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Review Article

Adoption of Advanced Technology in Poultry Meat Production: Perspectives on the Critical Need from Brunei Stakeholders

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Abstract: Halal poultry technology such as machineries that include life birds handling, slaughtering tools, scalding and plucking machine, evisceration, pre-cooling, cutting and packaging produce efficiency in poultry meat production. A lot of poultry slaughterhouses worldwide has adopted technology in their companies. However, in Brunei, technology usage has not been embraced fully by all slaughterhouses except the commercial companies. Therefore, this research aims to investigate if the speed, safety, quality and Halal aspects of poultry meat production in Brunei are improved by the help of advanced technology as well as other related aspects as to meet the increasing demand of poultry meat supply. Additionally, the research also aims to identify the level of desire of slaughterhouse owners in Brunei to invest in advanced technology for their service. To achieve these objectives, a qualitative approach was used. An interview was conducted with a few government and private sectors who are involved in the poultry meat production in Brunei. The results of the research showed that technology contributed to the improvement of poultry meat production in Brunei which can be seen in a number of aspects such as improvement in term of speed, safety, quality and cleanliness with an assistance from manual handling and practice. Moreover, the need for technological adoption is also highlighted on its contribution during a disease outbreak and as a way to tackle increasing demand for poultry meat production. It was also found that the owners of local poultry slaughterhouses have the desire to invest further in

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advanced technology as a way to improve their service. Nevertheless, it is hoped that future research could broaden the term of technology including robotic and artificial intelligent aspect as a few of the companies have shown interest on them.

1. Introduction

As an effect of the growing Muslim population, the demand for meat production has increased (Moekti, 2020). This leads to the need of mass production of meat to frequently happen in slaughterhouses. An initiative that has been made by slaughterhouses to increase the efficiency of the meat production is by technology usage. This statement is supported by Wang (2021), where she mentioned that various machines and instruments were invented to aim automated process of mass slaughter as a way to cope with escalating demand while maintaining the Halal integrity of the meat supply chain.

A lot of countries have used advanced technology in their slaughterhouses, especially those that produce poultry. In New Zealand, Anago Ltd has developed an advanced machine that serves the purpose of checking the sharpness of the slaughtering knife accurately, where it tests the entire length of the blade and provide overall score to the blade. In addition to that, the machine gives an empiric graph of the blade and currently this machine is able to test knives about 30cm long (Farouk *et al*., 2016). This type of technology is absent in the poultry industry of Brunei Darussalam as it still uses the traditional paper test. Meanwhile in Australia, there is a usage of machine slaughter for poultry meat production (Shahdan *et al*., 2016). However, this is forbidden in Brunei based on PBD24:2007, the Halal Food Standard of Brunei. Therefore, despite the relation with the third goal of Wawasan Brunei 2035, which the country aims to have the transformation of becoming a developed nation with a high income, utilizing knowledge and technology as the basis of development and boosting private sector involvement (Wawasan 2035, 2019) and as well is currently moving forward to the fourth industrial revolution of automating basically everything including immense use of machineries, robotics and sensors (Sait & Anshari, 2021), the need of technological development in Brunei's businesses including meat production is needed yet must strictly comply with the Halal standard of Brunei.

The usage of advanced technology in poultry slaughterhouses increases the efficiency in producing poultry meat as manually producing the meat can cause a few issues to rise such as cross contamination between carcasses from manual handling (Barbut, 2014). Therefore, advanced technology is involved in most part of the poultry meat production industry in some of the steps as to help in improving the work environment, accelerating the poultry meat production to meet the increasing demand of poultry meat by the consumers and minimize

the contamination that could rise. However, there is a limit on technology usage for Brunei due to the lack of Bruneian automation engineers (Sait & Anshari, 2021). Added by Sait and Anshari (2021), the human to machine interaction jobs in Brunei is still lacking as they require high technical skills.

Moreover, technology usage in the meat production is required in case of emergence of another disease outbreak. Based on Hashim and Sulaiman (2022), COVID-19 had caused disruption to the livestock production food security due to the restrictive measure where only a small amount of people is allowed to leave and work in their respective working places. It is hypothesized that technology such as machines produce efficiency in poultry meat production. Therefore, the objectives of this research are to investigate if the speed, safety, quality and Halal aspects of poultry meat production in Brunei are improved by the help of advanced technology as well as other related aspects as to meet the increasing demand of poultry meat supply and to identify the level of desire of slaughterhouse owners in Brunei to invest in advanced technology for their service.

