

BLOCKCHAIN FOR RESILIENT HALAL FOOD CERTIFICATION DURING THE POST-COVID ERA

Stephen Sim

Faculty of Business, Government & Law, University of Canberra, Australia.
stephen.sim@canberra.edu.au

ABSTRACT

This study examines the overwhelming effects of the COVID-19 pandemic on the global food industry with a specific focus on the challenges faced by the Muslim community in validating and certifying Halal food. The unprecedented disruptions caused by the pandemic, including border closures and lockdown measures, underscored the urgent need for a sustainable ecosystem to ensure food security and maintain the integrity of Halal standards. This study explores the potential of blockchain technology as a robust and transparent solution for enhancing Halal food validation, certification, and auditing. Moreover, this research examines how blockchain is applied in the Halal sector using eHalal.io as a case study and netnography to understand online communities' behaviour regarding Halal products. By facilitating secure transactions and instilling trust in the supply chain, blockchain emerges as a transformative tool that can empower Halal authorities to adapt to the evolving demands of Muslim consumers, especially in the rapidly expanding online realm during crisis and post-pandemic era. Through an in-depth analysis of the benefits and implications of blockchain adoption, this study contributes to the discourse of leveraging technology to navigate the challenges Muslim communities face and establish resilient Halal food certification practices in the wake of and after the COVID-19 pandemic. These findings highlight the potential of blockchain as a catalyst for innovation, efficiency, and sustainability in the Halal food industry, paving the way for a more resilient and inclusive future.

Keywords: *Blockchain, consumer behaviour, COVID-19, food security, Halal certification*

1. Introduction

The COVID-19 pandemic has significantly impacted food security and supply chain challenges worldwide. Disruptions in the food supply chain, from production to distribution, commonly referred to as the 'farm to fork' process, have raised important societal concerns and necessitate a reevaluation of how to respond to global crises (Chen et al., 2021; Mahajan & Tomar, 2021). The systemic volatility brought about by the pandemic has influenced consumer behaviour, particularly in terms of food purchasing patterns, disruption in the supply chain (Ocampo et al., 2016), and changes in demand (Asian & Nie, 2014). Lockdowns and quarantines, coupled with closed borders, have compelled individuals across the globe to adapt/change their food-buying habits and will continue to remain even after the pandemic subsides (Rozhkov et al., 2022).

The shift to online and e-commerce platforms has been a key aspect of the new global pandemic era, impacting various industries, such as education, health, and food (Aryani et al., 2021). Consumer behaviour has also shifted towards online and e-commerce purchases, including the Halal industry, where consumers have displayed an increased interest in Halal certification of food products and concern for potential contamination in the supply chain (Hidayat et al., 2022). Consequently, the pandemic has prompted a heightened focus on food security policies, particularly trade and development, within the Halal supply food chain (Nizar & Abidin, 2021). This presents a new challenge after the pandemic in managing the Halal food industry, given its substantial size and significance. Therefore, this study is conducted as an attempt to investigate the efficacy of blockchain technology within the context of blockchain technology, particularly during the post-COVID era.

2. Background of Study

The COVID-19 crisis accentuated the importance of addressing food security concerns, disruptions, and implementing robust policies, including practices to ensure a resilient and sustainable food supply chain (Alabi & Ngwenyama, 2023). It also highlights the need to adapt and embrace technology-driven solutions, such as online platforms and certification systems, to meet the evolving demands of consumers in the COVID-19 and post-pandemic era (Hidayat et al., 2022). As the world navigates through this challenging period, the Halal food industry, as with many others, must continue to adapt, innovate, and ensure the integrity and safety of its products within the changing/evolving global food security landscape.

According to Standard Dinar - State of the Global Islamic Economy Report (Standard Dinar, 2020, p. 12), the Islamic community demonstrated substantial economic activity in 2021, with expenditures amounting to US\$2 trillion across key industries, such as pharmaceuticals, fashion, travel, and food. Despite the challenges presented by the pandemic, this upward trajectory is expected to continue until 2022, with an estimated growth rate of 9.1% for the Islamic economy, excluding the Islamic Financial Sector. Notably, expenditure on food by Muslim consumers alone witnessed a notable increase of 6.9% in 2021, reaching an impressive US\$1.19 trillion.

Furthermore, the Organization of Islamic Cooperation (OIC) economic sector, comprising both OIC and non-select markets, experienced remarkable growth of 118% from US\$11.8 billion in 2019/20 to US\$25.7 billion in the 2020/21 report. The Halal food industry accounts for a significant portion of this sector, covering 15.5% of the overall market (Standard Dinar, 2020, p. 4). However, ensuring food security, mainly through Halal certification, remains challenging.

