islamic law and local

customs. Therefore, a dedicated Halal retailer in Malaysia will not carry alcoholic beverages, non-halal meat, products containing animal ingredients that are not *Halal*, cigarettes, and non-food products (such as cosmetics) containing non-halal components. The supply chain to the retailer should be segregated from non-halal items (as defined according to the country's *Halal* standards).

The retailing issue is also not far from warehousing and transportation, where there is a need to separate between *Halal* and *Haram* goods while in the store. Indeed, Muslim retailers do not sell goods except *Halal* goods, of course, so as not to mix with *Haram* goods. All these retailing activities refer to the principle of *sadd al-dzariah,* which aims to safeguard the benefits of retailing with *Halal* goods, avoiding harm that is being exposed to *Haram* goods. This, in line with the principle of *Maslahah* also aims to maintain the guarantee that *Halalan Toyyiban* remains in the store until it reaches the consumer.

6. Conclusion

The principles of *Shari'ah* guide all matters in living life comprehensively. Undoubtedly, these principles are indeed abundant in Islamic *Shari'ah*, to be used as a reference on life issues. This problem is, of course, related to the logistics or the supply chain in the *Halal* industry. Among the *Shari'ah* principles that are always taken in general is the principle of *Halalan Toyyiban*. The Halal industry always refers to the main principle of doing business. From carrying out logistic movement activities, such as the separation between *Halal* and *Haram* goods and the provision of special transportation to transport *Halal* goods specifically aimed at achieving common interests under the principle of *Maslahah*. *Maslahah* leads to the guarantee of *Halalan Toyyiban*. Apart from that, the principle of *sadd al-dzariah* is also a guide to the principles of *Shari'ah* as a precautionary measure in avoiding things that are *Haram*, to keep *Halal* things.

Halal logistics and supply chain management is important in ensuring *Halal* integrity for the Muslim consumer and protecting the brand of manufacturers and retail chains. As today's food supply chains are complex and require crossing borders, logistics plays a key role in extending the *Halal* integrity from source to the point of consumer purchase. As an international *Halal* logistics standard has been developed, there is today a reference in how to organise *Halal* logistics for the *Halal* industry, which addresses both the differences in market requirements (based on the Islamic schools of legal thought, local fatwas and local customs) as well as the complexities of last-mile logistics in non- Muslim countries. *Halalan Toyyiban* is a general *Shari'ah* principle that should be referred to as the basis and principle of *Maslahah,* which is a *Shari'ah* principle that should also be referred to in all units that conduct *Halal* logistics.

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Applying Ethical Climate Theory in Whistleblowing Intentions Study among Employees in *Halal* Food Companies: A Protocol

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Abstract

Halal food fraud, such as fake *Halal* logos and adulteration, may happen due to irresponsible manufacturers seeking to maximise profit. Furthermore, *Halal food* fraud has been increasing over the years in Malaysia, and this issue needs to be considered since it is a major threat to Malaysia's reputation as an international *Halal* hub. One of the effective measures in reducing *Halal food* fraud is whistleblowing. In order to encourage whistleblowing, governments have established laws and policies to protect whistleblowers, but a lot of people are still unwilling to blow the whistle due to the retaliation that whistleblowers will face. Factors that may influence this ethical behaviour need to be studied. Therefore, the purpose of this article is to conceptually discuss potential factors (ethical climate types, organisation size, tenure, supervisor status, and religious obligation) that influence employees' intention to be involved in whistleblowing. A research model is proposed, followed by the developing of research hypotheses to test the model. In addition, the study's protocol (detailed plan) is later described. The theory of Ethical Climates will be used to guide this study. Data will be collected through convenience sampling by distributing self-administered questionnaires to 300 employees from *Halal food* companies in Malaysia. The collected data will be tested using Exploratory Factor Analysis (EFA) and Structural Equation Modelling-Partial Least Square (SEM-PLS). The findings from this study will help *Halal food* companies improve their whistleblowing practices. In addition, this study is useful for relevant policymakers to support whistleblowing practices.

1. Introduction

The *Halal* industry is extremely important to Muslims worldwide because it assures them that whatever they eat or buy complies with *Shari'ah*. The *Halal* industry has expanded enormously since the initiation of the Malaysian International *Halal* Showcase (MIHAS), which was held in 2004. In the past decade, the *Halal* industry has been one of the major contributors to economic growth in many countries (Mujar & Hassan, 2014). The *Halal* industry's growth is mainly due to the growth of the Muslim population over the years, reaching 25% of the world's population, or 1.9 billion (World Population, n.d). The rise in the number of Muslims has led to a rise in demand and awareness for Shariah-compliant products and services, creating a significant opportunity for *Halal* business growth (Jaffar & Musa, 2014).

Amidst its rapid growth, the *Halal* industry continues to encounter a number of challenges that threaten the integrity of *Halal* and *Toyyib* products. It is important to note that *Halal* products must be free from prohibited ingredients and be accurate in terms of quality, weight, content, expiration date, and brand. Due to personal interests and profit maximisation, fraudulent practices such as mislabelling, contamination, or adulteration are becoming more common in the *Halal* industry (Ariffin *et al.*, 2021). Spink and Moyer (2011) identified seven types of food fraud: adulteration, theft, tampering, diversion, simulation, over-run, and counterfeiting. Each food fraud potentially threatens public health and may lead to illness or death.

There have been a lot of cases of food fraud in Malaysia. Several cases have been reported in the Halal food context, such as the intentional exchange of prohibited meat (pork or dog meat and meat that has not been properly slaughtered according to Islamic law) for *Halal* meat (Ramli, 2018). These fraudulent practices can negatively impact Muslim consumers' confidence and damage the brands' reputations. Therefore, a deterrence measure such as whistleblowing should be promoted as an effective way to discourage fraud or other wrongdoings (Schultz & Harutyunyan, 2015).

Whistleblowing is defined by Near and Miceli (1985) as the act of former or current members of an organisation disclosing their coworkers' immoral or unlawful actions to other individuals within or outside the organisation. There have been countless examples of how whistleblowing incidents have helped expose fraud or malpractice that has occurred in the food industry over the course of the years. One of the examples

was in 2012 when a local Chinese TV broadcast reported that a number of poultry suppliers in Shandong Province, China, were using harmful chemicals in their feed to accelerate the growth of chickens. One of the suppliers, the Liuhe Group, was supplying chicken to Yum Brands, the parent company of Kentucky Fried Chicken (KFC) restaurants. It was reported that even though Shanghai food safety officials had informed Yum Brands that excessive antibiotics were found in their chicken supplied to them, the company did not report it and continued to purchase the chicken from the same supplier. Upon the news release, the company promptly published an open letter to customers on their official website to apologise for their lack of action (Soon & Manning, 2017). This case, however, pales in comparison to the Chinese milk scandal, when melanin was found in milk and made public by a whistleblower. In 2008, melamine was intentionally added to diluted raw milk to increase the protein content. This major food safety incident caused about 300,000 Chinese infants and young children to be affected by kidney and urinary tract effects. Six deaths were reported. In another case in the United States of America, a manager of Peanut Corporation America (PCA) internally reported the leaky roof and mouse infection to the company's owner, but his complaints were ignored. The manager was prompted to blow the whistle externally when his granddaughter became ill after consuming one of the products from PCA (Soon & Manning, 2017). The salmonella outbreak linked to bad peanuts from the plant has resulted in 600 illnesses and an estimated nine deaths. As a result of the action, massive amounts of peanut products were recalled, which saved lives.

In the *Halal food* context, the most recent issue was the illegal meat cartel syndicate, which happened at the end of 2020 and was reported by an anonymous whistleblower to the local media. The local media revealed that an illegal meat cartel smuggled 1,500 tonnes of non-halal certified meat from foreign countries, namely Brazil, China, Argentina, and Ukraine. Among the smuggled meats were buffalo, kangaroo, and horse, then sold in the domestic market with a counterfeit *Halal* logo. The diseased and low-quality meat, hazardous to consumers' health, was also sold as *Halal*-certified meat. This appalling scandal exposed a wide range of issues, including non-halal meat processing, the issue of integrity in the *Halal* supply chain, the safety issues of imported meat, and illegal slaughterhouses. This issue also indicates the loophole in the governance of the *Halal* meat supply chain that fails to ensure its *Halal* integrity (Ariffin *et al.*, 2021). This scandal reflects the importance of not relying only on the *Halal* authorities to safeguard the *Halal* supply chain. The fight against *Halal* fraud is the responsibility of all stakeholders, including suppliers, manufacturers, distributors, and consumers. Therefore, whistleblowing is one of the countermeasures that can be used against fraud and crime. Soon and Manning (2017) argued that a whistleblowing strategy can form an effective part of the food crime management system (FCMS).

The establishment of laws and policies could encourage an individual to speak out against any malpractices or wrongdoings in an organisation without fear of retaliation. In order to encourage whistleblowing, Malaysian governments attempt to protect whistleblowers by establishing laws and policies. Malaysia introduced the Whistleblowing Protection Act (WPA) in 2010, replacing the Anti-Corruption Agency (ACA) Act in 1997, in order to create a more comprehensive whistleblowing system and encourage more individuals to come forward and report any corruption, fraud, or misbehaviour (Rachagan & Kuppusamy, 2013). Whistleblower protection is critical for individual protection, reducing food crime, and protecting consumers from harm. Even though the Malaysian government has established a whistleblower protection act, many people are still hesitant and unwilling to report any wrongdoings or misconduct within an organisation due to the potential retaliation that whistleblowers will face (Dasgupta & Kesharwani, 2010).

Halal food fraud is a serious issue, which is why it is encouraging to see companies take steps to prevent it. One effective strategy for reducing food fraud is to have a workplace whistleblowing culture. For example, when employees have a safe and secure channel to report food fraud without fear of retaliation, it is easier to catch and prevent it before it reaches consumers. On the other hand, the internal whistleblowing system enables confidential reporting of irregularities. Internal reports can help to uncover cases of wrongdoing and minimise financial damage. Therefore, it is critical to investigate potential factors influencing employees' willingness to participate in whistleblowing in *Halal* companies. This study aims to investigate whistleblowing behaviour in Halal companies to address the problem by exploring potential predictors influencing employees' intentions to be involved in internal whistleblowing.

In an effort to improve employee reporting behaviours, organisations must understand and pay attention to the factors that facilitate and hinder whistleblowing intentions. Several attempts have been made to determine the factors that encourage an individual to perform whistleblowing. Previous studies have identified a number of different possible factors in the individual's willingness to blow the whistle, which are personal (Ahmad *et al.*, 2012; Said *et al.*, 2017), organisational (Ab Ghani *et al.*, 2011; Ahmad *et al.*, 2010; Wen & Chen, 2016) and situational factors (Ahmad *et al.*, 2010; Apadore *et al.*, 2018; Vadera *et al.*, 2009). Many previous studies have tried to use a variety of theories to explain why people want to report wrongdoing. These include the Theory of Planned Behavior (Mustafida, 2020; Owusu *et al.*, 2020), the theories of prosocial behaviour (Ahmad *et al.*, 2010; Ahmad *et al.*, 2012), and the Theory of Marketing Ethics (Zakaria, 2015). On the other hand, Hadiyati and Yusup (2020) used the Ethical Climate Theory.

In highlighting the chosen respondents among employees in *Halal food* companies, this study deviates from typical samples of auditors (Ahmad *et al.*, 2010; Alleyne *et al.*, 2013), police departments (Park & Blenkinsopp, 2009; Zakaria *et al.*, 2016), public sector (Salleh & Yunus, 2015; Park *et al.*, 2005), supervisors (Ab Ghani *et al.*, 2011), undergraduate students (Apadore *et al.*, 2018; Pangestu & Rahajeng, 2020) and accounting (Gao & Brink, 2017; Latan *et al.*, 2018). It is equally important to reduce wrongdoings and fraud associated with *Halal food* products as it is to raise ethical standards in the *Halal food* industry. Employee professional and ethical conduct, such as their willingness to whistleblow, is influenced by their personal moral values and professional ethics and the companies in which they work. This study, therefore, leverages Ethical Climate Theory to study the association between ethical climate and whistleblowing intention. Furthermore, most of the research into whistleblowing is conducted in Western countries. Therefore, this study intends to fill the research gap by extending the whistleblowing study to a Malaysian context, specifically in *Halal food* companies.

2. Literature review

2.1 Whistleblowing

2.1.1 Definition of whistleblowing and whistleblower

There is no universally accepted definition of whistleblowing. However, in the literature, one of the most commonly used definitions is by Near and Miceli (1985), who define whistleblowing as the act of former or current members of an organisation disclosing their coworkers' immoral or unlawful actions to other individuals within or outside the organisation. On the other hand, Jubb (1999:78) proposed that whistleblowing is a "deliberate, non-obligatory act of disclosure, which gets onto the public record and is made by a person who has or had privileged access to data or information of an organisation, about non-trivial illegality or other wrongdoing, whether actual, suspected, or anticipated, which implicates and is under the control of that organisation, to an external entity having the potential to rectify the wrongdoing." Under this definition, whistleblowers could be employees, suppliers, or even consumers. In the context of food safety, instead of using the term "wrongdoing," the term "incidence" is used.

A "whistleblower" is defined as "a person who is not indifferent to food safety incidents and reports them to protect the consumer and the food company's reputation." The incident, in this context, refers to "events that occurred as a result of the employee's misbehaviour, intentional and unintentional, which led or could have led to negative consequences for the safety and health of the consumer." It is important to note that terms such as "raising concerns," "speaking up," and "whistleblowing" are sometimes used interchangeably in the whistleblowing literature (Blenkinsopp *et al*., 2019).

2.1.2 Whistleblowing channels (internal and external whistleblowing)

Internal whistleblowing occurs when a report of wrongdoing is made to people within the organisation, such as high-level and immediate supervisors, the personnel office, the CEO, and managers (Jeon, 2017). Meanwhile, external whistleblowing occurs when the report is made to an external body outside the organisation, such as the news media, government, law enforcement agencies, or law minister (Azis *et al*., 2019). Each type of whistleblowing will have a different outcome for the whistleblower, the organisation, and the societal efforts to control organisational wrongdoing. Several factors may affect the choice between internal or external complaint recipients. Dworkin & Baucus (1998) found that employees with long tenures tend to choose internal reporting channels. Meanwhile, Jeon (2017) found that fear of retaliation, supervisors' status, proper education, and fair treatment from the organisation are predictors of employee selection of internal whistleblowing channels.

2.1.3 Islamic perspective of whistleblowing

An effort to combat fraud, corruption, and wrongdoing is a noble act demanded by Islam to produce a harmonious and prosperous community. Even though whistleblowing is not specifically mentioned in the *Qur'an*, the Islamic concept of *"Amr ma'ruf nahy munkar"* is similar to whistleblowing action since both attempt to defeat injustice in society (Khalid *et al*., 2015). The importance of reporting or exposing any corruption or wrongdoing is clearly stated in the *Qur'an* through the concept of *"Amr ma'ruf nahy munkar"* (Enjoining what is right and forbidding what is wrong) (Qudus & Fahm, 2021). For example, as stated in *Al-Imran*, 3:104:

"And let there be [arising] from you a nation inviting to [all that is] good, enjoining what is right and forbidding what is wrong, and those will be successful."

According to Abd Samad and Khalid (2015), the whistleblowing report is not limited to wrongdoings that Allah and the Prophet prohibit but also includes violations of laws and regulations and actions that may cause harm to society. Furthermore, Muslims are obliged to protect people's interests from harm, particularly when it comes to the five basic needs established in the Maqasid al-Shariah framework, which are to preserve religion, life, intellect, and property/wealth selection of internal whistleblowing channels.

2.2 Previous studies on whistleblowing intention

Several studies have examined the factors that make people want to blow the whistle. These factors can be put into three groups: personal factors of the whistleblower, organisational factors, and situational variables (Vadera *et al*., 2009).

Personal factors are based on two moral philosophies: deontological (rule-based views) and teleological evaluations (consequences-based views). Any individual who inculcates both moral philosophies will measure goodness against badness and have a feeling of moral responsibility and obligation to expose and report any wrongdoings within an organisation (Zakaria, 2015). A number of factors thought to be influencing whistleblowing intentions have been explored in several studies. Research conducted by Fitri *et al.* (2019) showed that locus of control affects whistleblowing intention among internal auditors in Indonesia. Thus, the whistleblowing action is driven by circumstances beyond their control. Ahmad *et al.* (2012) found that the higher the ethical judgement, the more likely to engage in internal whistleblowing among internal auditors in Malaysia.

Situational factors (sometimes called contextual factors) describe environmental or external decision factors such as situation cues, psychological situation characteristics, or situation classes (Kandala *et al*., 2011). Vadera *et al.* (2009) discovered two situational factors influencing whistleblowing intention: perceived wrongdoings and the job or organisation. Other situational factors that positively impact whistleblowing intention include the seriousness of wrongdoings and the status of wrongdoers. The seriousness of wrongdoing has been identified as a variable that may influence whistleblowing intention among Malaysian internal auditors (Ahmad *et al.* 2010). Seriousness can be measured by the risk to one's safety and health, the financial consequences, and the frequency of wrongdoing. For example, Winardi (2013) found that the status of wrongdoers positively correlates with whistleblowing intention among civil servants in Indonesia. If a higher-level organisation member commits the wrongdoing, civil servants in Indonesia may be hesitant to report it.

The term "organisational factors" refers to factors that influence how the organisation and its employees act. Organisational factors such as the organisation's ethical culture can influence employees to have a strong conscience and report any fraud or wrongdoings. According to Kwon *et al.* (2021),

public organisations should provide training programmes and whistleblowing policy guidelines to increase employees' knowledge regarding the whistleblowing process and protection. Chane *et al.* (2007) proved that greater knowledge of whistleblowing procedures and channels would increase whistleblowing intention among South Korean public officials. Meanwhile, Ab Ghani *et al.* (2011) found that ethics training has a positive relationship with whistleblowing intention among supervisors from manufacturing companies in Malaysia since ethic training helps the employees learn how to act ethically during the decision-making process. Wen & Chen (2016) conducted a two-wave survey and found that ethical leadership has significantly influenced whistleblowing intention among managers from China's public universities. This study found that leaders with ethical leadership will become role models for others and influence their employees' behaviour and attitudes.

2.3 Ethical climates theory

The ethical climate theory is one of the theories that is frequently used in the context of whistleblowing. An organisational factor that significantly impacts employees' ethical decision-making in the workplace is the ethical climate (Ismail, 2017). An ethical climate is defined as the prevalent perception of common organisational procedures and practises that include ethical content (Victor & Cullen, 1988) or aggregated individual views of ethical norms in an organisation (Cullen *et al.*, 1993). Ethical climates are not based on an individual's level of moral development or ethical standards but rather represent components of the individual's environment as perceived by its members. Furthermore, ethical climates help employees during the decision-making process when dealing with any ethical issues or dilemmas that may occur within an organisation by serving as a perceptual lens through which the employees may access and analyse situations (Cullen *et al.*, 2003)

2.4 Potential factors influencing internal whistleblowing intention

Possible factors from organisational, situational/contextual, and personal aspects that influence internal whistleblowing intentions are discussed. This includes ethical climate types, organisation size, tenure, supervisor status, and religious obligation.

2.4.1 Ethical climate types and whistleblowing intention

As mentioned in section (2.3), crossing the locus of analysis and the ethical criterion yields nine ethical climate types. However, these nine ethical climate types are not expected to exist in all organisations (Martin & Cullen, 2006). Several empirical studies have shown that different ethical climate types emerge from different organisations. Among the nine ethical climate types, Victor and Cullen (1988) found only five ethical climate types, which are: "law and code," "caring," "rules," "instrumental," and "independence" climates. Kim and Miller (2008) found six ethical climate types, which are "moral caring," "team spirit," "efficiency," "self-interest," "law and code," and "rules" climates in the Korean tourism industry, and these ethical climate types are affected by individual and organisational characteristics. Meanwhile, Agarwal and Malloy (1999) found "individual caring," "social caring," "machiavellianism," "independence," and "law and code" climates in not-for-profit organisations, and these emerging ethical climates are dispersed only between individual and cosmopolitan loci. The differences in ethical climate types within organisations may be due to several factors, which include organisational and cultural contexts, organisational practices, leadership and managerial practices, and individual differences (Newman *et al.*, 2017).

