

# ปฐิวัตติ Vegan Dog Food

## ก้าวข้ามขีดจำกัดโภชนาการพืชสู่มาตรฐานสารอาหารที่เทียบเท่าเนื้อสัตว์

1<sup>st</sup> July 2026, 11.15-12.15 @ Novotel Bangkok, Future Park Rangsit, Thailand

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- การเติบโตของอาหารแพลนท์เบสและความปลอดภัยตามหลักวิชาการ
- ข้อดีและข้อจำกัดของการพัฒนาอาหารวีแกนสำหรับสุนัข
- แนวทางการประเมินความปลอดภัยในสัตว์ทดลอง

## Vegetarians

(Meat free diet, Plant-based diet)



Consume foods derived from **plants**, with or without dairy products, eggs and/or honey

## Vegan

- Complete absence of animal-based products
- Cosmetics and household products
- Animal testing?

# Raw materials for plant-based diets



**Common plant-based raw materials**  
(Soybean, corn gluten & wheat gluten)



**Novel current plant-based raw materials**  
(Pea, potato, oat & rice protein)



**Future plant-based raw materials**  
(Hemp, algae, single cell proteins & cultured meat)

# Examples: Plant based formulation

Table 1. Compositions of vegetable and animal protein diets for dogs.

Animal protein diet (in %)		Vegetable protein diet (in %)	
Fish powder	16.0	Soybean meal	53.0
Meat meal	16.0	Wheat flour	10.0
Wheat flour	10.0	Corn powder	23.0
Corn powder	48.0	Beet pulp	5.0
Beet pulp	5.0	Soybean oil	4.0
Soybean oil	2.0	Vitamin mixture	2.0
Vitamin mixture	2.0	NaCl	0.5
NaCl	0.28	CaHPO <sub>4</sub>	2.0
Soybean meal	0.78	CaCO <sub>3</sub>	0.5
Total	100.0	Total	100.0

## Plant-based diet<sup>b</sup>

**Ingredients:** Dried Peas, Pea Protein, Brown Rice, Oatmeal, Potato Protein, Sorghum, Canola Oil (preserved with Mixed Tocopherols), Natural Flavor, Suncured Alfalfa Meal, Brewers Dried Yeast, Dicalcium Phosphate, Flaxseeds, Millet, Calcium Carbonate, Lentils, Peanut Hearts, Quinoa, Sunflower Chips, Salt, Potassium Chloride, Choline Chloride, Taurine, Vitamins (Vitamin E Supplement, Vitamin A Supplement, Niacin Supplement, d-Calcium Pantothenate, Riboflavin Supplement, Vitamin D2 Supplement, Thiamine Mononitrate, Vitamin B12 Supplement, Pyridoxine Hydrochloride, Biotin, Folic Acid), Dried Carrots, Minerals (Ferrous Sulfate, Zinc Sulfate, Copper Sulfate, Sodium Selenite, Manganese Sulfate, Calcium Iodate), DL-Methionine, Dried Parsley, L-Ascorbyl-2-Polyphosphate (source of Vitamin C), preserved with Citric Acid, preserved with Mixed Tocopherols, Dried Celery, Dried Blueberries, Dried Cranberries, Dried Beets, Yucca Schidigera Extract, Dried Lettuce, L-Carnitine, Dried Watercress, Dried Spinach, Rosemary Extract.

Table 1. Composition of diets before extrusion

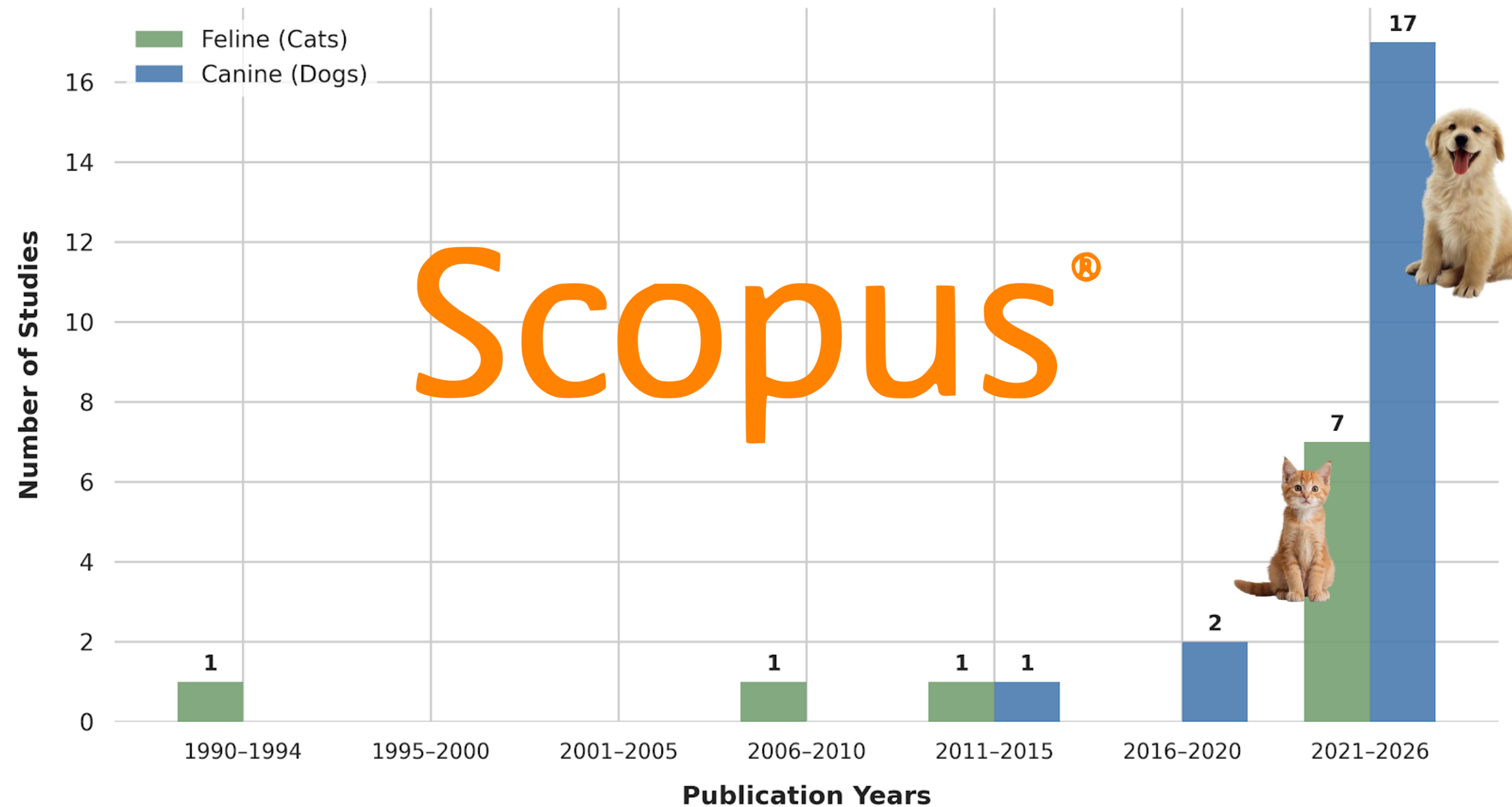
Ingredient (g/kg)	Diet	
	Meat-based	Meat-free
Rice (broken)	120	120
Maize (whole)	170	250
Sorghum	140	–
Poultry meal	430	–
Maize gluten	60	300
Fine soya meal	–	130
Sodium caseinate	–	60
Vegetable mix	–	60
Sugarbeet pulp	30	–
Vitamin and mineral mix	50	80

## PLANT Diet Ingredients

Peas, barley, oats, potato protein, sunflower oil (preserved with mixed tocopherols), pea protein, lentils, quinoa, calcium carbonate, dicalcium phosphate, primary dried yeast, flaxseed, natural vegetable flavouring, salt, dried marine algae, choline chloride, vitamins (vitamin A supplement, vitamin D2 supplement, vitamin E supplement, niacin, L-ascorbyl-2-polyphosphate (a source of vitamin C), d-calcium pantothenate, thiamine mononitrate, riboflavin, pyridoxine hydrochloride, folic acid, biotin, vitamin B12 supplement), minerals (zinc proteinate, iron proteinate, copper proteinate, zinc oxide, manganese proteinate, copper sulphate, ferrous sulphate, calcium iodate, manganous oxide, selenium yeast), DL-methionine, potassium chloride, L-lysine, taurine, L-carnitine, dried rosemary

# Trends

Publications on plant-based, vegetarian, and vegan diets for dogs and cats are increasing.



# Trends: Acceptability of vegetarian diets in pets related to the owner's diets

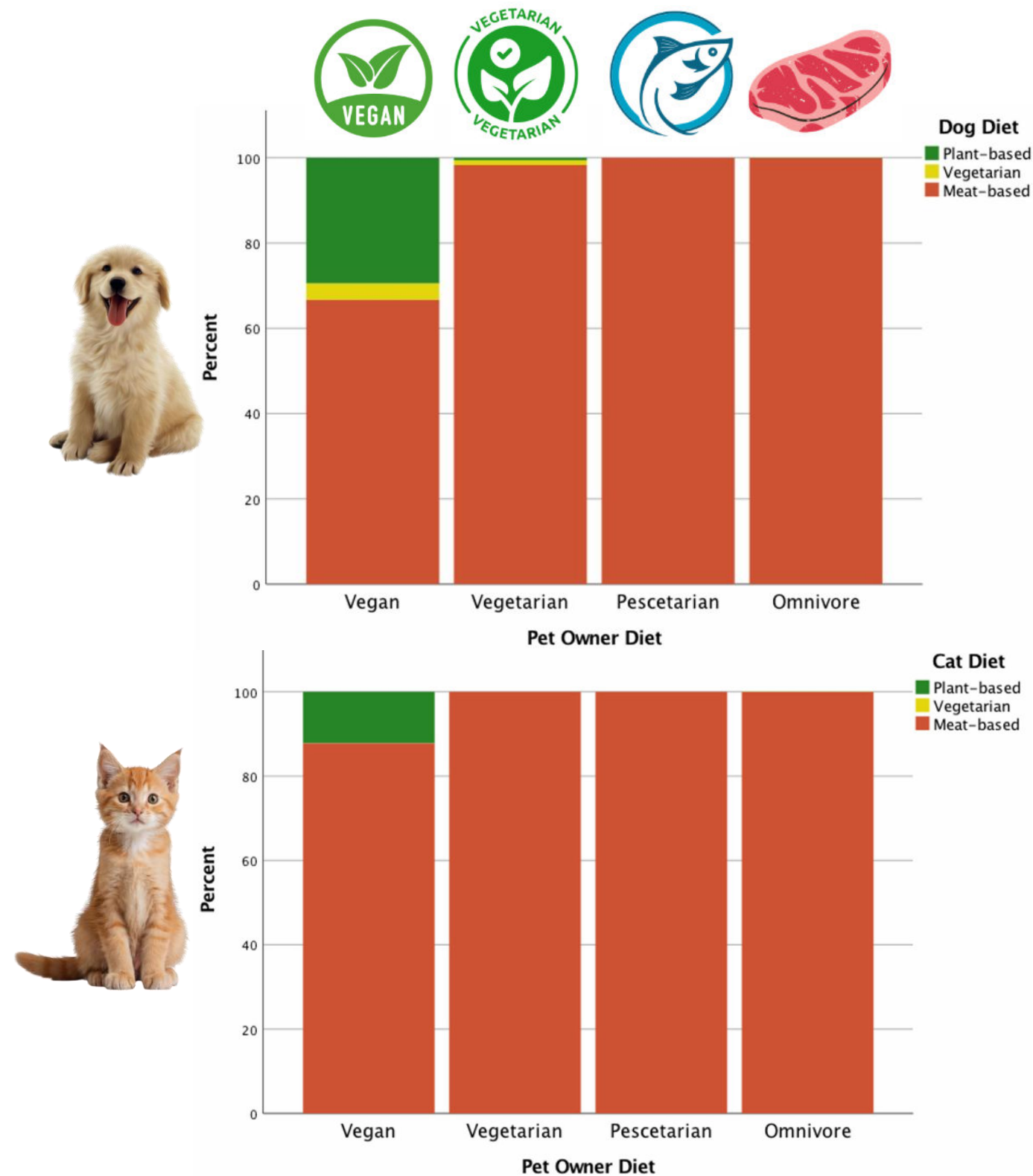
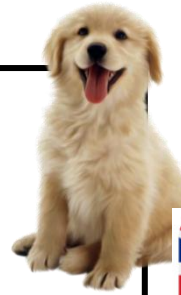


Fig 2. Composition of pet diets according to their owners' diet. Based on responses of pet owners to the "Pet Feeding Practices" survey, dog top, cat bottom. The Y axis represents percentage of pet owners within a given diet group.

- **Study population (N=3,673)**
  - Owner diets were an omnivorous diet (84%), followed by vegetarian (6.2%), vegan (5.8%) and pescetarian (4%).
- **The Vegan Connection**
  - Only one vegan owners fed meat-based diet to dogs.
- **Concerns with Meat-Based Diets**
  - Farm animal welfare
- **Concerns with Plant-Based Diets**
  - Nutritional completeness
- **Future Interest**
  - Vegan owners stated they would switch to a plant-based pet diet if a diet meeting their specific criteria were available.

# Trends: Consumer Acceptance of Sustainable Dog (N=2,639) and Cat Diets (N=1,380)

## Dogs



### • Prevalence of diets

- 84.2% Meat-based diets
  - 52.3% Commercial meat
  - 31.9% Raw meat
- 12.8% Vegetarian diets

### • Purchasing motives

- 94.5% Health and nutrition
- 75.8% Diet quality
- 65.3% Palatability

### • Openness to alternatives of meat-feeding owners

- 43% Consider for sustainable alternative diets

### • Ranking alternative diet

- 24.4% Cultivated meat-based diets
- 16.6% Vegetarian diets
- 15.5% Insect-based diets
- 13.4% Vegan diets
- 7.1% Fungi-based diets
- 6.7% Algae-based diets

### • Key drivers for alternative diet selection

- 84.5% Trust in nutritional soundness
- 82.8% Confidence about pet health

## Cats

### • Prevalence of diets

- 84.2% Meat-based diet
- 9.1% Vegetarian diets

### • Purchasing motives

- 84.9% Health and nutrition
- 77.6% Palatability
- 60.1% Diet quality
- 41.9% Price
- 36.5% Naturalness

### • Openness to alternatives of meat-feeding owners

- 51.2% Consider for sustainable alternative diets

### • Ranking alternative diet

- 33.1% Cultivated meat-based diets
- 18.2% Vegan diets
- 14.8% Insect-based
- 13.8% Vegetarian

### • Key drivers for alternative diet selection

- Pet health, nutritional soundness, palatability, good quality and environmental sustainability.

# Trends: Environmental impacts on pet food.

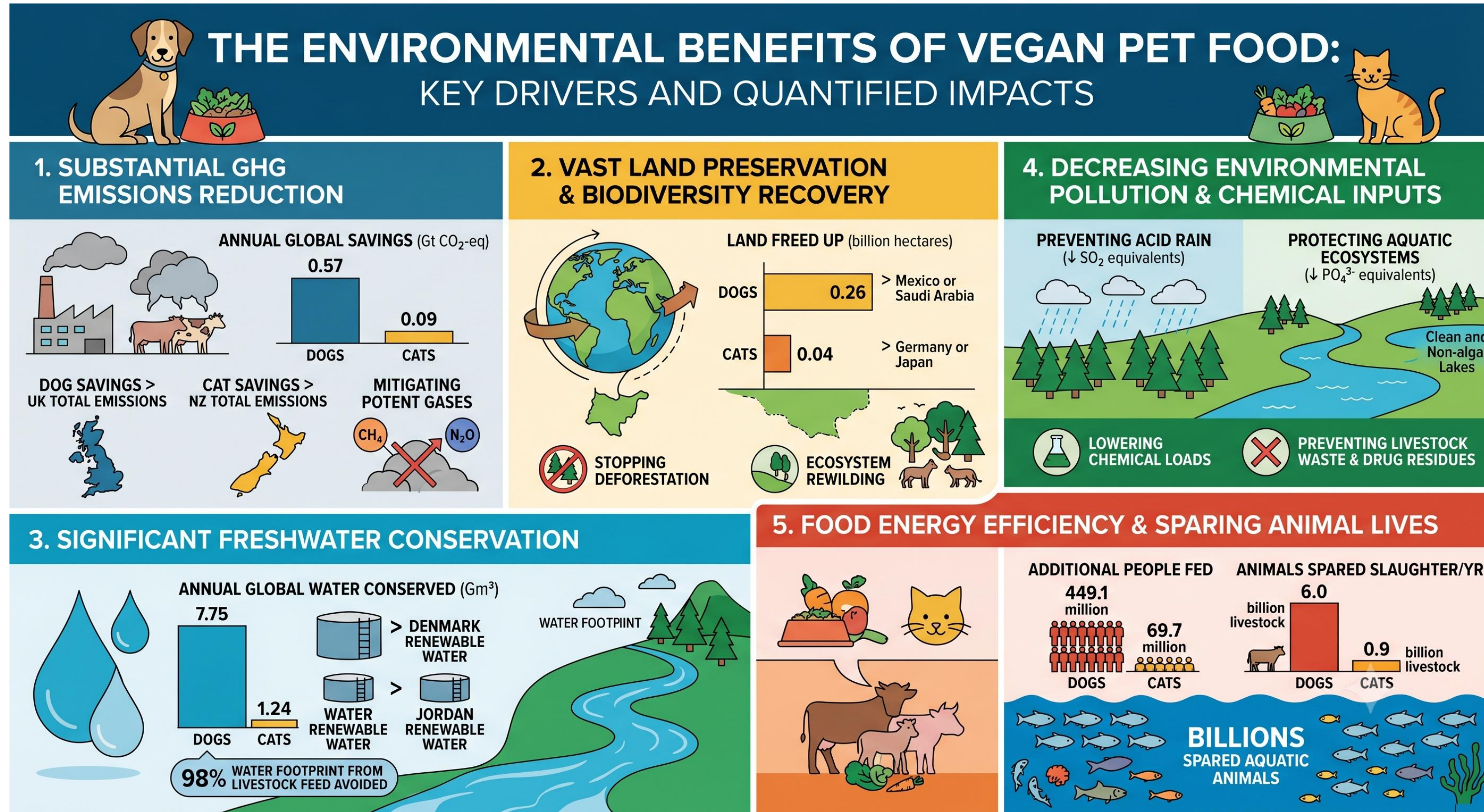


**Table 11.3** Terrestrial vertebrates killed for food in 2020, within the US, used within the diets of dogs, cats and humans.

