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Effect of replacing chicken with goat meat residue (*Ajamamsa* residue) as a novel protein source on feed intake, nutrient digestibility, and faecal score in adult dog diets

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Abstract
A feeding trial was conducted in a switch-over experiment design over four months at the Department of Animal Nutrition, College of Veterinary and Animal Sciences, Mannuthy. Four medium-sized, healthy adult dogs were assigned four isocaloric and isonitrogenous diets: A control diet containing 100 per cent chicken protein and three test diets where 25 per cent, 50 per cent, and 100 per cent of the chicken protein were replaced with chevon residue from *Ajamamsa* rasayanam preparation.
Results showed no significant differences (p>0.05) in dry matter intake, faecal condition scores, and apparent digestibilities among the diets. The digestibility of crude protein, ether extract, crude fiber, and nitrogen-free extract remained comparable across all treatments. These findings suggest that *Ajamamsa* residue (Goat meat/Chevon residue) can serve as a viable alternative protein source for dog food, promoting sustainability by utilizing meat industry byproducts. This study contributes to the development of cost-effective, nutritionally adequate, and environmentally friendly pet food formulations reducing dependency on conventional animal protein sources such as chicken.

Keywords: *Ajamamsa* rasyanam, goat meat residue, chevon residue, digestibility, chicken protein, feed intake, faecal score

1. Introduction
The Dog population in India is increasing steadily at a rate of 26 percent annually, and about 16.90 percent of households own a dog, indicating the prominence of pet ownership in society (Sudarshan *et al.*, 2006) [24]. As a result, the pet food industry is also growing tremendously, leading to an increase in sales (Abinaya *et al.*, 2020) [2]. The demand for high-quality pet diets has increased with the rising standard of living and a stronger pet-human bond (Deng *et al.*, 2016) [9], and there is a growing interest in pet parenting. Proteins are the most expensive and essential macronutrients in dog diets. The Use of proteins from the human food chain in the pet feed market has to meet various sustainability criteria. Chicken is a commonly used animal protein in the pet food industry, and the price is highly fluctuating. Increasing the amount of chicken in pet diets could strain the global chicken supply and lead to competition with the human food industry (Okin, 2017; Nijdam *et al.*, 2012) [18, 16].
There is an undeniable need to explore alternative, cost-effective animal protein sources from animal husbandry, meat, and allied industries, which has previously led to the identification of slaughterhouse byproducts, dairy products, and hatchery byproducts as protein ingredients in pet foods (Chuppava *et al.*, 2023) [8]. In a zero-waste economy, the utilization of byproducts from agro-industrial sources contributes to waste reduction, mitigates global food competition, and leads to greater economic and environmental efficiency. The use of by-products from aquatic and meat industries, namely crustaceans, green-lipped mussels, meat byproduct meal, blood meal, and insect maggot with high protein content and bioactive compounds.

(Al Khawli *et al*., 2020, Olsen *et al.*, 2014) [4, 19], such as carotenoids, chondroitin sulphate bioactive peptides, and chitin/chitosan (Olsen *et al.*, 2014, Bierer and Bui, 2002) [19, 7], which may offer antioxidant, anticoagulant, anti-inflammatory, and antimicrobial effects (Ghosh *et al*., 2022, Bierer and Bui, 2002) [11, 7]

Furthermore, as novel protein sources, many byproducts from industries need to be carried out. Goat meat processing and product preparation are rare in India due to the high demand for raw meat. Additionally, there has been only limited commercial use of these products for pharmaceutical and industrial purposes (Rao *et al*., 1985) [22]. According to Ayurveda, goat meat is similar to human body tissues and it does not cause any imbalance in the body (Wanjarkhedkar and Pathak, 2024) [25]. *Ajamamsa rasayanam* is an ayurvedic medicine commonly produced and used in Kerala as a nutritional supplement for humans with meat-based extract. It is made from goat meat and more than thirty herbs, cooked at a controlled temperature of 80-90 degrees Celsius with ghee, honey, sugar, and jaggery. This medicine is nutritious and flavorful, and promotes overall improvement in the body's health (Wanjarkhedkar and Pathak, 2024) [25]. Goat meat is the key ingredient in the production of the aforementioned medicine, with the meat being extracted into the broth, leaving behind fibrous muscle tissue and small bone fragments as residue. This chevon residue is commonly available as an industrial byproduct and can be dried and supplied in bulk. The proposed study investigates the inclusion of chevon residue (*Ajamamsa* residue) as an alternative to chicken in dog food, evaluating its feasibility at various levels while assessing acceptability, digestibility, and fecal characteristics in healthy adult dogs to support the pet food industry with more sustainable novel protein diets.