Previous studies have indicated that whistleblowing intention is related to an individual's perception of the ethical climate within an organisation. Rothwell and Baldwin (2006) discovered a significant relationship between "instrumental," "caring," and "rules" climates and their willingness to blow the whistle and the frequency of whistleblowing among civilian public employees in Georgia. Then, in 2007, Rothwell and Baldwin found that a "friendship or team" climate positively correlates with the willingness to blow the whistle among police officers in Georgia. In addition, Huang et al. (2013) research show that the "law and rules" climate has a positive relationship with internal and external whistleblowing among workers in Taiwan's construction industry. Therefore, this study hypothesises that:

H1: Ethical climate type has a significant relationship with the intention of employees from *Halal* companies to carry out internal whistleblowing actions.

		Locus of Analysis		
		Individual	*Local*	*Cosmopolitan*
Ethical criterion	*Egoism*	Self-interest	Company Profit	Efficiency
	Benevolence	Friendship	Team Interest	Social Responsibility
	Principle	Personal Morality	Company Rules and Procedures	Laws and Professional Codes

Figure 1: Original conceptualization of ethical climate - Nine theoretical types of ethical climate (Victor & Cullen, 1987).

2.4.2 Organisation size

According to the bystander effect by Darley and Latané (1968), the larger the number of observers present, the possibility of bystander intervening in an emergency is lower since the responsibility for intervention is shared among all the observers. In the current situation, the bystander effect suggests that an individual would be less likely to blow the whistle when he or she is in a larger organisation than a smaller one. According to Miceli and Near (1992), there are three reasons why internal whistleblowing would be more likely in a smaller organisation. Firstly, employees in large organisations may be reluctant to report wrongdoing to upper-level managers because whistleblowing channels may be impeded. Reporting to the upper level requires a lot of parties and processes that may slow down or inhibit communication flow. Secondly, it is difficult for top managers in large organisations to ensure all their employees are aware of the establishment of whistleblowing channels. Lastly, employees in small organisations may feel more satisfied than those in large organisations because they believe choosing internal channels would be less damaging than external channels. Empirical research and review show that the small size of an organisation encourages whistleblowing action (Keenan, 2000; Miceli & Near, 1992; Near & Miceli, 1985). However, several prior studies failed to predict a relationship between organisation size and whistleblowing intention (Ahmad *et al.*, 2010; Rothwell & Baldwin, 2006). Hence, it is proposed that:

H2: Employee from *Halal food* company is more likely to whistle blow if the person is from smaller companies

2.4.3 Tenure

Tenure is the period an individual has spent in an organisation or job. Tenure is one of the crucial factors that may affect different employee attitudes in organisational settings, including whistleblowing intentions (Maden, 2014). According to Miceli and Near (1992), employees having a longer tenure are more likely to engage in whistleblowing since they are familiar with whistleblowing channels and procedures. Older employees with more years of experience have a better understanding of their organisation's formal and informal authorities and control systems (Keenan, 2000). Longer tenure also leads to greater organisational commitment, which can increase the desire to correct any wrongdoing within an organisation via whistleblowing. Furthermore, employees with more tenure will have stronger power bases, which may give them more confidence in reporting any wrongdoing through whistleblowing channels (Mesmer-Magnus & Viswesvaran, 2005).

A number of authors have demonstrated a positive relationship between tenure and whistleblowing intention (Ahmad *et al.*, 2010; Miceli & Near, 1988). However, several studies fail to show such a relationship (Cassematis & Wortley, 2013; Rothwell & Baldwin, 2007). Mesmer-Magnus and Viswesvaran (2005) found that tenure appears to be related to actual whistleblowing but not to whistleblowing intention. Rothwell and Baldwin's (2007) study fails to predict a relationship between tenure and whistleblowing intention among police officers in Georgia. Such a result is due to the impact of social pressure over time on police culture and the emergence of the code of silence. Employees that have worked for a long time have more time to develop strong relationships with other employees, which might reduce the tendency to engage in whistleblowing. Regardless of the mixed results from previous studies, this study expects that longer tenure positively impacts whistleblowing intention. Therefore, this study hypothesises that:

H3: Employee from a *Halal food* company is more likely to whistle blow if the person has longer tenure in the organisation.

2.4.4 Supervisor status

Employees with supervisor or managerial status often have role prescriptions that command reporting any misbehaviour. Whistleblowing is an action that is consistent with their role as they are responsible for the misconduct of their subordinates. Therefore, supervisors enforce standards and regulate employee behaviour (Rothwell & Baldwin, 2006). Furthermore, supervisors and upper-level managers set the ethical climate and culture for their employees at lower levels and are responsible for providing the necessary direction and objectives for the organisation in order to maintain a competent connection between the organisation and the external environment (Keenan, 2000). The willingness to blow the whistle is high when an individual has supervisor status because they may receive a lot of support from outside the organisation due to their socialisation process (Miceli & Near, 1988).

Studies on the relationship between supervisor status and whistleblowing intention support a positive and significant relationship between these two variables (Ahmad *et al.*, 2010; Keenan, 2000; Rothwell & Baldwin, 2007). These studies found that supervisor status is the most consistent predictor of whistleblowing intention. Keenan (2000) found that the different managerial levels (first-level, middle-level, and upper-level managers) have different attitudes towards whistleblowing behaviour and found that whistleblowing is more favourable among upper-level and middle-level managers compared to first-level managers. Therefore, it can be hypothesised that:

H4: Employee from a *Halal* company is more likely to whistle blow if the person is holding supervisor status.

2.4.5 Religious obligation

Religiosity refers to terms that relate to cognition (religious knowledge and belief), affect (emotional attachment to religion) and behaviour (Barnett *et al.*, 1996). Religiosity has been associated with spiritual values, which play a crucial role in work behaviour. Religious values will influence human behaviour, which varies for every person from different societies (Othman & Hairi, 2012). Individuals who behave according to the values inherent in religious behaviour will not tolerate any unethical behaviour. Thus, the probability of whistleblowing in the workplace is high (Fernando & Jackson, 2006). Religiousness can influence ethical decision-making through personal characteristics, cultural environment, and a dominant basis for deontological norms (Rashid & Ibrahim, 2008).

Furthermore, religion can answer questions about the meaning of life and activities. Every religion teaches people to be good. Islam provides a complete code of life and builds the basis of belief in right and wrong rules and regulations based on the *Qur'an* and *Hadith*. These rules will produce a standard of morality that can impact how an individual responds to any

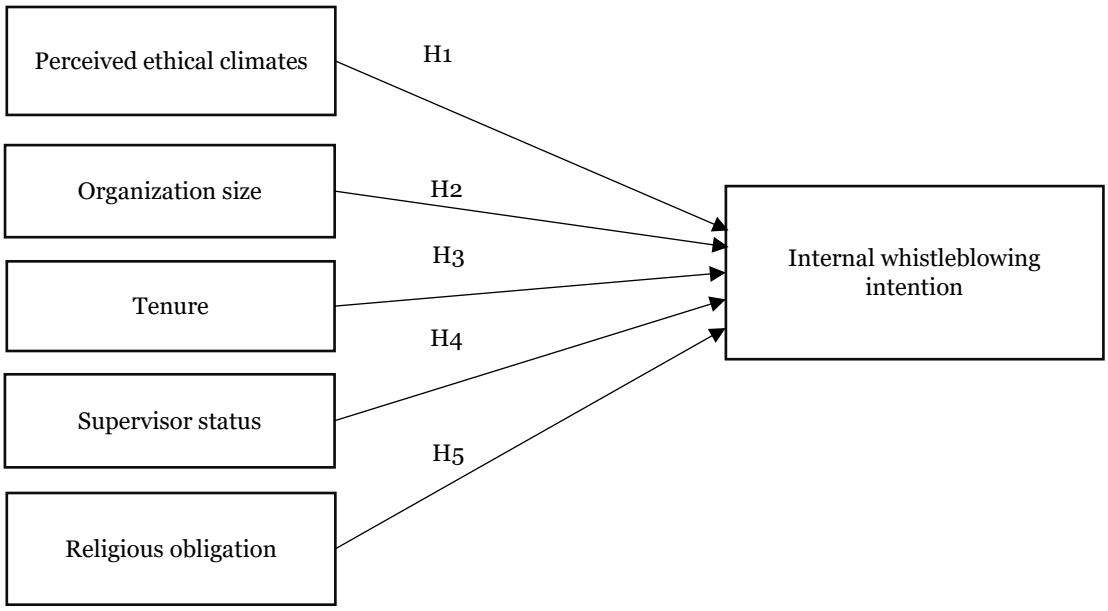

Figure 2: Conceptual framework for the whistleblowing intention among employees from *Halal food* companies.

ethical issues in an organisation (Fitri *et al.*, 2019).

A lot of previous studies have been conducted to examine the relationship between religious obligation and human behaviour, such as *Halal* purchase intention (Astuti & Asig, 2021; Khan et al., 2019); environmental behaviour (Ghazali *et al.*, 2018); and prosocial behaviour (Xygalatas, 2013). Our aim is to investigate the relationship between religious obligation and whistleblowing intention among employees in *Halal food* companies. Several previous studies showed a positive relationship between religious obligation and whistleblowing intention (Fitri, 2019; Puni *et al.*, 2016; Toker Gokce, 2015). However, Yudha and Rizal (2018) found no significant relationship between whistleblowing intention and religion, as religious respondents reported a low desire to report wrongdoing. Despite mixed results, this study proposed that:

H5: Religious obligation is positively associated with internal

whistleblowing intention among employees from *Halal food* companies.

2.4.7 Conceptual framework

Based on the ethical climate theory and evidence gathered from a literature review, this study proposed several factors that may influence the whistleblowing intention of *Halal food* companies' employees in Malaysia. This study proposed five independent variables: perceived ethical climates, organisation size, tenure, supervisor status, and religious obligation (as shown in Figure 2).

3. Methods

A quantitative approach will identify the relationship between the proposed variables. Respondents will complete a self-administered questionnaire with close-ended or structured questions at their convenience. The questionnaire has two parts: part A and part B. Part A consists of gender, age, marital status, religion, educational level, size and type of organisation, length of tenure, nature of employment and position in company. Meanwhile, part B consists of questionnaire items for ethical climate, religious obligation and internal whistleblowing intention. The questionnaire items were adapted from various literature, and all items are based on a 5-point Likert scale. Ethical Climate Questionnaires (ECQ) 36 items from Cullen *et al.* (1993) and Victor and Cullen (1988) will be used as the construct items for the ethical climate. Meanwhile, the questionnaire items from Ghazali *et al.* (2022) will be used for the religious obligation. The last construct item, internal whistleblowing intention, will be adapted from Park and Blenkinsopp (2009). Prior to the main data collection, an expert review (n=5) and a pre-test (n=5) will be conducted. Based on the feedback and recommendations, modifications will be made to the original statements used in the questionnaires.

The target population selected for this study is employees from *Halal food* companies in Malaysia. The companies must be listed in JAKIM's database (*www.Halal.gov.my*) as *Halal*-certified companies and may produce multiple *Halal* products such as beverages, dairy, seafood, beef, chicken, and bakery products, among others. This study uses a non-probability sampling design and a convenience sampling method (Ludin *et al.*, 2014; Reza *et al.*, 2021). Convenience sampling often helps researchers overcome some limitations associated with the research since this method is convenient, affordable, and less time-consuming (Etikan *et al.*, 2016). For the data collection, researcher will use the drop-off and pick-up (DOPU) method to distribute questionnaires (Trentelman *et al.*, 2016). This method requires the researcher to first contact the *Halal food* companies to schedule appointments. Then, the researcher will travel to the respondents' locations to drop off questionnaires that will be picked up. Hair *et al.* (2019) recommends a minimum sample size based on the basic measurement model characteristics. A minimum sample size of 300 for models with seven or fewer constructs and a minimum sample of 500 for models with a large number of constructs. Therefore, this present study uses a sample size of 300 since this study uses a model with five constructs.

After the data collection is complete, the overall profile of the respondents will be analysed using Statistical Package for the Social Sciences (SPSS) version 20 for its frequency, percentage, mean and standard deviation. Before hypotheses testing, this study will use exploratory factor analysis (EFA) to investigate the ethical climate types present in *Halal food* companies. EFA attempts to access the linkage between hypotheticals (latent variables) and observed variables (indicators). Principal component analysis (PCA) will be used to analyse the correlation matrix. To test the relationship between variables, this study will employ partial least-squares path modelling (PLS-SEM) using Smart-PLS as the software. This study will assess the properties of measurement scales for convergent and discriminant validity and then construct composite reliability (CR) by confirmatory factor analysis (CFA). SEM followed the analyses to verify the path relationships of independent and dependent variables. This study will also employ a one-way ANOVA or t-test using SPSS to compare differences between whistleblowing intention and organisation size, tenure, and supervisor status.

4. Conclusion

Halal food fraud is a major concern that should be considered since it negatively impacts the *Halal* industry. One of the most effective efforts in reducing *Halal food* fraud is whistleblowing. Therefore, this study recommends several key factors that may influence internal whistleblowing intention among employees of *Halal food* companies. Understanding these factors could help organisations, specifically *Halal* companies, improve their current practices to encourage their employees to whistleblow any fraudulent activities in the company. This is important in order to protect the reputation of the company and to avoid consumers' having a negative perception of the company, which makes it seem untrustworthy. In addition, this study also investigates the ethical climate types that may be present in *Halal food* companies, and the findings of this study may have important applications for future studies.

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HALALSPHERE
International Islamic Univerity Malaysia - INHART

Challenges Faced by *Halal* Meat Industry: A Review

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Abstract

The demand trend for *Halal* meat and meat-based products among *Muslim*s worldwide has increased in recent years. Meanwhile, the awareness among non-*Muslim*s of *Halal* meat and meat products is due to their high quality and safety, thus resulting in more access to *Halal* meat and meat-based products for them. Due to the technological advancements in the meat processing sector, adulteration and fraud have grown more widespread due to the financial gain that can be realized. The issues associated with *Halal* meat have created an opportunity for researchers, scientists, consumers, manufacturers, and regulators to work together to determine whether meats produced in the industry are *Halal*, safe to be consumed and free from food-borne pathogens. *Halal* authentication technology can assist in addressing this issue, whilst as a result, can assist juries in assessing the status of the products with a high degree of precision. The objectives of this review paper are to discuss and review the challenges of the *Halal* meat industry, including the analytical procedures used to ensure that *Halal* meat products have long-term viability in Malaysia. The methods used to review the selected topics are searching the extant literature available in the online and offline sources, screening for topic inclusion, assessing, extracting and discussing the available data obtained in the updated journals. In conclusion, numerous challenges are faced by the *Halal* meat industry, and they should be addressed by focusing on realistic prospects to enhance the production of local meat, which is critical in guaranteeing the supply of *Halalan Toyyiban* meat is bounteous and secured.

1. Introduction

Halal is a root word derived from the Arabic language that means 'permissible' or 'lawful'. *Halal* can also be defined as something permitted by *Islam*ic law without punishment being put on the perpetrator. It is banned and unlawful to do something *Halal*, which is *Haram*. Meanwhile, *Toyyib* is a root word derived from the term *Toyyib*, which means 'good'. As a result, *Halalan Toyyiban* refers to a product that is 'permissible to consume or use and must be good and useful to the user'. *Halal* and *Toyyib* lifestyle is a way of life where only the best allowed and wholesome choices are applied or practised to ensure the safety and well-being of humankind (For this write up, the terms *Halal* and *Toyyib* are written in print). Such a lifestyle is practised throughout the world and not only in countries with a *Muslim* majority but also in *Muslim* minority populations (Hidayat & Siradj, 2015).

Customers are entitled to acquire the wholesomeness and the best food product that does not contain illegal elements harmful to health. Besides, for *Muslim*s, consuming *Halal* food is an obligation. Raw materials that contain animal meat slaughtered according to *Shari'ah* guidelines will be safe to eat because their hygiene and safety are guaranteed. Thus, it is the right of *Muslim* consumers worldwide to confirm that the meat products are not contaminated with the presence of pork or pork derivatives as well as there is no adulteration with the *Halal* logo endorsed by each community (Erwanto *et al.*, 2018).

Food authenticity is the completeness of significant components and is not messed up with the complete or partial replacement of food ingredients with non-proclaimed alternative ingredients (typically cheaper), cover-up food damage or the use of cheap foodstuffs and the addition of an unannounced substance to increase the mass of the production to improve the taste of a product (Luxminarayan *et al.*, 2017) as well as the application of pork by-product. Pork by-products used in meat processing comprise lard extracted from adipose tissue, Mechanically Recovered Meats (MRM), pork gelatine and pork blood plasma. In *Islam*ic legislation, consuming pork derivatives have been banned, as addressed clearly in the *Qur'an* and consuming pork and its derivatives are forbidden for *Muslim*s (*Qur'an* 5:3). Scientifically, pigs are hosts to several parasites that can endanger human health. Thus, the scientific findings enlighten the forbiddance

of consuming pigs and their derivatives in *Islam*ic law. From this matter, it is necessary to develop and test a standardization of analytical methods to identify pig derivatives in food products (Mursyidi, 2013).

The analytical techniques for contaminating pig's derivatives and other prohibited elements are Fourier Transform Infrared (FTIR) Spectroscopy, Electronic Nose, Chromatography Method and Polymerase Chain Reaction (PCR). These authentication techniques can assist in addressing adulteration issues in meat. Therefore, this review paper aims to review and discuss the current state of the challenges and issues of adulterating meat and several techniques used to identify prohibited elements such as pork in food products to create an understanding among readers regarding the challenges faced by the *Halal* meat industry including the technical method to validate the *Halal* status of the meat products by reviewing the selected topics are through the searching of the extant literature available in the online and offline sources, screening for topic inclusion, assessing, extracting and discussing the available data obtained in the updated journals.

2. Basic concepts of *Halal* meat

The basic concept of *Halal* food is clearly explained in the *Qur'an* and *Hadith*. *Muslim*s are required to consume the meat of an animal upon which Allah's name has been called, according to the *Qur'an* (invocation during the slaughtering of the animal) as stated in the *Qur'an* in *Surah Al-An'am* Verse 118:

> *"Therefore, eat of that upon which Allah's name has been mentioned if you are believers in His communications,"* (*Qur'an* 6:118)

Halal meat must not be derived from any of the forbidden meats listed in the *Qur'an*, as stated in *Surah Al-Maidah* Verse 3:

> *"Forbidden to you is that which dies of itself, blood, and flesh of swine, and that on which any other name than that of Allah has been involved, and the strangled (animals) and beaten to death, and that killed by a fall and that killed by being smitten with the horn, and that which wild beasts have eaten, except what you slaughter before, and what is sacrificed on stones set up (for idols); and that you divide by the arrows, that is transgression. This day, those who disbelieved have despaired of your religion, so fear them not, and fear Me. This day, I have perfected your religion for you and completed My favour on you and chosen Islam as the religion for you, but whoever is compelled by hunger, not inclining willfully to sin, surely Allah is Forgiving, Merciful"* (*Qur'an* 5:3)

All animals that are slaughtered accordingly to *Islam*ic practices are *Halal* except for *Haram* animals which were mentioned in the holy *Qur'an*, such as pigs, dogs, and predatory animals that are slashed and killed, such as lions, tigers, cats, bears, and similar animals; animals with tusks such as elephants; animals that are permissible to be exterminated in *Islam* such as centipedes, scorpions, rats, and other similar animals; while land animals are *Halal*. Similarly, all birds are *Halal* except for birds of prey and scavengers, defined as those with claws that feed by snatching and tearing, such as eagles, and birds that are prohibited from being killed in *Islam*, such as woodpeckers (Anonymous, 2021).

From the verses of the *Qur'an* mentioned above, the specifications of *Halal* meats are clearly explained. Technically, in the food industry, raw materials for food production should be obtained from *Halal* sources coming from *Halal* certified suppliers. *Halal* sources of food are not only *Halal* as described by the Holy *Qur'an*. However, they must also be certified by an authorized organization such as the Department of *Islam*ic Development Malaysia (JAKIM), the agency responsible for *Islam*ic affairs, including *Halal* certification in Malaysia.

