CPD article

Raw food diets for companion carnivores: an untapped panacea or a disaster waiting to happen?

Raw food diets are being fed to companion animals with ever-increasing frequency in the UK and elsewhere; however, the advantages and disadvantages are frequently debated. There is currently no accepted consensus regarding the best advice for clinicians to give to owners about raw feeding their pets. This review aims to discuss some of the areas where most of the debate exists.

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Raw food feeding is the practice of providing domestic dogs and cats with a diet consisting primarily of uncooked meat, bones, and viscera (Schlesinger and Joffe, 2011; Freeman et al, 2013; Goh, 2016; Fredriksson-Ahomaa et al, 2017)

Owners who feed their pets raw diets, alternatively referred to as either biologically appropriate raw feeding (BARF) or feeding raw meat based diets (RMBD), are divided into two groups: those who choose to make homemade raw diets to feed their animals and those who predominately feed commercially available raw food diets (Schlesinger and Joffe, 2011; Freeman et al, 2013; Goh, 2016; Fredriksson-Ahomaa et al, 2017).

For both groups of owners in the UK, the majority of these diets are comprised of meat that has been deemed fit for human consumption, though in England and Wales, but not Scotland, under European Union Animal By-Products Regulations (Regulation No 1069/2009) Category 3 material can also be fed raw to pets (Schlesinger and Joffe, 2011; Freeman et al, 2013; Goh, 2016; Fredriksson-Ahomaa et al, 2017).

The practice of raw food feeding has becoming increasingly widespread in the UK and Europe as well as Australia and the USA during the last decade, very much in parallel with the changes in human dietary trends for more organic products and more 'natural' diets such as veganism (Laflamme et al, 2008). In the USA, sales of RMBD doubled in the five years to October 2017 while in the UK seven companies supplying RMBD were registered in 2007, which rose to more than 80 registered suppliers in 2018 (Wall, 2018). In Europe, a study from The Netherlands found that 51% of dog owners fed their animals either completely or partially a RMBD, while a survey of Australian cat breeders found that raw meat was fed as an integral constituent of the diet by 89% of respondents (Shapiro et al, 2017). The most recent publication questioning owners over the internet about RMBD practices highlighted that 1-in-25 respondents had handled raw pet food in the previous 7 days (Raschkowan et al, 2018).

People who feed their dogs and cats raw food diets do so for a multitude of reasons including, but not limited to, cultural trends; beliefs surrounding the health benefits; what is perceived to be more natural for their pets; and allowing the pet to 'stay in touch' with their wild, pre-domesticated ancestry (Morgan et al, 2017). However, there are concerns regarding the risk of food-borne illnesses, including zoonoses, and nutritional imbalances (Dodds, 2018). As such, the veterinary profession has not yet formed a consensus regarding the best raw feeding advice for clients, and practitioners may have strongly held personal opinions that may be in conflict with those held by clients and colleagues alike. This short discussion aims to highlight and briefly explore the key areas of raw food feeding where there remains least consensus: the possible risk of microbiological contamination of RMBD including by zoonotic agents; the evidence in support of the health benefits for feeding RMBD; and the risks of nutritional deficiency and/or excesses.

Infectious and zoonotic agents

By far the most commonly cited concern with RMBD is the risk posed by infectious agents that have not been destroyed or inactivated as they would be by conventional cooking methods (Fredriksson-Ahomaa et al, 2001; Weese et al, 2005; Finley et al, 2006; Bojanić et al, 2017; Davies, 2018; van Bree et al, 2018; Clark, 2019; Davies et al, 2019; Jones et al, 2019; Loeb, 2019; O'Halloran and Gunn-Moore, 2019; O'Halloran et al, 2019a; O'Halloran 2019b). Instead, almost all RMBD are sold frozen in order to extend their expiry dates and, in the case of some organisms (such as the nematode *Trichinella* species), either reduce or eliminate contamination (Davies, 2018; Davies et al, 2019).

