



Cysticercosis in Lamb and Goat Meat and Edible Offal Produced In an Abattoir in Iran in 2021

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ABSTRACT

Introduction: *Cysticercosis* is a worldwide disease that affects farm animals and, in some cases, like bovine and porcine *cysticercosis*, is considered zoonosis. This condition, in sheep and goats, results in economic losses especially due to the condemnation of edible offals or meat. In this concern, the aim of this study was to examine cysticercosis and factors influencing the frequency and weight of relevant meat or red offals condemnation among the sheep and goats slaughtered at a slaughterhouse in Iran.

Methods: A one-year retrospective cross-sectional epidemiological study was carried out to examine the presence of cysticercosis at postmortem inspection. Data regarding the date of slaughter, animal species, sex, and the type of cysticercosis infection (*Cysticercus ovis* or *Cysticercus tenuicollis*) were recorded.

Results: A total of 17530 carcasses were contaminated with different types of cysticercosis, and among them, 9072 offals were rejected and 291 cases were totally condemned. During winter the number of contaminated samples was higher compared to the other seasons. Goats were only infected with *C. ovis* and none of them were totally condemned. The mean proportion of condemned tissues in each contaminated sample was higher in sheep (0.5 kg/case). The damaging effects of cysticercosis in male carcasses were greater than in females, and *C. ovis* infection resulted in higher weight and rate of offal and carcass condemnation.

Conclusion: In conclusion, it seems that a comprehensive antihelminth strategy must be followed by the relevant food animal producers to decrease the economic losses and zoonoses problems caused by cysticercosis.

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Introduction

Red meat has been a significant component of the human diet throughout the evolution of mankind. It is recognized as an important food source of protein and essential nutrients, like iron, zinc, and vitamin B₁₂. In Iran, a main part of red meat is obtained from sheep and goats. These ruminants may harbor different stages of various parasites in their edible organs and tissues (meat and offal). Among those parasites, *Taenia* spp. are considered important ruminant parasites that cause a significant loss of protein sources during the slaughtering process annually. The disease caused by *Taenia* spp. is cysticercosis. Humans can also get infected by consumption of undercooked or raw tissues obtained from ruminants harboring immature stages of *Taenia* spp. (1). Sheep and goats are intermediate hosts of several *Taenia* spp. and

harbor the larval stages in their organs and tissues. During postmortem inspection at abattoir, the macroscopic lesions of these parasites can be detected making the organ or carcass unfit for human consumption.

Cysticercosis in sheep and goats is caused by the larval or intermediate stage of two important parasites from the dog tapeworm family, *Taenia ovis* and *Taenia hydatigena*. The larval stage of *T. ovis*, known as *Cysticercus ovis*, results in cystic lesions in the skeletal and cardiac muscles of sheep. Over time, the muscular cysts degenerate, calcify, and form small nodules with a gritty texture, known as "sheep measles". On the other hand, *Cysticercus tenuicollis*, the larval stage of *Taenia hydatigena*, migrates through the intermediate host's intestines and can be mainly found in the peritoneal cavity and liver of ruminants (2). The migrating larvae can be found

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primarily in the liver parenchyma within 7 to 10 days and can potentially cause traumatic hepatitis in young animals.

Although cysticercosis in sheep and goats is not classified as a zoonotic disease, it can result in economic losses due to reduced productivity, commercial limitations, and condemnation of organs or whole carcasses at slaughterhouses.

Due to the significant economic losses caused by cysticercosis, particularly in developing countries, this disease has become a major concern in the livestock industry. A major part of these financial damages is related to the condemnation of infected tissues during meat inspection. Monitoring and evaluating the level of condemnation caused by different diseases benefit the food animal industry by having better plans and strategies for controlling farm animal diseases. In this regard, this study was conducted to examine cysticercosis and factors influencing the frequency and weight of relevant condemned meat or red offals in sheep and goats slaughtered in an industrial slaughterhouse in Iran.

