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Evaluating Palatability of Lipopolysaccharide Supplement in Cats With and Without Flavoured Treats

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Abstract

Background: Administering oral medication to cats poses significant challenges, particularly due to their acute sensitivity to odours, which can hinder acceptance of drug-infused food. **Methods**: This study investigated the palatability of lipopolysaccharide (LPS) supplement, with or without, flavoured semi-liquid treats for cats, in five domestic shorthair cats using a two-bowl preference test conducted over seven days. Key behavioural metrics included first approach, first consumption, total approach, total intake, and intake ratios. Additionally, a sensory evaluation was conducted with human participants (n=18) to assess the aroma acceptability of treats formulated with either salmon or sprat. Statistical analyses included Chi-Square tests for approach and consumption frequency, one-way ANOVA for total consumption, and descriptive statistics for sensory outcomes (p<0.05). **Results**: A consistent preference for salmon-based treat, with or without LPS, reflected in higher consumption frequencies and intake ratios (0.76 and 0.74, respectively), compared to sprat-based and LPS-only options. Human sensory ratings also favored the aroma of salmon-based over sprat-based treat. **Conclusion**s: These findings underscore the critical role of palatable formulations—particularly salmon—in improving voluntary ingestion of medicated supplements and enhancing compliance in feline care.

Keywords

Aroma, Lipopolysaccharide, Medicine wastage, Cat treats, Palatability, Two-bowl method

1. Introduction

Cats are widely recognized for their remarkable adaptability to compact environments, autonomous behavior, and minimal care demands. They offer emotional comfort, companionship, and affection, which in turn nurtures a sense of responsibility in their owners. Numerous cat owners report forming bonds with their pets that resemble familial or close friendships, underscoring the profound emotional ties that may arise between felines and their human counterparts [1]. Despite these benefits, cats are susceptible to a range of health conditions that often necessitate either therapeutic or palliative interventions. Administering such treatments poses significant difficulties for caregivers. Compliance with veterinary-prescribed medication regimens remains a largely underexplored area in feline health management. Owners frequently encounter challenges when medicating uncooperative cats, which may result in physical harm, incomplete dosing, and broader concerns such as the emergence of antimicrobial resistance [2]. A variety of techniques are employed to deliver oral medications, including the

"poke down" method—placing the drug at the base of the tongue, followed by closing the mouth and gently massaging the throat to prompt swallowing. Another frequently used strategy involves concealing medication within food; however, this is not always effective, particularly when drugs must be administered on an empty stomach or possess a bitterness that cannot be easily camouflaged [3]. Moreover, many cats exhibit aversion to physical restraint, adding further complexity to the medication process [4].

In optimal scenarios, medications should be consumed voluntarily, particularly when gentle handling is required due to the animal's medical condition [5]. For voluntary ingestion to be successful, the formulation must be palatable. Palatability encompasses the sensory and chemical characteristics of a substance that influence an animal's pre-ingestive behavior, and it plays a vital role in determining acceptance of food or medication products [6]. This concept involves multiple sensory factors, including visual appearance, smell, mouthfeel, and taste, all of which stimulate gustatory and olfactory receptors that contribute to the animal's flavor perception [7,8]. Felines exhibit a unique palatability profile, primarily shaped by their taste receptor physiology. Despite possessing only around 470 taste buds—a number lower than that found in humans and various other species—cats demonstrate a marked sensitivity to bitter flavors, a trait that often underlies their reluctance to accept medicinal compounds [9]. Moreover, olfactory cues are a key factor in food acceptance, as the nasal cavity's scent receptors, together with the vomeronasal organ (Jacobson's organ), provide heightened scent sensitivity in both felines and canines [10,11].

Further complicating the situation, a significant number of cat owners report receiving insufficient instructions from veterinarians regarding proper medication administration techniques. As noted by [2], approximately half of surveyed cat owners stated they either "sometimes" or "never" received guidance on how to administer prescribed treatments. Additionally, one-third of respondents were not advised on whether medications could be delivered with food, and only a minority received information about the appropriateness of crushing tablets or opening capsules. Providing clear and comprehensive instructions is vital for effective communication and for ensuring optimal therapeutic outcomes in companion animal care. Considering the existing challenges—such as issues with palatability, the need for physical restraint, and communication gaps—it is crucial to investigate alternative strategies. The present study aims to evaluate the use of flavored semi-liquid treats, specifically those incorporating salmon or sprat, as a potential means of enhancing medication palatability, streamlining the administration process, and reducing the likelihood of injury to both cats and their caregivers.