To address these challenges, the OIC, in collaboration with the Islamic Organization of Food Security (IOFS), has developed a comprehensive 10-year strategic plan known as Vision 2031. This strategic plan encompasses five key pillars and 16 strategic programs, focusing on enhancing production practices, traceability of Agri-produce, and addressing supply chain issues and digitalisation challenges. Notably, digitalisation initiatives were highlighted to optimise the procurement processes within the Halal food supply chain, ensuring transparency and efficiency from "farm to fork" (IOFS, 2021, p. 13).

The COVID-19 pandemic has brought critical issues relating to food security to the forefront, including concerns about quality, traceability, and the role of digitalisation in addressing supply chain complexities (Kazancoglu et al., 2021). Considering these challenges, this study argues for the urgency of addressing trust-related issues. It highlights the potential of blockchain technology as a tamper-proof transformative audit tool (Iftekhhar & Cui, 2021) for validating the integrity of Halal food throughout the entire supply chain management.

Hence, the substantial economic activities within the Islamic economy, particularly in the Halal food sector, underscore the need for more robust measures to ensure food security. The strategic initiatives the OIC and IOFS put forth, along with the adoption of blockchain technology, hold significant promise in building and creating trust and guaranteeing the authenticity of Halal food from its origin to consumers' tables.

3. Literature Review

3.1 Halal Food

In the Islamic world, online searches and digital interactions play a significant role in Muslim consumers' decision-making processes and brand choices (Islam & Chowdhury, 2018). This reflects their concerns, Islamic beliefs and principles, and the importance of commerce in their lives (Hussaini, 1993; Wilson et al., 2013). Halal branding is inseparable from the faith of Muslim consumers, as it must align with their beliefs and adhere to Sharia standards (Alserhan, 2010; Hussaini, 1993; Wilson et al., 2013). The COVID-19 pandemic created massive lockdowns that presented new challenges and opportunities in Halal branding, particularly in the food sector, emphasising the need for Halal certification to be integrated into a sustainable ecosystem (Hidayat et al., 2022).

3.2 Food Security

Food security encompasses political determination, agricultural capabilities, supply chain efficiency, and international collaboration (Prosekov & Ivanova, 2018). It is crucial for more than a billion Muslims to depend on climate-resilient agricultural systems and effective governance (Mbow et al., 2019). Previous global crises, such as the Global Financial Crisis, have highlighted the impact on poverty and hunger (Gohar & Cashman, 2016; Lipton & Saghai, 2017; Myers & Caruso, 2016). For Muslim consumers, food security is closely tied to Halal origins (Hussaini, 1993; Jalil et al., 2017), and in Malaysia, it involves proper planning and ensuring the safety of the "farm-to-fork" processes from an Islamic perspective (Ishak, 2005).

The Islamic Organization for Food Security (IOFS) has outlined its 10-year strategic plan, "Vision 2031," which comprises 16 programs under five pillars: food governance, food crisis response, capacity building, industry development, and resource mobilisation (IOFS, 2021). The IOFS considers food security from "gene to fork," encompassing consumer behaviour, supply chain management, food production, and waste reduction (Standard Dinar, 2020). Food security remains a central focus of the IOFS in establishing a well-managed food ecosystem that ensures the sustainability of the international food system and aligns the interests, policies, investments, and legal aspects of all parties involved.

As IOFS works towards its vision, it becomes necessary to transform food security into a digital food system. Halal verification of food is increasingly carried out through mobile applications utilising barcodes for validation purposes (Junaini & Abdullah, 2008). Critical success factors such as Halal certification, transparency of standards and guidelines in adherence to Sharia law, and Halal traceability within the supply chain are essential (Ab Talib et al., 2015; Aziz & Chok, 2013; Noordin et al., 2009; Shafii & Khadijah, 2012; Shafii et al., 2013). However, vulnerabilities within the Halal supply chain exist, and disruptions may lead to non-Halal issues (Ab Talib et al., 2015; Tieman, 2011). The COVID-19 pandemic has further emphasised the need for validation tools like blockchain to ensure the integrity of Halal food from "farm to fork."

