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# Phosphorus Contents of Raw Chicken Meat and Processed Chicken Meat Products

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## ABSTRACT

**Introduction:** The per capita consumption of chicken meat and related products has increased steadily in Malaysia, as it is affordable and can be consumed without religious constraints. There is concern for the widespread use of phosphate additives in processed meats, which may lead to hyperphosphatemia, especially among chronic kidney disease (CKD) patients. The objective of this study was to determine and compare the phosphorus content in raw chicken breast meat (RCBM) and selected processed chicken meat products. **Methods:** Samples of RCBM, chicken frankfurters, chicken patties and chicken nuggets of different brands were studied. The phosphorus content of the samples were determined via the dry ashing method and a Perkin-Elmer 5300DV inductively coupled plasma–optical emission spectrometer (ICP-OES). **Results:** The mean phosphorus content in RCBM was 209.15±3.13 mg per 100 g. Chicken nuggets contained the highest phosphorus content, followed by RCBM, chicken patties and chicken frankfurters. Compared to the RCBM, the mean phosphorus content of chicken frankfurters and chicken patties were 21.42% and 4.81% respectively lower, whilst that of chicken nuggets was 1.74% higher. The same type of chicken meat products from different brands also differed significantly in their phosphorus content. **Conclusion:** There were significant differences in the phosphorus content among different types of chicken meat products, and among the same chicken meat products from different brands. Caution should be exercised, especially by CKD patients, in consuming processed chicken meat products due to the risk posed to them by phosphorus content..

**Keywords:** Chronic kidney disease, hyperphosphatemia, phosphate additives, processed chicken meat products, phosphorus contents.

## INTRODUCTION

The excessive dietary intake of phosphorus is one of the factors that contributes to the accumulation of phosphorus in the blood, which may lead to hyperphosphatemia and secondary hyperparathyroidism among chronic kidney disease (CKD) patients (Martin & González, 2011). Uncontrolled secondary hyperthyroidism can cause brittle bones, calcification of blood vessels, increase risk of cardiovascular diseases, worsen hyperparathyroidism, and renal osteodystrophy (Cunningham, Locatelli & Rodriguez, 2011). Accumulating evidence

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from studies in healthy populations suggests that mild elevations of serum phosphate within the normal range are also associated with increased risk of cardiovascular disease (Foley *et al.*, 2009; Larsson *et al.*, 2010), justifying the increased concern in relation to the excessive dietary intake of phosphorus.

Despite advancements in medical technology, hyperphosphatemia remains a huge challenge for CKD patients. The aetiology for hyperphosphatemia is multifactorial and may include issues such as the inability of standard dialysis treatment to remove phosphorus from the blood (Kooienga, 2007), the non-compliance to phosphate binders due to a variety of impediments, including pill burden (Tomasello, Dhupar & Sherman, 2004), the poor compliance to dietary phosphorus (Kugler *et al.*, 2005; Chan, Zalilah & Hii, 2012), and the binding of phosphate with protein in foods (Kalantar-Zadeh *et al.*, 2010). It is generally recognised that changes in eating habits associated with the growing availability of processed foods and the increasing cumulative use of phosphorus-containing additives by food manufacturers over recent decades have led to increasing consumption of dietary phosphorus (Uribarri and Calvo, 2013). The widespread use of easily absorbed inorganic phosphate as additives in processed foods to extend shelf life further increases the amount of dietary phosphorus intake and contributes to higher levels of phosphorus in the blood (Kalantar-Zadeh *et al.*, 2010). The proportion of inorganic phosphorus ingested can be substantial (Coates *et al.*, 2005). The use of inorganic phosphate additives can increase the phosphorus intake of an individual by as much as 1 g/day (Uribarri & Calvo, 2003).

To date, there is no recommended intake of dietary phosphorus in Malaysia. Given that a national survey in the United States of America (USA) showed that more than one-third of Americans have an excessive dietary intake of phosphorus (more than 1400 mg/day) (Chang *et al.*, 2014), a similar phenomenon may exist in Malaysia. Therefore, despite there being no evidence of an excessive intake of dietary phosphorus among the general population of Malaysia, the reality may most likely reflect systematic underestimation of the dietary intake of phosphorus currently available in nutrient content databases (Uribarri and Calvo, 2013; Calvo & Uribarri, 2013).

