# Financial Impacts and Epidemiological Characteristics of Lumpy Skin Disease in Cattle in Ampara District of Sri Lanka

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***Abstract***

*Cattle farming is a major economic sector in the Ampara district of Sri Lanka, yet there is limited information on lumpy skin disease (LSD) in the region. This study addresses this gap by investigating the prevalence, mortality rate, distribution, and age-related factors of LSD, as well as assessing the financial impacts of outbreaks. Data of LSD from nineteen government veterinary offices were collected through surveys and interviews. The data was analysed using Microsoft Excel 2021 and Minitab 19. Findings indicate that LSD had spread to nineteen out of twenty ranges in the Ampara district. The highest prevalence was observed in the Irakamam range (20.77%), while the lowest was in the Alayadivembu range (3.81%), with an overall prevalence of 8.59%. Nintavur and Addalaichenai had significantly higher mortality rates of 6.5% and 3.5%, respectively, compared to other regions in the Ampara district, where the mortality rate was much lower at 1.7%. Statistical analysis revealed that the affected animals were predominantly under one year of age. Financial impact assessment showed that 78% of affected farms experienced reduced growth rates in their cattle, while 22% faced infertility issues. Major risk factors for LSD spread included animal transportation, communal grazing lands, and presence of ticks. These findings provide valuable insights into the epidemiology and economic burden of LSD in Ampara, offering a basis for developing targeted interventions to protect livestock farmers' livelihoods and sustain the local economy.*

***Keywords:*** ***Lumpy Skin Disease (LSD), Cattle, Financial impacts, Ampara district of Sri Lanka***

## I. INTRODUCTION

Lumpy Skin Disease (LSD) is a severe systemic illness in cattle caused by the Lumpy Skin Disease virus, which belongs to the Capripoxvirus genus within the Poxviridae family. Key symptoms of LSD include fever, nodular lesions on the skin and mucous membranes, and lymph node enlargement (Molla et al., 2017). Morbidity rates can range from 10% to 85%, depending on factors such as regional differences, cattle population density, and the effectiveness of control measures. While LSD generally has a low mortality rate of 1% to 5%, it can still cause significant economic losses due to reduced milk production, weight loss, and secondary infections, particularly in regions with high morbidity (Sherrylin et al., 2013; Namazi & Khodakaram Tafti, 2021).

Ampara District of Sri Lanka, where livestock farming plays a crucial role in the local economy, the spread of LSD has raised concerns due to its potential impact on dairy farmers' livelihoods. The variation in morbidity and mortality rates during LSD outbreaks depends on several factors, including geographic location, climate, cattle management conditions, and the virulence of the virus. Reported morbidity rates range from 5% to 45%, with mortality rates typically between 1% and 5%. However, higher rates have been observed in certain regions, such as in Oman, where a 2009 outbreak in a Holstein cattle population saw morbidity and mortality rates of 30-45% and 12%, respectively (Sherrylin et al., 2013).

LSD primarily affects cattle and buffaloes, with all breeds being susceptible, although imported breeds with thinner skins, such as Bos Taurus, are more vulnerable than indigenous breeds. Young calves are particularly susceptible, developing characteristic lesions within 24 to 48 hours of infection. In rare cases, wild species like impalas, Thomson's gazelles, and giraffes have also developed LSD lesions following experimental inoculation (Ali et al., 1990; Greth et al., 1992; Young et al., 1969).


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The exact transmission mechanism of LSDV is not fully understood, but it is believed to be mechanically spread by flying insects, with epidemics often coinciding with periods of high insect activity. Variations in attack rates, ranging from 10-15% to nearly 100%, may be attributed to differences in vector species across regions. Blood-sucking ticks have also been implicated in the transmission of LSDV in sub-Saharan Africa (Lubinga et al., 2013). While transmission through semen has not been experimentally confirmed, the virus has been isolated in the semen of infected bulls, suggesting potential intrauterine infection. The movement of animals from infected herds has frequently introduced the virus to new areas, with old skin lesions serving as a source of infection (Weiss, 1968; Kitching & Mellor, 1986; Carn & Kitching, 1995).

Pathologically, the acute stage of LSD is characterized by thrombosis, vasculitis, perivascular fibroplasia, and infarction, with inflammatory cells infiltrating affected areas. Gross pathology includes edema, congestion, and enlargement of lymph nodes, as well as nodular lesions in fascia and musculature. The incubation period for LSD is approximately 28 to 35 days in natural infections and 4 to 7 days in experimental settings (Al-Salihi, 2014; Mulatu & Feyisa, 2018; Ratyotha et al., 2022).

Clinically, LSD manifests as anorexia, fever, salivation, nasal discharge, enlarged lymph nodes, weight loss, and decreased milk production. The most distinctive sign is the presence of firm, raised skin nodules that appear on the legs, neck, back, and tail. These nodules can lead to complications such as myiasis, abortion, mastitis, and orchitis. Postmortem examinations often reveal lung edema, congestion, and nodules throughout the lungs and gastrointestinal tract (Namazi & Khodakaram Tafti, 2021).

The objective of this study is to assess the prevalence and mortality of LSD in the cattle population of Ampara district of Sri Lanka, analyze the risk factors contributing to the spread of LSD, and relate the occurrence with age, and evaluate the economic impact of LSD on livestock farming in the Ampara district.

## II. MATERIALS AND METHODS

### *A. Study area and Study Population*

The study focused on cattle farms affected by Lumpy Skin Disease (LSD) in the Ampara district over three months from September to December 2023. Data was collected from 19 selected Veterinary ranges within the district, based on the number of reported LSD cases in each farm. The Veterinary ranges included in the study were Addalaichenai, Akkaraipattu, Alayadivembu, Ampara, Dehiattakandiya, Irakkamam, Kalmunai, Karaitivu, Lahugala, Mahaoya, Navithanveli, Nintavur, Padiyathalawa, Pottuvil, Uhana, Sainthamaruthu, Sammanthurai, Damana, and Thirukkovil. These ranges were specifically chosen to provide comprehensive data from farms significantly impacted by LSD.

### *B. Data Collection*

Epidemiological data were systematically gathered, focusing on cattle demographics, clinical signs of LSD, vaccination status, and management practices. This information was obtained through a combination of veterinary records and on-site farm visits. During sampling, details such as the sex, age, and management system of the cattle were meticulously recorded.

To assess the financial impact, data collection involved conducting surveys and interviews with farmers. These methods provided insights into production losses, veterinary expenses, and other economic consequences associated with LSD.