Materials and Methods

Study design

The present study was conducted in an industrial slaughterhouse located in Khorasan Razavi province in the east of Iran. The lamb and goat meat and edible offals produced in this slaughterhouse are obtained from 4000-9000 sheep and goats slaughtered per day. A retrospective cross-sectional epidemiological study was carried out from April to March 2021. All of the meat products at this slaughterhouse are examined for the presence of cysticercosis by official veterinary inspectors during postmortem inspection.

Study Animals

The meat products examined in this study were obtained from sheep and goats that brought to the abattoir predominantly from the nearby regions. These animals were kept under traditional and industrial farming systems, and they were transported to the slaughterhouse by different vehicles. The species, date of slaughter, and sex of all of the studied animals were recorded.

Determination of Cysticercosis

For the determination of different types of cysticercosis in the studied products, the classic approach of postmortem examination including

observation, palpation, and incision was followed.

The determination of *C. ovis* was carried out by detecting the vesicular larvae encysted in the skeletal or cardiac muscles of the animal. Based on the FAO regulation, typical inspection areas for the determination of cysticercosis include the muscles of mastication, cardiac muscle, triceps, diaphragm and its pillars (3). In the case of heavily infected carcasses, which demonstrated the lesions in at least two of the usual inspection sites, total condemnation was indicated.

Edible offals, including the liver, lung, mesentery, and omentum, and abdominal, thoracic and pelvic cavities were visually examined for detecting *C. tenuicollis*. A transparent cyst filled with watery fluid and a single white scolex with a long neck was considered to be *C. tenuicollis* (2). In mild cases, only the cysts were removed, but if extensive infection was detected the organ, mostly liver, or tissue were condemned.

Statistical analysis

All information obtained during postmortem inspection was stored in a Microsoft Excel spreadsheet (version 2013), and the statistical analysis was carried out by SPSS software (version 16.0). Descriptive statistics were used to measure the frequency and weight of tissue losses in this study. Moreover, the difference between the infection frequency and loss weight among different species, sexes, and seasons were also calculated.

Results

During one year of investigation for cysticercosis, a total of 17530 samples were infected with different types of cysticercosis, and among them 9072 offals were totally rejected and partial condemnation was applied for 8458 cases. Moreover, 291 carcasses were totally condemned due to the heavy cysticercosis infection. In total 8856 kg of infected carcass tissues were condemned during postmortem inspection.

The Impact of the Season

Figure 1 represents the frequency and weight of red offals and carcass condemnation in terms of different seasons of 2021. In this regard, the highest number and weight of condemnation due to different types of cysticercosis was reported in winter with 5728 carcasses and 3298 kg weight of condemnation. On the other hand, during spring, the least frequency and weight of losses

were recorded with values of 2530 animals and 1319 kg respectively. The weights of condemnation in summer and autumn were close together. The highest and lowest proportion of

condemnation with the values of 0.57 and 0.4 kg/case were recorded in winter and summer respectively, while no significant difference was recorded in spring and fall.

