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A comparative analysis of the effects of feeding raw meat, BARF diets versus commercial diets.

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1. Introduction

The topic of discussion and further analysis is "A comparative analysis of the effects of feeding BARF (bone and raw food) diets versus commercial diets". BARF diets mainly consist of raw meat with bones, offal, fruits and vegetables. Commercially prepared diets may be in the form of pellets or wet food. In this study, the commercial diet examined was in pellet form. This Para dime was chosen in order to identify the positive and negative aspects of each chosen diet based on previous clinical tests done on animals on these diets, as well as clinical tests done by the by the researcher of this thesis to further investigate the possible benefits or pitfalls of the BARF diet. The researcher will explore if BARF diets are successful depending on the execution of the diet itself. Furthermore, to investigate whether there is scientific data to corroborate the claims of the benefits of the BARF diets from peer reviews, as the establishment of commercial diets are underpinned by dieticians, veterinarians and scientists alike.

The researcher seeks further information on the benefits and barriers to successful deliverance of a BARF diet and whether it may be equivalent to the nutritional value of commercial diets. This study will investigate the perceived knowledge of the participants that effect the efficacy of the chosen diet. This research will focus on the limitations of the understanding of BARF diets. There has been a recent surge in the popularity of feeding pets' raw food-based meals over the last few years. By analysing previous research, it will be determined the reasoning behind the incline of this diet and where owners are obtaining their information from, what the perceived benefits are and why they think this diet is more suitable for their pet instead of the commercial diets.

To determine if a BARF diet can be successful, when comparing it to a well-known commercial diet the researcher will explore the daily nutritional requirements of a canine in order to gain further knowledge to be able to then investigate both the commercial diet and the BARF diet in this study with more depth. A Semi-structured questionnaire was also prepared to ascertain the reasoning behind the participants choice of diet in each case. The questionnaire was imperative in order to rule out any obvious signs of illness, etc., in order not to skew the results of the physical exam as well as the haematology and biochemistry exam. The test subjects were two Bernese Mountain dogs of the same age and sex, one solely on a BARF diet while the other on a commercial diet.

To compare the diets chosen the following tasks will be undertaken by the researcher: to establish the daily recommended nutritional intake for dogs of this weight and age.

To summarise the diets chosen by the participants. Additionally, to carry out a full physical exam of the dogs in order to evaluate their general state of health. Finally, A haematology as well as a biochemistry analysis will be completed on each test subject in order to compare the results and how they may be linked to each subject's diet.

The aim of this research is to determine whether the daily nutritional recommendations are being met with these individual diets based on a physical examination, haematological and biochemical examinations. Also, the nutritional content of each diet shall be investigated and compared to the recommended daily intake of macro and micronutrients. From this study, it is hoped that the results will aid in further understanding whether a BARF diet can be balanced and safe for pets receiving it and if it can in fact be equivalent in nutrients to that of a balanced commercial diet.

2. Review of literature

2.1. The "BARF" diet

The "BARF" diet is an abbreviation to describe bone and raw food or biologically appropriate raw food and was first established by a veterinarian and nutritionist named Dr. Ian Billinghurst. This diet is aimed to be high in protein and low in carbohydrates. The aim of the diet is to mirror or come closer to the diet of that which of the dogs' wolf ancestors would normally consume. The diet mainly consists of raw meats, bones, organs, some fruits and vegetables and supplements.

2.1.1. The increase in popularity of raw diets

There has been an increase in the quantity of the population that feed their dogs BARF diets instead of commercial diets, due to the increasing number of claims that it is "better for their health" or "more natural". BARF diets have also been claimed to have other health benefits such as better stool quality, shiny coat and better teeth (McKenzie, MA, MSc, VMD, cVMA, 2021).

2.1.2. The effects of the BARF vs commercial diet on the microbiota

A study was done to compare the nutritional value of the BARF diet versus commercial diet by analyzing the fecal microbe environment after each diet. Nutritional parameters such as crude protein was measured as well as the microbiota, using PCR method. It was discovered both diets are significantly different in microbial content, specifically parameters such as clostridium perfringens, in which the BARF diets had a higher amount in (Schmidt et al.,2018).

2.1.3. The potential risks of feeding a raw based diet

A critical review was done to establish the benefits and potential risks of feeding a raw meat diet to companion animals. It was found that of the 5 raw meat diets studied, 3 were low in calcium and phosphorus, 2 were deficient in potassium, magnesium and zinc, while a further 2 were too high in vitamin D (Freeman and Michel, 2001).

A study was carried out to determine the frequency of the presence of salmonella species in raw chicken that was being fed to dogs as part of their diet. This was carried out in order to identify the potential spread of zoonotic diseases due to the different strains of salmonella in the feces of the dogs. BARF food and commercial food were tested as well as the stools of 20 test subjects, half on commercial diets while the other half on BARF diet. Of the BARF food that was tested; 80% contained a pathogenic salmonella species, while all the commercial tested negative for any. 30% of the feces of the test subjects that were on the BARF diet tested positive for salmonella species, while none of the commercial diet test subjects tested positive for any species (Joffe and Schlesinger, 2002).

The risk of parasitic infection due to feeding a BARF diet is drastically increased in comparison to feeding a commercial diet which has been prepared hygienically and processed thoroughly. This may also lead to the spread of zoonotic parasites to humans in the household. Parasitic species such as toxoplasma gondii, taenia species and sarcocystis species may be spread through the raw meat. A study was completed in order to determine the frequency of parasites in a raw meat-based diet (RMBDs). Of the 35 RMBDs, 4 products contained sarcocystis cruzi, 4 contained S. tenella and 2 more products contained toxoplasma gondii. If the meat is frozen, however, the parasites will be destroyed (J van Bree et al., 2018).

2.1.4. The claims of the benefits of feeding BARF diets

Dr. Ian BillingHurst claims that by feeding dogs a balanced raw meat diet, it significantly reduces the chances of bowel, eye, heart and kidney problems. Also, when feeding a BARF diet, it increases the longevity of the dog. Other claims consist of better haircoat, skin, teeth as

well as better growth and reproduction potential. Dr. Ian BillingHurst also states that an owner will see an increase in energy levels of their pet, and it will be more inclined to play with their family. Another benefit that is discussed is the fact that the likelihood of ear infections is decreased because of changing the diet to raw based due to increased immunity levels. Other diseases such as arthritis and incontinence will "disappear" (Billinghurst, 2016).

2.1.5. The difference in nutrient content of BARF vs commercial diets

An experiment was done in order to determine the effectivity of high-fat diet (NPHF) which was a commercial diet and the heat-processed high carbohydrate diet (HPHC). This was composed of either MUSH BARF Vaisto Pork-Chicken-Lamb or MUSH BARF Vaisto Beef-Turkey-Salmon or both and are raw-frozen dog foods. The study obtained a physical exam of the dogs and took blood samples for hematological as well as biochemical examinations. Within the commercially fed dogs, there was a decrease in their white blood cell count, while also having an increased platelet, red blood cell count. MCHC and hemoglobin concentration. The dogs who were fed the raw meat diet had an increase in the MCHC and the MHC. There were major differences on the biochemical analysis; the dogs fed the commercial diets (NPHF) had an increase in albumin, potassium, sodium, creatinine, and total protein. In contrast, the dogs fed the raw meat diet (HPHC) had an increase in albumin, inorganic phosphate, sodium, cholesterol, and total protein. The study concluded that each diet type can have a significant effect on the physiological homeostasis of the dog (Anturaniemi et al, 2020).

To determine the nutritive value of home prepared and commercial diets, a breakdown of the macro and micronutrients was done in order to determine which diet came closer to the optimum daily diet for dogs. The protein content was significantly higher in the home prepared diets. The home prepared diets also were a lot lower in micronutrients such as calcium and phosphorus. The home prepared diets were low in fat soluble vitamins such as A, D and E. Trace minerals such as zinc and copper were too low, whereas magnesium, iron, manganese and sodium were exceeding the recommended limit. It was determined that when feeding home cooked diets, nutrient deficiencies may occur and in order to have a balanced diet for the animal some supplementation would be required (L. Streiff et al, 2002).

2.1.6. Hematological changes of individuals eating raw meat versus commercial diets

An analysis was carried out in order to determine the effects of different diets on the hematology and biochemistry of dogs. 107 dogs were examined and were divided into groups of dogs who were on 100% dry food, 100% raw meat diet or mixed diet. The population was then further divided into 5 groups based on the percentage of either raw or dry food. The results showed that as the amount of raw food increased, the hematological values increased, excluding MCH and MCV. There were significant differences in the concentrations of ALP, creatinine and cholesterol. When the amount of raw food in the diet increased, so did the creatinine. The glucose was low in both dry and raw food, it showed highest results in the mixed diet (Frisk, 2018).

2.1.7. Reasons owners feel it is more beneficial to feed their pet a BARF diet

When a group of owners were asked why they chose to feed their dogs a BARF diet, the most popular answer was because dogs are carnivores and they wanted to respect that. Other reasons given were to improve their dogs' health or because they had previously had problems with commercial food in the past and did not trust it. Most of the owners indicated that whilst feeding their dogs the BARF diet; their coats were shinier, teeth whiter and their muscle mass had also increased. Much of the people interviewed felt that feeding the BARF diets to their pets was completely safe. Over 60% of the owners in the study believed that there was no possible way for their dog to become ill due to the raw meat diets. Although, in contrary to the previous answer; 45% of owners did report that their animals had constipation, vomiting and diarrhea. When asked where they learned exactly how to feed their dogs this particular diet and how they came up with a formulation, the majority of the study said they got their information online, while only a small percentage sought out information from a veterinarian or a nutritionist (Morelli et al, 2019).

Many individuals feel that because dogs are descendants of wolves, they should eat a diet like them. Dogs diverged from wolves roughly about 17,000 years ago, during the first human settlements. Since then, the anatomy of the dog has changed drastically from their wolf ancestors as they were domesticated. Although some attributes of the wolf's digestion mechanisms are still present in dogs, such as the "feast or famine" lifestyle which is how wolves can go prolonged amounts of time without feeding. A major evolutionary change that occurred during the domestication of dogs was that they became omnivores, meaning they require both plant and animal sources for nutrition. This is unlike their carnivorous ancestors or cats who are

also true carnivores, meaning that they only require meat sources for survival (Bosch, Hagen-Plantinga and Hendriks, 2015).