2. Materials and Methods

2.1 Feed Preparation

Dried Goat meat residue (*Ajamamsa* residue) sourced from six different batches were obtained from Kottakkal Arya Vaidyashaala, Malappuram and Kerala. Nutritional quality of the residue was evaluated by proximate analysis (AOAC, 2016) [5] and found to have a high crude protein content of 60.84 per cent and dry matter of 97 per cent. Feed ingredients were ground, mixed, and extruded.

2.2 Experimental programme

A feeding trial in switch over experiment design was conducted at the Animal Nutrition and Production (ANP) shed, Department of Animal Nutrition, College of Veterinary and Animal Sciences, Mannuthy for a period of four months. The study aimed to evaluate the effect of replacing chicken with *Ajamamsa* residue in complete dry dog food meeting maintenance requirements of medium-sized dogs.

2.3 Experimental animals and housing

Four medium sized healthy adult dogs of non-descript breed were selected for the study. They were of two to four years of age and with a body weight ranging from 11 to 13 kg. All dogs were healthy and uniform with regard to age and weight. Animals were dewormed before the start of study. Each experimental dog was housed in a well-ventilated, clean, dry individual kennel at ANP shed throughout the experiment. Such housing prevented the consumption of foreign material by the dogs. They were provided with food and water and maintained under identical management conditions.

2.4 Experimental ration and feeding

Four isocaloric and isonitrogenous feeds were formulated with 18 per cent crude protein and 3500 kcal ME/kg (IS: 11968, 2019) [13] presented in Table 1. A feeding trial was conducted in a switch over design. The ingredient composition of the ration is presented in Table 2. All treatment diets were offered for a period of three weeks to all animals selected for the experiment. An adaptation period of one week was given before the start and also in between the switching of diets to nullify the carryover effect. Diets to be fed subsequently were offered during this switch over period, and the entire feeding trial was for a period of four months, with each period lasting for 21 days.

Table 1: Treatment diet specifications

Experiment type	Specifications
Control (C)	Dog food with 100 per cent chicken meat as animal protein
T_1	Dog food with 25 per cent of chicken meat (on protein basis) replaced with *Ajamamsa* residue as animal protein
T_2	Dog food with 50 per cent of chicken meat replaced with *Ajamamsa* residue as animal protein
T_3	Dog food with 100 per cent of chicken meat replaced with *Ajamamsa* residue as animal protein

Table 2: Ingredient composition of experimental dog foods

Ingredient	Percentage composition			
	T_1	T_2	T_3	T_4
Wheat	27	27	27	27
Maize	14	14	14	14
Ragi	10	10	10	10
Soyabean meal	10	10	10	10
Chicken	7	5.27	3.50	-
Ajamaamsa residue	-	1.80	3.62	7.25
Meat cum bone meal	6	6	5.88	6
Wheat bran	21	20.93	21	20.75
Rendered fat	4	4	4	4
Supplevit-M*	0.5	0.5	0.5	0.5
Vitamin supplement *	0.5	0.5	0.5	0.5
Total	100	100	100	100
Nutrient composition (Analysed)				
CP%	18.36±0.10	18.25±0.05	18.38±0.11	18.45±0.08
CF%	3.57±0.14	3.03±0.32	3.20±0.34	3.43±0.29
ME Kcal/kg (calculated)	3510.20	3516.30	3512.60	3518.37
Calcium (%)	1.81±0.02	1.90±0.02	1.84±0.02	1.77±0.08
Total phosphorus (%)	0.63±0.06	0.64±0.06	0.67±0.07	0.65±0.07