A well-structured questionnaire was prepared and completed to gather detailed information. This questionnaire covered various aspects including the owner's particulars, herd composition, management practices, and the health, disease, and vaccination status related to LSD.

In addition, an interview guide was meticulously developed and utilized. This guide focused on gathering insights about experiences with LSD, identifying which types of animals were affected, and assessing production losses.

### *C. Statistical Analysis*

Qualitative data were analysed using a cohort study design to evaluate the independence of various epidemiological factors. Quantitative data were processed and analysed using Microsoft Excel. For the financial impact analysis, survey data and interview responses were meticulously examined in combination to provide a comprehensive assessment.


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Figure 01: Jerzy Crossbreed Cow in Kalmunai Infected with LSD Exhibiting Multiple Skin Nodules

Figure 02: Jerzy Crossbred Calf in Ampara infected with LSD reveals multiple skin nodules

## III. RESULTS

### *A. Prevalence of Lumpy Skin Disease (LSD) in Ampara District*

The data on LSD prevalence in the Ampara district is illustrated in Figure 03. The highest prevalence of LSD was observed in the Irakamam veterinary range, with a rate of 28.46%. The second highest prevalence was reported in the Samanthurai veterinary range at 20.77%. Overall, the prevalence of LSD in the Ampara district from September to December 2023 was 8.59%.

### *B. Mortality Rate of Lumpy Skin Disease*

The highest mortality rate was reported in the Ninthavur veterinary range at 6.50%, followed by the Addalaichenai range with a mortality rate of 3.46% (Figure 04). The overall mortality rate in the Ampara district for the same period was 1.70%.

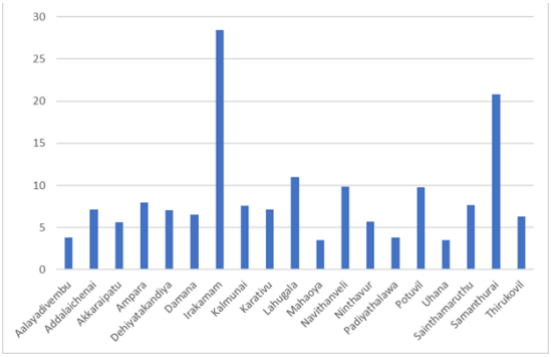


Figure 03: Prevalence (%) of Lumpy Skin Disease in Cattle in Ampara district: September to December 2023

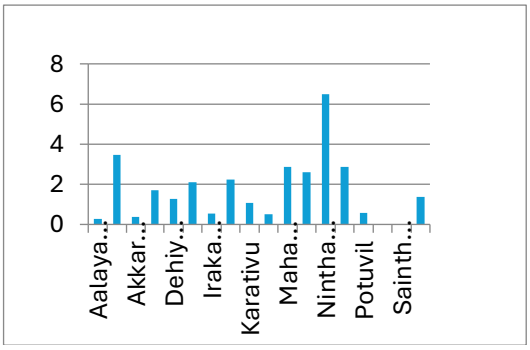


Figure 04: Mortality rate (%) of Lumpy Skin Disease in Cattle in Ampara district: September to December 2023

### *C. Age Distribution of Affected Animals*

The analysis, as illustrated in Table 01, reveals that the highest percentage of Lumpy Skin Disease (LSD) cases were observed in animals under one year of age, while the lowest number of affected animals were in the over one-year age category.

### *D. Financial and Production Impacts*

Figure 05 shows the impact of Lumpy Skin Disease (LSD) on farms in the Ampara district. The data indicate that 78% of LSD-affected farms experienced a reduction in growth rates among the affected animals. In contrast, 22% of the affected farms reported issues related to infertility in their livestock.

Table 01: Reported LSD in Two Age Groups: "Animals below one year and Animals above one year in cattle in Ampara district'' (September to December 2023)

| **Affected Ranges** | **No. of cattle below one year** | **No. of cattle above one year** |
|---|---|---|
| Aalayadivembu | 265 | 95 |
| Addalaichenai | 277 | 70 |


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| | | |
|---|---|---|
| Akkaraipatu | 206 | 64 |
| Ampara | 196 | 36 |
| Dehiyatakandiya | 86 | 16 |
| Damana | 117 | 62 |
| Irakamam | 68 | 36 |
| Kalmunai | 307 | 50 |
| Karativu | 107 | 78 |
| Lahugala | 310 | 75 |
| Mahaoya | 565 | 65 |
| Navithanveli | 582 | 30 |
| Ninthavur | 89 | 34 |
| Padiyathalawa | 188 | 20 |
| Potuvil | 302 | 58 |
| Uhana | 289 | 58 |
| Sainthamaruthu | 24 | 6 |
| Samanthurai | 760 | 117 |
| Thirukovil | 987 | 113 |

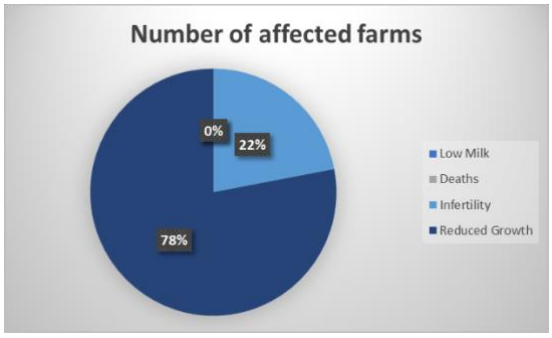


Figure 05: Financial Impact of Lumpy Skin Disease in Cattle on affected Farms in Ampara district of Sri Lanka

## IV. DISCUSSION

This study, conducted across nineteen veterinary ranges in the Ampara district from September to December 2023, provides a comprehensive assessment of the prevalence, mortality, and impact of Lumpy Skin Disease (LSD) in cattle. The data collected from this three-month survey, along with interviews with local farmers, highlights significant variations in LSD prevalence and mortality rates across different ranges. The study corroborates previous findings that the morbidity rate for LSD ranges from 5 to 45% (Sherrylin et al., 2013). same as this study found notable differences in LSD prevalence across veterinary ranges in the Ampara district. The Irakamam range had the highest prevalence at 20.77%, while the Alayadivembu range had the lowest at 3.81%. The overall prevalence of LSD in the district was 8.59%. These figures suggest substantial regional variability, which may be influenced by local environmental, management, and biosecurity factors. Conversely, the mortality rate due to LSD varied significantly, with the highest rate observed in the Nintavur range (6.50%) and zero mortality recorded in the Sainthamaruthu and Uhana ranges. The total mortality rate across the district was 1.7%. Like that, the previous study reveals that mortality rates of 1 to 5% are considered more usual (Sherrylin et al., 2013). The absence of mortality in some ranges indicates effective local management or lower virulence of the virus in those areas, while higher mortality in other ranges suggests more severe outbreaks or less effective control measures.

