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ECONOMIC IMPACT OF EDIBLE OFFAL REJECTION AT EL-QUREIN SLAUGHTERHOUSE, EGYPT

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Abstract

The thorough examination of animal carcasses and organs intended for human consumption is crucial for food safety. However, it is not always conducted adequately due to time constraints during the slaughter process. A cross-sectional study was undertaken to identify the key reasons for the rejection of edible offal in slaughtered animals at El-Qurein slaughterhouse in Sharkia province, Egypt, and to evaluate the associated economic losses during the period from August, 2020 till July, 2021. The study examined 1,218 organs (406 livers, 406 lungs, and 406 hearts) from various animals (cattle, buffaloes, camels, sheep and goats), among which 138 organs (78 livers, 38 lungs, and 22 hearts) were rejected, primarily due to lesions caused by Cysticercus ovis, fascioliasis, Cysticercus tenuicollis, pneumonia, and hydatid cysts. The financial loss at the slaughterhouse due to organs rejection over the twelve-month period totaled 1,113,905.24 Egyptian pounds (equivalent to 71,865 USD). The high frequency of meat rejection and resulting financial impact exceeded the region's local revenue. This study highlights the persistent prevalence of parasitic diseases, resulting in significant detrimental economic repercussions in Sharkia province, Egypt. Furthermore, the present work underscores the necessity for the development of an effective control program addressing the causes of meat rejection in the region.

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Introduction

The sustainable rise in the global number of human population necessitates a corresponding proportional increase in the production of animal-derived food products, fostering a balanced growth in both developed and developing countries [1]. In Egypt, cattle, camels, sheep, and goats are the vital sources of red meat, offering crucial protein for human diets [2,3]. Acknowledged for its nutrient richness, red meat contains high-quality proteins, trace elements, and vitamins, contributing significantly to dietary balance [4]. Additionally, the edible offal like livers, kidneys, and tongues despite their lower consumption rates compared to meat, hold the considerable economic value and gastronomic appeal [5]. However, persistent challenges arise from infectious diseases and climate change, thus hindering the meat industry's efforts to maintain red meat's dietary importance [6].

Meat and edible offal often harbor various contaminants, including pathogens, posing health risks and potential negative impacts [7,8]. Widespread bacteria in food of animal origin pose transmission risks to humans during meat handling, preparation, cooking and consumption, as well as during rejection procedures at the slaughterhouse [9]. Diseases like bovine tuberculosis, and parasitic infections such as cysticercosis, hydatidosis, and fascioliasis further threaten human health and meat safety [10,11,12, 13,14]. Consequently, ensuring meat safety and hygiene is a critical concern for all parties concerned, including producers, distributors, and consumers.

In developing countries, the slaughterhouses play a crucial role in providing data on disease prevalence, public health importance, and financial losses due to organ rejection [15,16]. Stringent meat inspection regulations, that include pre- and post-slaughter analyses, are vital for protecting consumers from foodborne hazards [17,18]. Veterinarians conduct thorough examinations to assess carcass quality and safety, addressing potential health risks [19]. However, certain diseases, like fasciolosis, hydatidosis, and cysticercosis, inflict significant economic losses through partial organ or carcass rejection, impacting both public health and the economy [20].

In Egypt, numerous studies have been conducted at various slaughterhouses across various regions of the country, with a primary focus on the epidemiological aspects of specific disease conditions such as parasitic and bacterial diseas-

es [21,22]. Nevertheless, there is currently a lack of available data on the primary causes of rejection and the corresponding economic losses in Sharkia province slaughterhouses in Egypt. Therefore, the objectives of this study were to identify the major causes of total edible organs (lungs, liver, and heart) rejection and to assess the associated direct financial losses as a result of total edible organs rejection at El-Qurein slaughterhouse in Sharkia province, Egypt.