2.1.8. The effects of dietary protein on renal function

Various studies have shown how dietary protein is linked to renal health. It has been shown that when there is a higher intake of protein in the diet, it has a negative impact on the kidneys. This is since higher protein intake changes the renal blood flow, leading to an increase in the glomerular filtration rate. For example, in a study that was carried out on canines separated into groups based on their protein intake, it was concluded that the dogs on the high protein diets had higher glomerular filtration rates (GFR). Furthermore, that the GFR was dose dependent on the protein intake (Moustgaard, 1947).

According to Brenner et al, a high protein diet may have a negative impact on renal function due to increasing the glomerular filtration rate and glomerular pressure. The *Modification of Diet in Renal Disease* (MDRD) study was carried out in order to determine the effects of protein on kidney function. Patients with renal disease were split into groups based on their protein intake. It was discovered that those patients who had less protein in their diets, had a slower progression of renal failure (Brenner, Meyer and Hostetter, 1982).

3. Own investigation

3.1. Aim of the study

The aim of this study is to compare the nutritional value of a BARF diet to a well-known commercial diet. This will be done in three ways.

1. A small questionnaire shall be given to the participants in order to determine why they choose each diet. Furthermore, what they believe to be the benefits of each choice, as well as ruling out any other factors that could influence the results of the trials.
2. Next, the daily recommended intake of both macronutrients and micronutrients shall be investigated. This will be based on the references of nutritionist guidelines that have been peer reviewed to further understand the nutrient requirements of these animals. Then, to outline what the animals chosen for this study are being fed.

3. Finally, a general examination of each dog shall be carried out. This will be followed by taking blood samples from the subjects for hematological and biochemical analysis. These results will then be reviewed and interpreted to observe the connection between diet and animal health, based on any deficiencies or disease discovered.

   On investigating this topic, it is hoped that there may be more clarity as to whether a BARF diet can meet the nutritional needs of a dog if it is balanced, just as well as a commercial diet has been proven to.

   3.2. Materials and methods

   3.2.1. Study Participants

   In this study the investigator worked with two dog owners. One owner fed their dog only a specific commercial diet of high quality. The second owner fed their dog only a BARF type diet. this diet consisted of raw meat, bones, offal, vegetables, yoghurt and other additives in order to create a balanced diet.

   In order to make the results more accurate, the dogs chosen were both Bernese Mountain dogs, both male and four years old. Both dogs were apparently healthy with no disease. Neither of the animals were on any medications that may have affected the results.

   3.2.2. Materials used included

- Sterile needles
- EDTA tube- for hematological analyses
- LI heparin tube- for biochemistry
- Razor to trim the hair
- Ethanol to disinfect
- Hematology machine
- Biochemistry machine
- Thermometer
- Stethoscope

3.3. Questionnaire

A questionnaire was devised in order to determine the reasoning behind why the owner chose each diet to feed to their animal.

This was also a necessity to rule out any factors that may have affected the results of the hematological and biochemical analysis that were not diet related. For example, if the dog had been on previous medications that may have affected the biochemical results.

The questionnaire consisted of ten questions. Some of which were closed ended style, others which were open ended. This acted as a guide to the reasoning behind the choice of diet for the individuals as well as figuring out where they acquired information on the different diets.

Questionnaire asked to the participants

1. How old is your dog?
2. What breed is your dog?
3. How often do you give your dog a worm dose?
4. Has your dog ever suffered from any illness, if so what type?
5. Has your dog been on any long-term medication, or any short-term medication of recent? If yes, what type?
6. Does your dog suffer from any skin allergies or any skin conditions now or in the past?
7. Has your dog experienced episodes of gastroenteritis (vomiting and diarrhea)?
8. What exactly do you feed your dog? Give the most details you can.
9. In your opinion, what do you think is the benefit of feeding your dog this diet?
10. Why did you choose this diet for your pet?

3.4. Nutritional investigation and delineation of the diets

This is carried out by researching the recommended daily nutritional intake of a canine. The information that shall be gathered is based on experts in this field of knowledge. Then a general outline of the diets chosen by the owners will be discussed.

3.5. Physical Exam

A short physical exam was carried out in order to further evaluate the general health of the animals. This was carried out firstly, in order to rule out any obvious problems that may not be diet related and skew the results. Also, specifically focusing on the skin, hair, teeth, ears and joints. This was evaluated in order to discover if any of these diets were more beneficial to these aspects of the animal, as these aspects were indicated as a reasoning behind the choice of the diets by the owners.

The general exam was completed on each dog with aided knowledge of a senior veterinarian.

1. Vitals of each dog were taken (heart rate, breaths per minute, temperature)
2. A body condition score was marked
3. Eyes, nose, ears teeth and gums were checked (and mucous membranes)
4. Lymph nodes were examined
5. Palpation of the abdomen was carried out
6. The skin and hair were evaluated
7. Flexion and extension of the joints was done to finalize the general exam

3.6. Hematological and biochemical exam

These examinations were recorded in order to discover any differences in the blood works of each dog tested. It was used to determine the overall health of the animals, as well as to either corroborate or contrast the results that other studies have found previously. The results were also used to further evaluate if the nutritional needs of the dogs were being met, as well as to discover any deficiencies or disease that may be present.

The hematology parameters analyzed included a white blood cell count with the number of neutrophils, eosinophils, monocytes and lymphocytes. The red blood cell count was also measured along with the hematocrit (HCT), hemoglobin (HGB), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), mean corpuscular volume (MCV) and red cell distribution width (RDW). The platelet count was also analyzed.

The biochemistry parameters analyzed included glucose, urea, creatinine, alkaline phosphatase (ALP), alanine transaminase (ALT), gamma-glutamyl transferase (GGT), amylase, lipase, calcium, phosphorus, total protein, albumin, globulin, cholesterol and total bilirubin.

3.7. Method of blood collection

Firstly, the dogs were sufficiently restrained by another person. The forearm was clipped of hair and then disinfected with ethanol. A blood sample was then retrieved from each dog using a sterile needle and syringe. The blood was then evenly divided into the EDTA tubes and LI Heparin tubes respectively. The bloods were then put through the hematology and biochemistry machines for analyses.

4. Results

4.1. Results of the questionnaire

1. How old is your dog?

Owner feeding a Commercial diet (CD)	Owner feeding a BARF diet (BARF)
4 years old	4 years old

These dogs are both quiet young which decreases the chance of them having acquired a disease due to their age. Having them the same age also reduces the variables of the reasoning behind any differences discovered.

2. What breed is your dog?

CD	BARF
Bernese Mountain dog	Bernese Mountain dog

Both dogs in this study are of the same breed, therefore the genetic predisposition of certain disease such as Canine Hip Dysplasia (CHD), Elbow Dysplasia and histiocytosis are equally probable in both test subjects chosen.

3. How often do you give your dog a worm dose?

CD	BARF
Over 3 months ago	3-4 months ago

The reason this question was posed is because from previous studies, there is a correlation between feeding a BARF diet with the prevalence of endoparasites. Namely, roundworm species such as toxocara canis or toxocara leonina. The eosinophil count on the hematology report is a good indication of the prevalence of internal parasites.

4. Has your dog ever suffered from any illness? if so, what type?

CD	BARF
He had one bout of gastro-enteritis 2 years ago, he stopped eating and had diarrhea	Has never had any illness

5. Has your dog been on any long-term medication, or any short-term medication of recent? If yes, what type?

CD	BARF
no	no

This question was posed in order to rule out any fluctuations of blood parameters that are linked to some long-term medications such as corticosteroids or if the animals had been on any short-term medications such as antibiotics which may have led to immunosuppression.

6. Does your dog suffer from any skin allergies or any skin conditions now or in the past?

CD	BARF
no	no

7. Has your dog experienced episodes of gastroenteritis (vomiting and diarrhea)?

CD	BARF
Once 2 years ago	Never

8. What exactly do you feed your dog? Give the most details you can.

CD	BARF
500g of "Gain Kindness-grain free" pellets daily.	Whole chicken carcass (including bones), eggs, natural yoghurt, carrots and apple cider vinegar. (Other foods such as sardines in oil and offal are given on occasion, apples and carrots are given as a treat).

From the information given I then researched "Gain Kindness- grain free" commercial dog food in order to outline the ingredients, nutrient content and physical form of the food. The Gain Kindness-grain free" dog food comes in pellet form. From researching the commercial dog food online, I discovered the ingredients list outlined below:

Ingredients (2kg bag):

Freshly Prepared Deboned Chicken	33%
Dehydrated Chicken	22%
Potato, Sweet Potato, Chicken Fat	4.5%
Fish meal	2%
Chicken Gravy	2%
Beet Pulp, Fish Oil	1.25%
Dried Egg	1.25%
Linseed, Peas, Minerals, Yeasts, Prebiotic FOS	0.3%
TruCal, Glucosamine HCl	300mg/kg
Methylsulphonylmethane	300mg/kg

Of which additives (per kg):

Vitamin A	20,000 IU
Vitamin D3	2,000 IU
Vitamin E	E 200 IU
L-Carnitine	50mg
Ferrous sulphate monohydrate	200mg
Calcium iodate anhydrous	3mg
Cupric sulphate pentahydrate	40mg
Cupric chelate of amino acid hydrate	50mg
Manganous sulphate monohydrate	15mg
Manganese chelate of amino acid hydrate	50mg
Zinc sulphate monohydrate	278mg
Zinc chelate of amino acid hydrate	333mg
Sodium selenite	0.11mg
Selenised yeast inactivated	50mg
Antioxidants (mixed tocopherols)	-

I then asked the owner feeding the BARF diet further questions of the exact amounts of each food that is given to get a better understanding of the diet:

Weekdays:

Whole chicken carcass, raw (including the bones, excluding the internal organs)	1 whole chicken carcass (roughly 1kg)
Eggs, raw	2 medium sized
Natural yoghurt	3 tbsp
Apple cider vinegar	2 tbsp
Carrots	2

Weekends (as an added extra supplement to the diet):

offal	Can be a variety of different organs
Sardines in oil	1 can

Raw apples and carrots are given as treats on occasion.