Bacteria of the Enterobacteriaceae are the most frequently recovered bacteria from commercially available RMBD; in one study 72.5% of samples tested did not meet the microbiological standards for Enterobacteriaceae set out by EU regulations for animal by-products intended for pet food (Davies et al, 2019). Of particular concern, *Escherichia coli* serotype O157:H7 was isolated from 23% of RMBD samples in a further study, while a human disease outbreak of Shiga toxin-producing *E. coli* (STEC) O157:H7 has been attributed to exposure via contaminated raw pet food (Nemser et al, 2014). Whole genome sequencing techniques have been used to establish with a high degree of certainty that bacterial strains shed in the faeces of RMBD-fed companion animals are the same as those present in their diets (Jones et al, 2019). Additionally, RMBD have been identified as a risk factor for the shedding of antimicrobial-resistant (AMR) Enterobacteriaceae from pets (Nüesch-Inderbinen et al, 2019). Antimicrobial resistance is currently one of the most pressing threats to human and animal health worldwide, affecting humans, animals and the environment. Raw meat sold at the retail level (predominately beef, poultry and fish) has been identified as a major source of exposure of humans to AMR bacteria. Through the inactivation of beta-lactam antibiotics (e.g. penicillins and cephalosporins), extended-spectrum beta-lactamase (ESBL) and AmpC beta-lactamase producing bacteria contribute to the increased risk of antibiotic treatment failures (Schlesinger and Joffe, 2011; Davies et al, 2019). Studies of RMBD products have consistently identified AMR bacteria in between 60–80% of the samples tested, the majority of which have been shown to be resistant to third-generation cephalosporins, due to the production of ESBL variants including CTX-M-1, which is widespread in livestock, and CTX-M-15, which is the most common ESBL variant worldwide (Weese et al, 2005; Dodds, 2018; Jones et al, 2019). Furthermore, colistin and aminoglycoside-resistant isolates, producing MCR-1 and RMTB enzymes respectively, were additionally identified in 3.9% and 2% of the samples tested in one study (Nüesch-Inderbinen et al, 2019). These findings have been confirmed by a case control study that found a significant association between ESBL shedding and feeding raw pet food products (odds ratio of 31.5); in this particular study, ESBL-producing Enterobacteriaceae were isolated from 14 of 18 (77.8%) raw pet food products and none of the 35 cooked pet food products (Trott, 2013; Davies et al, 2019; Nüesch-Inderbinen et al, 2019).

Zoonotic infections with *Campylobacter* spp. and *Salmonella* spp. are of human health concern as the most common bacterial causes of enteritis in people (Michel, 2006; Acke, 2018). Several hundred patients per year in the UK die from these foodborne infections; *Campylobacter* causes nearly 280 000 infections annually and 100 deaths, while *Salmonella* accounts for 200 deaths each year, and the main culprit for these infections is undercooked and raw poultry meat (Lund, 2015; Lake, 2017). However, the overwhelming majority of these infections are from handling and storage of human food products rather than pet foods. Similarly, subclinical infections probably occur more frequently in animals than disease, although both *Salmonella* spp. and *Campylobacter* spp. can occasionally cause gastroenteritis and even septicaemia in rare animal cases; for example fatal septicaemic salmonellosis was reported in two cats fed poultry RMBD (Stiver et al, 2003). In a study of 200 raw-fed companion animals, the prevalences of *Campylobacter jejuni, C. upsaliensis* and *C. helveticus* were 36%, 13%, 23% and 1% in dogs and 16%, 5%, 5% and 7% in cats respectively, while two further studies recovered viable *Salmonella* spp. organisms from 7% and 20% of the frozen RMBD tested (Finley et al, 2008; Bojanic et al, 2017). A raw chicken diet has also been found to be a significant risk factor for dogs developing acute polyradiculoneuritis, believed to be due to the presence of *Campylobacter* spp. in a similar mechanism to that which causes Guillain-Barré Syndrome in humans (Rautelin and Hänninen, 2000; Holt et al, 2011).

The prevalence of these potentially zoonotic organisms in the faeces of RMBD-fed companion animals has raised the additional concern of legal liability in the possible situation of veterinary surgeons who advocate feeding raw diets if those patients or their owners go on to contract an infection as a result. This specific issue was raised in a public lecture given by Mike Davies, an RCVS-recognised specialist in veterinary nutrition: 'these organisms can be transmitted between pets and their owners and can lead to potentially harmful, even fatal consequences, I asked the Veterinary Defence Society not long ago if I were to recommend feeding raw to an owner and 6 months later a child next door ended up in intensive care or worse, would I be liable? They said I would be liable.' This should therefore be a careful consideration of clinicians thinking of actively advocating raw food diets (Davies, 2015).

