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Physicochemical Properties of Premium, Standard and Economic Commercial Cat Foods in Malaysia

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Abstract

The importation of cat food into Malaysia has been very phenomenal of late. At the moment, there is no clear legislation with regards to the quality and established standards for cat food imported into Malaysia. In this study, 2 cohort of cat food flavoured chicken (dry) and tuna (wet) were sampled. For each cohort, the cat food were categorised into premium, standard and economy. Composite samples were made from each of these categories and analysed. The macro-nutrients Ca, P, Mg, K, Na and Cl^- in the premium, standard and economy dry cat food products are above the recommended values given by The Association of American Feed Control Officials (AAFCO), with some marginal concession recorded for elemental K. For wet cat food, all the studied macro-nutrients were below the recommended values given by AAFCO, with exception of elemental Cl^- (in premium wet cat food). It is interesting to note that premium wet cat food, had significantly lower macro-nutrient concentrations compared to standard and economy wet cat food ($p<0.05$). Therefore, the quality of dry cat food in premium, standard and economy is good. However, the quality of wet cat food in premium, standard and economy is below par from the recommendation of AAFCO.

1. Introduction

It has been estimated that, cat food industry alone in Malaysia is worth USD 40 million annually (Amir & Mona, 2013) and expected to grow at 2%. This industry is dominated by Thailand followed by the United States, Australia and the European Union nations. To date, there is no local player involves in manufacturing cat food product in Malaysia, even though a few foreign players do produce but for export. Thus, it is high time that the Malaysian government, through the Veterinary Department to outline the legislation on cat food products in order to control the cat feed quality and to ensure the products are safe and also 'halal' since majority of the cat owners in Malaysia are Muslims (Amir & Mona, 2013). Macro-nutrients are the fundamental structural components of body-organs and tissues such as

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Calcium (Ca), Magnesium (Mg) and Phosphorus (P) for bones and cartilage formation, whilst Sodium (Na), Potassium (K) and Chloride (Cl^-) are for enzyme based reactions, acid-base balance; aiding oxygen movement in the blood stream, hormones production, transmission of nerve impulses and muscle contraction (NRC 2006; Wedekind et al. 2013). The main source of macro-nutrients derived from green leafy vegetables, sardine, salmon, nuts for calcium; muscle, offal, beans, poultry for phosphorus; while potassium can be derived from meat, whole grains, fish and poultry; magnesium from leafy chlorophyll, meat, bean, whole grain and sodium chloride the main source for salt. In this paper, the macro-nutrients of commercial cat foods in Malaysia were determined based on the recommended values set by The Association of American Feed Control Officials (AAFCO).

2. Materials and methods

2.1 Samples

The samples were bought from pet-shops in Malaysia covering the three categories which were premium, standard and economy of cat food products available locally. The categorization of the cat food according to premium, standard and economy were done based on the prices (Table 1).

Table 1: Categorization of premium, standard and economy cat food

Class / Cohort	Approx. Price/kg (USD) Premium	Standard	Economy
Chicken flavoured kibbles (dry)	13	7	2
Fish flavoured canned cat foods (wet)	46	24	17

Later, the country of origins, ingredients, and price of cat food for 2 cohorts, chicken flavoured kibbles (dry) and fish flavoured canned cat foods (wet) were documented (Table 2 & Table 3). From each of the category (premium, standard and economy), ten composite samples were prepared. Each composite sample comprises of fifteen samples of cat food. Every composite dry sample, fifteen samples were emptied into a clean sterilised glass bowl, thoroughly mixed, half and then quarter. The samples were dried for 6 hours at 105°C and later ground using commercial kitchen blender (model OmniBlend1) in order to achieve homogenised fine powdered granules. All individual samples were tagged and packed into a plastic bag and stored at -20°C prior to analysis. Wet composite samples underwent the same mixing process, except being freeze-dried for 72 hours, ground and stored as described for dry samples.

