The Impact of Probiotics as Alternative Medication for Amoebiasis

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Abstract

The protozoan parasite *Entamoeba histolytica* is the cause of amoebiasis. This disease is found worldwide but is more common in developing nations where social and sanitary conditions are insecure. Serious clinical symptoms such as amoebic colitis, amoebic ulcer, ameboma, and amoebic liver abscess can accompany amoebiasis, worsening the host's illness and perhaps leading to death. Medications used for treating amoebiasis have several disadvantages such as the development of resistance and toxicity, therefore, recent research approved probiotics as alternative medication for amoebiasis without any side effects. Probiotics can control the multiplication and proliferation of pathogenic microorganisms in the intestinal wall and enhance the host's immune response. There are numerous popular probiotics viable today and are used in the treatment of amoebiasis such as *Enterococcus fecium, Lactobacillus casei,* and *Lactobacillus acidophilus*. This book chapter aimed to overview the amoebiasis and use of probiotics as a potential medication for amoebiasis.

Keywords: Amoebiasis, *Entamoeba histolytica*, Probiotics, Alternative medicine

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Introduction

Amoebiasis is a protozoan disease caused by *Entamoeba histolytica (E. histolytica*) and is widely distributed throughout the world, mainly in poor nations (Haji & Ismael, 2023; Oliveira et al., 2023). Amoebiasis is characterized by a wide range of clinical manifestations between asymptomatic, intestinal, and extraintestinal signs (Kantor et al., 2018; Stanley, 2003). The most clinical phases of amoebiasis are intestinal and extraintestinal. Intestinal amoebiasis dysentery, amoebic ulcer, amoebic colitis, and ameboma (Espinosa-Cantellano & Martínez-Palomo, 2000). While the extraintestinal phase clinical manifestations depend on the affected organs, which causes hepatic abscesses, pulmonary amoebiasis, cutaneous amoebiasis, genital amoebiasis, etc. (Shamsuzzaman & Hashiguchi, 2002; Tanyuksel & Petri, 2003; Shenoy et al., 2010; Saidin et al., 2019). The amoebiasis if left without medication may be lethal (Carrero et al., 2020). Also, amoebiasis occurs among tourists visiting regions where the amoebiasis is endemic there (Carrero et al., 2020; Haji & Ismael, 2023).

According to the severity of amoebiasis and forms of the disease (intestinal or extraintestinal), the medication (antiamoebics) is given (Martínez-Castillo et al., 2018; Cuellar-Guevara et al., 2019). The antiamoebics drug is divided into two types: the intestinal antiamoebic drugs such as diloxanide furoate, iodoquinol, nitazoxanide, and paromomycin, and they are used for managing amoebic dysentery, and amoebic colitis, and the extraintestinal antiamoebic drugs such as chloroquine, emetine, metronidazole, and tinidazole, they are used for managing of amoebic abscess in liver, lung, skin etc. (Martínez-Castillo et al., 2018; Shirley et al., 2018). This chapter aimed to overview the role of probiotics in the management and treatment of amoebiasis.

1.2. Amoebiasis

Amoebiasis is a protozoan parasitic infection, caused by *E. histolytica*. *E. histolytica* has two main stages, the trophozoite, and mature cyst stages; the trophozoite or the active stage is irregular in shape has a single eccentric nucleus, and is moved by single pseudopodia, and the inactive or cyst stage; is oval or round in shape, and have with four nuclei (Adl et al., 2019). The protoplasm is the basic structure of the protozoa as usual the *E. histolytica*, which is differentiated into cytoplasm and nucleus. The cytoplasm is divided into parts the clear portion named ectoplasm and the inner granular portion named endoplasm, which have a single spherical eccentric nucleus with central karyosom, food, and contractile vacuoles. *E. histolytica* is multiplied and reproduced by simple binary fission (Samba-Louaka et al., 2019). Is estimated that of the burden of amoebiasis globally, about 10% of five hundred million infected people have symptoms (Shirley & Moonah, 2016; Cui et al., 2019; Tharmaratnam et al., 2020). The amoebiasis is an endemic disease in America (central and South), Africa, and Asia (Ximénez et al., 2009). These reports which depend on the geographical region, clinical manifestations, severity of infection, and incubation of parasite, study design, sample size, and the sensitivity of the diagnostic methods were used modality used. Furthermore, amoebiasis in the endemic region restricted the ability of diagnostic tests and surveillance (Carrero et al., 2020).