The study corroborates previous findings that younger animals are more susceptible to LSD (Badhy et al., 2021). The data revealed that the majority of affected cattle were below one year of age, consistent with the heightened vulnerability of younger animals to the disease. In contrast, older cattle were less frequently affected. This age-related susceptibility underscores the need for targeted vaccination and preventive strategies for younger cattle to mitigate the impact of LSD.

The economic consequences of LSD on farms include not only direct losses from animal deaths but also secondary impacts such as reduced growth rates and infertility (Namazi & Khodakaram Tafti, 2021). In this study, 78% of LSD-affected farms reported reduced growth in affected animals, while 22% experienced infertility issues. The lack of reported issues with milk production suggests that milking animals were not significantly affected by LSDV during the study period, which may be due to the timing of the outbreak or effective vaccination coverage in dairy herds.

The spread of LSD is influenced by several known risk factors, including insect populations, communal grazing, the introduction of new animals, and vehicle movements (Ratyotha et al., 2022). According to government records and farmer interviews, the initial introduction of the LSD virus in the Ampara district is believed to have occurred through animal transportation from the Batticaloa district. Subsequent spread likely occurred via arthropod vectors, communal grazing, and shared watering sources. These findings emphasize the importance of controlling vector populations and managing communal resources to prevent the spread of LSD.

The findings of this study highlight the need for targeted control strategies tailored to the specific conditions and risks of different veterinary ranges. Effective vaccination programs, vector control measures, and improved biosecurity practices are essential to reducing both the prevalence and mortality of LSD. Additionally, farmer education on the importance of early reporting and prompt treatment of affected animals can help mitigate the spread of the disease.

In conclusion, the study underscores the significant regional variability in LSD prevalence and impact within the Ampara district. Addressing these variations through targeted interventions and enhanced management practices will be crucial for controlling future outbreaks and minimizing the economic impact of LSD on local cattle populations.

## V. CONCLUSION AND RECOMMENDATION

The LSD outbreak in the Ampara district resulted in high morbidity but low mortality among the cattle population. The primary modes of transmission included the transportation of animals from affected areas, as well as further spread through ticks, communal grazing, and shared water sources. Calves under one year of age were particularly vulnerable, resulting in significant financial losses due to stunted growth and infertility. To control the outbreak effectively, we recommend implementing vaccination programs, restricting animal movement, and culling infected animals. Strategic government policies should be developed, alongside further research on vector insects and robust quarantine practices. Educating herd owners about prevention measures and prioritizing vaccination efforts are also essential for mitigating future outbreaks.

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# How Broiler Meat Quality Influenced by Halal and Kosher Slaughtering Methods?

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***Abstract***

*The increasing global demand for broiler meat has highlighted the significance of religious slaughtering methods, such as Halal and Kosher, due to their impact on meat quality and consumer preferences. This study examines the effects of these methods on the quality of broiler meat, focusing on nutritional composition, physicochemical properties, and sensory attributes. A total of 25 birds were slaughtered using each method, and the resulting meat samples were analysed for moisture, ash, fat, protein content, pH, colour, texture, and sensory qualities. The results showed no significant differences between Halal and Kosher methods in moisture, ash, fat, and protein content. However, Halal meat exhibited higher pH and lightness values, which could influence its appearance and shelf life. Sensory evaluation revealed no significant differences in consumer preference, although Halal meat scored slightly higher in aroma, taste, and overall acceptability. While these findings align with some previous studies, the small sample size limits the generalizability and credibility of the results. Future research with larger sample sizes is necessary to validate these findings and provide a more comprehensive understanding of the differences between Halal and Kosher slaughtering methods. Ultimately, the choice between these methods may be driven more by religious and cultural beliefs than by significant differences in meat quality. This study affirms that both Halal and Kosher methods are effective in producing high-quality broiler meat, reflecting the diversity of dietary practices and the importance of respecting consumer preferences in the global market.*

***Keywords: Halal, Kosher, Slaughtering, Meat quality, Broiler***

## I. INTRODUCTION

The global demand for meat products has steadily increased, driven by a growing population, rising incomes, and changing dietary preferences. Among the various types of meat, broiler chicken remains one of the most consumed worldwide due to its affordability, versatility, and nutritional value (Nusairat, 2022). As consumers become more conscious of food safety, animal welfare, and religious dietary laws. Two religiously prescribed methods, Halal and Kosher, have been particularly scrutinized and debated for their impact on meat quality and ethical considerations (Nakyinsige et al., 2012). Halal and Kosher slaughtering methods, which are required by Islamic and Jewish dietary laws, respectively, have gained significant attention in recent years due to the growing demand for religiously-compliant meat products (Bang, 2016; Farah, 2020). Traditionally, Halal and Kosher slaughtering have been the subject of debate, with concerns raised about animal welfare, pre-slaughter handling, and the potential impact on meat quality (Aghwan et al., 2016). Both methods emphasize the importance of humane treatment of animals and the ritualistic aspect of the slaughtering process. Halal, derived from Islamic law (Sharia), requires that the animal be healthy at the time of slaughter, a prayer be recited, and the blood be fully drained (Sukardi et al., 2022). Kosher slaughter, dictated by Jewish law (Kashrut), similarly mandates a swift cut to the throat, complete blood drainage, and adherence to specific handling protocols (Regenstein et al., 2003). These practices are not only rooted in religious traditions but are also believed to affect the physical and chemical properties of the meat.

The quality of broiler meat is assessed based on various attributes, including tenderness, juiciness, flavor, shelf life, and microbiological safety. Factors influencing these attributes encompass the animal's health, handling, slaughtering method, and post-slaughter processing (Pogorzelski et al., 2022). Even though, the quality of broiler meat is


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a key consideration in the global food industry, as it directly influences consumer satisfaction, industry profitability, and public health (Marchewka et al., 2023). Given the distinctive procedures involved in Halal and Kosher slaughter, there is a growing interest in understanding how these methods impact meat quality compared to conventional slaughtering techniques (Farouk et al., 2014). The scientific community has undertaken numerous studies to evaluate the implications of religious slaughtering on meat quality. These studies often focus on parameters such as pH levels, water-holding capacity, color, texture, and microbial load (Lambooij et al., 2014; Sukardi et al., 2022; Farah, 2020; Della et al., 2021). Broiler meat quality with slaughter methods yet to be study. Therefore, objectives of this study are to: compare the nutritional composition (moisture, ash, fat, protein content) of broiler meat obtained from Halal and Kosher slaughtering methods, Evaluate the physicochemical properties (pH, color, texture) of the meat from each slaughtering method and assess the sensory attributes (aroma, taste, overall acceptability). This comprehensive analysis will provide clear insights into the effects of Halal and Kosher slaughtering methods on broiler meat quality.