2.2 Instruments and calibration

Acid digestions of the samples were done as suggested by Ruth (2005). The samples and the blank were analyzed with Inductive Coupled Plasma - Mass Spectrometry (Perkin-Elmer) (ICP-MS). ICP-MS was calibrated using concentration range of standard stock solution for the following nutrients for dry and wet cat food: calcium (Ca) and potassium (K): 5.0 mg/L, 10.0 mg/L, 30.0 mg/L, 50.0 mg/L, 100.0 mg/L; phosphorus (P) and sodium (Na): 5.0 mg/L, 10.0 mg/L, 50.0 mg/L; magnesium (Mg): 5.0 mg/L, 10.0 mg/L, 30.0 mg/L. Chloride (Cl-) was determined using Mohr method (Deniz, 1998), whereas the procedure and calculation were done as suggested by Skoong et al.,(1996) and Deniz (1998). The pH meter (CRISON, Micro pH 2001) was calibrated with pH 4 and pH 7 buffer solutions and readings were later taken in the aqueous solution. For moisture analysis, the oven was set at 105°C for 24 hours prior to drying.

2.3 Standard solution and reagents

All reagents used were of analytical grade. Distilled water was utilised throughout the analytical procedure.

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Table 2: Category, country of origin and ingredients of dry chicken flavour cat food.

Class	Origin	Ingredients	Approx. Price/kg (USD)
Premium	Italy	Fresh chicken and turkey meat, rice, corn gluten, dehydrated chicken and turkey meat, maize, poultry fat, beef pulp, flaxseed, maize oil, pea fire, brewer yeast	13
Standard	USA	Chicken by products meal, corn gluten meal, rice, corn meal, chicken fat, dried beef pulps, chicken liver digest, dried egg product, fish meal, brewer’s yeast	7
Economy	Thailand	Chicken-by-product meal, fish meal, fat removed soy, corn, rice, wheat bran, vegetable oil, seafood flavour, chicken flavour, vegetable flavour.	2

Table 3: Category, country of origin and ingredients of wet fish flavour cat food.

Class	Origin	Ingredients	Approx. Price/kg (USD)
Premium	Australia	Tuna, Sea bream, gelling agents, and vitamin E	46
Standard	Australia	Tuna, sardine, vegetables gels, oligo-sugar, vitamins and minerals	24
Economy	Thailand	Tuna red meat, gelling agents, soybean oil, vitamins and minerals	17

Glassware were thoroughly cleaned by soaking in 10 % HNO3 solution and rinsed with distilled water before usage. Deionised water, nitric acid (HNO3, 1.2 %), hydrochloric acid (HCl), Aqua Regia Solution (3 HCl: 1 HNO3), stock standard solutions of P, K, Ca, Mg, Na (1000 mgL-1) from MERCK were used for standard solution preparation. Blank samples were prepared by adding 4 ml of Aqua Regia Solution into digestion tubes set at 110°C. Two blank samples were prepared and analysed along with the cat food samples for each batch of analysis.

2.4 Wet digestion procedure

Fined ground cat food sample was weighed (0.5g) and placed into the digestion tube. Ten replicates for each sample were done. 4ml Aqua Regia Solution was added into every digestion tubes, then transferred to digestion blocks in the fume hood and digested at 110°C. Acid-washed glass beads were added into the digestion tubes to prevent squirting of the samples. In order to enhance the digestion quality, HCl acid with the presence of HNO_3 were used as suggested by Matthew et al. (2011) and Zarcina et al. (1987). When the samples were digested about 1 ml, the digestion tubes were cooled at room temperature.

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Ten ml of 1.2% of HNO_3 was then added into every digestion tube and the temperature of the digestion blocks was increased to 80^0C for 30 minutes. The samples were then marked up to 20 ml with deionised water and shaken using vortex mixer. Then, the samples were filtered into volumetric flask with Whatman filter paper (No. 42). The volumetric flasks were marked up to 50 ml with deionised water.

2.5 Statistical analysis

Data collected were analysed using SPSS (version 16). Analysis of Variance (ANOVA) was used to analyse whether there is any significant differences in the macro-nutrient contents among the premium, standard and economy cat food. If any of the results showed there is significant differences, Tukey post-hoc test was conducted to observe which category of cat food show significant result. Additionally, Ca:P ratio in the sample was also calculated.