2. Materials and Methods

2.1 Research location, study period, and animals

The study involved five neutered, adult domestic shorthair cats, consisting of two males and three females, with a median age of two years. The cats' body weights ranged from 3 to 4 kg, with a median weight of 3.5 kg. A detailed history of cats is provided in Table 1. The cats, which were exclusively housed indoors together, were owned by a single individual who voluntarily consented to their inclusion in the study. These cats were housed in an individual cages (in the same room) at the Animal Research Facility within the Faculty

Table 1. Summary of physical and health parameters of study cats.

Cat ID	Sex	Age (years)	Weight (kg)	Health Status	Neuter Status	BCS (1-9 scale)
Cat 1	Male	2	3.3	Healthy; vaccinated, dewormed, defleaed	Neutered	5
Cat 2	Female	1.5	3.4	Healthy; vaccinated, dewormed, defleaed	Neutered	5
Cat 3	Male	2.5	3.7	Healthy; vaccinated, dewormed, defleaed	Neutered	5
Cat 4	Female	2	3.5	Healthy; vaccinated, dewormed, defleaed	Neutered	5
Cat 5	Female	2	3.6	Healthy; vaccinated, dewormed, defleaed	Neutered	5

of Veterinary Medicine at Universiti Putra Malaysia from September 4 to September 14, 2023. To ensure the health and welfare of the cats throughout the experimental period, routine physical examinations were carried out by a licensed veterinarian. These examinations took place at both the commencement of the study and at regular intervals during the research, ensuring that the well-being of the animals was continuously monitored.

2.2 Acclimatization and palatability test

An acclimatization period of one week was provided, during which the cats were given unrestricted access to their habitual diet—seafood-flavoured dry kibble of the same commercial brand routinely provided by the owner. The kibble was administered twice daily, at 6 a.m. and 6 p.m., throughout this period. Upon completion of the acclimatization phase and for the remainder of the study, the quantity of kibble offered was adjusted based on the calculated maintenance energy requirements (MER) expressed in kilocalories per day (kcal/day), as determined using the approach described in [12]:

$$\text{MER (kcal/day)} = 70^{*} (\text{Body weight}_{kg})^{0.75}$$

To evaluate the palatability of the LPS supplement and treats, a two-bowl test was conducted following the protocol described by [13], with modifications. Briefly, cats were offered two identical bowls (round, plastic, double-feeding dish) simultaneously, each containing either the 1) LPS only, 2) flavoured semi-liquid treat for cats—specifically Sprat or Salmon, or 3) combination of LPS and treat over a one-week period. The LPS was administered in powder form (white, 140 mg per tablet; dosage: two tablets per 5 kg body weight), while the treats were provided in a semi-liquid form (4 g per sachet; one sachet per cat). To ensure consistency, all test feedings were conducted at 8 a.m. and 8 p.m., precisely two hours following the provision of standard kibble. Both the LPS and the treats were obtained from a commercial supplier, the identity of which remains undisclosed. Where necessary, two tablets of LPS were crushed and blended with the treats to facilitate administration.

Over the course of seven days, each cat was presented with various combinations of treats and LPS. The schedule was as follows: Day 1 (A and B), Day 2 (A and C), Day 3 (C and D), Day 4 (B and C), Day 5 (B and D), Day 6 (A and D), and Day 7 (A or B with E). In this context, (A) represented Sprat treat; SpT, (B) Salmon treat; SaT, (C) SpT + LPS, (D) SaT + LPS, and (E) LPS alone. During the test, the treats and LPS (either individually or combined) were placed in labelled bowls (1 and 2). Consumption was observed qualitatively for a period of 30 minutes (finished or unfinished). To minimize any potential bias, the bowl placement was alternated during the evening trial.

2.3 Human volunteer olfactory assessment

A total of 18 volunteers were presented with random samples of Salmon- or Sprat-based treats and instructed to evaluate the odor using a rating scale from 1 to 4, where 1 indicated the least pleasant scent and 4 indicated the most pleasant. To minimize potential bias and neutralize the olfactory effects of the previous sample, volunteers were provided with coffee beans to sniff between evaluations, allowing them to reset their sense of smell before proceeding with the next sample.

2.4 Statistical analysis

Data analysis was conducted using Statistical Software for Social Sciences (SPSS) for Windows, Version 19.0 (SPSS Inc., Chicago, USA). The Chi-Square test was utilized to assess the variables "First Approached" and "First Consumed," while the "Total Consumption" variable was examined using one-way analysis of variance (ANOVA). Descriptive statistics were applied to the data collected from the human sensory evaluation, and statistical significance was established at a threshold of $p<0.05$.

