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EFFECT OF DIFFERENT TYPES OF MEALS ON URINE PH

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ABSTRACT

The study was conducted to compare how different types of meals (carbohydrates, fat, protein and fibre) affect the urine pH in individual. This is a laboratory based observation with cross sectional study, the cross-sectional study involved 25 MBBS students of UniKL RCMP with normal body mass index (BMI). The method is to take pre-urine samples (20 ml sample bottle provided) from respondents and measure the urine pH using pH meter. The pre-urine samples are taken after the respondent being put to a fasting period of 10 hours. Then, they are given a specific meal. Within 2 hours, the post urine sample are taken and tested with pH meter and the result was taken again 2 hours after that. These are implemented for four days as each day for specific nutrient meal (carbohydrate, protein, fibres and fat). Overall, protein and fat shows changes that agrees with our assumption that is there will be increase in urine pH after meals ingestion that would be from pre to post 1 and decrease back from post 1 to post 2. On the average, carbohydrate and fibre shows increase in urine pH from pre to post 1 and from post 1 to post 2. The changes in urine pH from pre to post 1 agrees with our initial assumption, but the increase in urine pH from post 1 to post 2 is in contrast to our assumption. We can infer that among the four types of meals tested against their influence on urine pH, protein has the strongest influence, followed by fat, carbohydrate and dietary fibre.

Keyword: *Carbohydrates; fat; meals; protein; pH; urine.*

1. INTRODUCTION

Malaysia is a country where there are varieties of food choices and have been described by the foreigners as haven of food. With different cultural and religion background, there are diverse food choices that come with it. Some of the most famous food includes roti canai, curry mee, spicy fried chicken and others including the ones that evolved due to modernization and assimilation from other cultures in the world like the western food for example baked cheese sandwich, oat bran cereal and more. Different types of food have different compositions of anions and cations and other chemical substances for example yogurt and buttermilk contains high amount of sulphur-bound amino acid which affect the urine pH to become more acidic[1]. In addition to that, with modernization and industrialization, there has been changes in mineral composition in the diet for example decrease in potassium compared to sodium and increase in chloride compared to bicarbonate. It is also found that people nowadays have diet poor in magnesium and potassium as well as fibre and rich in saturated fat, simple sugars, sodium and chloride which lead to the induction of metabolic acidosis[2]. Moreover, with aging there is a gradual loss of renal function for acid-base regulation and a resultant increase in diet-induced metabolic acidosis while on the modern diet due to aging[3]. This makes us wonder how these different types of food affect our body functions; how they are digested and what are the signs showing that they are being digested in the gastrointestinal tract. The digestion starts from the mouth by ingesting the food and they move towards the stomach and into the intestine. From previous studies, it shows that HCl secretion in the stomach by the parietal cells will lead to a condition called as the alkaline tide phenomenon due to the efflux of bicarbonate ions into the circulation from the basolateral membrane of the parietal cells which possesses transporters to maintain intracellular homeostasis and from that we assume that the phenomenon indirectly affect the urine pH because there may be some processes to remove the excess bicarbonate ions from the circulation via urine. What make us curious is that what happen during the fed state of the body (period of the starting of nutrient absorption until it is complete) when absorption of food mainly occurs and during the fasting state. There may be various effects on to the urine pH in order to maintain the acid-base balance in the internal environment of the body; and from that we assume that the phenomenon indirectly affect the urine pH because there may be some processes to remove the excess bicarbonate ions from the circulation via urine. As stated before, the alkaline tide serves to maintain the intracellular pH in the parietal cell as to prevent parietal cell alkalization concomitantly with acid secretion, so the bicarbonate need to be extruded to prevent cell death[4]. This process, with physiologic consequences, was first recognized in the 1960s as alkalization of the blood and urine after a meal and was termed the "alkaline tide"[5]. As for our study on different types of meals effect on urine pH, we assume that after ingestion of any meals, there will be an increase in urine pH especially after 2 hours of eating which is in the absorptive state where first post prandial pH urine sample is taken and there will be decrease back in pH of urine during the post-absorptive state where the second post prandial pH urine sample is taken after 4 hours. From this assumption, we can correlate it to the alkaline tide phenomenon and we would like to determine which food suite our assumption best. Thus, our study is basically to determine the effect of different types of food on the urine pH in relation with the HCl secretion in the stomach and the acid-base balance mechanism of the body with the referral to the alkaline tide phenomenon.