Objects and methods

Samples collection and preparation

The present research was carried out at El-Qurein slaughterhouse in Sharkia province, Egypt at the period from August, 2020 till July, 2021. Sharkia province is situated in the eastern region of the Nile delta in Egypt, with geographical coordinates ranging from approximately 30.7 °N to 31.63 °E. Furthermore, it has the second-largest agricultural area within the country, following Beheira province, boasting a cultivated plant area covering 824,098 acres.

Research project

The cross-sectional study was carried out to determine the major causes of lungs, livers, and heart rejection and to evaluate the direct financial losses. In total 220 randomly selected cattle, in particular: 89 buffaloes, 40 camels, 47 sheep, and 10 goats were subjected to ante-mortem and postmortem examinations following the guidelines outlined in Ministerial Decision No. 517/1986 issued by the Egyptian Ministry of Agriculture and Land Reclamation (MALR) [23].

Antemortem inspection

All animals were observed while resting and moving within the lairage pens. Furthermore, their general behavior, visual cleanliness, symptoms of diseases, nutritional status, and any other irregularities were monitored according to standard ante-mortem inspection procedures. Animals deemed suitable for slaughter, being free from any diseases or abnormalities, were then sent for slaughter [24].

Postmortem meat inspection

The thorough postmortem examination was carried out, involving visual inspection, palpation, and systematic incision of each internal organ, with particular attention given to the liver, lungs, and heart, in order to detect cysts, various types of adult parasites, and any other abnormalities.

Assessment of financial loss

As local visceral organs such as lungs, livers, and hearts were assessed for rejection, only the direct losses associated with rejection were calculated. Meanwhile, the average prevailing market prices of each organ were determined by surveying the prices in the shops of the various butchers who purchase the meat from the slaughterhouse. These variables were then input into the following formula to determine the annual financial loss resulting from rejection of the organs deemed unsuitable for human consumption due to gross pathological lesions [25].

Thus, the estimated annual economic loss (EL) due to organ/carcass rejection from local market was defined by the following formula:

$$EL = S_{rx} \times C_{oy} \times R_{oz} \quad (1)$$

Where,

S_{rx} — annual animal slaughter rate of the slaughterhouse;
C_{oy} — average cost of each liver/lung/heart/carcass;
R_{oz} — rejection rates of liver/lung/heart/carcass.

Ethics statement

The search protocol has been revised and approved by the Institutional Animal Care and Use Committee, Zagazig University, Egypt, with an approval number (ZU-IACUC/2F/286/2022).

Statistical analysis

The data of infected organs were analyzed with *Chi-square (χ2)* tests using IBM SPSS Statistics for Windows software version 21. *P-values* ≤ 0.05 were considered statistically significant.

Results and discussion

Rejection rate of edible organs of the slaughtered animals

According to the findings outlined in the Table 1, a total of 1,218 edible organs were examined, consisting of 406 livers, 406 lungs, and 406 hearts sourced from various slaughtered animals including cattle, buffaloes, camels, sheep, and goats. Among these organs, 138 were deemed unsuitable for consumption, with 78 livers, 38 lungs, and 22 hearts being rejected. This resulted in rejection rates of 0.19 (19%), 0.09 (9%), and 0.05 (5%) for rejected livers, lungs, and hearts, respectively, attributed to various lesions.

Table 1. Rejection rate of edible organs of animals slaughtered at El-Qurein slaughterhouse during 2020 and 2021

Animal species	No. of examined edible organs			No. of rejected edible organs			Rejection rate, (%)		
	Liver	Lung	Heart	Liver	Lung	Heart	Liver	Lung	Heart
Cattle	220	220	220	52	3	5	0.24 (24%)	0.01 (1%)	0.02 (2%)
Buffaloes	89	89	89	11	26	2	0.12 (12%)	0.29 (29%)	0.02 (2%)
Camels	40	40	40	2	9	2	0.05 (5%)	0.23 (23%)	0.05 (5%)
Sheep	47	47	47	12	0	13	0.26 (26%)	0.00	0.28 (28%)
Goats	10	10	10	1	0	0	0.10 (10%)	0.00	0.00
Total	406	406	406	78	38	22	0.19 (19%)	0.09 (9%)	0.05 (5%)

The recent study indicates that there were no reasons for rejection noted during the antemortem inspection of the animals prior to slaughter. However, all rejections were attributed to diseases identified during postmortem

inspection. Table 2 provides a summary of the postmortem findings from the animals inspected and slaughtered at El-Qurein slaughterhouse in the years 2020 and 2021.

