

Raw meat based diet (RMBD) for household pets as potential door opener to parasitic load of domestic and urban environment. Revival of understated zoonotic hazards? A review

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ABSTRACT

RMBD (acronym of Raw Meat Based Diet) and BARF diets (acronym for Biologically Appropriate Raw Food or Bones and Raw Food) account dietary regimens based on raw ingredients (including raw meat), popular in pet feeding. Animal tissues and organs as well as other uncooked ingredients are more and more popularly used by pet owners to feed household pets. However, the increased risk of exposure to microbiological and parasitic agents poses the question as to whether such diets may be recommendable to be handled and offered to domestic cats and dogs co-living in domestic and urban environment. Above all, the threat of human and animal infections by parasites from raw meat fed to pets is not sufficiently explored and tracked, meanwhile deserving particular surveillance, instead. At this regard, raw meat feeding to pets may represent a route of exposure to the increased risk of environmental load. In fact, some parasites typically found in rural environment can be given the chance to complete their life-cycle, for the closeness between definitive and intermediate hosts. This is of particular concern, as potentially infected pets serving as definitive hosts can become a continuous source of environmental diffusion of parasites, both at domestic and urban level. The handling of raw meat requires adequate knowledge and awareness of the hygienic principles to prevent the onset of disorders related to both manipulation by pet owners and uncooked food consumption by the pet. This review aimed to shed a comprehensive overview of the hygienic aspects related to raw pet feeding, as to handling of raw meat in domestic environment, with special emphasis on parasitic agents and related zoonotic hazards.

1. Introduction

In recent years, the trend of feeding raw meat based diets (RMBD) to domestic cats and dogs has significantly grown among pet keepers [1]. Approximately, 60% of pet owners feed their cats and dogs completely or partially raw meat based diet, and this practice is popular in several European countries [2]. RMBDs consist of raw ingredients such as organs, muscle tissues and bones of slaughtered animals which may be prepared and offered as home made diets, or purchased, either refrigerated, frozen or dried from the market likely complemented by cooked carbohydrate premix. These diets are also referred as BARF (Biologically Appropriate Raw Food or Bones and Raw Food) when feeding regimen is completely based on raw ingredients including carbohydrate part [3]. It

is a common belief that raw diet is a natural and healthy way to advance pet health, because respectful of ancestral feeding habits. However, such opinions are not supported by scientific evidence of beneficial effects on pet health, most of times empirically supported by owner persuasion [4,5]. Anecdotes circulating on the web support the benefits of raw feeding, including the boost of immune system with maximization of general health and body conditions, accompanied by behavioural improvements [3,6]. However, plausible evidence indicated nutritional imbalances, as well as metabolic and gastrointestinal dysfunction in some cases, as a result of unbalanced and “self-prepared BARF diets [7].

The European legislation on pet food safety is the same for feeds destined to livestock. In particular, the legislation in force concerning animal by products (ABP) accounts Regulations of the (EC) no. 1069/

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2009 [8] and no. 142/2011 [9]. Health rules on the use of the different categories of ABP are a reference point for the use of ingredients of animal origin for pet food production. Raw pet food suppliers are subjected principally to abide by regulation (EC) No. 1069/2009 governing animal by-products and derivatives, which are fit but not intended for human consumption. The type of byproducts allowed in pet food is regulated in “Category 3” raw materials. This also include human food containing animal byproducts which are safe and hygienic but removed from human food chain owing to certain commercial reasons [10]. In addition, the regulation also entails those by products which are declared unfit for human consumption but permitted for use in pet diets, provided that animal was slaughtered at abattoir and approved fit for human consumption during *ante mortem* examination and didn't manifest any evidence of communicable diseases during post mortem inspection [1,8].

Along with this, the publication of Regulation of the European Union 2017/625 also serves to secure feed hygiene with limitation and prevention of risk to animals and humans, ruling the conduction of official controls and adoption of a series of measures across all stages of the production chain [11].