2. MATERIALS AND METHODS

2.1. Participants

Twenty-five respondents from UniKL RCMP students were randomly selected with normal (Body Mass Index) BMI range (18.50 – 24.99) and age between 19 – 20 years old.

2.2. Sampling

The method was to take pre-post prandial urine samples from respondents and the urine pH were measured using pH meter for 4 days specifically for each meal type. The respondents were being put to a fasting period of 10 hours. The respondents were asked to fast from 12.00 am to 10.00 am on the next morning. The pre-prandial urine samples were taken right before the respondent take their meal prepared by us. Then, they were given a specific meal of carbohydrate for day 1, fat for day 2, fiber for day 3 and protein for day 4; the respondents ate the meal provided from 10.00 to 10.30 am. The meal nutritional amount of each meal was kept constant for every food served for the respondents; 45 g carbohydrate, 45 g fat, 45 g fibre and 45 g protein. Within 2 hours, the first post prandial urine samples were taken and tested with pH meter and the results were recorded in which the urine was taken at 12.30 pm. The second post prandial urine samples were taken again 2 hours after the first post prandial urine sample was taken at 2.30 pm. Within the period between 10.30 am to 2.30 pm which was the time respondents require to send their last urine sample for the day, the respondents were not allowed to eat or drink anything except for plain water. We decided to take 2 post prandial urine sample based on to the theory of fed state and fasting state. Fed state which was also known as absorptive state is the 2 to 4 hours prior ingestion of a normal meal; characterized with transient increase in plasma glucose, amino acids and triacylglycerol and lots of enzymatic changes occur to aid in digestion and absorption of food. Excess fuel nutrients are stored in which glucose is converted to glycogen in muscle and liver, triacylglycerol in adipose tissue and amino acid is converted to body protein. Fasting state or non-absorptive state begins if no food is ingested after the absorptive period. If another meal is taken within few hours, the individual will return to the absorptive state. In the initial stages of fasting state, stored fuel will be used for energy production and similar to fed state there are lots of enzymatic changes to adapt to this condition. The pH of the urine samples was taken twice for the pre, post 1 and post 2 urine samples and the mean was taken to avoid error in reading and the temperature of the urine samples were kept constant at room temperature (25°Celcius).

3. RESULTS AND DISCUSSION

3.1. Carbohydrate

As shown on Table-1, Pair 1 is the comparison of mean of pH of urine sample between pre and post 1 while Pair 2 is the comparison of mean of pH urine sample between post 1 and post 2. The mean pH for pre, post 1 and post 2 were 5.52, 5.72, and 5.90 respectively. As shown on fig.1, there was a significant increase in urine pH 2 hours after ingestion of carbohydrates meals among the respondent from pre to post 1 and also increase in urine pH from post 1 to post 2, 4 hours after ingestion of meal. From this result, the increase in urine pH from pre to post 1 agrees with our assumption but the increase in urine pH from post 1 to post 2 does not follow our assumption that will be discussed later. On the average, there was only slight increase in the urine pH from pre to post 1 which was about 0.20 when compared to other types of meals like protein which has higher pH changes. As been stated before, the main site for the digestion of carbohydrate mainly occurs in the small intestine and the enzyme that works to break down carbohydrates favours alkaline condition[2]. These explain why there was slight increase in urine pH among the respondent. Less HCl secretion by the stomach because of the carbohydrate digestion mainly occurs in the small intestine, so there would be less bicarbonate ion release into the portal blood. Thus, the renal system would compensate the bicarbonate ion release into the blood via excretion into the urine. This will make the pH of the urine slightly increase. As for the changes in urine pH from post 1 to post 2 results, there was also slight increase in urine pH changes. This does not correlate to our assumption. This must be due to the conditioned reflexes in anticipation of food by the respondents as they were prohibited to eat any food until post 2 urine sample is taken. For this reason, the overall result of respondent showed increase in urine pH in post 2 urine sample. Some of the respondents also showed abnormal changes like respondent 10 who showed abrupt increase in urine pH from post 1 to post 2. Respondent 12 showed low pre-urine pH and respondent 21 showed decrease in urine pH from pre to post 2. For respondent 10, the increase was more likely because of the conditioned reflex where presence of food was not necessary, just the thought, smell, hearing of food that can stimulate gastric acid secretion[6]. Thus, cause increase in urine pH. For respondent 12 who showed low pre urine pH must be due to decalcification that takes place during the night in neutralizing excess acids. Besides, this condition might be due to dehydration as stated by the respondent in the questionnaire, who only drinks four times of plain water per day. This might also be related to some pathological condition. In addition to low urinary pH, dehydration from any cause resulting in a low urine volume with increased urinary uric acid concentrations and a low urinary pH may create a setting for uric acid stone[7]. Furthermore, this condition also can be caused by high degree of acidity produced by carbon dioxide during normal metabolism that is eliminated from the body by the kidneys and the lungs[8]. As for respondent 21 who showed decrease in urine pH from pre to post 2, this might also be due to dehydration and underlying pathological condition as stated above. Disruption of the normal acid-base balance regulation also might play some role on the changes of urine pH in the respondent.

