ISSN: 1220-3173; E-ISSN: 2457-7618

# TRICHINELLOSIS: A CONSTANT PRESENTS WORLDWIDE INVOLVED IN THE PUBLIC HEALTH

## TRICHINELOZA: O PREZENȚĂ CONSTANTĂ LA NIVEL MONDIAL, CU IMPLICAȚII ÎN SĂNĂTATEA PUBLICĂ

Claudia BORZA[1)], Nilima Rajpal KUNDNANI[1)], G. DĂRĂBUȘ[2)], Narcisa MEDERLE[2)], Corina PASCU[2),*)], S. ABHINAV[3)], R. PAVEL[1)], V. HERMAN[2)]

**ABSTRACT | REZUMAT**

The article presents known objective information on the global source of concern, both in terms of public health and economically, caused by trichinosis, a disease triggered by the consumption of food infested with the parasite Trichinella spiralis *(T. spiralis).* It is a widespread disease, being identified in all continents, less in Australia. In animals, the main route of transmission is by carnivorism, but also through the placenta and milk.

Outbreaks force the authorities to declare entire zones as endemic areas for Trichinellosis infection. During such outbreaks, a large number of cases incur huge financial losses in diagnosing and treating and in destroying the source of infection. The most frequent causes of *Trichinella* infection in humans is ingestion of infected meat of pigs, and wild boars. Consuming raw or improperly cooked meat is another reason for outbreaks but the number of such cases has shown a decline in the last decade, moreover due to increasing public awareness and modern techniques of cooking, where the use of food thermometers has become a trend in every household. Outbreaks lead to mass slaughtering of the causative animals leading to monetary losses to the big and small-scale livestock industry. Constant checks are required to supervise the health of animals and the quality and safety of animal products. Infection in humans can be asymptomatic, mild, moderate or severe, sometimes leading to serious life-threatening complications, requiring immediate medical attention. The symptoms are discreet in animals. Trichineloscopic examination is mandatory for all susceptible animals. In the EU the artificial digestion method prevented infection in humans.

Anti-helminthic medications are inexpensive and quite effective in controlling the disease but diagnosis

Articolul prezintă informațiile obiective cunoscute privind sursa de îngrijorare pe plan global, atât din punct de vedere al sănătății publice cât și din punct de vedere economic, cauzate de trichineloză, o boală declanșată de consumul de mâncare infestată cu parazitul *Trichinella spiralis (T. spiralis).* Este o infecție larg răspândită pe toate continentele, mai puțin în Australia. La animale, calea de infecție cea mai răspândită este carnivorismul, dar infecția poate fi transmisă și transplacentar sau prin lapte. Epidemiile de trichineloză obligă autoritățile să declare zone extinse ca zone endemice afectate de infecția cu trichineloză. În timpul unor asemenea epidemii, un număr mare de cazuri atrag după sine cheltuieli foarte mari necesare pentru diagnostic, tratamentul bolii și eradicarea sursei infecției. Cele mai frecvente cauze de infecție cu *Trichinella* la om sunt reprezentate de ingestia cărnii de porc și mistreț sau a produselor derivate infectate. O altă cauză a declanșării epidemiilor este consumul de carne crudă sau insuficient gătită, dar numărul acestor cazuri este în scădere în ultimul deceniu, în special ca urmare a informării publicului și introducerii metodelor noi de gătit care utilizează termometrele de bucătărie pe scară largă pentru a stabili gradul de gătire al unui aliment. La om, infecția poate fi ușoară, moderată sau severă, uneori ducând la complicații severe cauzatoare de deces și care necesită intervenție medicală promptă. La animale, simptomatologia este discretă. Epidemiile duc la sacrificarea în masa a animalelor cauzatoare de boală, ceea ce duce la pierderi financiare atât pentru micii cât și pentru marii producători din industria cărnii. Astfel, sunt necesare controale permanente pentru a superviza sănătatea animalelor, calitatea și siguranța produselor de origine animală. Trichineloscopia este metoda obligatorie de testare a animalelor susceptibile. În UE, digestia artificială este metoda prin care se previne infecția la om.