*Supplevit-M (250 gram) contains 15 g Choline chloride, 75 g of calcium, 2.75 g of Manganese, 0.1 g of Iodide, 0.75 g of Iron, 1.5 g of Zinc, 0.2 g of Copper, 0.045 g of Cobalt, 5,00,000 IU of vitamin A, 1,00,000 IU of vitaminD3, 0.2 g of vitamin B2, 75 units of vitamin E, 0.1 g of vitamin K, 0.25g of calcium panthothanate, 1 g of Nicotinamide, 0.6 g of Vitamin B12

*Vitamin supplement (1 kg) contains vitamin A-25 MIU, vitamin D3-8 MIU, vitamin E-16g, vitamin B3-26g, vitamin B5-16g, vitamin B2-10g, vitamin K3-3g, vitamin B6-3g, vitamin B1-2g, vitamin B9-0.5g, biotin-0.05g, vitamin B12-0.016g

2.5 Daily feed intake

Dogs were fed once daily at 3 PM, in sufficient quantities to meet their energy needs as per NRC (2006) [17], and water was provided ad libitum. The leftover feed was collected after twenty minutes. The quantity of feed consumed by each dog was recorded daily. It was subjected to moisture estimation to determine dry matter intake.

2.6 Digestibility studies and faecal scores

A digestibility trial of three days duration was conducted in all the experimental animals during the last week of each feeding period to evaluate nutrient digestibility. The faecal condition score was evaluated weekly using a score using a five-point scale (Abd-El-Wahab *et al.*, 2017) [1] included in Table 2 and Figure 1. Stool was manually collected and weighed as it was voided, ensuring that it remained uncontaminated by urine or dirt. A representative sample of the thoroughly mixed faeces was placed in double-lined polyethylene bags, labelled and stored in a deep freezer at -20 °C for further analysis.

Table 2: Faecal condition score chart

Score	Specifications
1	Very hard, Crumbly
1.5	Hard and dry
2	Well formed; doesnot leave a mark when picked up
2.5	Well formed; slight moist surface; leaves a mark when picked up
3	Moist beginning to lose form
3.5	Very moist; still has some defenite form
4	Poor consistency; Viscous
4.5	Diarrhoea with some consistency
5	Watery diarrhoea

Fig 1: Faecal score chart

2.7 Statistical anlaysis

As the design adopted was switch over design, variation between treatments were analysed after removing the variation due to period and also variation due to animal. Three way ANOVA without interaction was adopted for this. Statistical analysis was carried out by analysis of variance (ANOVA) using SPSS version 24.0 as per Snedecor and Cochran (1994) [23].

3. Results and discussion

3.1 Dry matter intake

The average daily dry matter intake (DMI) and DMI per kg body weight of dogs maintained on four experimental dog foods are given in Table 3. DMI Values were 226.88±8.84, 235.03±13.89, 232.60±13.84, 231.00±15.65 g for control, T_1, T_2 and T_3 groups respectively and that of DMI per kg bodyweight were 18.54±0.38, 19.60±0.23, 18.69±0.46, 19.12±0.36 g for Control, T_1, T_2 and T_3 respectively. There was no significant difference (p>0.01) among all four treatment groups during the entire period of study. The results of the present study align with observations of Folador *et al.* (2006) [10], who reported a dry matter intake of 17.70 to 21.20 g/kg body weight for diets with salmon crushed bone meal and salmon protein hydrolysate. Areerat *et al.* (2021) [6] also reported a similar dry matter intake value as obtained in the present study of 18.26 g/kg body weight for dogs fed a diet containing 20 per cent house cricket meal. Guilherme-Fernandes *et al.* (2024) [12] reported a dry matter intake of 21 g/kg bodyweight for dogs fed with diets formulated with shrimp hydrolysate as an animal protein source, which was higher than the values obtained in the present study.