9. In your opinion, what do you think is the benefit of feeding your dog this diet?

CD	BARF
It's a consistent balanced diet, the dogs' stools are hard, also the coat is shiny. The dog is a good weight and doesn't fluctuate too much. The food I choose is high in protein and grain free. I never had any problems with this diet.	I feel that the commercial diets are full of additives and that the raw diet is better for my dog. I've done my own research. The price of the commercial dog food is also very expensive. My dog has a shiny coat, and the feces are dry and crumbly.

10. Why did you choose this diet for your pet?

CD	BARF
It is what most people recommended to me and what I have always fed this to my dogs.	It is what my dog breeder was feeding his dogs and he recommended this diet to me.

4.2. An investigation into the daily nutritional requirements of a dog and outlining the feeding regime of the canines in this study

1. Investigation into the daily nutritional requirements for the macronutrients and micronutrients of dogs

All numerical data gathered on the nutritional requirements for canines was obtained from the AAFCO (The Association of the American Control Feed Officials) and are expressed on a dry matter (DM) basis (Aafco, 2021).

The AAFCO states that there are six nutrients that are vital to a dog's survival. These are protein, carbohydrates, fats, vitamins, minerals and water. The nutrients are needed in varying amounts depending on the dogs' stage of life (during growth, gravidities, breed, etc.). A balanced diet is paramount if all the nutrients are to be properly absorbed by the intestines of the dog. Energy plays a vital role in this aspect of digestion. If the dog is on a high energy diet they will be inclined to eat less and vice versa. Therefore, it is important to factor in this fact when deciding the amount of each macro and micronutrient being supplied in the food chosen (Tupler, 2021).

Protein:

Protein is needed by the body for growth and repair, as well as formation of muscle, cartilage, hair, skin, blood, etc. Proteins will later be broken down by the body into essential amino acids and utilized. There are ten essential amino acids that a canine will require as they cannot be created by their own bodies and must be obtained by food. These are: arginine, histidine, leucine, isoleucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine. Consequently, not only the amount of protein that the canine is eating is important, but also the quality of the protein. The quality of protein is based on its source, availability and the amount of essential amino acids present (Ardente, 2020). It is to be noted, that the best source of protein for canines is that from an animal origin. The AAFCO recommendations for daily protein requirements a minimum of 22.5% DM for growth and 18% DM for maintenance. It is interesting that feeding an excess amount of protein (over 30% DM) for any stage of life will be unused by the body and can even be harmful to the animals' wellbeing.

Fat:

Fats contain roughly twice the amount of energy as protein and carbohydrates do. Like protein, there is also essential fatty acids that canines require from their diet as their bodies cannot synthesize them. These are the omega-3and omega-6-fatty acids. Fats are obligatory for the body for normal growth and function of body cells, nerves and muscles. Fat is also used as an insulator for the body to maintain heat. They are needed to produce prostaglandins, which play many roles in the body including reducing inflammation. Fats are needed for the absorption of essential fat-soluble vitamins, namely A, D, E and K. Without fat in the diet, deficiencies in these vitamins would develop over time. Omega-fatty acids are essential for the maintenance of healthy skin and a shiny coat. Fat increases the palatability of the food also. Arachidonic acid, which is derived from linoleic acid, is an essential omega-6-fatty acid that can be obtained from sources such as chicken. Omega-3 fatty acids such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) can be obtained from sources such as fish oils. The minimum daily requirement of fat for growth and reproduction is 8.5% and for maintenance is 5.5%. Additionally, the minimum requirements of linoleic acid for growth and maintenance are 1.3% and 1.1% respectively.

Carbohydrates:

As well as being used as a source of energy (from glucose) carbohydrates are required for the production of heat, are a source of dietary fiber (which is obligatory for carnivores), for the production of other nutrients, etc. Carbohydrates are broken down into mono, di, oligo and polysaccharides. Polysaccharides are complex carbohydrates which can be found in foods such as fruits, corn and potatoes. The AFFCO does not have a recommended minimum requirement of carbohydrates. However, the more active the dog is, the more energy it will require therefore the more carbohydrates it should ingest per day.

Fiber:

Fiber plays an important role in the digestion processes in canines. It slows down the movement of food through the gastrointestinal tract, allowing more absorption of nutrients. It hardens stool and prevents diarrhea, aids in the prevention of anal gland impaction, etc. There are two main types of fiber, insoluble fiber, for example, hemicellulose and lignin and soluble fiber. Examples of soluble fiber are inulin, fructooligosacharides and pectin.

Insoluble fiber passes through the gastrointestinal tract of the dog virtually unchanged. This can be beneficial to add bulk to the feed, which can prove advantageous for canines needing to lose weight as it gives satiety. Also, it will slow digestion down as mentioned above. Soluble fiber influences the microbiota of the large intestine. The bacteria in the large intestine will break down the soluble fiber and utilize it for energy. Soluble fiber acts as a sort of prebiotic and is imperative for the overall gut health of canines (Coates, 2015).

Vitamins:

Vitamins are organic compounds that cannot be synthesized in the body, they are required in small amounts to uphold normal functioning of the body. When these requirements are not met, deficiency occurs. Equally, if there is too much of a vitamin, damage to the bodily function due to hypervitaminosis occurs. Therefore, it is paramount that the right amount of each vitamin is supplied to the canine. Vitamins cannot be naturally produced in the body and are required from an external source that is not derived from protein, fats or carbohydrates. The vitamins are divided into fat soluble (A, D, E, K) and water soluble (B, C), (Tupler, 2021).

-Vitamin A (retinol): is mandatory for normal vision, growth, skin development, gastrointestinal health, immunity, bone development etc. Deficiencies in vitamin A can lead to diseases such as night blindness. Some sources of vitamin A include animal tissues, milk and eggs, mainly in the form of retinyl- palmitate. Provitamin A is present in both plant and animal products (Combs and James McClung, 2017). The AAFCO recommends 5,000IU/kg DM, irrespective of the age of the dog.

-Vitamin D (Cholecalciferol-D1, Ergocalciferol-D2): The role of vitamin D is to maintain the homeostasis of calcium and phosphorus, along with the parathormone (PTH). Vitamin D plays a role in bone mineralization, mainly through the intestinal flux of calcium and phosphorus. Calcitriol, an active form of vitamin D synthesized in the kidney stimulates the expression of calbindin-D28k, which is a kidney- specific transporter of calcium, which increases the absorption of calcium through the kidneys (Nijenhuis et al, 2003). When serum calcium is low, the PTH recognizes this and stimulates the production of calcitriol. Calcitriol and PTH both stimulate bone reabsorption through osteoclastic activity, which in turn will increase the serum calcium levels (Rubin et al, 2000).

Vitamin D has also been shown to improve muscle function (Pfeifer et al, 2003). Furthermore, vitamin D has been proven to reduce inflammatory responses by inhibiting prostaglandins and stress kinase signaling, which in turn will inhibit the expression of cytokines (Krishnan and Feldman, 2011). A deficiency in vitamin D has a cascade effect on the homeostasis of calcium and phosphorus levels in the blood serum. There will be a decrease in the reabsorption of calcium from the intestines and the kidney, which will lower the serum calcium levels. This will in turn activate the PTH which will further lead to osteoclastic action on the bones. This will lead to diseases such as rickets and osteomalacia. (Wharton and Bishop, 2003).

On the other hand, vitamin D hypervitaminosis can lead to hypercalcemia, muscle weakness, joint pain and later, calcification of organs such as the heart, kidneys and blood vessels. Therefore, it is critical to have the correct amount of vitamin D in the diet. Sources of vitamin D include salmon, tuna, fish liver oils and to a lesser extent animal liver and egg yolks (Tupler, 2021). The AAFCO recommends 500IU/kg DM for dogs of all age groups.

-Vitamin E (alpha-tocopherol): The compounds of vitamin E have antioxidant properties, with alpha-tocopherol being the most biologically active one. The main role of vitamin E is to prevent the lipid peroxidation of the polyunsaturated fatty acids of lipid membranes. The antioxidant activity of the tocopherols is done by cleaving free radicals of unsaturated lipids (Yamauchi, 2021). Deficiencies in vitamin E may lead to hemolytic anemia and neurological disorders, due to the destruction of the red blood cells and the deterioration of neurons.

Other diseases a canine may acquire due to a vitamin E deficiency is muscular weakness as well as decreased fertility, as vitamin E plays a role in reproduction (Vitamin E Deficiency in Dogs | NASC LIVE, 2021). The only source of vitamin E is plants, since they can synthesize it. Good sources of vitamin E are vegetable oils, cereal grains and seeds. The AAFCO recommend 50IU/kg DM for canines.

-Vitamin K (Menadione): upholds functions such as blood clotting and bone development. Deficiencies of Vitamin K will lead to disorders such as hemorrhaging, effusions and other bleeding disorders. Good sources of vitamin K are green leafy vegetables, cereal grains and vegetable oils. (Tupler, 2021). The AAFCO recommends 1.64mg/kg for puppies and adults.

-Water-soluble vitamins (B and C (ascorbate)): because these vitamins are not readily stored in the body the same way the fat-soluble vitamins are and are utilized rapidly, deficiencies of these vitamins can be quite common. The most important B vitamins are B1(Thiamin), B2(Riboflavin), B3(Niacin), B6(Pyridoxine), B5(Pantothenic acid), B7(Biotin),

B9(Folic acid) and B12(Cobalamin). The water-soluble vitamins are required for normal cellular function. Deficiencies of any of these can lead to a variety of diseases such as neurological disorders and growth retardation (Bier et al, 2015). Unlike humans, dogs can synthesize their own vitamin C, so they do not require it in their diets.

Water soluble vitamin	**Source**	**AAFCO recommendation**
B1(Thiamin)	Animal tissues, liver, grains	1mg/kg DM for all ages
B2(riboflavin)	Milk, eggs, yoghurt	2.2mg/kg DM
B3(Niacin)	Animal and fish by-products, cereals	11.4mg/kg DM
B5(Pantothenic acid)	Meat, liver, wheat bran, fish	10mg/kg DM
B6(Pyridoxine)	Vegetables, meat, grains	1mg/kg
B7(Biotin)	Oilseed, liver, egg yolk	N/A
B9(Folic acid)	Green vegetables, liver, egg yolk	0.18mg/kg DM
B12(Cobalamin)	Milk products and meat	0.022mg/kg DM

-Minerals: Dogs require a daily amount of both macro-minerals and trace minerals in their diets to support normal bodily function. The macro-minerals are comprised of calcium (Ca), phosphorus (P), potassium (K), sodium (Na), chloride (Cl) and magnesium (Mg). Trace minerals include iron (Fe), copper (Cu), zinc (Zn), manganese (Mn), selenium (Se), iodine (I).

