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Noodle waste as a functional ingredient in canine biscuits formulation: Nutritional characterisation and palatability evaluation in dogs

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Abstract

The growing demand for sustainable, cost-effective and nutritious pet foods has encouraged the exploration of alternative ingredients in canine diets. This study evaluated the use of noodle waste (NW), a by-product from the food processing industry, as a functional substitute for maize in dog complete feed biscuit formulations. NW was incorporated at 0%, 25%, 50% replacement levels and the resulting biscuits were analysed for proximate composition, colour, and palatability in Labrador dogs. The NW exhibited high metabolizable energy (4032.25 kcal/kg DM), crude protein (11.2%) and ether extract (16.28%), indicating its potential as an energy-rich feed ingredient. Nutritional profiling showed that biscuits with up to 50% NW remained isonitrogenous and isoenergetic. Colour analysis revealed no significant variation ($p > 0.05$) across treatments, thereby preserving visual appeal. Palatability testing showed no significant differences in intake ratio or first choice at 25% inclusion compared to control and 50% NW-based biscuits. The study concludes that NW can successfully replace maize up to 50% in dog biscuits without compromising nutritional value, appearance or palatability. This finding demonstrates the potential of noodle waste as a sustainable, safe and effective ingredient in functional pet food products.

Keywords: Noodle waste, Complete feed Dog biscuits, Pet food, Palatability, Nutritional profiling

Introduction

Nowadays, pet dogs are increasingly regarded as integral members of families worldwide (Deuri *et al.*, 2019) ^[1]. The rapidly expanding 'Pet Economy' has transformed how people view companion animals. Today, pet food products are distinguished by several specific features, including appearance, texture, aroma, shape, and branding aspects such as country of origin and brand image (Boya *et al.*, 2015) ^[2]. Globally, there is a noticeable shift in consumer preference toward healthier, more nutritious and organic pet food options (Chauhan, 2017) ^[3]. Industry reports suggest that the Indian pet food market has surpassed 50,000 tonnes, with an annual growth rate of 10-15%. This trend has significantly increased the local production of pet food nationwide. Ensuring that a dog receives the best possible treat is the responsibility of the pet owner. This involves offering healthy snacks made from high-quality ingredients. Dry pet foods, such as biscuits and treats, are widely favoured due to their convenience in storage, ease of feeding, and cost-effectiveness (Pandey 2012) ^[4].

Dog biscuits are hard, snack-like supplements designed for dogs and other canines, resembling human treats in form. Dog biscuits can supplement nutrients that may be lacking in a dog's regular diet. Their low moisture content helps prevent mould and bacterial contamination, ensuring a longer shelf life. With growing interest among vegetarian pet owners, the popularity of vegetarian dog biscuits is expected to rise. Additionally, incorporating "human-grade" and natural ingredients into biscuit formulations meets specific needs based on breed, age, gender, size, or dietary restrictions such as allergies. The demand for pet food products has surged, particularly in countries like China and India, following concerns about the safety of US-manufactured pet foods (Pet Industry in India and China, 2017).

The formulation of most commercial pet foods relies on nutritional data from ingredients

sourced from publicly accessible databases (Morelli *et al.*, 2021) [6]. According to Souza *et al.* (2022) [7], the production of various foods for dogs and cats utilises by-products or leftovers from human food processing. This approach supports the concept of nutritional ecology, where waste from one phase of the food production chain is repurposed in subsequent stages for pet food formulation. Commonly used ingredients in biscuit preparation include wheat flour, sugar, salt, baking powder, milk, and various flavouring agents (Obasi *et al.*, 2012) [8]. Rice and wheat flour blends are commonly utilised in biscuit production, with rice flour typically incorporated at levels up to 20% (Rossel 2014). Corn flour is often blended with other flours in varying proportions. For example, in bread making, it can be used in combination with wheat or rice flour at a rate of up to 50% (Zhou 2014) [10].