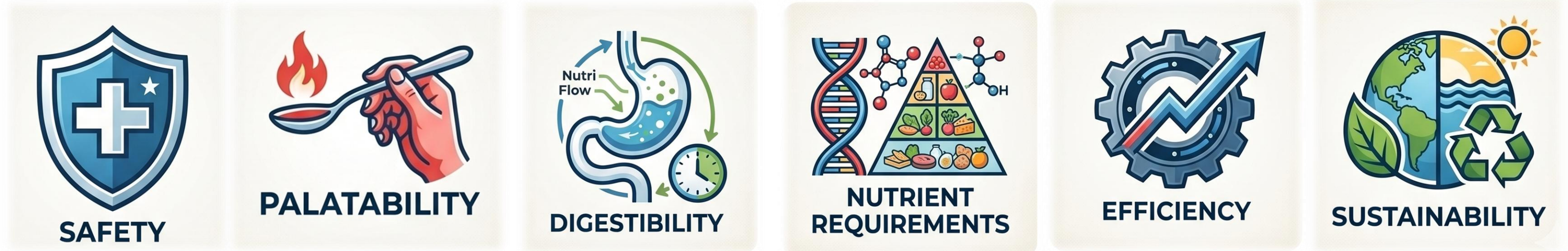
Animal Category	US total (2020)	Humans (80.0% Total)	Dogs (17.7% Total)	Cats (2.3% Total)	Dogs and cats (20.0% Total)
Poultry	9,592,147,000	7,673,717,600 (80.0%)	1,697,810,019 (17.7%)	220,619,381 (2.3%)	1,918,429,400 (20.0%)
Pigs	131,639,000	105,311,200 (80.0%)	23,300,103 (17.7%)	3,027,697 (2.3%)	26,327,800 (20.0%)
Bovine animals	33,366,100	26,692,880 (80.0%)	5,905,800 (17.7%)	768,420 (2.3%)	63,032,200 (20.0%)
Sheep and goats	2,942,800	2,354,240 (80.0%)	520,876 (17.7%)	67,684 (2.3%)	588,560 (20.0%)
Other land animals	77,594	62,075 (80.0%)	13,734 (17.7%)	1,785 (2.3%)	15,519 (20.0%)
<b>Total</b>	<b>9,760,172,494</b>	<b>7,808,137,995 (80.0%)</b>	<b>1,727,550,531 (17.7%)</b>	<b>224,483,967 (2.3%)</b>	<b>1,952,034,499 (20.0%)</b>

Knight, A. (2024). The environmental benefits of vegan pet food. In *Regenerative Farming and Sustainable Diets* (pp. 92-104). Routledge.  
<https://www.taylorfrancis.com/chapters/oa-edit/10.4324/9781032684369-15/environmental-benefits-vegan-pet-food-andrew-knight>

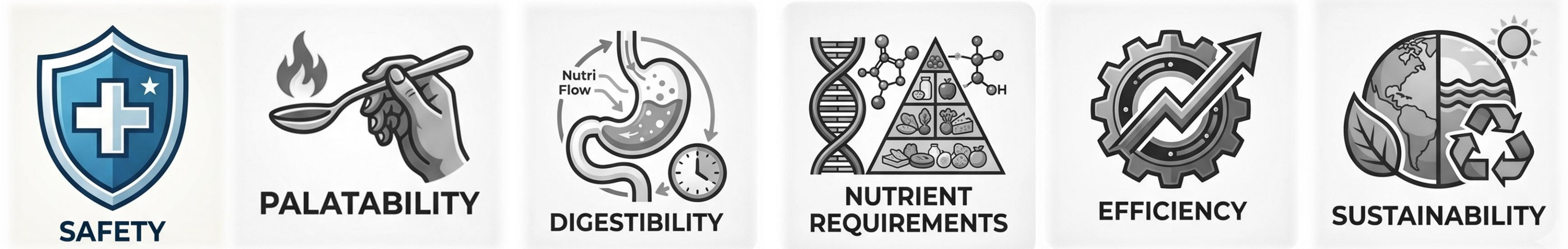
# Trends: Environmental impacts on pet food



# Advantages and limitation of vegetarian diets in pets



# Advantages and limitation of vegetarian diets in pets





# Safety of vegetarian diets

1. Physiological safety

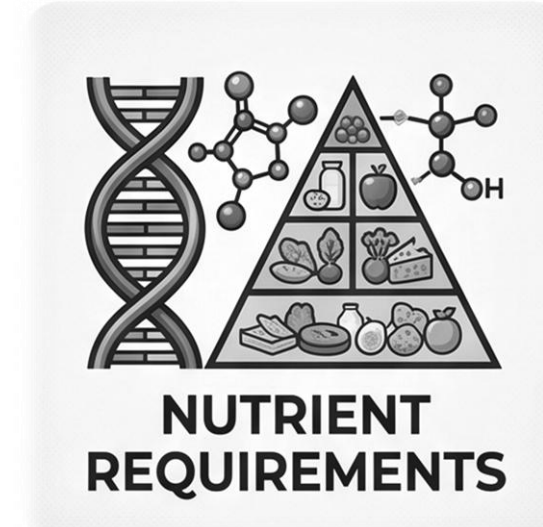
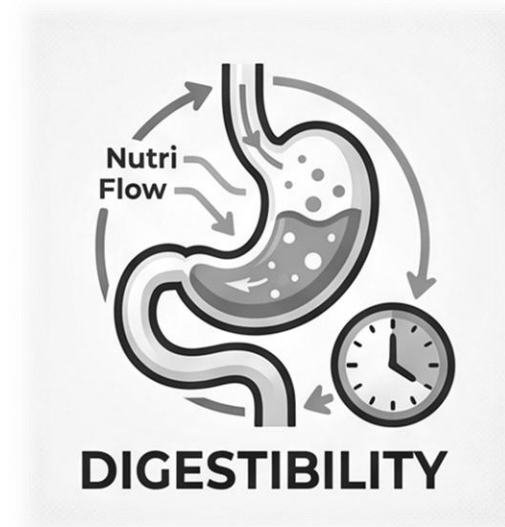
2. Chemical safety

- Pesticides, Heavy metals, Anti-nutritional factors or Contaminants

3. Biological safety

- Pathogenic bacteria, parasites or viruses

# Advantages and limitation of vegetarian diets in pets



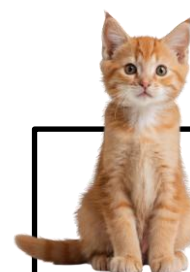


# Palatability of vegetarian diets



## Canine palatability drivers

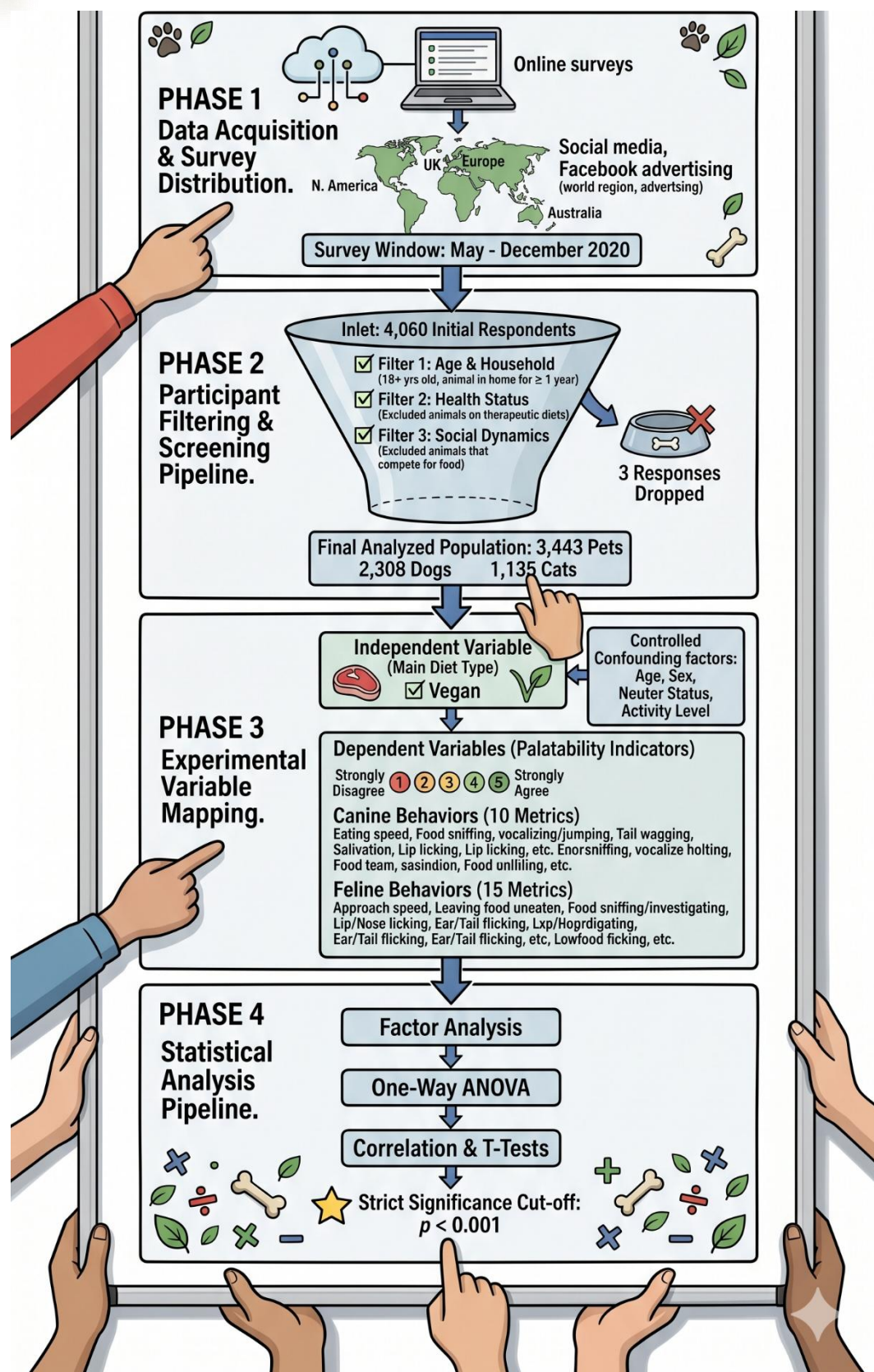
- Olfactory senses rather than taste
- If it smells like meat, eat it
- Meat type preference hierarchy
  - Beef > Lamb > Chicken > Horsemeat
- Physical form and preparation preference for
  - Canned or cooked meat over fresh meat
  - Minced meat over large chunks of meat



## Feline palatability drivers

- Highly complex
- Dominated by taste rather than smell
- Early-life conditioning
- Chemo-responsive tongue receptor
  - Amino acid preference (Obligate carnivore nature)
  - Preferred ("Sweet") amino acids
    - L-proline, L-cysteine, L-ornithine, L-lysine, L-histidine, and L-alanine (Completely lack functional sweet taste receptors)
  - Rejected ("Bitter") amino acids
    - L-arginine, L-iso-leucine, L-phenylalanine, and L-tryptophan.
  - Umami and Kokumi modalities
    - L-glutamic acid
    - Agonists like glutathione (GSH),  $\beta$ -aspartyl and  $\gamma$ -glutamyl peptides.
- Contrary to the belief that they drive aversion to decomposing meat, monophosphate nucleotides accumulate postmortem to attract mammals by enhancing flavor.
- Diet: Fish (specifically salmon) > meat flavors.
- Water-diluted meat products: pork liver > pork kidney > tuna > chicken

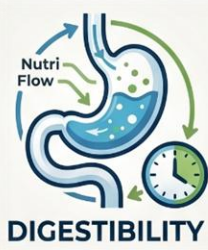
# Palatability of vegetarian diets



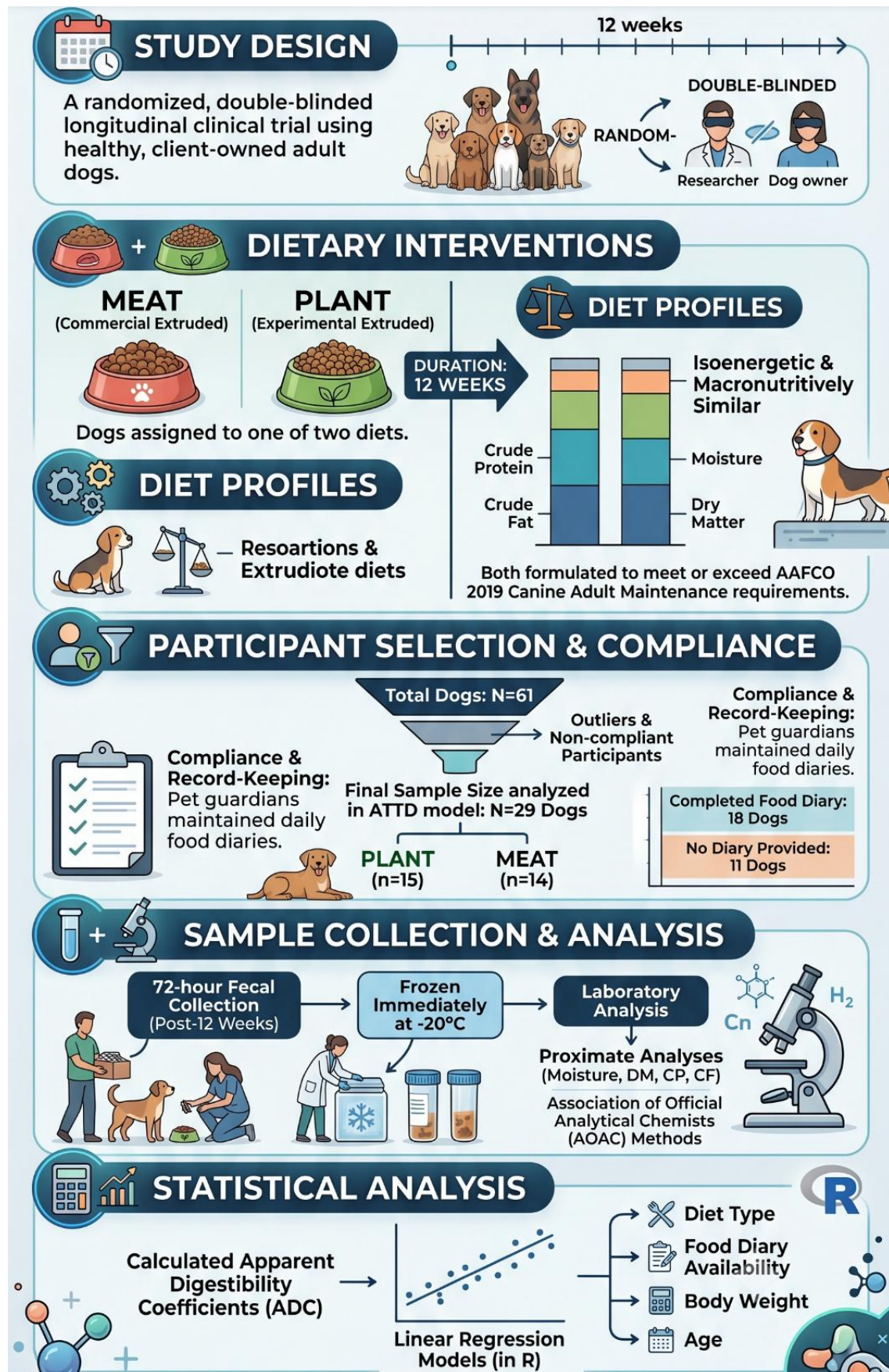
- Canine Palatability (2,308 Sampled)
- Feline Palatability (1,135 Sampled)
- The study concludes that vegan pet foods are generally at **least as palatable** to dogs and cats as conventional meat or raw meat diets.

# Advantages and limitation of vegetarian diets in pets

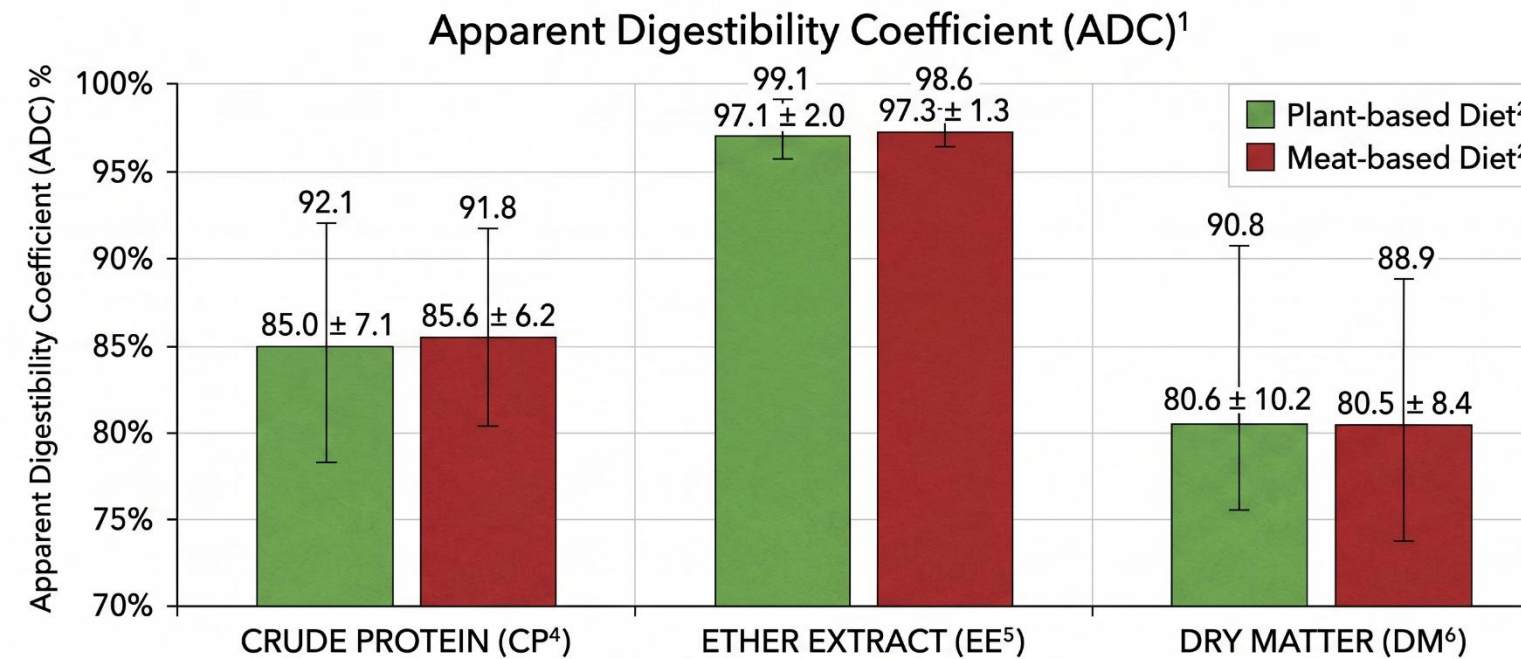




# Digestibility of vegetarian diets



No statistically significant differences were observed in digestibility in dogs ( $P > 0.05$ ).