-Calcium (Ca): Calcium is needed by the body for normal bone mineralization, muscular contractions and vascular tone, as well as many other activities (Bier et al, 2015). Deficiencies in calcium can lead to osteoclastic activity on the bones, due to stimulation of PTH, which can in turn lead to diseases such as osteoporosis, bone fractures, joint pain and limping. An excess in calcium will lead to hypercalcemia, which may lead to disorders such as kidney failure, eclampsia and muscle weakness (Bier et al, 2015). Sources of calcium include green leafy vegetables, milk and canned fish (Titchenal and Dobbs, 2007). The AAFCO recommends a minimum of 1.2% DM for growth and reproduction and 0.5% DM for maintenance. The ratio of calcium to phosphorus is minimum 1:1 and a maximum of 2:1.

-Phosphorus (P): this macro-mineral is the second most abundant mineral in the body, after calcium. It has both an extracellular and intracellular function in the body. Phosphorus is a basic constituent of teeth and bones. It also abets in forming DNA, RNA, and phospholipids. Phosphorus facilitates in protein activation through phosphorylation, is part of the acid base balance, regulates gene transcription, etc. (S Calvo and J Lamberg-Allardt, 2015).

Phosphorus is readily available in most feedstuff, therefore a deficiency of phosphorus is mostly linked to total emaciation. Symptoms of hypophosphatemia include anorexia, osteomalacia and muscle weakness (Bier et al, 2015). It has been shown that too much dietary phosphorus can negatively affect the Ca:P homeostasis leading to diseases such as chronic kidney disease (CKD), skeletal and cardiovascular diseases. Feeding an excess amount of meat and dairy products may lead hyperphosphatemia, due to the high quantity of phosphorus in these commodities (Dobenecker et al, 2021).

All meat syndrome may occur in dogs being fed a diet predominately meat-based. Due to the high phosphorus in the meat, hyperphosphatemia may occur, changing the calcium:phosphorus ratio. This in turn may lead to subsequent hypocalcemia. These two factors along with vitamin D hypovitaminosis can cause secondary hyperparathyroidism. Therefore, it is crucial that that there is not an excess of phosphorus in the diet (R. Stillion and G. Ritt, 2009). The AAFCO recommends a minimum of 1% DM for reproduction and growth and 0.4% DM for maintenance.

-Magnesium (Mg): Magnesium has many functions in the body, including being a cofactor for many hundreds of enzymes. It plays a role in neuromuscular as well as myocardial contractions (Gröber, Schmidt and Kisters, 2015). A deficiency in magnesium can elicit signs such as tremors, fasciculations, seizures (British Medical Journal, 1967). Sources of magnesium include seeds, nuts and green vegetables. The AAFCO 0.04% DM for growth and reproduction and 0.08% DM for maintenance.

-Potassium: This nutrient is the most copious cation in the intracellular fluid. Potassium is needed for membrane potential and is part of the Na:K ATPase pump mechanism. The superlative sources of potassium are vegetables and fruit (Stone, Martyn and Weaver, 2016). Hypokalemia may cause indications such as muscle tremors and cramping, metabolic acidosis, rhabdomyolysis, intestinal paralysis, arrhythmias and even heart failure. The AAFCO recommend 0.6% DM for dogs.

-Sodium (Na): This macro-mineral passes between the extracellular and intracellular fluid via the Na:K pump using ATP as an energy source. Sodium is essential for maintaining normal cellular function and electrolyte balance. It is imperative for osmotic homeostasis and for excitability of nerve and muscle cells (Seldin and Giebisch, 1990). When discussing sodium, deficiency is highly unlikely, even if the animal is on a low sodium diet. an excessive amount of sodium in the diet is far more likely. Hypernatremia can cause irreversible cell and organ damage, although primary toxicity is still rare. The AAFCO recommends 0.3% DM for growth and reproduction and 0.08% DM for maintenance.

-Chloride (Cl): This mineral has a vital role in regulating body fluids, acid base homeostasis and electrolyte equilibrium (Berend, Hendrik van Hulsteijn and O B Gans, 2011). Deficiencies in chloride can lead to metabolic alkalosis. This is due to the chloride-bicarbonate (Cl-/HCO3-) exchanger, which is positioned on the B-intercalated cells in the kidney cortical collecting duct and tubules. It exchanges chloride and secretes bicarbonate into the lumen of the kidney tubules (Roy, M. Al-bataineh and M. Pastor-Soler, 2015). Chloride can be found in table salt and vegetables such as seaweed, tomatoes and celery. The AAFCO recommends 0.45% DM for reproduction and growth and 0.12% DM for maintenance.

-Trace minerals: Dietary trace minerals are central and hold a significant role in various metabolic processes in organisms. Deficiencies of trace minerals can frequently be initiated by malnutrition and inadequate diets.

- Iron (fe) is a prerequisite for electron transportation in addition to oxygen initiation. Iron is transferred into the bone marrow where it is expended to synthesis hemoglobulin (Case et al, 2000). A large quantity of iron can be found in meats and organs (Tupler,2021). The AAFCO recommends 80mg/kg for dogs.
- Zinc (Zn) is necessary for immunological function, normal growth and skin integrity. It plays a fundamental role in the lipid and protein metabolism. Furthermore, it aids in controlling the storage and liberation of insulin from the pancreas (Case et al, 2000). Zinc is present in meat and fibre sources (Gross et al, 2000). The AAFCO recommends 120mg/kg DM for canines.
- Copper (Cu) is essential for the transformation of tyrosine to melanin, the production of ATP, haemoglobin formation, iron transport as well as synthesis of collagen and to assist in regular osteoblastic activity. Sources of copper are grains, nuts and organs (Whitney and Rofles, 2008). The AAFCO recommends 7.3mg/kg DM for dogs at minimum.

- Selenium (Se) is used along with vitamin E and glutathione peroxidase to protect cellular membranes from oxidative destruction. Selenium has a sparing effect of vitamin E by protecting the pancreas, therefore decreasing the amount of vitamin E necessary to preserve the cellular membranes. Sources of selenium include eggs, liver and fish (Gross et al, 2000). The AAFCO recommends 0.11mg/kg for dogs.
- Iodine (I) has a major role in synthesising the hormones of the thyroid gland, such as thyroxine. Thyroxine stimulates oxidative processes in the cells; therefore, iodine is indirectly required for maintaining the basal metabolic rate. Consequently, iodine is imperative for stable thermoregulation, growth, reproduction, circulation, etc (Case et al, 2000). Eggs and fish are both good sources of iodine. The AAFCO recommends 1.5mg/kg DM for dogs.
- Manganese (Mn) is involved in the formation of many different enzymes, for example hydrolases and isomerases. Importantly, Manganese is an element of the Mn superoxide dismutase which is required for the cleavage of reactive oxygen species (ROS). It also partakes in the lipid and glucose metabolism, the synthesis some vitamins such as vitamin C, plays a role in hematopoiesis and immunity (Li and Yang, 2018). Fibre and fish products are both good sources of manganese. The AAFCO suggests 5mg/kg DM for dogs per day.

2. A restatement of the feeding regime of the dog being fed the BARF diet

Weekdays:

Whole chicken carcass, raw (including the bones, excluding the internal organs)	1 whole chicken carcass (roughly 1kg)
Eggs, raw	2 medium sized
Natural yoghurt	3 tbsp
Apple cider vinegar	2 tbsp
Carrots	2

Weekends (as an added extra supplement to the diet):

offal	Can be a variety of different organs
Sardines in oil	1 can

Raw apples and carrots are given as treats on occasion.

To calculate the exact nutritional value of this canines' diet per day is extremely difficult. This is because we do not know the exact sizes and weights of each ingredient given and they may vary greatly from day to day. This is a major pitfall in the self-prepared BARF diets, as it cannot be sure if the diet is truly balanced and safe for animal consumption. This contrasts with feeding a commercial diet, as all commercially sold pet foods are underpinned by legislations. These legislations include minimum requirements in food hygiene (Regulation (EC) no 183/2005), health rules regarding animal by-products (Regulation (EC) no 1069/2003) and placing the feedstuff on the market for animal consumption (Regulation (EC) no 767/2009).

A whole raw chicken is prodigious in protein of high quality. Furthermore, chicken is a good source of essential fatty acids such as linoleic acid and is also high in fat soluble vitamins which are A, D, E and K. These essential fatty acids are beneficial for healthy skin and coat. Chicken skin is a very good source of omega-3 fatty acid similarly.

On the other hand, chicken is also quite high in saturated fats which can cause a spike of these nutrients in the diet and can potentially lead to health complications. Chicken is high in B vitamins such as B12 and the fat-soluble vitamins. It is also high in selenium, iron and other minerals (Marangoni et al., 2015). The bones' of the chicken contains large quantities of phosphorus and calcium. The possible pitfalls of feeding a whole raw chicken carcass include the chances of salmonella poisoning, the spreading of zoonotic agents and an increase in the chances of a parasitic infestation. Other problems may likely arise too, such as secondary hyperparathyroidism due to too high of phosphorus intake (although this is reduced by feeding the bones along with the chicken meat as the bones are high in calcium). Finally, the chances of a mechanical trauma due to ingestion of the sharp chicken bones may result in grave injury to the animal (Delaney and Fascetti, 2012).

Eggs are plentiful in protein, fats and have a copious amount of carbohydrates. Additionally, they are abundant in many vitamins and minerals, including B vitamins and fat-soluble vitamins alike. Important minerals such as calcium, magnesium phosphorus, iron is of high quantity in eggs. On the negative side, eggs are quite high in cholesterol, which can lead to symptoms associated with hyperlipidemia. These symptoms include vomiting, diarrhea and abdominal pain (Kuang et al., 2018). In addition, feeding raw eggs to dogs increases greatly the risk of them contracting salmonella poisoning and consequently having stints of gastroenteritis.