Due to the rising costs and limited availability of traditional feed ingredients, further intensified by competition between human and animal consumption and insufficient emphasis on feed production, there is a growing interest in exploring cost-effective agro-industrial by-products as alternative feed sources (Tiwari and Dhakal, 2021). Due to its abundance and high energy value, bakery waste (BW) has gained attention as a potential alternative to maize in animal feed formulations (Yadav *et al.*, 2014). India generates significant amounts of BW that can be effectively utilised in animal feed. For example, in 2017, India produced approximately 16.6 thousand metric tons of cakes, pastries, and muffins, along with around 257 thousand metric tons of bread, buns, and croissants (Statista, 2021). In 2024, the Indian bakery market recorded a 9.12% compound annual growth rate (CAGR) and a value of \$ 13.8 billion (www.imarcgroup.com). BW generally consists of a diverse assortment of discarded bakery items (Macgregor, 2000). The term "ex-food" describes two main categories of food industry by-products: one primarily consisting of bakery items, such as bread and pasta, and the other mainly composed of confectionery products, including chocolates and biscuits. Items like bread, savoury cakes, and snacks undergo extended baking processes, making them high in starch and a readily digestible, energy-rich feed source (Pinotti *et al.*, 2019).

Noodle waste (NW), a byproduct from the food processing industry, is frequently utilised as feed for livestock. It presents several benefits compared to other non-conventional feed ingredients, primarily because it is originally manufactured for human consumption and is usually packaged under sanitary conditions, thereby minimising contamination risks. NW is also free from anti-nutritional factors and is rich in energy content (Eniolorunda *et al.*, 2008). Noodles can be produced from a variety of ingredients such as rice, buckwheat, wheat, potatoes, legumes, and cereal-based starches (Fu, 2008). Research indicates that NW meal has a nutritional profile comparable to maize, offering around 3799 kcal/kg of metabolizable energy (ME), 89% dry matter (DM), 8.57% crude protein (CP), and 17.14% ether extract (EE). In comparison, maize contains approximately 3315 kcal/kg ME, 91.8% DM, 8.9% CP, and 4% fat (Laila *et al.*, 2010). As a result, NW serves as a cost-effective and efficient alternative to maize, one of the primary conventional ingredients in animal feed (Omole *et al.*, 2013). Recent research in dog biscuit formulation has focused on incorporating novel and sustainable ingredients such as insect protein, upcycled BW, plant-based additives like inulin, spirulina and psyllium fibre to enhance nutrition, digestibility, and palatability. But there is a lack of studies on the utilisation of NW inclusion in dog

biscuit formulation. Thus, the present study was undertaken to evaluate the nutritional composition of NW-based dog biscuit and their effect on the palatability of dogs

Materials and Methods

Noodle Waste (NW)

The NW used in the study was sourced from Forplanet Ingredients Pvt. Ltd., located in New Delhi.

Experimental design and treatments

The research was carried out at the Department of Animal Nutrition, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana-141004, Punjab, India. All feed samples were dried at 60°C for 36 hours using a forced hot air oven, then ground using a Wiley mill and passed through a 1 mm sieve. The dried feed ingredients, comprising maize grains, noodle waste, wheat flour, black gram, skim milk powder, flax seeds, soybean meal, deoiled rice bran, oil, limestone powder, dicalcium phosphate, and salt, were thoroughly mixed with feed additives and homogenised using an electric blender. Experimental diets for Labrador dogs were formulated according to established nutritional standards (AAFCO 2007; ICAR 2013), with NW incorporated at 0%, 25%, and 50% levels by partially replacing maize grains.

Preparation of NW-based dog biscuits

The base ingredients for the NW-based complete dog biscuits were combined to prepare dough in three different formulations: 0%, 25%, and 50% NW, respectively. The dough was formed by blending refined wheat flour with the remaining ingredients and hydrogenated vegetable oil for approximately 3 minutes. It was then rolled out on a wooden surface using rolling pins. The flattened dough was cut into specific shapes using a biscuit cutter. Shaped biscuits were baked in a preheated oven at 200°C for 20 minutes. After baking, the biscuits were allowed to cool and temper at room temperature. Both the control and test biscuits containing varying proportions of NW and maize were aseptically packed in pre-sterilized low-density polyethylene (LDPE) bags (100 gauge) and stored at room temperature.