A number of other zoonotic bacterial species have only infrequently been isolated from RMBD and/or have been associated with disease in pets fed entirely or mostly on RMBD, including *Clostridium perfringens, Brucella suis, Listeria monocytogenes* and *Mycobacterium bovis*, while other studies have successfully recovered other taxa of viable zoonotic pathogens, including parasites such as *Sarcocystis* spp. and *Toxoplasma gondii* (Schlesinger and Joffe, 2011; Freeman et al, 2013; Nemser et al, 2014; Goh, 2016; Fredriksson-Ahomaa et al, 2017; Davies, 2018; van Bree et al, 2018; Loeb, 2019; O'Halloran et al, 2019). Zoonotic viral infections may also be of concern, as it is believed that the canine H3N8 influenza epidemic originated in 2004 from feeding Greyhounds contaminated raw equine material which, as an influenza A virus, was evaluated by the Centres for Disease Control and Prevention (CDC) as potentially posing a significant risk to any immunocompromised owners — who make up nearly a third (62 of 218, 28%) of owners choosing to feed RMBD, according to

a recent client survey (Gibbs and Anderson, 2010; Sun et al, 2017; Wang et al, 2017).

Reduced inflammation, improved health

The potential risk of feeding RMBD to companion animals is often countermanded with the benefits that can be derived from them. These cited benefits include better muscle condition as well as improved dental, periodontal, dermatological and gastrointestinal health (Freeman and Michel, 2001; Stogdale et al, 2003). The latter is particularly thought to be true in cases of patients suffering from chronic enteropathies such as food-responsive inflammatory bowel disease, where many clinicians have had owners report often a dramatic and rapid improvement in clinical signs (usually chronic diarrhoea and weight loss) after switching from a 'traditional' cooked to commercially available RMBD (Freeman and Michel, 2001; Stogdale et al, 2003). However, there are unfortunately no systematic prospective, or even retrospective, studies that have yet properly evaluated these observations, so it is impossible to exclude alternative reasons for the observed improvements.

In recent years there has been an increasing research focus on the intestinal microbiota and changes therein (e.g. dysbiosis) as both a source and consequence of disease in both humans and companion animals (Kaur et al, 2011; Suchodolski, 2011; Nibali et al, 2014; Das and Nair, 2019). Raw diets have been shown to lead to a wider diversity and complexity of organisms in the faeces of RMBD-fed dogs (Bermingham et al, 2017; Kim et al, 2017; Sandri et al, 2017; Schmidt et al, 2018). Based on the species of bacteria present as well as their relative abundance, it would seem that these differences likely reflect the relatively higher fibre and carbohydrate content of most commercial cooked diets, as compared to BARF diets that tend to contain more protein and fat (Kim et al, 2017; Sandri et al, 2017; Schmidt et al, 2018; Sandri et al, 2019). The effect on animal health and disease of the significantly different microbiotia between diet types that has been reported in number of studies is currently unknown.

A recent study analysed and compared the effect of cooked kibble and raw meat diets on peripheral blood mononuclear cell gene expression in dogs (Anderson et al, 2018). This found that diet significantly influences canine immune cell gene expression, with RMBD generally causing a decrease in the expression of pro-inflammatory cytokine genes, which supports the frequently highlighted anecdotal observation that RMBD can be beneficial in the management of patients with chronic inflammatory conditions (Anderson et al, 2018). However, these changes were only seen at the 3- and 6-week time points of the study and had been lost by the time dogs had been on their respective diets for 9 weeks. Additionally, quantifying the mRNA of a cytokine is not the same as measuring the concentration of cytokine secreted by these cells, as there are a number of feedback mechanisms influencing the translation of immunological molecules as well as post-translational modifications that could prevent protein synthesis and secretion, even in the presence of increased mRNA copy numbers. The dogs in this study were also clinically normal, so it was not possible for the authors to assess if the RMBD had an actively anti-inflammatory effect on a disease process within individual animals.

Nutrient balance: are diets complete?