Plain natural yoghurt is a good source of calcium and protein and can also act as a probiotic, aiding in the dogs' digestion of food by propagating the development of the beneficial bacteria of the gut. It is to be noted however, that canines cannot readily digest lactose due to a lack of the enzyme as they grow older. Therefore, high levels of lactose can lead to vomiting and diarrhea. Similarly, yoghurt is high in fat. When given in large amounts, it may lead to hyperlipidemia and additionally, pancreatitis may follow (Ripley, 2015).

From investigating online sources there has been an array of claims of the health benefits of giving a few teaspoons of apple cider vinegar per day to a dog. Claims such as aiding digestion, reducing inflammation, detoxifying the kidneys, decreasing the risk of urinary tract infections and even preventing a flea infestation were mentioned (Woodley, 2021). Although adding two teaspoons of apple cider vinegar will most likely do no harm to a canine, there is not enough scientific data to corroborate the health claims posed by these online sources. This is not to rule out all the claims posed, but merely to say that there is not enough evidence to corroborate these statements and more research should be done on this topic.

Billinghurst, 2016, recommends feeding raw fruit and vegetables as part of a raw balanced diet. the recommended amount of fruit and vegetables Billinghurst suggests is 15% of the diet and should include a variety of green leafy vegetables such as broccoli and spinach as well as root vegetables such as carrots and an array of seasonal fruits. based on these recommendations, for this raw diet to be more complete, some other types of fruit and vegetables should be added to this dog's diet, especially green leafy vegetables (Billinghurst, 2016).

Offal is high in protein and essential fatty acids. It also contains large quantities of essential vitamins and minerals. According to Billinghurst, 2016, offal should make up 10-15% of the canines' diet. The dog chosen for this study receives an array of different offal products on the weekend, depending on what the butcher has in stock. This may include heart, liver, kidneys or tripe (Billinghurst, 2016).

Sardines are plentiful in protein, fats and a range of vitamins and minerals including vitamin B12 and vitamin D, calcium, zinc and iron. Sardines are high in omega-3 fatty acids, which are advantageous for healthy skin and hair and in addition have been shown to have anti-inflammatory properties (Marengo, 2020).

4.3. Physical exam results

1. Dog being fed the commercial diet:

Firstly, I listened to the heart for any arrhythmias or heart murmurs. On auscultation of the heart, no abnormalities were heard. Secondly, I auscultated the lungs for any abnormal musical or non-musical sounds. Again, there were no abnormalities. Thirdly, I measured the heart rate, respiratory rate and the temperature.

Heart rate (Beats Per Minute-BPM)	112 BPM
Respiratory rate (Breaths Per Minute-BPM)	35 BPM
Temperature (Degrees Celsius)	38.8 Degrees Celsius

All vital measurements above are within normal limits. I measured a body condition score of three (BCS 3). I continued the examination by a head-to-toe assessment, beginning with the mucous membranes of the eyes and gums, which were pale pink in colour. The lymph nodes were normal shape and size, firm in consistency and bounced back into place as I grasped them. I then examined the skin and hair. The skin was intact, dry, slightly flaking, there was no ectoparasites present. The hair was dry and a little brittle, but overall, in good condition and had a shine to it (see figure1). Following this, I examined the eyes, nose, mouth with the gums and teeth and then the ears. The eyes were in the correct position and moved with my finger, pupillary reflex present. The nose was symmetrical on each side, no discharge present. The mouth appeared to be normal. The gums, however, did appear slightly inflamed around the area of insertion of the teeth. This is because there was plaque present at the base of the teeth, especially the premolars and molars (see figure 2). The teeth themselves were not in bad condition, but there was plaque beginning to form and brown discolouration of the canines were also existing. The ears were slightly dirty, but only towards the outer ear. It should be noted that this dog lives on a farm, so the outer ear being dirty is most likely related to the environmental conditions. No indication of an ear infection present. I percussed the chest to evaluate the state of the lungs and compared it to the dull sound over the heart. I then palpated the abdomen; it was not tense and there was no signs of discomfort or pain. Lastly, I examined the flexion, extension, abduction and adduction of each joint on both the forelimb and hindlimb. Each joint examined moved freely in every direction and no pain was present. I checked movement of the head and the state of the spinal cord. No abnormalities were unearthed.

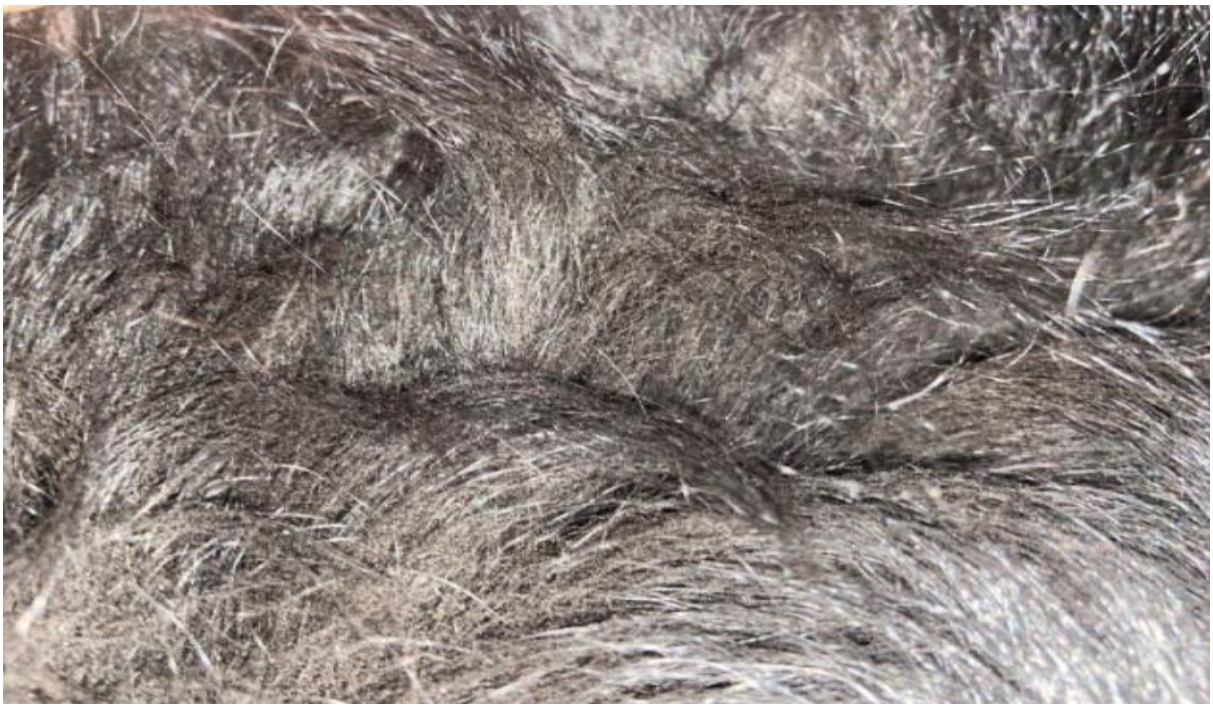

FIGURE 1-HAIR COMMERCIAL DOG

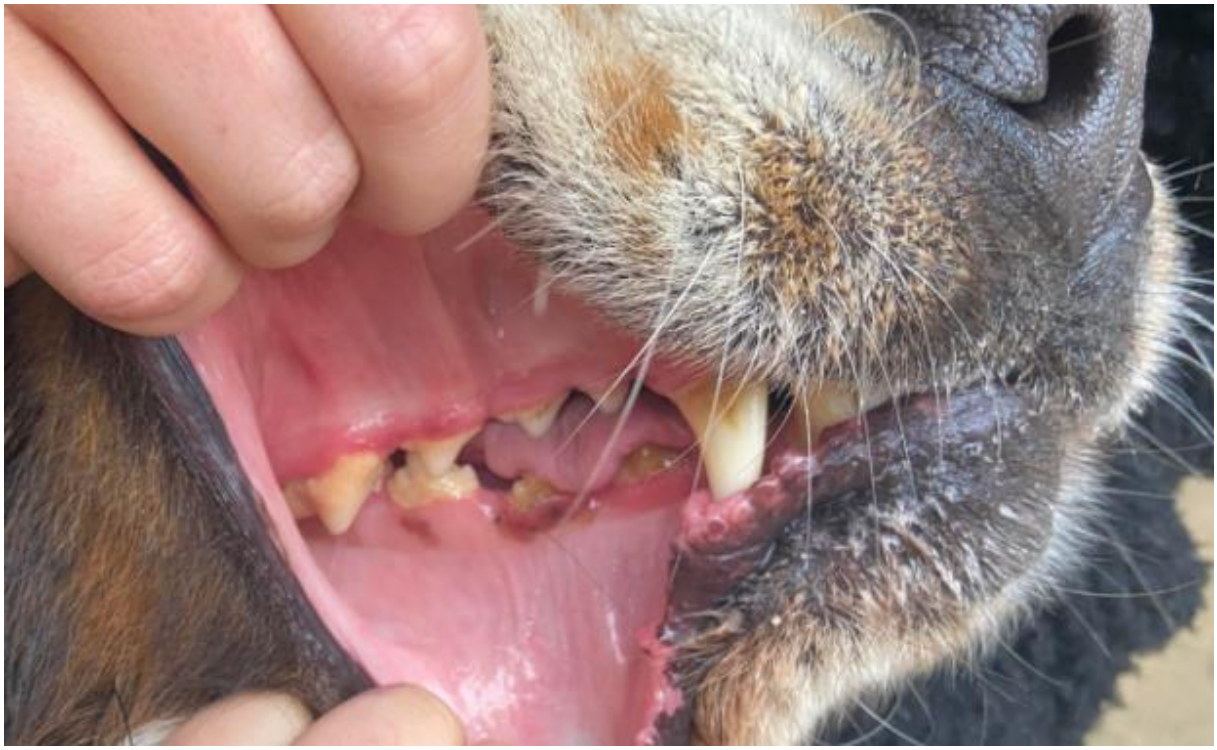

FIGURE 2-TEETH AND GUMS COMMERCIAL DOG

2. Dog being fed BARF diet

I completed the examination in the same order as the previous dog discussed. On auscultation of the heart, no abnormalities were heard. On auscultation of the lungs there was also no abnormal sounds heard. I then proceeded to take the heart rate, respiratory rate and temperature of the dog.