However, feeding raw ingredients to household cats and dogs may pose some concerns as to the safe handling and use at home. Investigations on hygiene of raw diets have highlighted how the occurrence of positive testing to various zoonotic bacterial pathogens, such as *Escherichia coli*, *Clostridium* spp., *Salmonella* spp., *Listeria* spp. and *Campylobacter* spp., could pose a concrete risk to pets and to the people handling raw meat products together with the challenge of fecal shedding by infected pets [12–14]. In addition, pets may also get infected after eating raw fish, with the potential presence of diverse types of parasites such as *Anisakis simplex* in cats [15], *Diocotophyma renale* (giant kidney worm), *Diphylllobothrium latum* (fish tapeworm), *Opisthorchis tenuicollis* (trematodes of the small intestine, bile duct and pancreatic ducts) and salmon infection to dogs by *Nanophyetus salmincola* [14]. Should those infections occur, a health issue for cats and dogs must be faced, but the parasitic load in the domestic environment is not expected to be of concern, as infection requires direct consumption or manipulations of infected raw fish. Very recently (2020), the outbreak of feline tuberculosis in England was possibly linked to BARF feeding and this fact supports the debate on a series of concerns about the safety of such feeding practice [16]. It is reasonable to consider that RMBD diets are often adopted without adequate awareness about hygienic aspects. A number of potentially dangerous parasites, bacteria and viruses (Table 1) could represent a serious threat for animal and human health when raw feeding is adopted [1,3,12,13]. The exposure to such pathogens is multifaceted, due to infected pets which can transmit pathogens to their owners by direct contact, or through contamination of surfaces at home (Fig. 2) [3].

The potential hazard of parasitic infections in pet animals is based for some parasites upon the ingestion of raw meat. Cats and dogs can act as definitive hosts (harboring the adult stage of the parasites which shed

eggs via the faeces, thus leading to environmental burden) and livestock as intermediate hosts, carrying cysts in their meat (Fig. 1) [1,3,12,13] and enhancing the chance to make the human an occasional host. This scenario is of great significance in view of the one health principle which considers animal, human and environment as a whole, in a reciprocal health cycle. Though some of those parasites are very rare thanks to veterinary surveillance and inspection throughout the food chain (i.e., trichinellosis, which however may find in game meat a potential route of infection) it appears reasonable to improve the awareness of consumers/owner on the risk associated with reintroducing such rare diseases due to the increased risk of exposure of their household pets via RMBDs.

Information about the risk of parasites to either pets or owners as a result of raw feeding is scanty to date, whereas microbiological investigations have pointed to several risks from the manipulation of raw meat, above all as to some bacterial agents like *Salmonella* spp., *E. coli* and *Campylobacter jejuni* [13,14,17]. It appears of utmost importance for pet owners to acquire knowledge, in terms of safe handling of raw meat, meanwhile being aware of the possibility of exposure to and from environmental contamination through pet raw feeding. The control of parasitic hazards associated with meat safety is of major economic significance. For those reasons, a series of potential parasites, as infectious agents from raw meat consumption by cats and dogs, is reported according to their life cycle along with the main potential zoonotic hazards brought and potentially diffused in domestic or urban environment.

2. Life cycle of some parasites from raw meat feeding involving pets and humans

Safety issues related to raw meat based diets are of utmost importance as untreated meat products pose a risk of infection to pets as well as to humans. Several notable parasites may be present in organs and muscular tissues of carcasses, including protozoans, cestodes, trematodes and nematodes. If no thermal treatments are adopted, raw meat can harbor larval stages of parasites which may find in cat and dogs the definitive hosts, to complete the life cycle (adult stage parasite) (Table 2). Occasionally, if livestock is missing, humans can serve as intermediate host and develop the disease, presumably coming into contact with accidentally contaminated domestic environment.

2.1. Cestodes

2.1.1. *Echinococcus granulosus*

Cystic echinococcosis (CE) or hydatidosis, is a fatal cosmopolitan neglected zoonosis [18] with overwhelming health significance due to high prevalence, morbidity and mortality in humans and livestock [19]. Hydatidosis, is typically through the larval stage of canids tapeworm *Echinococcus granulosus sensu lato*, a species complex that has many genotypes and cryptic species [20]. The tapeworm involves synanthropic cycle with canids. In particular, the dog (definitive host) harbors the adult stage in the intestine, for this reason capable to shed parasite eggs via the faeces. Intermediate hosts, such as domestic ungulates, accidentally grab infection from the environment and develop larval cysts in internal organs [21]. The lifecycle of echinococcosis, biologically perpetuate when dogs are fed on raw organs of infected domestic ungulates and dog remain asymptomatic but contain residual worm burden [22]. Epidemiological evidence, verify that humans are dead-end intermediate hosts and acquire infection through inadvertent consumption of eggs shed by the dogs or by physical contact with them [23]. CE constitutes a rising public health threat, with average annual incidence in humans estimated to be as high as 7.74 cases/100,000 population in different countries, around the world [24]. High CE infection in humans is circumstantially linked to environmental dissemination of eggs on various matrices and surfaces by infected dogs [25]. To date, there are no specific research studies which detected the presence of CE in purchased RMBD's.