3.3 Blockchain Technology in the Halal Food Industry

During the pandemic, the lockdowns or movement restrictions led to massive disruption to the food industry with profound implications (Hailu, 2020; Nakat & Bou-Mitri, 2021), as

well as their supply chains (Galanakis, 2020). Traceability is tantamount to ensuring food quality and safety; however, traditional solutions created on a centralised architecture may not be tamper-proof in their data sharing (Iftekhhar & Cui, 2021). In contrast, blockchain, an emerging technology, provides real-time tamper-proof data sharing, offering a promising solution for enhancing traceability in food supply chain management. Blockchain technology is undeniably a powerful tool for Halal certification/validation. Blockchain technology enables cryptocurrencies, with Bitcoin being the most renowned. Satoshi Nakamoto created it to prevent double-spending using distributed peer-to-peer networks (Nakamoto, 2008). In a similar light, “*a decentralised network of computers’ nodes of which each Halal certification organisation has a copy*” that “*allows any Halal certification organisation to run a fully automated audit*” (Irwan, 2021). The eHalal Blockchain Network operates as a decentralised system, with each Halal certification organisation having a copy of the blockchain. This network enables automated audits to adhere to the standards set by the Organization of Islamic Cooperation (OIC) and The Standards and Metrology Institute for the Islamic Countries (SMIIC) (Irwan, 2021). The eHalal.cloud platform, launched in several countries, including Germany, Malaysia, Singapore, Turkey, and the United Kingdom, serves as a comprehensive solution for food traceability, ensuring transparency from ‘farm to fork’ and addressing consumption trends and food security (Dholi, 2021).

Blockchain technology in the Halal industry has emerged as a transformative solution to ensure supply chain integrity and transparency. By leveraging blockchain, the Halal industry can address key challenges related to traceability, trust, and authentication throughout the supply chain process (Gligor et al., 2022; Rashid et al., 2022).

The inherent features of blockchain, including immutability, decentralisation, enhanced security, transparency, and smart contracts, can significantly enhance the efficiency and reliability of supply chain operations (Duan et al., 2020). Moreover, the decentralised nature of blockchain enables real-time visibility and traceability, ensuring that Halal products meet rigorous Sharia standards that adhere to consumer expectations (Rashid et al., 2022).

4. Research Methodology

This study investigates the impact of blockchain technology on the Halal industry and adopts a comprehensive research methodology. A case study approach focuses on the eHalal.io blockchain system, a representative example of blockchain implementation in the Halal sector. This approach allows for in-depth exploration of the social and epistemological contexts surrounding blockchain adoption (Denzin & Lincoln, 2008; Denzin & Lincoln, 2011).

In addition, a netnographic approach was utilised to gain insights into individual experiences within the networked digital space of Halal online communities. Netnography, as an ethnographic examination of the digital sphere, provides a valuable framework for understanding the dynamics of these communities and their evolving consumer behaviour (Kozinets, 2010; Kozinets, 1997, 2002; Kozinets & Gretzel, 2022). This study delves into the online community by employing observational and non-participatory methods, capturing its shared values, customs, and beliefs related to Halal products (Costello et al., 2017).

Ethical considerations are paramount in this study, aligned with the ethical guiding principles established by the Association of Internet Researchers (Markham & Buchanan, 2012). The research acknowledges online platforms' participatory and interactive nature, recognising the importance of active engagement while maintaining ethical standards (Kozinets, 2015). By adhering to these principles, this study aims to provide valuable insights into the impact of blockchain technology on the Halal industry and contribute to a broader understanding of digital transformations in supply chain management.

This study sheds light on blockchain technology's potential to enhance supply chain transparency in the Halal industry. Through a rigorous research methodology encompassing case study analysis and netnographic exploration, this study aims to generate valuable knowledge for industry practitioners, policymakers, and researchers interested in the intersection of blockchain and the Halal sector.

5. Findings and Discussion

5.1 Importance of Blockchain Technology

The findings of this study highlight the role of blockchain technology in Halal certification and validation, particularly within the context of the eHalal Network and Marketplace.

The case study analysis focuses on the eHalal network's blockchain technology data, specifically the Halal Quality Management System, which follows the official Standard of OIC/SMIIC 18:2021. This system, offered as a software-as-a-service (SaaS) solution, provides a framework for efficient Halal certification and management (eHalal.io Token (HAL), 2022). The study also considers the Marketplace.eHalal.io platform, further enhancing transparency and accessibility for consumers and businesses seeking Halal-certified products (Marketplace ehalal, 2022).

The rankings obtained from eHalal.io and marketplace.eHalal.io present the top 20 searches based on consumer trust in Halal food certification/validation. The rankings reflect the number of inquiries (or 'clicks'), with Rank No. 1 indicating the lowest consumer trust due to the highest number of inquiries. It is worth noting that the dataset contains over 1000 products; however, for the sake of brevity, only the top 20 searches are presented in Table 1.

The results of this study highlight the importance of blockchain technology for building trust and ensuring transparency in the Halal certification process. By leveraging the decentralised nature of blockchain, the eHalal Network and Marketplace offer a reliable and auditable system for Halal certification, enabling consumers to make informed decisions regarding the authenticity and compliance of Halal products. This level of transparency aligns with the expectations of Muslim consumers, who consider Halal certification a crucial aspect of their dietary choice (Alserhan, 2010; Wilson et al., 2013).