<sup>1</sup>Apparent Digestibility Coefficient (ADC). <sup>2</sup>Diets. <sup>4</sup>Crude Protein. <sup>5</sup>Ether Extract. <sup>6</sup>Dry Matter. Values are mean ± SD. Transcribed from <IMAGE 0>.

Liversidge, B. D., Dodd, S. A., Adolphe, J. L., Gomez, D. E., Blois, S. L., & Verbrugghe, A. (2023). Extruded diet macronutrient digestibility: plant-based (vegan) vs. animal-based diets in client-owned healthy adult dogs and the impact of guardian compliance during in-home trials. *Frontiers in Animal Science*, 4, 1288165. [https://www.frontiersin.org/journals/animal-science/articles/10.3389/fanim.2023.1288165/full?utm\\_source=chatgpt.com](https://www.frontiersin.org/journals/animal-science/articles/10.3389/fanim.2023.1288165/full?utm_source=chatgpt.com)

## Digestibility in cats

- Studies confirm that cats can effectively digest and utilize well-formulated vegan diets and plant-based ingredients.
- Extruded feline diets utilizing micronized soybeans, corn gluten meal (CGM), or rice protein concentrate (RPC) achieved dry matter digestibility over 80% and fat digestibility up to 90%.

# Digestibility of vegetarian diets: Rice protein

## Replacing the hydrolyzed chicken liver and heart

### ANIMALS AND HOUSING

- Participants:** 24 healthy adult domestic shorthair cats, aged 1+ year
- Housing:** Individual, temperature-controlled facilities with natural light, daily group socialization, toys, and interaction with caretakers
- Feeding regimen:** Once daily to maintain ideal body weight with ad libitum water

### EXPERIMENTAL DESIGN & DIETS

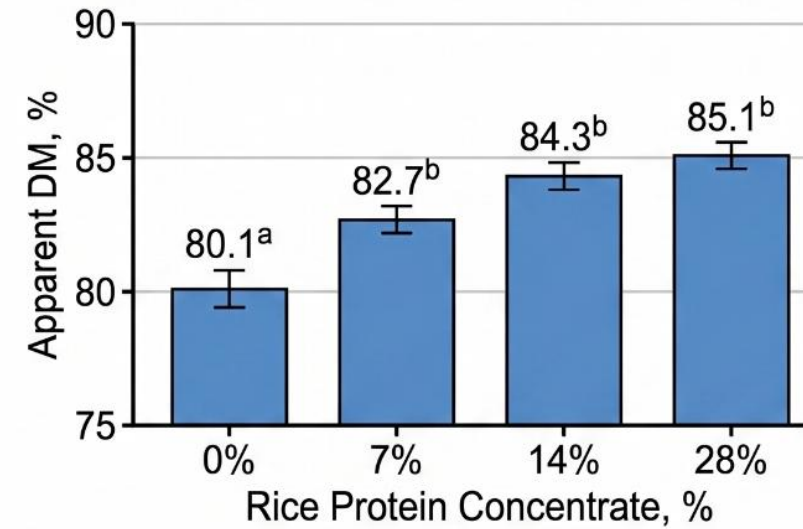
1	2	3	4
1	4	x	0
2	0	0	4
3	4	0	6
4	0	0	3

- 4x4 Latin square design**
- Four 15 day periods. No washout phase
- 4 experimental diets:**
  - 0% (control), 7%, 14%, and 28% rice protein concentrate (RPC)
- Diet formulation:**
  - Total protein was kept similar by adjusting hydrolyzed chicken liver/heart and brewers rice
  - All diets met or exceeded AAFCO maintenance requirements with 0.2% taurine supplement

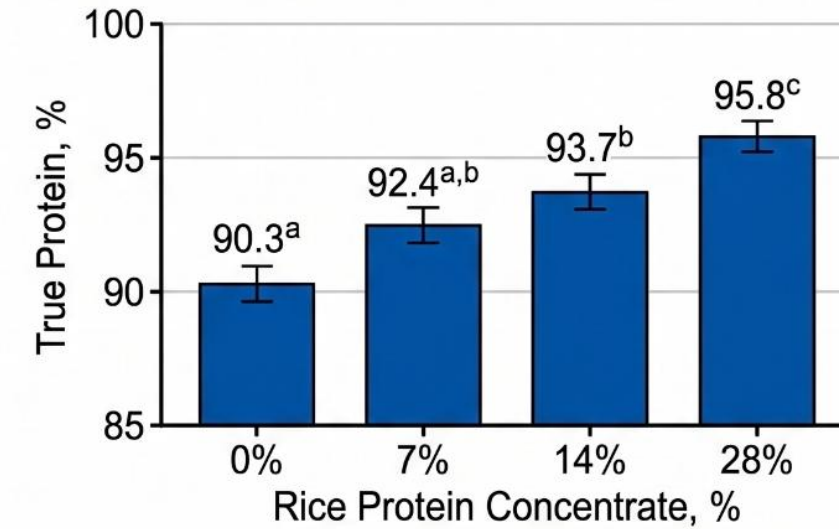
### SAMPLE COLLECTION & ANALYSIS

- Daily food intake recording and fecal score evaluation** (days 10-15) using 6-point scale (normal is 3-5)
- Fecal collection:** Total output from days 11-15 using non-absorbent litter beads
- Laboratory analysis of food and day 15 feces for**
  - ash, crude fiber, fat, protein, moisture, dry matter (DM) and gross energy (GE)
- Digestibility calculations for symmols for**
  - Apparent digestibility of DM, fat, GE, carbohydrates
  - True protein digestibility with estimated endogenous protein subtracted
- Statistical methods:** Analysis of Variance (ANOVA), orthogonal contrasts, and linear regression to predict nutrient digestibility of 100% RPC

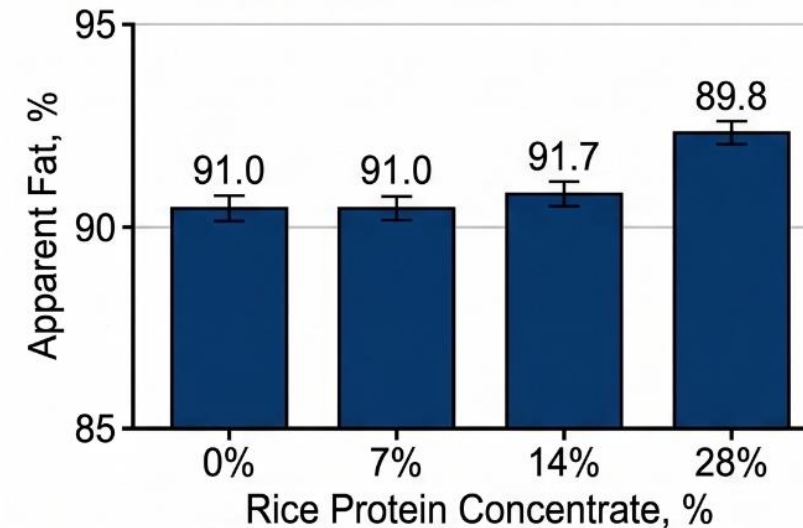
**A. A. Apparent Dry Matter (DM)**



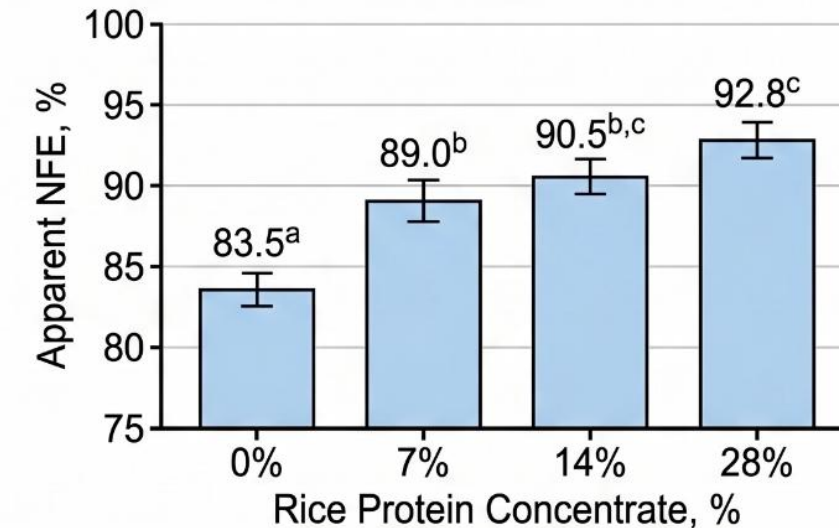
**B. B. True Protein**



**C. C. Apparent Fat**

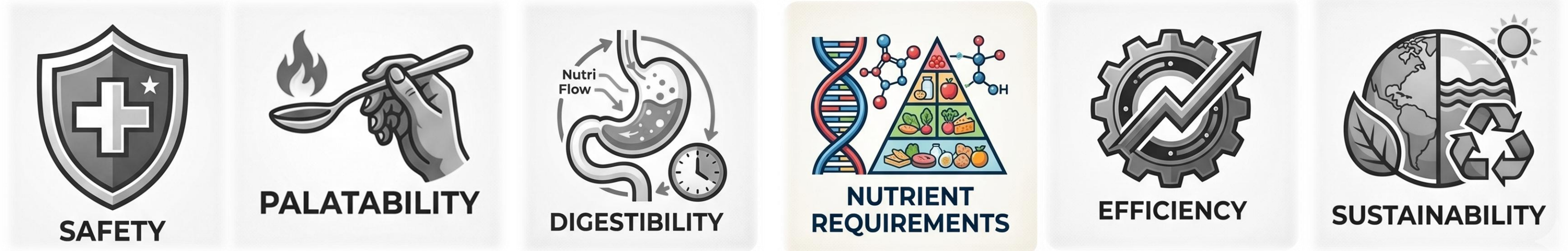


**D. D. Apparent Carbohydrate (NFE)**



**Figure 1:** Nutrient digestibility in experimental diets with increasing levels of rice protein concentrate. Columns with different lowercase superscript letters are significantly different ( $p < 0.05$ ).

# Advantages and limitation of vegetarian diets in pets





# Gastrointestinal physiology and diets

**Table 1.** Key differences between dogs and cats in nutritional requirements and related physiology [10–12].

Feature	Omnivore	Carnivore
	Dogs	Cats
Protein requirement	Moderate	High
Essential amino acids	10	Same 10 plus taurine = 11
Enzyme regulation	Adaptive	Fixed high catabolism
Pancreatic amylase	High	Low
Gluconeogenesis from amino acids	Regulated	Constant



# Nutrients consideration and limitation in vegetarian diets

## Inaccurate nutrient levels in products (Dogs and Cats)

### 1. Deficiency in essential amino acids

**Dogs:** Methionine, cysteine, leucine, threonine and phenylalanine

**Cats:** Arginine, methionine, cysteine, histidine, isoleucine, leucine, lysine, tryptophan, threonine, phenylalanine, tyrosine, glutamine and taurine

### 2. Fatty acid profiles

- MUFA & PUFA
- EPA and DHA
- Arachidonic acids (Cats)

### 3. Minerals

- Iodine, Potassium, Sodium, Chloride
- Calcium, Ca:P
- Selenium, Zinc

### 4. Vitamins

- Vitamin A (Retinol)
- Vitamin D
- Thiamine (B1)
- Niacin (B3)
- Cobalamin (B12)
- Folate (Vitamin B9)

### 5. Urinary pH (Alkaline)

### 6. Anti-nutritional factors



# Amino acids of meat- and plant-based raw materials

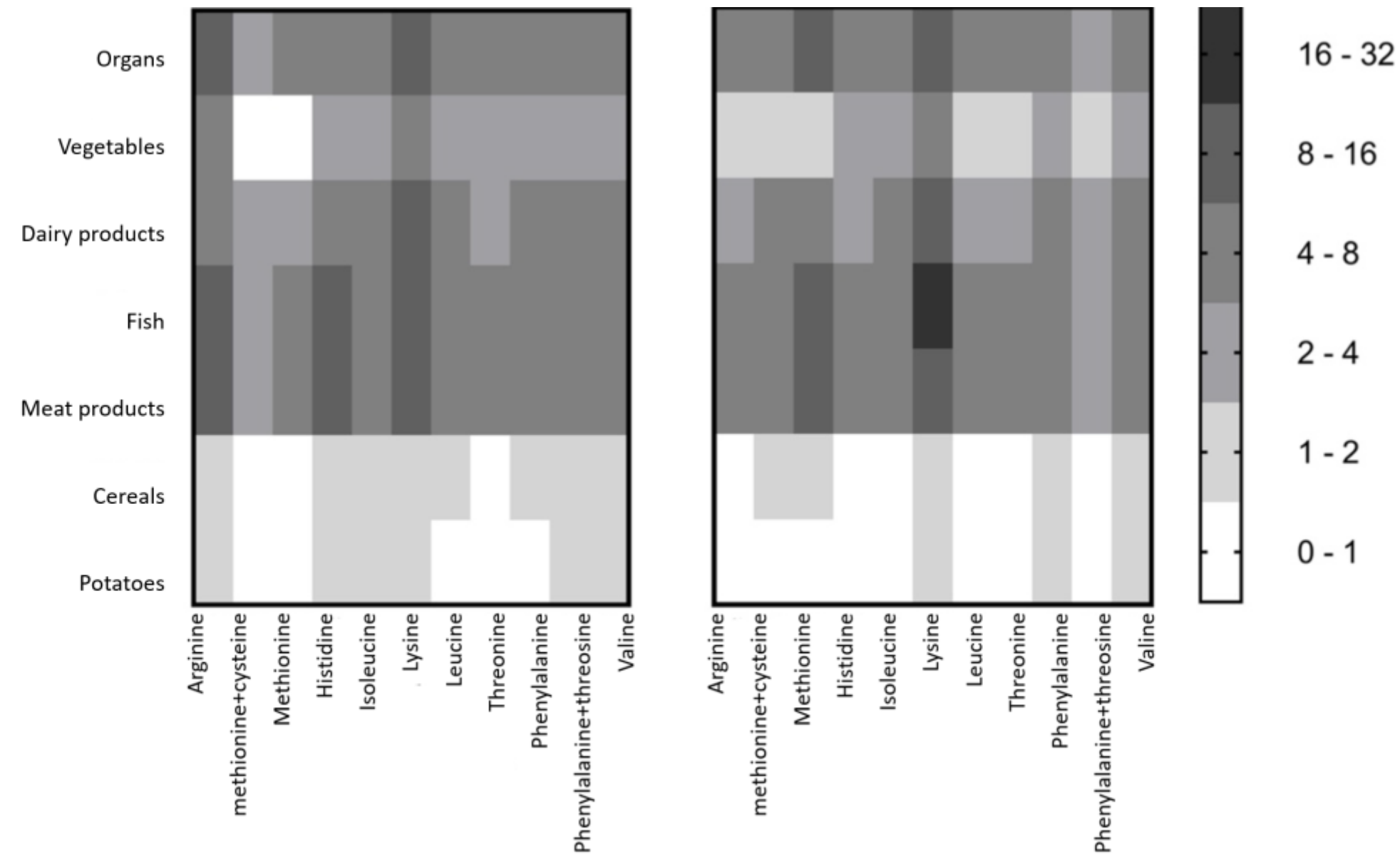
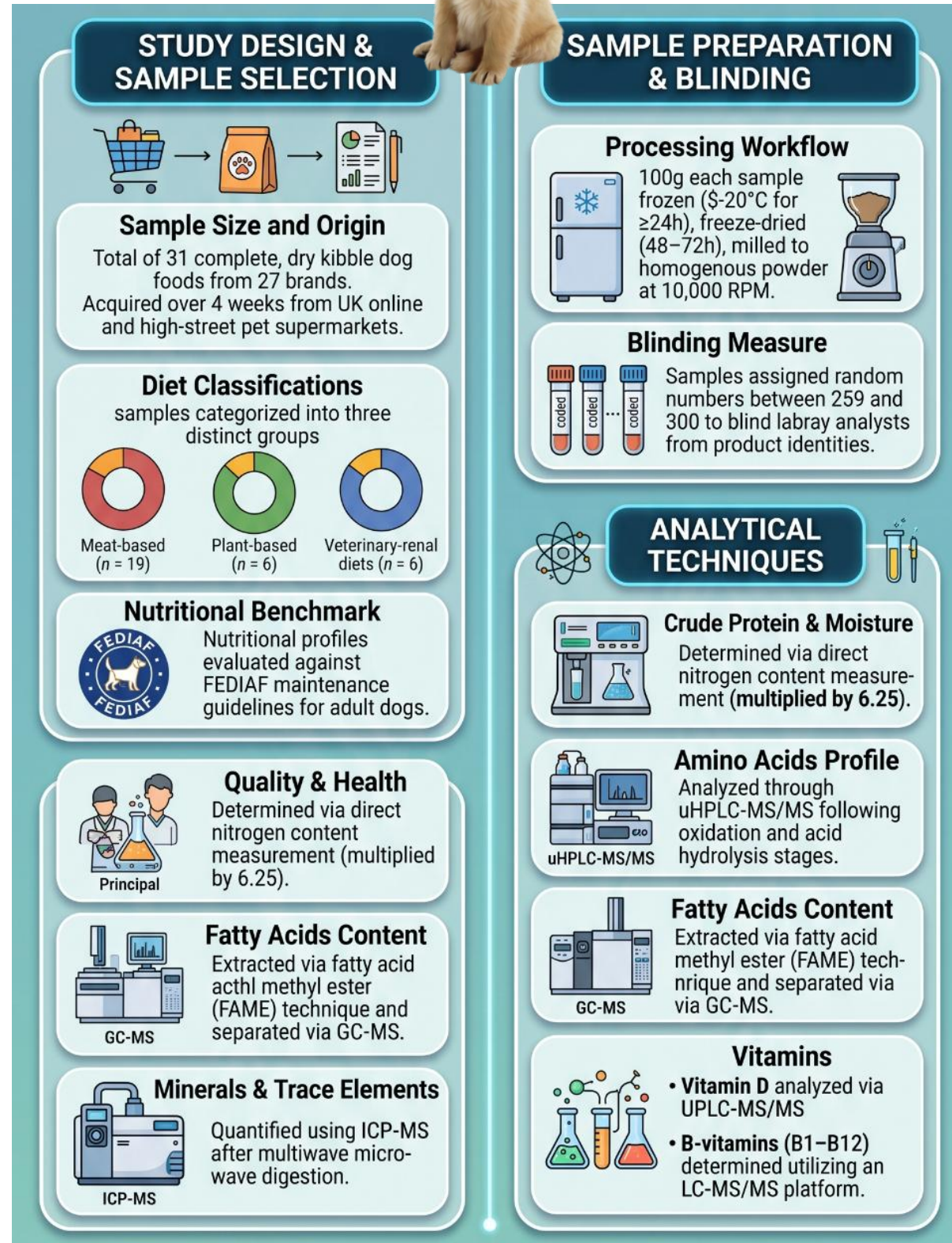