3. Results

For chicken flavoured kibbles, Mg, K, Na, and moisture were found to be significantly different among the premium, standard and economy cat food. For Ca, P, and pH, either one of the category were significant among the premium, standard and economy cat foods. However, no significant differences found in Cl for the premium, standard and economy cat food. All the macro-nutrients in premium, standard and economy of dry cat food were above the AAFCO recommended levels, with the exception of K.

Fish flavoured canned cat foods (wet) cat food, Ca, P and Na, were found to be significantly different among the premium, standard and economy cat food. For Mg, K, Cl, moisture and pH, either one of the category were significant among the premium, standard and economy cat food. However, the macro-nutrients, Ca, Mg, K and Na in premium, standard and economy of fish flavoured wet cat food were below the AAFCO recommended levels, with the exception for the K and Cl.

For the cohort chicken flavoured kibbles, all the Ca:P were within the range of recommended value of AAFCO. However, for the cohort fish flavoured canned cat foods (wet) cat food, premium and standard category did not achieve the AAFCO standard.

Table 4: Macronutrients in chicken flavoured kibbles (%) by premium, standard and economy category.

Macronutrients / Category	Ca	P	Mg	K	Na	Cl-	Moisture	pH
Premium	0.88 ± .05 a	0.895 ± .03 a	0.088 ± .00 a	0.33 ± .01 a	0.47 ± .04 a	0.78 ± .07 a	8.40 ± .44 a	4.99 ± 0.03 a
Standard	1.12 ± .05 b	0.812 ± .02 b	0.091 ± .00 b	0.48 ± .01 b	0.28 ± .01 b	0.75 ± .06 a	9.36 ± .30 b	5.02 ± 0.04 a
Economy	1.08 ± .03 b	0.922 ± .04 a	0.178 ± .00 c	0.80 ± .01 c	0.35 ± .02 c	0.77 ± .07 a	7.51 ± .32 c	5.53 ± 0.01 b
Mean±s.d	1.02±.04	0.88 ±.03	0.092±.00	0.54±.01	0.37±.02	0.77±.07	8.42±.35	5.18±.03
AAFCO Standard	0.6	0.5	0.04	0.6	0.2	0.3	-	-

Note: Means in the column followed by the different letter are significantly different $p<0.05$, $\alpha = 0.05$.

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Table 5: Macronutrients in fish flavoured canned cat foods (%) by premium, standard and economy category.

Macronutrients / Category	Ca	P	Mg	K	Na	Cl⁻	Moisture	pH
Premium	0.00 ± .00a	0.107 ± .01a	0.017 ± .00a	0.23 ± .03a	0.08 ± .04a	0.60 ± .05a	81.86 ± 1.83a	6.39 ± .14a
Standard	0.02 ± .00b	0.087 ± .02b	0.016 ± .00a	0.29 ± .02b	0.17 ± .01b	0.63 ± .06a	84.67 ± 3.19b	6.26 ± .06b
Economy	0.15 ± .01c	0.217 ± .02c	0.013 ± .00b	0.25 ± .02a	0.14 ± .01c	0.42 ± .04b	84.92 ± 0.93b	6.22 ± .03b
Mean±s.d	0.06 ±.00	0.137±.01	0.015±.00	0.26±.02	0.13±.02	0.55±.05	83.82±1.98	6.29±.08
AAFCO	0.6	0.5	0.04	0.6	0.2	0.3	-	-

Note: Means in the column followed by the different letter are significantly different $p<0.05$, $\alpha = 0.05$.

Table 6: The Ca : P ratio of different category of cat foods in Malaysia.