The life cycle of amoebiasis is direct and simple, humans, mainly children are infected through ingestion of the infective stage (mature

cysts) within grasses, food, vegetables, or deinked water (Ismael et al., 2024). Then after the mature cyst reaches the small intestine an excystation occurs and trophozoites are released and multiplied asexually by binary fission, trophozoites migrate from the small intestine to the large intestine, some trophozoites invade the intestinal wall and via blood reach to extraintestinal organs such as liver, lung, brain, ovary, skin, etc. and the rest trophozoites passe with stool and become cyst under unfavorable condition (Barwari & Ismael, 2011; Guillén, 2023). Acute amoebiasis is characterized by the most common symptoms, which include colic, bloody diarrhea, fever, and other systemic symptoms are rare (Ali et al., 2008; Ximénez et al., 2010). The amoebiasis has two phases the intestinal and intestinal phases (Abasszade et al., 2020; CDC, 2024), the main clinical signs of the intestinal phase are gastrointestinal disturbance and amoebic ulcer for extraintestinal phase is abscesses in different organs such as the liver, lung, spleen, uterus, skin, etc. because trophozoites can penetrate tissues and bypass the epithelium due to their rapid motility and enzymatic activity. Once in the bloodstream, they can harm other organs, particularly the liver (Thibeaux et al., 2013; Abasszade et al., 2020). There most prevalent and fatal types of amoebiasis are colon ameboma, megacolon, and necrotizing colitis (Tanaka et al., 2021; Morán et al., 2023). Since the host's immune system and the parasite's virulent molecules both contribute to the disease's pathogenesis by damaging tissues that allow entrance to systemic locations, *E. histolytica* has a multifactorial etiology. *E. histolytica's* destructive methods include phagocytosis, cytolysis, and interaction with target cells, as well as the breakdown of ingested cells (Betanzos et al., 2013; Shahi et al., 2019). The severity of infection depends on the strains of *E. histolytica* because there are 22 strains and only seven are pathogenic, infective dose (number of mature cysts are ingested), host immune status, host nutritional status, present of chronic disease, pregnancy, etc. (Castellanos-Castro et al., 2020). The main clinical manifestations of amoebiasis in the endemic regions are gastrointestinal disturbance, and dysentery and these signs need medication to prevent extraintestinal manifestations (*Guarner, 2019).*

The main diagnosis of amoebiasis depends on the identification and detection of trophozoite and mature cysts of *E. histolytica* in stool samples. This is done by direct stool examination (including direct dry and direct wet stool smears) (Barwari & Ismael, 2011). There are several serological tests used for the diagnosis such as ELISA, and molecular tests such as polymerase chain reaction (PCR) (Saidin et al., 2019). The molecular methods are highly sensitive and specific for the identification of the strains of *E. histolytica* (Saidin et al., 2019; Mukbel et al., 2024).

The treatment of amoebiasis, called antiamobics, and its dosage is based on the severity of the infection and the clinical signs (Palombo, 2006; Martínez-Castillo et al., 2018). Antiamoebics work on both intestinal and extraintestinal forms of infections such as diloxanide, adiiodohydroxyquinoline, nitroimidazoles, and paromomycin (Maroyi, 2016; Al-Areeqi et al., 2017; Gonzales et al., 2019). Depending on the several studies, amebiasis has resistance to several of these antiamobic medications, therefore probiotics are used as a medication to decrease the resistance and their toxicity (Garfias & Álvarez, 2008). There are different probiotics used for the treatment and prevention of amoebiasis *Saccharomyces boulardii* yeast in combination with antibiotic medication (Mansour-Ghanaei et al., 2003).

1.2. Using of Probiotic in Treating of Amoebiasis

Probiotics are live microorganisms that help the host's health when given in sufficient dosages (Ouwehand et al., 2002; WHO, 2023). The ideal probiotic strain should be non-pathogenic, tolerant to low pH and acids, which allows it to stay in the intestine, able to stick to the gut epithelium, and provide positive properties (immune activation, protection against infections, metabolism, etc.) (Gupta & Garg, 2009). The majority of probiotics are gram-positive bacteria that have been extracted from the gut microbiota of humans or other dairy products including kulfi, curd, and lassi. The therapeutic effects of probiotics, however, have mostly been shown in model animals rather than via direct clinical data, and they are highly dependent on the dosage that is consumed (Gupta & Garg, 2009; Oelschlaeger, 2010). There are three ways by which the using of probiotics affects the microorganism (Travers et al., 2011).