Table 1

Non exhaustive list of pathogens potentially present in raw meat, posing risk of infection. Among parasites, only those presenting potential zoonotic hazard are reported.

Pathogens in raw meat posing health risk		
Parasites [1,3,12,13]	Bacteria [1,3,12,13]	Viruses [1]
<i>Toxoplasma gondii</i>	<i>Staphylococcus</i> spp.	Rabies (<i>Lysavirus</i>)
<i>Neosporium caninum</i>	<i>Enterococcus</i> spp.	Feline and canine Calicivirus
<i>Sarcocystis</i> spp.	<i>Clostridia</i> spp.	African Horse Sickness
<i>Cryptosporidium</i>	<i>Listeria</i> spp.	(<i>Orbivirus</i>)
<i>parvum</i>	<i>Brucella</i> spp.	Hepatitis E (<i>Hepatitis E Virus</i>)
<i>Echinococcus</i>	<i>Campylobacter jejuni</i>	
<i>granulosus</i>	<i>Salmonella</i> spp.	
	<i>Escherichia coli</i>	

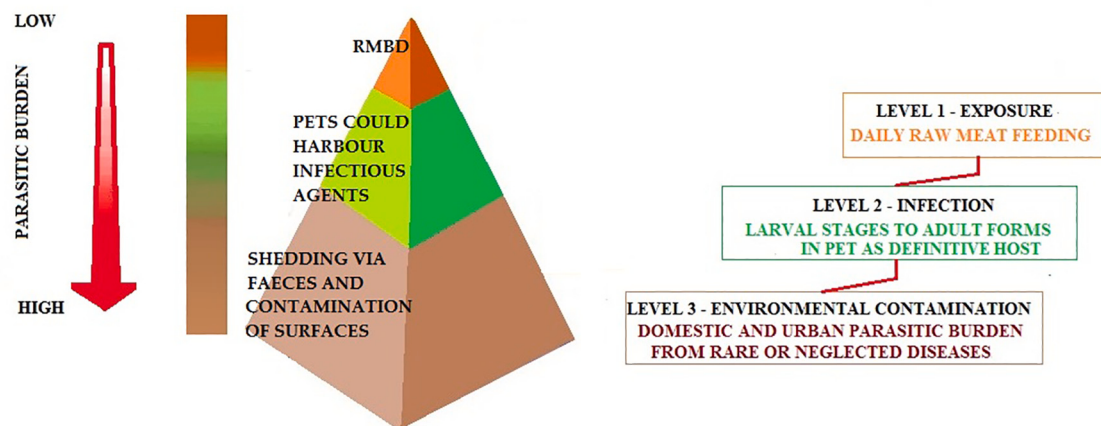


Fig. 1. Zoonotic agents potentially present in the raw meat of intermediate hosts, fed to domestic cats and dogs.