Antihelminticele nu sunt scumpe și sunt eficiente în ținerea bolii sub control, dar diagnosticarea necesită teste de laborator costisitoare care în unele țări nu sunt decontate de casele de asigurări de sănătate, ceea ce duce la întârzieri in inițierea tratamentului. Persoanele care nu sunt vegetariene, în special cele

1) "V. Babeș" University of Medicine and Pharmacy, Timisoara, Romania
2) Banat's University of Agricultural Science and Veterinary Medicine "King Michael I of Romania" Faculty of Veterinary Medicine, Timișoara, Romania
3) Municipal Emergency University Hospital, Arad, Romania
*) *Corresponding author:* corina_pascu_ro@yahoo.co.uk
*Statement: Claudia Borza and Nilima Rajpal Kundnani contributed equally as co-first authors*

requires expensive laboratory tests, which in many countries are not supported by health insurance schemes and lead to unnecessary delays. Non-vegetarians specifically those consuming red meat are in constant danger of grabbing parasitic-infested meat. Due to this, the inflammatory response mounted by the human body as a defence mechanism can further lead to complications, especially in COVID-19 infected cases, where the cytokine storm is known to increase disease severity. Recent studies have shown that meat consumers tend to have a chronic inflammatory state due to the presence of high titers of serum anti-Neu 5Gc IgG. The authors of this review hope that in near future, the availability of three-dimensional (3D) printed food products, would suffice the nutritional and taste requirements, and minimize the chances of acquiring food-borne zoonotic diseases. It will also help reduce the financial burden caused by zoonotic endemic situations and gain a healthy environment. The severe damages caused over the years by the food industry on the environment must be reduced as well.

**Keywords**: *Trichinella spiralis*, raw meat, chronic inflammation, anti-Neu5Gc IgG

care consumă carne roșie, sunt expuse în permanență riscului infecției cu acest parazit. Din această cauză, răspunsul inflamator al organismului, care apare ca un mecanism de apărare, poate genera noi complicații, în special în cazurile infectate cu COVID-19 unde furtuna de citokine contribuie la creșterea gravității bolii. Studii recente au arătat că persoanele consumatoare de carne sunt predispuse la un status inflamator cronic cauzat de prezența anti-Neu5Gc IgG seric cu titru crescut. Autorii prezentei recenzii speră că în viitorul apropiat apariția alimentelor care să satisfacă cerințele nutritive ale consumatorilor să minimalizeze si riscul zoonozelor cauzate de alimente. Acest lucru va diminua și impactul financiar al zoonozelor endemice și va duce la crearea unui mediu mai sănătos. De asemenea, trebuie reduse efectele negative dezastruoase generate de industria alimentară asupra mediului înconjurător.

**Cuvinte cheie**: *Trichinella spiralis*, carne neprocesată, inflamație cronică, anti-Neu5Gc IgG

Trichinellosis caused by roundworms of *Trichinella* species, having a zoonotic mode of transmission, is of major health concern, resulting in many outbreaks in the carnivorous population. *Trichinella spiralis* (*T. spiralis*) is a nematode of the genus *Trichinella*, which is known to target many hosts, where pigs and humans top the list (5, 10, 39). Consuming undercooked or raw meat containing the infective larvae present inside *Trichinella* cysts leads to this parasitic infestation in humans (8, 33, 39). It is estimated that approximately 11 million people around the world are infected by this parasite (30). Many outbreaks are reported across different continents (Europe, Asia and America North and South), indicating the persisting potential threat caused by this zoonotic species along with *Echinococcosis* (4, 12, 32, 35). Previously, it was believed that pork and its products are the main culprits but recent research has shown that human infection can be caused even by consuming wild carnivores and scavengers infected meat (14, 34). Wild boar, deer, moose, walrus, and dog meat are other important sources of human infection by *T. spiralis* (6, 12, 20). Outbreaks are still witnessed in various countries despite strict rules and regulations; improvement in animal husbandry industry, meat inspections and regular checks and constant testing done at slaughterhouses, at production and storage levels of products, consumer education, and better medical care. Trichinellosis not only can be denoted as a major public health concern but also adds to financial burden, as huge economic losses are incurred when infected pigs are being slaughtered in millions if found positive through mandatory vigorous testing. A study conducted in China stated that the Chinese government spent around 26 million dollars on mere annual swine inspection, and treating infected human cases adds more to it (29).