The probiotics can control the multiplication and proliferation of pathogenic microorganisms in the intestinal wall. The majority of pathogenic bacteria require iron, and probiotics may compete with them for their availability, making iron a limiting nutrient. Using siderophores that chelate and transfer iron or bind ferric hydroxide to its surface (Elli et al., 2000), Lactobacillus can make iron inaccessible to harmful microbes (Oelschlaeger, 2010). Probiotics use strain-specific processes that rely on competition, chemical release, and/or immunological induction to either kill or inhibit infections. According to the majority of the interactions reported, the same gut compartment is colonized by a pathogen (Hayes et al., 2010). Probiotics can reduce the risk of infectious disease and antibiotic use, and prevent or limit the spread of microorganisms' resistance to certain medications (Wohlgemuth et al., 2010; Li et al., 2022).

Postbiotics can be used in combination with and can used for treating several clinical infectious diseases that are caused by bacteria, and parasites (protozoa). Examples of protozoan parasitic diseases such as giardiasis, amoebiasis, Trypanosomiasis, and leishmaniasis. Probiotics can inhibit the proliferation and spread of parasites (Ramesh & Dharumadurai, 2024). Probiotics are used as alternative treatments for intestinal and extraintestinal amoebiasis and reduce its prevalence (Nagaraja & Ankri, 2019). Also, the use of probiotics in the case of amoebiasis can avoid the adherence of the parasite, *E. histolytica* to the intestinal epithelium and prevent colonization (Rigothier et al., 1994; Mansour-Ghanaei et al., 2003). Today, *Enterococcus fecium, Lactobacillus casei,* and *Lactobacillus acidophilus* are examples of probiotics used as a medication for amoebiasis in humans (Hertzberger et al., 2014; Sarjapuram et al., 2017; Varet et al., 2018).

Luis et al. (2016), approved that probiotics act as an active agent for the management and treatment of intestinal microorganisms including parasites. Probiotics are tough and can control the multiplication and proliferation of microorganisms in the intestine. Martin et al. (2014), suggested that the main idea of using probiotics is to prevent the clinical symptoms are caused by the gastrointestinal infections are caused by the parasites such as amoebiasis, giardiasis, and cryptosporidiosis. Probiotics reduce the burden of parasites and decrease the severity of infection (Carlos et al., 2010).

Probiotics play an important role in the deworming of intestinal parasites (Travers et al., 2011). Gupta and Garg, (2009), said that the use of probiotics as an alternative treatment can prevent the colonization and proliferation of other bacteria and interact with parasites, which increases the severity of infection. For instance, iron is a finite resource that most bacteria require, and probiotics can compete for its availability. Lactobacillus can bind ferric hydroxide to its surface or release siderophores that chelate and transfer iron, which can deprive harmful microbes of iron (Elli et al., 2000; Oelschlaeger, 2010). According to Wohlgemuth et al. (2010), probiotics also affect the balance and makeup of the gut microbiota. Finally, probiotics have the ability to control their biotic environment by regulating the peristaltic movement

and mucus secretion (Gupta and Garg, 2009).

Probiotics release antibiotics, bacteriocin, hydrogen peroxide, and free fatty acids, all of which can successfully stop the growth and survival of parasites in the area. Bacteriocins that are secreted usually disrupt essential enzymes or permeabilize the membranes of closely related bacteria, resulting in their death. *Lactobacillus reuteri* produces 3 hydroxy propionic aldehydes, a broad-spectrum antibiotic that works against bacteria, yeast, fungi, viruses, and parasites (Travers et al., 2011). Probiotics can also change the growth of acid-sensitive organisms by lowering the pH of the localized gut environment with lactic acid (Wohlgemuth et al., 2010).

Additionally, probiotics change immunity by strengthening the host immune system's response to a variety of illnesses. The probiotics affect immune cells, Peyer's patch cells of the intestine, and epithelial cells. As a result of these interactions, secretory IgA and IgM which are essential for mucosal immunity and aid in forming a barrier against harmful organisms are produced in greater quantities along with the number of cells that generate IgA (Marie-Agnes et al., 2011; Vitetta et al., 2016). Additionally, probiotics may also affect dendritic cells, which collect gut antigens and present them to naive T cells, leading them to undergo differentiation of either T-helper or T-regulatory lymphocytes (Travers et al., 2011). Furthermore, probiotics have been found to influence the secretion of cytokine (IL 10 & 12, TNF-α, & IFN-γ), which are crucial for maintaining the delicate balance between appropriate and excessive immune system responses (Travers et al., 2011; Helmy et al., 2023).