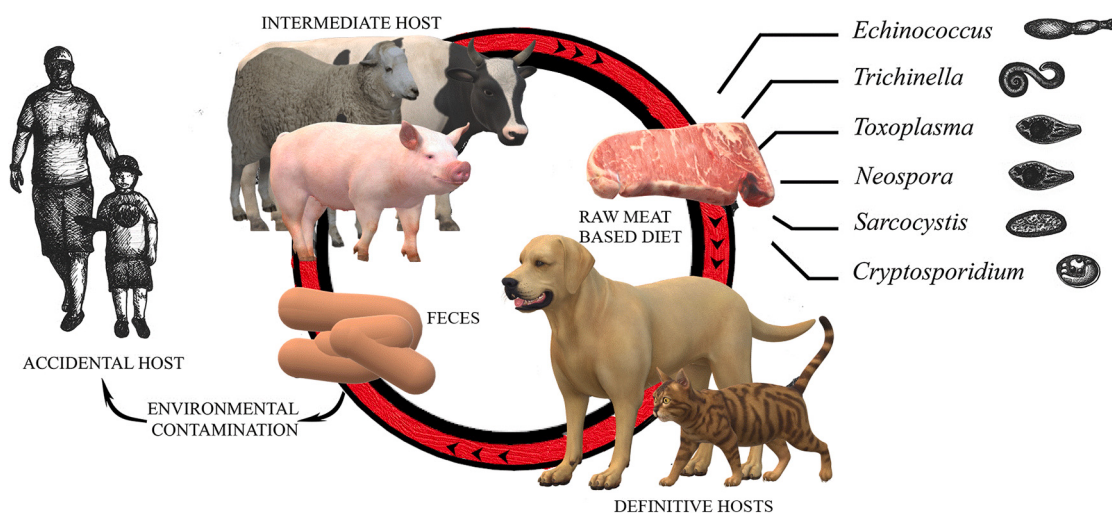


Fig. 2. Scheme of potential magnification of parasitic burden in case of consumption of contaminated raw meat based diet by domestic cats and dogs harboring different infectious agents.

Table 2

Parasites in raw meat based diets with their potential intermediate and final hosts along with summary of literature reported.

Parasite	Intermediate hosts	Definitive hosts	Sampling details	Literature available
<i>Echinococcus granulosus</i>	Domestic ungulates	Mostly dogs sometimes cats	N/A	N/A
<i>Sarcocystis</i> spp	Domestic ungulates	Dogs	35 Commercial frozen RMBD's	<i>S. cruzi</i> in 11% of diets based on bovine meat and <i>S. tenella</i> in 11% of diets based on bovine or sheep meat [13]
<i>Toxoplasma gondii</i>	Many mammals and birds	Domestic Cats	Frozen commercial BARF diet	6 samples positive for <i>T. gondii</i> [13]
<i>Neospora caninum</i>	Domestic ungulates as well as dogs	Dogs	Fresh raw meat	6 (37.5%) of the 16 seropositive (16 on 218 samples; 7.33%) bitches positive of <i>N. caninum</i> [55]
<i>Cryptosporidium</i> spp.	Vertebrate host (dogs, cats, humans and livestock) on consumption of contaminated food and water or contact with infected animal.	–	Commercial BARF diets containing raw bovine meat or raw turkey meat in canned food	2.11% of samples tested positive to <i>Cryptosporidium</i> spp. [65]
<i>Trichinella</i> Spp	Two generations in the single vertebrate host (humans, pigs, horses acting both as definitive and potential intermediate host	–	N/A	N/A

N/A = Not Available.

(–) = No definitive hosts.

2.2. Protozoans

2.2.1. *Sarcocystis* spp.

Sarcocystis spp. is an intracellular apicomplexan protozoan, infectious to a wide range of vertebrates, including some species zoonotic to humans [26]. *Sarcocystis* spp., lifecycle is characterized by obligatory predator-prey interplay involving sexual and asexual multiplication in host species. In striated muscle of herbivores and omnivores it replicate asexually behaving as intermediate hosts; sexual proliferation occurs in the intestinal epithelium of cervids as definitive hosts, leading to expulsion of oocysts with faeces in the environment [27]. Frequently, domestic dogs are infected by ingesting infected muscle tissue of various intermediate hosts [28] and intermediate hosts are horizontally infected by ingesting feed and water contaminated by sporocysts, shed from the faeces of definitive hosts [29]. Most *Sarcocystis*, species infect distinct hosts or closely linked host species [30] and humans act as both intermediate and definitive hosts in many *Sarcocystis* species [31]. Sheep act as intermediate host to four species of *Sarcocystis* (*Sarcocystis gigantea*, *Sarcocystis medusiformis*, *Sarcocystis tenella* and *Sarcocystis arieticanis*) with felids and canids as definitive hosts [26]. Among them, *S. medusiformis* and *S. gigantea* are non-infectious, disseminated through felids and produces macroscopically visible cysts in tissues [32]. However, *S. tenella* and *S. arieticanis* are infectious, spread through canids and produce microscopic cysts [33]. In cattle, six species of *Sarcocystis* act as intermediate hosts, with canids (*Sarcocystis cruzi*), felids (*Sarcocystis hirsute* and *Sarcocystis bovis*), and humans (*Sarcocystis heydorni* and *Sarcocystis hominis*) as definitive hosts [28,34]. The prevalence of humans *Sarcocystis* infection has been estimated to be 10.4% in Europe, between 0.4% to 23.2% in Asia and 0.5% in Australia [35]. A study, on 35 commercial frozen RMBD's found out *S. cruzi* in 4 products (11%), and *S. tenella* in another 4 products (11%) based on bovine or sheep meat [13].