## II. METHODOLOGY

### *A. Location*

The research was conducted at Nelna Farm (Pvt) Ltd. slaughtering of broilers was done at Nelna Processing Plant, Meethirigala, Sri Lanka. Broiler breast meat samples were analyzed in the Animal Science Laboratory at South Eastern University of Sri Lanka (SEUSL).

### *B. Sample Collection*

Breed of Arbor Acres plus broilers were slaughtered at the age of 38+ days with an average weight of 2.05 kg. 25 birds in each methods were selected randomly from cage and slaughtered. Availability of reagents and laboratory facilities; that sample size was limited to 25 birds per method.

### *C. Halal Method*

Birds were shackled by their legs and hung vertically for easy bleeding, with sharp knife a person cut the neck in jugular vein area (just below the gullet and the core of the neck); saying Bismillah and Allahu Akber. Let the birds for bleeding and did the evisceration.

### *D. Kosher Method*

Investigation was performed to check the abnormalities in the birds and individual slaughtering was performed in the presence of butcher called “Shochet”. Then carcass were soaked in clean water for 30 minutes. After soaking drip and dry in a downward position for a few minutes. After dripping, meat is salted and left to hang for 60 minutes to draw out any remaining blood, then did the evisceration.

### *E. Storing of Samples*

Once the packed carcass’s temperature reaches -32 $^0$C, which transferred into cold room (T -20$^0$C) and kept for 3 days for the travelling arrangements then transferred to Laboratory in SEUSL for the meat quality parameters’ testing and sensory evaluation.

### *F. Proximate Analysis*

Moisture (Air Dry Oven), Ash (Muffle Furnace), Crude fat (Soxhlet apparatus) and Crude protein (Semi-Automatic Kjeldhal Machine) were analyzed through AOAC Analytical Methods (AOAC, 2006).

### *G. Physiochemical Properties Analysis*

pH, Color and Texture parameters were analyzed in the sample.

#### *1) pH*

pH measured by 2 g of samples homogenized with 18 mL distilled water (60 s homogenized). The mixture was filtered by using filter paper then filtrate was determined by using a pH meter (Model: EUTECH) at room temperature (25 $^0$C).

#### *1) Color*

Color was measured by using a KONICA MINOLTA Chroma meter (CR-410). The values of lightness (CIE L*), redness (CIE a*), and yellowness (CIE b*) were determined by deriving the average of the recorded measurements.

#### *2) Texture*

Texture was measured using a texture analyzer (Model: TA-XT2) and took the readings of hardness, cohesiveness and sponginess.


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*H. Sensory Analysis*

The sensory evaluation was conducted using the 9-point hedonic scale to assess various sensory attributes, including color, tenderness, aroma, texture, taste, and overall acceptability of fried chicken. The evaluation involved 30 untrained panelists who were randomly selected from students enrolled in the Biosystems Technology courses at the Faculty of Technology, South Eastern University of Sri Lanka.

The panelists were not provided with any prior training, as the goal was to reflect general consumer preferences. To minimize biases, the panelists were not informed of the exact purpose of the study or the specific parameters being tested. The samples of fried chicken were served in a consistent and controlled environment to reduce external factors that might influence the panelists' perception. Randomization of panelists and sample order was employed to avoid order effects. Each participant received the same piece of fried chicken to ensure uniformity in the evaluation process.

Additional measures to control for potential biases included standardized lighting, temperature, and presentation of the samples. Panelists were also instructed to cleanse their palate between samples, ensuring that previous tastes did not affect their subsequent evaluations

*I. Data Analysis*

Collected data were subjected normality test and identified as a not normal distribution of data. For that, Mann-Whitney U-Test for the comparisons between Halal and Kosher methods slaughtered meat quality parameters and sensory evaluation analyzed by Friedman test. All statistical analysis were performed by SPSS Ver. 25.0 at the significant level of 0.05.

## III. RESULTS AND DISCUSSION

*J. Nutritional Analysis of Poultry meat*

The proximate analysis was conducted to evaluate the nutritional composition of broiler meat obtained through Halal and Kosher slaughtering methods. The analysis focused on determining the moisture, ash, fat, and protein content of the meat samples. The results are presented in Table 01. There is no significant difference between Halal and Kosher slaughtering methods ($p > 0.05$) in all proximate parameters. Moisture content was high value in Kosher method (77.78 %) and least value for Halal (73.53 %). The mean moisture contents for Halal meat and Kosher meat were in close range to the values (74.16%, 77.42% respectively) reported by Rahman et al. 2019. The moisture content of meat is primarily influenced by factors such as the technique of slaughter, the type of meat, the pH value, and the amount of drip loss. During the slaughtering process, the moisture levels in the meat decrease slightly as a result of the dipole forces acting on the tissues (Varnam & Sutherland, 1995). Due to the greater amount of blood extracted during Halal slaughtering compared to other procedures, the moisture level in Halal meat is slightly lower than in meat from other slaughtering methods (Rahman et al., 2019). Ash content of Halal meat was 3.09 % which higher than Kosher meat (3.18 %). Highest crude fat was recorded in Halal meat (2.07 %) and lowest in Kosher meat (2.05 %). In protein highest value recorded in Halal meat (21.23 %) followed by Kosher meat (21.09 %). According to Rahman et al. 2019 that, the decreased value of non-Halal slaughtered meat may be attributed to protein degradation caused by elevated stress levels. During the process of slaughtering, animals and birds experience significant stress, leading to the release of muscle glycogen into the bloodstream and the creation of lactic acid in the muscles. This mechanism leads to the acidification of muscles and triggers several biochemical changes in muscles after death (Bender, 1992). These alterations result in a reduction in the ability to extract protein, leading to an increase in the loss of nitrogen from muscles and ultimately causing protein degradation. In addition, muscle proteins begin to break down shortly after death as a result of several microbial and enzymatic processes. Due to its preference for efficient blood drainage, the Halal method exhibited lower levels of protein degradation compared to alternative slaughter procedures.