3. Results

The data from the "First to Approached" (Fig. 1.) measure clearly indicate that cats showed a significant preference for Salmon-based formulations, both with and without LPS, compared to Sprat-based options and LPS alone

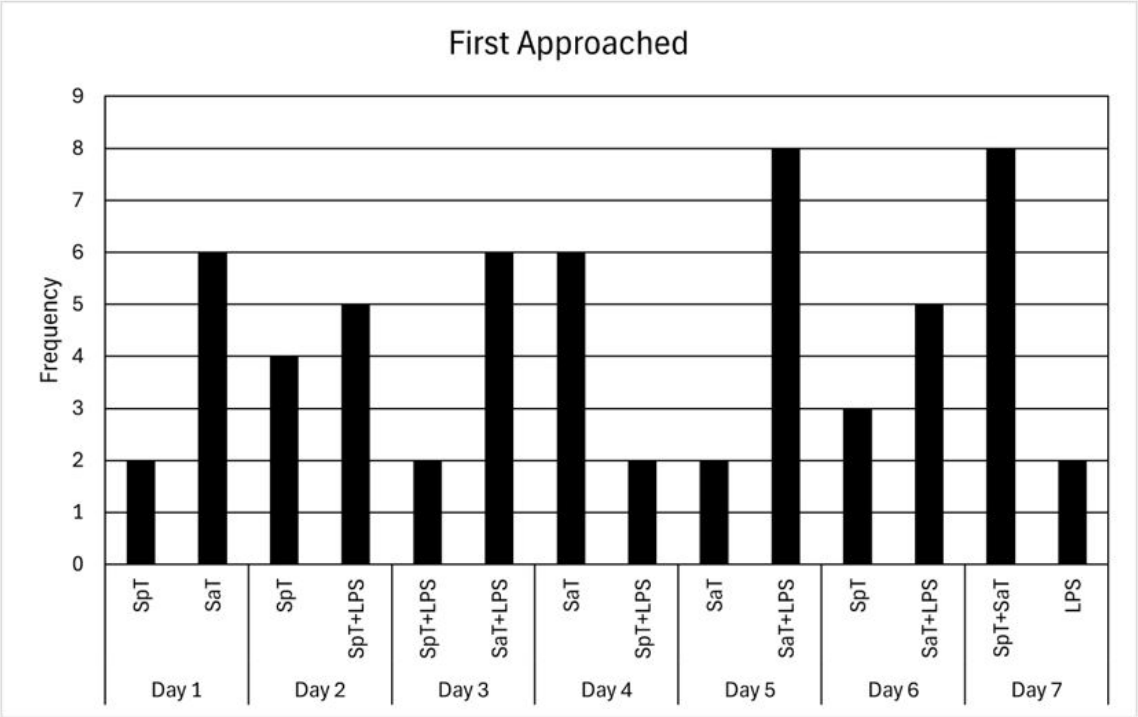

Fig. 1. Cat preferences for first approached in a two-bowl test over seven days.

(p<0.05). The highest levels of initial engagement were observed with SaT and SaT + LPS, while the Sprat-based options exhibited more inconsistent responses, and LPS alone was the least attractive. These findings underscore the superior palatability of salmon-based treats in capturing the cats' attention. This has practical implications for the development of pet products, suggesting that salmon-based treats, particularly when paired with functional ingredients like LPS, may enhance initial interest and promote voluntary intake. The statistical significance of the results (p<0.05) further confirms the strong preference for salmon, which could be an important consideration for creating more effective products aimed at improving feline health and medication adherence.