In the investigated slaughterhouse, out of a total of 220 cattle slaughtered, the rejection rates for liver, lung, and heart were 0.24 (24%), 0.01 (1%), and 0.02 (2%), respectively. According to the study, the highest proportion of liver rejection was caused by fasciolosis, accounting for 20.45%, while abscesses were the least common cause, accounting at 3.18%. *Cysticercus bovis* was identified as the primary cause for heart rejection, accounting for 2.27%, and hydatidosis was the leading cause for lung rejection, with a portion of 0.91%. Additionally, this research indicated that the incidence of liver rejection in buffaloes was 0.12 (12%), while for lungs and hearts, it was 0.29 (29%) and 0.02 (2%), respectively. The study identified fasciolosis as the primary cause of liver rejection, accounting for 7.87% of cases. Pneumonia was identified as the predominant reason for lung rejection, constituting 15.73% of cases, while pericarditis was the leading cause of heart rejection, representing 2.25% of cases.

Moreover, the primary reasons for rejecting the camel edible organs such as the liver, lung, and heart were hydatid cyst and abscess (2.5% each), hydatid cyst (12.5%), and *Cysticercus dromedary* (5%), respectively.

Regarding sheep carcasses, the primary reasons for liver, lung, and heart rejection were *Cysticercus tenuicollis*, accounting for 17.02% of liver rejections, and *Cysticercus ovis*, responsible for 27.66% of heart rejections. Lungs showed no signs of lesions.

Concerning goat carcasses, *Cysticercus tenuicollis* (10%) was the primary reason for liver rejection, whereas the lungs and heart showed no abnormalities.

The rejection rate of cattle liver was significantly higher than lung and heart (P-values ≤ 0.05). Moreover, the rejection rate of liver in goats was significantly higher than lung and heart (P-values ≤ 0.05).

Causes of liver rejection

In the recent research, it was observed that the liver manifested the most significant number of abnormal conditions, totaling 78 cases. Among the various animals studied, cows had 52 liver lesions, buffaloes had 11, camels had 2, sheep had 12, and goats had 1. The main reasons for liver rejection were identified as fasciolosis (accounting for 28.32%), *Cysticercus tenuicollis* (27.02%), necrosis (6.55%), abscess (3.62%), and hydatid cyst (2.5%). Lower obtained rate of fascioliasis in cattle was recorded by Tembo and Nonga [26] in Tanzania (4.5%) and Assefa and Tesfay [27] in Ethiopia (9.26%). Moreover, in the study of Jaja et al. [28], the prevalence of fascioliasis among cattle carcasses in South Africa was equal to 5.95%, 4.48%, and 2.7% for the years 2010, 2011, and 2012, respectively. While, according to Denbarga et al. [29], Mohammed et al. [16] in Ethiopia, Cadmus and Adesokan [30] in Western Nigeria, and Dukundane et al. [31] in Gicumbi districts of Rwanda, the higher prevalence of fasciolosis in cattle carcasses with percentages of 86.4%, 36.06%, 29.44%, and 90%, respectively was noted.

Fasciolosis significantly contributes to the onset of various liver conditions in buffaloes, such as bile duct hyperplasia, hepatitis, and fatty degeneration. The prevalence of fascioliasis in Egyptian slaughterhouses is notable, likely due to the abundance of larvae and favoring climatic conditions. This parasitic infection is widespread across several African nations and typically doesn't result in mortality in livestock. However, it does lead to diminished productivity in animals and the discard of infected livers in slaughterhouses [32].