Table- 1: Paired samples correlations between type of meals and urine pH

Type of Meal	Correlation	Significant
Carbohydrate		
Pair 1 (pre & post 1)	0.639	0.001
Pair 2 (post 1& post 2)	0.488	0.013
Fat		
Pair 1 (pre & post 1)	0.596	0.002
Pair 2 (post 1& post 2)	0.325	0.113
Fibre		
Pair 1 (pre & post 1)	0.677	0.000
Pair 2 (post 1& post 2)	0.746	0.000
Protein		
Pair 1 (pre & post 1)	0.427	0.033
Pair 2 (post 1& post 2)	0.730	0.000

Data is presented as mean.

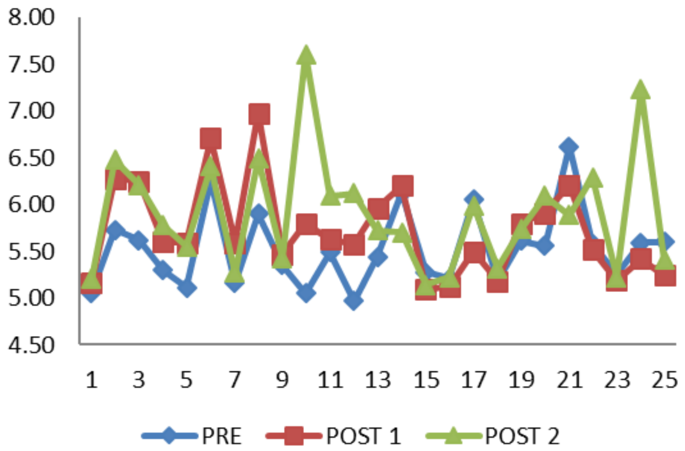

Fig.1: Relation between carbohydrate meal and urine pH for pre, post 1 and post 2 urine samples

3.2. Fat

Based on Table- 1, Pair 1 is the comparison of mean of pH of urine sample between pre and post 1 while Pair 2 is the comparison of mean of pH urine sample between post 1 and post 2. The mean pH for pre, post 1 and post 2 are 5.99, 6.07 and 5.80 respectively. Slight increase of urine pH sown (fig.2) from pre to post 1 and decrease in pH of urine from post 1 to post 2 which was more likely similar to protein results. The increase in pH of urine in post 1 from pre may be due to the gastric phase of gastric secretion; a condition in which when food enters the stomach, this will excites vagovagal reflexes, local enteric reflexes and gastrin mechanism and causes food gastric juice secretion in several hours while the food is still in the stomach leading to more secretion of HCl by parietal cells and with the compensation processes by the kidney to normalized the extracellular pH due to the alkaline tide phenomenon, the urine pH increases[5]. Previous studies showed that lingual lipase hydrolyzes 10 to 30% of fat in the stomach. Lingual lipase is secreted by the lingual glands in the mouth and the enzyme is swallowed with the food passing through oesophagus to the stomach and the secretion of lingual lipase from lingual glands in the stomach catalyzes the conversion of triglyceride to partial glycerides and free fatty acids proving that it is the start of lipid digestion. Lingual lipase also functions actively in the acidic pH (3.5 to 6) which is possible for the activity of the enzyme to continue in the duodenum. Furthermore, there were some studies revealed that there is the presence of activity of gastric lipase which is a predominant enzyme in human and baboons and also it is the major non-pancreatic digestive lipase[4]. Gastric lipase is confined to the chief cells of the mucosa in the fundus of the stomach and lipid digestion in the stomach maintain sterility of the gastrointestinal tract and there is therapeutic suggestion that said that lingual and gastric lipase might be useful for supplementation in patients with steatorrhea and alcoholic pancreatic insufficiency. The decrease in urine pH from post 1 to post 2 is similar the protein elaboration regarding the decrease of food content will result in decrease stimulation of the HCl by the parietal cells and thus leads to the decrease in urine pH. As for respondent 11, his condition might be due to dehydration as stated in the questionnaire that he only drinks 3 times a day. It will lead to low urine volume and increased in urinary uric acid. This is the reason why there was increased in urine pH from pre to post 1.