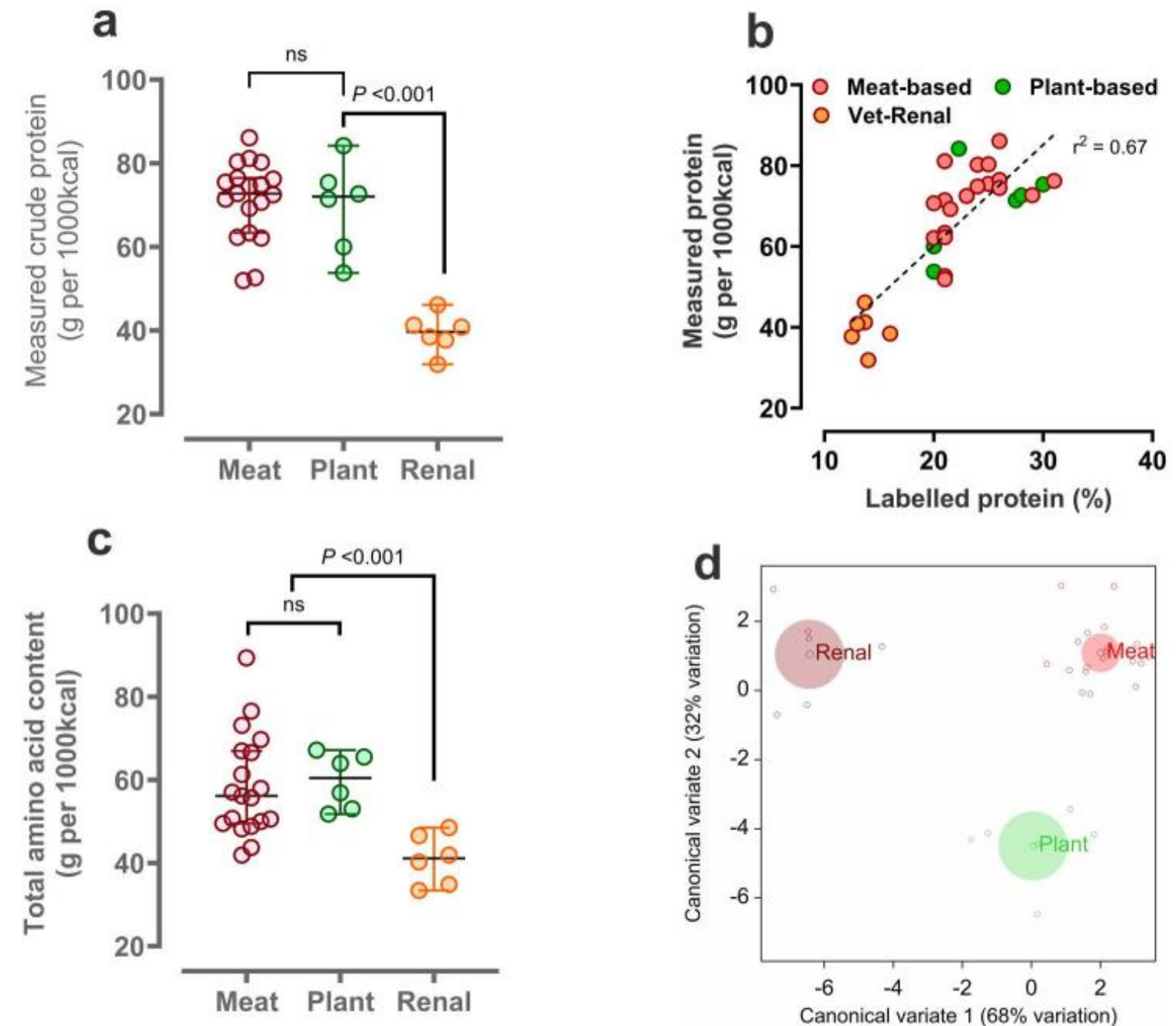
Figure 1 **Averages of essential AA intakes from different food families, in terms of the number of times the requirement is covered, for dogs and cats**  
 (Lefebvre, 2019) (National Research Council, 2006)

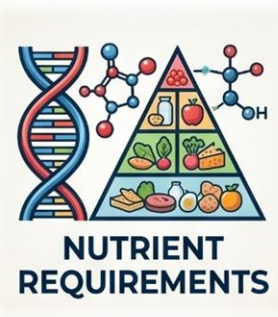
# Inaccurate nutrient levels in products (Dogs)



## Amino acids

- Plant based diets contain enough amino acids based on requirements.
- 66% of renal diets lacked at least one amino acids (Mainly Threonine).



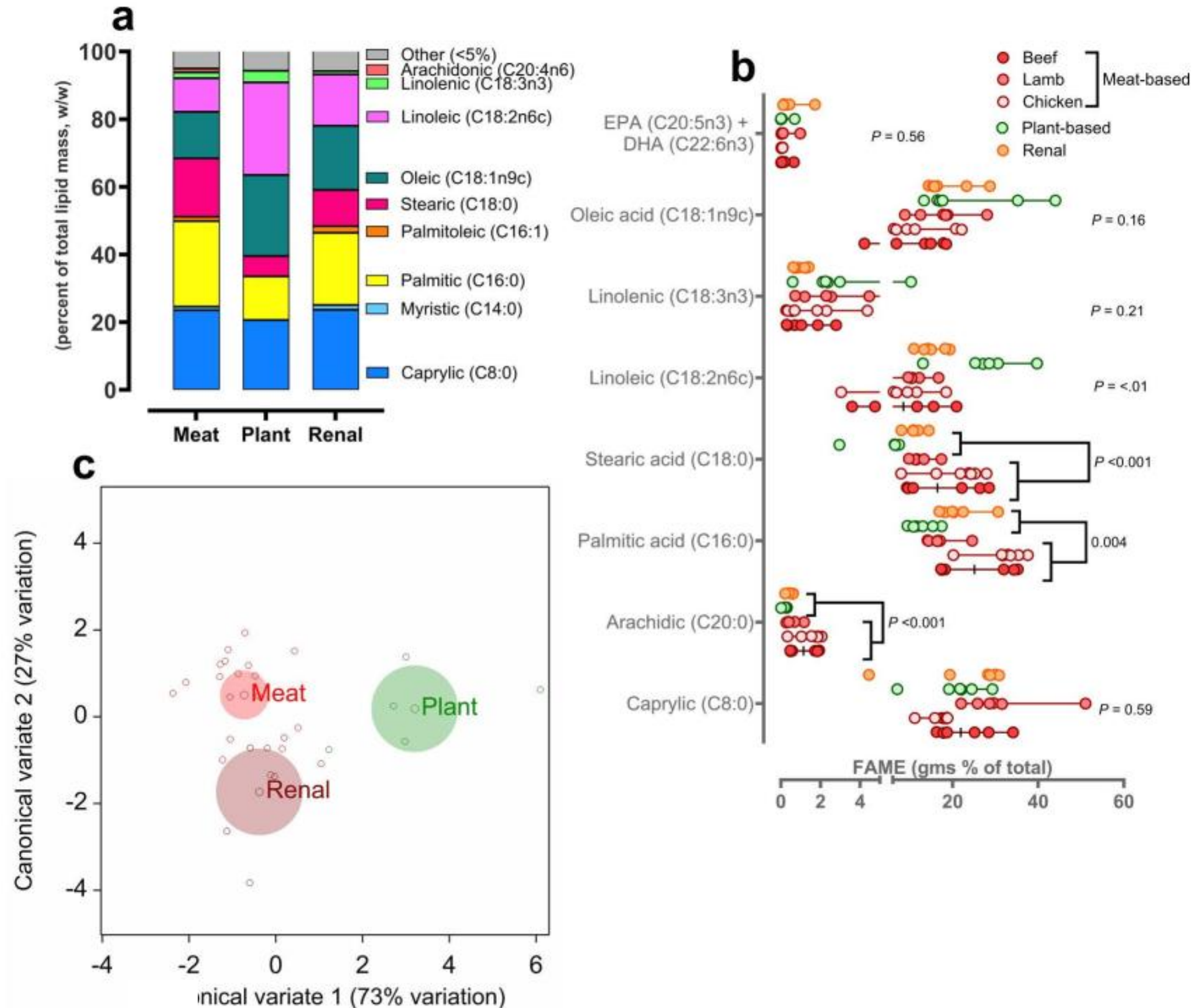


# Inaccurate nutrient levels in products (Dogs)



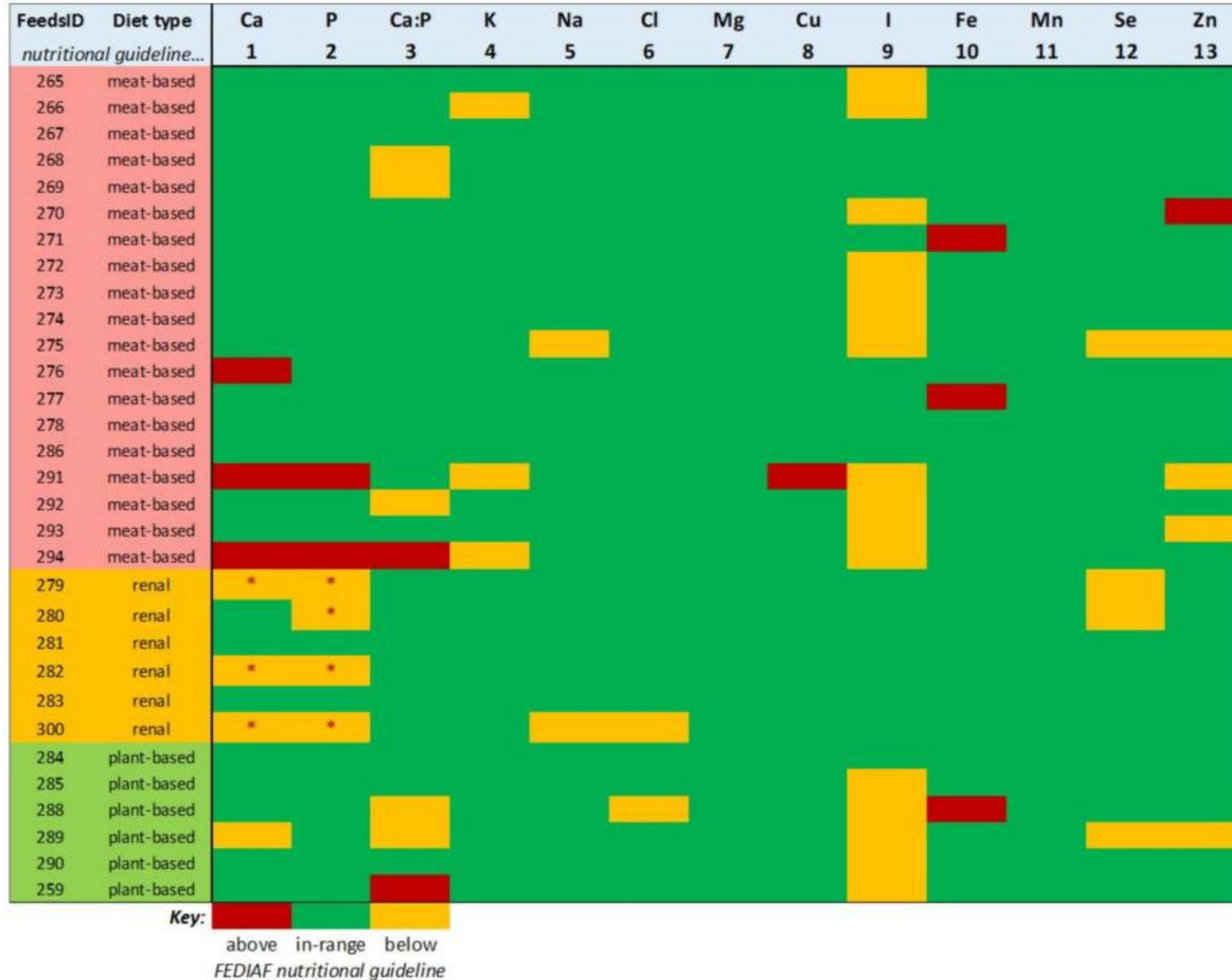
## Fatty acids (Plant based diets)

- ↑ MUFA & PUFA
- Mainly linoleic & linolenic acids
- ↓ Arachidonic acids
- ● EPA and DHA