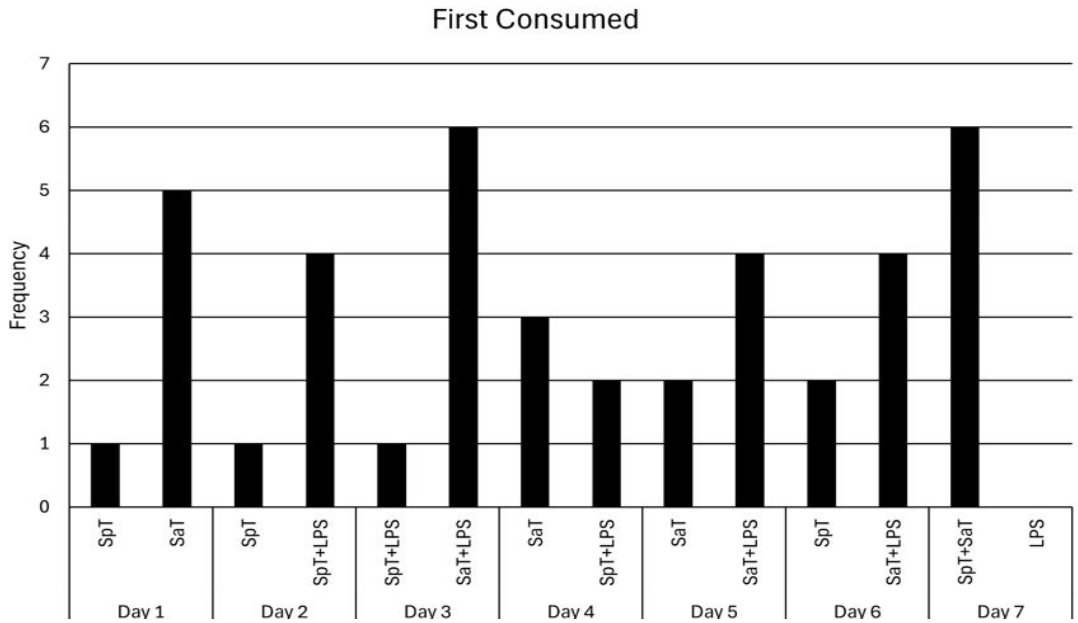

Figure 2. Cat preferences for first consumed in a two-bowl test over seven days.

The "First to Consumed" data (Fig. 2.) showed that salmon-based formulations, particularly SaT and Sat + LPS, were consistently consumed first, indicating high palatability. In contrast, Sprat-based options were less accepted, and LPS alone was never consumed. These differences were statistically significant ($p<0.05$), highlighting the preference for salmon-based treats.

The "Total Approached" data (Fig. 3.) revealed that SaT and SaT + LPS were approached more frequently (17 and 19 times, respectively), indicating a strong preference for Salmon. In contrast, SpT and SpT + LPS were approached less often (14 times each), and the LPS-only treatment was the least approached (2 times), suggesting low palatability. These results, with $p<0.05$ considered statistically significant, emphasize the importance of palatability in promoting approach behavior. The strong attraction to Salmon-based treatments suggests that enhancing sensory appeal, particularly through Salmon, could improve the effectiveness of pet products, especially in medication adherence.

The "Total Consumed" data (Fig. 4.), with $p<0.05$ considered statistically significant, shows that Salmon-based treatments (SaT: 13 and SaT + LPS: 14) were consumed the most, highlighting the strong palatability of Salmon. In contrast, Sprat-based treatments (SpT and SpT + LPS) were consumed only seven times each, suggesting lower palatability and acceptance. The LPS-only treatment was not consumed at all, further reinforcing its lack of appeal. These results emphasize the practical implication that

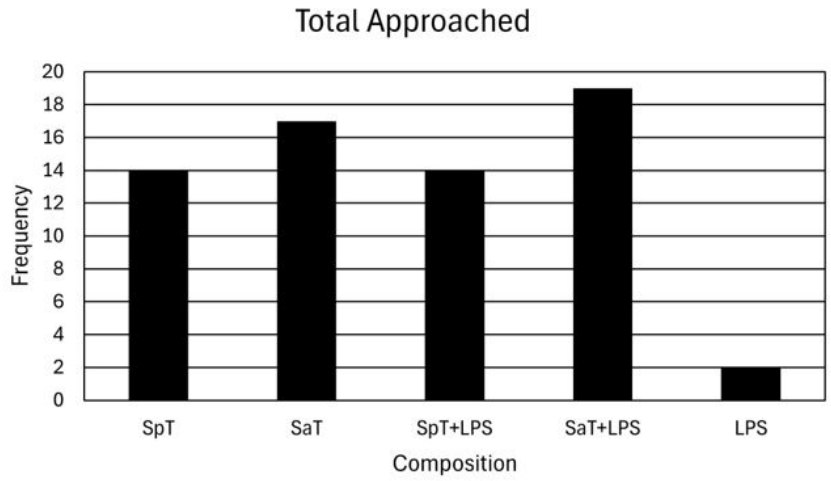

Figure 3. Total approached counts for treats and LPS across the study period.