Proximate analysis

The biscuit samples were analysed for DM, total ash, EE, crude fiber and nitrogen content by the Kjeldahl method (AOAC 2007). Organic matter (OM) was calculated by subtracting the ash content from the DM value. The nitrogen-free extract (NFE) was computed using the formula: $NFE (\%) = 100 - [Protein (\%) + Fat (\%) + Fiber (\%) + Ash (\%)]$. Metabolizable energy (ME) was estimated using the modified Atwater equation recommended by ICAR (2013): $ME (kcal/kg) = [3.5 \times CP (\%) + 3.5 \times NFE (\%) + 8.5 \times Crude Fat (\%)] \times 10$

Colour analysis

L^* , a^* , and b^* values of developed biscuits were recorded by performing the instrumental colour analysis using a Chroma meter (Konica Minolta- CR-300), and values were presented as L^* (+lightness/- dark) a^* (+red/-green) and b^* (+yellow/-blue) values. Calibration of the device was carried out according to the manufacturer's standard procedures. Colour measurements were taken from both surfaces at three distinct points.

Palatability test in dogs

A two-plate palatability test based on the method described by

Souza *et al.* (2019) was conducted to assess the acceptance of NW-based biscuits by dogs. Ten Labrador dogs (14-16 months of age, 24.5 ± 0.688 kg body weight) were randomly divided into two groups. The dogs were housed individually in kennels and fed in accordance with nutritional standards outlined by AAFCO (2007) and ICAR (2013). Group I was offered a choice between the control biscuits (T_1) and those containing 25% NW (T_2), while Group II was tested with the control biscuits (T_1) and biscuits with 50% NW inclusion (T_3). This evaluation was conducted over three consecutive days to ensure accurate assessment of palatability.

Each day at 09:00 a.m., five dogs were simultaneously presented with both control and test biscuits in two separate bowls. The amount offered exceeded the dogs' daily maintenance requirement by 30%. Once one of the bowls was emptied, both were removed, and the leftovers were recorded. To avoid location-based preference, the position of the bowls was alternated on the second and third days. Palatability was determined based on the intake ratio and the dog's first choice, identified by observing which bowl the dog approached first. The intake ratio was calculated using the following formula to determine the quantity of biscuits offered and the amount left uneaten.

$$\text{Intake ratio} = \frac{\text{g of control or experimental food intake}}{\text{g of total food consumed (control + experimental)}} \times 100$$

Statistical analysis

The experimental data were analysed using a completely randomised design with treatment considered as the independent variable. Standard statistical methods were employed using SPSS version 20.0, and significance was assessed at the $P < 0.05$ level. To identify any significant differences among the treatment groups (based on different levels of noodle waste inclusion), Tukey's b test was performed. The statistical model used was

$$Y_{ij} = \mu + T_i + \epsilon_{ij}$$

Where, Y_{ij} is each observation; μ is the overall mean; T_i is the effect of the treatment, and ϵ_{ij} is the residual error. Palatability was assessed by evaluating the dogs' initial food preference using Fisher's Exact Test ($P < 0.05$), while the intake ratio was analysed using the Student's t-test ($P < 0.05$).

Results and Discussion

Proximate and energy analysis of NW

The analysis of NW revealed that it contained 11.20% CP, 16.28% EE, 1.48% crude fiber, 2.52% total ash, 97.48% OM, 96% DM and 64.47% NFE (Fig. 1). On a dry matter basis, the gross energy (GE) was calculated at 4800.29 kcal/kg while the ME was 4032.25 kcal/kg. The elevated EE and ME values suggest that NW is a highly energy-rich ingredient.

These results are comparable to those reported by Aderolu *et al.* (2011), who reported similar CP (12.94%) and EE (18.05%) values, although they observed a slightly lower CF content (1.25%), suggesting a marginally higher proportion of indigestible components in the NW used in the present study.

In contrast, Laila *et al.* (2010) reported lower DM (89%), CP (8.57%) and ME (3799 kcal/kg) but a slightly higher EE (17.14%) than those recorded in this study. Narayanan *et al.* (2009) also reported lower values for all proximate components in biscuit waste compared to the present noodle waste findings, except for a nearly identical NFE value of 64.19%. As noted by Animashahun *et al.* (2018), the high starch content in noodle waste contributes significantly to its energy value, making it a suitable source for meeting the maintenance energy requirements of animals.