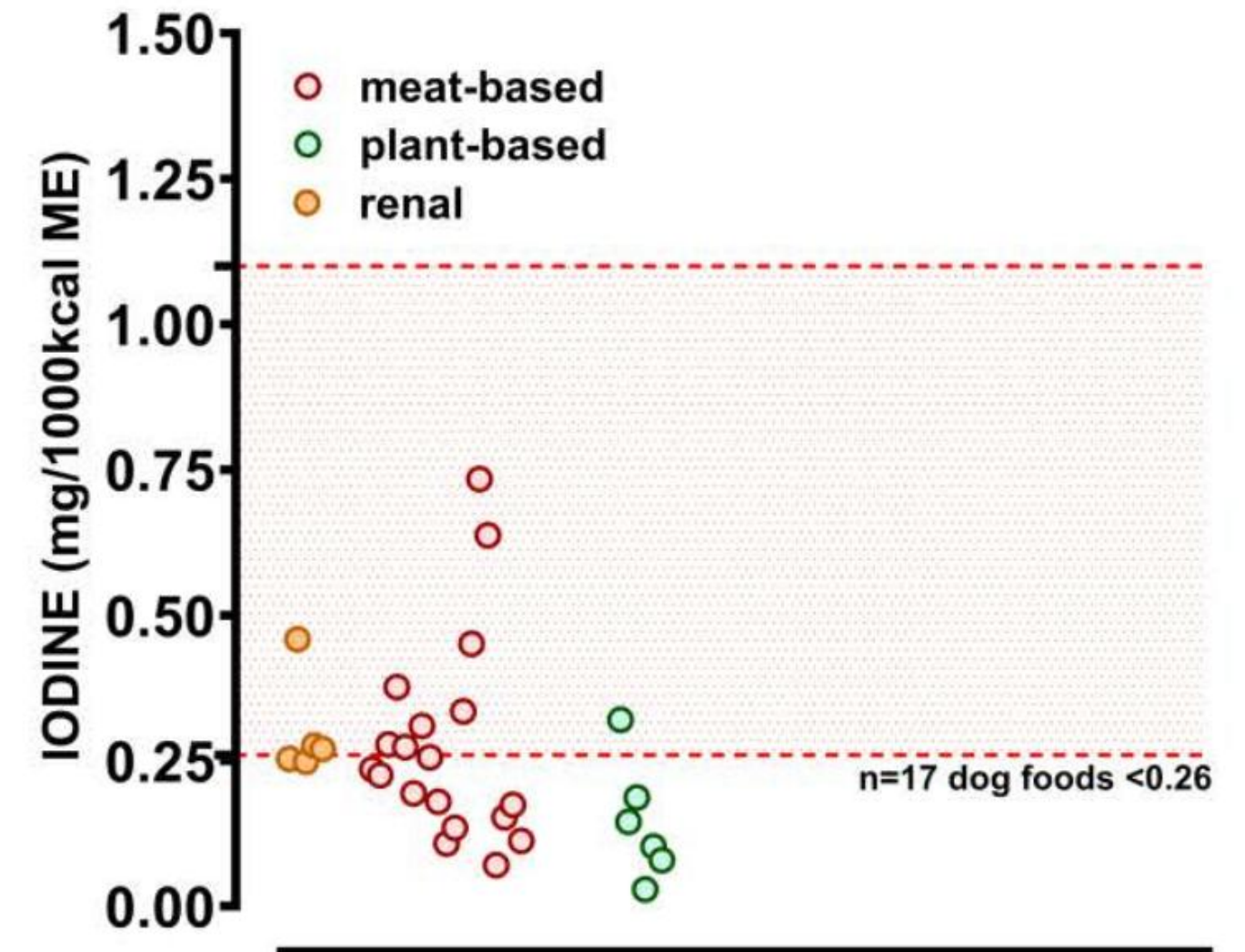


# Inaccurate nutrient levels in products (Dogs)



## Minerals (Plant based diets)

- ↓ Iodine





# Inaccurate nutrient levels in products (Dogs)

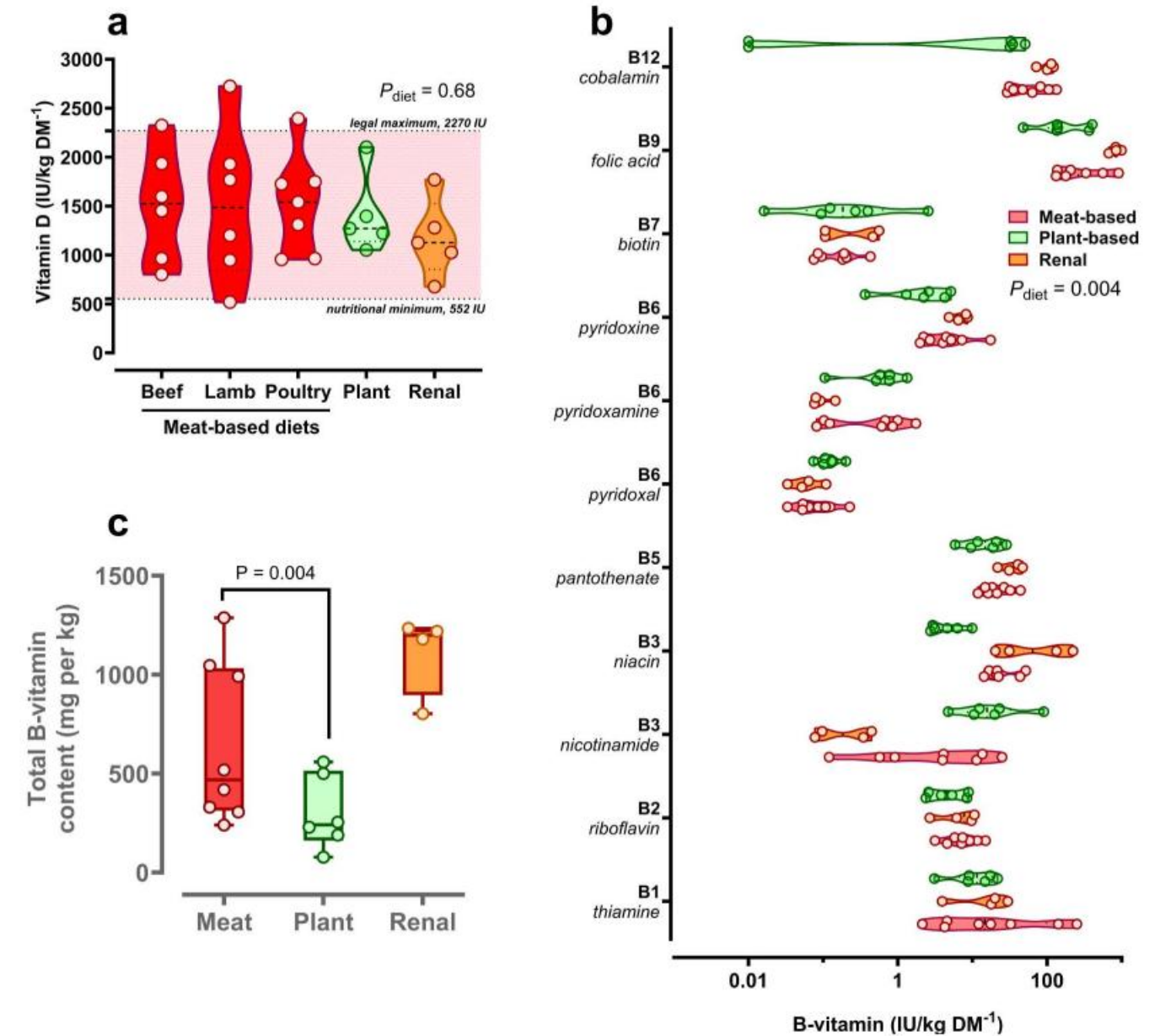


DietID	Diet-Group	Ingredient	B1-Thiamine	B2-Riboflavin	B3-Niacin	B5-Pantothenate	B6-Pyridoxine	B9-Folic acid	B12- Cobalamin
			Min: 2.1	Min: 6.0	16.4	14.2	1.5	258	33.5
271	meat-based	beef	17.59	11.63	16.68	16.21	4.01	137.07	31.18
272	meat-based	beef	nd	nd	nd	nd	nd	nd	nd
273	meat-based	beef	32.52	9.16	14.32	26.47	7.25	178.39	46.93
292	meat-based	beef	nd	nd	nd	nd	nd	nd	nd
293	meat-based	beef	nd	nd	nd	nd	nd	nd	nd
294	meat-based	beef	nd	nd	nd	nd	nd	nd	nd
274	meat-based	lamb	250.53	7.17	20.81	32.10	4.44	131.94	63.50
275	meat-based	lamb	4.25	7.38	22.32	11.83	2.70	332.82	35.24
276	meat-based	lamb	nd	nd	nd	nd	nd	nd	nd
277	meat-based	lamb	4.56	3.14	21.52	21.31	5.18	907.52	81.32
278	meat-based	lamb	2.13	4.59	43.38	14.81	1.99	1112.33	105.72
291	meat-based	lamb	nd	nd	nd	nd	nd	nd	nd
265	meat-based	poultry	nd	nd	nd	nd	nd	nd	nd
266	meat-based	poultry	nd	nd	nd	nd	nd	nd	nd
267	meat-based	poultry	nd	nd	nd	nd	nd	nd	nd
268	meat-based	poultry	nd	nd	nd	nd	nd	nd	nd
269	meat-based	poultry	142.06	14.97	51.84	44.10	17.50	559.77	133.86
270	meat-based	poultry	nd	nd	nd	nd	nd	nd	nd
286	meat-based	poultry	12.12	5.77	17.91	18.31	2.22	206.61	29.22
284	plant-based	veg	21.72	8.44	4.59	20.84	5.15	135.23	32.03
285	plant-based	veg	17.38	8.85	6.32	28.56	4.26	366.49	32.66
288	plant-based	veg	14.75	2.37	9.90	9.53	2.59	139.32	34.58
289	plant-based	veg	9.03	2.58	3.11	5.86	0.36	47.93	0.01
290	plant-based	veg	8.72	3.80	10.50	18.77	2.22	136.71	0.01
259	plant-based	veg	3.08	5.33	19.86	11.73	1.30	403.00	50.83
279	renal	varied meat	nd	nd	nd	nd	nd	nd	nd
280	renal	varied meat	3.93	2.68	20.22	21.76	4.86	672.69	71.84
281	renal	varied meat	17.80	6.15	31.23	40.63	6.46	990.94	121.98
282	renal	varied meat	29.83	9.72	222.20	31.11	8.61	828.95	100.30
283	renal	varied meat	20.08	10.65	133.27	46.93	8.22	842.63	113.85
300	renal	varied meat	nd	nd	nd	nd	nd	nd	nd

Key: ■ above ■ in-range ■ below  
FEDIAF nutritional guideline

## Vitamins (Plant based diets)

- ↓ B3, B9 and B12
- Vitamin D is enough





# Inaccurate nutrient levels in products (Dogs)



**Table 1.** Measured nutrient content in 20 plant-based canine foods commercially available in Canada and labeled for adult or all life stages compared to the AAFCO and FEDIAF recommended essential nutrient concentrations for canine adult maintenance on a dry matter basis (unit per 100 g dry matter).

Nutrient (Unit/100 g DM)	Median	Range	AAFCO *	FEDIAF	
				95 kcal/kg <sup>0.75</sup> **	110 kcal/kg <sup>0.75</sup> ***
Crude protein (g)	27.6	<u>17.3</u> –36.6	18.0	21.00	18.00
Arginine (g)	1.62	1.03–2.57	0.51	0.60	0.52
Histidine (g)	0.60	0.36–0.76	0.19	0.27	0.23
Isoleucine (g)	1.40	0.88–1.65	0.38	0.53	0.46
Leucine (g)	2.41	1.49–5.26	0.68	0.95	0.82
Lysine (g)	1.26	<b>0.59</b> –2.09	0.63	0.46	0.42
Methionine (g)	0.52	<u>0.22</u> –1.50	0.33	0.46	0.40
Methionine + Cystine (g)	0.83	<u>0.25</u> –1.97	0.65	0.88	0.76
Phenylalanine (g)	1.48	1.03–2.24	0.45	0.63	0.54
Phenylalanine + Tyrosine (g)	2.56	1.61–3.89	0.74	1.03	0.89
Taurine (g)	0.11	0.00–0.21		n/a	
Threonine (g)	1.30	0.85–1.56	0.48	0.60	0.52
Tryptophan (g)	0.29	<u>0.15</u> –0.38	0.16	0.20	0.17
Valine (g)	1.53	0.96–1.90	0.49	0.68	0.59
Crude fat (g)	13.8	8.5–25.1		5.5	
Linoleic acid (g)	6.41	1.40–17.88	1.1	1.32	1.53
ALA (g)	0.70	0.16–2.13		n/a	
Arachidonic acid (g)	0.01	0.00–0.03		n/a	
EPA + DHA (g)	0.00	0.00–0.05		n/a	
GLA (g)	0.01	0.00–0.07		n/a	
Calcium (g)	1.07	<u>0.38</u> –1.90	0.5–2.5	0.58–2.50	0.50–2.50
Phosphorus (g)	0.8	0.5–1.5	0.4–1.6	0.46–1.6	0.4–1.6
Ca:P ratio (g)	1.3	<u>0.8</u> –2.5		1:1–2:1	
Potassium (g)	1.11	0.73–1.72	0.6	0.58	0.50
Sodium (g)	0.34	<u>0.02</u> –1.27	0.08	0.12	0.10
Chloride (g)	0.93	<u>0.09</u> –2.47	0.12	0.17	0.15
Magnesium (g)	0.15	0.10–0.23	0.06	0.08	0.07
Iron (mg)	22.76	10.71– <u>75.04</u>	4.0	4.17–68.18 (L)	3.60–68.18 (L)
Copper (mg)	2.34	0.89– <u>5.47</u>	0.73	0.83–2.80 (L)	0.72–2.80 (L)
Manganese (mg)	4.13	1.39–7.39	0.50	0.67–17.00 (L)	0.58–17.00 (L)
Zinc (mg)	15.52	<u>4.46</u> – <u>35.93</u>	8.0	8.34–22.70 (L)	7.20–22.70 (L)
Vitamin A (IU)	1001	<u>274</u> –3973	500–25,000	702.00–40,000	606.00–40,000
Vitamin D <sub>2</sub> (IU)	0	0–152		n/a	
Vitamin D <sub>3</sub> (IU)	73	0–172		n/a	
Total vitamin D (IU)	91	<u>0</u> –172	50–300	63.90–227.00 (L)	55.20–227.00 (L)
Vitamin B <sub>12</sub> (mg)	0.00434	<u>0.0000</u> –0.69074	0.0028	0.00387	0.00335

\* AAFCO nutrient profile for adult maintenance of dogs (minimum or minimum–maximum) [1]. \*\* FEDIAF recommendations for adult maintenance of sedentary dogs, for an expected daily energy intake of 95 kcal/kg<sup>0.75</sup> (minimum or minimum–maximum) [2]. \*\*\* FEDIAF recommendations for adult maintenance of active or working dogs, for an expected daily energy intake of 110 kcal/kg<sup>0.75</sup> (minimum or minimum–maximum) [2]. Bolded values are outside of the AAFCO recommended range. Italicized values are outside of the FEDIAF recommended range for dogs with an energy intake of 95 kcal/kg<sup>0.75</sup>. Underlined values are outside of the FEDIAF recommended range for dogs with an energy intake of 110 kcal/kg<sup>0.75</sup>. AAFCO = Association of American Feed Control Officials, FEDIAF = European Pet Food Industry Federation, NR = No recommendation, (L) = Legal limit.

## Plant based diets (Some products)

- ↓ Crude protein
- ↓ Lysine, Methionine, Met+Cyt, Tryptophan
- ↓ Calcium, Ca:P
- ↓ Sodium, Chloride, Zinc
- ↓ Vitamin A and Vitamin D
- ↓ Vitamin B12



# Inaccurate nutrient levels in products (Cats)



**Table 3.** Measured nutrient content in eight plant-based feline foods commercially available in Canada and labeled for adult or all life stage compared to the AAFCO and FEDIAF recommended essential nutrient concentrations for feline adult maintenance on a dry matter basis (unit per 100 g dry matter).

Nutrient (Unit Per 100 g)	Median	Range	AAFCO *	FEDIAF	
				75 kcal/kg <sup>0.67</sup> **	100 kcal/kg <sup>0.67</sup> ***
Crude protein (g)	31.61	29.16–35.31	26.0	33.30	25.00
Arginine (g)	1.59	1.27–2.45	1.04	1.30	1.00
Histidine (g)	0.63	0.40–0.75	0.31	0.35	0.26
Isoleucine (g)	1.40	0.81–1.61	0.52	0.57	0.43
Leucine (g)	2.39	1.40–4.30	1.24	1.36	1.02
Lysine (g)	1.26	0.88–2.07	0.83	0.45	0.34
Methionine (g)	0.47	0.27–0.85	0.20–1.5	0.23	0.17
Methionine + Cystine (g)	0.68	0.42–1.16	0.40	0.45	0.34
Phenylalanine (g)	1.54	0.98–1.87	0.42	0.53	0.40
Phenylalanine + Tyrosine (g)	2.52	1.55–3.19	1.53	2.04	1.53
Taurine (g)–extruded	<b>0.09</b>	<b>0.01–0.21</b>	0.10	0.13	0.10
Taurine (g)–canned	<b>0.13</b>	<b>0.00–0.14</b>	0.20	0.27	0.20
Threonine (g)	1.30	0.73–1.46	0.73	0.69	0.52
Tryptophan (g)	0.33	0.19–0.40	0.16–1.7	0.17	0.13
Valine (g)	1.59	0.94–1.82	0.62	0.68	0.51
Crude fat (g)	10.3	<b>8.5–14.6</b>		9.0	
Linoleic acid (g)	5.64	1.40–15.80	0.6	0.67	0.50
ALA (g)	0.68	0.17–1.83		NR	
Arachidonic acid (g)	<b>0.009</b>	<b>0.006–0.026</b>	0.02	0.008	0.006
EPA + DHA (g)	0.00	0.00–0.01		NR	
GLA (g)	0.01	0.00–0.04		NR	
Calcium (g)	0.84	<b>0.48–1.42</b>	0.6	0.53	0.40
Phosphorus (g)	0.79	0.56–1.07	0.5	0.35	0.26
Calcium to phosphorus ratio	1.1	<i>0.8–1.4</i>	NR		1:1–2:1
Potassium (g)	1.06	0.68–1.72	0.6	0.80	0.60
Sodium (g)	0.33	<b>0.17–0.73</b>	0.2	0.10	0.08
Chloride (g)	0.95	0.38–1.46	0.3	0.15	0.11
Magnesium (g)	0.17	0.09–0.19	0.04	0.05	0.04
Iron (mg)	26.47	10.49–42.24	8.0	10.70–68.18 (L)	8.00–68.18 (L)
Copper (mg)	2.49	1.43– <b>3.44</b>	0.5	0.67–2.80 (L)	0.50–2.80 (L)
Manganese (mg)	4.11	1.31–6.72	0.76	0.67–17.00 (L)	0.50–17.00 (L)
Zinc (mg)	18.69	<b>8.90–35.93</b>	7.5	10.00–22.70 (L)	7.50–22.70 (L)
Vitamin A (IU)	907.5	<b>251.4–2319.3</b>	333.2–33,330.0	444.00–40,000	333.00–40,000
Vitamin D <sub>2</sub> (IU)	0	0–26		NR	
Vitamin D <sub>3</sub> (IU)	103	0–155		NR	
Vitamin D (IU)	111.4	<b>0–154.5</b>	28.0–3008.0	33.30–227 (L)	25.00–227 (L)
Vitamin B <sub>12</sub> (mg)	0.00587	<b>0.00000–0.71690</b>	0.0020	0.00235	0.00176

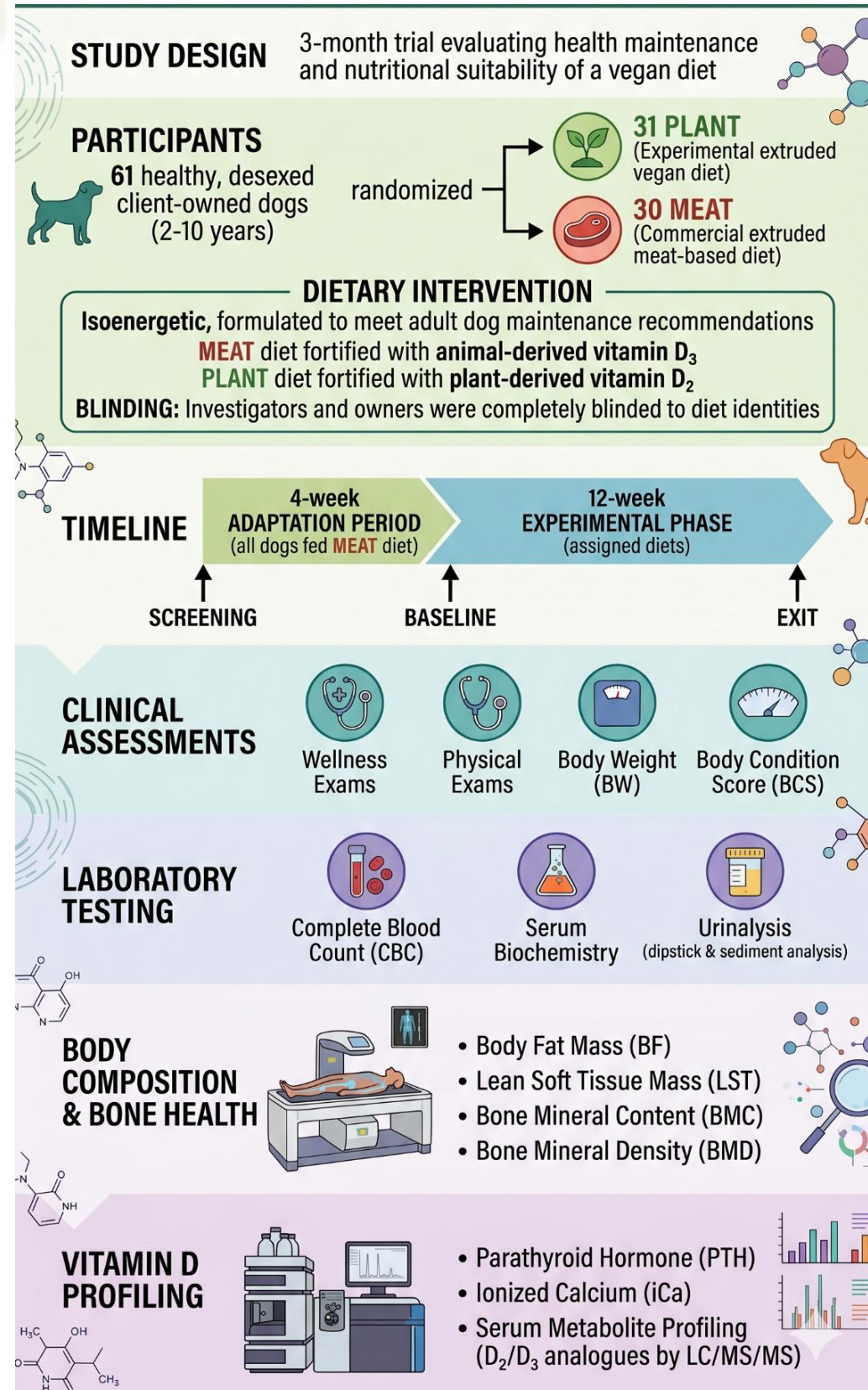
\* AAFCO nutrient profile for adult maintenance of cats (minimum or minimum–maximum) [1]. \*\* FEDIAF recommendations for adult maintenance of indoor and/or neutered cats, for an expected daily energy intake of 75 kcal/kg<sup>0.67</sup> (minimum or minimum–maximum) [2]. \*\*\* FEDIAF recommendations for adult maintenance of active cats, for an expected daily energy intake of 100 kcal/kg<sup>0.67</sup> (minimum or minimum–maximum) [2]. Bolded values are outside of the AAFCO recommended range. Italicized values are outside of the FEDIAF recommended range for cats eating 75 kcal/kg<sup>0.67</sup>. Underlined values are outside of the FEDIAF recommended range for cats eating 100 kcal/kg<sup>0.67</sup>. AAFCO = Association of American Feed Control Officials, FEDIAF = European Pet Food Industry Federation, NR = No recommendation, (L) = Legal limit.