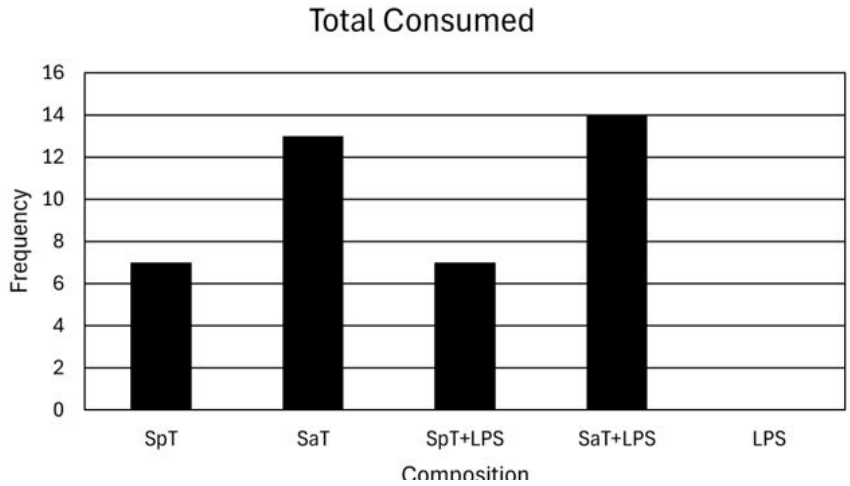

Figure 4. Total consumed counts for treats and LPS across the study period.

combining a highly palatable treat like Salmon with supplements (such as LPS) can significantly increase consumption.

The "Intake Ratio" data (Fig. 5) reveal notable differences in consumption rates among the treatments. SaT had the highest intake ratio (0.76), indicating its strong palatability, with SaT + LPS showing a slight decrease (0.74) due to the addition of LPS. These differences were statistically significant (p<0.05), suggesting that while the addition of LPS reduced the intake slightly, the combination still maintained high palatability. In contrast, SpT and SpT + LPS had lower intake ratios (0.50), highlighting the lower appeal of Sprat. The LPS-only treatment had an intake ratio of 0.00, emphasizing its lack of attractiveness.

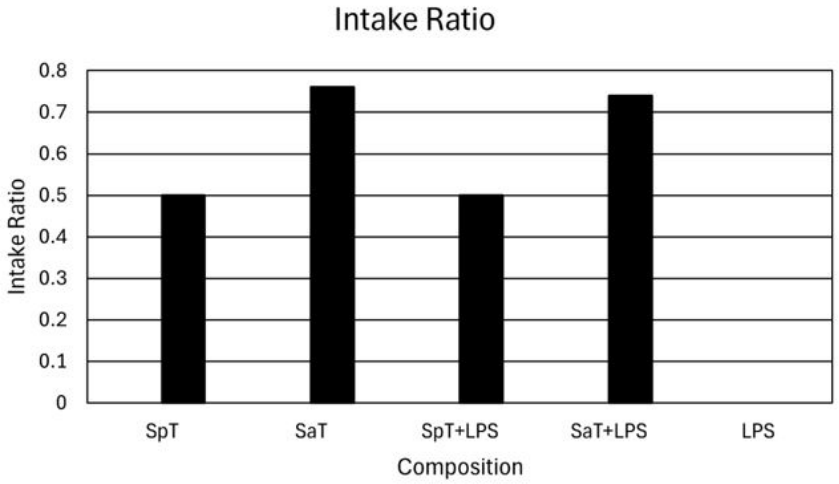

Figure 5. Intake ratio of treats and LPS among cats.

A total of 18 participants participated in the sensory survey. Table 2 summarizes their perceptions of the aromas of two types of treats: Sprat and Salmon. The aroma of each treat was rated on a 1 to 4 scale, where 1 indicated the least pleasant and 4 the most pleasant. The results demonstrated significant differences in the aroma perceptions of the two treats. Overall, most participants found the aroma of SaT to be more pleasant than that of SpT.

4. Discussion

In this study, the two-bowl test was adapted to evaluate the palatability of lipopolysaccharide (LPS) supplement, with or without, flavoured semi-liquid treats for cats. The assessment incorporated various parameters, as defined by [14], including measures of "First Approached," "First Consumed," "Total Approached," "Total Consumed," and "Intake Ratio." Additionally, a sensory evaluation was conducted to assess the acceptability of the treat aromas by human participants.

The results demonstrated that cats consistently showed a marked preference for SaT + LPS, as opposed to plain SaT or SpT. On the other hand, LPS administered alone was notably aversive to the cats. These findings suggest that SaT may enhance the palatability of LPS when combined.

Table 2. Human olfactory assessment of treats' aroma.

Flavors of treat	Score			
	Least Pleasant (1)	Less Pleasant (2)	More Pleasant (3)	Most Pleasant (4)
Sprat (SpT)	13	10	8	5
Salmon (SaT)	8	5	10	13

Moreover, the cats displayed a stronger preference for SaT over SpT, aligning with prior research that suggests cats generally favour fish, especially salmon, over other flavours commonly found in commercial cat foods, such as liver, chicken, beef, or even rats [15]. Several factors influence feeding behaviour and preferences in cats, including flavour, aroma, texture, temperature, appearance, and size [9; 11].