Globalisation and a hectic lifestyle has led to increasing consumption of pre-cooked, processed and ready to eat foods at the expense of the consumption of fresh produce among Malaysians (Norimah *et al.*, 2008). Meat products such as burger patties, sausages and nuggets are widely accepted and consumed by all the ethnic groups in Malaysia, both at home as well as in fast food restaurants (Babji & Seri Chempaka, 1995). Although processed chicken products are widely consumed sources of protein, information about their phosphorus content is limited. The significant expansion of the fast food industry and the increased consumption of processed meats drive the need for more accurate information on their phosphorus contents. The objective of this study was to determine and compare the phosphorus contents of raw chicken breast meat (RCBM) and selected types of processed chicken meat products.

## METHODS

Samples of RCBM and three different brands per type of processed chicken meat were purchased for this study. Chicken frankfurters were covered by brands A, B and C. Chicken patties were covered by brands D, E and F. Chicken nuggets were covered by brands G, H and I. The RCBM was purchased from three stalls located in the retail markets of Serdang, Selangor, whereas the processed chicken meat products were purchased from hypermarkets in Serdang, Selangor.

Convenience sampling was used to collect the samples. The samples chosen were relatively uncomplicated products without side dishes, complex sauces or flavourings.

Chicken meat was studied as it represented one of the top ten weekly consumed foods regardless of ethnicity and religion in Malaysia (Norimah *et al.*,2008) and the phosphorus content is higher than those of beef or mutton (Tee *et al.*,1997). Prior to the study, observation surveys were conducted where processed chicken foods were found to be more commonly sold in the market and consumed by Malaysian compared to other types of processed meat for the same reasons. Chicken breast meat was selected for this study because it had the highest phosphorus content compared to other parts of the chicken (Tee *et al.*, 1997).

**Preparation of samples**

The edible portions of the RCBM samples bought were homogenised into one sample by using a commercial blender. For the processed chicken meat products, each sample was blended using a commercial blender to ensure the sample taken for analysis represented the products accurately. Phosphorus content was determined in duplicate for each sample. Ash solution was prepared from the samples by using the dry ashing method and concentrated hydrochloric acid was used to digest the samples (AOAC, 2000).

**Determination of phosphorus contents**

The ash solution was sent to the Malaysian Agricultural Research and Development Institute's (MARDI) Food and Agriculture Analysis Laboratory in Serdang for the analysis of phosphorus content using a 5300DV inductively coupled plasma-optical emission spectrometer (ICP-OES). The samples were subjected to high temperatures causing dissociation of the samples into atoms. This allowed the collisional excitation and ionisation of the dissociated atoms to take place. When the energy of a particular atom is high enough, the electron from the atom will move to an excited state. In the excited state, the electrons become less stable and tend to move back to a less excited state by losing energy through electromagnetic radiation, or photons. The intensity of the light emitted at a wavelength of 213.617 nm was measured and used to determine the concentration of the phosphorus (Boss & Fredeen, 1997). The concentration of phosphorus (P) per 100 g of food samples was calculated using the formula below:

P content (mg) = (P content (ppm) x 1/1000 x 100 x dilution factor)/(wet sample weight (100g))

**Statistical Analysis**

IBM SPSS software version 21 (SPSS Inc., Chicago, IL, USA) was used to analyse the data collected. Data was presented as mean ± standard deviation (SD) as all samples were duplicated. One way analysis of variance (ANOVA) followed by Games-Howell test as a post-hoc test were used for the inferential analysis to compare the mean difference between the phosphorus content of RCBM and processed chicken foods. Comparison of the mean difference of phosphorus content among different brands of processed chicken foods was done by using ANOVA followed by Games-Howell test as a post-hoc test. For all tests, statistical significance was set at a 95% confidence level ($p<0.05$).