Concerning *Cysticercus tenuicollis*, lower rates of 7.81%, 5.73%, and 0.71% were observed in sheep liver through the investigation of Bayu et al. [33], Mandefro et al. [34], and Dejene et al. [35] in Ethiopia, respectively. The presence of *Cysticercus tenuicollis* is linked to the extent of pasture contamination caused by unrestricted dogs' movement and the husbandry practices as well as grazing habits of these animals. These factors play a role in facilitating the transmission cycle among ruminants, dogs, and other wild canines [33].

Causes of lung rejection

The combined total of 38 lesions were identified in the lungs. Specifically, cows had 3 lesions, buffaloes had 26 lesions, and camels had 9 lesions. The primary reasons for lung rejection included pneumonia (20.73%), hydatid cysts (17.9%), tuberculosis (9.44%), and abscesses (5%). These results were nearly similar to the previous studies conducted by Mummed and Webb [36], and Cadmus and Adesokan [30] who documented that the prevalence of pneumonia cases among cattle carcasses in Ethiopia and Western Nigeria was equal to 22.68% and 21.38%, respectively. Lower prevalence of pneumonia cases was detected in Nigeria by Raji et al. [15] with a rate of 8.79%. In another study performed by Jaja et al. [37], lower rates of pneumonia (1.09%, 2.21%, and 0.77%) were recorded at three Namibian slaughterhouses. In contrast to that, Abdel-Rassol et al. [38] showcased a greater proportion of 47.4% in Egypt.

Hydatidosis prevalence rates vary across various regions, as evidenced by studies conducted in Tanzania by Tembo and Nonga [26], in Kenya by Kere et al. [39], in Tanzania by Komba et al. [40], and in Egypt by Abd El-Aziz et al. [41] who reported lower incidence rates of 3.1%, 5.3%, 0.04%, and 0.038%, respectively. In contrast, Kerala et al. [19] found a significantly higher prevalence in Southern Ethiopia (23.04%), along with Denbarga et al. [29] (82.5%) and Mulatu et al. [42] (20.05%) in other parts of Ethiopia. This variance in occurrence could be attributed to factors such as geographical location, the population of dogs, and the standards of the livestock sanitation [43,44].

Concerning lung tuberculosis prevalence, Okeke et al. [45] found a comparable bovine tuberculosis rate of 9.1% in Nigeria. Furthermore, in Tanzania, Komba et al. [40]

detected a lower prevalence of 1.87%. Moreover, Shitaye et al. [46] reported that the prevalence of bovine tuberculosis in slaughterhouses across various regions of Ethiopia varied from 3.5% to 5.2%. In another study conducted by Woldemariyam et al. [47], the prevalence of bovine tuberculosis in cattle carcasses slaughtered at the Debre Birhan municipality slaughterhouse in Ethiopia was recorded at 4.7%. Alternatively, Dechassa [48] reported a greater incidence of bovine tuberculosis at rates of 24.7% in Ethiopia, while Cleaveland et al. [49] observed a rate of 20% in Tanzania.

Causes of heart rejection

The combined heart lesions observed in cows, buffaloes, camels, and sheep totaled 22 cases, with respective occurrences of 5, 2, 2, and 13. The primary reasons for heart rejection were cysticercosis, accounting for 34.93% of cases, and pericarditis, which constituted 2.25% of cases. In comparison with the obtained results, a decreased occurrence of cysticercosis (0.27%) was identified at the Adigrat municipal slaughterhouse in the northern part of Ethiopia by Assefa and Tesfay [27], while EDO et al. [50] reported a lower rate (0.9%) in Adama municipal slaughterhouse, Ethiopia. Furthermore, Dyab et al. [51] documented a prevalence of 12.6% in El-Minia governorate slaughterhouses, Egypt, between June 2017 and May 2018. On the other side, Aziz et al. [52] conducted a study in various slaughterhouses located in Sohag governorate, Egypt, which revealed a higher prevalence rate of 64.43%. Similarly, Rabi and Jegede [53] observed a higher prevalence rate of cysticercosis in the heart, reaching 66%, within the Kano slaughterhouse, Nigeria. As for pericarditis, a lower incidence rate (1.6%) was reported by EDO et al. [50] on the basis of bovine carcasses slaughtered at Adama municipal slaughterhouse, Ethiopia. However, other studies by Mummed and Webb [36], Ahmed et al. [54], Raji et al. [15], and Madzingira et al. [55] observed higher prevalence rates of pericarditis (4.59%, 8%, 17.06%, and 19.7%) in various regions including Ethiopia, Egypt, Nigeria, and Namibia, respectively.