Aroma appeared to be the dominant factor influencing the palatability of treats for cats, as indicated by the "First Approached" and "Total Approached" results. Most cats were attracted to SaT, whether with or without LPS. Similarly, the human sensory assessment revealed that SaT's aroma was generally rated as more pleasant than that of SpT. While these findings are significant, palatability involves both aroma and flavour [16], with flavour not being assessed in this study by human participants. Unlike humans, cats possess highly developed olfactory abilities [17] and rely on both aroma and taste to select their diets. Cats' olfactory systems are especially responsive to high-protein foods and fatty acids, which are abundant in salmon. As noted by [11], cats utilize their olfactory senses to detect and process various environmental chemicals, enabling them to distinguish both familiar and novel odours. Furthermore, the volatile compounds released by salmon during cooking likely contribute to its appeal to cats [18]. This heightened olfactory sensitivity may explain the cats' selective attraction to aromas.

Additionally, the protein content in treats may also play a role in palatability. SaT contains a higher protein content (10.5%) and lower carbohydrate content (1.4%) compared to SpT (protein: 7.9%, carbohydrate: 1.6%). Cats generally prefer high-protein and high-fat foods while avoiding those high in carbohydrates [19]. Research by [20] indicated that protein content significantly influences the amount of food consumed by cats, suggesting that they prioritize protein over carbohydrates, which is consistent with the current study's findings. Cats' low carbohydrate intake is associated with various sensory and metabolic adaptations, including the absence of sweet taste receptors, which prevents them from perceiving sweet flavours [19]. This is attributed to the pseudogenization of the T1R2 receptor. In contrast, cats have more sensitive umami receptors than humans, allowing them to detect a broader range of amino acids. As obligate carnivores, cats do not encounter sweet compounds in their diet, but their ability to detect proteins and amino acids is crucial for their nutritional needs [21]. Previous studies have demonstrated that cats favour foods with pronounced "umami" or savoury flavours, typically associated with high concentrations of amino acids [14, 20, 22]. Additionally, cats can recognize diets that meet their specific nutritional requirements, particularly their higher protein and amino acid needs, with taurine supplementation often included to ensure adequate intake [23].

Another factor influencing palatability is a cat's prior exposure to food, linked to neophobia and neophilia. Cats tend to show greater acceptance and preference (neophilia) for foods they are familiar with, while unfamiliar foods may induce hesitation or initial rejection (neophobia) [24]. Studies of feline food preferences support this notion, showing that when presented with multiple food options, cats often choose based on sensory properties such as aroma, flavour, and texture, as well as their past dietary experiences [25]. Maternal influences also shape food preferences in cats [18]. Kittens raised on a single food type are more likely to develop neophobia when exposed to new foods, whereas those exposed to a variety of meats early in life are less likely to exhibit this behaviour [26]. Domestic cats frequently show a preference for novel foods over their regular diet, although their exploratory behaviour does not always apply to all new foods, even those that meet their nutritional needs [27].

Overall, these findings have direct implications for product development in the pet food industry. The demonstrated preference for salmon-based treat suggests that incorporating highly palatable, high-protein ingredients such as salmon can enhance the acceptance of functional treats or supplements, particularly those containing bioactive compounds like LPS. This may guide the formulation of more effective, voluntarily consumed medication-delivery systems for companion animals.

5. Conclusions

The use of treats in this study revealed a clear feline preference for salmon over sprat, with the addition of LPS further enhancing overall

palatability. These findings align with previous research indicating that cats favor fish-based flavours, particularly salmon, and suggest that functional additives like LPS can be more readily accepted when delivered in a palatable matrix. To gain a more comprehensive understanding of feline dietary preferences, future research should explore additional variables such as food temperature, texture, and presentation. Importantly, these results highlight the potential clinical applications of treats. By improving the palatability of medications, treats offer a promising strategy to enhance treatment compliance in cats, especially for chronic or long-term therapies. This approach could simplify medication administration for pet owners and contribute to more effective veterinary care.

Availability of Data and Materials

All data are available in this study.

Author Contributions

Conceptualization, M.A; Funding acquisition, M.A.; Project administration, M.A., N.I., G.T.S., and M.F.W.C.; Supervision, M.A., N.I., G.T.S., and M.F.W.C.; Resources, M.A.; Methodology, M.A., N.I., G.T.S., and M.F.W.C.; Investigation, N.A.A.A.R. and A.R.R.; Data curation, N.A.A.A.R., A.R.R., and N.I.; Formal analysis, N.A.A.A.R., M.A., and N.I.; Software, N.I.; Visualization, N.I.; Validation, M.A., N.I., G.T.S., and M.F.W.C.; Writing – Original Draft, N.A.A.A.R., and N.I.,; Writing – Review & Editing, N.I., and M.A.