## RESULTS

The phosphorus content of the RCBM and nine selected processed chicken meat products, per 100 g of samples, is shown in Table 1. The amount of phosphorus content found in RCBM was 209.15±3.13 mg per 100 g. Chicken frankfurters, represented by brands A, B, and C. Brand C, were found to contain the highest amount of phosphorus among the three types of chicken frankfurters selected, which was 191.40±2.58 mg per 100 g. This was followed

**Table 1.** Phosphorus content of raw chicken breast meat and selected processed chicken foods (per 100 g of wet samples)

| *Samples* | *Phosphorus content (mg/100g) Mean±SD* | *Percentage difference from 100g of raw chicken breast meat (%)* |
|---|---|---|
| Raw Chicken Breast Meat | 209.15±3.13 | |
| Chicken Frankfurter | 164.36±20.64 | -21.42 |
| Brand A | 151.95±1.24* [a] | |
| Brand B | 149.72±6.81* [a] | |
| Brand C | 191.40±2.58 *[b] | |
| Chicken Patty | 199.08±15.96 | -4.81 |
| Brand D | 188.66±3.26 *[a] | |
| Brand E | 188.72±3.33 *[a] | |
| Brand F | 219.87±4.91 [b] | |
| Chicken Nugget | 212.80±8.90 | 1.74 |
| Brand G | 224.11±1.73 *[a] | |
| Brand H | 209.53±2.98 [b] | |
| Brand I | 204.76±0.30 [b] | |

* Significant mean difference between processed chicken meat sample and raw chicken breast meat with $p < 0.05$
Mean±SD with different superscripts indicated significant difference between brands of same types of processed chicken foods ($p < 0.05$)

by brands A and B with 151.95±1.24 mg and 149.72±6.81 mg, respectively per 100 g. Chicken patties were represented by brands D, E, and F. The amount of phosphorus found in brands F, E and E were 219.87±4.91, 188.72±3.33, 188.66±3.26 mg, respectively, per 100 g. Brand F was found to contain the highest amount of phosphorus among the three types of chicken patties selected. Chicken nuggets were represented by brands G, H and I. The amount of phosphorus found in brands G, H and I were 224.11±1.73, 209.53±2.98 and 204.76±0.30 mg, respectively, per 100 g.

A comparison of mean phosphorus content of processed chicken foods from different samples was made with the results shown in Table 1. The mean phosphorus content of the chicken frankfurters and chicken patties were 21.42% and 4.81%, respectively, which was lower than the RCBM, whilst the mean phosphorus content of the chicken nuggets was 1.74% higher than the phosphorus content of RCBM.

Whilst the reporting of phosphorus content per 100 g of food sample is important for comparison, serving size may be a better representation of dietary phosphorus being consumed in a meal. The phosphorus content of the samples for each serving size was calculated and is shown in Table 2. The serving size of the RCBM was retrieved from Tee *et al.*(1997). The serving sizes for the processed chicken foods were retrieved from the recommended serving sizes in the nutrition labels on their respective packaging.

Brand H (chicken nuggets) was found to contain the highest phosphorus content per serving, which was 335.25±4.77 mg or 142.86% higher compared to one serving of RCBM. This may be attributed to its higher serving size as recommended on the nutrition label (160 g/serving). The phosphorus content of brands G and I (chicken nuggets), and brand F (chicken patty) were respectively 94.82%, 48.33%, and 11.50% higher per serving compared to RCBM. On the other hand, the phosphorus content of brands E and D (chicken patties) were 17.97% and 31.66% lower per serving compared to RCBM. All the three samples of chicken frankfurters had lower phosphorus content compared to RCBM, with 58.40%, 62.58% and 67.46%

lower phosphorus content per serving respectively.

The results obtained from this study were compared with Tee *et al.*(1997) and Health Promotion Board Singapore (2003) as shown in Table 3. The phosphorus content of the RCBM in this study (209.15±3.13 mg) was 2.02% higher than that quoted by Tee *et al.*(1997) and 6.71% higher than that quoted by the Health Promotion Board Singapore (2003), which were 205 mg and 196 mg, respectively. Meanwhile, the mean phosphorus content of the chicken frankfurters in this study (164.36±20.64 mg) was 19.82% lower than that quoted by Tee *et al.*(1997)(205 mg) and 0.22% higher than that quoted by the Health Promotion Board Singapore (2003) (164 mg).