Moreover, Table 1 illustrates the presence of a Halal food community within the eHalal.io blockchain. At the top of the ranking is 'Tea Garden Halal,' which holds the distinction of being Halal certified by the Malaysian Department of Islamic Development, also known as Jabatan Kemajuan Islam (JAKIM). This certification has been maintained for two consecutive years, as it remains on the JAKIM's approved list. JAKIM's certification

process involves on-site evaluations conducted by assessors who collect samples for laboratory analyses (Noordin et al., 2009; Tran, 2022).

Table 1. Organisations data/No of ‘clicks’

Rank	Top Queries coming regarding	‘clicks’
1	Organisation A	307
2	Organisation B	146
3	Organisation C	128
4	Organisation D	125
5	Organisation E	121
6	Organisation F	100
7	Organisation G	91
8	Organisation H	79
9	Organisation I	77
10	Organisation H	67
11	Organisation I	66
12	Organisation J	59
13	Organisation K	56
14	Organisation L	55
15	Organisation M	55
16	Organisation N	53
17	Organisation O	53
18	Organisation P	51
19	Organisation Q	49
20	Organisation R	48

Note. Top 20 organisations listed from over one thousand items
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Overall, the findings demonstrate the potential of blockchain technology to address trust and validation issues within the Halal industry. With their innovative use of blockchain, the eHalal Network and Marketplace enhance supply chain transparency, traceability, and consumer confidence in Halal-certified products. Further research and development in this area hold promising prospects for the future of Halal certification and its alignment with technological advancements.

However, during the COVID-19 pandemic, when lockdown measures were imposed, the Malaysian government implemented a Movement Control Order (MCO) to restrict the movement of the population. Consequently, this hindered assessors from conducting on-site inspections, affecting various Halal-certified organisations. In the case of 'Tea Garden Halal,' their Halal status was unexpectedly removed by JAKIM instead of being listed as expired. This decision confused Halal consumers, who were subsequently alerted to this issue through the Marketplace eHalal.io site. When an organisation garners the highest number of ‘clicks’ on a website and triggers signals within the blockchain, it also signifies a potential concern regarding validating its Halal certification.

The situation surrounding 'Tea Garden Halal' exemplifies the challenges faced by Halal-certified organisations during the pandemic, particularly in maintaining the accuracy and up-to-date status of their certifications. The disruption caused by restricted mobility and on-site evaluation limitations underscores the need for alternative approaches, such as

leveraging blockchain technology to ensure the continued validity and trustworthiness of Halal certifications.

In summary, Table 1 highlights the significance of the eHalal.io blockchain in capturing Halal food communities. The prominence of 'Tea Garden Halal' and the subsequent issue of its certification status exemplifies the complexities and vulnerabilities inherent in validating Halal certifications, particularly in times of crisis. By leveraging blockchain technology, the Halal industry can enhance transparency, traceability, and consumer confidence in the certification process, mitigate potential concerns, and strengthen the integrity of Halal products in the marketplace.

5.2 Review of the Countries' Trust

The Codex Alimentarius Commission had given Malaysia the top accolade for Halal food. In contrast, COVID-19 brought about a 'chink in their armour,' as Malaysia was unable to support their online community.

Table 2. Least trusted countries/ based on the number of 'clicks'

Rank	Countries	No of 'clicks'
1	Malaysia	13992
2	France	2634
3	Germany	2565
4	Spain	1144
5	United Kingdom	819
6	Italy	780
7	United States	758
8	Sweden	681
9	Singapore	659
10	Netherlands	572
11	Indonesia	562
12	Belgium	487
13	Denmark	465
14	Canada	434
15	Australia	419
16	Poland	400
17	Iran	379
18	Turkey	357
19	Bangladesh	337
20	Norway	303

Note. Top 20 countries listed from 231 countries
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When the amount of 'clicks' is noted higher, it inevitably indicates the consumer perceptions of that said country to have lower trust levels. The consumers rely on the blockchain to determine the viability and traceability of their products (Iftekhar & Cui, 2021). As such, during the pandemic of COVID 19, it was noted that Malaysia as it was unable to sustain the online community (see Table 2)

Codex Alimentarius Commission, an international body established by the Food and Agriculture Organization (FAO) and the World Health Organization (WHO), has recognised Malaysia for its achievements in the field of Halal food. The commission has awarded Malaysia with the highest accolade for its efforts in ensuring the production, certification, and regulation of Halal food. This recognition highlights Malaysia's commitment to maintaining high standards of Halal food practices and its dedication to meeting the needs of Muslim consumers. The Codex Alimentarius Commission's acknowledgement demonstrates Malaysia's success in implementing effective Halal food management systems, including robust certification processes and rigorous quality control measures.