It has been demonstrated that probiotics, such as Lactobacillus and Saccharomyces, can reduce the severity of intestinal symptoms and repair damage, particularly in giardiasis cases (Mansour-Ghanaei et al., 2003). Probiotics have the potential to improve the makeup of commensal microbiota, which could lead to therapeutic outcomes. Probiotics can reduce parasite-induced mucosal damage by increasing antioxidant capacity, decreasing oxidative products, and regulating mucosal and immune systems, as demonstrated by preclinical and clinical research (Vitetta et al., 2016). They can also reduce the burden of *E. histolytica* by concentrating on the parasite directly. They can break down the parasite's cellular structure and prevent the development and growth of trophozoites by producing specific compounds with anti-amoebal qualities. Further research will be necessary to identify suitable probiotics for amoebiasis treatment and prevention (Dashti & Zarebavani, 2021). Finally, the mentioned probiotics have been demonstrated to decrease cyst excretion, trophozoite viability, and proliferation, and in certain situations, eradicate the infection in both in vitro and in vivo settings (Oliveira et al., 2024).

Conclusion

Around the world, amoebiasis is regarded as a serious public health concern, particularly in developing nations where a sizable portion of the populace lacks easy access to basic sanitary conditions and, as a result, lacks adequate hygienic conditions, rendering strategies to reduce its transmission ineffective. Probiotics are live products that are important and beneficial for the body, mainly the intestine. This book chapter has been concluded that probiotics considered an effective therapeutic and alternative medication for intestinal parasitic diseases such as amoebiasis and giardiasis. Through strain-specific mechanisms, probiotics can generate physical or chemical barriers in the intestinal epithelium to stop pathogen penetration and either kill or inhibit the parasites. There are several factors contributed with using of probiotics as alternative medication for parasitic disease (amoebiasis). Probiotics can balance the between normal flora and bad bacteria in the intestinal tract, and reduce intestinal parasitic diseases.

References

Abasszade, J. H., Little, R., Yeaman, F., Robertson, M., & Bell, S. (2020). Amoebic colitis: A case series of a recurring missed diagnosis. *JGH Open: An Open Access Journal of Gastroenterology and Hepatology*, *5*(3), 404–407. https://doi.org/10.1002/jgh3.12484

Adl, S. M., Bass, D., Lane, C. E., Lukeš, J., Schoch, C. L., Smirnov, A., Agatha, S., Berney, C., Brown, M. W., Burki, F., Cárdenas, P., Čepička, I., Chistyakova, L., Del Campo, J., Dunthorn, M., Edvardsen, B., Eglit, Y., Guillou, L., Hampl, V., Heiss, A. A., & Zhang, Q. (2019). Revisions to the Classification, Nomenclature, and Diversity of Eukaryotes. *The Journal of Eukaryotic Microbiology*, *66*(1), 4–119. https://doi.org/10.1111/jeu.12691

Al-Areeqi, M.A., Sady, H., Al-Mekhlafi, H.M., Anuar, T.S., Al-Adhroey, A.H., Atroosh, W.M., Dawaki, S.S., Elyana, F.N., Nasr, N.A., Ithoi, I., Lau, Y.L., & Surin, J. (2017). First molecular epidemiology of Entamoeba histolytica, E. dispar and E. moshkovskii infections in Yemen: different species-specific associated risk factors. *Tropical Medicine & International Health, 22* (4), 493-504.

Ali, I. K., Clark, C. G., & Petri, W. A., Jr (2008). Molecular epidemiology of amebiasis. *Infection, Genetics and Evolution: Journal of Molecular Epidemiology and Evolutionary Genetics in Infectious Diseases*, *8*(5), 698–707. https://doi.org/10.1016/j.meegid.2008.05.004

Barwari, W. J., & Ismael, S. S. (2011). Detection of Pathogenic Strains of *Entamoeba histolytica* in Children Using ELISA Technique in Duhok. *Journal of Duhok University*, *8*(2), 109-119.