Table 3: Average Dry matter intake (DMI) and DMI per kg bodyweight of dogs maintained on experimental rations

Variables	Treatments				P-Value
	C	T_1	T_2	T_3	
Average DMI	226.88±8.84	235.03±13.89	232.60±13.84	231.00±15.65	0.399 ^{ns}
DMI/kg	18.54±0.38	19.60±0.23	18.69±0.46	19.12±0.36	0.213^{ns}

3.2 Faecal condition score

The weekly faecal condition score (FCS) of the dogs fed with four experimental dog foods (Fig. 2) showed that there was no significant difference (p>0.05) in the FCS of the dogs fed with Control, T_1, T_2, and T_3 diets. The five-point faecal scoring chart was used to score the faecal condition (Abd-El-Wahab *et al*., 2017) [1]. The average initial faecal condition scores recorded for Control, T_1, T_2, and T_3 groups were 2.38, 2.38, 2.13 and 2.50, respectively, and the final faecal scores were 2.50, 2.38, 2.25, and 2.38, respectively, in Control, T_1, T_2, and T_3 groups. During the experiment, the average faecal condition score (FCS) of dogs in all four treatment groups remained the same and in the normal range 2.00 to 2.50, indicating well-formed faeces. Quigley *et al.* (2004) [21] found that the average faecal condition scores of dogs did not differ between the control diet with chicken and diets that included two per cent spray-dried animal plasma, and both diets had a faecal score of 3.80, indicating well-formed faeces. Marx *et al*. (2015) [15] observed that adult dogs fed a diet with 13 per cent beef tallow had a faecal score of 2.80, which closely matches the results of the current study. Pinto *et al*. (2021) [20] found that dogs fed a diet with 26 per cent hydrolysed chicken liver powder had similar fecal scores compared to those on a control diet containing poultry meal and bovine meat, with scores ranging from 2.00 to 2.17, indicating firm and well-formed feces.

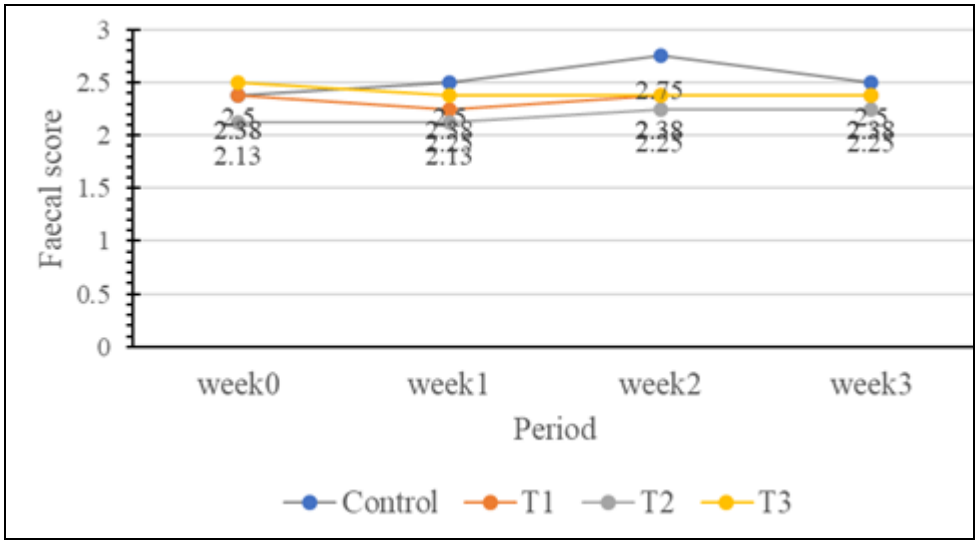

Fig 2: Weekly faecal condition score of dogs maintained on four experimental rations

3.3 Apparent digestibility coefficient

The digestibility coefficient of nutrients in four experimental dog foods is given in Table 4.