3. Prohibition of pork and its by-product

*Muslim*s are not allowed to eat pork and its derivatives; consuming it is sinful (*Haram*). Scientifically, many studies have proven that consuming pork and its derivatives will lead to adverse effects on human health. According to Musdja (2018), pigs have several negative characteristics, such as being the most voracious animal, filthy and raunchiest in their class, and gluttonous pigs that go above and beyond the gluttony of other animals. Pigs also enjoy eating carrion and the faeces of other animals they come into contact with. Because of the greedy nature of pigs, if there is nothing else for them to eat, they will consume the vomit from their stomachs.

Furthermore, pigs are notorious for urinating on their food, and they will eat food contaminated with other pigs. Besides their negative characteristics, they are a variety of harmful bacteria and viruses found in pigs that can be transmitted to humans. Hence, their meat is more difficult for the human body to digest as it is almost identical to human genetics out of all species studied (Musdja, 2018).

According to Denner (2014), the retrovirus virus found in the pig is harmful, and this virus is responsible for developing cancer disorders. Besides retrovirus, the virus H3N2 (Hong Kong flu) is a pig-borne virus that has caused sickness. Hong Kong's influenza epidemic in 1968 triggered the pandemic, resulting in over 34,000 deaths in the United States (Kulkarni, 2019). On the other hand, the pig breeder is always looking for ways to gain an economic advantage. As a result, pig breeders will only breed pigs with a genetic predisposition to obesity. In this instance, the pigs' enzyme and obesity gene may drive the consumer to become obese. According to a medical study, obesity is a significant risk factor for cardiovascular disease owing to the high cholesterol and fat content of pork, both of which are difficult for the human body to metabolize (Anand *et al.*, 2015). Foods cause various disorders with high cholesterol and fats. These include, among other things, arterial hardening, increased blood pressure, gripping chest discomfort (angina pectoris) and inflammation (pain) of the joints of the body (Denner, 2014).

4. *Halal* meat adulteration issues

Adding undisclosed chemicals or materials to a product to increase the bulk or weight is considered adulteration. This practice makes the product appear more valuable than it is (Roberts & Turk, 2017). In the case of meat and meat

products, adulteration relates not only to the substitution of ingredients but also to the provision of incorrect information regarding the provenance of raw materials (Johnson, 2014). Literature research has revealed various difficulties associated with confirming food product adulteration. Some of the issues are as follows:

4.1 Carcasses

The term 'carcass' is employed when it comes to animals that have died, whether from an accident or disease. The death of an animal without slaughter is usually caused by one of two factors: first, the animal dies on its own without the intervention of people, such as sickness; and second, the animal dies because humans do not comply with Shariah's standards for slaughter. Due to the non-halal status of the dead carcass or animal, before it is slaughtered, it is not permissible to consume it (Fatmawati, 2020). In parts of Malaysia, chickens are likely to drown due to discharge into the water. Besides, there have also been cases of chickens being slaughtered twice after the first slaughter was imperfect. Hence, it is already dead before it is slaughtered.

4.2 Formalin meat

Formalin is a type of chemical that has been used to preserve meat. Formaldehyde solution in water or also known as formalin typically used to cure carcasses or dead bodies. It contains 30% - 40% formaldehyde. The use of formalin in foodstuffs, on the other hand, has the potential to be detrimental due to the presence of carcinogenic chemicals that can result in cancer. Additionally, eating meat that includes formalin might lead to the consumer's development of asthma and skin disorders. Besides, formalin is also used to preserve the chicken from decomposition at room temperature for two days and keep flies away from the meat (Ricke *et al.*, 2019).

4.3 Mıxıng meat

Meat that has been mixed typically combines two sorts of animals, with expensive and *Halal* meat combined with expensive and *Haram* meat. For example, butchers frequently combine beef and pork meats to generate additional profits because swine is cheaper than beef in most cases. On the other hand, a visual inspection will be more challenging to distinguish between formalin beef and pig. Muflih *et al.* (2017) published an article about tilapia fed pig faeces. The report was compiled and published based on activities conducted by the Perak *Islami*c Department at the fish farms in Tronoh, Papan and Batu Gajah. Farmers claim that feeding their fish with pig faeces has accelerated the growth of the fish, allowing them to be marketed in three months instead of a year if they were not provided such a diet. Another example is the Chinese Ministry of Public Safety seizing rat meat sold as goat meat in Shanghai in 2013 and foxes and rats meats sold as goat meat in some places (Buckley, 2013).

4.4 Fake meat

Substituting textures, natural characteristics, and relish of meat as a new physical texture and taste of other meat is considered fake meat. According to Ali *et al.* (2015), in China, there are many ways to produce fake meat, especially counterfeit pork, into beef by chemically using cow flavouring. However, long term effects from this chemical will have adverse effects on human health, such as intoxication, and chronic diseases such as cancer. Besides that, other fake meat issues reported involving butchers who sell fake beef and mutton obtained from repulsive animals such as foxes and rats. Meanwhile, other worse issues related to fake meat created from recycled human waste were reported by a team of researchers in Japan waste (Salahudin *et al.*, 2018).

5. Challenges in the *Halal* meat industry

There have been challenges associated with the *Halal* meat industry. Among others are issues related to authority, awareness, cost, supply chain management and adulteration that are discussed in the sub-topic below:

5.1 Authority

The most pressing issue today is *Halal* food legislation, which is under the jurisdiction of several government agencies, each of which has its own set of *Halal*-related rules. In addition to the Trade Descriptions Act (TDA) of 1972 and the Food Act of 1983, the Consumer Protection Act of 1999 and the Animal Rules of 1962 (Ahmad *et al.*, 2018) are connected to *Halal.* Besides, as the extent of *Halal* jurisdiction is broad (Soraji *et al.*, 2017), this impacts the implementation of *Halal* laws in Malaysia, allowing for overlapping enforcement efforts. There are also other government organizations tasked to deal with *Halal* issues, *Halal* meat and meat-based products that cannot be dealt with promptly as it necessitates thorough investigation to determine the core cause of the issue. Only meat and animal-based products that comply with the criteria of the Malaysian government can be made available in this country. The requirements consist of abattoirs and processing plants that are recognized by the Department of Veterinary Services (DVS) and JAKIM; meat and meat-based products that have been *Halal* certified by the approved foreign *Halal* certification body of the respective country which JAKIM recognizes; health certificate from the authorized veterinary agency from the respective exporting countries is provided and the imported meat approval is obtained the from Department of Malaysian Quarantine and Inspection Services (MAQIS), before permitting meat and meat-based products enter the Malaysian market (Jusoh, 2020).

With the recent *Halal* meat scandal and fraud involving the cartels of *Halal* meat importers, it is impossible to resolve this issue quickly and efficiently. Indeed, this meat scam has stoked the flames of discontent among the *Muslim* majority and, as a result, has compromised the Malaysian *Halal* system (Whitehead, 2021). Consequently, this incident has spurred the need for the Malaysia *Halal* Council (MHC) to be reactivated as soon as possible, with the Malaysian Prime Minister serving as the council's temporary chairman to address the meat cartel controversy. A significant effort is being made to develop separate *Halal* regulations in each country, but this goal has yet to be achieved (Palanisamy, 2021). No official *Halal* laws deal with *Halal* difficulties, such as *Halal* meat issues, making the situation uncontrollable.

5.2 Smuggling

Another issue, the lack of severe monitoring at the entry point into Malaysia, has triggered another challenge, particularly at the land border crossing between Malaysia and Thailand.

Several problems have been reported in the media, including the seizure of frozen chicken worth RM500,000 at the Bukit Kayu Hitam entry point (Bernama, 2021); the widespread smuggling of frozen chicken and meat along the border of Kelantan and Narathiwat (Abdullah, 2020) and numerous other cases involving smuggling activities at the border have also been reported.

5.3 Cost

Another obstacle that meat industry operators must overcome is the rising cost of keeping animals (Webmaster, 2017). The meat sector continuously faces the ebbs and flows of demand and supply. Due to it being challenging to foresee market volatility, pricing will fluctuate as a result, although, on the whole, it is increasing. According to a recent Technavio report (Linker, 2020), the global meat processing equipment market will grow at a compound annual growth rate (CAGR) of more than 6% over the next four years, owing to an increase in demand for pork in China, a greater emphasis on processed meat products, and an increase in consumer preference for protein-rich foods. Processors must find a means to deal with rising expenses on a short or potentially long-term basis to enhance production to overcome this issue. To get an answer, it is necessary to examine the cost of the protein in raw material and compare it to the cost of the protein in the finished product. Understanding this may assist processors in lowering costs while still maintaining quality (Webmaster, 2017).

The meat industry's reliance on imported feedstuffs such as maize, vegetables and animal proteins for ingredients in feed rations is also a significant concern, given the industry's high dependency on imported feedstuffs. The cost of imported feed ingredients is subject to fluctuations in foreign exchange markets. As a result of the currency crisis, it is costly to sustain present levels of feedstuff importation, which leads to an increase in feed prices (Mohamad Hifzan Rosali, 2015).

5.4 Supply chain

Managing *Halal* goods from different suppliers to different levels of purchasers or customers is all about supply chain management (SCM) in the *Halal* food sector (Shah *et al.*, 2016). According to Whitehead (2021), the *Halal* meat industry must deal with the risk of cross-contamination or violation of any Shariah principles because of the lengthy and complex *Halal* meat supply chain that must be followed before reaching Malaysia. This problem occasionally occurs due to the differences in regulatory standards between the exporting countries and Malaysian regulations. In logistics, issues arise in transportation, warehousing, and storing goods (possibilities of hybrid storage and cross-contamination). The ability to provide logistic service management capabilities is critical in maintaining the integrity of *Halal* products (Karia, 2019).

5.5 Adulteration

There is insufficient information and technology available to detect counterfeit and contaminated items. Regarding physical site inspection, only a tiny percentage of the facilities can be covered. It is difficult to determine the actual number of foreign sources of the products being used (Choudhary *et al.*, 2020). According to the Food and Drug Administration, the most significant obstacle to food adulteration is a lack of acceptance in the market due to a suspicion of its originality (Ayza & Yilma, 2014).

A finding involving the adulteration of *Halal* food violated the Food Act 1983 and its rules. In 2017, the Malaysian Quarantine and Inspection Services (MAQIS) seized four containers suspected of containing a mixture of pork and mutton products. This scenario was meant to never occur in Malaysia because the incidence violated the Food Regulation 1985, specifically Clause 11 (c), which dealt with labelling. It was essential to state on the label whether the item contained beef, pork, or derivatives of these meats and fats. This standard is sufficient to regulate the adulteration of *Halal* food in Malaysian markets (Ruzulan *et al.*, 2021).

Furthermore, under Clauses 36 (2) and (3) of the Food Hygiene Regulation 2009, food handlers are required to separate food processing from swine-origin (sus suscrofa) and the appliances (Ruzulan *et al.*, 2021). Similarly, MS1500:2019 specifies that it is not permissible to transport *Halal* meat in the same vehicle as non-*Halal* meat. As a result, it will cause widespread consternation among *Muslim*s, who will be concerned about the possibility that *Halal* meat and its products have been contaminated with non-*Halal* chemicals, leading to widespread panic.

6. Authentication method for *Halal* meat

6.1 DNA-based method

Due to advancements in gene technology, detection methods based on genetic differences for *Halal* authenticity have been developed quickly. For example, DNA is more stable at high temperatures than proteins, can be found in all tissue types, and exhibits more significant variation with genetic code. DNA is a relatively stable molecule that can provide universal and identical information from all tissues of an organism and can withstand the pressure, chemical stresses and extensive heat of food processing. In meat speciation, DNA-based techniques have the advantage of being more accurate and reproducible. Uncompromising conditions such as natural decomposition or deteriorated specimens where protein-based markers have been denatured or degraded; this method is equally stable in uncompromised situations. Therefore, the DNA-based technique is more robust than the protein-based technique (El Sheikha *et al.*, 2017).

6.2 Polymerase chaın reactıon (PCR) technıque

A polymerase chain reaction (PCR) is a chain activity involving polymerase DNA enzymes that, in principle, results in DNA fragmentation when particular primers are utilized. The polymerase chain reaction (PCR) is considered one of the most sensitive procedures for determining the identity of a chemical. A significant advantage of this technology is that it is susceptible and can detect unlawful chemicals in a short period, even in tiny quantities of DNA. Target ranges are applied to DNA moulding, and the result is that DNA can be detected even in small amounts (Mustafa, 2017). PCR is also known as a chain action involving DNA polymerase enzymes. It is used to distinguish the animal species in the laboratory, hence can be classified into two categories:

Conventional PCR is straightforward and valuable, but it depends on end-point analysis. However, it cannot provide quantitative information on the targets initially present in the sample under consideration. Traditional PCR methods consist of three main steps: extraction of DNA from the sample to be studied and preparation of PCR reactions, which can be divided into three main processes: denaturation, annealing and extension. The last step is the detection of reaction results using agarose gel electrophoresis. Through using a fluorescently tagged signalling probe, real-time PCR has successfully circumvented this constraint by allowing for direct and independent monitoring of cycle-to-cycle amplification. The intensity of the fluorescent signal is directly proportional to the number of PCR products that have accumulated in each cycle, allowing for detection in real-time at an early point in the process. The rt-PCR method has several advantages, the most important of which are quicker analysis times, more sensitive results, and the absence of dangerous substances. As it is self-automated, it is intrinsically more accurate and promising than conventional PCR, and it does not require the time-consuming agarose gel or polyacrylamide electrophoresis (Mustafa, 2017). The rt-PCR method has several advantages and the most important of which are quicker analysis times, more sensitive results, and the absence of dangerous substances (Salahudin *et al.*, 2018).

In a study by Qin *et al.* (2019), they developed a detection method using a multiplex PCR system to simultaneously identify adulterated ingredients of chicken, duck and pork in beef with a limit detection of 0.05% for each species. Primer pairs were designed and tested for the mitochondrial genes Cyt b, CO III, ATPase subunit 8/6, and Cyt b in chicken, duck, pork and beef. The multiplex PCR method identified five beef samples adulterated with pork and one beef sample adulterated with chicken among the 35 commercial samples examined, demonstrating the feasibility of this method for identifying adulterated chicken, duck and pork ingredients in commercial beef products.

The advantages of multiplex PCR include the fact that it is highly repeatable. It saves time and money because it allows for the simultaneous identification of different species using a single PCR experiment and is more economical when compared to other methods. It can simultaneously amplify primer mixes in a one-step PCR reaction, overcoming the limitation of single PCR detection, which only amplifies a pair of primers in a single reaction. Besides, multiplex PCR has several drawbacks, namely low amplification efficiency, variable efficiency across different templates and poor universality. All these points to the necessity for a more sophisticated multiplexing strategy to be developed. Furthermore, a DNA template that is both substantially longer and length-variable for diverse species is required (Mustafa, 2017).

6.3 Fourıer-transform ınfrared (FTIR) spectroscopy

Fourier transformed infrared (FTIR) spectroscopy is considered a green analytical method because it requires only a tiny amount of chemical reagents and solvents. Besides, it is fast, non-destructive, and in some cases, does not require any sample preparation. As a result, FTIR spectroscopy can be considered a green analytical technique. FTIR spectroscopy and multivariate calibration have been used in *Halal* authentication analysis to analyze lard mixed with other animal fats such as beef, chicken and lamb. It has also been used for the quantitative analysis of lard present in chocolate products and cake formulation, as well as the quantitative analysis of lard extracted from pork in beef meatball products and meatball broth (Rahayu *et al.*, 2018).

Based on one study by Guntarti *et al.* (2018), they developed a detection method using Fourier Transformed Infrared (FTIR) spectroscopy combined with chemometrics to analyze the pork content in beef meatballs. The identification of pork in meatballs using FTIR yielded a determination coefficient of 0.9984 and a relative mass standard error of 1.09%. It is proven that the chemometrics method can be used to discriminate between pork meatballs and beef meatballs. Moreover, Rahayu *et al.* (2018) assessed the suitability of FTIR spectroscopy coupled with multivariate analysis of partial least square regression (PLSR) along with pattern recognition technique of principal component analysis (PCA) for rapid quantitative and qualitative (identification) analysis of dog meat in beef meatball formulation. The results of FTIR spectroscopy combined with multivariate analyses of PLSR and PCA proved to be a valuable method for screening dog meat in meatball products in a short amount of time.

The effectiveness of FTIR is a non-destructive technique, and it has high precision. Besides, it requires no external calibration, is fast and time-saving, mechanically simple, sensitive to changes in molecular structure, and can detect functional group ranges. The absence of a signal is a conclusive indication that the functional group is absent, and the identification of a compound is confirmed by comparing its spectrum to that of a known sample. The limitation is that the structure cannot be determined only by infrared imaging; hence some signals may be confusing (Rahayu *et al.*, 2018).

6.4 The electronic nose

The electronic nose (E-nose) is a low-cost analytical technique for food authenticity that is quick, simple and easy to use. This non-destructive analytical method has a wide range of applications, including quality control, the differentiation between real and fraudulent food and the determination of the provenance of food. In its most basic form, the E-nose is benchtop portable equipment meant to duplicate the critical functions of the human nose in terms of recording, detection, memory search and identification to profile an odour (Yakubu *et al.*, 2021). Although the uses of E-nose in the food sector are widely recognised, including monitoring processes, authenticity, shelf-life, freshness, and other quality controls, the capability of E-nose in validating *Halal* status is relatively new and has only a limited number of applications.

Sarno *et al.*, (2020) successfully analyzed seven meat classes, comprising seven different mixtures of beef and pork, using an Optimized Electronic Nose System (OENS). OENS has advantages such as proper noise filtering, an optimized sensor array and optimized support vector machine (SVM) parameters. Noise filtering is accomplished using cross-validation with various mother wavelets, including the Haar, Dmey, Coiflet, Symlet, and Daubechies wavelet families. Principal component analysis optimized the sensor array by reducing the number of dimensions (PCA). The optimization of the SVM parameters is accomplished through the proposed method (Sarno *et al.*, 2020). The first and seventh classes contained 100 per cent beef and 100 per cent pork, respectively.

In contrast, the second, third, fourth, fifth, and sixth classes held 10%, 25%, 50%, 75%, and 90% of beef in a sample of 100 grams, and the eighth class contained 10%, 25%, 50%, 75%, and 90% of beef in a sample of 100 grams, respectively. Tests on the samples were carried out for 15 minutes per sample. The classification test results to distinguish between beef and pork were accurate to 98.10% when the support vector machine (SVM) was optimised. As a result, OENS has a favourable performance in detecting pork adulteration in beef for *Halal* authenticity.

6.5 Differential scanning calorimetry (DSC)

A type of thermos analytical technique, Differential Scanning Calorimetry (DSC), or calorimetry method, is used to detect changes in the physical and chemical properties by detecting changes in its thermal conductivity. As the most versatile technique, differential scanning calorimetry (DSC) has a wide range of applications based on the premise of heat differences in a sample caused by thermo-physical transitions (exothermic and endothermic changes) (Sudhakar *et al.*, 2021). The DSC offers information on the melting and crystallization processes of oils, which are directly impacted by their physicochemical features, such as the composition of fatty acids and triglycerides (TAG) and their structural and chemical qualities (Sudhakar *et al.*, 2021). The DSC method is based on maintaining the same temperature for both the sample and the reference in separate micro-ovens. The amount of electrical power required for the adjustment is equal to the calorimetric effect that exists. Thermal analysis by DSC is a direct approach to evaluating the thermal properties of a variety of materials. It can potentially be used as a quality control procedure for food adulteration in the future (Sudhakar *et al.*, 2021).

For *Halal* authentication, a study by Any Guntarti *et al.* (2017) has proven to be successful in detecting wild boar meat in meatball formulation using differential scanning calorimetry (DSC) combined with multivariate calibration. DSC thermal profiles of oil derived from wild boar meat show substantial differences in cooling and heating compared to other oils. A study has also been conducted to determine how oil's specific exothermic and endothermic events alter as crystallization and melting enthalpy increase and how these processes develop across a tighter temperature range. Wild boar meat in beef meatballs was the subject of this study, in which the created DSC and multivariate calibration of Partial Least Square (PLS) calibration examined the wild boar meat. The chemometrics of Principle Component Analysis (PCA) is utilized to differentiate between wild boar meat and beef in the meatball.