Betanzos, A., Javier-Reyna, R., García-Rivera, G., Bañuelos, C., González-Mariscal, L., Schnoor, M., & Orozco, E. (2013). The EhCPADH112 complex of *Entamoeba histolytica* interacts with tight junction proteins occludin and claudin-1 to produce epithelial damage. *PloS One*, *8*(6), e65100. https://doi.org/10.1371/journal.pone.0065100

Carlos, R. S, Luciana, P. V., Michele, R. S., Adriane, B. P. M., Caroline, T. Y., Juliano, D. L Ashok. P. & Vanete, T. S. (2010). The potential of probiotics: Review. *Journal of Food Technology and Biotechnology, 48*(4), 413-434.

Carrero, J. C., Reyes-López, M., Serrano-Luna, J., Shibayama, M., Unzueta, J., León-Sicairos, N., & de la Garza, M. (2020). Intestinal amoebiasis: 160 years of its first detection and still remains as a health problem in developing countries. *International Journal of Medical Microbiology: IJMM*, *310*(1), 151358. https://doi.org/10.1016/j.ijmm.2019.151358

Castellanos-Castro, S., Bolaños, J., & Orozco, E. (2020). Lipids in *Entamoeba histolytica*: Host-Dependence and Virulence Factors. *Frontiers in Cellular and Infection Microbiology*, *10*, 75. https://doi.org/10.3389/fcimb.2020.00075

Center for Disease Control and Prevention (CDC) (2024). https://mavink.com/explore/Pathophysiology-of-Amoebiasis

Cuellar-Guevara, F. L., Barrón-González, M. P., & Menchaca-Arredondo, J. L. (2019). Effect of lactobacillus postbiotics on entamoeba histolytica

trophozoites. *Revista de investigacion clinica; organo del Hospital de Enfermedades de la Nutricion*, *71*(6), 402–407. https://doi.org/10.24875/RIC.19003134

Cui, Z., Li, J., Chen, Y., & Zhang, L. (2019). Molecular epidemiology, evolution, and phylogeny of Entamoeba spp. *Infection, Genetics and Evolution: Journal of Molecular Epidemiology and Evolutionary Genetics in Infectious Diseases*, *75*, 104018. https://doi.org/10.1016/j.meegid.2019.104018

Dashti, N., Zarebavani, M. Probiotics in the management of *Giardia duodenalis*: an update on potential mechanisms and outcomes. *Naunyn-Schmiedeberg's Arch Pharmacol, 394*, 1869–1878 (2021). https://doi.org/10.1007/s00210-021-02124-z

Elli, M., Zink, R., Rytz, A., Reniero, R., & Morelli, L. (2000). Iron requirement of Lactobacillus spp. in completely chemically defined growth media. *Journal of Applied Microbiology*, *88*(4), 695–703. https://doi.org/10.1046/j.1365-2672.2000.01013.x

Espinosa-Cantellano, M., & Martínez-Palomo, A. (2000). Pathogenesis of intestinal amebiasis: from molecules to disease. *Clinical Microbiology Reviews*, *13*(2), 318–331. https://doi.org/10.1128/CMR.13.2.318

Garfias, C. R. B., & Álvarez, M. D. C. T. (2008). The inoculation of *Lactobacillus casei* in NIH mice induces a protective response against *Trypanosoma cruzi* (Ninoa strain) infection. *Veterinaria Mexico*, *39*(2), 139-144.

Gonzales, M. L. M., Dans, L. F., & Sio-Aguilar, J. (2019). Antiamoebic drugs for treating amoebic colitis. *The Cochrane Database of Systematic Reviews*, *1*(1), CD006085. https://doi.org/10.1002/14651858.CD006085.pub3

Guarner, V. (2019). Treatment and Prevention of Amebiasis. In: Kretschmer R.R., editor. Amebiasis: Infection and Disease by Entamoeba Histolytica. CRC Press; Boca Raton, FL, USA: 221–23.

Guillén N. (2023). Pathogenicity and virulence of *Entamoeba histolytica*, the agent of amoebiasis. *Virulence*, *14*(1), 2158656. https://doi.org/10.1080/21505594.2022.2158656

Gupta, V., & Garg, R. (2009). Probiotics. *Indian Journal of Medical Microbiology, 27*(3), 202–209. https://doi.org/10.4103/0255-0857.53201

Haji, H.M., & Ismael, S.S. (2023). Prevalence of *Entamoeba histolytica* and *Giardia lamblia* in children in Duhok Province, Kurdistan Region, Iraq. *Journal of Duhok University, 26*(1), 274-80.