The per cent digestibilities of nutrients for dog foods Control, T_1, T_2, T_3 were 77.81, 77.62, 77.85, 78.07 for dry matter, 79.62, 80.67, 81.61, 81.77 for CP, 44.96, 43.09, 44.33, 43.34 for CF, 83.51, 82.38, 83.85, 84.11 for NFE, respectively.

The dry matter digestibility coefficient was similar between the treatment groups throughout the trial (p>0.05). Areerat *et al*. (2021) [6] found similar dry matter digestibility of 72 and 79 per cent, respectively, while replacing poultry meal with seven per cent silkworm pupae meal. Guilherme-Fernandes *et al.* (2024)[12] also found comparable dry matter digestibility between dog diets with poultry meal (69.20 per cent CP) and those with five percent shrimp hydrolysate (69.90 per cent CP

The crude protein digestibility also showed similar results between the treatment groups during the feeding period trial. Similar results to those of the present study were obtained by Abinaya (2019) [2], reporting a crude protein digestibility of 79 per cent when fed diets with 56 per cent beef to dogs. Areerat *et al*. (2021) [6] replaced poultry meal with 10 per cent house cricket meal in dog diets and found similar crude protein digestibility with the present study of 72.80 and 75.40 per cent, respectively. Guilherme-Fernandes *et al.* (2024) [12] fed dogs diets containing shrimp hydrolysate meal at five, ten, and fifteen per cent inclusion levels, replacing chicken, and found similar crude protein digestibility values ranging from 75 to 77 per cent in consistent with observations recorded in the present study.

The Ether extract digestibility coefficient values were also similar between the treatments (p>0.05). Areerat *et al*. (2021) [6] used various levels of silkworm pupae meal replacing chicken meal in dog foods and observed similar ether extract digestibility in the range 92 to 93 per cent among treatment groups. Guilherme-Fernandes *et al*. (2024) [12] fed dogs diets containing shrimp hydrolysate meal at 10 and 15 per cent inclusion, compared with a poultry meal diet, and found similar ether extract digestibility values ranging from 91 to 92 per cent.

The crude fibre and nitrogen-free extract digestibility values were also similar between the four treatment groups (P>0.05). Similar results to those reported in the present study were also reported by Pinto *et al*. (2021) [20] while feeding dogs diets with hydrolysed chicken liver powder compared to a control diet containing bovine meat as protein with NFE digestibility of 88 to 90 per cent. For crude fibre digestibility similar to the present study, Akhil *et al*. (2023) [3] reported that diets for medium-sized adult dogs had crude fiber digestibility values ranging from 46 to 48 per cent. Kahraman and Inal (2021) [14]

also reported a crude fibre digestibility of 44 per cent in dogs fed diets containing lamb meat.

Table 4: Apparent digestibility coefficient [1] of nutrients of the four experimental dog foods,%

Variables	Treatments				P-Value
	Control	T_1	T_2	T_3	
Dry Matter	77.81±1.01	77.62±0.96	77.85±0.90	78.07±1.03	0.993^{ns}
Crude Protein	79.62±0.92	80.67±0.71	81.61±0.91	81.77±1.04	0.108^{ns}
Ether Extract	87.39±0.61	88.73±0.98	89.15±0.65	89.41±0.99	0.220^{ns}
Crude Fibre	44.96±0.53	43.09±0.99	44.33±0.86	43.34±0.91	0.201^{ns}
Nitrogen Free Extract	83.51±0.91	82.38±0.70	83.85±0.65	84.11±0.93	0.287^{ns}

[1]Mean of four values with SE
NS-Non-significant

4. Conclusion

This study is the first to highlight the potential of *Ajamamsa* residue (goat meat residue) from Ayurvedic pharmaceutical industries as a novel protein source for dog nutrition. The residue demonstrated a protein content comparable to commonly used protein sources in dog diets. Its inclusion in the diet up to 100 per cent replacement of chicken resulted in similar dry matter intake, nutrient digestibility, and fecal scores as diets containing chicken, suggesting that it could effectively replace chicken in high-protein, easily digestible dog diets.

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Conflict of Interest

Not available

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