Meanwhile, for the correlation between actual wild boar meat (x-axis) and DSC predicted value (y-axis), the validation model using crystallization profiles yielded a coefficient of determination (R2) of 0.999 with an equation of y= 0.9999 x + 0.0027, as well as a root mean square error of cross-validation (RMSECV) of 0.380 per cent and a root mean square error of prediction (RMSEP) of 0.203%. PCA is effective for classifying wild boar meat in beef meatballs. Wild boar meat in meatballs can be analyzed using DSC in conjunction with PLS and PCA, a more cost-effective alternative to traditional methods.

7. Conclusion

Islam highly emphasises the importance of food consumption among its adherents. If a *Muslim* consumes meat, it has to be from *Halal* animals that have been slaughtered following *Islam*ic practice. The meat must also not be harmful to humans and be essentially free of impurities. Accordingly, to address the issues that are currently facing the *Halal* meat industry, authority, public perception of the industry's importance or awareness, cost, supply chain management, and adulteration, scientifically based analytical methods are urgently required to detect elements that are prohibited by *Islam*, mainly pork or any other aspects that are considered harmful to humans. For the most part, this study aids in supplying extra knowledge to *Muslim* scholars, allowing them to provide a specific *Islam*ic judgement on a topic of great importance. Besides that, Malaysia urgently needs proper and systematic *Halal* meat management to ensure enough *Halal* meat is available to meet the growing demand of the *Muslim* community. The use of local meat rather than imported meat is desirable to maintain a higher level of integrity. Furthermore, it can shorten the *Halal* meat supply chain, as *Halal* meat adulteration has been found to occur often in imported meat and meat-based products.

According to reports, the fact that numerous government entities are involved with *Halal* topics raises the possibility that they may be ineffective in dealing with *Halal* triggering issues. Based on current circumstances, establishing stand-alone *Halal* legislation under the jurisdiction of JAKIM alone may be necessary to improve the *Halal* assurance system in Malaysia. Furthermore, the participation of young entrepreneurs in government-sponsored programmes is critical because many opportunities exist to expand the amount of meat produced in the region. For future research, it is crucial to investigate the agricultural tourism product derived from the *Halal* meat industry since this could substantially impact the commercial operations of local entrepreneurs in Malaysia.

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HALALSPHERE
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Moss and Polyaromatic Hydrocarbon in Malaysia: A Recent Ten-Year Evaluation

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Abstract

The ten-year evaluation of moss species related to Polyaromatic Hydrocarbons (PAHs) in Malaysia is discussed in this paper review. Mosses are excellent biomonitors and bio-indicators of PAH deposition in the environment, often by considering the diversity and development of naturally growing bryophytes and moss bags and have been extensively used in studies of atmospheric contamination over the past decades. The review also highlighted the sources of PAHs atmospheric pollution in the environment. The sample preparation, storage, and extraction methods are discussed and reviewed. Recent applications of gas chromatography for assessing PAH compound emission by mosses are also discussed. Aside from that, current efforts to reduce PAH pollution are mentioned.

1. Introduction

Combating air pollution is becoming increasingly important as the world becomes more crowded and hotter, with all of us pumping harmful gaseous and particulate matter into the air. Microscopic pollutants in the air enter our bodies and bypass our defence systems, deteriorating human health. Despite the availability of conventional technologies for monitoring air quality, biomonitoring with plants has emerged as a method of interest and has gained global attention in recent years. Mosses serve as air quality indicators and are sensitive to pollutant deposition. Heavy metal industries include sulfur dioxide (SO2), nitrogen oxides (NOX), hydrocarbons, and other air pollutants associated with bryophytes. Mosses (bryophyta) are non-vascular plants that play significant roles in ecosystems, such as stabilizing soil, reducing the risks of flooding and erosion and strongly influencing carbon, water, and nutrient cycling. Polycyclic aromatic hydrocarbons (PAHs) have been regarded as highly toxic, carcinogenic, and mutagenic to all various life forms. They are mainly formed from incomplete combustion materials at high temperatures. Once in the atmosphere, they can bind to and react with other pollutants.

The *Toyyiban* aspect must ensure the quality and safety of human life, concerning the air quality issue is not just a minute issue; it may affect an entire city, street, or suburb. People feel the effects of poor air quality in their neighbourhoods, so the message must reflect this. Breathing clean and fresh air is a slew of other health benefits and is necessary for humans to thrive and survive. Cleaner energy sources and the various sustainability requirements to combat air pollution must become more affordable and widely available. Since mosses are plants with substantial cation exchange capacity (CEC), high surface-to-volume ratio, and lack of true root system and well-developed cuticles, they can efficiently accumulate PAHs via dry and wet deposition over their surface. Since it is possible to sample many mosses that scatter relatively short distances from their origins, measuring pollution levels in mosses is a cost-effective and easy-to-manage method. A downside of the moss method is the comparatively small increments of pollutants relative to the pre-exposure concentrations for a few elements, at least in today's relatively clean Western environments. The use of mosses in biomonitoring describes pollution levels in background areas; nevertheless, locations classed as background sites that are barely polluted or have the lowest degree of pollution are becoming increasingly similar to

urban areas. Consequently, increases in pre-exposure concentrations are only detectable after prolonged exposure or at high pollution levels. PAH-related moss research PAH-related moss research is certainly threatened due to a lack of information and research. Most studies were focused on other pollutants like heavy metals. Efforts were made to integrate mosses with engineering to create a variety of industrial applications, such as a green wall integrated system to filter air pollution and the employment of mosses in moss bags for biomonitoring of environmental pollution.

2. Moss distribution and its ability to absorb pollutants

Mosses are relatively small phylum Bryophyta and non-vascular plants with at least 12000 species that carpets most of the forest floor except in salt water and predominantly in a moist, damp area. The bryophytes represent a large group of three unique seedless plants which comprise three phyla: Bryophyta (mosses), Anthocerotophyta (hornworts) and Marchantiophyta (liverworts) (Ishizaki, 2017; Jiang, 2018). Research studies have shown these plants are numbered between 11,000-13,000 mosses, 7,000-9,000 liverworts and 200- 250 hornworts, which make a total of 18,000 to 23,000 worldwide (Sabovljević and Sabovljević, 2020). Mosses represent about 90% (ca. 260,000 species) of all extant land plant species; mosses are observed in rapid diversification, outnumbered (Roberts *et al.*, 2012), rich in various ranges of forms, sizes, and heights, and play a significant role in various ecological niches and land plant diversity (Geffert *et al.*, 2013).

Mosses are particularly prominent in the tropics; however, they have a significant presence in the boreal forest due to the shadiness and damp conditions, the woodlands of the temperate zones, and tundra regions. Some moss species are drought or desiccation-tolerant though they typically are found in moist environments. Climatic factors (Song *et al.*, 2015); soil factors including type, moisture, and pH (Rousk *et al.*, 2018); topography attributes such as slope, altitude and gradient (Okuda *et al.*, 2011; Staniaszek-Kik *et al.*, 2019), vegetation type and coverage; and the type of substrate that mosses grow on (Staunch *et al.*, 2012; Sale *et al.*, 2016) are all critical environmental factors affecting the distribution of mosses. Humidity can be interpreted as the high-water content in a place. Khujjah and Ekowati (2018) mentioned what makes moss required to grow in humidity place because water outside male gametes body (sperm from antheridium) help them to reach female gametes to facilitate sexual reproduction.

Besides having phylogenetic diversity, mosses have also been reported to render physiological tolerance to environmental stresses (Roberts *et al.*, 2012). Cytological stress signals and vitality tests have been carried out to compare the moss sensitivity towards potential pollution stressors and accumulation capacities with other biomonitors and materials (Spagnuolo *et al.*, 2011), where mosses have higher and better potential capabilities in capturing variances of atmospheric pollutants compared to the lichens (Ndlovu *et al.*, 2019). Their ability to trap pollutants from the air on the surface and tissues is due to (1) the absence of roots, and they receive all nutrients primarily direct from the air, hence, simultaneously allowing the pollutants to concentrate over the moss surface, (2) large surface-region-to-volume ratio that enhances the absorption and retentions of pollutants (Parmar *et al.*, 2016), (3) absence of cuticle layer and lignified cell walls; thus, allow high capacity of metal ions exchange (González & Pokrovsky, 2014), (4) stable and homogenous species population becomes the best bioaccumulator to represent sampling area, (5) low-growing features provide the information over extended periods which is not limited to current pollution status. These factors allow real-time detection, easier sampling, and cost-effective biomonitoring of pollutants at multiple sites (Jiang *et al.*, 2018) and (6) easily grow on bare rock surfaces, building up ground soils, therefore become a primary succession and colonisers in urban areas (Haynes *et al.*, 2019).

Plants biomonitoring is widely distributed, relatively inexpensive, and offers large surface areas that can accumulate numerous amounts of organic pollutants than those in a smaller area (Baldantoni *et al.*, 2014). According to (Nowak *et al.*, 2022), active moss biomonitoring methods have been preferred, and these methods involve transplanting moss samples from clean, pristine areas to the study sites. Since native mosses may adapt to their surroundings and spontaneously respond to new pollutants, this method choice was observed to produce different results from passive biomonitoring.

The use of bryophytes to monitor fluorine pollution from industrial emissions started in the 1950s (De Agostini *et al.*, 2020). In the 1980s, mosses were a reliable air quality tool for evaluating atmospheric organic pollutants. Relatively, mosses are highly sensitive to many air pollutants. It will turn the colour to brown or black, reflecting its surrounding. They will decline and become extinct if exposed to long term pollution (Cen, 2015). The first work that utilises moss species as a bio-indicator for atmospheric heavy metal depositions was initiated by Ruhling and Tyler (1968) in Sweden (Donovan *et al.*, 2016). It was chosen merely because this leafy bryophyte receives all nutrients and pollutants directly from the air since they do not have a protective epidermis, as well as they have a high cation exchange capacity to accumulate high concentration of heavy metals to a high degree without damaging the cells (Shakya *et al.*, 2014). They once collected moss samples and vascular plants near the busy roadside, resulting in the moss accumulating Pb better than the vascular plants, which provided emissions data within 7-15 months (Donovan *et al.*, 2016). Likewise, Wilkie & La Farge (2011) mentioned that mosses could accumulate, sequester, and tolerate concentrations that are often toxic to other taxa. In 1990, the European moss Biomonitoring Network was established and coordinated by the UNECE ICP Vegetation Programme to quantify the deposition of heavy metals in naturally growing mosses (Shetekauri *et al.*, 2018). The programme was conducted every five years until 2010, aiming to study heavy metal concentrations on temporal and spatial patterns in Europe at a high spatial degree (Palma, 2016). In 2005, a pilot study of nitrogen, persistent organic pollutants (POPs), polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs) concentrations in mosses was carried out in selected countries using the pleurocarpous species since these species spread a thick cushion mats which has high surface-to-volume ratio that favour high accumulation of pollutants (Harmens *et al.*, 2013). Schröder & Nickel, (2019) found that 74 % of the moss biomonitoring studies employes *Pleurozium schreberi*, *Hypnum cupressiforme, Hylocomium splendens* and *Psedoscleropodium purum* as biomonitors in Europe and North America. Pleurozium schreberi was able to accumulate PAHs and PCBs road traffic (Sucharová & Holá, 2014a) (Danielson *et al.*, 2016). Among these PAHs, *Hypnum plumaeformae* show good relation with Phenanthrene concentration and traffic volume was observed in Hungary

(Janković-Mandić *et al*., 2015).

2.1 Type of moss monitoring

The biomonitoring method using mosses can be performed in two ways, through passive and active monitoring (Motyka *et al*., 2011). Passive moss biomonitoring has been used for decades, where native moss species are collected directly at the sampling site, and the moss is analysed to estimate the trace elements of atmospheric deposition. On the contrary, active biomonitoring involves transplanting mosses at the site of interest, especially to monitor pollutants in urban areas. The mosses are packed in nylon-net or fabric bags and exposed for certain periods and height exposure from the ground. Since the height placement of moss influences the accumulation uptake capacity (Di Palma *et al*., 2017), besides tunnels (Q. Wu *et al*., 2014), garages (G. Vuković *et al*., 2013), airports (Turgut *et al*., 2019), petroleum refinery (Cortis *et al*., 2016) and bodies of water (Gecheva *et al*., 2020), moss bags method assists the monitoring of air around volcanoes (Calabrese *et al*., 2015) and in cold climate regions (Salo *et al*., 2016). Airborne pollutants accumulated in mosses through wet or dry deposition remain for at least 2 to 3 years and reflect the level of pollution (Fabure *et al*., 2010; Schröder & Nickel, 2019). Details on studies that used both types of monitoring are shown in Table 1 and Table 1.1. Mosses are passive biomonitors in their natural environments, but in recent years, active biomonitoring with moss transplants has become a more popular method for environmental monitoring (Di Palma *et al*., 2017; González & Pokrovsky, 2014; G. P. Vuković, 2015). In most studies, moss-bags produced positive and satisfying results. Because of their sensitivity to natural climatic conditions, moss-bags are rarely used indoors. Long-term exposure has a significant advantage over technical tools with demanding infrastructure and maintenance typically only applicable in short-term assessments. Despite this, the moss bag method has not been standardised in terms of the amount of moss exposed in the bags, their shape, and the material used to make them. There is also little evidence to support the relationship between pollutant deposition and moss uptake. Another unstandardized aspect is the use of blanks or zero time controls. Typically, results are reported as spatial and temporal concentrations. PAHs can accumulate in plants through absorption and adsorption depending on their availability in the environment, physical chemical properties such as gaseous-to-particle partitioning, ambient variables (such as temperature, radiation, and humidity), and plant characteristics (Harmens *et al*., 2013; Loppi *et al*., 2015). These characteristics influence PAH levels and profiles in a given species, even in nearby background areas.

3. Sources of polyaromatic hydrocarbon

Polycyclic aromatic hydrocarbons (PAHs) are large organic substances, a group of about 10,000 compounds, and each of the individual compounds often shares similar characteristics. They generally appear in pale yellow solids or colourless white at room temperature (Han *et al*., 2015; Hindersmann & Achten, 2018). Chemically, PAHs consist of two or more fused benzene rings formed in linear, cluster or angular arrangements (Moyo *et al*., 2013; Okonkwo *et al*., 2014). Most PAH rings comprise six carbon-hydrogen units and are attached with shared edges. Since the structure varies in the ring system, the molecules probably carry different side chains instead of hydrogen atoms. The PAHs have different molecular weights; therefore, they are divided into low molecular weight PAHs (LMW-PAHs) and high molecular weight PAHs (HMW-PAHs). The LMW-PAHs comprise 2 to 3 rings, like Naphthalene, Acenaphtylene, Acenaphthene, Fluorene, Phenanthrene, and Anthracene (Moscoso *et al*., 2015; Shou & Li, 2015). The HMW-PAHs comprise more than four rings, such as Pyrene, Chrysene, Benzo(a)anthracene and Indeno(1,2,3-cd)pyrene. The LMW-PAHs are less hydrophobic, volatile and soluble in many organic solvents than HMW-PAHs. The HWH-PAHs have a melting point of> 100°C, making them solid and stable in the environment (Adeniji *et al*., 2018). The solubilities of PAHs are inversely proportional to the number of fused benzene rings. Therefore, HWH-PAHs are well dissolved in oil substances, sediments and soil, while LMW-PAHs are likely to dissolve in water.

PAHs developed several heat resistances, corrosion resistance, light intensity, conductivity, and physiological action. PAHs have characteristic UV reflectance spectra. Ultraviolet (UV) absorbance spectra of aromatic hydrocarbons contain special absorption bands with considerable fine structure, especially in non-polar solvents (Charriau *et al*., 2016). Each ring structure presented a unique UV spectrum, crucial in identifying the PAHs molecules. Generally, PAHs molecular weight is divided into two groups, low molecular weight and high molecular weight or heavy weight. PAHs usually dominate low molecular weight PAHs with 2 to 3 aromatic rings; for example, naphthalene, methylnaphthalenes, acenaphthylene, and fluorine, which are present in the gaseous phase (Balmer *et al*., 2019; Rengarajan *et al*., 2015) meanwhile high or heavier weight have more aromatic rings (usually four or more rings); for example, Pyrene, Benzo(a)anthracene, Benzofluoranthene which present in the particulate (PM) phase (Khan *et al*., 2015; Shen *et al*., 2017).

Chiu *et al*. (2018) mentioned that sources of PAHs are derived from two major groups: anthropogenic (human-caused) and non-anthropogenic sources. The anthropogenic sources entail pyrogenic (dominant source) and petrogenic sources, while natural sources are the non-anthropogenic sources. Pyrogenic PAHs are formed during the combustion of oil derivatives, coal tar, traffic-related pollution, agricultural fires, waste incineration and anything related to burning organic matter (Balmer *et al*., 2019; Dat & Chang, 2017). They are readily abundant in the gaseous phase and more abundant when the rings become more than 4 in the exhaust engines' particulate phase (soot). Abdel-Shafy & Mansour (2016) explained that the PAH molecular formation results from the incomplete combustion of carbonaceous material through pyrolysis (thermal decomposition) and pyrosynthesis (subsequent recombination) processes.

As for petrogenic PAHs, most of them are derived from direct contamination, such as refined petroleum products, spillage of oil products, municipal sewage treatment plants and engine oils, and emissions from vehicles, aluminium production facilities, making dyes, pesticides and plasticisers (Liu *et al*., 2017; Santos *et al*., 2017). Wildfires and volcanic eruptions produce natural-sourced PAHs (Kozak *et al*., 2017). Both anthropogenic and non-anthropogenic activities yielded parent PAHs and alkylated PAHs, where the alkylated PAHs are more persistent in the environment than the parent PAHs (Adeniji *et al*., 2018).