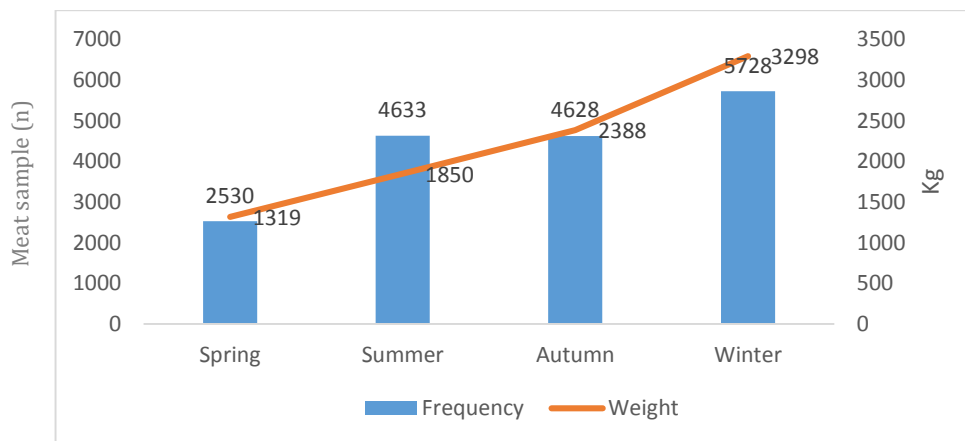


Figure 1. The effect of season on the number and weight of condemnation

Table 1. Differences in judgment and type of condemnation in infected cases in different seasons.

		Season	Frequency (n)	Weight (kg)
Judgment	Partial condemnation	Spring	2483	480
		Summer	2489	848
		Autumn	4547	796
		Winter	5620	1058
	Total condemnation	Spring	47	839
		Summer	55	1002
		Autumn	81	1592
		Winter	108	2240
Type	Trimmed	Spring	1038	202
		Summer	2013	358
		Autumn	2735	448
		Winter	2672	502
	Whole offal	Spring	1492	1117
		Summer	2631	1492
		Autumn	1893	1940
		Winter	3056	2796

Table 1 represents the effects of season on judgment and type of condemnation in contaminated samples. Here the number of total carcass condemnations and number of partial condemnations in winter was greater than in other seasons followed by autumn. However, regarding the type of condemnation, during winter and fall, the number of trimmed cases was close, while whole offal condemnation was also more prevalent in winter.

The Effect of Animal Species

Based on the results, during one year 17520 sheep and 10 goats were infected with different types of cysticercosis corresponding to 8853 and 10 kg of tissue condemnation respectively.

Regarding the proportion of tissue losses in each species, sheep with value of 0.5 kg/case demonstrated a higher proportion of condemnation per animal compared to goats with a value of 0.2 kg/case. As shown in Table 2, most of the contaminated sheep or goat carcasses were partially condemned, and only 1.6% of sheep cases was totally condemned. On the other hand, the number of whole edible offal condemnation and trimmed samples were close in sheep. None of the goat cases were totally condemned or had their infected organs trimmed.

Table 2. Differences in judgment and type of condemnation in contaminated cases among different animal species.

		Species	Frequency (n)	Weight (kg)
Judgment	Partial condemnation	Sheep	17229	3180
		Goat	10	2
Type	Total condemnation	Sheep	291	5673
		Goat	10	2
	Trimmed	Sheep	8458	1510
		Goat	10	2
Whole offal	Sheep	9062	7343	
	Goat	10	2	

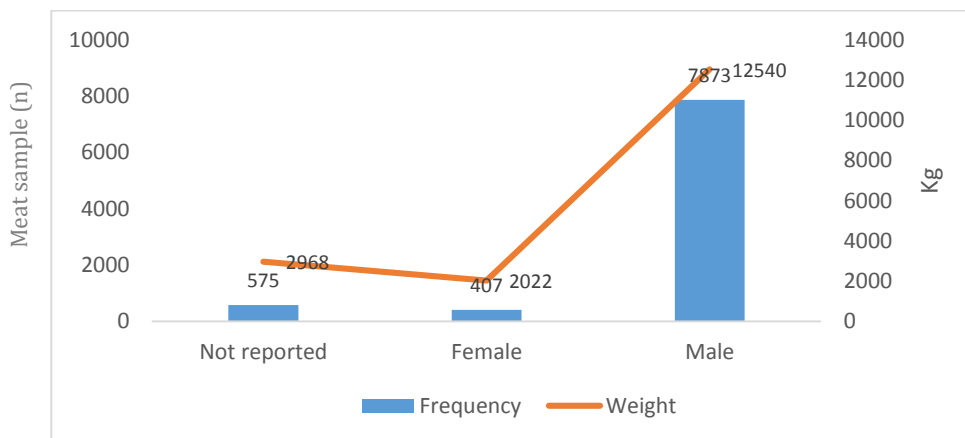


Figure 2. The effect of sex on the number and weight of condemnation

Table 3. Differences in judgment and type of condemnation in infected cases among different sex.