*K. Physicochemical Properties*

*3) pH*

The highest pH value was observed in the Halal method (6.03 ± 0.02), while the lowest pH was recorded in the Kosher method (5.91 ± 0.01). And there is a significant different between two methods ($p < 0.05$). The pH of meat is mostly determined by the metabolic condition of the muscle at the moment of slaughter. The levels


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fluctuate correspondingly at the beginning and after the last phase of severity mortis. The elevated pH levels observed at the time of slaughter may be attributed to the tension experienced by the muscles during the struggling of birds following the severing of their necks. During the exertion, the glycogen stores were exhausted, leading to a decrease in the generation of lactic acid in the muscles, which in turn caused an increase in pH levels (Grashorn, 2010).

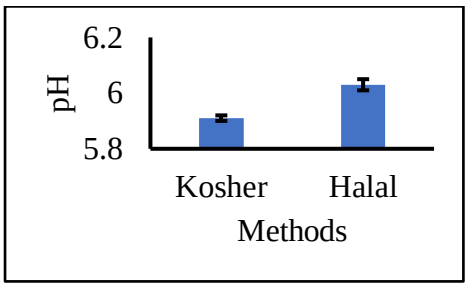


Figure 05: pH of meats

*1) Color*

The color of meat is strongly associated with the concentration of haem-containing substances, such as myoglobin, hemoglobin, and cytochrome C. Among these three molecules that include haem iron, myoglobin has the most impact on the color of poultry meat (Froning et al., 1968). The myoglobin level in the breast muscle was substantially lower compared to the leg/thigh muscle (Fletcher, 1999). Based on the research there was no significant difference in the redness (8.91 ± 0.57, 9.05 ± 0.44) and yellowness (10.83 ± 0.43, 10.73 ± 0.47) values between the Halal and Kosher slaughtering methods ($p > 0.05$). But significant difference was observed in the lightness of the meat ($p < 0.05$) and Halal slaughtered meat's lightness was 59.62 ± 0.82, Kosher method was 58.39 ± 0.82 (Table 2). The difference in lightness can be attributed to the variation in meat pH; and higher pH level associated with lighter meat color (Wattanachant, Benjakul, & Ledward, 2004). In this research Halal method have high pH (6.03) and lightness than Kosher method.

*2) Texture*

Texture is the primary sensory attribute that has the most impact on the evaluation of overall quality (Fletcher, 2002). Texture analysis of the meat samples, including measurements of hardness (93.00 ± 1.08, 94.00 ± 1.02), cohesiveness (0.65 ± 0.03, 0.60 ± 0.01) and sponginess (1.49 ± 0.07, 1.58 ± 0.05) revealed that no significant differences between the Halal and Kosher slaughtering methods ($p > 0.05$) (Table 02). These results justified that the slaughtering method does not have a substantial impact on the texture attributes of broiler chicken meat and but get high value of texture in Halal slaughter meat (Rahman et al., 2019). However, it is important to note that other factors such as breed, feed, and pre-slaughter handling, in addition to water-holding capacity and pH, can also influence meat texture (Mir et al., 2017).

*L. Sensory Evaluation*

The sensory evaluation revealed that (Figure 02), there is no significant different between Halal and Kosher method slaughtered meats ($p > 0.05$); aroma, taste and overall acceptability were recorded high hedonic scale for Halal method (Figure 02). Other parameters except tenderness remain same hedonic scale in both methods. Blood retention and the subsequent development of volatile compounds during cooking has influenced on aroma and taste of the meats that, blood retention negatively effects on aroma and taste (Farouk et al., 2014). Blood retention of poultry meats influenced by pre-slaughter stunning (Gregory, 2005). In this research stunning performed in Kosher method before slaughtering that may influenced the meat quality. Even though both methods were slaughtering by associate humane, that may give same hedonic scale for color and texture; which justified by Kua et al. 2022; Martuscelli et al. 2020, suggesting that consumers may associate humane slaughtering practices with better visual quality of the meat.

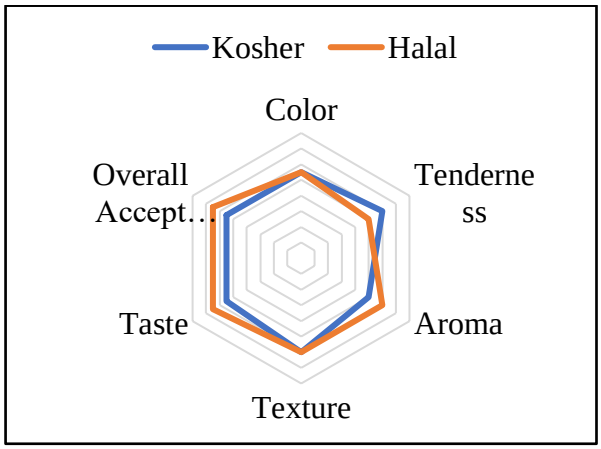


Figure 06: Sensory Evaluation of meats


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## IV. CONCLUSION

The findings from this study reveal that both Halal and Kosher slaughtering methods produce broiler meat of comparable quality across most parameters analyzed, including proximate composition, texture, and sensory attributes. While the proximate analysis showed no significant differences in moisture, ash, fat, and protein content, slight variations were observed, with Kosher meat having marginally higher moisture levels and Halal meat showing slightly elevated protein content. These differences are likely due to the specific blood drainage techniques employed in each method. The higher pH and lightness observed in Halal slaughtered meat could influence both the visual appeal and the shelf life of the meat, suggesting potential implications for marketing and storage practices. Sensory evaluation results, where Halal meat scored marginally higher in aroma, taste, and overall acceptability, indicate that subtle differences in meat processing can impact consumer perception and preference.

The small sample size, specific conditions under which the research was conducted, and potential biases inherent in the evaluation processes may have influenced the results. Acknowledging these limitations provides a more balanced view and Indicates the need for further research to confirm these findings across larger samples and different environments. Additionally, the study did not compare Halal and Kosher methods with conventional slaughtering techniques, which could provide a more comprehensive understanding of how these methods stack up against mainstream practices in terms of meat quality and consumer preference.