2. Materials and Methods

In this research, a qualitative approach was used as the method of research. An on-site interview with professionals from 3 local commercial poultry slaughterhouses, as well as 2 government agencies that are commonly involved in poultry meat production in Brunei was conducted. The professionals from the commercial poultry slaughterhouses were chosen as interviewees based on their involvement in the operation as well as their expertise on the technological aspects of the whole operation in producing poultry meat. “Government Agency A” was the only Halal certifying body in Brunei, that has the responsibility to maintain the Halalan Thayyiban aspect of the production and “Government Agency B” was the department under a ministry that is responsible to check the meat quality of the poultry meat. Meanwhile the three local commercial poultry slaughterhouses were labelled as “Company C”, “Company D” and “Company E”. They have adopted technology in their poultry meat production and the size of their production is on the large side. Additionally, they have been operating for more than 10 years.

The data from secondary resources such as academic articles were also used in this research. The interview questions evolved around their knowledge on advanced technology such as the importance of it and how it helps and maintains Halalan Thayyiban poultry meat production, also the extent they see the desire to adopt technology in Brunei poultry slaughterhouses. The data received was then analysed thematically by identifying the themes or keywords from the primary data obtained which produced a discussion on the research objectives.

3. Results

The results show that the respondents have agreed that technology did contribute to the poultry meat production in commercial poultry slaughterhouses as shown in Table 1.

Table 1. From your opinion, do technologies indeed contribute to the improvement of poultry meat production in Brunei?

Respondents	Responses
Government Agency A	Yes, I would say yes.
Government Agency B	Yes. It may contribute to an increased production of good quality meat, with less defect and wastes.
Company C	Technology does help, it eases the production but it still needs human intervention.
Company D	Yes and maybe
Company E	Yes, Technology 100 percent helped.

The agreements from the companies mainly came from their experiences in the industry as they have been operating for more than 10 years, where they have seen the massive change in the production performance with the help of technology usage. This also includes the government agencies that have been to a lot of poultry slaughterhouses in Brunei. However, manual intervention is still needed and not removed entirely as once the machines are broken, it will be hard to find the spare parts in Brunei. Assistance of humans on operating the machines is still needed as to handle and maintain the machines.

Moreover, when the respondents were asked whether manual production without any technological adoption is better, four out of the five respondents have disagreed as shown in Table 2.

Table 2. Do you believe that manual production without any technology adoption is better?

Respondents	Responses
Government Agency A	Disagree, technology is still needed. Both of them (technology and manual) needed.
Government Agency B	Disagree. Adopting technology in the meat production can lead to increase production with better quality and consistency.
Company C	Both have pros and cons. Agree.
Company D	Disagree, but both has disadvantages.
Company E	Disagree. Technology is better because with it, we can get good quality.

Company C agrees that manual production is better due to their opinion of Brunei being a bit behind on technological adoption and their view on the disadvantages of technological adoption outweighing the advantages. In contrast, as most of them disagreed, this shows that most of them have preferred technological adoption in the production due to their view of the advantages of using technology is higher and this include the higher capacity of slaughtering with better quality and consistency that will result with the end products confirming with the requirements and specifications though, it must be under intensive monitoring and training.

The contribution of technology to the improvement of poultry meat production in Brunei has been found which are from these three aspects: improvement in term of speed, safety and quality. However, in the Halal aspect, technology did not contribute as much, as can be seen in Figure 1.

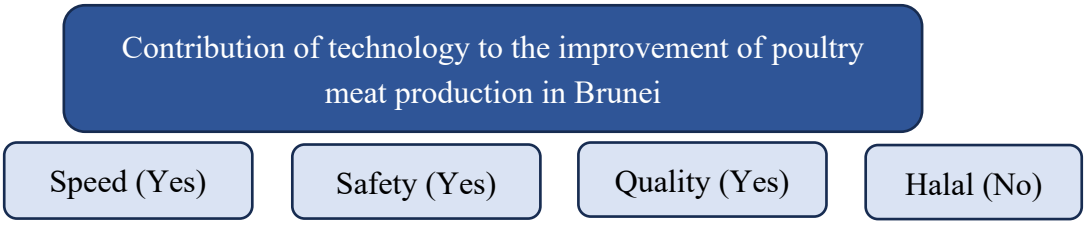

Figure 1. Improvements contributed by technology in poultry meat production.

In the case of a disease outbreak, technology was found to provide contribution in ensuring the poultry meat production is not affected, though the respondents have shown their opinion that manual interventions are still needed. This can be seen in Table 3 below.

Table 3. Do you think that technologies play a huge role in ensuring the poultry meat production is not affected in the case of another disease outbreak that cause restrictive measure?