We performed a thorough literature search by following a standard search protocol (using Boolean operators and a combination of the keywords "Trichinellosis, zoonosis, *Trichinella spiralis*, diet, red meat, swine inspection, cytokine storm, inflammation-causing vectors"). We thoroughly searched the databases of Google, Pubmed, and Google Scholar, for relevant articles.

## ETIOLOGY AND EPIDEMIOLOGY

Based on biological, biochemical and molecular characteristics, 12 genotypes were reported, marked from T1 to T12, some already well-defined species and others with an uncertain taxonomic status (17). In Romania, two species have been identified so far: *T. spiralis* and *T. britovi*. If the *T. spiralis* species has been known for a long time, *T. britovi* species was reported more recently (2009) in wolves (*Canis lupus*), lynx (*Lynx lynx*) and wild cat (*Felis silvestris*) (3).

*Trichinella spiralis* ranked first in the 2014 list among the parasites infecting humans, based on nine different criteria according to the Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO) (1). Encysted larva of the roundworms and the adult worm itself develop in a single vertebrate host, in accordance with the bio-

logical cycle which is autoheteroxenous.

The disease is widespread all over the world, on all continents except Australia, where it is very rare, especially affecting carnivores and omnivores. The epidemiological relationships of *Trichinella* spp. are based on two cycles: domestic and sylvatic, with connections between them. The domestic cycle takes place mainly between pig and rat. The sylvatic cycle is more complex, involving in addition to wild boar and rats also wild carnivores (10, 23). The main way of transmitting Trichinelosis in animals is through carnivorism. However, transplacental and galactogenic transmission, demonstrated experimentally in rats, is also possible (7).

Infection in humans is caused by ingesting raw or uncooked meat and cannot be transmitted by soil or respiratory droplets. Different age groups are infected but higher prevalence is noted in adults, particularly if alcohol is consumed. Studies have reported a potential link between the food behavior and trichinellosis and other food-borne parasites including the parasites infestations contracted by humans' race from fish consumption. All meat including the pork meat can be cooked safely at 74°C or higher for 15 seconds or more (1, 13, 15, 19). For meat with a size of more than 25 cm, the destruction of the larvae at -25 °C requires more than 10 days (7). In animal carcasses, the larvae survive for three weeks, despite rotting (5). The *Trichinella* larvae are not destroyed by salting and smoking. A similar outbreak noted in Northern Italy was able to pinpoint the dinner served at a farm on the New Year's Eve 2014, as the source of the infection, where *T. pseudospiralis* was the etiological agent (2, 18).

The meat industry has severely damaged the environment, adding to the state of global warming. The growing demand for meat products leads to the destruction of water, soil, extinction of some animals and plant species, excessive consumption of natural resources, and lead to an imbalance in the environment. As per the Food and Agriculture Organization (FAO) of USA report, 18% of the greenhouse gas emissions are caused by the livestock industry (14).

## CLINICAL SIGNS IN ANIMALS AND HUMANS

The symptoms are discreet in animals. In massive infestations, after incubation for several days, two phases are distinguished: intestinal and muscular. Cristea G. (1998) describes, among others, diarrhoea, abdominal pain, general manifestations, rigid gait, difficult mastication, sub-febrility, etc (9).