2.2.2. *Toxoplasma gondii*

Toxoplasma gondii is a zoonotic apicomplexan cyst forming protozoan, known to infect all warm blooded vertebrates, and a major concern of public health worldwide [36]. The disease involve felids as only definitive host and vast range of vertebrates as intermediate hosts [37]. Domestic cats however contribute to greatest source of environmental disease burden and may shed billion of oocysts, after consuming only one cyst from infected meat [38]. Acquisition of infection in humans is by ingestion of raw meat from infected animals or by ingestion of sporulated oocysts from contaminated environment or direct contact with infected cats [39,40]. Cats after getting infected start oocyst shedding, typically for a period of 1–2 weeks in primary infections [41] and re-shedding reactivate in super infection with other feline diseases, malnourishment and during the immunosuppression [42]. The global burden of human toxoplasmosis is remarkably high and about 60% people of population approximately one to two billion population are reported to be infected with illness [43,44]. There is established evidence proving that naive cats fed with RMBD diets have higher seropositivity rates and shed a large number of oocysts of *T. gondii* in their faeces [3] and a study in Netherland, found out 2 products (6%) out of 35 commercial frozen RMBD's samples positive for *T. gondii* [13].

2.2.3. *Neospora caninum*

Neospora caninum is an obligate apicomplexan parasite, with broad host spectrum [45] predominantly, emerged as a serious disease in dog and cattle [46]. The lifecycle of *N. caninum* is facultative, heteroxenous and superimposable from *T. gondii* [47]. Dogs are its definitive hosts as well as intermediate hosts. Infection can occur through oral uptake of ruminant infected raw meat, while asexual proliferation occurs in intermediate hosts infected horizontally via ingestion of oocysts from contaminated food or drinking water [48]. The unsporulated oocyst, shed via the faeces of dogs, are highly tenacious and play a significant role in contamination of environment and maintenance of infection

[49]. Because of its close relationship with *T. gondii*, it is considered that the resistance of *N. caninum* oocysts in environment is analogous to that of *T. gondii* oocysts [50]. The zoonotic potential of the disease is still unknown, however antibodies against *N. caninum* in humans are reported [48,51]. In Europe, prevalence of *N. caninum* in dogs ranges from 0.5% in Sweden [52] to as high as 15.3% in Denmark [53] and worldwide aggregated prevalence is 17.14% in dogs is estimated [54]. A research study, confirmed 6 (37.5%) of the 16 seropositive (16 on 218 samples; 7.33%) bitches were fed raw diets [55].

2.2.4. *Cryptosporidium* spp.

The protozoan *Cryptosporidium* are obligate, intracellular protozoan of veterinary and public health significance that infects, dogs, cats, humans and livestock [56] causing mild to severe gastrointestinal symptoms [57]. The transmission dynamics of *Cryptosporidium* is directly related to consumption of contaminated food and water, containing oocysts by single host [58] resulting in release of *Cryptosporidium* resistant oocyst with faeces in the environment [59]. The situation is of greater significance in case of infested pet, on account of closer association with household members and absence of personal and community safety guidelines constituting a zoonotic risk [60,61]. Molecular studies confirmed about 50 genotypes of *Cryptosporidium* few with broader host range such as zoonotic *Cryptosporidium parvum* and some highly host specific such as *Cryptosporidium felis* in cats and *Cryptosporidium canis* in dogs [62]. Dogs are regarded as one of potential reservoirs for transmitting the *Cryptosporidium* infection to humans [63]. The reports of the prevalence of *Cryptosporidium* in dogs are reported to be as high as 53% in some parts of the world [64]. In humans, 14% aggregated prevalence of *Cryptosporidium* infection is reported in HIV patients, and prevalence of 19.7% is reported in developing countries [63]. A study on commercial BARF diets in USA, molecularly confirmed, 2.11% of samples tested positive to *Cryptosporidium* spp. that had raw bovine and turkey meat as a integral component in canned diets [65].

2.3. Nematodes

2.3.1. *Trichinella* spp.