		Sex	Frequency (n)	Weight (kg)
Judgment	Partial condemnation	Female	2021	389
		Male	12250	2118
Type	Total condemnation	Female	1	18
		Male	290	5655
Trimmed	Trimmed	Female	586	115
		Male	6693	1163
Whole organ	Whole organ	Female	1436	292
		Male	5847	6710

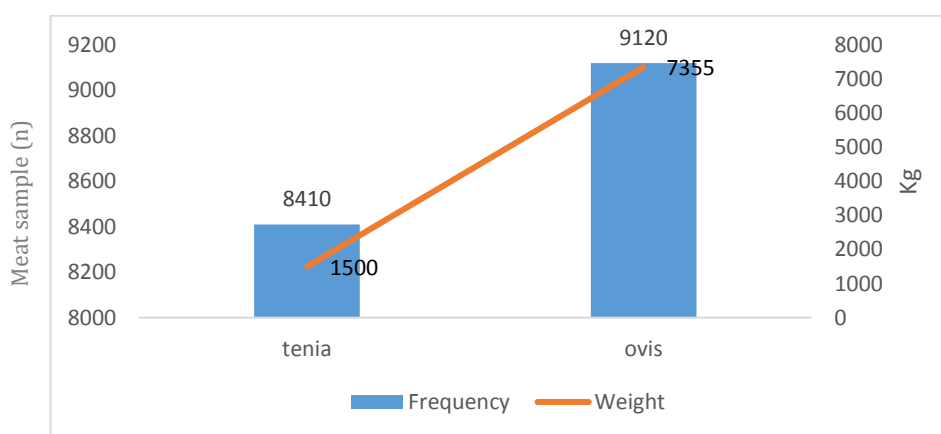


Figure 3. The effect of the type of cyst on the number and weight of condemnation

Sex

In total, 7873 and 407 contaminated male and female cases respectively detected in the studied slaughterhouse during 2021 (Figure 3). It should be mentioned that the sex of 575 cases corresponded to 2968 kg of tissue losses was missing during data collection. The weight of tissue losses in each male carcass was 0.2 kg, which was significantly higher than in female

animals (0.62 kg per animal). Table 3 shows that the percentage of male carcasses (2%) which totally condemned during postmortem inspection was much higher than the female cases (0.04%). Almost half of the contaminated offals of male cases were partially trimmed, while total offal condemnation was significantly greater in female cases compared to the trimmed organs.

Table 4. Differences in judgment and type of condemnation in different cases contaminated with different cysts.

		Cyst	Frequency (n)	Weight (kg)
Judgment	Partial condemnation	<i>C. tenuicollis</i>	8410	1500
		<i>C. ovis</i>	8829	1682
	Total condemnation	<i>C. ovis</i>	291	5673
Type	Trimmed	<i>C. tenuicollis</i>	8369	1492
		<i>C. ovis</i>	89	18
	Whole offal	<i>C. tenuicollis</i>	41	8
		<i>C. ovis</i>	9031	7337
Species	Sheep	<i>C. tenuicollis</i>	84100	1500
		<i>C. ovis</i>	9110	7353
	Goat	<i>C. ovis</i>	10	2

Type of Cyst

Data regarding the effects of the type of parasite on frequency and weight of condemnation are presented in Figure 3. As can be seen, while there were no substantial differences in the frequency of infection between *C. ovis* and *C. tenuicollis*, *C. ovis* caused a higher weight of condemnation. In this regard, average tissue condemnation due to the infection by *C. ovis* and *C. tenuicollis* were 0.8 and 0.17 kg/animal respectively. Based on Table 4, all total carcass condemnations were related to *C. ovis*. On the other hand, *C. tenuicollis* caused only 0.4% of total offal condemnation, while almost all (99%) of the offal contaminated with *C. ovis* were totally condemned. Finally, while the number of sheep infected with *C. tenuicollis* or *C. ovis* was close together, goats were only infected with *C. tenuicollis*.