Hayes, K. S., Bancroft, A. J., Goldrick, M., Portsmouth, C., Roberts, I. S., & Grencis, R. K. (2010). Exploitation of the intestinal microflora by the parasitic nematode Trichuris muris. *Science (New York, N.Y.)*, *328*(5984), 1391–1394. https://doi.org/10.1126/science.1187703

Helmy, Y. A., Taha-Abdelaziz, K., Hawwas, H. A. E., Ghosh, S., AlKafaas, S. S., Moawad, M. M. M., Saied, E. M., Kassem, I. I., & Mawad, A. M. M. (2023). Antimicrobial Resistance and Recent Alternatives to Antibiotics for the Control of Bacterial Pathogens with an Emphasis on Foodborne Pathogens. *Antibiotics (Basel, Switzerland)*, *12*(2), 274. https://doi.org/10.3390/antibiotics12020274

Hertzberger, R., Arents, J., Dekker, H. L., Pridmore, R. D., Gysler, C., Kleerebezem, M., & de Mattos, M. J. (2014). H(2)O(2) production in species of the Lactobacillus acidophilus group: a central role for a novel NADH-dependent flavin reductase. *Applied and Environmental Microbiology*, *80*(7), 2229–2239. https://doi.org/10.1128/AEM.04272-13

Ismael, S. S., Abdullah, B. H., Sadiq, A. J., Ajaj, J. S., Ali, N. S., Omer, D. M., & Nori, N. Y. (2024). Prevalence of Intestinal Protozoan Parasites among Children Attending the Hevi Pediatric Hospital in Duhok Province, Kurdistan Region, Iraq. *Archives of Razi Institute*, *79*(3), 507–512. https://doi.org/10.32592/ARI.2024.79.3.507

Kantor, M., Abrantes, A., Estevez, A., Schiller, A., Torrent, J., Gascon, J., Hernandez, R., & Ochner, C. (2018). Entamoeba Histolytica: Updates in Clinical Manifestation, Pathogenesis, and Vaccine Development. *Canadian Journal of Gastroenterology & Hepatology, 2018,* 4601420. https://doi.org/10.1155/2018/4601420

Li, X., Wang, Q., Hu, X., & Liu, W. (2022). Current Status of Probiotics as Supplements in the Prevention and Treatment of Infectious Diseases. *Frontiers in Cellular and Infection Microbiology*, *12*, 789063. https://doi.org/10.3389/fcimb.2022.789063

Mansour-Ghanaei, F., Dehbashi, N., Yazdanparast, K., & Shafaghi, A. (2003). Efficacy of saccharomyces boulardii with antibiotics in acute amoebiasis. *World Journal of Gastroenterology*, *9*(8), 1832–1833. https://doi.org/10.3748/wjg.v9.i8.1832

Marie-Agnes, T., Isabelle, F., Linda, K., & Philippe, G. (2011). Probiotics for the control of parasites: An overview. *Journal of Parasitology Research*, 1-11.

Maroyi A. (2016). Treatment of diarrhoea using traditional medicines: contemporary research in south africa and zimbabwe. *African Journal of Traditional, Complementary, and Alternative Medicines: AJTCAM*, *13*(6), 5–10. https://doi.org/10.21010/ajtcam.v13i6.2

Martin, R., Miquel, S., Ulmer, J., Langella, P., & Bermudez Humaran, L. G. (2014). Gut ecosystem: How microbes help us. *Beneficial Microbes, 5*, 219-233.

Martínez-Castillo, M., Pacheco-Yepez, J., Flores-Huerta, N., Guzmán-Téllez, P., Jarillo-Luna, R. A., Cárdenas-Jaramillo, L. M., Campos-Rodríguez, R., & Shibayama, M. (2018). Flavonoids as a Natural Treatment Against *Entamoeba histolytica*. *Frontiers in Cellular and Infection Microbiology*, *8*, 209. https://doi.org/10.3389/fcimb.2018.00209

Morán, P., Serrano-Vázquez, A., Rojas-Velázquez, L., González, E., Pérez-Juárez, H., Hernández, E. G., Padilla, M. L. A., Zaragoza, M. E., Portillo-Bobadilla, T., Ramiro, M., & Ximénez, C. (2023). Amoebiasis: Advances in Diagnosis, Treatment, Immunology Features and the Interaction with the Intestinal Ecosystem. *International Journal of Molecular Sciences*, *24*(14), 11755. https://doi.org/10.3390/ijms241411755