The mean phosphorus content of the chicken patties in this study (199.08±15.96 mg) was 27.62% higher than that quoted by Tee *et al.*(1997)(156 mg). There was no data available for chicken patties in the Health Promotion Board of Singapore (2003). For chicken nuggets, as there was also no data available in Tee *et al.*(1997), the data from this study was compared with the data of Health Promotion Board Singapore(2003). The phosphorus content of the chicken nuggets in this study (212.80±8.90 mg) was 24.0% lower than that quoted by the Health Promotion Board Singapore (2003) (280 mg).

The mean differences of phosphorus contents among the samples were tested with one way ANOVA statistical test followed by Games-Howell as post-hoc test. There were significant differences in the means for phosphorus content between RCBM and all the selected processed chicken foods ($p<0.05$), except for brands F, H and I ($p>0.05$), as shown in Table 1. Meanwhile, within the chicken frankfurter samples, there was a significantly higher phosphorus content in brand C compared to brands A and B ($p<0.05$), whilst there was no significant differences in the means for phosphorus content between brands A and B. Among the chicken patties samples, the phosphorus content in brands D and E were significantly lower when compared to the phosphorus content in brand F ($p<0.05$). Similarly, whilst there was no substantial differences in means for phosphorus content between chicken nuggets from brands H and I, the phosphorus content from brand G was significantly higher compared to brands H Brand I ($p<0.05$).

## DISCUSSION

According to the National Kidney Foundation (2003), the recommended dietary phosphorus for stages 3 and above CKD patients is within 800 to 1000 mg/day. This study found that consuming as little as 100 g of processed chicken foods can contribute approximately 20% to 28% of the recommended dietary phosphorus for CKD patients. Although the actual amount of phosphorus in each processed chicken food item could be low, the total intake over a long period of consumption may be considerable. As nutritional labelling for phosphorus is not mandatory in Malaysia, it is a challenge to estimate the actual amount of phosphorus consumed due to phosphorus-containing additives. Note that the bioavailability of phosphorus-containing additives (90-100%) is much higher than that of organic sources of phosphorus (40-60%) (Bell *et al.*, 1977; Karp *et al.*, 2007). Therefore, it is plausible that a given amount of phosphorus contained in food additives could have a greater effect on the accumulation in a person than the same amount of phosphorus in a much less bioavailable form (Uribarri & Calvo, 2013). If CKD patients consumed processed chicken meat products according to the serving sizes recommended on the packaging (e.g., brand H suggests 160 g per serving or 8 pcs), it would contribute as much as 41.90% to their recommended dietary phosphorus per meal. Overconsumption of high phosphorus content foods can contribute

**Table 2.** Phosphorus content of raw chicken breast meat and selected processed chicken foods per serving size

| *Samples* | *Serving size (g)* | *Mean±SD (mg)* | *Percentage difference from one serving of raw chicken breast meat (%)* | *Percentage of recommended phosphorus for CKD patients[3] (%)* |
|---|---|---|---|---|
| Raw Chicken Breast Meat [1] | 66 | 138.04±2.07 | | 17.26 |
| Chicken Frankfurter[2] | | | | |
| Brand A | 34 | 51.66±0.42 | -62.58 | 6.46 |
| Brand B | 30 | 44.92±2.04 | -67.46 | 5.62 |
| Brand C | 30 | 57.42±0.77 | -58.40 | 7.18 |
| Chicken Patty[2] | | | | |
| Brand D | 50 | 94.33±1.63 | -31.66 | 11.79 |
| Brand E | 60 | 113.23±2.00 | -17.97 | 14.15 |
| Brand F | 70 | 153.91±3.44 | 11.50 | 19.24 |
| Chicken Nugget[2] | | | | |
| Brand G | 120 (6pcs) | 268.93±2.08 | 94.82 | 33.62 |
| Brand H | 160 (8pcs) | 335.25±4.77 | 142.86 | 41.90 |
| Brand I | 100 (5pcs) | 204.76±0.30 | 48.33 | 25.60 |