Discussion

The effect of season on parasitic infection in different livestock has been extensively evaluated by several authors. For instance, Hashemnia et al. (2016) reported that the prevalence of ovine cysticercosis in spring (1.8%) was higher than in other seasons, followed by summer, autumn, and winter (4). They stated that the suitable weather conditions in late spring and summer and also the ease of access to acquire infection from contaminated grass led to higher infection rates during warm weather. Hajipour et al. (2020) also reported that the highest prevalence of ovine cysticercosis was

in spring, but in summer the lowest rate was recorded (5). In this study, the prevalence of cysticercosis could not be calculated, since the number of total slaughtered animals was unknown. Therefore, the higher number of the infections recorded in winter may be related to the number of animals brought to the slaughterhouse in winter.

Differences between the occurrence of cysticercosis among goats and sheep have been also assessed. Dyab et al. (2017) reported that while both *Cysticercus ovis* and *Cysticercus tenuicollis* were detected in meat products obtained from sheep, goats only harbored *C. tenuicollis* (6). Moreover, they reported a higher prevalence of parasitic lesions in goats. The higher prevalence of *C. ovis* in lamb meat (2.9%) compared to goat meat (1.2%) was reported in another study (5). These differences have been connected to the level of contact between sheep/goats and dogs, and also different protective immunity among them. Unlike the aforementioned studies, in the present study, only *C. ovis* was detected in goat samples. This might be related to the chance and also the lower number of goats slaughtered in the studied abattoir. Moreover, due to the lower number of detected contaminated goat products, it seems irrational to compare the weight and type of condemnation between the two species in the present study.

Regarding the impact of sex on the disease consequences in slaughterhouses, controversial

data existed in the literature. In the present study, the deteriorative effects of cysticercosis in male cases were higher than in females. Mohammed (2021) and Dyab et al. (2017) reported no significant difference in the prevalence of *C. ovis* between males and females at postmortem inspection (6,7). On the contrary, Hashemnia et al. (2016) reported a significantly higher infection rate of *C. ovis* in male sheep compared to females.

The reason why *C. ovis* infection resulted in higher weight and rate of meat and offal condemnation is most probably related to the pathogenesis of the parasite and its pathological lesions on the carcass. The *C. ovis* cysts can generally be generated in skeletal tissues like the cheek, tongue, esophagus, diaphragm, and also cardiac meat. Therefore, the great edible parts of small ruminant carcasses can be condemned during postmortem inspection, while *C. tenuicollis* lesions are generally limited to the surface of the liver or peritoneum, omentum, mesentery and urinary bladder (8), which in comparison are less important tissues of carcasses and their contamination usually results in limited condemnation.

The prevalence of *C. ovis* and *C. tenuicollis* were previously evaluated in different geographical locations. For example, Sissay et al. (2008) reported that in eastern Ethiopia, in sheep meat and edible offal the overall prevalence was 26% for *C. ovis*, and 79% for *C. tenuicollis*, while for goats, the corresponding rates were 22% and 53% (9). In fact, *C. tenuicollis* was more prevalent in both species. A study in Egypt also showed that *C. tenuicollis* was more prevalent in small ruminants meat products compared to *C. ovis* (6).

Conclusion

According to the data gathered and analyzed in the present study, a significant number of meat products and red offals produced in the studied abattoir were infected with cysticercosis, and this resulted in large products and economic losses. In conclusion, based on the level of condemnation, it seems that a comprehensive

antihelminth strategy must be followed by the relevant food animal sectors to lessen the level of infection in small ruminants.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

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