Respondents	Responses
Government Agency A	The machines indeed helped as they increase the capacity. But to ensure the poultry meat production is not affected, not entirely. Because the machines need to be cleaned and operated with manual labors still. It still needs manual.
Government Agency B	Yes, provided that there is regular equipment inspection and preventative maintenance. Nevertheless, this should not remove completely of human intervention or supervision for a reliable and continuous meat supply.
Company C	The production was not affected, it was still the same. But technology did help. However, manual intervention is still needed.
Company D	Yes, we can at least require less manpower to operate, and reduce their physical contact.

Respondents	Responses
Company E	The poultry production was not affected, we have a lot of staff so they just replace those that are affected. With the technology we have, the business must still continue. Of course, the technology really helps.

The question above was asked about the respondents' experience during the COVID-19 situation where they mentioned that technology helped in reducing the physical contact. Hence, fewer manpower and lower risk of the disease being spread around. Meanwhile, the production was not affected.

Another finding revealed that technology adoption in the poultry slaughterhouses can be considered as one of the ways to tackle increasing demand for poultry meat production in Brunei. It was agreed by all five respondents which is displayed in Table 4.

Table 4. Can technology adoption in poultry slaughterhouses be considered as one of the ways to tackle the increasing demand for poultry meat production in Brunei?

Respondents	Responses
Government Agency A	Yes, it does help. However, it (technology) is more needed in the farming area, increase the chicken stocks
Government Agency B	Yes. Technology adoption will be able to cater to the consumer demand more efficiently, while maintaining quality and food safety standards.
Company C	Yes, but not the main way.
Company D	In terms of processing efficiency, yes. However, increasing demand can be addressed by increasing the live birds production volume at farm level.
Company E	Yes.

Increasing demand without a doubt will be helped by technology usage as they have shown their contribution in term of speed. Nevertheless, the respondents highlighted that the adoption of technology will not offer much in speeding the poultry meat production if the live birds production volume at the farm is not increased in the first place.

In term of investment on technology, this aspect was only asked to Company C, D and E as it was not applicable to be answered by Government Agency A and Government Agency B. They have shown that they have the willingness to invest further in technology and upgrade the technologies they already had. This can be seen in Table 5.

Table 5. Will you continue to improve your service by investing in further advanced technologies in the future?

Respondents	Responses
Company C	Yes, it is in the plan for the future to renew and upgrade.
Company D	Yes
Company E	For sure

4. Discussion

Technological adoption in poultry meat production has shown its contribution in term of efficiency as well as reducing product contamination, infection spread and increase productivity yield (Ross *et al.,* 2022). However, in term of preference to which one is better between manual or technological approach, the respondents have different views. Most of the respondents have opined that poultry production with technological adoption is better, that is taking into consideration the capacity and increased production with better quality and consistency and better time management. However, the technology still needs to be operated with human intervention. Once an error happens in the setting up of the machine, as small as a minor error, it could lead to machine breakdown which will then result in high volume of wastage. Nevertheless, both approaches have their own advantages and disadvantages as mentioned by Company C in Table 2 regardless most of them have preferred technological approach is better.

4.1 Improvement in Term of Speed

When it comes to efficiency, the main aspect that usually comes with it is speed. Quicker production could lead to an overall improvement on producing something especially to quickly meet demands of consumers. Technology machines have helped strongly in the speed department in poultry meat production which it increased by triple to ten times more than before. Company E, have strongly agreed on this improvement. They used to only produce 1,000 birds, pre-technology adoption, which caused them a long day up to a number of hours to finish. However, with the technology they have adopted now, if they were to produce 1,000 birds, they can finish it in one hour. They stated that "*So if we were to produce 1,000 birds only with the technology we have now, if we come at 5am, we will come back home at 6am"* when asked about the difference in production speed during technology adoption and during manual production. From this statement, it is believed that technology machines helped in speeding up the poultry meat production.

In contrast, Government Agency B has commented that while technology adoption can provide faster production rate, it is considered difficult to assess. This is due to automated system are used widely in large capacity commercial slaughterhouses compared to the SMEs (Small Medium Enterprises) that have smaller scale production. Therefore, in term of speed,

it is indeed improved with the use of technology. However, to actually assess the rate of quickness, it can only be done by the company itself and not from comparing between commercial slaughterhouses and SMEs as they have different amount of stocks and scales of production.