In humans, trichinellosis develops more severely, also in two phases, intestinal and muscular, after an incubation of 3 to 30 days (38). Trichinellosis patients might present with a milder version of the disease and or exhibit serious forms, where the larva invades the muscles and can cause swelling, aches, rashes and inflammation of the face. Generally, the initial symptoms noted are diarrhoea, abdominal pain and vomiting when it invades the intestines. It also carries the potential of causing life-threatening complications due to cardiac and CNS involvement, leading to conditions like arrhythmias, myocarditis or encephalitis, and can also cause inflammation of the lungs leading to severe dyspnea (16, 28, 32, 41). Mild to moderate forms of the disease are cured on their own if left untreated. Detection can be done by identification of specific antibodies in the blood or spotting the larva on the muscle biopsy. Blood tests usually show marked eosinophilia, and elevated muscle enzymes (e.g., creatinine phosphokinase, lactate dehydrogenase, and aldolase) indicating myositis. Detection anti-*Trichinella* antibodies specific against the *Trichinella* antigen is considered the gold standard for diagnosing Trichinellosis. Laboratory diagnosis at the time of outbreaks cannot be relied on, and it becomes extremely important to identify the source of infection, as it takes a longer duration of time to show positive results (1, 22). Cardiac involvement as documented in many cases can mimic acute myocardial infarction or can exhibit severe cardiac arrhythmias leading to death. In a case presented by Mohib et al (29), the patient was found to have eosinophilic myocarditis with high levels of Troponin T, and positive *Trichinella spiralis* serology. Echocardiographic changes with preserved ejection fraction and non-significant ECG changes simulated the findings of acute myocardial infarction but were resolved with proper anti-helminthic treatment (29). Outbreaks were reported in 15 European countries in 2017, wherein France and Serbia documented facial paralysis and pulmonary embolism in some infected cases, while the Trichinella-induced myocarditis was not reported. Because the serology comes positive after an extended period, some physicians had missed the diagnoses at the initial phase (2, 27).

Interestingly, during this ongoing COVID-19 pandemic, studies have suggested that meat consumers are at higher risk for severe disease due to the prevailing inflammation seen in them caused by the presence of N-glycolylneuraminic acid (Neu5Gc) glycan, a xeno-antigen present in the red meat and dairy products, but normally absent in the human body. Researchers believe that Neu5Gc elicits an antigen-antibody reaction, leading to the formation of high titers of serum anti- Neu5Gc IgG antibodies. COVID-19 disease caused by SARS-CoV-2, which is hypothetically a zoonotic disease, is capable of generating a strong inflammatory response, where high levels of IL-6, C-reactive protein and ESR are noted. With existing inflammation in the body of meat consumers, COVID-19 can worsen the state, further compounding the severity of disease in a patient infected with *T. spiralis*.

All three factors together have the potential to cause severe inflammation, leading to an intense cytokine storm, which in turn can cause multiple organ failure and death (6, 40, 42, 43).

People with a compromised immune system should be encouraged to consume a vegetarian diet, if and when possible, or else, follow proper cooking techniques to eliminate the risk of ingesting such parasites.

## PREVENTION

Trichineloscopic examination is mandatory for all susceptible animals slaughtered in or outside slaughterhouses. Meat from pigs, wild boars, bears, horses and nutria could be a public danger to human health (20). The artificial digestion method is used in the European Community. It is the method by which infection is prevented in humans. Prevention can be achieved completely by consuming fully cooked meat, using a food thermometer and following proper guidelines. Rapid treatment with anthelminthic drugs albendazole or mebendazole can help cease the larva penetration and save from devastating complications. Many authors recommend albendazole with prednisolone and high-fat content meals to obtain better control. Analgesics can help in relieving pain caused by muscle inflammation. However, in patients with suppressed bone marrow, anthelminthic drugs should be used with caution (25, 37).