Trichinella spp. is a cosmopolitan food-borne parasite and a zoonotic nematode, of public health concern worldwide [66]. The lifecycle of the genus *Trichinella* is peculiar among all nematodes due to diverse host spectrum, lifecycles with development of two generations in the single vertebrate host, acting both as definitive and potential intermediate host [67]. In human, the occurrence of trichinellosis is reported from consumption of undercooked meat from domestic pigs, horses and wild boars [68]. *Trichinella* larvae, can survive in decomposed carcasses for a long time and act similar to the animals spreading larvae or eggs of nematodes [69]. Dogs and other carnivores are important reservoirs of a number of *Trichinella* species, such as *T. britovi*, *T. spiralis*, *T. nelsoni*, *T. pseudospiralis* and *Trichinella* spp. T9 [70]. Household dogs are found to be frequently infected with *Trichinella* spp. in many parts of the world due to their scavenging behavior [71]. There are studies verifying Trichinellosis in cats fed on infected pork scraps, during food preparation at home or during slaughtering [72]. The main risk for humans is either by consuming undercooked meat from infected animals or horizontally by cutting boards, knives and other utensils used for handling contaminated raw meat at home and afterwards employed in raw food dishes preparation, such as salads [73]. Human trichinellosis, estimated to affect a population of 11 million in 55 countries with clinical cases of about 10,000 reported each year [74]. The infection rate dropped significantly worldwide after the imposition of sanitary regulations on feeding lots of domestic pigs with veterinary control and prohibition of feeding animal waste to animals [75].

3. Methods to reduce parasite burden in meat

Different methods are available to inactivate parasites such as

cooking, freezing, curing, and traditionally applied food-processing techniques, as well as high-pressure treatment and irradiation. Table 3 provides an overview of different treatments available to inactivate parasites in raw meat.

3.1. Thermal methods

Thermal treatment is considered as robust method for the control of parasite in meat. However its efficacy depends on parasite species, developmental stage, as well as temperature and time combinations [76]. In general, it is believed that cooking at core temperature of 60–75 °C for 15–30 min and freezing at –21 °C for 1–7 days kills most of parasites in food of animal origin [77]. Among protozoans, *T. gondii* is an intensively studied parasite with its freezing inactivating temperature for meat ranges between –12 to –25 °C, for a variable period time (2–35 days) [78,79]. Yet, freezing at –20 °C for three days is a requisite to neutralize *T. gondii* in meat tissues [80]. *T. gondii* is vulnerable to cooking, consequently temperature range of 60–70 °C is adequate to kill *T. gondii* cysts in meat, provided that heat is evenly distributed in tissues [80]. Furthermore, high temperature can kill both sporulated and unsporulated *T. gondii* oocysts [81].

As to *Sarcocystis* spp., experiments reveal conflicting results. A study reported cooking buffalo meat to 65 °C and freezing at –4 °C inactivates sporocysts [82]. Another study suggested that pork containing *Sarcocystis* spp. requires cooking at a minimum of 70 °C for 15 min or freezing at –4 °C for 2 days or –20 °C for 1 day [83].

In regard to *Cryptosporidium* spp., little evidence is available pertaining inactivation by thermal treatment. However, a single evidence in the literature reports that freezing at –20 °C for one hour or by cooking at 70 °C for one minute inactivate oocysts [84].

On the other hand, for *Trichinella* spp. cooking at core temperature from 70 °C to 71.1 °C inactivates *Trichinella* in pork meat, game birds and horse meat [85] and freezing at –21 °C for 7 days inactivates *Trichinella* in wild boar meat [86].

Regarding metazoan parasites, such as *E. granulosus*, robust guidelines are extremely low. A study demonstrated that freezing at –18 °C for 6–9 h proved to be effective in neutralizing hydatid cysts in meat. Besides that, research also ascertained that infested organs, if frozen at –18 °C for a minimum of 6 h, can potentially sanitize from hydatid cysts [87]. It is pertinent to mention, that standard indications for thermal inactivation of several meat borne parasites is still lacking e.g. *N. caninum* which requires attention in future for safe handling as well as harmless consumption of meat from domestic pets.