4.2 Improvement in Term of Safety

In this research, safety aspect of poultry meat production involves the inspection and hazard part. Three of the respondents have agreed on having extra inspection with the help of technology when asked if technology can act as an extra inspection tool for the production. "*Beneficial in ensuring food safety and quality and reducing the risk of contamination while improving efficiency in production"* and *"manual checking on all areas of one whole bird may not be effectively done due to mis looked"* are the statements made by Government Agency B and Company D that show that technology helped in the improvement of the safety aspect in the poultry meat production. Company E went as far as showing interest to buy and implement it if it is available, when being told about the computer vision system (Sandberg *et al*., 2023). Nevertheless, Government Agency A said that "*Technology can only do so far, it has limitations*". Thus, in term of inspection, technology can help but without removing manual inspection entirely.

Meanwhile, in term of hazard, the respondents have highlighted the system implemented instead of technology aspect. Showing that hazard is not about technology intervention. It is about the practice and system they adhere to. This can be supported by Nastasijevic *et al*. (2020a) and Nastasijevic *et al*. (2020b) where they have opined that implementing biosecurity measures and GMP or HACCP strictly can reduce *Camplyobacter spp.*, bacteria that cause meat borne disease by colonizing the broilers and contaminating the carcasses. Between technological hazard and manual hazard, it cannot be identified which one is easier to be controlled. Government Agency B mentioned that tackling both hazards have the same approach that is by the help of existed system such as "*trained personnel by a competent of experts, regular maintenance of premise and facilities, and proper standard operating procedures".* This is also supported by the statement made by Government Agency A which he said that *"Both hazards can be controlled as long as they implement the system like HACCP, ISO or FSSC".*

Company D has also agreed on how both hazards have their own controls, in which she differentiated biological hazard and physical hazard in her answer *"Biological hazards are better minimized when there is less human handling involved in the process and maintaining the Good Manufacturing Process (GMP). Physical hazards can be controlled by having a rigorous preventive maintenance in place and screening device such as metal detector"*. This shows that biological hazard can be controlled with technological adoption assisted with a

proper system. While physical hazard can also be controlled with technology such as the metal detector.

In term of cleanliness, using machines do minimize the risk of contamination due to low density of man power and it ensures hygienic meat. However, some of the respondents believe that cleanliness is attributed from the system applied. Nevertheless, it can be concluded that cleanliness is achievable with technology assisted with a system as well. In a nutshell, safety can be improved with the help of technology. Yet, it needs to be assisted with a proper system. Manual intervention should not be removed entirely as it is still needed in the improvement of this aspect. A system backed up with technological development in meat production has successfully led to a change in the public health threats that originate from meat significantly (Nastasjievic *et al*., 2020a).

4.3 Improvement in Term of Quality

The statement "quality can be assured with the use of technology in the poultry meat production" has caused different views from the respondents. Quality can be assured by defects detection, acquiring meat cuts precisely, the auto grading system that involved separating the weight precisely and packaging with consistent quality with the help of technology machines.

Nevertheless, Government Agency A strongly opined with the system in which he said *"Without technology, it would contaminate, but at the same time, it depends on the system they use, for me, its not the technology plays a huge role in this situation, it's the practice, quality still falls on the practice and how they handle the poultry meat".* His view shows that quality cannot be fully assured with technology itself, if the practice is not maintained, it will still affect the quality of the meat if it is not handled properly. Same goes to Company C's answer. Company D stands in the middle as she said that it depends on the capability of the machine itself to assure the quality of the meat. Thus, quality can be assured as technology machines helped in providing precise cutting and weights, but in term of internal quality, proper handling must be taken into consideration.

4.4 Improvement in Term of Halal

For the poultry meat to be Halal, the production must be free from any Haram substances, the slaughtering of the chickens must be Halal and the handling of the meat must be hygienic and good (Mahardika, 2020). Therefore, in poultry slaughterhouses there are Halal checkers to check as extra precaution that the chickens are indeed Halal slaughtered. Nonetheless, the respondents were asked if this extra precaution to double check that the slaughtering is indeed Halal using technology is crucial such as computer monitor or CCTV. Government Agency A and B have strongly disagreed with this idea as slaughtering process and the checking

afterwards still needs to be done manually. This is due to the method is the most precise and reliable. Adopting technology in this stage could lead to the replacement of Halal checkers which should not happen. The officer from Government Agency A argues that Halal checkers should not be replaced as he said "*If a chicken is slaughtered, it cannot be seen as it is, to make sure it is Halal, the skin must be lifted upward so that the marikh and halqum can be seen, which this can only be done if the neck is held physically".* Thus, checking Halal status of the chicken with the use of technology is not supported.