## PERSPECTIVES

The review summarizes the fact that parasitic infestations with *Trichinella* remain to be a constant threat worldwide. With advances in the livestock industry and increased public awareness regarding proper cooking techniques have led to a decline in outbreaks, however, complete eradication may be difficult to attain. Early diagnosis and treatment along with adequate destruction of the source of the outbreak can help reduce financial losses and save lives. It can also reduce the chances of developing serious forms of illness or complications involving the central nervous system, respiratory, or cardiovascular system, which can be life-threatening. New hopes emerge with the advancements in the 3D food products industry, having the potential of minimizing zoonotic diseases to a larger extent. As witnessed in the ongoing COVID-19 pandemic, the damages caused by viruses, bacteria, fungi, and parasites could sometimes be beyond repair, and therefore, all possible efforts should be made to avoid these infections. Taking into consideration the negative effects of meat consumption on human health, the environment and endangering animals, lab-grown meat is a ray of hope, which is currently being tried and tested. Once we make these products cost-effective, the end consumer will not only benefit from the same texture, taste, color, shape, nutrition but will also have a reduced risk of developing such food-borne diseases. In the current scenario, minimizing the risk of parasitic ingestion by food will also reduce the already overwhelmed health care sector (21, 24, 26, 38).

***Acknowledgement**:*

The authors are grateful to all the authors/ editors/publishers of all the articles / books / journals from which the literature for this article has been reviewed and discussed.

## REFERENCES

1. *Bai X., Hu X., Liu X., Tang B., Liu M.,* (2017), Current research of trichinellosis in China. Front Microbiol, 8:1472
2. *Barruet R., Devez A., Dupouy-Camet J., Karadjian G., Plavsa D., Chydériotis G., Vallée I., Sofronic-Milosavljevic L., Yera, H.,* (2020), A common source for a trichinellosis outbreak reported in France and Serbia in 2017. Euro Surveill, 25(24):1900527
3. *Blaga R., Gherman C., Cozma V., Zocevic A., Pozio E., Boireau P.,* (2009), Trichinella species circulating among wild and domestic animals in Romania. Vet Parasitol, 159(3-4):218-221
4. *Borza C., Neghina A.M., Dumitrascu V., Tirnea L., Calma C.L., Neghina R.,* (2012), Epizootiology of trichinellosis in pigs and wild boars in Western Romania, 1998-2011. Vector borne and zoonotic dis, 12(8):712-713
5. *Bussiera J., Chermette R.,* (1992), Parasitologie veterinaire - Helminthologie, Service de Parasitologie, (Ed.) E.N.V. d'Alfort, France
6. *Cook G.C., Alimuddin Z.,* (2009), Manson's Tropical Diseases. Elsevier Health Sciences. Diagnosis and Treatment, (Ed.) Springer, Berlin, Germany, 325
7. *Cosoroabă I., Orjanu N.,* (1998), Congenital trichinellosis in the rat. Vet Parasitol,77:147-151
8. *Costan V.V., Popescu E., Cucu C., Ianole V., Cobzaru R. G., Bordiniuc M.D.,*(2018), Incidental discovery of human trichinellosis associated with oral squamous cell carcinoma. Case report. The Medical-Surg. J., 122(2):336-341
9. *Cristea G.,* (1998), Animal trichinosis and the risk of human disease (in Romanian), (Ed.) Ceres, Bucharest
10. *Dărăbuș G., Oprescu I., Morariu S., Mederle N.,* (2016), Parasitology and parasitic diseases, 2nd revised edition (in Romanian), (Ed.) Mirton, Timisoara, Romania
11. *De Bruyne A., Ancelle T., Vallee I., Boireau P., Dupouy-Camet J.,* (2006), Human trichinellosis acquired from wild boar meat: a continuing parasitic risk in France. Euro Surveill, 11(9):E060914.5
12. *Diaz J.H., Warren R.J., Oster M.J.,* (2020), The disease ecology, epidemiology, clinical manifestations, and management of trichinellosis linked to consumption of wild animal meat. Wilderness Environ Med, 31:235-244
13. *Dobrescu C., Hriscu H., Emandi M., Zamfir C., Nemet C.,* (2014), Consumption of untested pork contributed to over two-thousand clinical cases of human trichinellosis in Romania. Folia parasitologica, 61(6):558-556
14. *Dopelt K., Radon P., Davidovitch N.,* (2019), Environmental effects of the livestock industry: The relation-