[1] Serving size was computed from Tee *et al.* (1997)
[2] Serving size recommended on the packaging of respective processed chicken foods;
[3] Recommended dietary phosphorus for CKD patients with stage three and above is 800 to 1000 mg/day according to the KDOQI Clinical Practice Guidelines for bone metabolism and disease in chronic kidney disease (2003)

**Table 3.** Comparison of mean phosphorus contents of food samples with existing databases (per 100 g of wet samples)

| *Samples* | *Mean phosphorus content (mg/100g) in this study* | *Phosphorus content (mg/100g)* | | | |
|---|---|---|---|---|---|
| | | *Malaysian database[1]* | *Percentage difference (%)* | *Singaporean database[2]* | *Percentage difference (%)* |
| Raw Chicken Breast Meat | 209.15±3.13 | 205 | 2.02 | 196 | 6.71 |
| Chicken Frankfurter | 164.36±20.64 | 205 | -19.82 | 164 | 0.22 |
| Chicken Patty | 199.08±15.96 | 156 | 27.62 | NA | - |
| Chicken Nugget | 212.80±8.90 | NA | - | 280 | -24.00 |

[1] Phosphorus content from Tee *et al.* (1997)
[2] Phosphorus content from Health Promotion Board Singapore (2003)
NA: Not available

to hyperphosphatemia in CKD patients (Fourtounas, 2011). In addition, a high phosphorus intake can also affect bone metabolism and cardiovascular health of the general population (Kemi, Kärkkäinen & Lamberg-Allardt, 2006; Itkonen *et al.*, 2013). Hence, it is important for both the general public and CKD patients to be aware of the high phosphorus contents in processed chicken foods.

The phosphorus content of the RCBM in this study was 2.02% higher than that reported by Tee *et al.* (1997) and 6.71% higher than that reported by the Health Promotion Board Singapore (2003). The difference may be due to differences in breed and the state of maturity of chicken used in this study. According to Greenfield & Southgate (2003), the breed and state of maturity of animals can cause variations in food composition. Additionally, variations in food marketing and food preparation may also result in variation in the result obtained (Greenfield & Southgate, 2003). Furthermore, the RCBM samples in this study were selected from retail markets in Serdang, Selangor, which may not be representative of RCBM found throughout Malaysia.

As with RCBM, the phosphorus contents of the selected processed chicken foods also differed from data in the existing databases of Malaysia and Singapore. The variations may be due to the processed chicken foods used in this study being different to that of previous studies. Neither Tee *et al.*(1997) nor the Health Promotion Board Singapore (2003) mention specific brands of processed chicken foods. Moreover, the differences may be caused by the testing methods used. Phosphorus content in Tee *et al.*(1997) was determined based on the vanadate-molybdate method whereas the method used in Health Promotion Board Singapore (2003) and in this study was based on ICP.

A comparison of the phosphorus content between RCBM and all the selected processed chicken foods showed significance differences ($p<0.05$) except for brands F, H, and I ($p>0.05$). The phosphorus contents of all the three samples of chicken frankfurters (brands A, B, C) and two out of three samples of chicken patties (brands D and E) were significantly lower compared to RCBM. This may be due to the loss of phosphorus during the meat processing. Meat processing usually involves a wide range of physical and chemical treatments (Heinz & Hautzinger, 2007). One of the treatments is moist heat treatment. Cupisti *et al.* (2006) state that boiling meat can cause the loss of phosphorus as it is water soluble. Additionally, different parts of the chicken are used in the production of processed chicken meats. Chicken meat used for the production of processed foods is usually categorised into four different grades (Heinz & Hautzinger, 2007). Grade one is chicken white muscle meat with visible fat, but without the connective tissue and skin. Grade two consists of chicken muscle meat with adhering subcutaneous and inter-muscular fat. Grade three is for chicken skin or fat. Grade four is mechanically deboned chicken meat.