Cat foods	Category	Ca:P ratio*
Chicken flavoured kibbles (dry)	Premium	0.99:1
	Standard	1.38:1
	Economy	1.17:1
Fish flavoured canned (wet)	Premium	0:0.17
	Standard	0.22:1
	Economy	0.68:1

*AAFCO recommended value is 1.3 :1 (NRC, 2006)

4. Discussion

In comparing the macro-nutrient in dry chicken flavoured kibbles and the wet fish flavoured cat food, fish flavoured cat food failed to achieve the AAFCO standard with exception for Cl. The quality of the cat foods is affected by the raw materials used. Premium cat food used fresh meat instead of meat meal or meat-meal by-product and addition of dehydrated chicken and turkey may have caused the Na and Cl^- to be high. Meanwhile, fish based raw materials were known to be inferior in macro-nutrients concentration as compared to meaty based raw materials (Decuyrere, 2013). In all three category of wet cat food (premium, standard and economy) the macro-nutrients percentage ranging from 0.017-0.013 % as compared to values of 0.088% to 0.178% found in dry cat food. Furthermore, the composition of the raw materials used in dry and wet cat food vary significantly, with the former being richer in meaty materials and grains while the latter being dominated by tuna, with some oils and negligible amounts of vegetable gels.

Ca was not detected in the premium wet cat food and very negligible recorded in the standard (0.02%) and economy category (0.15%). The high amounts of Ca found in the economy brand of wet cat

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food in comparison to standard and premium wet samples maybe due to the addition of tuna head and tuna off-cuts to the formulation rather than meaty tuna. In the manufacturing of fish canned cat food, the choice of raw materials may influence the macronutrient concentration. However, these canned cat food can be enriched with addition of nutrients in order to conform to AAFCO's standard. Those alternative sources of dietary for Ca were dairy products, broccoli and cabbage (Pennington, 1998). Unfortunately, none of these are the common ingredients of dog and cat food. The common sources of Ca used were bone meal, dibasic calcium phosphate, monobasic calcium phosphate and calcium carbonate (NRC, 2006).

Phosphorus was found to be highest (0.217 %) in economy, 0.107% in premium and the least (0.087%) in standard category for cohort fish flavoured cat food. The P percentage was several folds lower in comparison to the AAFCO standard (0.5%). Fish based ingredient, particularly tuna is an inferior source of P compared to combined meaty source (Decuypere, 2013). Whilst dry cat food has an average of 0.88% compared to 0.14% in wet sample (Table 4) which is 6 folds higher and well over the AAFCO recommended value of 0.5% (AAFCO, 2012).

Magnesium content in dry cat food differ significantly amongst the premium (0.088%), standard (0.92%) and economy (0.178%) and all the values exceed the AAFCO recommended value (0.04%). The reverse is true for wet cat food, with premium, standard and economy at 0.017%, 0.016% and 0.013%, respectively. High amounts of Ca (1.08%), and P (0.92%) and that of Mg (0.18%) in the economy brand of dry cat food will highly to cause, calcium oxalate urolithiasis (Kirk *et al.,* 1995; Osborne *et al.*, 1995b) and struvite crystal formation. In order to prevent feline lower urinary tract disease, the Mg concentration in cat food should be less than 0.1% (Anderson, 2013). Studies suggested that high amounts of Mg intake are directly related to the formation of struvite uroliths (Lewis *et al.,* 1978; Kallfelz *et al.,* 1980; Lewis & Morris, 1984). However, the effect of Mg on struvite uroliths formation is dependent on urinary pH. High concentration of Mg with low urinary pH does not cause struvite uroliths formation in cats, whereas alkaline urine with high concentration of Mg causes struvite uroliths formation (Buffington *et al.,* 1985 & 1990).

In this study, the K content in the dry kibble differ significantly between premium, standard and economy products, with values of 0.33%, 0.48% and 0.80%, respectively. Whilst for wet products their values ranges from 0.23-0.29%, all of which are below AAFCO standards (0.6%). The economy dry product had the highest K value (0.80%). Cat and dog food should contain at least 0.6% K, on a dry matter basis (AAFCO, 2012). Low amount of K in wet products is due to tuna, the dominating raw material which is known to have low K content (Decuyrere, 2013). For the economy, standard and premium wet cat food had 0.25%, 0.29% and 0.23% of K, respectively, all below AAFCO standards (0.6%). Potassium is the second highest cation after Ca (Lobaugh, 1996), with almost 90% found in the intercellular fluid, 7.6% in bone, 0.1% as interstitial fluid, plasma 0.4% and 1% in the connective tissues (Tannen, 1996). Cat as well as kitten and new born puppies are reported to contain 2.3g/kg and 2.12g/kg total body K concentration, respectively (Meyer *et al*., 1985; Kienzle *et al*., 1991). Potassium helps in proper muscle coordination, fluid and ionic balance, nerve impulse transmission, cofactor in enzyme reaction and transportation (NRC, 2006). There are several supplemental sources of K available in the market such as: potassium bicarbonate, potassium chloride, and potassium sulphate (NRC, 2006) which can be added to wet cat food formulation in order to meet the AAFCO requirement.