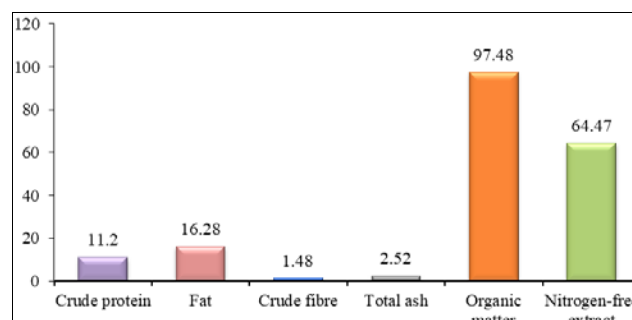


Fig 1: Nutrient composition of noodle waste (% DM basis)

Formulation and nutrient profiling of NW-based pet biscuits

The experimental diets were formulated by replacing maize with NW at inclusion levels of 0%, 25%, and 50% on a DM basis (Table 1). To maintain uniform nutritional quality across all diets, the proportions of black gram, soybean meal, and oil were adjusted, ensuring the diets were isonitrogenous and isoenergetic.

The nutritional analysis of NW-based biscuits revealed that the key proximate components, including CP, CF, EE, NFE, and ME, remained largely consistent across all dietary treatments (Table 2). However, an increase in ash content was observed with higher inclusion levels of NW, rising from 5.8% to 6.15%. As a result, there was a slight reduction in OM content, decreasing from 94.2% to 93.85%. When compared to the findings of Muthulakshmi *et al.* (2024), who reported 16.62% protein, 18.23% fat, and 3.08% ash in biscuits containing chicken skin, the NW-based formulation used in this study demonstrated a higher CP level, moderate fat content, and significantly ($p < 0.05$) greater ash values. This variation is likely due to the fact that the current formulation was designed as a nutritionally complete feed, aligning with the dietary requirements of canines.

In contrast, Virk *et al.* (2019) adopted a more straightforward approach by incorporating 10-30% poultry liver and gizzard in place of wheat flour, along with a fixed 2% inclusion of dicalcium phosphate. Likewise, Muthulakshmi *et al.* (2024) formulated their diets using various animal-based proteins, such as chicken meat, skin, and meat-and-bone meal, combined with cereal ingredients like wheat, rice, maize flour, and rice bran, and supplemented with sugar and leavening agents. Thus, NW-based diets in this biscuit trial represent a more diverse plant-based formulation whereas the previous diets focused primarily on enhancing palatability and protein content through animal-derived components.

Table 1: Formulation of NW-based pet biscuits

Ingredients	% Replacement of maize with noodle waste		
	0	25	50
	T ₁	T ₂	T ₃
Maize	41.00	28.25	15.50
Noodle waste	0.00	12.75	25.50
Wheat flour	10	10	10
Skim milk	2.00	2.00	2.00
Black Gram	0.86	4.36	8.86
Flax seed (Alsi)	1.00	1.00	1.00
Soyabean meal	24.00	22.00	19.00
Deoiled rice bran	8.00	8.00	8.00
Hydrogenated vegetable oil	10.00	8.50	7.00
Limestone powder	0.90	0.90	0.90
Dicalcium phosphate	0.70	0.70	0.70
Salt	0.70	0.70	0.70
Feed additive	0.84	0.84	0.84
Emulsifier	0.03	0.03	0.03
Enzyme cocktail	0.05	0.05	0.05
Butylated hydroxytoluene	0.05	0.05	0.05
Bioplex organic trace minerals premix	0.20	0.20	0.20
Acidifier/pot. Sorbate	0.20	0.20	0.20
Mycosorb	0.05	0.05	0.05
Dried yeast	0.20	0.20	0.20
Vitamin B complex	0.02	0.02	0.02
Vitamin B ₁₂	0.025	0.025	0.025
Vitamin premix (A, D, E)	0.015	0.015	0.015

Table 2: Nutrient profiling of NW-based pet biscuits

Parameters	% Replacement of maize with noodle waste		
	0	25	50
	T ₁	T ₂	T ₃
Crude protein,%	18.55	18.62	18.59
Fat,%	12.4	12.5	12.6
Crude fibre,%	5.41	5.24	5.23
Total ash,%	5.8	5.9	6.15
Organic matter	94.2	94.1	93.85
Nitrogen-free Extract	57.84	57.74	57.43
Gross energy, kcal/kg	4545.91	4555	4550.85
Metabolizable energy, kcal/kg	3727.65	3735.1	3731.7