For the poultry industry and policymakers, these findings suggest that both Halal and Kosher methods are effective in producing high-quality broiler meat, aligning with humane slaughter principles while satisfying consumer expectations. The minor differences observed may be leveraged for targeted marketing strategies that emphasize specific sensory attributes preferred by certain consumer groups. This study contributes to the existing literature by highlighting the subtle but potentially market-relevant differences between Halal and Kosher slaughtering methods, offering valuable insights that can inform product differentiation and consumer choice in a culturally diverse market landscape. These insights underline the importance of considering both religious and cultural practices alongside scientific evidence when shaping industry standards and policies.

Table 01 : Proximate analysis of Halal and Kosher slaughtering methods

[a]

| Methods | Moisture% | Ash% | Fat% | Protein% |
|---|---|---|---|---|
| **Kosher** | 77.78 ± 5.38[a] | 3.18 ± 0.51[a] | 2.05 ± 0.10[a] | 21.09 ± 0.28[a] |
| **Halal** | 73.53 ± 3.87[a] | 3.09 ± 0.53[a] | 2.07 ± 0.11[a] | 21.23 ± 0.22[a] |

*superscript, similar superscript not significantly different in column wise at the level of 0.05*

Table 01: Color and Texture Parameters of meats from Halal and Kosher slaughtering methods

[a, b]

| Methods | Color | | |
|---|---|---|---|
| | L* | a* | b* |
| **Kosher** | 58.39 ± 0.82[a] | 9.05 ± 0.44[a] | 10.73 ± 0.47[a] |
| **Halal** | 59.62 ± 0.82[b] | 8.91 ± 0.57[a] | 10.83 ± 0.43[a] |
| | **Texture** | | |
| | Hardness | Cohesiveness | Sponginess |
| **Kosher** | 94.00 ± 1.02[a] | 0.60 ± 0.01[a] | 1.58 ± 0.05[a] |
| **Halal** | 93.00 ± 1.08[a] | 0.65 ± 0.03[a] | 1.49 ± 0.07[a] |

*superscript, similar superscript not significantly different in column wise at the level of 0.05*


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# Development and Evaluation of Low-cost Automatic Incubator that Applied Inverter Technology

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***Abstract***

*An incubator is a device that is used to turn the fertile eggs hatching successfully at suitable environmental conditions by regulating the temperature and humidity of the enclosure. To meet the high demand of poultry production artificial egg hatching is needed. So temperature controls are an important factor for the incubation process. The source of power in an incubator is electrical energy. Energy is limited on earth. So proper use of energy is an important factor. By controlling the temperature and humidity efficiently we can reduce the electrical energy consumption. In this paper, we have discussed energy-saving techniques in hatching incubators which can save energy. The possibility of hatching egg is about 35-40° centigrade but the optimum temperature should be kept at 37.5° centigrade for 21 days and Below 35° centigrade and above 40.5° centigrade no embryo can be survived for hatching. Cooling eggs for short periods says 30-40 minutes out of 24 hours regularly with no harmful effect during incubation and probably profit. So to reduce energy consumption we introduced a power-saving mood that keeps the system shut off for 15-20 minutes within 24 hours during incubation. Using the inverter, we have simulated the backup system which has improved the temperature rise time and settling time compared to the conventional egg incubator. Calculation shows that this system is energy efficient.*

***Keywords: fertile, temperature, hatching, survived, embryo, simulate,***

## I. INTRODUCTION

An incubator is most important part of the poultry production process (hatching) and protects the environment conditions. Incubator an insulated enclosure in which temperature, humidity, and other environmental conditions can be regulated at levels optimal for growth, hatching, or reproduction. There are three principal kinds of incubators: poultry incubators, infant incubators, and bacteriological incubators. Incubators are core actors in entrepreneurial ecosystems. Incubator is a device used to grow and maintain microbiological, cell cultural practices. [Boleli, I.C. et al. (2016)]

Incubator based on the working principle that organisms require a particular set of parameters for their growth and development with the optimal condition (under artificial conditions) of temperature, humidity, oxygen, and CO2 levels. Avian incubation is a technique that keeps eggs warm in an artificial environment. An incubator is used for the artificial hatching of eggs; it lets the foetus grow inside without the presence of the mother to provide the conditions for growth and hatching. [J.A. Oluyemi and F.A. Robert,1982.]

The high cost of incubators is a major factor restraining the growth of this market. The higher cost of machines is due to the costly raw material required for egg incubators. Additionally, the energy cost is another hampering factor to this market in the forecast period. [ E.A.O. Laseinde, Woye and Sons, 1994] Poultry farming has to face other challenges associated with high vaccination costs, and veterinary care services. [M.E. Ensminger, Poultry Science (Animal Agricultural Series)] The non-availability of credit is another issue affecting this industry. The growing population and increasing consumption of processed food along with government initiatives promoting the consumption of protein-rich diets are expected to increase the demand for eggs. Increasing the hen population would be required to meet the growing demand for eggs. [ Hsieh, H. F., and Shannon, S. E., 2005.]

The ability of an incubator to improve the hatchability of eggs further assists the increase of hen population thereby grows up the demand for automatic incubators. [S. Sansomboonsuk, "An Automatic Incubator," J. Energy Research,] At a global level, the market growth for poultry


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consumption will be in-line with the global GDP in the long-term forecast. The increasing disposable incomes and lifestyle standards are further flourishing this industry. [Audretsch, D. B., 2007.] The equipment runs on solar energy and has an efficiency of around 90% for hatching chicken eggs. Such innovations for sustainable products will prevail in the egg incubator market. [ Lamine, W., Mian, S., Fayolle, A., Wright, M.,Klofsten, M. and Etzkowitz, H., 2016] Most small-scale egg incubators are domestically fabricated with simple incubation technology and it leads to several complications and less hatching percentages. Egg incubators available in market have not the inverter technology. Hence development of low-cost small-scale incubator with improved technology has become very important Hence, this was an attempt to develop an automatic egg incubator with inverter technology. [Barbero, J. L., Casillas, J. C., Ramos, A., & Guitar, S., 2012.]

## II. MATERIALS AND METHODOLOGY

Research was conducted in the School of Agriculture, Kundasale, Sri Lanka and the incubator obtained here was prepared using the following materials and equipments.

### *A. Materials*

Temperature controller, Timer, 220v current indicator, DC fan, holder, bulb, TT wire, 3 core wire, 13A plug top, 12v power supply, 12v to 220v ac inverter, reform box small, tape, turning motor, Switch, Aluminums bar. Measurement tape, Paper cutter, wrench, Screw driver, lighter, Glue gun, Glue stick, revert gun, Bouth Machine, soldering iron.