Heart rate (Beats Per Minute-BPM)	136 BPM
Respiratory rate (Breaths Per Minute-BPM)	40 BPM
Temperature (Degrees Celsius)	38.6 Degrees Celsius

All vital measurements above are within normal limits (BCS 3). The mucous membranes were pale pink in colour. The lymph nodes were normal in shape and size, firm in consistency and bounced back into place as I grasped them. Next, I evaluated the skin and hair. The skin was intact, dry, there was no ectoparasites present. The skin was flaking marginally less than the dog being fed the commercial diet. The hair wasn't brittle and was very soft and shiny. There was an environmental factor to be considered when judging the state of the hair and that was the fact that the commercially fed dog did live on a farm and was not being regularly groomed. However, I did take this fact into consideration when examining the dogs and looked at the hair in detail rather than an overall appearance. I concluded that this dog did in fact have a stronger coat than the dog being fed the commercial diet, irrespective if it was groomed more frequently or not (see figure 3).

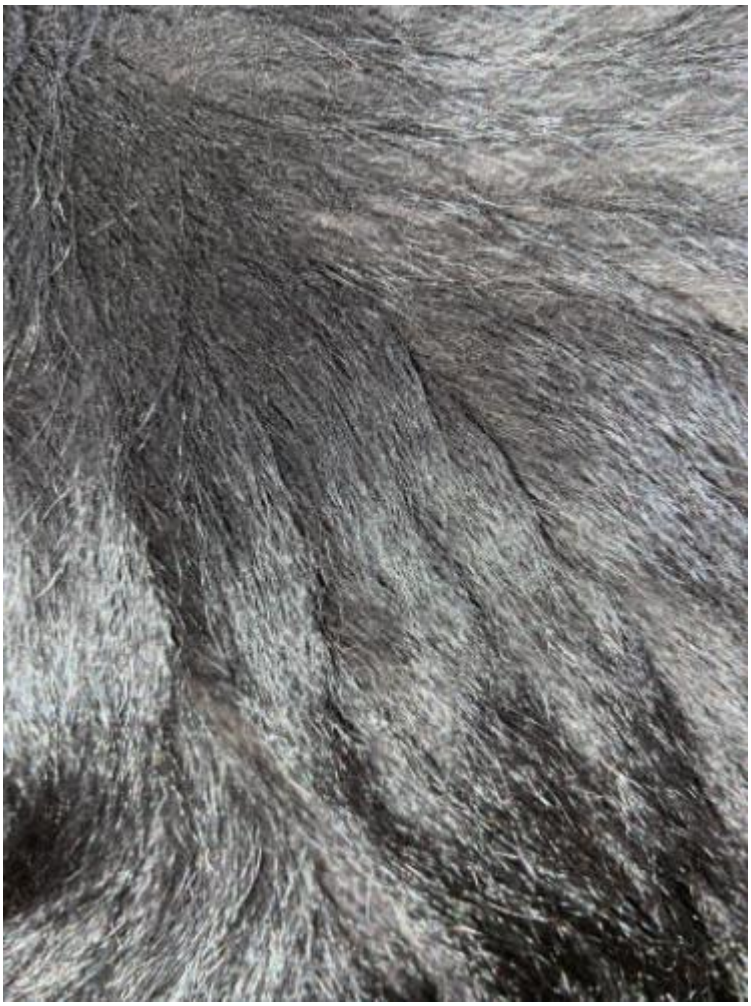

FIGURE3 - HAIR BARF DOG

Following this, I examined the eyes, nose, mouth with gums and teeth and the ears. The eyes were in the correct position and moved with my finger, pupillary reflex present. The nose was symmetrical on each side, no discharge present. The mouth appeared to be normal. The gums were not inflamed, and the teeth were white with virtually no plaque on them and only a slight discolouration on the canines (see figure 4). The ears had no signs of infection and were basically clean, they had a slight bit of debris towards the external portion of the ear. I percussed the chest to evaluate the state of the lungs and compared it to the dull sound over the heart. I then palpated the abdomen; it was not tense and there was no signs of discomfort or pain. Lastly, I examined the flexion, extension, abduction and adduction of each joint on both the forelimb and hindlimb. Each joint examined moved freely in every direction and no pain was present. I checked movement of the head and the state of the spinal cord. No abnormalities were discovered.

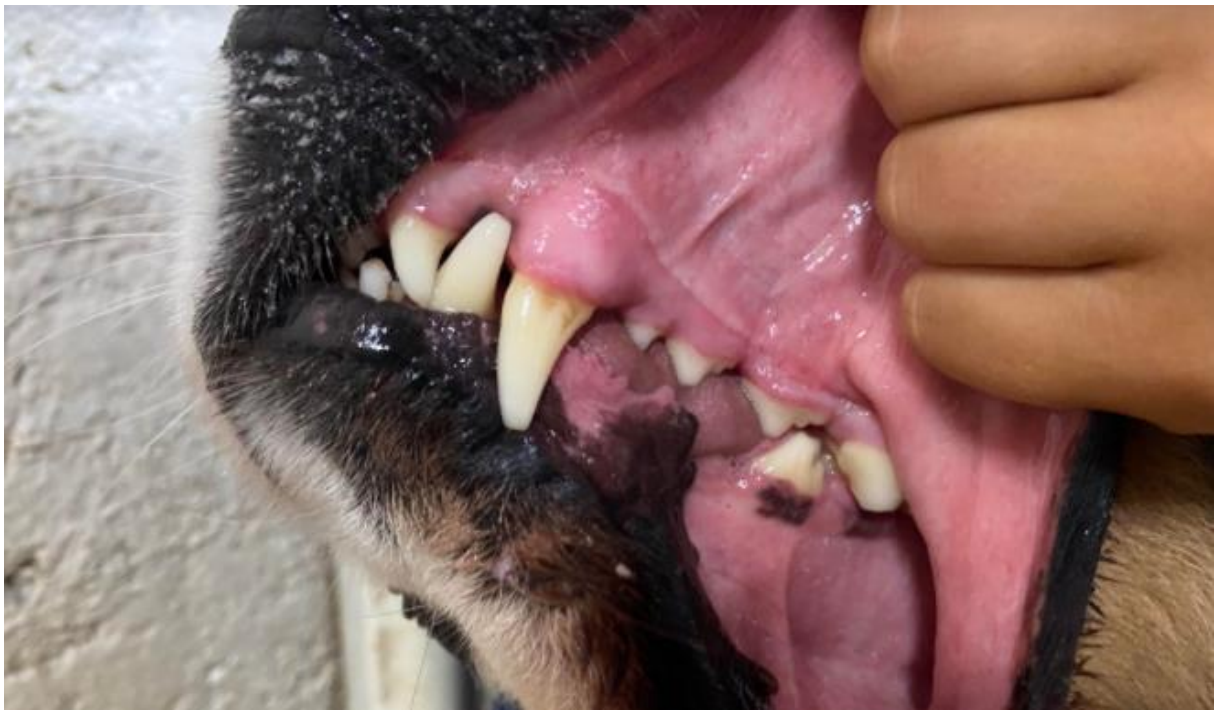

FIGURE 4- TEETH AND GUMS BARF DOG

From performing these general examinations, a lot of useful information was uncovered. Both animals had normal vitals, overall were apparently healthy and were indicating no signs of pain anywhere. By performing a general examination before retrieving a blood sample individually, it aided me in ruling out any obvious reasons for discrepancies in the results. Furthermore, both dog owners indicated that good coat and teeth was one of the reasonings behind their choice in diet. So, examining these attributes of the animals was essential in order to further corroborate their claims. On investigating these attributes of the animals, I discovered that in the case of the canine being fed the commercial diet, the skin was flaking and the hair itself did appear drier and brittle in texture. The dog being fed the BARF diet however, had a very shiny coat and the individual hairs were stronger and smooth. There was tarter build up and inflamed gums in comparison to the dog being fed the BARF style diet, who had no inflammation of the gums and the tarter build up was at a minimum level. Based on this physical exam alone, the results showed me that when it comes to skin, hair and teeth, feeding the BARF diet apparently does elicit a better quality in these aspects. This may be because the dog must break down the bones and spends more time chewing than the commercial dog being fed small pellets, as the mechanical action may be physically breaking the plaque from the teeth. The hair coat may be from the increased amount of lipids in the diet from the high meat consumption of the animal.

I suggest that further research into this topic needs to be carried out in order to make a definite conclusion on whether feeding a raw diet truly does benefit the hair, skin and teeth. From these results I have concluded that there may be some truth to some individual aspects of his claims.

4.4. Hematological and biochemical results and interpretation

-Red colored parameters indicate that the value is above the reference range

-Blue colored parameters indicate that the value is below the reference range

1. hematological results of the dog being fed the commercial diet (Canine A):

-White Blood Cell (WBC) analysis

			normal range	
WBC	10.0	$10^3/mm^3$	6.0	12.0
LYM %	12.8	%	0.0	100.0
MON%	3.6	%	0.0	100.0
GRA%	83.6	%	0.0	100.0
EOS%	2.6	%	0.0	100.0
LYM#	1.20	$10^3/mm^3$	1.00	3.60
MON#	0.30	$10^3/mm^3$	0.00	0.50
GRA#	8.50	$10^3/mm^3$	3.00	10.00
EOS#	0.25	$10^3/mm^3$	0.00	0.60

-Red Blood Cell (RBC) analysis

			normal range	
RBC	7.37	$10^3/mm^3$	5.50	8.50
HGB	19.6	g/dl	15.0	20.0
HCT	53.2	%	44.0	57.0
MCV	72	μm^3	60	77
MCH	26.5	pg	17.0	26.0
MCHC	36.8	g/dl	31.0	38.0
RDW	13.3	%	14.0	17.0

-Platelet (PLT) analysis

			normal range	
PLT	222	$10^3/mm^3$	200	460
MPV	7.0	μm^3	6.7	11.1

Biochemistry results of dog being fed a commercial diet:

Analyte	Result	Reference Range	Unit
GLU	101	74-146	mg/dl
BUN	17.9	7.0-29.0	mg/dl
CREA	1.2	0.3-1.5	mg/dl
B/C	15	-	-
PHOS	2.8	2.0-6.0	mg/dl
CA	<4.0	9.0-13.4	mg/dl
TP	6.7	5.3-8.4	g/dl
ALB	2.7	2.2-3.9	g/dl
GLOB	4.0	2.1-4.9	g/dl
A/G	0.7		-
ALT	55	12-101	μ//l
ALP	61	18-214	μ//l
GGT	5	0-7	μ//l
TBIL	0.18	0.00-1.00	mg/dl
CHOL	239	100-330	mg/dl
LIPA	80	0-155	μ//l
AMY	1047	500-1400	μ/l

Interpretation of the results of canine A:

On analysis of the white cell count of canine A (the dog being fed a commercial diet), all parameters are within normal limits. The mean corpuscular hemoglobin (MCH) was slightly elevated. MCH is the average amount of hemoglobin in the red blood cells. Hyperchromasia can be caused by decreased oxygenation of the blood, but in this case, it is only increased by 0.5 therefore it is most likely not indictive to this disorder. Even a minor dehydration can lead to

hyperchromasia (Masood Ashraf and Rea, 2017). Mild hyperchromasia without any pathological changes to MCV, MCHC or the RBCs does not give much diagnostic value. Red blood cell Distribution Width (RDW) defines the size and heterogenicity of the erythrocytes (Mazzotta et al., 2016). The RDW was just under the normal reference range. A shorter RDW means non-regenerative processes that are associated with anemias, so similarly, this does not give much diagnostic value in this case since the RBC count is within the normal range.