Mukbel, R., Hammad, H., Enemark, H., Alsabi, R., & Al-Sabi, M. (2024). Molecular characterization of Giardia duodenalis, Cryptosporidium spp., and Entamoeba spp. infecting domestic and feral/stray cats in Jordan. *Parasitology Research*, *123*(10), 351. https://doi.org/10.1007/s00436-024-08358-z

Nagaraja, S., & Ankri, S. (2019). Target identification and intervention strategies against amebiasis. *Drug Resistance Updates: Reviews and Commentaries in Antimicrobial and Anticancer Chemotherapy*, *44*, 1–14. https://doi.org/10.1016/j.drup.2019.04.003

Oelschlaeger, T. A. (2010). Mechanisms of probiotic actions - A review. *International Journal of Medical Microbiology: IJMM, 300*(1), 57–62. https://doi.org/10.1016/j.ijmm.2009.08.005

Oliveira, F.M., Prado, G., Cruz, R.E., Gomes, M.A., & Caliari, M.V. (2023). Amoebiasis and probiotics: perspectives on complementary

treatment. *Reviews and Research in Medical Microbiology, 34*, 225 - 235. https://doi.org/10.1097/MRM.0000000000000367

Oliveira, V. M., de Corrêa, M. R., Silva, I. C. V., Corrêa, L. R., & Gomes, M. A. (2024). Probiotics as a therapeutic alternative in amoebiasis. Where are we?. *Research, Society and Development*, *13*(10), e43131047039. https://doi.org/10.33448/rsd-v13i10.47039

Ouwehand, A. C., Salminen, S., & Isolauri, E. (2002). Probiotics: an overview of beneficial effects. *Antonie van Leeuwenhoek*, *82*(1-4), 279–289.

Palombo, E. A. (2006). Phytochemicals from traditional medicinal plants used in the treatment of diarrhoea: modes of action and effects on intestinal function. *Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives*, *20*(9), 717-724.

Ramesh, L., Dharumadurai, D. (2024). Antiprotozoan Activity of Postbiotics. In: Dharumadurai, D. (Eds.), *Postbiotics. Methods and Protocols in Food Science*. Humana, New York, NY. https://doi.org/10.1007/978-1-0716-3421-9_29

Rigothier, M. C., Maccario, J., & Gayral, P. (1994). Inhibitory activity of *Saccharomyces* yeasts on the adhesion of *Entamoeba histolytica* trophozoites to human erythrocytes in vitro. *Parasite Research, 80*(1), 10–15. https://doi.org/10.1007/BF00932617

Saidin, S., Othman, N., & Noordin, R. (2019). Update on laboratory diagnosis of amoebiasis. *European Journal of Clinical Microbiology & Infectious Diseases: Official Publication of the European Society of Clinical Microbiology*, *38*(1), 15–38. https://doi.org/10.1007/s10096-018-3379-3

Samba-Louaka, A., Delafont, V., Rodier, M. H., Cateau, E., & Héchard, Y. (2019). Free-living amoebae and squatters in the wild: ecological and molecular features. *FEMS Microbiology Reviews*, *43*(4), 415–434. https://doi.org/10.1093/femsre/fuz011

Sarjapuram, N., Mekala, N., Singh, M., & Tatu, U. (2017). The Potential of Lactobacillus casei and Entercoccus faecium Combination as a Preventive Probiotic Against Entamoeba. *Probiotics and Antimicrobial Proteins*, *9*(2), 142–149. https://doi.org/10.1007/s12602-016-9232-z

Shahi, P., Moreau, F., & Chadee, K. (2019). *Entamoeba histolytica* Cyclooxygenase-Like Protein Regulates Cysteine Protease Expression and Virulence. *Frontiers in Cellular and Infection Microbiology*, *8*, 447. https://doi.org/10.3389/fcimb.2018.00447

Shamsuzzaman, S. M., & Hashiguchi, Y. (2002). Thoracic amebiasis. *Clinics in Chest Medicine*, *23*(2), 479–492. https://doi.org/10.1016/s0272-5231(01)00008-9

Shenoy, V. P., Vishwanath, S., Indira, B., & Rodrigues, G. (2010). Hepato-pulmonary amebiasis: a case report. *The Brazilian journal of infectious diseases: an official publication of the Brazilian Society of Infectious Diseases*, *14*(4), 372–373.