ship between knowledge, attitudes, and behavior among students in Israel. Int J Environ Res Public Health, 16(8):1359
15. *Franssen F., Swart A., van der Giessen J., Havelaar A., Takumi K.,* (2017), Parasite to patient: A quantitative risk model for Trichinella spp. in pork and wild boar meat. Int J Food Microbiol, 241:262-275
16. *Gallardo M.T., Mateos L., Artieda J., Wesslen L., Ruiz C., García M.A., Galmés-Truyols A., Martin A., Hernández-Pezzi G, Andersson Y, Gárate T, Christensson D.,* (2007), Outbreak of trichinellosis in Spain and Sweden due to consumption of wild boar meat contaminated with Trichinella britovi. Euro Surveill, 12(11):pii=3154
17. *Gherman C.,* (2014), Trichinosis, in: Treatise on Veterinary Medicine, Vol VI Veterinary Parasitology (in Romanian), (Ed.) Risoprint, Cluj-Napoca, Romania, 843-871
18. *Gómez-Morales M.A., Mazzarello G., Bondi E., Arenare L., Bisso M.C., Ludovisi A., Amati M., Viscoli C., Castagnola E., Orefice G., Magnè F., Pezzotti P., Pozio E.*, (2021), Second outbreak of Trichinella pseudospiralis in Europe: clinical patterns, epidemiological investigation and identification of the etiological agent based on the western blot patterns of the patients' serum. Zoonoses Public Health, 68(1):29-37
19. *Gottstein B., Pozio E., Nöckler K.,* (2009), Epidemiology, diagnosis, treatment, and control of trichinellosis. Clin Microbio Rev, 22(1):127-145
20. *Grema C., Hotea I., Imre M., Dărăbuș G., Pascu C., Mariș C., Herman V.,* (2016), Seroprevalence of toxoplasmosis and salmonellosis in wild boars. Revista Romana de Medicina Veterinara, 26:18-22
21. *Handral H.K, Hua Tay S., Wan Chan W., Choudhury D.,* (2020), 3D Printing of cultured meat products. Crit Rev Food Sci Nutr, 1-10
22. *Ilie M.S., Imre K., Imre Mirela, Morariu S., Mederle N., Oprescu I., Hora F., Badea C., Tobă C., Dărăbuș G.,* (2016), Zoonotic aspects and molecular approach in trichinellosis in Gorj County, Romania. Revista Romana de Medicina Veterinara, 26(4):44-46
23. *Imre K., Pozio E., Tonanzi D., Sala C., Ilie M.S., Imre M., Morar A.,* (2015), The red fox (Vulpes vulpes) plays a minor role in the epidemiology of the domestic cycle of Trichinella in Romania. Vet Parasitol, 212(3-4):448-450
24. *Jayaprakash S., Paasi J., Pennanen K., Flores Ituarte, Lille M., Partanen J., Sozer N.,* (2020), Techno-economic prospects and desirability of 3D food printing: perspectives of industrial experts, researchers and consumers. Foods, 9(12):1725
25. *Kennedy E.D., Hall R.L., Montgomery S.P., Pyburn D.G., Jones J.L., Centers for Disease Control and Prevention (CDC),* (2009), Trichinellosis surveillance - United States, 2002-2007. MMWR Surveill Summ, 58(9):1-7
26. *Lille M., Kortekangas A., Heiniö R.L., Sozer N.,* (2020), Structural and textural characteristics of 3D-Printed Protein- and dietary fibre-rich snacks made of milk powder and wholegrain rye flour. Foods 23;9(11):1527
27. *Lupu M.A., Lazureanu E.V., Olariu T.R.,* (2016), Trichinellosis in western Romania a 4 year retrospective study. Int J Infect Dis, 53(Supp):83