Table 1: Active moss monitoring and descriptions

Type of monitoring	Species	Sample preparation	Moss bag description	After exposure	Reference
Active	*Pseudoscleropodium purum* 1) Wide surface area and temporal and spatial distribution. 2) Widely and successfully used.	1) 3-4 cm of apical shoots were washed with bidistilled water for 30 min. 2) The excessive moisture was removed using filter paper. 3) Placed 10 g into moss bag.	1) Size: 10 cm x 20 cm. 2) Material: Polythene net (1 mm mesh). 3) Height placement: 3-4 m, on a PVC tube attached vertical to the lamp post. 4) Total bags: 50 were placed at the study area, 3 as controls and 4 as blanks in vacuum packed.	Samples were homogenized, dried at 80°C prior to analysis.	(Ares *et al.*, 2011)
Active	*Hypnum amabile*	NM	1) 600g of mosses placed in 5 bags were exposed at residential, commercial and industrial areas with 30 days duration. 2) Control mosses were kept in the chamber with filtered air.	NM	(Gómez-Arroyo *et al.*, 2021)
Active	*Sphagnum girgensohnii*	NM	1) Size: 10 cm x 10 cm. 2) Material: Nylon net (1 mm mesh). 3) Height placement: 5-10 m, exposed for 3 months. 4) Total bags: 21 were placed in the central zone.	Samples were homogenized, dried at 40°C to a constant weight for next chemical analysis.	(Hajiyeva *et al.*, 2017)
Active	*Hypnum cupressiforme*	NM	1) Size: 10 cm x 10 cm. 2) Material: Nylon net (1 mm mesh). 3) Total bags: 30 bags were exposed for 6 weeks, and 10 bags were unexposed as controls.	Samples were kept at a temperature of 4 °C prior to next analysis.	(F. Capozzi *et al.*, 2017)
Active	*Hypnum cupressiforme*	1) Dried overnight in a humid chamber. 2) Only green part of moss shoots was selected (10 l per 100 g dry weight) and washed with distilled water.	1) Size: 12 cm x 12 cm. 2) Material: Nylon net (2 mm mesh). 3) Height placement: 3, 6 and 9 m. 4) Total bags: 500 mg of fresh moss was placed in 6 bags at each point were exposed for 30 days.	Refer to (Ares *et al.*, 2011)	(De Nicola *et al.*, 2013)
Active	*Pleurozium schreberi, Sphagnum fallax*	Only the green parts of mosses were selected.	1) Size: NM 2) Material: Nylon net. 3) Height placement: 3, 6 and 9 m.	NM	(Świsłowski *et al.*, 2021)

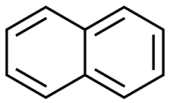
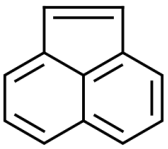
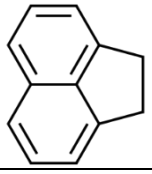
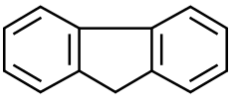
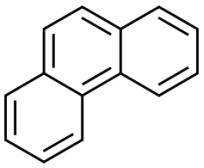
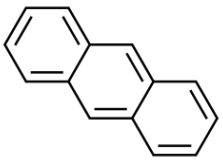
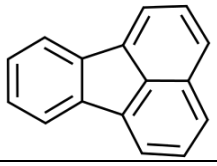
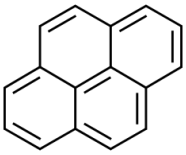
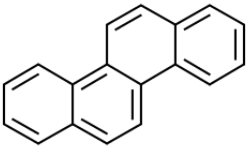
	and Dicranum *polysetum*		4) Total bags: 2 g of fresh moss was placed in 9 bags were exposed for 3 months (3 bags for each species). Control moss was left for pre-exposure analysis.		
Active	*Sphagnum capillifolium* and *Hypnum cupressiforme*	The samples were cleaned with 10 L of distilled water for every 100 g dry weight.	1) Size: Diameter ca. 4 cm. (in a spherical shape). 2) Material: Nylon net (2 mm mesh). 3) Height placement: 4 m above the ground and hung up on plastic sticks. 4) Total bags: 500 mg of fresh moss was placed in 3 bags were exposed at 3 different site background (urban, rural and semi-rural) for 10 weeks (3 bags for each species). Control moss was left for pre-exposure analysis.	Samples were homogenized for the next analysis.	(Vingiani *et al.*, 2015)
Active	*Hypnum cupressiforme*	NM	1) Size: 15 mg cm^{-2} 2) Material: Nylon. 3) Height placement: NM. 4) Exposed for 6 weeks.	Samples were kept at a temperature of 4 ◦C in the freezer until next analysis.	(Fiore Capozzi *et al.*, 2021)

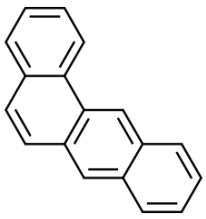
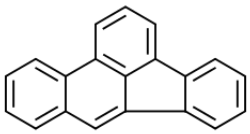
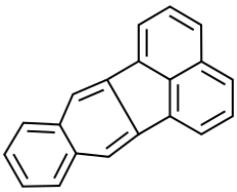
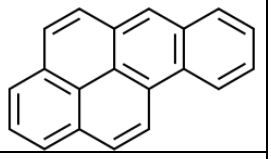
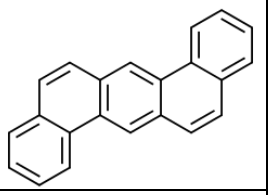
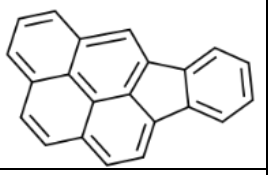
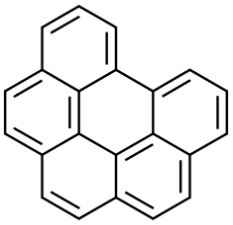
Table 1.1: Passive moss monitoring and descriptions

Type of monitoring	Species	Sample preparation	Reference
Passive	*Hypnum plumaeforme*	1) At each 2 m plot, a sample was collected from several points and grouped together. Attached soils and litter were cleaned of mosses, and only green and brown-green moss tips were chosen for further analysis. 2) The average length of moss tips was 2.67 ± 0.47 cm (mean ± SD). 3) The samples were prepared in aluminium foil, air-dried at room temperature, and stored in paper bags secured in polyethylene bags in the dark until PAH analysis.	(Oishi, 2013)
Passive	*Pleurozium schreberii*	1) The samples were collected from 5 – 10 points in a 2500 m^2 (50 x 50 m) and sealed together in polythene bags. 2) They were brought back to the laboratory with a cooler box and maintained frozen for next analysis. 3) The green living parts were selected for the analysis.	(Godzik *et al.*, 2014)
Passive	*Orthotrichum lyellii*	1) The samples were taken from 226 randomly selected points within each 1 km grid cell. An additional 52 points were plotted to help in the prediction of PAHs in moss at points along the city's edge with a 1 km extension further than the city boundary. However, 72 resamples within 100 m were taken to estimate the dataset's semivariograms and define the spatial correlation. A total of 350 samples were collected over the course of three weeks. 2) Mosses were sampled at a height of 1 m from the ground to avoid spray from vehicles on the roads.	(Jovan *et al.*, 2021)

		3) 5 g dry weight of moss were cleaned for next chemical analysis.	
Passive	NM	The samples were taken at a distance of roughly 5 metres or more from roadways and homes. The same distances were used to gather samples from adjacent parks and other green spaces. Physical impurities were carefully removed from the samples. Moss apical shoots measuring 3 to 4 cm were air-dried at room temperature under 22º C for 72 hours and then homogenised for subsequent analysis.	(Rotaru *et al.*, 2017)
Passive	*Funaria hygrometrica*	The samples were collected from diverse substrates and habitats and then packaged in aluminium foil to prevent exposure to sunlight. Before the next analysis, samples were cleansed of any physical contaminants under dry surroundings.	(Adie *et al.*, 2021)
Passive	*Hypnum cupressiforme* and *Isothedum myosuroides*	About 0.5 m2 of each species was gathered, yielding 50 and 25 g (dry weight) of I. myosuroides and H. cupressiforme, respectively.	(Foan & Simon, 2012)
Passive	*Sphagnum magellanicum*	1) The samples were pooled together from various sampling points and homogenized. 2) 0.1 g of moss was then placed in a glass vessel and mix with in situ microbes. A total of 12 vessels were incubated under a controlled chamber with 26 °C and 60% relative humidity for 120 days exposure. They were collected after 0, 30, 40, 60, and 120 days, respectively. 3) All samples were dried and passed through a 0.25-mm sieve before subjected for analysis.	(Wang *et al.*, 2018)
Passive	*Dicranum scoparium, Hylocomium splendens,* and *Racomitrium lanuginosum*	All mosses were sampled in triplicate across five different time localities.	(Martinez-Swatson *et al.*, 2020a)
Passive	*Sanionia uncinate* and *Warnstorfia sarmentosa*	The samples were obtained at various locations and intervals. These are a result of the fire catastrophe, the cleanup of debris, and environmental changes around the Brazilian Antarctic Station. The samples were kept frozen at 20 °C in metal containers for future analysis.	(Colabuono *et al.*, 2015)

Table 2: 16 EPA priority pollutant PAHs (Keith, 2015)

	Compound (IUPAC Name)	Chemical formula	Molecular weight	Structure
1	Naphthalene (Nap)	$C_{10}H_8$	128.2	
2	Acenaphthylene (Acpy)	$C_{12}H_8$	152.2	
3	Acenaphthene (Ace)	$C_{12}H_{10}$	154.2	
4	Fluorene (Flt)	$C_{13}H_{10}$	166.2	
5	Phenanthrene (Phe)	$C_{14}H_{10}$	178.2	
6	Anthracene (Ant)	$C_{14}H_{10}$	178.2	
7	Fluoranthene (Flt)	$C_{16}H_{10}$	202.3	
8	Pyrene (Pyr)	$C_{16}H_{10}$	202.3	
9	Chrysene (Chry)	$C_{18}H_{12}$	228.3	

10	Benzo(a)anthracene (BaA)	$C_{18}H_{12}$	228.3	
11	Benzo(b)fluoranthene (BbFL)	$C_{20}H_{12}$	252.3	
12	Benzo(k)fluoranthene (BkFL)	C20H12	252.3	
13	Benzo(a)pyrene (BaP)	$C_{20}H_{12}$	252.3	
14	Dibenz(ah)anthracene (DahA)	$C_{22}H_{14}$	278.4	
15	Indeno(1,2,3-cd)pyrene (InP)	$C_{22}H_{12}$	276.3	
16	Benzo(ghi)perylene (BghiP)	$C_{22}H_{12}$	276.3	

Seventeen PAHs have become a concern among health personnel due to their carcinogenic characteristics (Table 2) and are commonly found in waste sites. Besides these 17 PAHs, alkylated PAHs including 7,12-dimethylbenzo(a)anthracene; 1-methylphenanthrene; 2,3,5-trimethylnaphthalene; 1 methylnaphthalene; 2-methylnaphthalene and 2,6-dimethylnaphthalene.

Between diesel-fuel type and gasoline, the PAHs emission rate is higher from diesel compared to gasoline; however, the effects are less toxic than those emitted from gasoline type. Flt and Pyr are emitted from petrol and diesel vehicles, with additional IP from petrol vehicles and Chry, BbFL, BkFL from diesel powered vehicles. The PAH profile of diesel bus emissions has also shown a large predominance of phenanthrene and small amounts of chrysene and benzo(e)pyrene. The sum of the concentration of nine major combustions PAH (CPAH) (Flt, Pyr, BaA, Chry, B(b+k)F, BaP, BeP, InP and BghiP) in these samples (excluding BeP) accounted for 73% of the total PAH mass. The ratio of CPAH/TPAH was 0.73. The value of CPAH/TPAH ratio has been calculated for non–catalyst (0.41) and catalyst (0.51) automobiles and heavy duty diesel trucks (0.30). Higher CPAH/TPAH ratios indicate more extensive combustion activities in the city. A less efficient emission control system in the vehicle fleet may also account for this high CPAH/TPAH ratio. In India, vehicles are not equipped with a

catalytic converter. According to Rogge *et al.* (1993), non–catalyst vehicles emit 27 times more PAH, especially HMW PAH, than catalyst equipped vehicles (Rajput & Lakhani, 2010). Also, increased PAH emissions in vehicles under cold start have been observed, especially for low-speed cars (Zheng *et al.*, 2018). Valle-Hernández *et al.* (2013) reported that gasoline vehicles had emitted HMW PAHs such as BkFL, BaP, InP and BghiP during the non-Olympic summer period; the three main sources found a total of 93% of the PAHs emission along the road.

The largest PAHs fraction was 42% produced from diesel vehicles, followed by 36% from gasoline vehicles and coal combustion recorded 15% as low coal consumption produced during non-Olympic summer. Hence, the roadside site favoured the direct emissions from vehicle exhaust. Furthermore, they observed that the BaA and Chry emissions were produced by diesel emissions, while BaP was from vehicles with and without catalytic converters. Catalytic converters are used in automobiles as an emission control method to reduce toxic by-products pollutants (such as hydrocarbons, CO and NO_x) and oxidation process to less harmless substances like CO_2, water vapour and nitrogen gaseous (Xin & Pinzon, 2014). Old design cars powered by diesel and petrol with an outmoded catalytic converter produced 5-10 times higher PAH emissions than modern design cars. Soot formation is linked with the existence of hydrocarbons from most combustion processes, as hydrocarbons become a precursor for the soot particles in the atmosphere. The condensation of volatile particles could happen in the atmosphere in two ways: nucleating to form new particles or condensing on the existing particle surfaces. They first develop a coating layer on the non-volatile particles surface when precursor species condense. However, condensation of PAHs can occur several feet behind a vehicle by adsorption on existing particles, thereby allowing some mixing of exhaust plumes from different sources of pollution (Wang *et al.*, (2019). Black carbon particle results from incomplete carbon-based fuel combustion like diesel and directly contributes to global warming simply because they could absorb sunlight.

4. The fate of polyaromatic hydrocarbon

PAHs are widespread and easy to access into the environment through various pathways; hence the toxicity impacts on organisms could also happen through various actions. These compounds' fate is moderately persistent in the environment, including air, soil, water, plant, food and human.

4.1 Fate on air

The PAHs are commonly found via gaseous and particulate phases (Lammel, 2015). Air is one of the major pathways for the environmental distribution and transboundary deposition of PAHs (Hussain *et al.*, 2019). Long-range PAHs airborne transportation is deposited to the air via evaporation from the earth's surface.

The occurrence of airborne PAHs in the atmosphere as gaseous and absorbed to particulate phases depends on the molecular weight, reaction with other air components, volatility, temperature, relative humidity, precipitation and type of fine particles that exist in the atmosphere, which can influence

Table 3: Sources of PAHs

Polyaromatic hydrocarbons	Sources					
	Cigarettes/ e-cigarettes	Diesel fuels	Grilled /charred food	Petroleum products, coal tar, coal-burning	Wildfire/ agricultural smoke	Health concern(s)
Acenaphthene (Acp)	/	/	/	/	/	Irritant
Acenaphthylene (Acy)	/	/	/	/	/	-
Anthracene (Ant)	/	/	/	/	/	-
Benzo(a)anthracene (BaA)	/	/	/	/	/	Cancer risk
Benzo(a)pyrene (BaP)	/	/		/	/	Cancer risk
Benzo(e)pyrene (BeP)	/		/	/	/	-
Benzo(b)fluoranthene (BbFL)	/	/	/	/	/	Cancer risk
Benzo(j)fluoranthene (BjFL)	/	/	/	/	/	Cancer risk
Benzo(g,h,i)perylene (BghiP)	/		/	/	/	-
Benzo(k)fluoranthene (BkFL)	/	/	/	/	/	Cancer risk
Chrysene (Chry)	/	/	/	/	/	-
Dibenz(ah)anthracene (DahA)	/		/	/		Lung irritant
Fluoranthene (Flt)	/	/	/	/	/	Cancer risk
Fluorene (Flu)	/	/	/	/	/	Irritant
Naphthalene (Nap)		/	/	/	/	Irritant
Indeno(l,2,3-cd)pyrene (InP)	/	/	/	/	/	Cancer risk
Phenanthrene (Phe)	/	/	/	/	/	Irritant
Pyrene (Pyr)	/	/	/	/	/	Irritant

partitioning (Amato-Lourenco *et al.*, 2017; Ravindra *et al.*, 2008). Meteorological conditions, including wind direction, wind speed, solar radiation and temperature, influence the presence of particle number and distribution. These factors determined the particles physical and chemical modification (Dominick *et al.*, 2018).

PAHs with more than five aromatic rings are often absorbed by particles and undergo a high condensation temperature. While PAHs with 2 to 3 aromatic rings were found mainly in the gaseous phase, their dispersal globally and dominant during winter or preferential in Arctic regions (Abdel-Shafy & Mansour, 2016). The reactions of PAHs with nitrogen oxides which are simultaneously emitted, can result in the conversion of inactive PAHs to nitroarenes, compounds of potent carcinogenic activity. Photochemical reactions under ambient conditions can also form nitroarenes. Many experimental studies have shown that PAH can react readily with ozone at ambient concentrations; quinones and epoxides are possible products of such reactions. PAHs and NPAHs appeared to be coated with a single or a mixture of PAH because individual congeners are produced similarly.

Atmospheric residence time is rendered by particulate matter's dynamic behaviour (Shilla & Routh, 2018).

This residence time also is an essential parameter in discussions of the natural cycles of such compounds and is, therefore, of significant importance whenever we wish to consider the atmosphere as a link in geochemical and ecological systems. It has been established that both coarse particles (larger than 3 to 5 μm) and nuclei range particles (below 0.1 μm) are similarly limited in their atmospheric residence times and, consequently, in their effects, although their removal mechanisms are different. The removal mechanism between the coarse particles and nuclei range particles are different, but both share similar limited residence times. Nuclei range particles are formed by fossil fuel combustion, whereas coarse particles are mainly generated by mechanical wear processes such as abrasion of automobile tires, roadway asphalts, and soil resuspension. Size ranges of between 0.1 to 3 μm diffuse more slowly and are expected to stay longer in the atmospheric because they can be transported over long distances upon weather and barely removed by rainwater. Pollution survey shows the PAHs concentration differs based on seasonal variations. Their concentrations during the winter are more complex than in summer (Škrdlíková *et al.*, 2011). Contrasting with global emission scenarios and threats, PAHs concentration in the Arctic regions does not show declination trends, and PAHs are identified as chemicals of emerging concern in the Arctic (Yu *et al.*, 2019).

Moreover, snow efficiently soaks atmospheric pollutants because individual snowfall renegades are mostly dendritic snow crystals that cl together once they collide Over the past decades, studies suggested that snow and ice interact physically and chemically with the atmosphere to form a large surface area and a medium for adsorption and dissolution of pollutants and physicochemical reactions. The interaction involves the oxidation potential and gas-to-particle partitioning McNeill *et al.*, (2012). Snowpack can serve as a reaction medium and a temporary or permanent sink for air pollutants and their potential emission source (Błaś *et al.*, 2010; Nazarenko *et al.*, 2016).

Being a semi-volatile compound under atmospheric conditions allows them to move between the earth's surface in repeated temperature-driven deposition cycles and volatilisation (Igwe & Ukaogo, 2015). PAHs are persistent pollutants that are deposited at far distances from their origin and are mostly found everywhere in the environment, which are in the air, vegetation, soils, sediments, inland and seawaters (Augusto *et al.*, 2013; Edokpayi *et al.*, 2016; G. P. Vuković, 2015). PAHs are deposited into the atmosphere in two ways: natural petroleum, volcano eruptions, forest fires and erosion of ancient sediment, and anthropogenic processes.

However, PAH contamination along the roadside and industrial levels in urban areas is higher than in rural areas. Actually, they also contaminate indoor spaces without realizing the effect of PAHs. The indoor air quality is even worse and worse than outdoor air quality. Humans tend to bring outdoor pollution to their houses.

Subsequently, the presence of these organic compounds caused the droplets, rainwater or storm water to become saturated, eventually, wash away to the water bodies and land.

4.2 Fate on soil/water

Responding to low biodegradability, some PAHs are present in the environment (Olayinka *et al.*, 2018). By comparing the water residence time between LMW-PAHs and HMW-PAHs, LMW-PAHs have a shorter duration in the water column. They tend to be rapidly volatile and degraded; meanwhile, the HMW-PAHs accounted with high soluble in lipids and more hydrophobic, which makes them insoluble in the water and tend to accumulate on surfaces, settle on the sea floor, potentially enter the food chain or in non-polar matrices (X. Wang & Wang, 2006; Nasher *et al.*, 2013).

The petroleum industry has also greatly impacted many degrees of biota life in coastal waters, between pyrogenic (high temperature between 100°C and 300°C and short duration from incomplete combustion) and petrogenic (related to oil-derived samples) (Sinaei & Mashinchian, 2014). Similarly, the by-product petrogenic is closely related to oil-polluted; meanwhile, pyrogenic PAHs are characterized for samples from industrial fields. The pyrogenic hydrocarbons mainly result from maritime transportation and harbour activity. The exhaust products released from ships are composed of elemental, organic and inorganic carbon, sulphate, and ash, as well as nitrates—meanwhile, the type of fuel used by maritime transport influences the PAHs concentration produced.
The coastal environment suffered from the disposal of used lubrication oils, gas flaring, leakages from ship vessels, runoff from crude oil tanks, offshore drilling, and production operations. Though oil is a major energy source globally, it is a mixture of hydrocarbon compounds, and once they spill into the sea, they gradually mix with water or drift to the bottom and decay marine life.

Biotransformation and biodegradation by benthic organisms are why PAHs settle in sediments.

PAHs have two or more aromatic rings causing them to have a stable molecular structure. PAHs with heavier weights have lower vapour pressures, are less water-soluble, and are carcinogenic and mutagenic (Gupte *et al.*, 2016). On the other hand, PAHs with low weight are considered less carcinogenic as they are more soluble in water and remain in the gaseous

phase than heavier weight in the atmospheric particulate phase (Srivastava *et al.*, 2017). However, PAHs with low molecular weight are less persistent but much more abundant and can react with other pollutants, such as O3 and NOx, to create highly toxic nitrated and oxy-PAH compounds (Lammel, 2015).