Ethics Approval and Consent to Participate

This study was approved under the permission and guidelines of the Institutional Animal Care and Use Committee (IACUC) of Universiti Putra Malaysia (UPM) with reference number UPM/IACUC/AUP-U031/2023.

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Funding

This research received no external funding.

Conflict of Interest

The authors declare no conflict of interest.

Abbreviations

LPS, lipopolysaccharide; MER, maintenance energy requirements; SpT, sprat-flavoured treat; SaT, salmon-flavoured treat; BCS, body condition score.

References

[1] Bouma, E.M., Reijgwart, M.L., & Dijkstra, A. (2021). Family member, best friend, child or 'just' a pet, owners' relationship perceptions and consequences for their cats. *International Journal of Environmental Research and Public Health*, *19*(1), 193. https://doi.org/10.3390/ijerph19010193.

[2] Taylor, S., Caney, S., Bessant, C., & Gunn-Moore, D. (2022). Online survey of owners' experiences of medicating their cats at home. *Journal of Feline Medicine and Surgery*, *24*(12), 1283-1293. https://doi.org/ 10.1177/1098612X221083.

[3] Thombre, A.G. (2004). Oral delivery of medications to companion animals: Palatability considerations. *Advanced Drug Delivery Reviews*, *56*(10), 1399-1413. https://doi.org/10.1016/j.addr.2004.02.012.

[4] Sivén, M., Savolainen, S., Räntilä, S., Männikkö, S., Vainionpää, M., Airaksinen, S., & Juppo, A.M. (2017). Difficulties in administration of oral medication formulations to pet cats: An e-survey of cat owners. *Veterinary Record*, *180*(10), 250-250. https://doi.org/10.1136/vr.103991.

[5] Petry, G., Fourie, J., & Wolken, S. (2014). Comparison of the palatability of a new flavoured Drontal® plus tablet (Drontal® plus treat 10 kg) and Milbemax® chewable

tablets when presented to privately owned dogs. *Open Journal of Veterinary Medicine*, *4*(8).https://doi.org/10.4236/ojvm.2014.48018 .

[6] *Nutrient Requirements of Dogs and Cats. Animal Nutrition Series. National Research Council of the National Academies,* (2006). Washington DC: National Academy Press.

[7] Koppel, K. (2014). Sensory analysis of pet foods. *Journal of the Science of Food and Agriculture*, *94*(11), 2148-2153. https://doi.org/10.1002/jsfa.6597.

[8] Li, T., Zhao, M., Raza, A., Guo, J., He, T., Zou, T., & Song, H. (2020). The effect of taste and taste perception on satiation/satiety: A review. *Food & Function*, *11*(4), 2838-2847. https://doi.org/10.1039/C9FO02519G.

[9] Pekel, A.Y., Mülazımoğlu, S.B., & Acar, N. (2020). Taste preferences and diet palatability in cats. *Journal of Applied Animal Research*, *48*(1), 281-292. https://doi.org/10.1080/09712119.2020.1786391.

[10] Sandau, M. M., Goodman, J. R., Thomas, A., Rucker, J.B., & Rawson, N.E. (2015). A functional comparison of the domestic cat bitter receptors Tas2r38 and Tas2r43 with their human orthologs. *BMC Neuroscience*, *16*, 1-11. https://doi.org/ 10.1186/s12868-015-0170-6.

[11] Aldrich, G.C., & Koppel, K. (2015). Pet food palatability evaluation: A review of standard assay techniques and interpretation of results with a primary focus on limitations. *Animals*, *5*(1), 43-55. https://doi.org/10.3390/ani5010043.

[12] Gross, K.L., Yamka, R.M., Khoo, C., Friesen, K.G., Jewell, D.E., Schoenherr, W. D., & Zicker, S. C. (2019). Macronutrients. In: Hand, *Small Animal Clinical Nutrition*, *5*, 49-105.

[13] Tobie, C., Péron, F., & Larose, C. (2015). Assessing food preferences in dogs and cats: A review of the current methods. *Animals*, *5*(1), 126-137. https://doi.org/10.3390/ani5010126.

[14] Watson, P.E., Thomas, D.G., Bermingham, E.N., Schreurs, N.M., & Parker, M.E. (2023). Drivers of palatability for cats and dogs—What it means for pet food development. *Animals*, *13*(7), 1134. https://doi.org/10.3390/ani13071134.