3.2. Non thermal methods

Several other conventional techniques of particular relevance, such as drying, salting curing etc. are also employed to inactivate parasitic transmission at different stages from meat [88]. Inactivation of *T. gondii* cysts in mutton meat, salted with 4.2–6.2% NaCl, takes at least 64 h [89]. Another study reports that *T. gondii* cyst are inactivated at a 2.5% NaCl in mice muscle after 24 h [88]. A trial revealed, that Parma ham dry cured for at least 12 months with 5% salt concentration doesn't infect mice when inoculated [90]. For *Trichinella* spp., curing conditions include >1.3% NaCl combined with fermentation at a low pH of 5.2, which results in the deactivation of a 96% of *Trichinella* larvae found in muscles within 7–10 days [91]. However, owing to high resistivity of *Trichinella* to curing and smoking, those are not recommended as single methods [92]. Some other novel approaches are also in operation now a days to eliminate the threat of parasites in meat tissues. Among them, high pressure processing (HPP) and irradiation are of highest interest and significance [77]. High pressure processing, uses liquid medium to compress at constant rate, resulting in the deactivation of parasites. Parasites like *C. parvum* [93], *T. gondii* [94] and *T. spiralis* [95] were observed to be inactivated at a low pressure (110–400 MPa) [96]. Irradiation, is also a spread technique at present, which uses high energy electrons [97] and gamma irradiation [98] for inactivation in tissues. The minimum effected dose (MED) for *Trichinella* cyst inactivation is 0.3–0.6 kGy [99], *C. parvum* 1–2 kGy [93] and *T. gondii* 0.4 to 0.7 kGy [100]. The available literature is very diverse pertaining inactivation methods in meat, calling meticulous attention for standardization to deactivate parasites in meat in future.

4. Safe use of RMBD diet

In light of the literature explored, the practice to feed RMBD diets largely overlooks the potential health-threatening consequences to household pets and owners. The spreading of selected parasites, for which cats and dogs serve as definitive hosts and could get infested by means of potentially positive raw meat, can be amplified notably on daily exposure from raw meat consumption. In fact, the opportunity offered to parasites to complete their life-cycle otherwise highly limited in the case of cooked meat, poses non negligible risks of domestic and urban parasitic burden responsible of diseases considered rare to date because limited to certain areas and condition (rural areas). A One Health approach is of relevance for mitigating and tackling parasitic infections with safeguarding human health and for safe feeding of pets. Responsible care by the pet owner feeding raw meat based diets to pets should therefore be accounted and adequate information should be provided by veterinary practitioners. As a general rule, it is

Table 3
Summary of methods available for inactivation of parasites in meat.

Parasite	Heating	Freezing	High pressure processing (HPP)	Gama irradiation	Other non-thermal methods Salting, curing etc.
<i>Sarcocysts</i> spp.	65 °C; 20-25 min (thigh muscles) [82,85] Or Min 70 °C for 15 min [83]	–4 °C; 2 days [82,85] –20 °C; 1 day [83] –4 °C for 2 days [83]	N/A	N/A	N/A
<i>Echinococcus granulosus</i>	N/A	–18 °C; 6–9 h [87]	N/A	N/A	N/A
<i>Cryptosporidium</i> spp.	≥70 °C and above; ≥ 10 s [84]	–20 °C for 1 h [84]	550 MPa; ≥3 min [93]	1–2 kGy [93]	N/A
<i>Trichinella</i> spp Muscle Larvae	71.1 °C (core temperature) [85]	–21 °C; 7 days [86]	>500 MPa [95]	0.3–0.6 kGy [99]	≥1.3% NaCl; pH 5.2; [91]
<i>Toxoplasma gondii</i> Tissue cysts	>61 °C; 3.6 min [80]	–20 °C; 3 days [80]	400 MPa; 30 s [94]	<i>T. gondii</i> 0.4 to 0.7 kGy [100]	4.2–6.2% NaCl; 64 h [89]

N/A = Not Available.

recommended to adopt hygienic measures to limit potential exposure to oral-fecal route and harmful load in the household, alongside with routine coprological examination of pets in order to keep at check any zoonotic parasitic infections [101]. At this regard, it must be also reported that some bacterial pathogens are associated with higher risk of causing infection in animals fed RMBDs (i.e., *Salmonella*): the same risk, despite lower, exists for pets fed manufactured foods if not correctly handled both in the plants and at home by the owner [102]. To the best of our knowledge, no evidence is reported in the literature regarding the risk of parasitic agents in manufactured pet food. In different Countries, the veterinary and pet food associations (WSAVA, AVMA, AAHA, CVMA, for instance) have clearly taken a position against the use of RMBDs because of the associated microbiological risks. The potential risk of parasitic infections, environmental contamination and zoonosis from handling or feeding client-owned pet with RMBD should be considered as well, in view of the additional evidence provided in this review, involving the need of specific recommendations and public education about the hygienic requirements concerning such feeding practice.

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Declaration of Competing Interest

The authors declare no conflict of interest.

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