The Calcium (Ca) was exceedingly low in canine A. Hypocalcemia will induce excess secretion of the parathormone, which will then signal the synthesis and release of calcitriol. This will have negative feedback on the synthesis of the parathormone. Symptoms of hypocalcemia include muscle tremors, seizures, behavioral changes, a stiff gait and restlessness. Also, the low calcium can lead to heart disorders such as arrythmias. Canine A has never shown any of these signs around the owner. Additionally, on the physical examination of the dog the symptoms were not evident (Coady, J. Fletcher and Goggs, 2019). Some reasons as to why the calcium may be so low include decreased resorption from the bones or kidneys, decreased calcium absorption from the GI tract or an increase of the precipitation of calcium. The most common disease that are linked to hypocalcemia include renal failure, primary hypothyroidism or malassimilation disorders (Nelson and Couto, 2013).

Renal failure can be excluded as the kidney parameters were within normal range. Malassimilation disorders normally are accompanied with failure to gain and maintain weight. Canine A is a good weight and is apparently healthy. Primary hypothyroidism is presented with weight gain, lethargy alopecia, hyperpigmentation of the skin and recurrent infections (e.g., otitis externa). Canine A is not exhibiting these symptoms. The bloods were retrieved in 2020. I carried out a second physical exam on this dog a year later and still, the dog is apparently healthy, no abnormalities found, and the dog has a lot of energy. In conclusion, the results of the haematology and biochemistry are all normal except for the exceptionally low calcium, to which the origin is still unknown.

2. Hematological results for the dog being fed the BARF diet (canine B):

-White Blood Cell (WBC) analysis

			Normal range	
WBC	7.5	$10^3/mm^3$	6.0	12.0
LYM%	28.5	%	0.0	100.0
MON%	4.9	%	0.0	100.0
GRA%	66.6	%	0.0	100.0
EOS%	4.6	%	0.0	100.0
LYM#	2.10	$10^3/mm^3$	1.00	3.60
MON#	0.30	$10^3/mm^3$	0.00	0.50
GRA#	5.10	$10^3/mm^3$	3.00	10.00
EOS#	0.34	$10^3/mm^3$	0.00	0.60

- Red Blood Cell (RBC) analysis

			Normal range	
RBC	7.78	$10^3/mm^3$	5.50	8.50
HGB	20.9	g/dl	15.0	20.0
HCT	58.6	%	44.0	57.0
MCV	75	μm^3	60	77
MCH	26.8	pg	17.0	26.0
MCHC	35.6	g/dl	31.0	38.0
RDW	13.9	%	14.0	17.0

- Platelet (PLT) analysis

			Normal range	
PLT	99	$10^3/mm^3$	200	460
MPV	9.3	μm^3	6.7	11.1

- Biochemistry results of the dog being fed BARF diet:

Analyte	Result	Reference Range	Unit
GLU	95	74-146	mg/dl
BUN	32.9	7.0-29.0	mg/dl
CREA	1.0	0.3-1.5	mg/dl
B/C	33	-	
PHOS	4.1	2.0-6.0	mg/dl
CA	11.0	9.0-13.4	mg/dl
TP	7.3	5.3-8.4	g/dl
ALB	3.2	2.2-3.9	g/dl
GLOB	4.1	2.1-4.9	g/dl
A/G	0.8	-	
ALT	45	12-101	μ//l
ALP	48	18-214	μ//l
GGT	<5	0-7	μ//l
TBIL	0.14	0.00-1.00	mg/dl
CHOL	322	100-330	mg/dl
LIPA	51	0-155	μ//l
AMY	612	500-1400	μ//l

Interpretation of the results of canine B:

-The white cell parameters were all within the normal reference ranges of canine B (the dog being fed the BARF diet). The eosinophil count was on the higher end of normal but still within the reference index. A higher reference index (RI) of eosinophils in the blood may indicate the presence of a parasitic infection as they are an important element of the type 2 cytokine-induced inflammatory response. They also can be a marker for allergies, since they are in control of the type 1 hypersensitivity reaction (Harvey, 2012). The haemoglobin was slightly elevated in canine B.

The mild elevation could be caused by a slight dehydration or absolute polycythemia, although absolute polycythemia is unlikely in this case considering the RBC count is normal. The high haematocrit and MCH alongside a low platelet count in this dog would also indicate dehydration.

In conclusion, canine B was mildly dehydrated when this blood was taken (Hyun-Kyung, Soo-Hwan and Jae-Ki, 2017). The RDW was marginally low (0.1). The phosphorus levels were towards the higher end of normal. Phosphorus levels in the blood depend on the intake from the diet. Elevated phosphorus levels have been correlated to a diet that is plentiful in meat sources. The balance of calcium and phosphorus in the plasma is paramount for good health in the dog. The total protein, albumin and globulin were at the higher end of the normal reference values. The higher values of total protein may be correlated to the large amount of protein in the diet itself. BUN (Blood Urea Nitrogen) was elevated in Canine B. Urea is an end product in the ornithine cycle which is needed to detoxify ammonia (which is a degradation product of protein). The causes of high BUN in this case are due to a prerenal factor. Prerenal causes of increased BUN include increased protein intake and dehydration. The dehydration in canine B is not severe and no other kidney parameters are abnormally elevated. However, the protein intake of canine B is extremely high, signifying that there is a large quantity of nitrogen products being degraded by the body and producing urea, which may have caused an elevation of urea in the blood (F Martin, E Armstrong and R Rodriguez, 2005).

-Further evaluation of the abnormally high levels of blood urea (BUN) of canine B:

The discovery of the abnormally elevated BUN levels of canine B is perhaps the most crucial finding of this experiment. The dog that was studied above has an excessive amount of protein in its diet. Protein that is derived from food will either be used to synthesise more protein, or it will be converted to urea in the liver. Therefore, the amount of protein taken in by the body is in equilibrium to the amount of urea that is synthesised in the liver.

It is well established that large quantities of protein can lead to kidney damage (Addis, 1917). In a study undertaken on dogs, it was discovered that an increased intake of protein in the diet increased the urea and creatinine excretion (Herrin, Rabin and Feinstein, 1937). From previous studies, it was concluded that changes in dietary protein effected the glomerular filtration rate (GRF) by changing the renal blood flow and can even lead to renal hypertrophy (Allen

and Cope, 1942). Brenner et al, stated that any situation that causes and increased GFR and glomerular pressure may lead to kidney damage. Therefore, an increase in dietary protein may negatively impact the kidney (Brenner et al, 1982).

High protein in the diet has been linked to kidney hyperfiltration, proteinuria and glomerular injury. Evidence shown within a further study that was carried out indicated that the higher the protein intake, the greater the GFR was, moreover, that the GFR was dose dependent on the protein intake (Moustgaard, 1947). Having a high protein diet may overwork the kidneys as protein is converted to urea, which then is excreted by the kidneys which requires a large quantity of water and energy. It has been speculated that a high protein diet may cause an animal to be more susceptible to dehydration also, as urea excretion is so water demanding, although remains to be conclusive.

The findings on this blood analysis did however corroborate this idea, as the canine in this study had an abnormally high urea alongside marked dehydration. To conclude, I believe that the BUN levels of canine B is above the reference range because of the excessive amount of protein in the diet. This excessive amount of protein is being converted to urea in the liver and entering the blood stream. It is then excreted through the kidneys. This large intake of protein may lead to kidney damage in later life for this animal.

5. Discussion

Results of the questionnaire gave insight as to why the individuals chose such a diet for their pets respectively. Furthermore, it aided in investigating where information about the BARF diets is being collected from and finally, what the perceived benefits of the diets chosen were. When asked why they felt that their chosen diet was better for their pet's health, the dog owner who feeds their dog the BARF diet informed me that he and the dog breeder he purchased his dog from ran their own experiment in which they measured the digestible energy (DE) of the BARF diet versus a well-known commercial diet called "Taste of the wild". The digestible energy is defined as the amount of energy lost in the feces. The digestible energy is calculated by subtracting the gross energy in the feces from the gross energy consumed by the animal. They carried this out by feeding the exact same weight of each diet to two dogs on the different diets respectively. They conducted this experiment out for three weeks and calculated an average of the results.

They discovered that there was less feces in the dog being fed the raw diet in comparison to the dog being fed a commercial diet. Therefore, the owner of the dog being fed a BARF diet has concluded that there is less nutritive value in the commercial diets and that they have more additives in them to bulk them out. It must be noted however, that when calculating the nutritive value of a feedstuff for dogs and cats, we use the metabolizable energy (ME), as it is more specific. The metabolizable energy is the net energy remaining after fecal and urinary energy loss. This epitomizes the energy that is available for metabolic processes, reproduction and growth.