Table 2. Major causes of rejection of each edible organs of the animals slaughtered at El-Qurein slaughterhouse during 2020 and 2021.

Livestock species	Rejected organs	Disease	Infection rate (%)
Cattle	Liver (52/220)	*Fascioliasis* (45/220)	20.45%
		Necrosis (7/220)	3.18%
	Lung (3/220)	*Hydatid cyst* (2/220)	0.91%
		Tuberculosis (1/220)	0.45%
	Heart (5/220)	*Cysticercus bovis* (5/220)	2.27%
Buffaloes	Liver (11/89)	*Fascioliasis* (7/89)	7.87%
		Necrosis (3/89)	3.37%
		Abscesses (1/89)	1.12%
	Lung (26/89)	*Pneumonia* (14 /89)	15.73%
		Localized Tuberculosis (8/89)	8.99%
		Hydatid cysts (4/89)	4.49%
	Heart (2/89)	*Pericarditis* (2/89)	2.25%
Camels	Liver (2/40)	*Hydatid cysts* (1/40)	2.5%
		Abscesses (1/40)	2.5%
	Lung (9/40)	*Abscesses* (2/40)	5.0%
		Hydatid cysts (5/40)	12.5%
		Pneumonia (2/40)	5.0%
	Heart (2/40)	*Cysticercus dromedary* (2/40)	5.0%
Sheep	Liver (12/47)	*Cysticercus tenuicollis* (8/47)	17.02%
		Necrosis (4/47)	8.51%
	Lung (0/47)	0	0
	Heart (13/47)	*Cysticercus ovis* (13/47)	27.66%
Goats	Liver (1/10)	*Cysticercus tenuicollis* (1/10)	10%
	Lung (0/10)	0	0
	Heart (0/10)	0	0

Financial losses due to rejections

The total economic impact resulting from the rejection of meat over the span of a year was assessed to be 1,113,905.24 Egyptian pounds, equivalent to USD 71,865 as detailed in the Table 3. In a study performed by Ciui et al. [56], the combined monetary losses stemming from the rejection of edible parts over a two-year period were calculated to be EUR4,021,717.3 at a cattle slaughterhouse located in southeastern Germany. In addition, Mohammed and Maky [11] undertook a study that lasted for two years (2017–2018) in both northern and southern regions of Egypt. Their investigation revealed a financial deficit of 4,529,010 Egyptian pounds (USD 383,063) attributable to meat rejection across three slaughterhouses. The primary factors leading to meat rejection were tuberculosis, icterus, pneumonia, hydronephrosis, parasitic cysts, and fasciolia-sis. The economic impact observed in this study surpasses the results reported in a previous study conducted in Egypt by Ahmed et al. [54], where they estimated an annual financial loss of 36,480 Egyptian pounds resulting from the rejection of organs from slaughtered male cattle at the Ismailia slaughterhouse. Moreover, Yibar et al. [1] undertook a survey within the slaughterhouses located in Bursa province, Turkey, revealing a financial deficit of USD 245,483 due to the rejection of organs and carcasses over a span of six months in two slaughterhouses. Hydatidosis and fasciolosis served as the primary factors for organ rejection, whereas tuberculosis and jaundice were identified as the primary causes leading to carcass rejection. Furthermore, Amuamuta et al. [57] conducted the research at the Bahir Dar municipal slaughterhouse in Ethiopia, determining that the rejection of liver and lung tissues resulted into a substantial economic loss amounting to USD 9,257.914. Primary reasons for rejection included fasciolosis and hydatidosis, which inflicted significant economic losses due to their prevalence. Furthermore, a yearly financial deficit amounting to USD 11,155.52 linked to zoonotic metacestodes found in cattle slaughtered at Yabello municipal slaughterhouse in Ethiopia during the timeframe spanning December 2017 to March 2018 was documented by Beyene and Hiko [58], where *Cysticercus bovis* and hydatidosis were the predominant causes of organ rejection. Moreover,