Despite this accolade and the disruption of the COVID-19 pandemic, many countries faced insurmountable challenges in supporting their food systems (Galanakis, 2020). The online Halal community was also affected, including Malaysia. As lockdowns and movement restrictions were implemented to curb the spread of the virus (Aziz et al., 2020), Malaysia faced difficulties in effectively catering to the needs of the online Halal community. The pandemic necessitated a shift towards digital platforms and online engagement, including the Halal food industry. With these restrictions on physical interactions and reduced access to traditional Halal certification processes, Malaysia experienced serious limitations in providing comprehensive support to the online Halal community. This inability to fully support the online community during the pandemic had implications for Halal consumers, who relied on digital platforms to access information, verify Halal certifications, and make informed purchasing decisions. The challenges faced by Malaysia in adapting and adopting to the online space highlighted the importance of robust digital infrastructure, technological advancements, and streamlined processes that ensure seamless online support for the Halal community.

The COVID-19 pandemic serves as a wake-up call for Malaysia and other countries to prioritise digitalisation, which will enhance their capabilities in serving the needs of the online Halal community. This includes developing user-friendly platforms, adopting technologies, such as blockchain, for transparent and secure certification processes, and the need to invest in digital literacy and education for both consumers and Halal certification authorities.

Though Malaysia has received recognition for its achievements in Halal food certification, the COVID-19 pandemic presented new challenges in effectively supporting the online Halal community. The experience draws to attention the importance of embracing digitalisation and implementing robust online infrastructure that can cater to the evolving needs of Halal consumers in an increasingly digital world. It is paramount for Malaysia and similar nations to strengthen their digital capacities and provide seamless online assistance for the Halal community. Moreover, such cultivates trust, accessibility, and dependability in the online Halal space.

The Halal food community product searches placed Malaysia at the top, followed by France in second place and Germany in third place. This ranking shows that Malaysian consumers actively search for Halal food products and certifications with low levels of trust. Trust plays a crucial role in the value chain process by influencing customers' decisions to support and engage with the Halal food industry (Steven, 2002).

Interestingly, France and Germany, despite being non-Muslim majority countries, demonstrate a significant level of interest in Halal food products, as evident from their high rankings. This suggests a growing global demand for Halal-certified options driven by dietary preferences, cultural diversity, and increased awareness of Halal principles among non-Muslim populations.

On the other hand, Indonesia, an Islamic nation, ranks 11th in product searches within the Halal food community. With only 562 ‘clicks’, Indonesia's level of engagement appears to be relatively lower and better than Malaysia's 13,992 ‘clicks’. This disparity may be attributed to multiple factors, such as differences in digital access, consumer habits, and market trends. Further research is needed to explore the specific reasons for this variation in the search activity.

Overall, the findings highlight Malaysia's dominant position in the Halal food community's product searches, indicating strong consumer interest and engagement. Furthermore, this suggests that consumers in Malaysia possess more incredible internet/online skills when it comes to sourcing Halal foods.

The high rankings of France and Germany, non-predominant Islamic nations, show the expanding global reach of the Halal food industry. Understanding these factors that influence consumer behaviour and trust within the Halal value chain is important for businesses and policymakers to cater to the evolving demands of the Halal market.

5.3 Types of Devices Used for Online Enquiries

Electronic devices play an important role in consumer behaviour when searching for Halal products online. The three main devices were mobile phones, desktop computers, and tablets.

Table 3. Types of devices used to make the enquiries.

S/No	Device	Impressions
1	Mobile Phone	672753
2	Desktop	266416
3	Tablet	9802

Note. The main three devices listed
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According to the findings in Table 3, mobile phones have emerged as the primary device used by the Muslim community to search for Halal certification and validation. Desktops and tablets followed this in terms of device preferences. Notably, during the pandemic, mobile phones took the lead in terms of usage, probably due to their accessibility, mobility and easy access to Wi-Fi data on these devices.

The prominence of mobile phones in accessing Halal certification information aligns with the global trend of increased smartphone usage and increasing reliance on mobile devices for e-commerce and various online activities (Kasriel-Alexander, 2016). The convenience and portability of mobile phones make them a popular choice among consumers (Sardjono et al., 2021), including those seeking Halal-certified products. The widespread

availability of Wi-Fi data further facilitates access to Halal certification and validation information.

It is important to understand the impact of the COVID-19 pandemic on consumer behaviour and device usage patterns. With restrictions in place, more people were staying at home and relying on mobile phones for online activities, including Halal certification searches. This trend is expected to continue post-pandemic due to the convenience and comfort of accessing information from mobile devices.