### *C. Methodology*

The measurement was taken of a regiform box by first (18.5 inches long, 15.7 inches, width, and 14.1 inches Height) was prevented, giving beauty fully covered by yellow color cello tape. The temperature controller, timer, switch, humidity meter, current indicator, and inverter were Arranged and fixed by a plastic tray and lid of the regiform box. Then put some holes on the side of the plastic tray to make air ventilation.

The wires of all devices were connected by the tray. Then fixed the 12-volt DC fan under the lid in the central position (DC fan 4-inch-long and wide,1-inch thickness), (fixing bolt and nut 8mm thickness and 8 inches long). The heat bulb was a fixed lid on the Regiform box between the fan and the lid (We used a motorbike head bulb for a heating source). The PVC pipe bulb holder was fixed by the center of the regiform lid and a small hole in the lid inserted the wire fixed bulb. Power was supplied and the incubator (All controlling devices are connecting the control panel) finally fixed the controlling unit on a regiform box (Take the measurement and fix the middle of the lid) using a 6mm wall plug and glue to fix the control panel.

Figure 01: Regiform box with tools

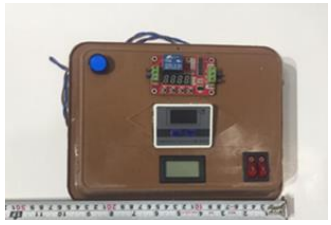

Figure 02: Control panel

Table 01: Cut the entire Aluminum bar for the automatic system with the measurement

| **Aluminium Bar Type** | **Length of the bar** | **Need Quantity** |
|---|---|---|
| 0.75:0.75 inch L bar | 17.7 inches | 2 pieces |
| 0.75:0.75 inch L bar | 15.7 inches | 2 pieces |
| 0.75:0.75 inch L bar | 3.5 inches | 4 pieces |
| 0.75:0.5 inch L bar | 12.9 inches | 4 pieces |
| 0.75:0.5inch L bar | 13.7 inches | 2 Pieces |
| 0.75:0.5 inch L bar | 5.9 inches | 1 pieces |
| 0.5:0.5 inch u bar | 12.5 inches | 5 pieces |
| 0.5:0.5 inch u bar | 4.7 inches | 1 pieces |

To develop the automatic system for an incubator, bind 11.7 inches 2 pieces of L bar along with 15.7 inch 2-piece L bar like rectangular shape by rivet gun. It acts as the outer tray of an incubator. Then bind the 12.92 inch 2 pieces of L bars with 13.7


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inch 2 pieces of L bars by rivet gun. It acts as an incubator tray and, after that binds 12.9inch 2 pieces of L bar with 3.5 inch 2 pieces of L bar like before. It's a water-content tray. Connect for H runner with inner tray and joint 12.5-inch U bar 5 pieces with inner tray at 5cm spacing. Fixed the bold and nut in the middle of the motor shaft (1.5-inch-long, 2 inch 3mm thickness bold and nut were used).

## III. RESULT AND DISCUSSION

Table 02: Hatching detail

| Trail | | HATCHING 1 Trail-1 | | HATCHING 2 Trail-2 | | HATCHING 3 Trail-3 | |
|---|---|---|---|---|---|---|---|
| Eggs | BOVEN BROWN | 15 | 14 | 30 | 27 | - | - |
| | DEKALB WHITE | 15 | 12 | - | - | 30 | 27 |
| Total | | 30 | 26 | 30 | 27 | 30 | 27 |
| Percentage (100%) | | 86.6% | | 90% | | 90% | |
| Average Percentage | | 88.8% | | | | | |

This Table 02 was illustrated of three trail hatching percentage of egg, were used to two type varieties of eggs first trail half of percentage brown and white eggs used to measure the percentage of hatching then trail 2 only used to brown eggs, trail 3 only used to white egg and make the calculation.

Table 03: Comparison between My incubator and Company product

.

| No | Data | Company Product | New Research Product |
|---|---|---|---|
| 1 | Incubator Body Material | Out Site Stainless Steel inside Aluminium sheet | Out Site insulation tape inside Regiform |
| 2 | Temperature Controller Model | XM -18 E Computerized controlling system 220V AC | W-300 temperature controller 12V-DC |
| 3 | Heating Material | electrical heater (500w) | motor bike head bulb |
| 4 | Air Ventilation System | AC-220 v 12inch fan | DC - 12 v 4 inch fan |
| 5 | Automatic Turning System | 45 angle rotation method | rolling type rotation method |
| 6 | Automatic Turning System Material | Iron steel | Aluminium bar |
| 7 | Electricity consumption | 90 unit (21days) 150 watts hour per day | 4.2 unit (21days) 0.2 watts hour per day |
| 8 | Hatching rate | 90-92% | 85-90% |
| 9 | Hatching time | 21days | 21days |
| 10 | Chicks Quality | Good | Good |
| 11 | Cost of Product | 75000/= | 12500/= |
| 12 | Used Technology | Recommendation method | Reducing electricity consumption inverter technology |
| 13 | Egg Candler Method | manual egg Candler | manual egg Candler |
| 14 | Humidity control | automatic motor | manual hand sprayer |
| 15 | Power Source | 220V direct current AC/single phase | AC DC 220V-12V inverter 220V AC single phase |
| 16 | Egg Capacity | 60 | 30 |


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| | | | |
|---|---|---|---|
| 17 | Total Weight of the Machine | 35 Kg | 1.8 Kg |
| 18 | Incubator Model | AP incubator (India) | My own product |
| 19 | Used Parameters | | |
| 20 | 1 – Temperature | 37.5C | 37.5C |
| 21 | 2 – Humidity | 1-18days 60-65%<br>18- 21 days 80% | 1-18days 60-65%<br>18- 21 days 80% |
| 22 | 3 - Turning Time | 1 hour interval per 1 turning | 1 hour interval per 1 turning |
| 23 | 4 - Candling time | 10-18 days | 10-18 days |
| 24 | Suitability | large scale farmers | Small Scale Farmers |
| 25 | Total Watts | 0.2 Kw / hr | 0.0083 Kw/hr |

This Table 03 was illustrated compared to the marketing products and our research products. The research products low cost and highly efficiency of small scale farmers,

*A. Sensory Analysis*

Above the quality & quantity parameters are used to develop incubators collection among small-scale farmers. According to their response, 20 customers were selected and given the incubators for trial and data collection. Then collected data were compared with standard incubators using parametric and nonparametric procedures. A 5 point Likert scale was used to evaluate the compatibility of the incubator.