When posed the question of what exactly the owners fed their dogs in detail, I discovered that the dog being fed the commercial diet gets fed 500g of this commercial diet daily. It is to be noted that this canine is 50kg. The recommended amount of the commercial food to be fed to a dog of this weight is 555g/day. This is the figure that was given by the nutritionists that created the commercial diet in question. This signifies that the canine studied is getting 55g less than the recommended intake every day.

The questionnaire also gave me insight to the general health of the animals. Both canines in this experiment were of the same age and breed, not on any medication and never had a serious illness in the past. Claims such as a better haircoat and teeth were made by both owners in this study, but this can be subjective opinions. In order to evaluate these aspects of the animal in more detail without bias, a general examination of the animals had to be carried out. In both cases, the vitals were normal, and no abnormalities were present. On examination of the haircoat and skin, it did appear to me that the animal being fed the BARF diet had better quality hair shafts and the skin was flaking less in comparison to the canine being fed the commercial diet. The appearance of the teeth was also improved with the dog on the BARF diet. Considering that these two dogs are the same breed, sex and similar weights. The haircoat and teeth differences may well be diet related. This would coincide the assertions by Billinghurst (2016), that feeding a raw diet improves haircoat, skin and teeth. Although, there was no difference in the ears of these dogs, so I could not corroborate what Dr.Ian Billinghurst stated in his book about ear health being increased with feeding a raw based diet (Billinghurst, 2016).

The research into the nutritional requirements of a dog was carried out in order to further understand where the nutrients can be obtained from, how much of each nutrient a dog would need for health and what are the exact amounts of each element they require per day.

Moreover, what are the typical symptoms that would occur should one of these nutrients be lacking or oversaturated in the diet. After researching in depth about the nutritional requirements of the dogs, it allowed me to further evaluate what the canines in this study were being fed with more comprehension. Commercial diets are only complete if the exact amount recommended is given (Chandler and Takashima 2014, review). Therefore, it was important to do the questionnaire as it was through that I discovered that the dog being fed the commercial diet gets 50g less than recommended by the "Gain Kindness" producers per day. Consequently, I kept this in mind while analysing the data collected. On outlining the exact diet, the dogs were eating daily some further information was gathered. Firstly, before a commercial diet is to be allowed to be put on the market it must pass through laws and legislations that protect the animal consumers and protect the health of the owners purchasing the feedstuff. This contrasts with feeding a BARF diet that has had to pass no such legislations. For this reason, the possible spread of zoonotic agents from canine to owner is increased greatly when feeding a raw diet (Joffe and Schlesinger, 2002).

Following this point, another downside to feeding a BARF diet is that there is no possible way to calculate the exact nutritional content of each ingredient at home. In the beginning, I attempted to make a rough estimate of the nutritional content of the BARF diet in this study, but discrepancies of weights of products, different types of offal and crude ash contents of each food posed as a major barrier to do this. This would have to be done by a nutritional expert. How can we be sure that the exact nutritional requirements of the canine are met every day? This could potentially be solved by a dog nutritionist cultivating a BARF diet and calculating the nutritional content before selling the product. The nutritional breakdown of the commercial diet was already completed by the manufacturers of "Gain Kindness" food, as they are legally obligated to do in order to sell their product on the market. In this way, it made it a great deal easier to evaluate the protein, carbohydrates, fat, vitamins and minerals that were in the food.

On evaluation of the haematological and biochemical analysis, it was discovered that there were great differences in the parameters of the BARF diet dog and the commercial dog. Granulocytes were lower in the BARF dog, but the eosinophil count was higher. The haemoglobin and haematocrit concentration were higher with the BARF diet, this would validate the results discovered by Frisk (2018), that the haemoglobin and haematocrit increase in dogs being fed a raw diet. There were strong differences throughout the biochemical results, with special attention to the urea, calcium, phosphorus, total protein and cholesterol levels, all of which the

BARF dog was higher in. The creatinine concentration was mildly higher in the commercial canine, this result supports the findings of Dobenecker and Braun (2015), who concluded that commercial dry food had higher concentrations of creatinine than raw food. The urea levels in the blood were elevated in the dog on the BARF diet. This is most likely due to the increased protein intake in the diet, therefore an increased amount of protein degradation and urea formation in the body, consequently being released into the blood. The total protein, albumin and globulin levels were all higher in the BARF dog. This is similar to the results uncovered by Anturaniemi et al (2020), whos' results indicated that the total protein and albumin significantly increased with canines being fed a raw diet. Cholesterol was highest in the BARF diet dog. This result contrasts with a study carried out by Frisk (2018), who concluded that feeding dry food increases the amount of cholesterol in the blood. However, the results I have gathered correspond to results obtained by Kronfeld et al. (1977), whos' findings demonstrated that increased fat and protein in the raw meat diet would eventually lead to a rise in cholesterol in the blood. The dog being fed a commercial diet had a greater glucose concentration, this is most likely attributed to having a more carbohydrate rich feedstuff in comparison to the raw diet, which is mainly consisting of meat, fruits and vegetables. Phosphorus levels were higher in the BARF dog. This is dissimilar to the results encountered by Anturaniemi et al. (2020), who found that dogs on a commercial diet have highest blood levels of phosphorus. They concluded however, that this is most likely due to the liberation of phosphate by ALP, which was higher in the commercial dogs. Dissimilarly in this study, there were no marked differences in the ALP concentrations of each diet respectively. Therefore, the higher blood phosphorus in the BARF dog is most likely due to the increased meat consumption.

5.1. Limitations and further research

Firstly, a larger study with a similar method should be carried out in order to make the results more conclusive. This study only used two animals. More dogs should be used in further research to fully support the results uncovered in this thesis. Secondly, Canine A had low blood calcium that is most likely not diet related, while Canine B was slightly dehydrated. Having a larger study would have gained an average of all dogs in a study, helping to alleviate barriers such as these. Further research into the balancing of the BARF diet is needed, following this, if it there is a safe way to deliver raw diets without the potential spread of zoonotic agents. Lastly, if feeding a BARF diet increases or decreases the probability of deficiency and disease in comparison to the commercial diet.

6. Conclusion

The investigation was initiated in order to compare BARF diets to commercial diets to their nutritional value and their effect on the canine regarding their physical and haematological state respectively. After an in-detail comparison of each of these aspects, I've concluded that both diets have their negatives as well as positives. The nutritional analysis of the commercial diet was easier to interpret in comparison to the BARF diet. This was due to the labelling that is legally obligated to be on the packaging of commercial dog food. Dissimilar to this, the BARF diet being fed in this study had no regulations and is not the same every day. In this way, it is extremely difficult to know whether the diet is nutritionally balanced for the canine. The other downfall to the BARF diet in this case is the probability of the spread of zoonotic infections, such as pathogenic salmonella species. These pathogens are not just a potential risk to canines, but also to the humans that feed them. On the other hand, I can understand the reasoning behind feeding the BARF diets in relation to it being less processed. In that sense, that is a very true statement. Also, when an owner can physically see good results from feeding a raw diet (such as a good hair coat) it propels the impression that this is the best diet for their pet. The debate on which diet gives better physical results to the dog, for example, teeth and skin was investigated. Regarding these aspects of the animal, the BARF diet seemed to give better results (see figure 3 and 4). The haematological and biochemical results showed varying differences between in the BARF and commercially fed dog. Many of these differences were concluded to be derived from the diet. Namely some haematological values (e.g., haemoglobin), phosphorus, total protein, cholesterol, urea, creatinine and glucose. In conclusion, feeding a BARF or commercial diet will render varying haematological and biochemical blood results, proving that the diet chosen will have a great impact on blood parameters. Furthermore, feeding a BARF diet may improve physical features of the canine, such as skin, haircoat and teeth. Additionally, feeding BARF poses an increased risk of an unbalanced diet, since there is no way to truly measure how much of each macro and micronutrient the canine is getting per day. However, I do believe that a balanced "homemade" diet can be achieved if created by a nutritional expert instead of feeding pellets if this is not something an owner wants to do. From this study, I do believe that there are some positive aspects to a BARF diet and some claims can be corroborated. It should be noted that the BARF dogs' blood parameters were mostly in the reference ranges, they were just differing to the commercial dog.

Hence, with the results obtained from this study, it cannot be concluded that the BARF diet is always going to cause deficiency or disease.

To conclude, further research into commercial and BARF diets must be done in order to clarify the risks of feeding BARF and commercial diets in order to aid owners in making the right choice for their pets.

7. Summery

The aim of the study "A comparative analysis of the effects of feeding BARF diets versus commercial diets" was to compare BARF and commercial diets to each other based on the physical and haematological examination of two dogs, one on each of these diets respectively. An investigation of the nutritional requirements of an average dog per day was examined, followed by an outlining of the components of diets being fed to the dogs in this study. A questionnaire was prepared to require a history of the dogs from their owner. Following this, questions such as what exactly make up the components of their dogs' diet and why they chose each diet respectively was asked. Next, a physical exam was carried out in detail of the two canines to assess the general health of the dogs. Moreover, the physical exam was completed to evaluate some physical features of the canines that the owners attributed to their diet, without the presence of bias. Finally, a complete blood analysis was taken and interpreted to determine if feeding a canine commercial or a raw diet would show contrasting trends in the blood and if so, what these contrasts were and why they would be present. Further aims of the study were to analyse possible negative or positive aspects of each diet based on previous research and research obtained from the results of this thesis, in order to better understand the link to the choice of both diets discussed and the possible outcomes of the choice. This thesis was chosen as there is a steady increase in the trends of feeding raw meat diets and an apparent lack of trust in the commercial diets over recent years with owners. The results obtained in this study suggest that a BARF diet has a higher probability to be unbalanced, due to the difficulty of identifying the nutritional content of the diet. BARF also has an increased risk of the potential spread of zoonotic agents, based on previous studies researched in this paper. Commercial diets are under strict legislations, making them undeniably the safest option when it comes to hygienic preparations. In saying this, the results of this study concluded that there were no deficiency or disease discovered in the BARF dog evaluated.

In contrast to this, the physical examination concluded that there may be some benefits of feeding a raw diet, such as good hair quality. The results of the haematological examinations indicated that there are vast differences in blood parameters of dogs being fed BARF versus commercial diet. This further strengthens the link between diet and health in dogs and how the diet chosen greatly impacts the parameters of the blood, especially when compared to each other directly.

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