Overall, the findings underscore the significance of mobile phones as the preferred device for the Muslim community searching for Halal certification and validation. As the world becomes increasingly interconnected and reliant on digital technologies, it is crucial for Halal certification authorities and businesses to optimise their online presence and ensure seamless access to reliable Halal certification information across various devices, with particular emphasis on mobile-friendly platforms/apps.

● eHalal Blockchain

Halal Verification (Trust Score by Muslim Consumers)

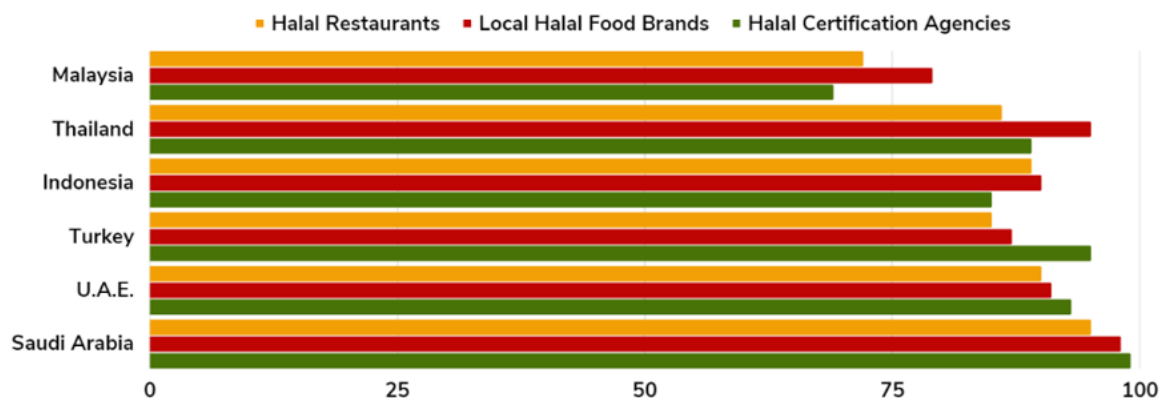


Figure 1: eHalal – Halal verification (Trust scores)

Note. Halal verification from eHalal Blockchain

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Trust scores for Halal verification can be categorised into three areas: Halal restaurants, local Halal food brands, and Halal certification agencies. These scores represent Muslim consumers' confidence level in each entity, with a maximum score of 100 indicating complete or high trust.

Food security strongly influences consumer behaviour in the context of Halal food. Muslim consumers place great importance on the assurance that their food choices align with their values, particularly in terms of being healthy, clean, and good (Khan et al., 2020; Rezai et al., 2009; World Halal Forum, 2009). The desire for Halal-certified products stems from these personal beliefs and the need for reassurance regarding the origins and quality of the food they consume (Mustafar & Borhan, 2013; Nardi et al., 2019).

Figure 1 presents the Halal verification trust scores, with Malaysia having the lowest score compared to Thailand, Indonesia, Turkey, U.A.E., and Saudi Arabia.

This suggests a lack of confidence in Halal reliability within the country. Malaysia's performance in providing assurance to Muslim consumers regarding Halal verification is hindered by the lack of Halal integrity in the supply chain, spanning from the farm to the fork (Tieman, 2011). Notably, the Department of Islamic Development Malaysia (JAKIM) has yet to adopt barcode technology to identify and verify the Halal status of products. Technology, such as barcode or Radio Frequency Identification (RFID), plays a crucial role in tracking food security and validating real-time updates on inventories (Junaini & Abdullah, 2008). According to Badrudin et al. (2012), JAKIM should focus on enhancing its non-core aspects and resources related to meeting Halal consumers' expectations, which includes improving the Halal verification process. The COVID-19 pandemic exposed JAKIM's weakness in adopting new technologies to support and streamline the Halal certification verification process (Junaini & Abdullah, 2008). Moreover, with the increasing concerns about food security, including biohazards and agroterrorism, it is imperative to adopt Blockchain technology, which can be instrumental in managing biotechnological threats and ensuring the integrity of the Halal food industry. Thus, aligning with the IOFS concept of "gene to fork."

On the other hand, Saudi Arabia ranks high in Halal verification and trust scores. The recent Saudi International Halal Expo 2022 showcased the eHalal.io blockchain, indicating Saudi Arabia's willingness to adopt such technology (CASCI Arab-Swiss Chamber of Commerce and Industry, 2022).

Overall, the trust scores of Halal verification revealed variations among different entities and countries. Enhancing Halal integrity, adopting technological advancements, and ensuring that online resources are sound and crucial considerations for strengthening Halal certification and verification processes. Embracing technologies, such as blockchain, can significantly manage potential threats to the Halal food industry that provide robust and transparent assurance to Muslim consumers.