4.3 Fate on plant/food/human

Foods like vegetation and fruit are also not excluded from being contaminated by PAHs, through the air, water, and soil from long-distance airborne transportation of contaminated particles (Adeyeye, 2019; Hamidi *et al.*, 2016; Zelinkova & Wenzl, 2015). Also, the cooking activities contribute to the exposure of food to the PAHs, which this paper does not discuss. The presence of PAHs in foods can be found in different food ranges, such as fruits and vegetables, cereal products, poultry, dairy products, oils, infant-based formulations, nuts and spices. The PAH levels found in unprocessed foods in rural areas reflect the background contamination that could originate from long-distance airborne transportation.

Compared to meat, the number of PAHs produced by fruits and vegetables is smaller because they are likely to be consumed raw and contain lower lipid content (Paris, Ledauphin, Lopez, *et al.*, 2018). Trace exposure to PAHs gets into a human via ingestion, as they are consumed in large consumption in their diet intake and uptake from the surrounding area of the crops (soils), polluted air on crops, or food processing steps. Furthermore, PAHs also naturally contaminate vegetables through gaseous deposition and emission from incomplete burning of fossil fuels to the fruits or vegetables and proximity grown nearby roadways, heavily travelled roads or in industrial areas (Abou-Arab *et al.*, 2014; Mohammad W. Ashraf *et al.*, 2013) and size of the spatial distribution pattern (Petrová *et al.*, 2017).

Daily intake consumption among nine vegetables studied in King Fahd Teaching Hospital, Saudi Arabia, revealed the potato as the primary source of PAHs exposure (0.85 µg p-1d-1), followed by carrot (58g µg p-1d-1) and cabbage (50g µg p-1d-1). Meanwhile, PAHs concentration on all vegetable parts revealed peel is contaminated more than the core. In the same study, the maximum B(a)A concentration was found in turnip cores (2.21 ±1.75 µg kg^{-1}), and the highest B(e)P concentration was found in potato (2.90 ±1.10 µg kg^{-1}) (Muhammad Waqar Ashraf & Salam, 2012). The concentrations of Shanghai green cabbage and Chinese cabbage grown near industrial areas of Shanghai detected almost 16 PAHs congeners. PAH intake via ingestion through green cabbage had the most significant contribution (6.97e14.06 ng p-1d-1) among sampled vegetables in the study (Jia *et al.*, 2018). In another study, 4.2 to 15.6 µg/kg of B(a)P was observed in kale in different locations in Western Germany, while in comparison to a different location, 0.19 to 0.34 µg B(a)P/kg was observed in wheat samples from rural area whereas, 0.72 to 3.52 µg B(a)P/kg was proximity to industrial power plants (Paris, Ledauphin, Poinot, *et al.*, 2018). Bivalves or bottom dwelling-filter feeders like oysters, mussels, and clams filter out water, and low metabolic activity allows the pollutants to concentrate within their tissues, making them reliable pollution bio-indicators. On their basis, it is possible to determine the ecological condition of the sea and its response to human activity. A high number of PAHs are bonded to particles that fall out from air deposition or mix with those on the sea floor. (Nwaichi & Ntorgbo, 2016).

Dreadful hydrocarbon pollution greatly impacts fisheries, molluscs and crustaceans subject to odour and flavour. However, this situation may suppress growth and impair reproduction. It has been discovered that exposure to PAHs occurs in fish through the food chain to fish and diffusion through gills and skin. Sediment-dwelling biota (crabs and molluscs) and bottom dwelling-filter feeders are inevitably exposed to contamination (Lamichhane *et al.*, 2016; Purcaro *et al.*, 2015). PAH is not significantly present in the marine food web because most organisms have degradative potential. The most important degradative processes for PAHs in aquatic systems are photooxidation, chemical oxidation, and biological transformation by bacteria and animals (Abdel-Shafy & Mansour, 2016).

More than hundreds of PAHs are formed; only 16 PAHs are listed in the list of priority pollutants by the U.S. Environmental Protection Agency (USEPA) in 1976 of the U.S. Clean Water Act as tabled in Table 3 (Edokpayi *et al.*, 2016; Kuppusamy *et al.*, 2017). These 16 compounds are often called parent PAHs and have become a primary environmental concern due to their persistence, the chance of exposure, ubiquitously in the environment and exert toxicity in humans and organisms and levels in the environmental samples. The UNECE Convention on Long-range Transboundary Air Pollution (LRTAP) has designated PAHs as persistent organic pollutants (POPs) based on their persistence, toxicity and anthropogenic emission. Also, in the OSPAR convention, PAHs have been added as hazardous substances (Balmer *et al.*, 2019). Most foreign and national agencies have agreed on PAHs as the most potent mutagens and carcinogenic that rapidly and widely spread in the human environment (Abdel-Shafy & Mansour, 2016; Gad & Gad, 2014).

The International Agency for Research on Cancer (IARC) classified Benzo[a]Pyrene (BaP) as one of the most carcinogenic compounds (Group 1 carcinogen) and has been extensively studied on its impact on human health (IARC, 2010b). In 2018, the European Food Safety Authority (EFSA) CONTAM agreed to conclude that BaP was not a suitable indicator for total PAHs in food contents. They decided that ΣPAH4 (benzo[a]pyrene, benz[a]anthracene, benzo[b]fluoranthene and chrysene) and ΣPAH8 (benzo[ghi] perylene, chrysene, dibenz[a,h]anthracene and indeno[1,2,3-cd]pyrene) were suitable markers to estimate PAHs contamination in food. Following the release of this EFSA opinion, Commission Regulation (EC) No 1881/2006 was substituted by Commission Regulation (EU) No835/2011 (European Commission, 2011), setting maximum limits for both benzo[a]pyrene and PAH4 (Ingenbleek *et al.*, 2019).

European Union agreed and highly recommends that PAHs exposure in food products be extensively studied in a wide range of food matrices. Based on the discussion above, it can be summarised that the more significant contributor for PAHs is greatly influenced by cooking temperature, method, and type of fuel or oil used for cooking and storage. Other routes to get to food are air, soil, and water. The emission rate for BaP emitted by cooking was significantly higher than those emitted from traffic sources, accounting for 675 kg/year and 61.4 kg/year. This was mainly attributed to cooking may release and regard as a significant source of PAHs more than traffic from carcinogenic potency (Abdullahi *et al.*, 2013).

Studies showed that the mechanism of harmful actions is closely associated with the function of membrane fluidity

(cellular membrane) and enzyme systems. Because of this, PAHs serve as potent immune suppressants and are confirmed as carcinogenic and mutagenic to all organisms. According to Gupte *et al.* (2016), several aspects also influence the rapidness of toxicity mechanisms, such as chemical oxidation, microbial degradation, visualisation, water and lipid solubility, sorption and atmospheric photolysis. The ability of PAHs to bind with DNA and proteins leads to carcinogenesis and mutation effects. Studies have shown evidence between PAH-DNA adduct covalently bond in PAH doses and different organs (Ewa & Danuta, 2017). The quick absorption of PAHs by aquatic organisms is because of their high lipophilicity and low water solubility. Along with the increase in molecular weight, the PAHs vapour pressure and water solubility continue to decline, and lipophilicity increases, making the PAHs structure more recalcitrant.

This is because pyrogenic sources produce more thermodynamic stable and noxious PAHs than petrogenic sources. For example, when benzo[a]pyrene undergoes photolysis. An increase in hydrophobicity endows these chemicals with high octanol: water partition coefficients (k_{ow}), as a result of which they tend to adsorb to soil organic matter, are less bioavailable and therefore are not easily degraded, giving rise to greater persistence in soil; thus it becomes naturally recalcitrant in soil (Okere, 2011).

Furthermore, all household activities elevate indoor pollution through cooking (frying, heating, and roasting in particular), cleaning products, fuel-burning combustion appliances, tobacco products and heating, cooling, or humidification devices. Other factors that contribute to the arose of nitrogen dioxide, carbon monoxide and fine particles from poorly installed wood-burning or gas. The EPA reported that indoor air pollutants could reach up to 2 to 5 times and occasionally become 100 times worse than outdoor levels (Van Tran *et al.*, 2020). To put it another way, the air quality inside can be more toxic than the air from outside. After such activities, pollutant concentrations can persist in the air for a long time. Indoor air pollution is synonymous with cooking and heating, as mentioned before. The widespread ability of PAHs to transport long distances and their presence influence their occurrence in foods depending on their physical and chemical properties.

The significant pathways for PAHs entry into plants are through plant roots (Bisht *et al.*, 2015; Kang *et al.*, 2010). In addition, surface absorption of volatile PAHs from the air can be regarded as another pathway concentrated into leaves through a wet and dry particle-bound deposition. These pollutants move through the cuticle and adsorb to plant cell walls. The influencing factors in retaining PAHs depend on leaf morphology (species, leaf, branch) and the abundance of stomata, trichomes, and cuticular wax. Studies showed that the coated wax on leaf surfaces and stomata aids plants in battling dust and airborne elements attached to or trapped in (Muhammad Waqar Ashraf & Salam, 2012; Liang *et al.*, 2017). Although PAHs accumulate mainly on the products surface, due to their lipophilic nature, some diffusion can occur to inner layers (Alagić *et al.*, 2015), where water activity and fat content have a determinant role in migration rate (Gomes *et al.*, 2013).

The aquatic environment often represents a particulate matter sink, receiving and accumulating; only approximately 33% are in dissolved form (Baali & Yahyaoui, 2020). As for marine organisms, they are intoxicated by PAHs from both point sources, such as direct discharge from waste and oil spills, and non-point sources, such as runoff from various land type usage and atmospheric deposition.

The most abundant environmental PAHs are low molecular weight even though they show less carcinogenic and mutagenic properties and become more toxic when they react with other pollutants (Barrán-Berdón *et al.*, 2012; Jamhari *et al.*, 2014). The LMW-PAHs existence in the environment samples emerges as petrogenic pollution, direct input from petroleum or its product, such as naphthalene, fluorine and acenaphthene. In contrast, the HMW-PAHs such as benzo[a]pyrene, benzo[a]anthracene, chrysene, and dibenzo[a,h] have high carcinogenic properties, which indicate pyrogenic sources and fewer LMW PAHs implies pyrolytic sources (Jamhari *et al.*, 2014; Lias *et al.*, 2014). The occurrence and biological activity of the large PAHs seem to be a continuation of the small PAHs. They are mostly present as combustion products but at lower levels than the small PAHs because of the kinetic limitation of their formation through the addition of successive rings. Specifically, the more isomers possible for larger PAHs, the lower the occurrence of specific structures. Naphthalene, consisting of two coplanar six-membered rings sharing an edge, is another aromatic hydrocarbon. It is not a true PAH by formal convention, though it is referred to as a bicyclic aromatic hydrocarbon (Malhat *et al.*, 2019). HMW-PAHs, due to their low vapour pressure, become resistant to surface to air exchange after deposition (Majumdar *et al.*, 2017).

5 Analysis of polyaromatic hydrocarbon from mosses

5.1 Moss sampling preparation and storage

Sample preparation may target the matrix of the sample, the analytes, or both. As general rules, there are general protocols involved for analysing organic pollutants in biological and environmental. Ambient air is sampled by collecting suspended particulate matter on glass-fibre, polytetrafluoroethylene, or quartz-fibre filters employing high-volume or passive samplers. Filters may not retain most PAH as they are volatile. Thus, they are commonly trapped by adsorption on polyurethane foam. Despite these filter instrumental methods, ambient PAH also can be trapped using green solutions; leaves have been widely used in biomonitoring studies. Concha-Graña *et al.* (2015) collected *Pseudoscleropodium purum* from unpolluted wood in Galicia (NW Spain) away from urban and industrial areas and cleansed using bidistilled water before being oven-dried at 45°C and ground it into a homogenous powder in a mill. *Pleurozium schreberi* was collected from a forest 10 to 100 meters from the southern roadside. Next, the samples were wrapped in aluminium foil, labelled, and transported in a cool box. Samples were frozen at -26°C in the lab. During the hand-cleaning process, only 2.5 year old green parts were chosen as a bio-monitor for the study in accordance with the protocol established by the UNECE ICP Vegetation International. Sucharová & Holá, (2014b) used two drying processes for the samples: half was air-dried in between filter paper sheets at ambient temperature up to 25°C, and the other half used a freeze dryer for 17 hours. The grounding processes were carried out in a rotor-speed grinder and vibratory ball micro grinder. Moss samples *Hypnum plumaeforme,* widespread distribution in urban areas. Only the green and brown-green tips of moss samples were collected for subsequent analysis. Plant samples were wrapped in aluminium foil, air-dried at ambient temperature, and stored in paper and sealed polyethylene bags in the dark at room

temperature until PAH analysis. To obtain a number of large samples, moss samples from multiple locations were combined for the next procedure (Concha-Graña *et al.*, 2015; Sucharová & Holá, 2014b)

To ensure sampling activity complies with the requirement of the scope of study while acknowledging the operational and economic constraints, Fernández *et al.* (2015) classified sampling types for mosses based on their research aims: (1) to characterize pollution derived from focal sites of emission (i.e., industrial facilities, mining areas, etc.); and (2) to characterize pollution distribution in a wide area (i.e., at regional, national or transnational levels). For aim (1), by following a logarithmic grid, moss samples are gathered around the focal site, and the number of sampling sites is reduced as the distance from the source increases. The extent of the pollution-affected area will determine the number of sampling sites. According to Fernández *et al.* (2015), mosses sampling is recommended to be carried out from 20 sampling sites for road and industrial areas and 20 - 49 sampling sites for urban areas within 6 to 40 km in the circumference of the focal site. For aim (2), various studies proposed cost effective sampling grid approaches such as follows: (a) 30 × 30 km sampling grid (Boquete *et al.*, 2009); (b) 25 × 25 km sampling grids (Pesch *et al.*, 2008); and (c) 32 × 32 km sampling grids Ferna'ndez *et al.* (2007). Hence, this manuscript suggests that the sampling grids between 25 x 25 km until 32 km x 32 km would be the cost-effective range of the sampling grid without compromising the sample representativeness. This range is equivalent to sampling 1 site/1000 km2 to 4 sites/1000 km2.

5.2 Analysis of polyaromatic hydrocarbons in mosses

The solvent selection is crucial for solvent extraction to ensure the excellent separation between samples and desired analytes. According to the theory of miscible and intermiscibility, "like dissolves like", the more similar polarity of the solvent to the solute will perform better extraction (Zhang *et al.*, 2018). A compound that separates solid materials into liquid form is called solid-liquid extraction, while liquid removal to another liquid is called liquid-liquid extraction. Several aspects must be considered when selecting solvents based on selectivity, solubility, safety, and cost. The selected solvent must have high extraction capacity, be safe to use, non-explosive, and offer low-price options. In addition, as much as possible, the solvent must not react chemically with the sample extract, low viscosity, high recovery, and low temperature to avoid degradation to the sample. The high temperature rapidly causes the loss of solvent and causes impurities in the matrices. For plant matrices extraction, the plant type, the part of the plant to extract, and the nature of bioactive compounds must also be highlighted (Altemimi *et al.*, 2017). The successful and effective extraction depends on the particle size of sample matrices, ease, and high penetration of solvents to the sample (Tzanova *et al.*, 2020). The extraction efficiency and quality depend on the period consumed in the extraction process. However, a more extended period will not affect the extraction after the solute equilibrium is reached inside and outside the solid material. The greater the solvent-to-solid ratio is, the higher the extraction yield is; however, a solvent-to-solid ratio that is too high will cause excessive extraction solvent and requires a long time for concentration (Zhang *et al.*, 2018). They mentioned in phytochemical studies that alcohols (EtOH and MeOH) are the most used solvents in the extraction process (Zhang *et al.*, 2018).

5.2.1 Extraction of polyaromatic hydrocarbon

Extraction is the prime step for accurate identification and subsequent analysis of atmospheric PAHs in the environment.

5.2.2 Solvents of extraction

Different solvents have different applications; polar solvents meet polar compounds, while nonpolar solvents meet nonpolar compounds. To begin with any extraction process, solvent selectivity is among the vital key in terms of volatility, cost, efficiency and environmental health impact (Płotka-Wasylka *et al.*, 2017). rephrase methanol, ethanol, acetonitrile, acetone, dichloromethane, toluene, cyclohexane and n-hexane (Abubakar & Haque, 2020).

5.2.3 Extraction method

Soxhlet extraction and ultrasonication are the two most prevalent traditional extraction techniques. Other alternative extraction methods, such as Pressurized Liquid Extraction (PLE) or Accelerated Solvent Extraction (ASE), Microwave-Assisted Extraction (MAE), Membrane Assisted Solvent Extraction (MASE), extraction methods that use liquid water as the extractant, such as Pressurized hot water extraction (PHWE), and Supercritical fluid extraction (SFE), which uses supercritical fluids as the extracting solvent, are also utilized. Different extraction methods use various organic solvents to improve extraction yield (Frantz *et al.*, 2015; Mukhopadhyay *et al.*, 2020; Yamaguchi & Lee, 2010). Modified extraction techniques with low or no solvent consumption have also been developed for improved extraction efficiency. More details on the method of extraction are shown in Table 4.

5.2.4 Analysis of the distribution of polyaromatic hydrocarbon in mosses

One of the difficulties associated with detecting PAHs in environmental samples is the complexity of the PAH mixture in these samples. Even after a thorough cleaning, trim levels of PAHs and hundreds of other compounds may still be present. Analytical procedures with strong chromatographic resolving power and detector selectivity are typically required to assess specific chemicals in such combinations. The three-step basic process for the analysis and PAHs determination in environmental samples are as follows (Guimarães *et al.*, 2013): (1) extraction and isolation from the sample matrices; (2) clean-up and a fraction of the PAHs mixtures into subgroups or layers to purify the samples; and (3) identification and quantitative determination of the individual components in each of these subgroups or layers. There have been a variety of analytical methods used to determine trace amounts of PAHs in environmental samples over the years, including gas chromatography (GC) and high-performance liquid chromatography (HPLC) equipped with various types of detectors, as well as thin-layer chromatography (TLC) equipped with fluorimetric detectors (Adeniji *et al.*, 2018). The most common analytical procedures for measuring PAH concentrations in environmental samples are GC/MS and HPLC with UV or spectrofluorimetric detectors. GC is one of the earliest chromatographic separation techniques to be invented and has retained its significance. The popularity of gas chromatography is due to a desirable combination of very high selectivity and resolution, good accuracy and precision, a wide dynamic concentration range, and high sensitivity. The gas chromatograph-mass spectrometer (GC-MS) is a powerful tool