## Plant based diets (Some products)

- ↓ Taurine (Canned below 100%)
- ↓ Arachidonic acids
- ↓ Calcium
- ↓ Sodium
- ↓ Vitamin A and Vitamin D
- ↓ Vitamin B12



# Blood parameters, Vitamin D and bone in dogs



• No significant changes in lean soft tissue or body fat percentages.

## • Hematological & Biochemical Shifts

### • PLANT

- ↓ Blood urea nitrogen (BUN), creatinine, serum cholesterol and platelet counts

### • MEAT

- ↑ Red blood cell parameters, serum osmolality

## • Urinalysis

- Urine pH and the presence of struvite crystals did not differ between the diet groups.

## • Vitamin D Metabolite

### • PLANT

- Shift from vitamin D<sub>3</sub> to vitamin D<sub>2</sub> metabolites

- ↓ Total serum 24,25(OH)<sub>2</sub>D concentrations

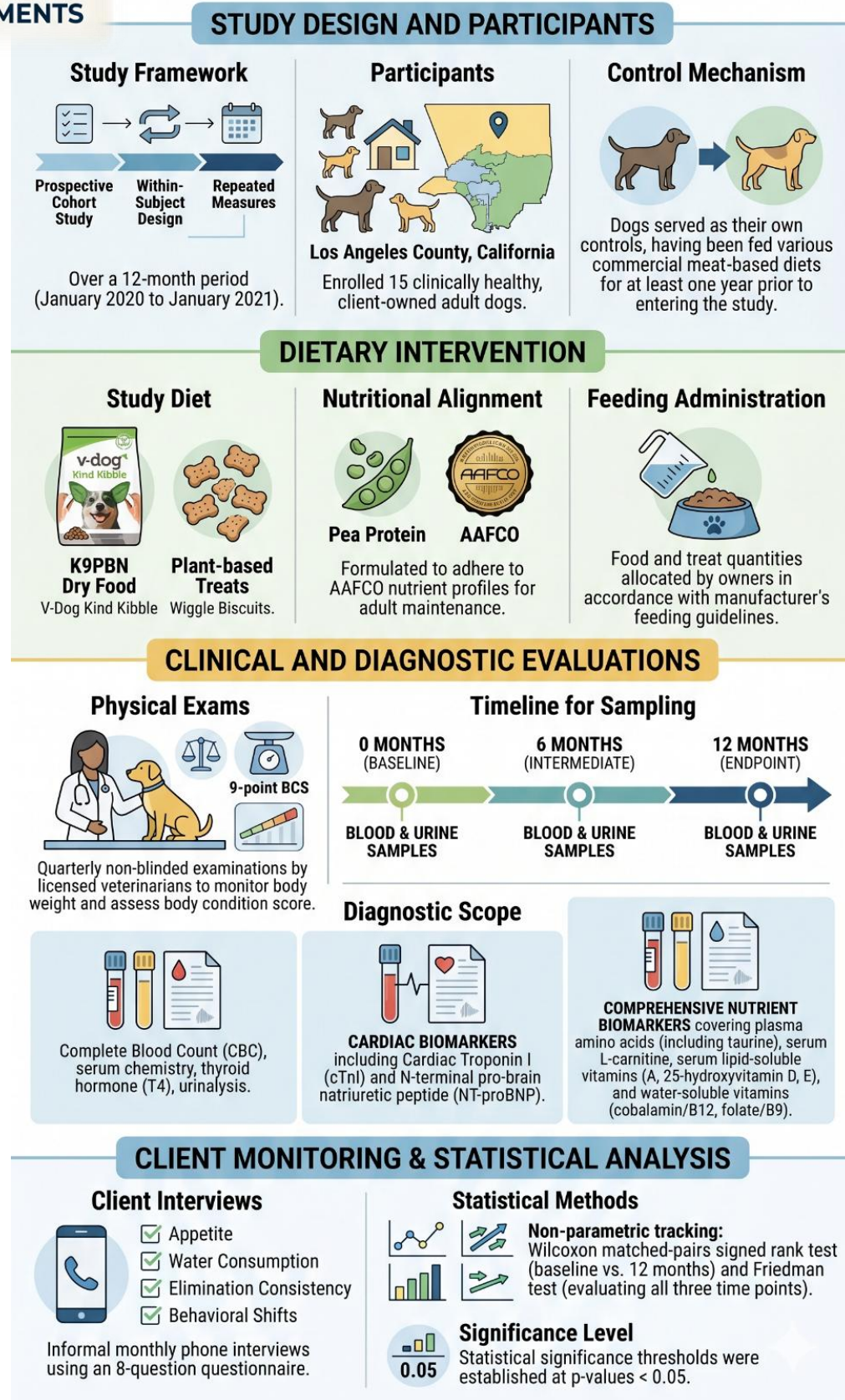
- Total serum 25(OH)D and PTH concentrations remained stable

## • Bone Mineralization

- No significant changes in bone mineral density (BMD), bone mineral content (BMC) or total body bone mass percentage



# Fed 1 year of vegetarian diet in dogs



Domestic dogs maintain clinical, nutritional, and hematological health outcomes when fed a commercial plant-based diet for a year.

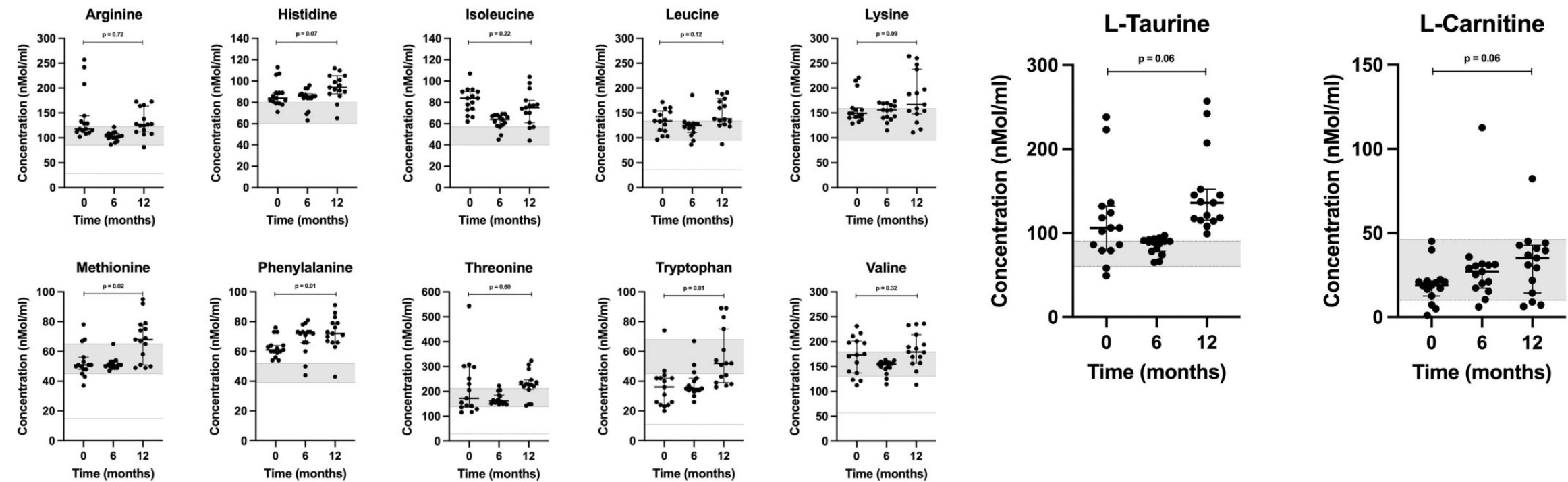
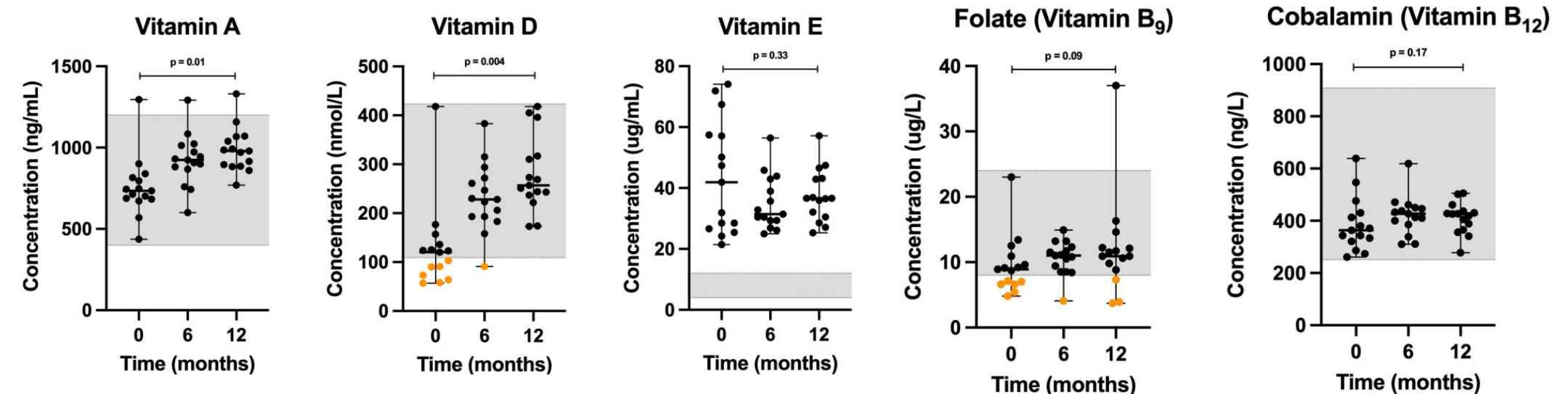


Fig 3. Scatter plots of essential amino acids (arginine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, valine) concentrations in dogs at 0, 6 and 12 months. Horizontal bars represent medians, while first and third quartiles are shown by short horizontal lines. The grey-shaded areas reflect the interquartile reference intervals (Q<sub>1</sub>–Q<sub>3</sub>) provided by UCD. Lower dashed lines (arginine, leucine, methionine, threonine, tryptophan, and valine) reflect calculated minimum values derived by extrapolation (S3 Table).

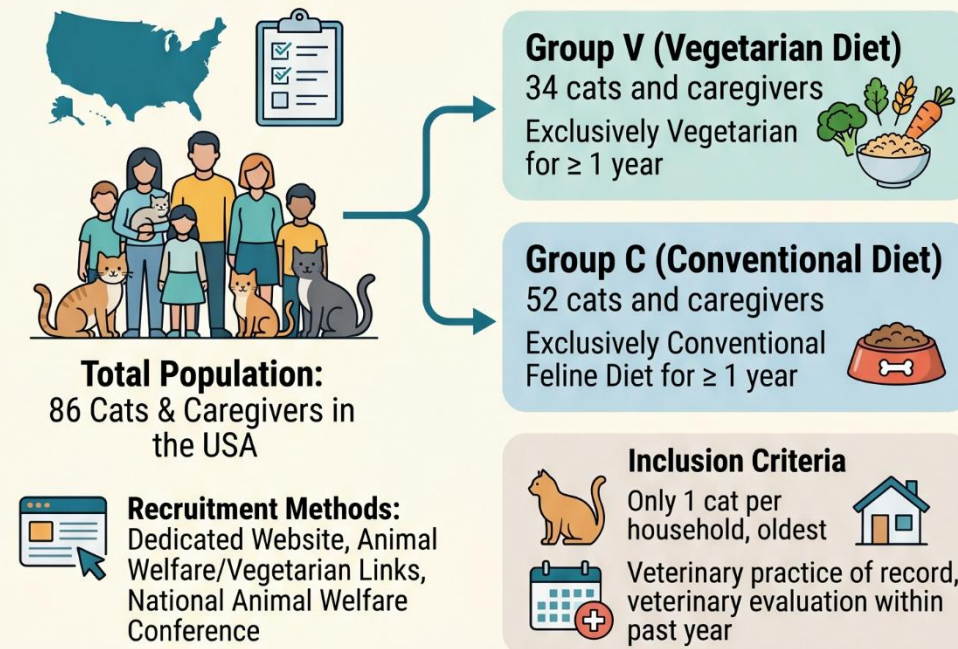




# Blood parameters after consumed >1 years in cats



## STUDY DESIGN AND PARTICIPANTS



## DATA COLLECTION AND TESTING PROCEDURES

### Telephone Questionnaires



- **Structured Interviews (Both Groups)**
- Feline Signalment, Housing, Body Condition
- Diet specifics (treats, supplements)
- Caregiver perceptions, motivations
- Dietary health risks/benefits awareness

(Group C omitted vegetarian details)

### Blood and Serum Analysis



- Subset of 17 cats from Group V
- **Criteria for Blood Subset:**  
Complete commercial vegetarian diet or home-prepared with supplement for  $\geq 1$  year

#### Measured Biomarkers

12-hour fast	Blood/Plasma Taurine Concentration
	Serum Cobalamin (Vitamin B <sub>12</sub> ) Concentration

### Statistical Analysis



- Categorical variables: Fisher exact test or equivalent
- Average age, Diet duration comparison: Student t-test
- Significance defined as:  $P < 0.05$

## Laboratory Blood and Serum Findings (Group V Subset, n=17)

- **Serum Cobalamin (B12): OK**

- **Plasma Taurine**

- 1 cat (n=15) was below the reference range but remained above the critical concentration of 40 nmol/mL

- **Blood Taurine**

- 3 cats (n=17) had marginal concentrations ( $< 300$  nmol/mL) but stayed above the critical deficiency threshold of 200 nmol/mL



# Negative outcomes from vegetarian diets



- **Hypokalemic episodic polymyopathy** in cats ([Leon et al., 1992](#))
  - Myopathy development
    - Acute ventroflexion of the head and neck
  - ↓ Plasma potassium
  - ↑ Creatine kinase (CK) activities: Confirming muscle membrane damage.
  - ↓ Taurine
  - ↑ Glutamic acid surge: Reflecting the high gluten/protein content of the vegetarian diets
  - ↓ Thiamin (B1)



- Two cats suffered from vegetarian diets ([Fantinati et al., 2021](#))
  - Mild muscle wasting, a dull/dry coat and abdominal distension
  - Mild macrocytic, hypochromic, non-regenerative anemia
  - ↓ Serum folate
  - Normal plasma thiamine and taurine
  - ↓ Serum cobalamin
  - Response to Folic Acid Supplementation
  - Response to Animal-Based Diet Transition

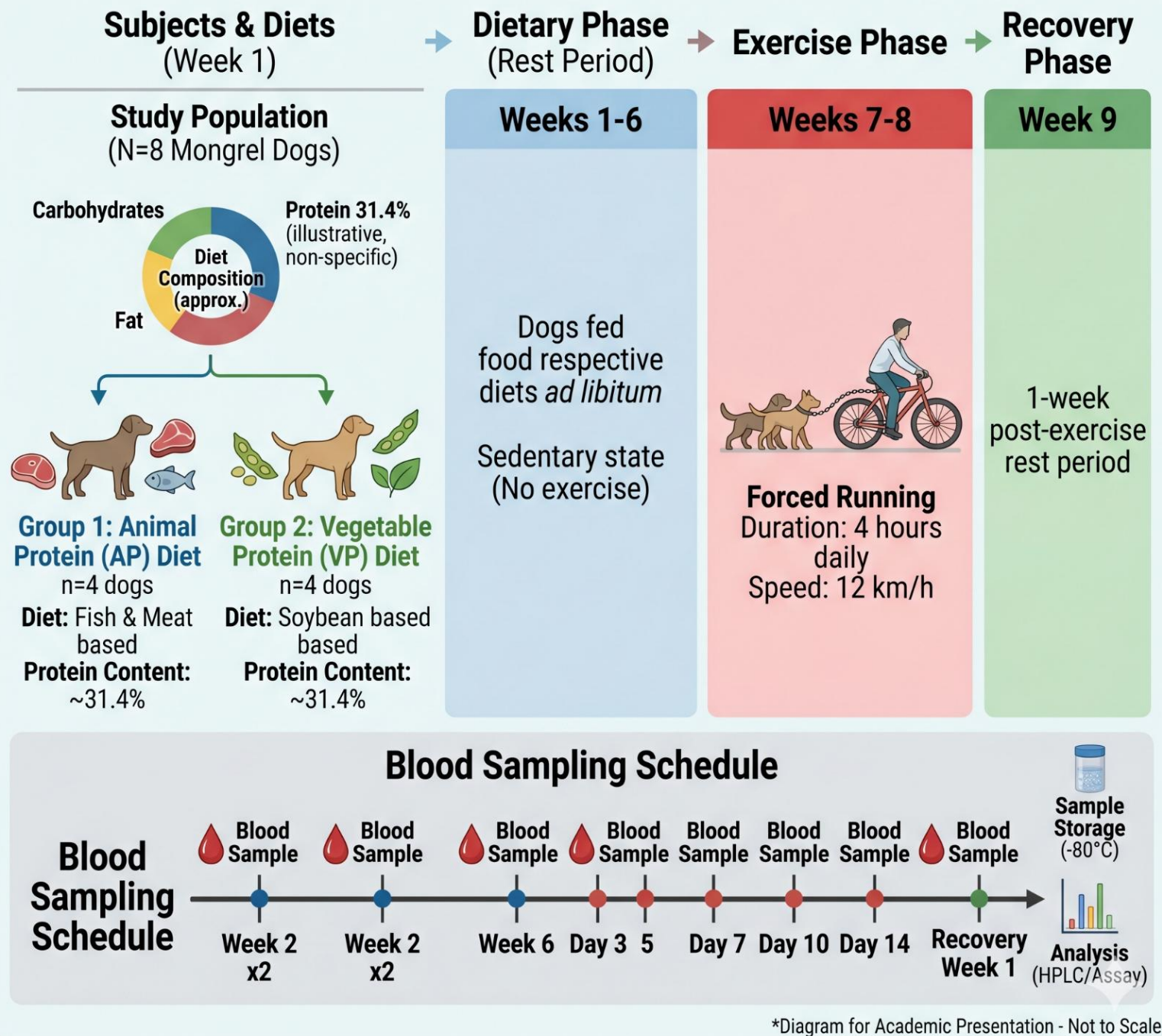


- **Normal** echocardiogram, Amino acids, Taurine, Hematology and Blood parameters in dogs ([Cavanaugh et al., 2012](#))