28. *Marincu I., Neghina A.M., Calma C.L., Neghina R.,* (2012), New foci of trichinellosis in western Romania, 2011. Acta Trop, 121(1):47-49
29. *Mohib O., Clevenbergh P., Truyens C., Morissens M., Castro Rodriguez J.,* (2020), Trichinella spiralis-associated myocarditis mimicking acute myocardial infarction. Acta clinica Belgica,1-6
30. *Murrell K.D.,* (2016), The dynamics of Trichinella spiralis epidemiology: Out to pasture? Vet Parasitol, 231:92-96
31. *Murrell K.D., Pozio E.,* (2011), Worldwide occurrence and impact of human trichinellosis, 1986-2009. Emerg Infect Dis, 17:2194-202
32. *Neghina R., Iacobiciu I., Neghina A.M., Marincu I.,* (2011), Trichinellosis, another helminthiasis affecting the central nervous system. Parasitology Int, 60:230
33. *Neghina R., Šnábel V., Bobic B., Djurkovic-Djakovic O., Moldovan R., Borza C., Dumitrascu V., Calma L.C., Neghina M.A.,* (2014), Hydatidosis of the central nervous system in central and eastern Europe, In: Turgut Mehmet, Hydatidosis of the central nervous system: diagnosis and treatment, (Ed.)Springer, Berlin,Germany, 35-47
34. *Nemet C., Dobrescu C., Balescu A., Idomir M., Buvnariu L., Rogozea L.,* (2011), Retrospective epidemiological survey of diagnostic errors and their implications in the development of human trichinellosis in Brasov County over a period of 10 years. Vet Parasitol, 194(2-4):139-141
35. *Pozio E.,* (2014), Searching for Trichinella: not all pigs are created equal. Trends in parasitol, 30:4-11
36. *Rostami A., Gamble H.R., Dupouy-Camet J., Khazan H., Bruschi F.,* (2017), Meat sources of infection for outbreaks of human trichinellosis. Food Microbiol, 64:65-71
37. *Shimoni Z., Froom P.,* (2015), Uncertainties in diagnosis, treatment and prevention of trichinellosis. Expert Rev Anti Infect Ther, 13:1279-1288
38. *Singhal S., Rasane P., Kaur S., Garba U., Bankar A., Singh J., Gupta N.,* (2020), 3D food printing:paving way towards novel foods. An Acad Bras Cienc, 92:e2018073
39. *Soulé C., Dupouy-Camet J., Ancelle T., Bourée P., Touratier L.,* (1991), La trichinellose: une zoonose en évolution (ed.) OIE/ CNEVA, Paris, France
40. *Tingting L., Wenhui L., Nianzhang Z., Zigang Q., Ohiolei J.A., Li L., Hongbin Y.,Wanzhong J., Baoquan F.,* (2021), Primary characterization of the immune responses in Tibetan pigs infected with Chinese Tibet isolate of Trichinella spiralis. BMC Vet Res, 17:94
41. *Tso M., Zherebitskiy V., Nosib S.,* (2020), Myocarditis and raw meat consumption: strange bedfellows! Can J Cardiol, in press, Available at: https://www.sciencedirect.com/science/article/abs/pii/S0828282X20310540
42. *Wang H., Wu Z.C., Hu P., Ren H.L., Li Y.S., Zheng Y., Wang C., Zeng-Shan L., Lu S.Y.,* (2021), Identification of chicken-derived scFv against N-glycolylneuraminic acid retrieved from an immune library by phage display. Protein Expr Purif, 182:105841
43. *Zhuang Y.Y., Zheng H.Y., Lan H., Li H.W.,* (2020), Study on the correlation between dietary N-glycolylneuraminic acid intake and chronic inflammation state of body. Zhonghua yu fang yi xue za zhi [Chinese journal of preventive medicine], 54:668-672.