Table 4: Method of extractions

Sample preparation	Sample weight	Extract method & description	Solvent information	Evaporation after extraction	Reference
NM	NM	Falc Sonicator: Twice	25 mL of dichloromethane, each for 20 minutes.	Nitrogen used to remove solvent	Capozzi *et al.*, (2017)
NM	NM	Matrix solid phase dispersion: C_{18} (octadecyl functionalized silica Supelclean-Envi 18 and hexane	Dichloromethane:hexane (20:80)	NM	Carrieri *et al.*, 2021
1) The homogenized samples were dried for 48 hours under 40 ˚C 2) The samples were kept in glass vials in the dark and at room temperature.	NM	FexIKA® vario control extractor: 5 hours	Hexane:dichloromethane (1:1)	NM	Ciesielczuk *et al.*, (2012)
The samples were stored at 20°C until drying, homogenisation and further analysis.	3g of moss	Soxhlet extraction	Acetone	Shaken out with n,n-dimethylformic amide and cyclohexane.	Dreyer *et al.*, 2018
The homogenized samples were dried at 40 °C to a constant weight.	0.5 g	Ultrasonic bath	Dichloromethane	1) Nitrogen used to remove solvent. 2) Evaporate to dryness at a temperature of water bath of 30±5°C	Hajiyeva *et al.*, 2017
NM	0.38–1.64 g	Pressurized liquid extraction	N-pentane:dichloromethane (90:10), Program: pressure 1,500 psi, preheat time of 2 min, static time of 5 min, 70% flush volume, 60 s purge time, 2 static cycles, 100°C	1) Evaporated to less than 5 mL. 2) The samples were reconstituted to 5 mL with n- pentane: dichloromethane (90:10) after 8µg ml^{-1} of recovery standard mix.	(Martinez-Swatson *et al.*, 2020b)
1) The samples were dried in an oven 40 ◦C. 2) The samples were kept in PE bags at 4 ◦C until analysis.	NM	Sonication-assisted solvent extraction (DSASE)	Dichloromethane: hexane (6:4)	Concentrated under a nitrogen stream to 0.5 mL from 2 mL.	Domeño *et al.*, 2012
The samples were dried using	1.5 g	Pressurized liquid extraction	Acetonitrile, cyclohexane,	1) Concentrated	Foan & Simon, (2012)

freeze dryer and homogenized using stainless steel mill.		(PLE) and Soxtec extraction followed by solid-phase extraction (SPE)	dichloromethane (DCM) and n-hexane	under a nitrogen stream to 0.1 mL. 2) 1 mL of ACN was added before filtered with PTFE syringe filters (I.D. 13 mm, 45 µm)	
NM	5 g	Accelerated Solvent Extraction (ASE)	Dichloromethane: acetone (1:1)	Concentrated under air stream and added 1 mL of ACN	Godzik *et al.*, 2014
The samples were air-dried for 72 hours at room temperature of 22° C and homogenized afterward.	3 g	Ultrasonic bath	n-hexane: dichloromethane (1:1)	The extracts were left evaporated for 24 hours until concentrated to 1 mL.	A.-M. Rotaru *et al.*, (2017)
The samples were air-dried at room temperature and kept in the dark room.	3.1 g	Soxhlet extraction	Toluene	NM	Oishi, 2013
The samples were oven-dried at 45 °C and homogenized afterward.	0.5 g	Syncore Analyst evaporator	Hexane: acetone (90:10)	Concentrated in the Syncore to 0.3 mL and 1 mL of hexane was added.	Concha-Graña, Piñeiro-Iglesias, *et al.*, 2015

Table 4.1: Method of detections

Equipment	Preparation	Column (Length x inner diameter x film thickness)	Flow/ Gas	Program	Injection/ Mode	Internal Standard (IS)	Reference
GC/HRMS	The homogenized samples were extracted with Soxhlet and purified with alkaline silica gel.	HP-5 capillary Size: 30 m x 0.25 mm x 0.25 µm	NM	1) Started at 50˚C for 1 min; 2) increased by 14˚C min^{-1} to 220˚C; 3) increased by 7˚C min^{-1} to 300˚C; 4) held for 40 min at 300˚C.	Splitless/SIM	NM	Oishi, 2013
PTV-GC-EI-MS-MS	1) The extracts were eluted with hexane: mix of hexane/dichloromethane (10:20:80) using a Visiprep	DB-XLB Size: 60 m×0.25 mm, 0.25 µm	NM	NM	NM	Anthracene D10	Vingiani *et al.*, 2015

	vacuum. 2) 20 µL of internal standard was added into the eluate after concentrated with Syncore.						
GC-MS	1) The extracts were concentrated to 4 mL with a rotary evaporator and dried under a gentle nitrogen stream. 2) The samples were added with 0.4 mL of mixture of ISs.	HP-5MS Size: 30m x 0.25mm x 0.25µm	1.11 mL min^{-1}, Helium	1) Started with 70℃; 2) up by 20℃ min^{-1} to 280℃; 3) held for 24min	SIM	Acenaphthylene D8, fluoranthene D10, benzo(k) fluoranthene D12, benzo(g,h,i) perylene D12	De Nicola *et al.*, 2013
GC	1) The samples were subjected to cleaned up using gel permeation chromatography (GPC). 2) Dried under gentle nitrogen stream. 3) Eluted with 10 mL of cyclohexane: ethylacetate (1:1). 4) Cleaned up to 5 mL by GPC and concentrated using rotary evaporator to 0.5 mL. 5) Cleaned up through adsorption chromatography (AC) with silica gel using mixture of petrolether and dichloromethane (4:1). 6) The eluates were mixed with propan-2-ol before final purification on a SephadexÒ LH-20 column and concentrated again under nitrogen stream. 7) Dissolved in 0.5 mL cyclohexane.	HP-5MS Size: 30 m x 0.25 mm x 0.25 µm fused-silica capillary column.	1 mL min^{-1}, ultra-pure Helium	1) Started at 90 °C for 4 min; 2) increased to 100 °C at a rate of 10 °C min^{-1}; 3) raised to 290 °C by 3 °C min^{-1}; 4) held at 290 °C for 22 min.	SIM	Deuterated acenaphthene, benzo(a) pyrene, and phenanthrene	Rodriguez *et al.*, 2010
GCeMSD	1) The extracts were purified through activated silica gel; 2) Dried under a nitrogen stream to 200 mL.	VF-17MS column	1.3 mL min^{-1}, Helium	1) Started at 50 °C; 2) ramped to 30 °C by min^{-1}; 3) raised to 350 °C; 4) held for 9 min.	SIM	Naphthalene D8, acenaphthene D10, phenanthrene D10, chrysene D12, and perylene D12	Capozzi *et al.*, 2017

GC with masses the selection detector (MSD)	1) The extracts were concentrated with a rotary evaporator at a water bath temperature of 30±5°C to 2 mL. 2) Dried under a gentle nitrogen stream to 1 mL before injected to samplers.	Column ZB Size: 60 m x 0.25 mm x 0.25 µm.	Flow rate: NM Helium	NM	SCAN	NM	Hajiyeva *et al.*, 2017
GC equipped with a triple quadrupole MS detector	The samples were extracted with 10 mL of methanol for 24 hours via lab shaker.	SCION 5 MS Size: 30 m × 0.25 mm × 0.25 µm	2 mL min^{-1}, Helium 5.0	1) Started at 70 ˚C, 2) raised 200 ◦C by 15 ˚C min^{-1}; 3) held for 5 min; 4) raised to 320 ˚C by 8 ˚C min^{-1}, 5) kept for 5 min.	NA	Naphthalene D8, phenanthrene D10, chrysene D12 and perylene D12	Świsłowski *et al.*, 2021
GC-MS	1) After sonicated for 4 hours with 3 x 40 mL of dichloromethane, the extracts then were concentrated to 1 mL using rotary evaporator. 2) Purified with concentrated tetraoxosulphate (VI) acid: silica gel (1:8). 3) The extracts were firstly eluted with 100 mL of hexane followed by 200 mL of dichloromethane.	Column coated with 10 µm porous silica with C_8-bonded Size: 15 cm x 4.6 mm	1.5 mL^{-1}, Purified helium	NM	Splitless mode	NM	Adie *et al.*, 2021
Trace GC Temperature vaporization-gas chromatography-tandem mass spectrometry	The homogenized dried samples were kept for storage in glass vials in the dark under room temperature before analysis.	DB-XLB column Size: 60 m x 0.25 mm x 0.25 µm	1 ml min^{-1}, Helium	1) Started at 50 ˚C and held for 3 min; 2) raised by 4 ˚C min^{-1} to 325 ˚C and held for 20 min		Dibenz(a,h)anthracene D14 (for Dibenz(a,h)anthracene, Indeno(1,2,3-cd)pyrene, and Benzo(ghi)perylene) and anthracene D10 (for the other PAHs)	Carrieri *et al.*, 2021
APGC-Q-TOF-MS	1) The 2 mL extracts were purified with SPE filled with dichloromethane: hexane (6:3). 2) The extracts were then eluted with a mixture of hexane:	HP-5MS Size: 30 m x 0.25 x 0.25 µm	1 mL $^{-1}$, Helium	1) Started at 50 ˚C and held for 2 min; 2) raised to 280 ˚C by 10 ˚C min^{-1}; 3) held for 12 min.	APGC	1-nitronaphthlene, 2-nitrofluorene, 1,5-	Domeño *et al.*, 2012

	dichloromethane (65:35).					dinitronaphthalene, 2-methyl-1-nitronaphthalene, 6-nitopyrene and 2-nitrofluoranthe and acenaphthene D10.	
GC-MS	The samples were cleaned up with activated silica.	HP-5 Size: 60 m x 0.25 mm x 0.25 µm	1.1 ml min^{-1}.	1) Started at 40°C and held for 2 min, 2) raised to 315°C by 5°C min^{-1} and held for 14 min.	SIM	NM	Martinez-Swatson *et al.*, 2020a
Trace GC chromatograph equipped with a GC Combi-PAL autosampler	20 mL of internal standard was added into 1 mL filled up with Hexane.	DB-XLB column Size: 60 m x 0.25 mm x 0.25 µm	1 ml min^{-1}, Helium	1) Started at 50 ˚C, held for 3 min; 2) increased to 325 ˚C, and held for 20 min.	NM	Anthracene D10	Concha-Graña, Muniategui-Lorenzo, *et al.*, 2015
Gas chromatography – tandem mass spectrometry	1) The samples were extracted with an ultrasonic clearner for 15 min and Soxhlet for 24 hours. 2) Both extracts later were concentrated using rotary evaporator to 5 mL; 3) 1 mL of filtrate and 10 µL of internal standard were subjected for analysis.	AB-5MS Size: 30 m × 0.25 mm × 0.25 µm	1.0 mL min^{-1}, Helium	1) Started at 70°C, a ramp and hold for 20 min; 2) increased to 300°C at 10°C min^{-1}; 3) kept for 7 min.	Splitless	Naphthalene D8, acenaphthene D10, phenanthrene D10, chrysene D12, and perylene D12.	(R. Wu *et al.*, 2017)
HPLC	1) 1 mL of acetonitrile was added into 0.1 mL of concentrated extracts. 2) The solvent was reconstituted by 80 ng of internal standard FTN d_{10}.	1) LC-PAH C18 column (particle size 5 µm) Size: 250 mm x 4.6mm Supelcosil™ Size: 20 mm x 4.6 mm precolumn (particle size	1.5 mL min^{-1}	1) 60% acetonitrile (ACN) at was maintained for 5 min; 2) linear ramped to 100% ACN by 25 min; 3)10min plateau at 100% ACN.	Selected fluorescence wavelengths	Anthracene D10 and Benzo(a) pyrene D12	Foan & Simon, 2012

		5µm)					
HPLC	The solvent after clean-up through semipermeable membranes for times was concentrated and re-dissolved in 1 mL acetonitrile.	Vydac 201TP5415 column	1 mL min^{-1},	Mobile phases were acetonitrile (ACN) and water. The gradient was 50-100% of ACN for 45 min.	CR104-100 (Certified reference material) was used to control the quantitative analysis.	NM	(Godzik *et al.*, 2014)

for detecting air, water, and soil (Fair *et al.*, 2010). It is beneficial for quantifying volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), organochlorinated pesticides, brominated flame retardants and polycyclic aromatic hydrocarbons (PAHs). More details on the method of detections are shown at Table 4.1.

6. Current works worldwide

Air pollution remains one of the world's most severe human threats and urban environmental issues. The World Health Organization highlighted that more than 91% of city dwellers deal with low air quality exceeding recommended limits. Rapid industrialization and urbanization in most developing countries significantly impact the increased emissions of air pollutants. The deposited particle-bound polycyclic aromatic hydrocarbons (PAHs) impose human health risk factors for diseases like skin, heart attack, lung cancer, and reproductive, respiratory, cardiovascular and cardiopulmonary system. Effective long-term air pollution mitigation solutions must be designed and executed to address these issues. Moss is an excellent alternative for addressing air quality issues because of its pollution-removing properties and its robust capacity to tolerate all kinds of temporal conditions and low maintenance requirements. Few actions have been taken to elevate mosses as an advanced tool for atmospheric biomonitoring. Even though moss cannot measure air pollution, it has the potential to be a useful screening tool. It could aid in identifying the most polluted areas, from which a government monitor could assess the severity of the problem.

6.1 The citytree by green city solutions, Germany

The CityTree technology is developed by Green City Solutions in Germany using various plants, including mosses and lichen, like natural air filters against harmful air pollutants (CITYTREE, 2019). According to the company's four co-founders, the idea is to choose species with a giant leaf surface area, allowing plants to absorb more toxins faster. A co-founder of Green City Solutions says moss is ideally suited to capture more pollutants because the leaf surface is substantially more prominent than any other plant (Tristan, 2017). He continues that the sensors are embedded within the structure to check its efficacy in filtering the air. Data collection, analyses and visualisation are the three main features of the CityTree. The developed technology is suggested as the world's first intelligent living air filter. The company focused on air quality challenges, particularly in an urban area that has worsened dramatically. They combine embedded mosses vertically on a wall with Internet-of-Things (IoT) technology and are engineered with an automatic water supply system to maintain the moisture and nutrients required for plant growth. The wall is a convenient, recyclable, living, breathing air filter that can be placed in cities to measure the level and types of pollution while actively clearing the air using a selected combination of plants that operate as effectively as a small forest. The goal of having CityTree as public furniture is to make it look like an urban forest (Chris, 2017). This public furniture structure is tailored to suit urban settings where mosses can hardly survive because of the lack of consistent moisture and shade (urbanNext, 2018). Incorporated into the structure are an irrigation water system that collects rainwater and pumps it into the soil and solar panels designed to generate electricity for the structure. Besides water, the irrigation system also alleviates the urban heat island effect by creating a cooling effect in response to its surroundings. By reducing particulate matter, nitrogen dioxide, and ozone profile at 240 tonnes per year, each CityTree is beneficial in pollution hotspots and locations where people spend much time. The system's performance and efficiency, the quality of air, as well as its health requirement for mosses (such as temperature, water quality and soil humidity) are monitored and analysed remotely (IMNOVATION, 2021). The remote technology merges the moss purifying factor with improving airflow through the moss. With this, cleaner air and high moisture content can be achieved. Hence filtration could happen increasingly varies on levels of pollution at different times of the day. It is shown that the structure is easily measurable. CityTree is a revolutionary technology that cleans the air 275 times better than a single tree while taking up only 1% of the space that real trees do (Kfw, 2021). Besides serving as an outdoor air purifier, CityTree also gives digital and visual information using technologies such as Wi-Fi, NFC and digital screens. CityTrees have already been installed in 50 locations worldwide, including Germany, the UK, Norway, Belgium, France, Macedonia and even Hong Kong (PSO, 2019). In 2020, the EU-sponsored Green City Solutions project placed 15 more at polluting hotspots across Berlin.

The company's objective is to integrate its technology into the construction of buildings all over the world. According to independent research, the moss filters 82% of fine dust in the air and cools the air by 2.5°C. The reduced fine particulate pollution of up to 53% was removed significantly in its place nearby. Every hour, the CityTree filters 3500 m^3 of air, equivalent to the breathing volume of around 7000 individuals (CITYTREE, 2019). The CityTree does not need daily manual watering as it already has an installed irrigation system. To some extent, Citytrees can be adjusted. They can be purchased with or without an attached bench and with or without vandalism protection.

1. London Borough of Wandsworth (CITYTREE, 2019). After ten weeks of installation, the CityTree has successfully filtered 1.3 million m3 of air and 65 grams of PM0.1 (ultrafine particles). These pollutant amounts were 14400 kilometres from mobile exhaust emissions, and 5400 burned smoke cigarettes.
2. Berlin (CITYTREE, 2019). After a year of installation, the CityTree has successfully filtered 6.3 million m^3 of air and 46.5 grams of PM0.1 (ultrafine particles). These pollutant amounts were 1.435 kilometres from mobile exhaust emissions, and 3.874 burned smoke cigarettes.
3. The Klima Pavilion, Hammersmith, Hampstead Hill Pre-Preparatory and Nursery School, and Berlin Charlottenburg are among the other pollution hotspots that feature the CityTree (CITYTREE, 2019).

6.2 MOSSpheres by MOSSclone Research Consortium

A new biotechnological tool keeps the moss inside the device and is placed at desired pollution hotspots as passive pollutant sensors. This project is a collaboration between partners from 5 universities, 5 SMEs in 5 EU countries (Germany, France, Ireland, Italy and Spain) sponsored by the European Union in the Seventh Programme (FP7) for "Eco-Innovation!" (Christian, 2015). The idea is to cultivate the moss clone in a controlled environment free of pollution, fungi, and bacteria

(Tepzz *et al.*, 2016). An axenic devitalized moss clone is used in the passive contaminant sensor devices of the present invention. As used here, the term axenic describes a state of a culture in which only one species, variety, or strain of organism is present, and all other contaminating organisms are absent. The moss must be treated to stop its metabolic activity, guaranteeing that the moss metabolism has no devitalizing effect. Following devitalization, freezing the moss's chemical composition and characteristics are required. To ensure that all plants have the same character and identity, they are all grown from the exact moss clone. Thus, it is crucial to ensure that the first grown are pollution-free (Christian, 2015). The device is called a moss bag or MOSSpheres, in a spherical shape. Mosses are heated to nearly 120°C and inactivated before being put into the ball (Tepzz *et al.*, 2016). Large contaminants have collected on the moss surfaces, they discovered. It demonstrated that pollution accumulation occurs whether they are alive or not. The upscaling of moss clones was carried out in massive bioreactors owned by Bovia, a Spanish company. The concept of the moss bag began with simple tea bags, upgraded in size and geometry optimized MOSSpheres (Christian, 2015). The moss-bag technique was developed to address one of the most common issues in biomonitoring surveys: a shortage of native moss material, particularly in places with poor environmental states (in this case, because there is a high level of air pollution). The moss bags are made of mosses, a substance that traps or accumulates air pollutants, and are sealed in a container format that protects the moss from vandalism, leaching, or being blown away on a suitable carrier. It could take a net shape with a precise mesh size that allows pollution molecules to pass through while larger particles are retained. The accumulation kinetics are influenced by the density of material inside the bag, the ratio between the outside surface and substance mass, and the surface exposed for rain interception. The European Patent Office already patents the design.

7. Current works in Malaysia

In Malaysia, awareness of moss species is minimal, and the hidden treasures receive little attention. Studies on moss biomonitoring of ambient air have tended to focus on metals and rarely on PAHs. Researchers in Malaysia should broaden studies on PAHs if different varieties of moss are available. Local mosses are employed as a bio-indicator for air quality monitoring since they can offer results suited to our local environment.

8. Conclusion

In conclusion, this review highlights the use of mosses to measure polycyclic aromatic hydrocarbons (PAHs) in the environment and presents useful analytical procedures for analysing PAHs in moss samples. Many studies have proven that mosses are powerful tools for monitoring PAHs in the atmosphere. PAH in the atmosphere is predominantly of anthropogenic origin. Once the major atmospheric sources of PAH have been identified, a number of other variables must also be considered. Combustion conditions, fuel composition, geographical location, climate and emission rates affect PAH concentrations in the atmosphere. Trends in the atmospheric levels of the various PAH compounds have been observed both in the long and short term. After PAH compounds are released into the atmosphere, they undergo various processes, namely removal, transport and degradation (reaction). The degradation of PAH can produce compounds which can be more or less mutagenic and carcinogenic than the parent PAH. A method for biomonitoring air quality in environments can be proposed based on the following steps: (1) Selection of the monitoring sites as a function of pollution grade, (2) Selection of plant species considering both availability of different species and capability of discriminate and bioaccumulate the pollutants of interest and (3) Sampling and analysis.

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Conflict of interest statement

We declare no conflict of interest.

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HALALSPHERE
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The Benefits, Challenges, and Opportunities of *Halal* Gastronomy Tourism – A Review Perspective

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Abstract

This paper examines the benefits, challenges and opportunities of *Halal* gastronomy tourism in tourist countries. The outcomes are intended to ensure the aspect and effectiveness of promoting *Halal* gastronomy tourism in the destination benefiting the national economy. Secondary approaches such as journals, websites, and books have been used for this research to gather the data. Reviewing and comparing articles on *Halal* gastronomy in a certain country to determine the benefits, challenges and opportunities of gastronomy at the selected destination. The results showed that promoting *Halal* gastronomy tourism can increase the country's income and give a positive impression among travellers, especially among *Muslim* travellers. Moreover, promoting *Halal* gastronomy tourism in a particular destination helps honour the culture and heritage of the designated destination. To explain, a destination's culture can be introduced to other tourists by promoting local food with *Halal* ingredients for *Muslim* travellers.