The protein and phosphorus content of processed chicken meats are therefore highly dependent on the grade of chicken meat used. Processed chicken meats that are manufactured from lower grades will contain lower content of protein and phosphorus. Several studies report a significantly lower protein content in locally produced sausage (Suriah *et al.*, 1997, Nurul *et al.*, 2000) and burgers (Babji & Sri Chempaka, 1995) compared to imported products. Romans *et al.* (1985) state that the lower protein content is due to the substitution of non-meat components (e.g., flour, milk protein, and egg) to produce lower cost products (meat proteins are relatively more expensive than non-meat components) while maintaining the texture and water holding capacity.

The phosphorus content of brand G was significantly higher than that of RCBM. The increase in phosphorus content in processed chicken foods may due to the phosphate additives used during processing. This was in agreement with Sullivan, Leon & Sehgal (2007) who state that the levels of phosphate additives in chicken products such as breast meat patties and breast meat nuggets are high and that the phosphate additives can contribute to a significant amount of phosphorus in the process foods. Data on the level of phosphate additives in processed meat products in Malaysia were scarce at the time of this study.

Within the group of processed foods, the phosphorus contents of the different types of processed chicken foods varied. This finding agreed with Sherman and Mehta (2009) who found that similar products (e.g., frankfurters) made by different manufacturers could differ markedly with respect to their respective phosphorus content. This variation may be due to the different process methods applied by different food manufacturers and also be due to the phosphate additives (Sullivan *et al.*, 2007). Hence, this makes it difficult for nutritionists and dieticians to give diet recommendations to their CKD patients as the phosphorus content of processed chicken meat products vary from brand to b brand.

According to the Ministry of Health Malaysia (2010), nutrition labelling is defined as "listing of the level of nutrient(s) as displayed on the food label." Nutrition labelling is meant to benefit the consumer by providing factual information about the nutritional contents of the products they are buying. Labelling of phosphorus is not mandatory in Malaysia (Ministry of Health Malaysia, 2010). Current regulations do not require manufacturers to display the total phosphorus content and inorganic phosphorus contributed by additives on the labels. The addition of phosphorus content to nutrition labels would be of substantial benefit to CKD patients as they need to closely monitor the amount of phosphorus consumed to prevent hyperphosphatemia (Sehgal *et al.*, 2008). There is also a lack of information about phosphate additives in processed foods. This makes it impossible for the CKD patients to differentiate processed foods with or without phosphate additives. The information on phosphate additives is important as Sullivan *et al.* (2009) state that educating end stage renal disease (ESRD) patients to avoid purchasing food items containing phosphorus-containing additives can result in modest improvements in their hyperphosphatemia. Hence, policymakers should take into consideration the impact of phosphate additives in the processed foods.to CKD patients and the general population.

## CONCLUSION

Phosphorus contents in the samples used in this study differed from the values in food composition databases available. There were also significant differences in the phosphorus content among different samples from the same product types. In general, the mean phosphorus content of chicken frankfurters and chicken patties were 21.42% and 4.81% lower when compared to the RCBM, whereas the mean phosphorus content of chicken nuggets was 1.74% higher as compared to the RCBM.

Despite the great variations between the chicken nugget samples, phosphorus contents in all the three samples were relatively higher than chicken frankfurters or chicken patty samples. Chicken nuggets are therefore not advisable for those individuals who require careful monitoring of dietary phosphorus intake. Despite the aetiology of hyperphosphatemia being multifactorial, the widespread use of processed meat and the difficulty in knowing the amount of dietary phosphorus intake (both organic and inorganic) in the absence of nutritional labelling pose a great challenge to achieve better serum phosphate level among CKD patients.

In view of this, although a conclusive finding may not be possible due to the small sample size in this study, excessive consumption of processed foods with high phosphorus bioavailability should be avoided. Natural sources that are derived from organic (animal and vegetable) food proteins should be the preferred food sources for CKD patients as well as the general population for the sake of a better quality of life.

## Conflict of Interest

The authors declare no conflict of interest with regard to the testing of processed chicken meat products.

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