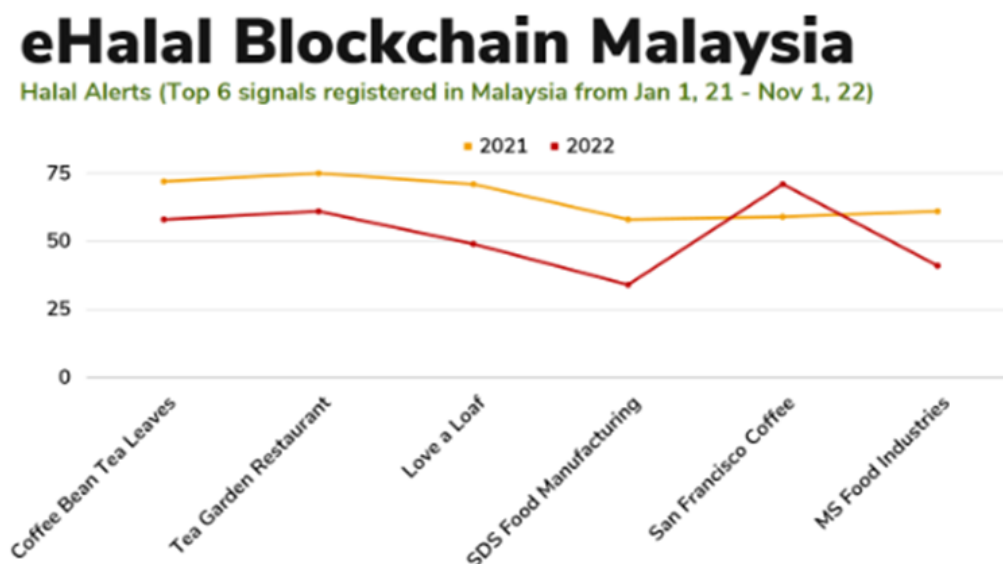


Figure 2: Top six signals found on the eHalal Malaysia site

Note. eHalal Blockchain Malaysia
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The figure above depicts the top six signals recorded in Malaysia between January 1, 2021, and November 1, 2022. The traffic pattern appears relatively stable on the yellow line during 2021. However, a significant spike was observed from the red line during 2022, particularly in relation to the ‘San Francisco Coffee’. This signal surge occurred despite JAKIM's efforts to improve Halal verification processes and systems. Although some housekeeping measures were implemented, a few glitches persisted in the system, leading to confusion among Malaysian Halal consumers.

The unexpected increase in signals pertaining to ‘San Francisco Coffee’ raises concerns about the accuracy and reliability of Halal certification in Malaysia. Despite efforts made by JAKIM to address these issues, further improvements are needed to ensure a more robust and trustworthy Halal verification process. These discrepancies in the system have confused Malaysian Halal consumers, who rely/depend on accurate and up-to-date information to make informed choices about the products they consume.

JAKIM and other relevant authorities must identify and rectify these issues in their Halal verification systems. By doing so, they can restore confidence among Malaysian Halal consumers and, therefore, reinforce the credibility of the Halal certification process. This could involve implementing more comprehensive quality control measures, enhancing transparency, and improving communication channels to provide Halal consumers with more precise and reliable information.

Addressing the challenges and glitches in the Halal verification system is vital for Malaysia's Halal industry, as it plays a significant role in meeting the needs and expectations of Muslim consumers. By ensuring the accuracy and reliability of Halal certification, Malaysia can maintain its position as a trusted provider of Halal products and strengthen its reputation in the global market.

Further research and continuous monitoring of the Halal verification system in Malaysia is necessary to identify and rectify any remaining glitches. This will contribute to the ongoing improvement and evolution of the Halal industry, ensuring that Halal consumers can make informed choices with confidence and trust in the certification process.

Top 10 Searches

Searches by Popularity (Weekly average 7 Nov 2022 - 13 Nov 2022)