Colourimetric evaluation of NW-based pet food biscuits

The statistical evaluation of the colour parameters (L^* , a^* , and b^*) of pet biscuits (Table 3) containing varying levels of NW (0%, 25%, and 50%) revealed no significant differences ($P > 0.05$) among the treatments. Lightness values (L^*) remained uniform across all formulations ($P = 0.308$), indicating that the addition of NW had minimal impact on surface browning or moisture loss during the baking process. Similarly, the redness component (a^*) did not show any notable variation ($P = 0.218$). However, minor shifts may have resulted from Maillard reactions between the proteins and carbohydrates present in NW, subtly influencing crust colouration without leading to statistically significant changes. The b^* values, which indicate yellowness, also remained statistically unchanged ($P = 0.120$). Slight variations

observed could be linked to natural pigments in ingredients such as wheat flour from the NW, but these were insufficient to significantly affect the overall yellowness of the biscuits. Previous studies have reported more pronounced colour changes with different protein sources. For example, Bukya *et al.* (2013) observed increased L^* and reduced b^* with defatted chicken meat, while control biscuits exhibited greater a^* . Virk *et al.* (2019) documented higher L^* , a^* , b^* values in biscuits enriched with 30% chicken liver and calcium, enhancing their visual appeal. Similarly, Zielińska and Pankiewicz (2020) found significant changes in all colour parameters when insect meal was incorporated into biscuit formulations. Unlike these findings, the present study suggests the inclusion of NW up to 50% without compromising product appearance and has no significant impact on the visual colour traits of the biscuits.

Table 3: Colour evaluation of NW-based pet food biscuits

Colour	% Replacement of maize with noodle waste			SEM	P-value
	0	25	50		
	T ₁	T ₂	T ₃		
L^*	45.0	41.5	44.1	0.978	0.308
a^*	5.36	4.99	5.91	0.221	0.218
b^*	18.1	16.6	18.4	0.385	0.120

L^* (lightness), a^* (red-green), and b^* (yellow-blue) values

Preference testing and acceptability of NW-based biscuits in dogs

The palatability trial indicated that the inclusion of NW in the biscuit composition did not significantly influence dogs' acceptance compared to the control group. Dogs showed similar preference for the control biscuits (T_1) and the 25% NW-based biscuits (T_2), with no significant difference observed in first-choice selection ($P = 0.052$) or intake ratio ($P = 0.848$), suggesting both were equally accepted. In contrast, when comparing the T_1 with the 50% inclusion group (T_3), dogs exhibited a greater preference for the control biscuits, as reflected by preference and a higher intake ratio (Table 4). However, these differences were not statistically significant ($P > 0.05$), indicating that even at higher inclusion levels, NW did not markedly reduce palatability. These findings align with those of Celegatti *et al.* (2021), who observed no differences in preference among dogs fed vegan biscuits containing ingredients like inulin and blackberry flour. Conversely, Poppi *et al.* (2023) reported a strong preference for meat-based biscuits rich in protein and fat, highlighting dogs' inclination toward animal-derived flavours.

Table 4: First choice and intake ratio of dog fed different NW-based pet biscuits

Variable	Control	Experimental	SEM	P-value
Control (T_1) versus T_2				
First choice	5	5	-	0.052
Intake ratio ¹	0.48	0.52	0.096	0.848
Control (T_1) versus T_3				
First choice	6	4	-	0.197
Intake ratio	0.537	0.463	0.091	0.700

¹Intake ratio is: g of control or experimental food intake/g total food consumed (control + experimental) $\times 100$.

Conclusion

Replacing maize with noodle waste up to 50% in complete feed dog biscuits resulted in a nutritionally balanced, visually appealing and well-accepted product. The formulations maintained isonitrogenous and isoenergetic properties with higher ash content, enhancing mineral density. No significant changes in colour or palatability were observed at the 50% level, indicating strong potential for sustainable utilisation of NW. These findings support its effective inclusion in biscuit-based canine diets, comparable to its use in conventional pelleted feed formulations.

Author contributions

J.S. Hundal and Nitin Mehta contributed to the study conceptualization. Material preparation, data collection and analysis were performed by Nilakshi Patil. The manuscript draft was prepared by Nilakshi Patil, J.S. Hundal and P. Kumar. R Kalola reviewed and edited the manuscript. All authors have read and approved the final manuscript.

Conflict of Interest

Not available

Financial Support

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