Concerns regarding nutritional imbalances are a frequent feature of debates about feeding companion animals RMBD, and it has occasionally been proposed that raw diets are not complete according to the legal definition: that a complete pet food must contain every nutrient required by an animal in sufficient amounts to keep it healthy so that the diet in question should not be detrimental to an animal's health if fed as a sole ration for an extended period of time (Anon, 2020). It is widely accepted that home-prepared RMBD are the most likely to be incomplete, due to the inherent difficulties in providing sufficient macronutrients, minerals and vitamins in combination so as to allow adequate bioavailability, and as such these diets are best avoided without the input of an experienced, specially qualified veterinary nutritionist (Weeth, 2013; van Zelst et al, 2015; Oba et al, 2019). Reported problems with such diets have included thiamine deficiency causing neurological syndromes; taurine deficiency resulting in feline dilated cardiomyopathy; hypervitaminosis A associated with diets with a high liver content; joint dysplasia due to inappropriate calcium to phosphorus ratios; and hyperthyroidism resulting from the ingestion of raw thyroid glands (Deka, 2009; Kritikos et al, 2017; Bischoff and Rumbeiha, 2018; Mansilla et al, 2019; Stogdale, 2019). In recent years, many food companies have produced RMBD products and brought them to market, offering similar reassurance to consumers with regards to completeness as the 'traditional' cooked food products.

However, it must be noted that cooked formulated diets are not necessarily always safe alternatives to RMBD with respect to nutritional imbalances. There has recently been good evidence published which links (cooked) grain-free diets with dilated cardiomyopathy in dogs, while Hill's voluntarily recalled canned (cooked) dog food due to excessive vitamin D levels after a dog was presented with clinical signs of hypervitaminosis D (Adin et al, 2019; Anon, 2019a). Additionally, due to a vitamin B1 (thiamine) deficient commercial diet, three cats exhibited symptoms of sudden collapse, fitting, widespread twitching and general unsteadiness, leading to a widespread product recall over safety concerns (Anon, 2019b). Therefore, with so many pet food manufacturers present in a crowded commercial market, it is more important than ever that owners are aware of the possibility that any diet can be affected by production problems and to always follow instructions regarding product recalls carefully.

Environmental enrichment

Raw food products have long been used as a source of environmental enrichment; this has particularly long history in the context of zoo animals where raw carcases or parts thereof provide carnivores with significant opportunities to display appropriate natural behaviours as well as the more obvious olfactory and gustatory enrichment. The same principals can be applied to domesticated carnivores, whose wild ancestors evolved many behavioural traits for the acquisition of food. Providing (supervised) raw food-based enrichment can help owners maintain an animals body weight and condition, while chewing raw bones can be beneficial for oral hygiene and chewing has been shown to be a self-soothing

KEY POINTS:

- Both biologically appropriate raw food (BARF) and cooked food diets for feeding domestic carnivore have both risks and benefits.
- The most frequently cited risk of BARF diets is the potential for microbiological contamination.
- The risk of zoonotic infections should be considered, especially by immunocompromised onwers.
- BARF diets may provide a series of health benefits compared to cooked diets.
- More research and evidence is needed to confirm observed benefits before BARF diets can be more widely advocated.
- It remains the advice of the British Small Animal Veterinary Association and the World Small Animal Veterinary Association not to recommend BARF diets.

behaviour for dogs, so may help prevent or alleviate stress related conditions such as separation anxiety (Lawson et al, 2019).

Conclusions

Overall therefore, there are clearly both advantages and disadvantages to feeding RMBD to our domestic carnivores. The main significant risk comes from the potential for microbiological contamination, therefore owners with particularly vulnerable health status such as long term immunodeficiency should think carefully before opting to feed their pets RMBD. Conversely, there are a large number of advocated benefits to raw feeding when the diets are complete and appropriately formulated, but as yet there is only weak evidence published in support of them. As such, many veterinary associations such as the American Veterinary Medical Association, British Veterinary Association and Canadian Veterinary Medical Association have warned against the practice of raw feeding and currently, the World Small Animal Veterinary Association Global Nutrition Committee recommends that RMBD not be fed to dogs and cats; however, these position statements will likely change as stronger evidence accumulates in the scientific literature (Cima, 2012; Anon, 2015). CA

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