1. Introduction

The word gastro is derived from the Greek words "gastros", which means stomach, and "gnomos", which means science or law (Amelda *et al.*, 2022). Gastronomy discusses the relationship between cultures regarding the enjoyment of food and drinks in an area. It studies the various cultural components through the lens of the culinary centre. Gastronomy explains food and beverages in physiological studies. It examines it from a regional culinary perspective as a cultural aspect and an asset for the region in promoting the tourism industry, increasing regional income, and improving people's welfare. In detail, gastronomy focuses more on appetisers and desserts than on these delicacies' history, origin, and raw materials.

Gastronomy is crucial in boosting the area's tourist attraction, increasing the number of tourists, improving the tourist experience, strengthening regional identity, and stimulating the growth of other sectors. Gastronomic tourism can be characterised as follows: gastronomy as an element and indicator of globalisation; tourists play a role in the evolution of gastronomy; tourism is a contributor to developing or renewing national identity; gastronomic tourism is a means of introducing culinary products as cultural products; the expansion of gastronomic tourism provides a direction for tourism development; gastronomy as a constructive element in the formation of an image in tourist destinations, as a tourist travel destination, as an element of heritage with a tourism dimension (Sufa *et al.*, 2020; Pramezwary *et al.*, 2021).

Tourism has become one of the most significant contributors to a country's gross domestic product in every nation as it continues to expand. Natural traits, such as natural resources, culture and heritage, and landscapes, are the most enticing features of a particular destination. People travel to experience a new environment they cannot find in their usual environment. For example, they may be travelling to a country with four seasons or experiencing a new culture, language, and food of one country. According to research by Mastercard & Crescent Rating (2019), by 2026, more than 230 million *Muslim* tourists will travel domestically and internationally. Moreover, it is anticipated that *Muslim* travellers will inject $300 billion into the global economy. Worldwide travel is likely to be enjoyable and comfortable for *Muslim* travellers.

Halal cuisine has been introduced to the tourism industry to meet the needs of *Muslim* travellers from around the globe. Based on Kivela & Crotts (2015), gastronomy is sometimes referred preparing tasty food. Other research also stated that gastronomy measures the relationship between culture and food. Moreover, the term refers to a person who is profoundly interested in gastronomy and enjoys flavouring, preparing, conducting experiments, exploring, researching, recognising, and publishing food.

The aim of this study is to explore and review the benefits, opportunities, and challenges of *Halal* gastronomy tourism in tourist countries. A few aspects have been highlighted to enhance the view of gastronomy tourism.

2. Enhancement of *Halal* gastronomy

Malaysia was the first nation with a *Muslim* majority to introduce the *Halal* sector as a possible driver of economic development in the country's industry and tourism. For example, its local cuisine is vital in promoting tourist destinations, products, and experiences (Som *et al.*, 2020). In his opening remarks at the 2010 World *Halal* Forum, the Malaysian Prime Minister described the *Halal* industry as a growing industry that strives for cultural coherence. It is founded on the universal appeal of Islamic beliefs that promote wellness and incorporates ideals that benefit *Muslim*s' health and everyone's. According to Othman & Sangaran (2017), a five-star hotel in Malaysia should introduce a *Halal* premises certificate and guidelines from JAKIM (Jabatan Agama Islam Malaysia). The main reason for this initiative is to encourage more *Muslim* tourists to eat and stay at their accommodations. Regarding cuisine, amenities, and other services, it is more *Muslim*-friendly.

Moreover, this paper focuses on food preparation, such as the methods for preparing ingredients, Islamic animal slaughtering practices, and kitchen cleanliness. As a result of this study, the respondent stated that establishing *Halal* certification is important, particularly in certain situations, such as the Middle East peak tourist season and public sector festivals. In conclusion, the *Halal* sector is a growing sector that needs solemn guidance. Participants in these surveys are expected to have detailed methodological rules based on the *Halal* Foods and Certifications or Handbook. To increase demand for *Halal* gastronomy tourism among *Muslim* tourists, the government should play a crucial role in ensuring all premises obtain a *Halal* certificate and prominently display it so that tourists acknowledge the premises as a *Halal* spot.

Indonesia, one of the most popular tourist destinations, offers a gastronomy tourism spot. Based on the article by Sagala *et al.* (2020), Indonesia has become a popular tourist destination. It must be distinct from the variety of gastronomy offered to domestic and international tourists. Many of its restaurants offer typical characteristics and uniqueness with vibrant and inviting brands for tourists. This situation motivates many visitors to Indonesia to partake in gastronomic tourism. This study focuses on Bandung, Indonesia, sometimes known as Chinatown; it is a destination where visitors may experience a unique Chinese village ambience. The problem with this place is that it contains Chinese concepts. Examining *Halal* culinary components that *Muslim* visitors can accept makes it problematic for tourists to visit Chinatown. This can affect the impression of tourists and the influence of brands on tourists' purchasing decisions at a Chinatown gastronomic destination.

The research has been undertaken in the city of Bandung. Due to Chinatown's application of an interesting concept, the destination's results indicate that it has a unique value as an attraction to attract more tourists. Besides, Chinatown Bandung is home to over 80 renters from Bandung SMEs, whose stalls feature a variety of gastronomic, style, and handcraft products. The PERMABA Foundation also owns a unique "Bandung Chinatown Museum" (Bandung Society Association). The museum features a range of antique Chinese furniture, an infographic, and Chinese history in Bandung. Furthermore, numerous enticing spots for leisure, hanging out, and photography exist. Also, tourists can engage in sightseeing since many colourful buildings with lanterns hanging over the road can serve as photography spots.

3. *Halal* gastronomy aspect

The trend has evolved occasionally to cater to the demand of the traveller. *Halal* gastronomy tourism is the latest trend in the tourism business. *Halal* gastronomy tourism is travelling from one destination to another to enjoy the authenticity of the local food prepared with *Halal* ingredients for *Muslim* tourists worldwide (Yousaf & Xiucheng, 2018). Furthermore, *Halal* gastronomy tourism is one of the fastest-growing facets of the global travel industry, as it introduces *Muslim* travellers to local food prepared with *Halal* ingredients. This is the driving factor behind the phenomenal growth in the tourism industry, as *Muslim* travellers seek out vacation experiences worldwide. It has gotten increasingly popular due to social media. People frequently upload photos of delicious food from a particular destination on social media to encourage others to visit and try the food (Oktadiana *et al.*, 2020). One person recommends the most excellent food to another, motivating others to travel to a specific location to sample the local cuisine.

On the other hand, gastronomy tourism increases the economic growth of tourism destinations. To explain, the traveller spends money not only on food but also on accommodation, transportation, and other expenses. Gastronomy tourism has become a trend since the food served is unique to a certain destination and is made by the locals. Those who wish to experience the uniqueness of the cuisine have no choice but to travel to the location. For example, a rapidly developing country such as Japan is starting to adopt the *Halal* gastronomy trend and serve *Halal* food to *Muslim* travellers (Battour *et al.*, 2021; Jia & Chaozhi, 2020). Local foods such as sushi, gyoza, and ramen frequently contain alcohol or pork. However, due to the *Halal* gastronomy trend, numerous shops in Japan sell *Halal* versions of sushi, gyoza, and ramen to *Muslim* travellers. Japan also collaborates with a few *Muslim* countries to provide *Halal* food ingredients. It is very convenient for *Muslim* travellers to eat, and they have tasted the authenticity of the local food (Yousaf & Xiucheng, 2018).

Table 1 indicates some aspects of gastronomy tourism that travellers typically anticipate. The availability of *Halal* food is not the determining feature in *Muslim* travellers' destination selection. However, *Muslim* travellers tend to stay longer in places that offer many certified *Halal* branches with verified *Halal* status (Jia & Chaozi, 2018). The availability of *Halal* food also influences the type of accommodation tourist chooses. In Malaysia, "fusion cuisine" has been formed influenced by the "multiracial" or "multi-ethnic" characteristics of the ethnic population of Malay, Chinese and Indian (Som *et al.*, 2020).

Table 1: Review of *Halal* gastronomy aspect

Country	*Halal* Gastronomy Aspect	Statement	Remarks
Indonesia	*Halal* ethnic food	• Chinatown serves *Halal* Chinese and Indonesian food	Caria & Nuraeni (2019)
	Culinary	• Boost natural resources of ingredients and reveal the Indonesian culture, e.g. Local food, street food etc	Sukenti (2014)
	Producing innovative products	• Produce new food, environmental, festivals, and handicrafts and cultivate the quality of taste, scent, presentation and service of the food and beverage	
	Collaboration	• Collaborate with Tourism and Culture and Majelis Ulama Indonesia (MUI)	
	Standard assessment	• Provide standard assessment for the employees, the products, and the service quality	
	Promoting online advertisement	• Such as online transportation and a Bandros (tourist bus) for airport transfer	
China, South Korea, Japan, Thailand	Tourism marketing	• Promoting *Halal* cuisine and culinary, *Halal* food culture, *Halal* food restaurant, and *Halal* service via the internet • Easy access for *Muslim* tourists to spot *Halal* restaurant • Guidebook on *Halal* restaurant destination	Yousaf & Xiucheng (2018)
Japan, Malaysia	Culture and heritage	• Main tourist attractions from Malaysia, Indonesia, and Singapore • Local food	Hariani (2017), Som *et al.*, 2020
United Arab Emirates (UAE)	Travel experience	• *Halal* food availability • Type of accommodation that satisfied *Muslim*s' need	Mannaa (2019)

Table 2 indicates the most listed heritage food in Malaysia. Many *Muslim* travellers prefer to rent a furnished place with a fully-equipped kitchen, particularly when travelling to non-*Muslim* destinations with children and the elderly. Most *Muslim*s who travel ensure that the restaurants they visit are *Halal*. All participants decided based on the Shari'ah principle of consuming *Halal* food. It depends on the individual's level of faith and background knowledge to choose the *Halal* status of the restaurant while travelling. However, some were genuinely cautious and aware of the food's internal and external components (i.e toxic chemicals, biological agents, and microorganisms) (Umarjonovna & Gulomjonovna 2022) before deciding to consume it, such as most Middle East participants who avoided eating meat while travelling.

4. Challenges and opportunities of *Halal* gastronomy

A few challenges and opportunities will be discussed in this paper.

4.1 Challenges: standardisation of *Halal* certificate and *Halal* logo

According to Andrianto (2019), the restaurant business must prioritise the uniformity of the *Halal* certificate. For example, in Bandung, restaurant managers and *Muslim* travellers who ignore the *Halal* status of their eateries are ignorant. This is due to the importance placed on the quality of ingredients and services supporting *Halal*ness hospitality, especially in *Halal* restaurants. In the restaurant industry, perceptions of the *Halal*ness of hospitality vary between management and local customers. This action by the restaurant owner may negatively affect the destination's reputation. A negative experience for *Muslim* tourists can lead to negative word-of-mouth and discourage others from visiting the destination or restaurant. This can ultimately harm the restaurant's business and lead to failure.

Halal status is crucial to attracting more *Muslim* and non-*Muslim* customers for restaurant operators who have not yet filed for *Halal* certification (Wannasupchue *et al.*, 2019). *Muslim* restaurants are mainly divided into two classifications: certified *Halal* and non-certified *Halal*. Both premises are managed by *Muslim* owners, who prepare and cook food. The difference is that the premise did not apply to the *Halal* certification. It is also known that a *Halal* certificate is important to ensure that *Muslim* tourists will visit and recommend the restaurant without hesitation.

Table 2: List of popular Malaysia heritage foods (Som *et al.*, 2020)

List of popular Malaysia heritage food	
Rice	**Side dishes**
Nasi ayam	Ayam percik
Nasi kerabu	Asam pedas
Nasi lemak	Rendang
Nasi dagang	Gulai tempoyak ikan patin
Nasi himpit	Rendang
Nasi ulam	Kari kepala ikan
Nasi goreng kampung	Serunding
Ketupat	Botok-botok ikan
Lemang	Gulai lemak umbut
	Gulai lemak cili padi
	Gulai asam rom
	Kurma daging/ayam
	Hinava/umai
	Ayam panggang
	Daging dendeng
	Masalodeh
	Telur pindang
Sauces/Ulam	**Noodle**
Pekasam	Mee goreng mamak
Tempoyak	Laksa
Sambal belacan	Yee sang
Kerabu mangga muda	Char kuew teow
Cencaluk	Mee kari
Sambal gesek ikan bilis	
Sambal tumis	
Pajeri	
Budu	
Acar	
Halwa	
Bread/wheat	**Cracker/snack**
Roti jala	Otak-otak
Lempeng	Sata
Roti canai	Yong tau foo
Putu mayam	Satay
Tosai	Pisang goreng
	Keropok lekor
	Ubi kayu
Sweet	**Local cake**
Bingka ubi	Penderam
Wajik	Karipap
Seri kaya	Kuih lopez
Dodol	Bahulu
Lempok durian	Ondeh-ondeh
Laddu	Epok-epok
Tapai	Kuih keria
Agar-agar	Kuihbingka
Porridge	**Drink**
Bubur as-sura	Teh tarik
Bubur kacang hijau	Cendol
Sagu gula Melaka	Air batu campur (ABC)
	Air selasih

Sources: Adapted from National Heritage Department 2005

(a)

(b)

(c)

Figure 1: Among the gastronomy aspects that attract tourist anticipation; are (a) authentication, (b) decoration, and (c) heritage food (Jia & Chaozi, 2020).

Halal status is crucial to attracting more *Muslim* and non-*Muslim* customers for restaurant operators who have not yet filed for *Halal* certification (Wannasupchue *et al.*, 2019). *Muslim* restaurants are mainly divided into two classifications: certified *Halal* and non-certified *Halal*. Both premises are managed by *Muslim* owners, who prepare and cook food. The difference is that the premise did not apply to the *Halal* certification. It is also known that a *Halal* certificate is important to ensure that *Muslim* tourists will visit and recommend the restaurant without hesitation.

On the other hand, the *Halal* Logo plays an important role in serving the *Halal* market. Haryani *et al.* (2017) and Aliff *et al.* (2015) stated that some business owners showing different types of private *Halal* logos on their premises aim to mislead customers. The absence of enforcement by the government in monitoring *Halal* food certification exacerbates this issue. This implicates consumer confidence and trusts in the *Halal* Logo. The industry has discovered that the logo and status can serve as a marketing instrument for business expansion. The government could capitalise on providing public information and minimise misunderstandings regarding *Halal* market difficulties by forming a consumer interest group like the Malaysian *Muslim* Consumers Association (PPIM). Governments and the public must collaborate to reduce the likelihood of future problems. This is mainly to help Malaysia become recognised as one of the best *Halal* gastronomy destinations worldwide.

4.2 The misconception of *Halal* tourism

Ethiopia's tourism destination has the potential to attract a more significant number of visitors. According to Ahmed & AKBABA (2018), stakeholders and scholars believe *Halal* tourism is only for *Muslim*s. The truth is that Non-*Muslim* travellers can also appreciate *Halal* tourism. *Halal* tourism may be characterised as the exclusive domain of *Muslim*s and may be targeted by terrorists to promote Islamophobia. However, the main idea is to create a destination that provides travellers with clean and safe cuisine. The definition of *Halal* tourism needs to be more understood by others. Most scholars define *Halal* tourism as Islamic tourism and interchangeably use both terms, which can lead to misunderstanding among non-*Muslim* tourists. The rise of Islamophobia among Christians in Ethiopia is one of the challenges foreseen, as this worldview causes *Muslim* travellers to fear visiting the nation. Ethiopia faces numerous obstacles in the transition to *Halal* tourism, but it presents a significant chance to increase its economy and promote the local culture to foreign tourists.

4.3 The application of *Halal* guidelines

In the research, Dwiyitno (2016) and Aliff *et al.* (2015) described to the audience the basic concept of *Halal* food, namely that all ingredients must be clean to be clean, meat must be slaughtered according to Islamic law, and ingredients containing alcohol or lard must be avoided. The establishment must adhere to a guideline for the preparation of the ingredients. The ingredients must be clean and cannot be made from lard alcohol, as it is the opposite and restricted to be consumed by *Muslim*s. Furthermore, introducing *Halal* requirements and healthy living is one of the standards and guidelines. According to Islam, a human cannot drink the blood of an animal for this reason. This is because animal blood contains pathogenic microorganisms and pathogenic worms that can enter the human body, harm the immune system, and cause illness. In addition, the cross-contamination of *Halal* products with non-*Halal* resource ingredients is strictly prohibited to ensure the cleanliness of *Halal* ingredients. *Halal* food may be consumed without a doubt because of the hygiene of the food.

Moreover, by implementing *Halal* requirements, it is possible to make items of a higher quality compared to those that adhere to the conventional standard. To explain, by adhering to *Halal* requirements, all the ingredients and actions would be monitored, and any illegal action would be a penalty. As a result, the tourists do not need to worry about the *Halal* status, as all preparation before making the food will be observed and free of local ingredients. Other than that, the importance of implementing *Halal* requirements is to ensure that *Muslim* travellers can enjoy their vacations without doubting the *Halal* status of the food they consume. The authors emphasise that the basic reasons for banning some substances are their uncleanliness and toxicity to our bodies due to their unclean components and toxic constituents.

Aliff *et al.* (2015) also added that genetically modified (GM) is added to processed food are dangerous as it has been altered. In this modernisation area, the *Halal* concept cannot be limited solely to "pork-free" meals. Ingredients that are *Halal* and not dangerous to be consumed by the human, such as gelatin, enzymes, lecithin, and glycerin, as well as additives such as stabilisers, flavourings, colourings, and others, are considered *Halal* ingredients. The authors urge that Jabatan Agama Islam (JAKIM) improve present *Halal* processes in the food industry to guarantee that the standard and guidelines are straightforward. The authors mentioned ensuring that the JAKIM enforces the *Halal* law on the premises that take advantage of their *Halal* status.

4.4 The awareness of local heritage food

Ghazali (2020 mentioned the significant factor of Malaysia's gastronomy tourism. The level of awareness of local heritage food among food industry players is important for identifying the promotion efforts made by food industry players in the marketing of local heritage foods and exploring the perceptions of food industry players about the potential, importance, and opportunities of local heritage foods as a factor in Malaysian gastronomy tourism. Due to a lack of cooks and visitor understanding of this type of cuisine, it is conceivable that the national heritage food will be forgotten. If the native food is lost, Malaysia will lose its. Furthermore, promoting Malay food in a large hotel with many visitors is suggested. Other than that, the government and authorities should continue to organise larger-scale events and festivals that may be used to introduce Malaysia as a paradise for food lovers to both local and international tourists.

4.5 The opportunities for *Halal* tourism

Kivela & Crotts (2015) mentioned several opportunities for Tourism and Gastronomy. In Hong Kong, gastronomy reinforces the concept that Hong Kong is the leading gastronomic destination. It also aims to improve the performance of business products and services and create new business opportunities. Moreover, providing experiences and motivating individual tourists can ensure that gastronomy tourism becomes even more popular in the future due to the authenticity of the food provided. The results also revealed that gastronomy is increasingly crucial in how tourists choose a

destination. Overall, having a major attraction in one destination will build a potential business and improve the country's economy.

5. Conclusion

In conclusion, *Halal* gastronomy tourism can be seen as a new attraction that can encourage more tourists to visit one destination. When a country promotes *Halal* culinary tourism at their places, there are numerous benefits. The first advantage is that the destination can primarily promote its culture and heritage through local food. Usually, local food is related to the culture of the place. For example, tourists can be introduced to foods served to the monarch and queen of the country or consumed during unique festivals. Besides, *Halal* gastronomy tourism can promote the authenticity of the local food at a particular destination. It has been proved that local food can be the main attraction of one destination, hence attracting more *Muslim* travellers. Other than that, promoting *Halal* gastronomy tourism can increase the country's economy. When tourists visit a destination, they spend money on lodging, transportation, and other services, which positively impacts the local and national economies. To explain, a visitor who visits a destination for its cuisine or gastronomy may also appreciate other attractions, such as the area's natural resources or the country's culture and history. Tourists who spend money on accommodations, transportation, and other services contribute to the local and national economies. The destination's original culture and heritage significantly ensure its success as a tourist attraction. However, many alternative techniques are available for promoting the country, such as food festivals or cultural events. By doing so, the country could become well-known, and tourists could spread the good word about the country, thus attracting more tourists to the destination and boosting the economy.

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