In adult mammals, the Na content is estimated at 1.2-1.4g/kg or 0.13% of the body weight (NRC, 2006). Keenzle *et al*. (1991) noted that the total body content of Na decreases from 1.9g/kg to 1.4g/kg from kitten to adulthood. The amounts of Na present in bone, interstitial fluid, blood plasma is 43%, 29% and 12%, respectively (Briggs *et al*., 1996) and the remainder at collageneous tissue and intracellular. Sodium is known to regulate the osmotic pressure which is essential in balancing the acid to base ratio and extracellular volume and maintaining

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the electrical potential in excitable tissues and nerve impulse (NRC, 2006). In all the three classes of dry and wet cat foods, Na concentration (premium, standard, economy) differ significantly, exceeding the AAFCO value of 0.2% for the dry products, but not wet products, with values ranging from 0.08 - 0.17% (Table 4). The high significant amounts of Na recorded in the premium kibble product (0.47%) are due to the fact that dehydrated chicken and turkey meat were used in the formulation. Yu and Morris (1997) estimated the minimal requirement of Na to be 1.6g/kg for kittens; when given a choice, they were inclined to choose diet with 10g/kg of Na (Yu *et al.*, 1997). Adult cats with good water intake may tolerate up to 15g/kg Na (Burger, 1979; NRC, 2006) without showing any abnormalities but not for kittens (Yu *et al*. 1997). In the case of deficiency, Yu and Morris (1997) found a figure of 0.1g/kg of Na, for 12-15 weeks, the kitten develop anorexia, impaired growth, polydypsia and polyuria. However, all abnormalities were corrected with diet containing 2.0g/kg Na. The recommended source of Na is: sodium chloride, sodium carbonate, sodium bicarbonate and monobasic sodium phosphate (NRC 2006). However, majority of the pet foods prefer Na from sodium chloride source.

Chloride is the most abundant anion present in extracellular fluid of mammalian species (De Morais, 2000) and is significant in maintaining the osmolality of extracellular fluid and in acid-base regulation (NRC, 2006). The most common Cl^- sources used are: ammonium chloride, hydrated calcium chloride, potassium chloride, and sodium chloride, and Cl^- are least found naturally in foodstuff but supplemented. Some vitamin supplements used in pet foods are the additional sources of Cl^- like choline chloride (NRC, 2006). There are no significant differences between premium, standard and economy dry cat food for Cl^-, with values of 0.78%, 0.75% and 0.77%, respectively (Table 3). For wet samples, no significant difference was noted between Cl^- concentration in premium (0.60%) and standard (0.63%); but these two, differ significantly with that of economy brand (0.42%) (Table 4) and all exceeded AAFCO value (0.3%). Yu and Morris (1999), noted Cl^- deficiency in kittens fed with diets containing 0.1,0.4 or 0.7g/kg Cl^- but not with diet containing 1.0g/kg or higher (Yu & Morris 1998 & 1999); which is far off compared to AAFCO recommended value (0.3g/kg). There is paucity of data to date on the adverse effects of Cl^- consumption by cats (NRC, 2006). Feeding with diet of 11.4 or 11.8g/kg Cl^- of calcium salt to cats and kittens did not exhibit any negative effects (Pastoor *et al*., 1994b & 1994c). However, feeding with 16g/kg Cl^- of ammonium salt resulted in adverse Ca and K balance in adult cats (Ching *et al*., 1989; Pastoor *et al*., 1994b). Negative balance of Ca and K is due to metabolic acidosis effect, which occurs when ammonium salt is used instead of NaCl. According to Yu and Morris (1999), the minimal requirement of Cl^- for kitten should be 1.0g Cl/kg, whilst for cats, 0.9g Cl^-/kg (NRC, 2006).