Table 3. Rejection rates, price, and annual financial loss of rejected organs of the livestock slaughtered at El-Qurein slaughterhouse during 2020 and 2021.

Item	Average weight (kg)	Price[a]	Cost[b] (C_{oy})	Rejection rate[c] (R_{oz})	Annual slaughter rate[d] (S_{rx})	Annual loss estimation (EL)
Cattle liver	8	200	1600	0.24	1,849	710,016
Buffalo liver	8	200	1600	0.12	143	27,456
Camel liver	8	200	1600	0.05	1,708	136,640
Ovine liver	1.2	210	252	0.26	47	3,079.44
Caprine liver	0.9	210	189	0.10	10	189
Cattle lung	8	60	480	0.01	1,849	8,875.2
Buffalo lung	8	60	480	0.29	143	19,905.6
Camel lung	8	60	480	0.23	1,708	188,563.2
Ovine lung	1.2	60	72	0.00	47	0
Caprine lung	1.2	60	72	0.00	10	0
Cattle heart	2.5	60	150	0.02	1,849	5,547
Buffalo heart	2.5	60	150	0.02	143	429
Camel heart	2.5	60	150	0.05	1,708	12,810
Ovine heart	0.5	60	30	0.28	47	394.8
Caprine heart	0.5	60	30	0.00	10	0
Total estimated loss						1,113,905.24 EGP (71,865 USD)

(a) Price: Average price of organs at the local market (Egyptian pound/kg); (b) Cost (Coy): Average cost of organs at the local market (Egyptian pound), calculated as Average weight × Price; (c) Rejection rate (Roz): The proportion of organs rejected during inspection; (d) Annual slaughter rate (Srx): The number of animal species slaughtered annually at El-Qurein slaughterhouse; (EL) Annual loss estimation: The financial loss due to rejected organs, calculated as Annual slaughter rate × Cost × Rejection rate.

1 US dollar was equal to 15.50 Egyptian pounds

Abd Elaziz et al. [41] reported financial losses amounting to approximately EGP 11,712.5 for fascioliasis, EGP 32,940.0 for cysticercosis, and EGP 2,410 for hydatidosis, resulting from the rejection of liver and lung tissues at a local Egyptian slaughterhouse situated in Cairo governorate. Differences in economic losses across the studies may stem from the variations in factors such as livestock numbers, disease occurrence rates, estimation methods, the scope of loss items analyzed, disparities in livestock productivity and market prices.

Conclusion

Substantial financial losses have been incurred to the Egyptian slaughterhouses due to various pathological conditions. The research highlights fascioliasis, parasitic infections, and pneumonia as the predominant ailments significantly impacting the Egyptian economy. It's evident that implementing preventative measures such as regular administration of anti-parasitic drugs and stringent monitoring of sanitation protocols, especially in Sharkia province, is imperative. Ensuring the thorough meat inspection and proper disposal of rejected meat are essential for safeguarding of the public health. Focus should be directed towards dealing with frequently identified illnesses in the slaughterhouses. Implementing the anti-parasite monitoring programs at farms is crucial for minimizing the risk of infectious diseases spreading and reducing financial losses. Furthermore, the construction of well-equipped slaughterhouses and comprehensive training for the slaughterhouse staff are the essential steps. Finally, more research is needed for better understanding the causes of pathological findings, particularly at the slaughterhouse level, to enhance our understanding of the zoonotic risks posed to the consumers.

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