However, if the technology is adopted to monitor that the Halal checkers are working, then all respondents agreed on it as supported by Company C, he stated that it is a must to check the Halal checkers because one Haram chicken could lead to the whole production to be contaminated.

4.5. Need for Technological Adoption in Brunei Poultry Slaughterhouses

4.5.1 Disease outbreak

During the COVID-19 situation, livestock production food security has been disrupted based on Hashim and Sulaiman (2022). Moreover, as mentioned by Fuseini *et al*. (2023), the poultry industry is at the risk of disease outbreaks. It is due to the restrictive measure where only a small amount of people is allowed to leave and work in their respective working places. However, it is not the case for poultry meat production in commercial slaughterhouses. Though it may have happened in the SMEs. The respondents have explained that the poultry production was not affected as they still need to meet the demand, regardless of the restrictive measures applied. Although it was not affected, selfish behaviors such as bulk buying during the disease outbreak has caused the companies to not only tried their best to meet the usual demand, but they increased the amount of production. With this increase, the respondents were thankful to have the technology machines which they indeed help in meeting the increased capacity.

In a case of another disease outbreak that causes restrictive measure, Respondent 1 is on the neutral side on the idea of machines helped in ensuring the poultry meat production is not affected. He stated "*The machines indeed helped as they increase the capacity. But to ensure the poultry meat production is not affected, not entirely"*. Whereas Respondent 2 and 4 have the same view which they agreed with the idea as it would require less man power to operate and reduce any physical contact that could cause contamination of the disease (Tech Gadgets, 2022). Respondent 2 as well added that regardless her agreement, regular inspection of equipment and preventive maintenance are still needed.

4.5.2 Way to tackle increasing demand

Technological adoption in Brunei poultry slaughterhouses can be said as one of the ways to tackle increasing demand for poultry meat production. This is agreed by the respondents.

However, to actually tackle the demand, the volume of live chickens need to be increased as well. Therefore, improvement on the technological aspect in the farm side needs to be the first step because as stated by Respondent 1, "*Technology adoption needs to be increased on the farming side first. If we were to increase machines in slaughterhouses only without increasing it as well in the farm, it will not balance".* Hence, technology can be a way to tackle the increasing demand for poultry meat production in Brunei, but the farming side cannot be left out.

The need for technological adoption in Brunei poultry slaughterhouses can be seen from the discussion above as to improve the poultry meat production. Thus, technology indeed contribute to the improvement of the production and this is agreed by the respondents in Table 4. However, human intervention as well shows its benefits along with technology, in some of the parts, both human and technology needs to work together to provide the maximum help in the production.

4.6 Desire to Invest in Technology

The desire of the companies to invest in technology can be seen from Table 5. Investing in technology has been considered as a good investment as it increases efficiency and reduce contamination. The respondents all planned to continue investing further in advanced technology which shows that the companies consider technology as reliable and needed to improv their service.

However, cost can be a problem in the investing case. Thus, subsidies from government may helped in the adoption of technology in poultry slaughterhouses to further improve the poultry meat production in Brunei as government has given subsidies to farmers for agriculture development. This is due to agriculture is seen as one of the key industries that can contribute to Brunei's economic growth other than oil and gas (The Scoop, 2018). Poultry meat production is also one of the key industries that contribute to the country's economic growth, which said subsidies can also be offered to the poultry industry.

5. Conclusion

Undoubtedly, there is a need for technological adoption in Brunei commercial poultry slaughterhouses. It is shown that technology has proven its contribution in the poultry meat production in term of speed, safety and quality. Nevertheless, it still needs assistance from manual labors in few of the steps in the production, such as the practice. Meanwhile in the improvement of the production in the aspect of Halal, technology helps in monitoring the Halal checkers and not replacing them. Checking the Halal status of the chickens still needs to be done manually. In case of a disease outbreak, technology also play a role to ensure the production is not affected, though the respondents have different views on this. Lastly,

technology adoption in poultry slaughterhouses contributed as a way to tackle the increasing demand of poultry meat production though not the main way.

In conclusion, slaughterhouse owners have shown their desire of investing and upgrading in further advanced technology as a way to improve their poultry meat production in the future and to meet one of the Brunei's Wawasan 2035's goals that is utilizing knowledge and technology as the basis of development and boosting private sector involvement. With the improvement in the technological aspect, it will indirectly tackle the lack of automation engineers in Brunei by the presence of more courses and training on producing and operating these advanced machines that are used in other countries. University courses on engineering will also be updated as such in University Teknologi Brunei, which is a university that mainly offers engineering courses in Brunei. Therefore, this will result in producing more technology experts in Brunei.

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