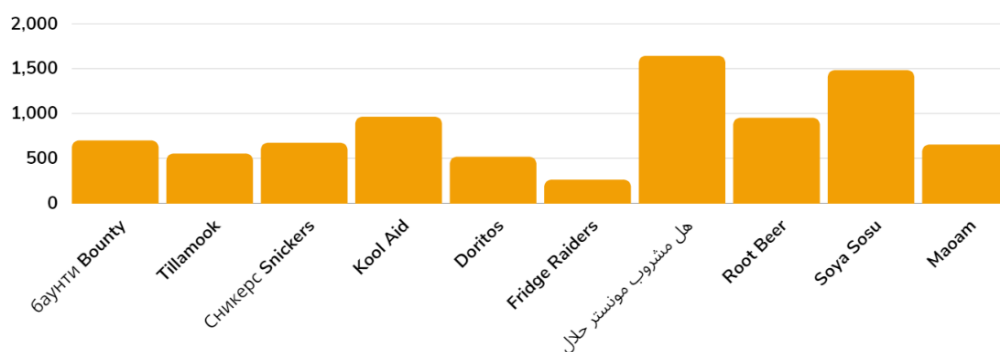


Figure 3: Top ten weekly searches for the period 7 to 13 November 2022

Note. Top ten weekly searches from November 7 to 12, in the year 2022

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This figure aims to provide insights into popular Halal product searches online on the eHalal.io site. The 7th item from the left, represented by Arabic characters, corresponds to the energy drink 'Monster,' which holds significant popularity in the Middle East. This region is the largest market for web and eHalal blockchains. Moreover, the Arabian and Indonesian markets have since emerged as leading consumers of Halal products.

It is important to note that the concept of Halal certification and verification should not revolve solely around religious aspects. Rather, it requires a broader perspective encompassing animal welfare, climate change, and food safety. Adopting a holistic approach toward Halal principles allows for a comprehensive understanding of the certification process, ethics, and implications (Rezai et al., 2012; Lipton & Saghai, 2017; Mustafar & Borhan, 2013).

The popularity of 'Monster', as an energy drink within the Halal market highlights the diverse range of products that Muslim consumers seek. As the demand for Halal products continues to grow, businesses and certification authorities must address religious requirements and broader considerations related to sustainability, ethical practices, and health concerns. By incorporating these aspects into the Halal certification process, the industry can better serve Muslim consumers' evolving needs and expectations.

Overall, this figure emphasises the significance of the Middle Eastern and Indonesian markets in driving the consumption of Halal products. It also underscores the need for a comprehensive approach to Halal certification that considers various factors beyond religious compliance. This holistic perspective contributes to developing a robust and sustainable Halal industry that aligns with the principles and values cherished by Muslim consumers.

6. Conclusion

In conclusion, this study demonstrated the significant impact and disruption that the COVID-19 pandemic had on the Halal food industry and the challenges it poses to consumers and certifying authorities. The existing practices and processes of Halal certification and validation have faced new challenges in adapting to the crisis, necessitating a re-evaluation of the current approaches.

These findings underscore the global nature of Halal certification and its importance in providing certainty, assurance, ethics and integrity to Muslim consumers worldwide (Rezai et al., 2012; Lipton & Saghai, 2017; Mustafar & Borhan, 2013). The pandemic has accelerated the shift towards online consumption and mobile e-commerce (Sardjono et al., 2021) and increased Muslim consumers' e-commerce and Internet abilities, aligning with their cognitive processes. In this context, blockchain technology has emerged as a promising solution, offering transparency, reliability, and ease of access to consumers seeking Halal information when making informed decisions about food products and retail outlets.

As the world continues to embrace online purchasing and e-commerce, even after the pandemic subsides, Halal certification authorities, such as the Department of Islamic Development Malaysia (JAKIM), must embrace new technologies that better serve the needs of the Muslim community. This requires consensus within the Islamic community to harness the potential of emerging technologies such as Artificial Intelligence (AI), Decentralized

Hyperledger, Big Data, and others that align with the vision of the Organization of Islamic Cooperation (OIC).

Further quantitative research is warranted to advance the understanding of the challenges faced by Halal certifying authorities and explore the broader application of blockchain technology. This research could delve into issues beyond Halal food, encompassing sectors such as finance, tourism, pharmaceuticals, cosmetics, fashion, travel, and media/recreation (Standard Dinar, 2020). Additionally, conducting netnography on social media platforms to capture the experiences and perspectives of Muslim consumers in validating Halal food products would provide valuable insights for future research.

It is important to note that this study focused solely on the eHalal.io blockchain system and the experiences of Muslim consumers with Halal food. Future research should aim to broaden the scope by considering multiple blockchain systems and exploring the perspectives of various stakeholders, including Halal certification authorities, retailers, and producers. By incorporating diverse viewpoints, researchers can gain a more comprehensive understanding of the challenges and opportunities within the Halal industry and develop strategies to meet Muslim consumers' evolving needs and expectations.

Overall, this study calls for proactive engagement with technological advancements and collaborative efforts within the Islamic community to ensure the integrity and reliability of the Halal certification processes. By embracing new technologies and conducting further research, the Halal industry can enhance consumer trust, strengthen the value chain, and contribute to the sustainable growth of the global Halal economy.

This research is focused solely on analysing a singular Blockchain system employed by eHalal.io that explicitly serves the requirements of Halal food consumers within the Islamic community.

7. Acknowledgements

I wish to acknowledge Mr. Irwan Shah bin Abdullah, the founder and Chief Technical Officer of eHalal.io, for his invaluable contribution to providing blockchain data.

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