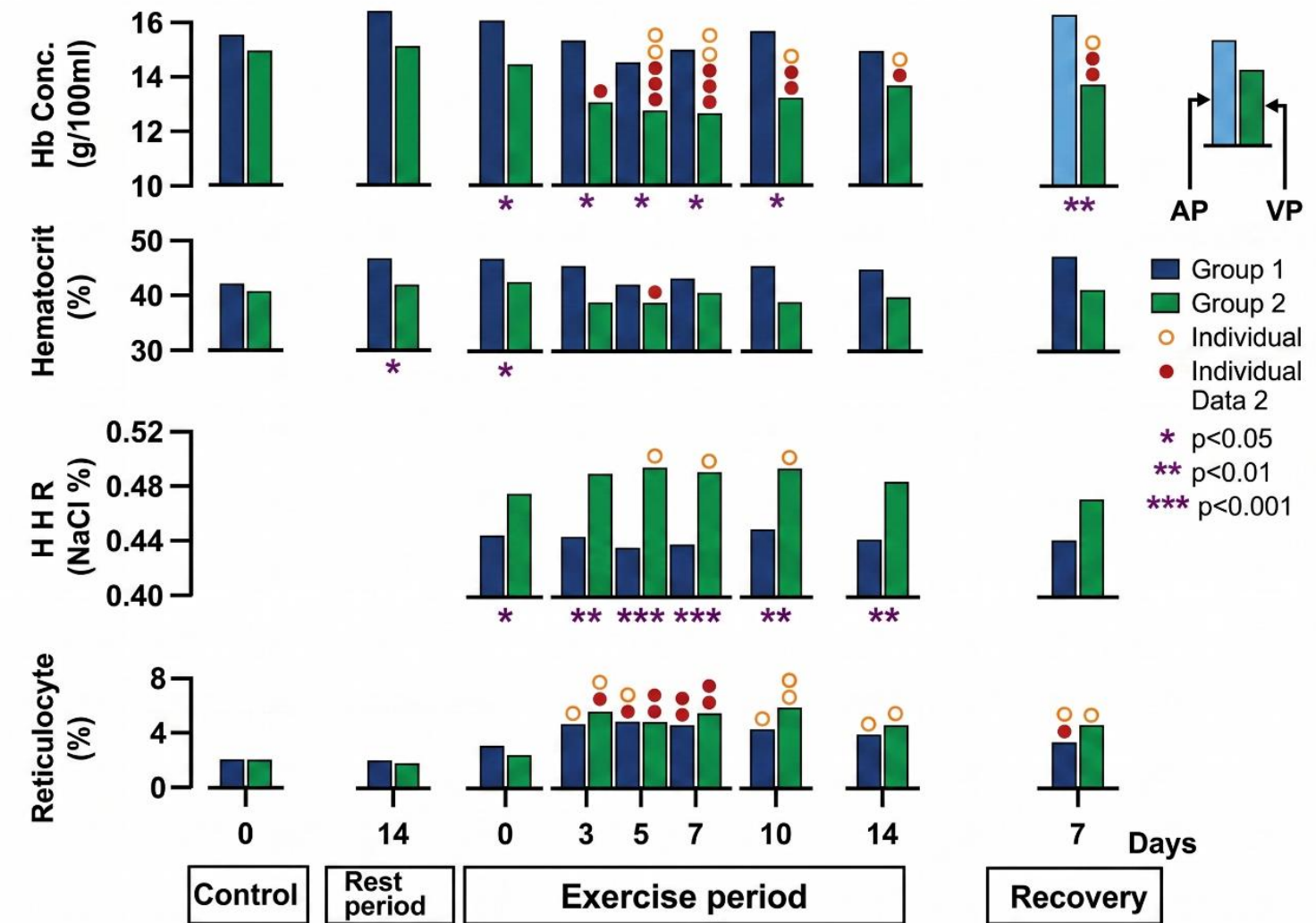
# Anemia: Exercised dogs fed vegetarian diets

## 'Experimental Protocol: Dietary Protein and Forced Exercise in Dogs'

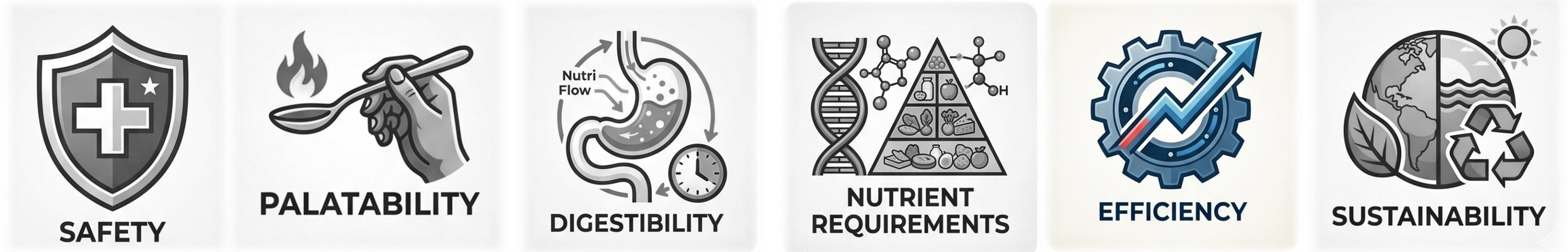


### Plant diets

- At week 6
  - ↓ Hemoglobin and hematocrit.
  - ↑ Red blood cell osmotic fragility (HHR).
- Exercise State (Sports Anemia Trigger)
  - Significant sports anemia
  - ↑ Red blood cell osmotic fragility (HHR)
  - ↓ Total and free cholesterol in the serum and erythrocytes



# Advantages and limitation of vegetarian diets in pets



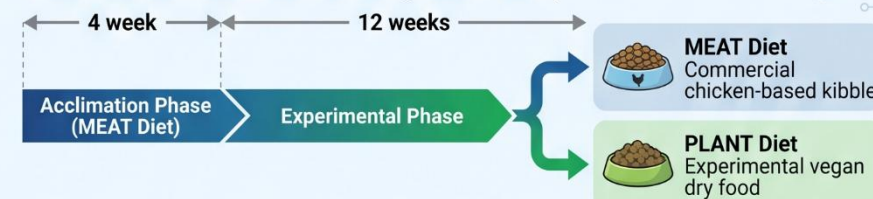


# Efficiency of vegetarian diets: Fecal metabolites

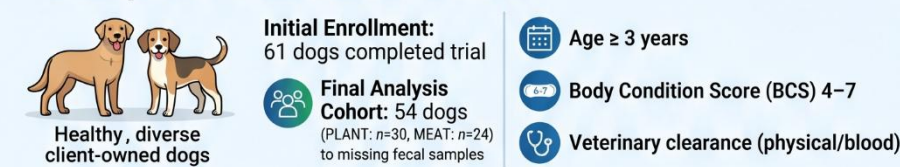
## SLIDE 1: STUDY METHODOLOGY & TRIAL DESIGN

### Study Design & Timeline

A randomized, double-blinded longitudinal study



### Participants & Inclusion Criteria



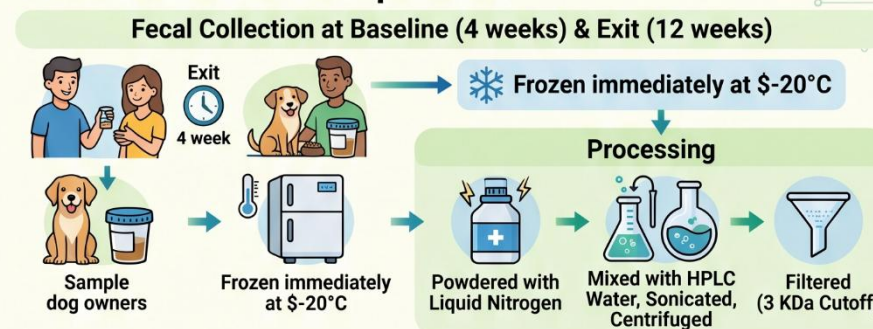
### Dietary Characteristics

Two isoenergetic, isonitrogenous diets

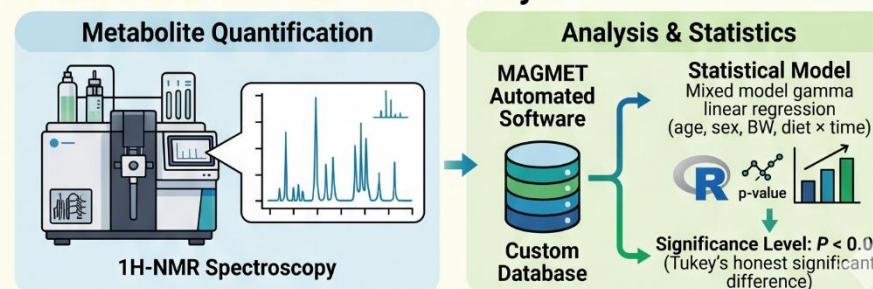


## SLIDE 2: SAMPLE PROCESSING & ANALYSIS

### Fecal Collection & Preparation

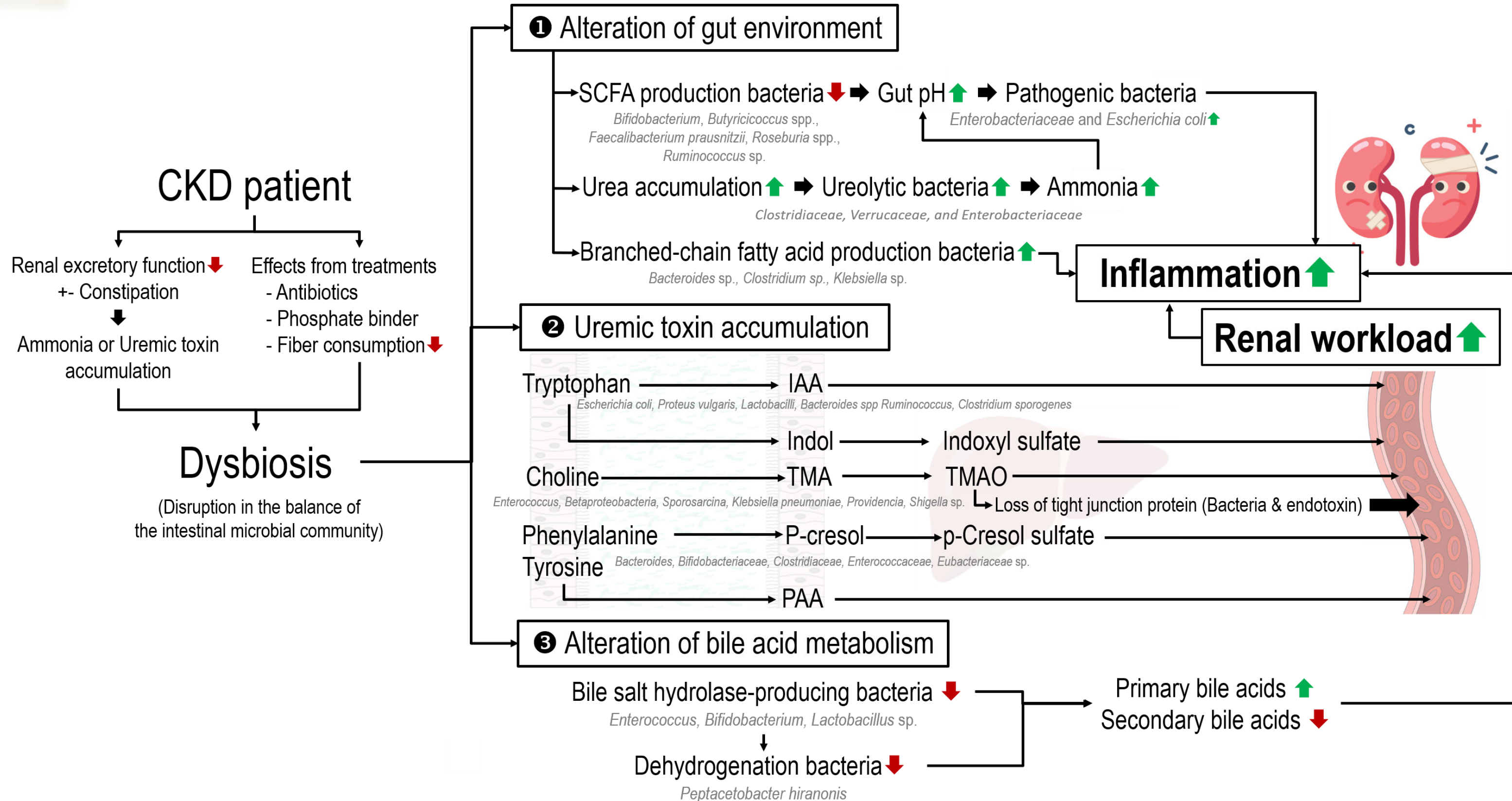


### Metabolomic & Statistical Analysis



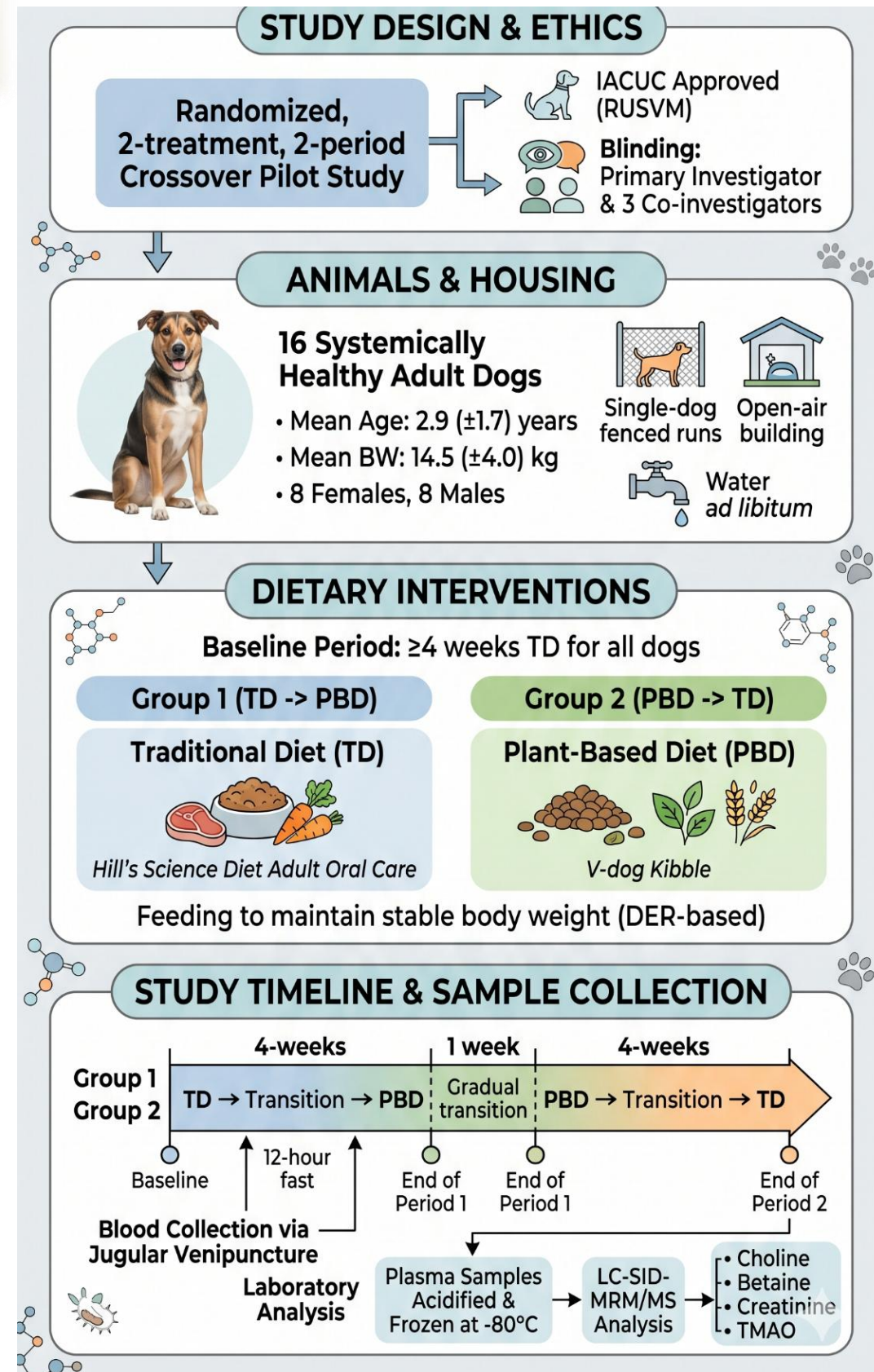
- Significant Shift in plant diet
  - 46 out of 66 metabolites changed significantly over time
- ↑ Carbohydrate fermentation.
- ↑ Acetic acid and propanoic acid
- ↑ Fecal sugar