Shirley, D. A., & Moonah, S. (2016). Fulminant Amebic Colitis after Corticosteroid Therapy: A Systematic Review. *PLoS Neglected Tropical Diseases*, *10*(7), e0004879. https://doi.org/10.1371/journal.pntd.0004879

Shirley, D. T., Farr, L., Watanabe, K., & Moonah, S. (2018). A Review of the Global Burden, New Diagnostics, and Current Therapeutics for Amebiasis. *Open Forum Infectious Diseases*, *5*(7), ofy161. https://doi.org/10.1093/ofid/ofy161

Stanley, S. L. (2003). Amoebiasis. *The Lancet*, *361*(9362), 1025-1034.

Tanaka, E., Tashiro, Y., Kotake, A., Takeyama, N., Umemoto, T., Nagahama, M., & Hashimoto, T. (2021). Spectrum of CT findings in amebic colitis. *Japanese Journal of Radiology*, *39*(6), 558–563. https://doi.org/10.1007/s11604-021-01088-7

Tanyuksel, M., & Petri, W. A., Jr (2003). Laboratory diagnosis of amebiasis. *Clinical Microbiology Reviews*, *16*(4), 713–729. https://doi.org/10.1128/CMR.16.4.713-729.2003

Tharmaratnam, T., Kumanan, T., Iskandar, M. A., D'Urzo, K., Gopee-Ramanan, P., Loganathan, M., Tabobondung, T., Tabobondung, T. A., Sivagurunathan, S., Patel, M., & Tobbia, I. (2020). *Entamoeba histolytica* and amoebic liver abscess in northern Sri Lanka: a public health problem. *Tropical Medicine and Health*, *48*, 2. https://doi.org/10.1186/s41182-020-0193-2

Thibeaux, R., Weber, C., Hon, C. C., Dillies, M. A., Avé, P., Coppée, J. Y., Labruyère, E., & Guillén, N. (2013). Identification of the virulence landscape essential for Entamoeba histolytica invasion of the human colon. *PLoS Pathogens*, *9*(12), e1003824. https://doi.org/10.1371/journal.ppat.1003824

Travers, M. A., Florent, I., Kohl, L., & Grellier, P. (2011). Probiotics for the control of parasites: an overview. *Journal of Parasitology Research*, *2011*, 610769. https://doi.org/10.1155/2011/610769

Varet, H., Shaulov, Y., Sismeiro, O., Trebicz-Geffen, M., Legendre, R., Coppée, J. Y., Ankri, S., & Guillen, N. (2018). Enteric bacteria boost defences against oxidative stress in Entamoeba histolytica. *Scientific Reports*, *8*(1), 9042. https://doi.org/10.1038/s41598-018-27086-w

Vitetta, L., Saltzman, E. T., Nikov, T., Ibrahim, I., & Hall, S. (2016). Modulating the Gut Micro-Environment in the Treatment of Intestinal Parasites. *Journal of Clinical Medicine*, *5*(11), 102. https://doi.org/10.3390/jcm5110102

Wohlgemuth, S., Loh, G., & Blaut, M. (2010). Recent developments and perspectives in the investigation of probiotic effects. *International Journal of Medical Microbiology: IJMM*, *300*(1), 3–10. https://doi.org/10.1016/j.ijmm.2009.08.003

World Health Organization (WHO). (2023). https://www.who.int/foodsafety/publications/fs_management/probiotics2/en/

Ximénez, C., Cerritos, R., Rojas, L., Dolabella, S., Morán, P., Shibayama, M., González, E., Valadez, A., Hernández, E., Valenzuela, O., Limón, A., Partida, O., & Silva, E. F. (2010). Human amebiasis: breaking the paradigm?. *International Journal of Environmental Research and Public Health*, *7*(3), 1105–1120. https://doi.org/10.3390/ijerph7031105

Ximénez, C., Morán, P., Rojas, L., Valadez, A., & Gómez, A. (2009). Reassessment of the epidemiology of amebiasis: state of the art. *Infection, Genetics and Evolution: Journal of Molecular Epidemiology and Evolutionary Genetics in Infectious Diseases*, *9*(6), 1023–1032. https://doi.org/10.1016/j.meegid.2009.06.008