Moisture content of all the three category of dry cat food were significantly difference, with the economy brand having 7.5%; 8.4% in the premium and the highest (9.4%) in standard brand. These were within the ranges of 8-12% for dry commercial kibbles (Amir & Mona, 2013). Interestingly, the economy cat food had the lowest moisture content, indicating that it offers more kibbles per dry basis compared to the other two categories. In addition to prolong their shelf life, prevent spoilage and rancidity of the dried kibble, the moisture content less than 14% is acceptable. Researchers reported feeding dry kibble with acidic pH and with low water intake will enhance formation of calcium oxalate urolithiasis (Kirk *et al.*, 1995; Osborne *et al.*, 1995a, Osborne *et al.*, 1995b), whereas, increased acidity in the cat’s body system will lead to Ca excretion (Ching *et al.*, 1989). Therefore, adequate supply of fresh water must be given to cats fed on dry kibbles. The pH of dried kibble in this study is 5 for premium and standard, and 5.5 for economy brands; where the former two are not significantly different to each other compared to the latter. Potential for struvite crystal formation in cat is reduced if the cat’s pH urine is less than 6.6 (Finke *et al.*, 1992) and normally cat food manufacturers try to induce cat’s pH urine concentration to 6.1 to 6.6 through their cat food formulation (Allen *et al.*, 1997).

Wet cat food contains about 75-85% of moisture (NRC, 2006; Amir & Mona, 2013) and in this study the moisture were 82% in the premium, and

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85% in both standard and economy wet cat food. Water intake is important to cats for digestion, circulation, and other metabolic processes in the cat's body. Dry cat food is often manufactured from plant materials such as grains and dried meaty meals, whereas wet cat food contains fresh fish and meaty materials with plenty of water added on. Cats fed on wet cat food have greater total water intake compared to those striving on dry cat food (Sauer *et al.*, 1985). High water intakes can dilute the urine concentration of the cats and prevent the formation of struvite urolithiasis and calcium oxalate urolithiasis.

The Ca: P ratio in cat food is important factor that determine the health of cats. In current study, the cohort fish flavoured canned cat foods (wet) cat food, premium and standard category did not achieve the AAFCO standard. Correct ratio had to be achieved in order to avoid nutritional diseases, weak or malformed bones as well as other serious health issues. Prolong feeding practice using wet premium and standard brands will have detrimental effect on the cat's health. The cat food manufacturer should maintain the Ca : P ratio within 1.3 : 1**,** or ideally 1: 1 as an increase of Ca will reduce the P and Mg absorption in cat due to the formation of insoluble Calcium-Magnesium-Phosphate complex (Pastoor *et al*. 1994a). However, high amounts of Ca and or P, had been found to affect Fe availability (Monsen & Cook, 1976; Snedeker *et al*., 1982), reduce Mn uptake (O'Dell, 1989; Wedekind *et al*., 1991), impair Cu absorption (Shackelford *et al*., 1994), and significantly reduce Zn uptake (Wedekind & Richards, 2012).

5. Conclusion

There is no perfect commercial cat food formulation in the market world-wide that may satisfy the AAFCO or NRC recommended standard for both kibble (dry) and wet canned cat food. The preparation of dry cat food using extrusion (116°C) and retort for canned products (105-118°C for 90 min. to 2 hours) where both are subjected to extreme temperatures may destroy some of the nutrients and vitamins and even denature the proteins. The use of meal-by-products may even make the cat food products much more inferior since the quality of this raw material is questionable? Based on this study, it is clearly indicated that inferior raw materials had been utilised to manufacture standard and economy brands dry cat foods, costing USD7/kg and USD2/kg, respectively; where almost all the macro-nutrients studied are extremely high and exceeded that of AAFCO recommended values. On the contrary, the premium (USD13/kg) did not satisfy the AAFCO standards in many ways but, the raw materials used are much more superior and the fresh meat first in the formulation with no meat-by-product-meals speaks volume of the product quality.

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