# Efficiency of vegetarian diets: Uremic toxins



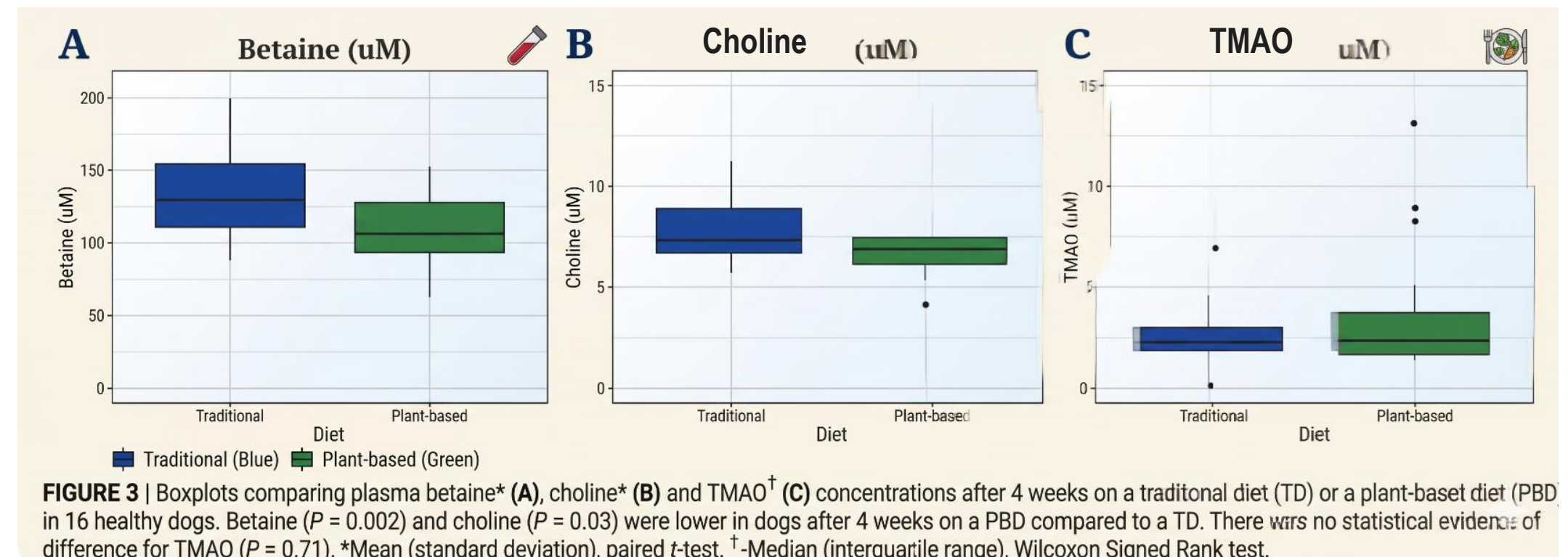


# Efficiency of vegetarian diets: TMAO



## Plant group

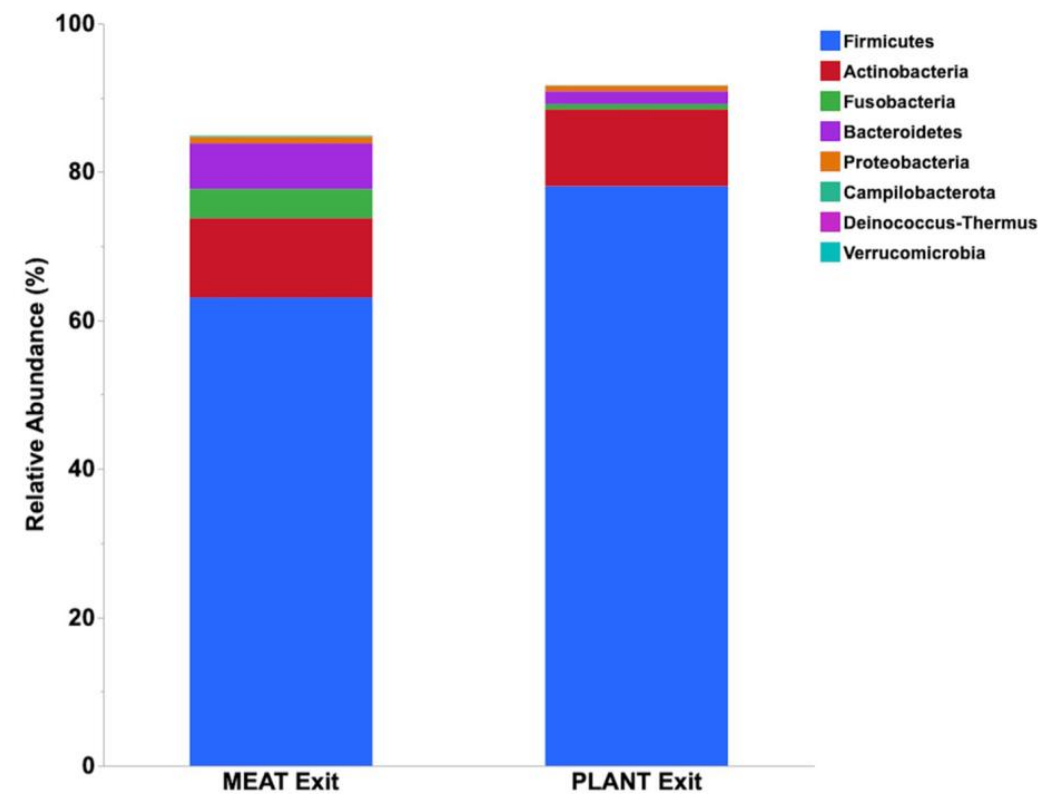
- $\downarrow$  Betaine & Choline
- $\uparrow$  L-Carnitine Content
- $\bullet$  TMAO and Creatinine



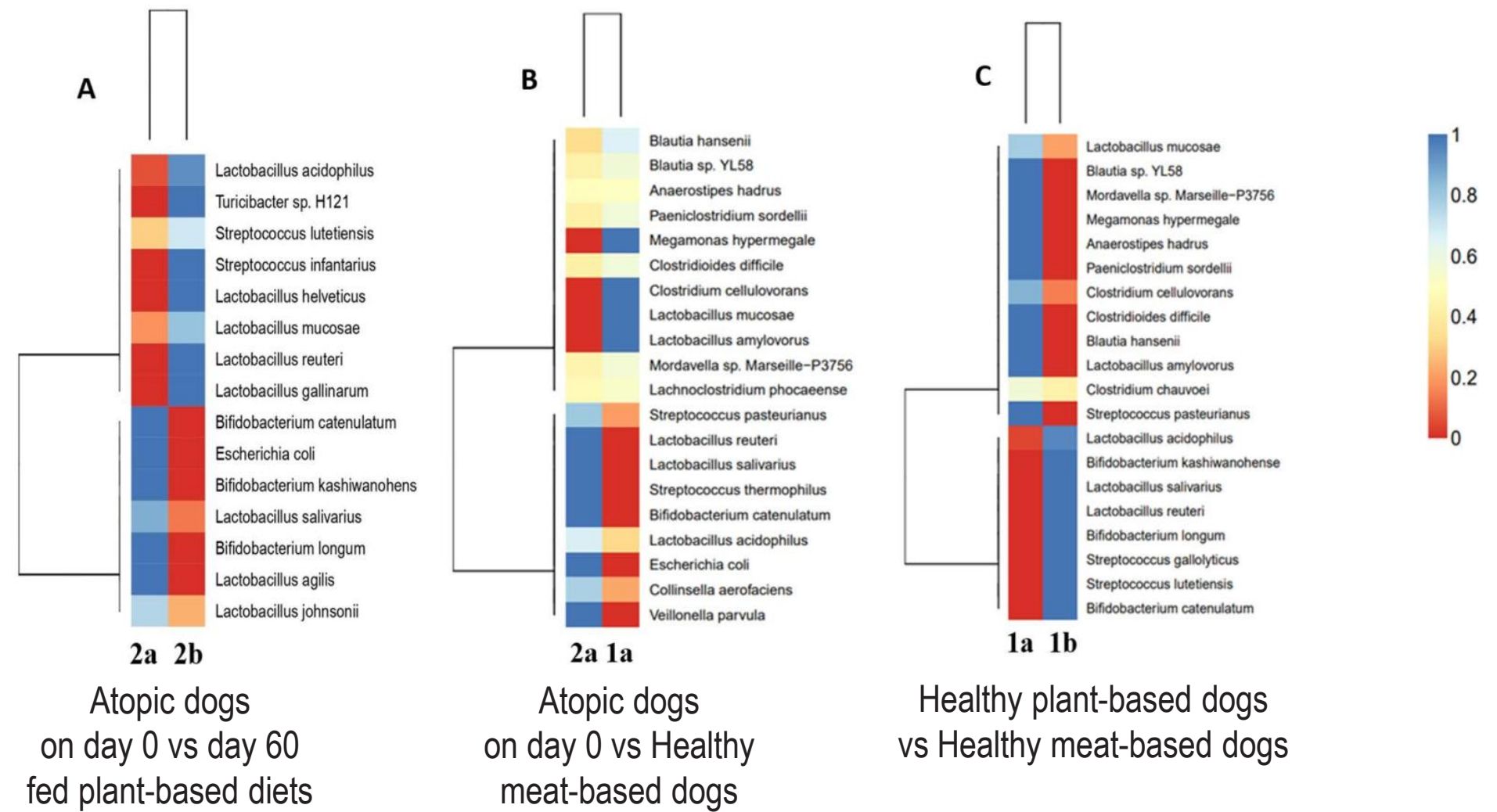


# Efficiency of vegetarian diets: Fecal microbiota

- [Liversidge et al. \(2024\)](#) in dogs
  - ↑ Firmicutes
  - ↓ Fusobacteria, Bacteroidetes and Campilobacterota



- [Swain et al. \(2025\)](#) in dogs







# Efficiency of vegetarian diets: Health and longevity

(N=1,413)



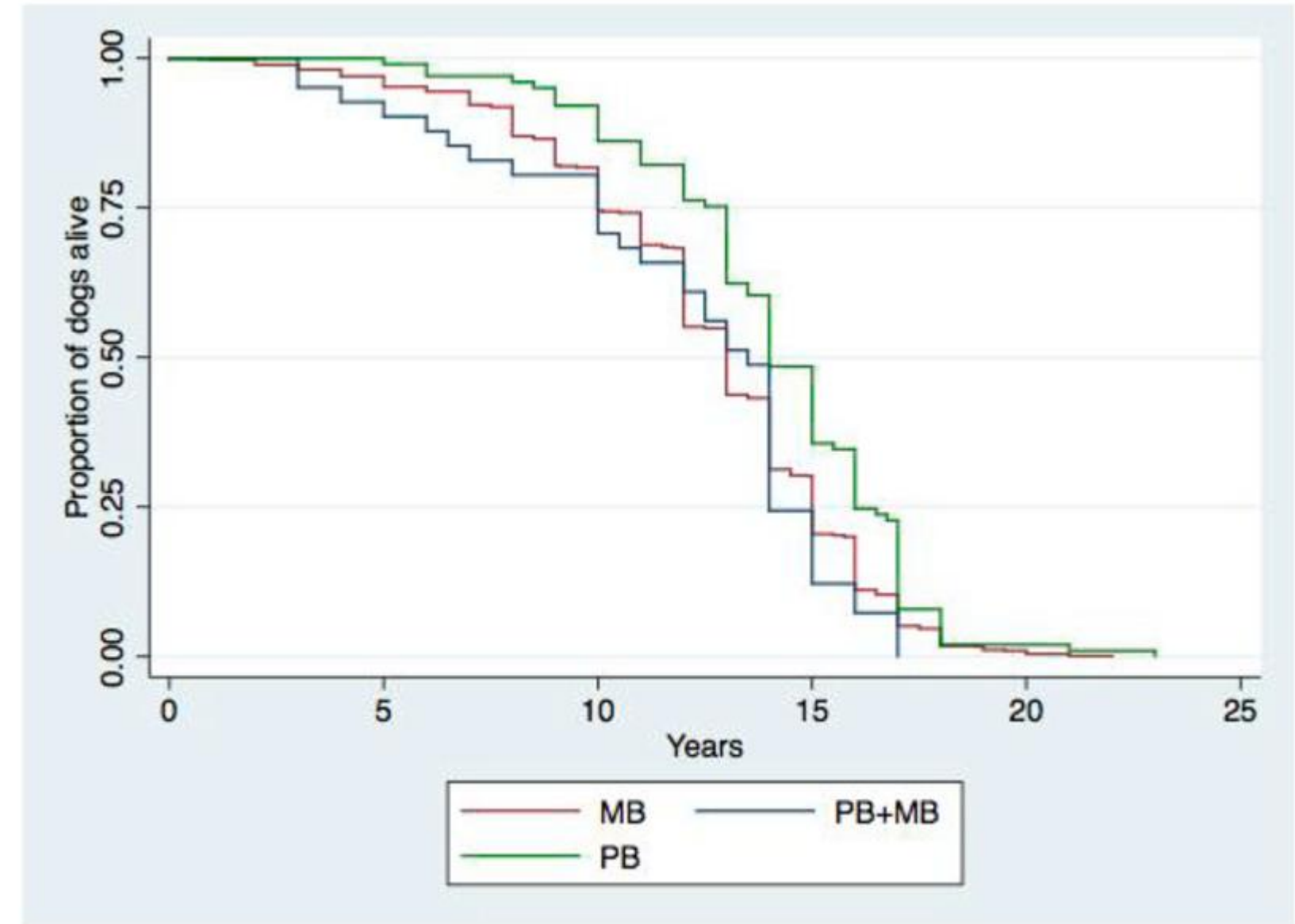
**Table 5**

Prevalence of canine health disorders as reported by participants in the “Pet Health and Wellbeing” survey, with comparison between dogs fed different diets.

Health disorder	Total		MB 		PB 		PB + MB/H	
	n =	%	n =	%	n =	%	n =	%
	1171		656		339		81	
Cardiac disease	29	2.4	14	2.1	11	3.2	3	3.7
Dental disease	232	20	128	19	65	19	15	19
Dermatopathy	245	21	132	20	63	19	21	26
Endocrinopathy	21	1.8	16	2.4	5	1.5	0	0
Gastrointestinal and hepatic diseases	145	12	96	15	26	7.8	9	12
Lower urinary tract disease	61	5.2	32	4.9	19	5.7	5	6.3
Neoplasia	36	3.0	20	3.0	13	3.8	2	2.5
Neurological	48	4.1	28	4.3	10	3.0	5	6.2
Obesity	43	3.7	22	3.4	14	4.2	5	6.3
Ophthalmic disorders	100	8.5	67	10	23	6.8	5	6.2
Renal disease	14	1.2	12	1.8	0	0	1	1.3

MB = meat-based, PB = plant-based, PB + MB/H = plant-based with animal-derived treats/snacks/supplements and/or ability to hunt.

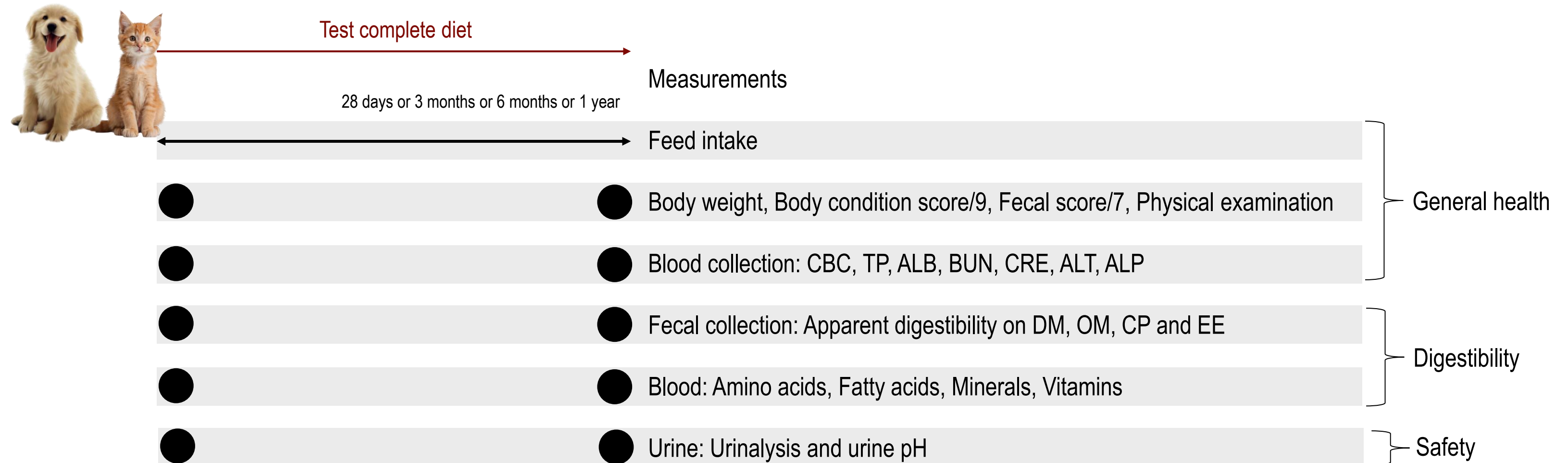
The numbers of dogs per category may not add up to total due to non-responders and indeterminable diet type.



**Fig. 2.** Kaplan-Meier survival plot depicting lifespan of previously owned dogs as reported by owners, comparing dogs fed plant-based (PB, n = 103), meat-based (MB, n = 907) or a combination (MB + PB, n = 42) diets.

# แนวทางการประเมินความปลอดภัยในสัตว์ทดลอง

# Experimental design



## Inaccurate nutrient levels in products (Dogs and Cats)

### 1. Deficiency in essential amino acids (Algae or bacterial protein)

**Dogs:** Methionine, cysteine, leucine, threonine and phenylalanine

**Cats:** Arginine, methionine, cysteine, histidine, isoleucine, leucine, lysine, tryptophan, threonine, phenylalanine, tyrosine, glutamine and taurine

### 2. Fatty acid profiles

- MUFA & PUFA (Vitamin E or antioxidants)
- EPA and DHA (Algae oils)
- Arachidonic acids (Cats)

### 3. Minerals (Supplements)

- Iodine, Potassium, Sodium, Chloride
- Calcium, Ca:P
- Selenium, Zinc

### 4. Vitamins (Supplements)

- Vitamin A (Retinol)
- Vitamin D
- Thiamine (B1)
- Niacin (B3)
- Cobalamin (B12)
- Folate (Vitamin B9)

### 5. Urinary pH (Alkaline) Electrolyte & Acidifiers

### 6. Anti-nutritional factors Processing



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