*B. Data Analysis*

Data analysed by SPSS Software, VERSION – 25, mean separation method is turkey. The Kruskal-Wallis Test analysed all the non-paramedic data.

*C. Questionnaire Survey on Developed Tool*

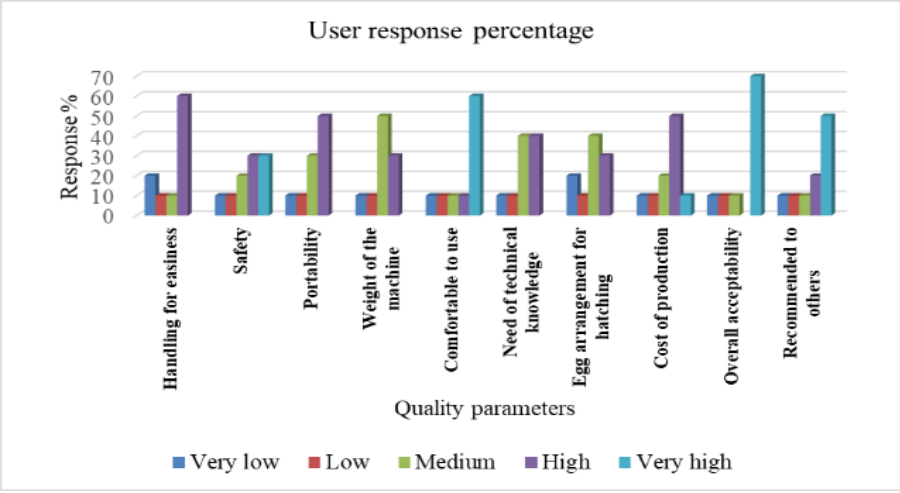


Figure 04: User responses collected through a survey

It was observed that the highest percentage (60%) of respondents highly accepted the handling for easiness, the lowest percentage (10%) of respondents low & medium level accepted and 20% of respondents very lowly accepted the handling for easiness.

An equal percentage of (30%) respondents were highly accepted and very highly accepted (30%) of the safety of the incubator and an equal percentage of respondents were lowly (10%) and very lowly (10%) of the safety and 20 % of respondents were medium level accepted the safety.


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The highest percentage of (50%) respondents highly accepted the portability comparatively lower percentages (10%) of respondents were very slowly and lowly accepted the portability and the remaining 30% of respondents accepted the portability medium level.

The highest percentage of (50%) respondents accepted the weight of the machine as medium level comparatively lower percentage (10%) of respondents accepted the weight of the machine as very low &low level

The highest percentage of (60%) respondents were very highly accepted the comfortable to use. From the remaining 40% of respondents, 10% of respondents accepted the very low level, 10% of respondents accepted the low level, 10% of respondents accepted the medium level & final 10% of respondents accepted the high level comfortable to use.

The highest percentage of (40%) respondents highly and medium level accepted the need for technical knowledge and the lower percentage (10%) of respondents very low & low level accepted the need for technical knowledge

The highest percentage of (40%) respondents were medium level accepted the egg arrangement for hatching and the lowest percentage (10%) of respondents lowly accepted 30% of respondents were high level accepted the egg arrangement remaining 20% of respondents were very low-level accepted.

The highest percentage of (50%) respondents highly accepted the cost of production, a lower percentage (10%) of respondents were very low, low, and very high levels of acceptance and the remaining 20% of respondents were medium level accepted the cost of production.

The highest percentage of (70%) respondents very highly accepted the overall acceptability 10% of respondents accepted very low level, 10% of respondents accepted low level and 10% of respondents accepted medium level

The highest percentage of (50%) respondents very highly accepted the recommendation 20% of respondents highly accepted and from the remaining 30% of respondents; 10% of respondents very low level accepted, 10% respondents accepted low level and 10% of respondents accepted medium level of recommended to others.

D. *Performance of the Machine*

Table 04: Mean value for treatments

| Data | Ranks Treatments | No | Mean rank | P-value |
|---|---|---|---|---|
| Easiness | My incubator | 20 | 15.05 | 0.000 |
| | Market product | 20 | 5.95 | |
| Safety | My incubator | 20 | 13.30 | 0.019 |
| | Market product | 20 | 7.70 | |
| Portability | My incubator | 20 | 15.50 | 0.000 |
| | Market product | 20 | 5.50 | |
| Weight | My incubator | 20 | 5.50 | 0.000 |
| | Market product | 20 | 15.50 | |
| comfortable | My incubator | 20 | 14.20 | 0.002 |
| | Market product | 20 | 6.80 | |
| Need of technical knowledge | My incubator | 20 | 5.95 | 0.000 |


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| | | | | |
|---|---|---|---|---|
| | Market product | 20 | 15.05 | |
| Egg arrangement | My incubator | 20 | 10.50 | 1.000 |
| | Market product | 20 | 10.50 | |
| Cost of production | My incubator | 20 | 5.50 | 0.000 |
| | Market product | 20 | 15.50 | |
| Overall acceptability | My incubator | 20 | 10.50 | 1.000 |
| | Market product | 20 | 10.50 | |
| Recommendation | My incubator | 20 | 15.50 | 0.000 |
| | Market product | 20 | 5.50 | |

The value represents 5 point Likert scale. The $p<0.05$ is significant for easiness, portability, safety, comfort, weight need of technical knowledge, cost of production & recommendation of the machine, according to fried man test. The $p<0.05$ is not significant for egg arrangement, overall acceptability.

## IV. CONCLUSION AND RECOMMENDATION

Performance evaluation of the incubator reveals the above average results; from 30 fertile eggs the average hatchability rate is 88.6%. Cost evaluation of incubator with minimal electricity consumption 4.2 units per 21 days Cost of production also very low compared with market product. So this incubator is highly accepted by farmers. Data collection from farmers also highly satisfied and accepted all the features therefore can highly recommend this incubator applies on inverter technology according to hatchability percentage, electricity consumption, cost of production, and easiness of handling.

In the future, there is a chance to modify the incubator to hold large numbers of egg capacity. Can use batteries instead of current. Can minimize the amount of electricity consumption than now. Can change the heating source and temperature controller instead of the XM -18 computerized controller. Energy storage solutions such as battery or renewable energy sources. Examine the possibility of establishing networks of incubators connected by the Internet of Things to exchange information and insights. Based on the power source renewable energy options are likely to gain attention in forecast years owing to manufacturers' focus on eco-friendly production and cost-effectiveness. With the renewable option, companies can decrease their carbon emission and aid in sustainability development

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