[15] Adamec, R.E. (1976). The interaction of hunger and preying in the domestic cat (*Felis catus*): An adaptive hierarchy? *Behavioral Biology*, *18*(2), 263-272. https://doi.org/ 10.1016/S0091-6773(76)92166-0.

[16] Houpt, K.A., Hintz, H.F., & Shepherd, P. (1978). The role of olfaction in canine food preferences. *Chemical Senses*, *3*(3), 281-290.

[17] Neufield, K., & Düngelhoef, M. (2012). Synergies of different flavours for dog and cat food: olfactory sense better developed. *Kraftfutter*, *95* (3–4), 15-18.

[18] Bradshaw, J.W. (2006). The evolutionary basis for the feeding behavior of domestic dogs (*Canis familiaris*) and cats (*Felis catus*). *The Journal of Nutrition*, *136*(7), 1927S-1931S. https://doi.org/10.1093/jn/136. 7.1927S.

[19] Hewson-Hughes, A.K., Hewson-Hughes, V.L., Miller, A.T., Hall, S.R., Simpson, S.J., & Raubenheimer, D. (2011). Geometric analysis of macronutrient selection in the adult domestic cat, *Felis catus*. *Journal of Experimental Biology*, *214*(6), 1039-1051. https://doi.org/10.1242/jeb.049429.

[20] Salaun, F., Blanchard, G., Le Paih, L., Roberti, F., & Niceron, C. (2017). Impact of macronutrient composition and palatability in wet diets on food selection in cats. *Journal of Animal Physiology and Animal Nutrition*, *101*(2), 320-328. https://doi.org/10.1111/jpn.12542.

[21] Laffitte, A., Gibbs, M., Hernangomez de Alvaro, C., Addison, J., Lonsdale, Z.N., Giribaldi, M.G., & McGrane, S.J. (2021). Kokumi taste perception is functional in a model carnivore, the domestic cat (*Felis catus*). *Scientific Reports*, *11*(1), 10527. https://doi.org/10.1038/s41598-021-89558-w.

[22] Alegría-Morán, R.A., Guzmán-Pino, S.A., Egaña, J.I., Sotomayor, V., & Figueroa, J. (2019). Food preferences in cats: Effect of dietary composition and intrinsic variables on diet selection. *Animals*, *9*(6), 372. https://doi.org/10.3390/ani9050219.

[23] Zafalon, R.V.A., Risolia, L. W., Vendramini, T.H.A., Rodrigues, R.B.A., Pedrinelli, V., Teixeira, F.A., & Brunetto, M.A. (2020). Nutritional inadequacies in commercial vegan foods for dogs and cats. *PLoS One*, *15*(1), e0227046. https://doi.org/10.1371/journal.pone.0227046.

[24] Kumar, R., & Goswami, M. (2024). Exploring palatability in pet food: Assessment methods and influential factors. *International Journal of Livestock Research*, *14*(4), 7-11.

[25] Bourgeois, H., Elliott, D., Marniquet, P., & Soulard, Y. (2006). Dietary behavior of dogs and cats. *Bulletin de L'Académie Vétérinaire de France*, *159*(4), 301-308.

[26] Watson, T. (2011). Palatability: Feline food preferences. *Vet Times*, *41*(21), 6-10.

[27] Stasiak, M. (2002). The development of food preferences in cats: The new direction. *Nutritional Neuroscience*, *5*(4), 221-228. https://doi.org/10.1080/1028415021000001799.

performance and efficiency of beef production in Western High Lands. *Vietnam Journal of Agricultural Sciences, 20(6)*: 741–750. [in Vietnamese].

[31] Xuan D. (2016, May 12). Technics for BBB crossbred cattle production. Lam-Dong Agricultural Extension Centre. Retrieved May 12, 2016, from https://khuyennong.lamdong.gov.vn/hoat-dong-khuyen-nong/chuyen-giao-khkt/217-k-thu-t-nuoi-bo-bbb. [in Vietnamese].

[32] Southern breeding livestock company limited. (2020, May 28). Technics for BBB cattle crossbreeding. Southern Livestock Breeding Limited Company. Retrieved Mar 28, 2020, from https://giongmiennam.com/ky-thuat-lai-tao-giong-bo-bbb-3b[in Vietnamese].

[33] Van Dinh. (2017, May 11). Technics for BBB cattle crossbreeding. Vietnam Animal Husbandry. Retrieved May 11, 2017 from https: *Vietnam J. Agri. Sci.,* //nhachannuoi.vn/ky-thuat-chon-giong-bo-bbb/ [in Vietnamese].