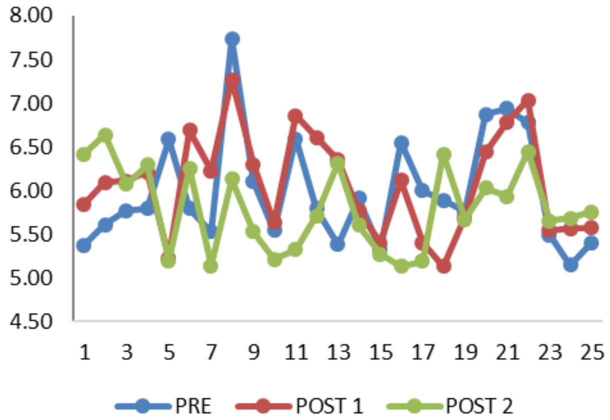

Fig. 2: Relation between fat meal and urine pH for pre, post 1 and post 2 urine samples

3.3. Fibre

Paired T test was used to analyze the mean of data collected and a line graph is plotted. Based on (Table- 1), Pair 1 was the comparison of mean of pH of urine sample between pre and post 1 while Pair 2 was the comparison of mean of pH urine sample between post 1 and post 2. Based on table -1, the mean urine pH reading for pre, post 1 and post 2 are 5.89, 6.18, and 6.25 respectively. Based on fig. 3 in average, there was a significant increase in the urine pH 2 hours after ingestion of dietary fibre meals among respondents which was in accordance to our earlier assumption. On average, there was slight increase of the urine pH which was about 0.29 when compared to other types of meal. As mentioned earlier, the main site for the digestion of dietary fibre mainly occurs in the large bowel by the action of colonic bacteria. The colonic mucosal pH varies along the length of the colon; right colon, pH 7.1; transverse colon, pH 7.4; left colon, pH 7.5; sigmoid colon, pH, 7.4; and rectum, pH 7.2.[1] This near- neutral pH in conjunction with low enzymatic activity has made the colon a good environment for normal flora to flourish and favourable for the metabolism of dietary fibre to take place which in contrast to the HCl secretion in the stomach. Less HCL secretion by the stomach as the digestion of dietary fibre mainly take places in the large bowel, so there will be less bicarbonate ion release into the portal system. Thus, the renal system would compensate the bicarbonate ion release into the blood via excretion into urine. This will make the pH of the urine slightly increase. Another theory that should be taken account into is the potential renal acid load (PRAL) of dietary fibres and its influence on urine pH. A more alkaline diet (low PRAL), high fruits and vegetables was significantly associated with a more alkaline urine pH based on a study conducted showed there was a continuous relationship between an increasingly alkaline urine pH and a more alkaline diet shown by PRAL. This mean that the renal net acid excretion is influenced by the dietary acid-base load provided kidney function is not compromised by disease[9]. This explains why 4 hours after the ingestion of dietary fibre, the urine pH still shows an increase in reading. There were extreme cases among respondents i.e. respondent 16 showed the lowest urine pH reading in post 2 that is 4.92, respondent 11 as well as a number of respondents showed a decrease in urine pH reading from pre to post 1 and from post 1 to post 2 and also respondent 18 showed abrupt increase from pre to post 1 and a decrease abruptly from post 1 to post 2. The underlying causes may varies from one individual to another. For respondent 18, the abrupt increase from pre to post 1 was more likely because of the conditioned reflex where presence of food is not necessary, just the thought, smell, hearing of food that can stimulate gastric acid secretion[6]. Thus cause increase in urine pH. As for respondent 16, condition might be due to dehydration as stated by the respondent in the questionnaire, who only drinks four times of plain water per day. This might also be related to some pathological condition. In addition to low urinary pH, dehydration from any cause resulting in a low urine volume with increased urinary uric acid concentrations and a low urinary pH may create a setting for uric acid stone[7]. Furthermore, this condition also can be caused by high degree of acidity produced by carbon dioxide during normal metabolism that is eliminated from the body by the kidneys and the lungs. There were also the possibilities of other underlying causes for instances one having underlying medical history, gastrointestinal tract disturbances, genetic factors, gender-related, daily lifestyle, dietary habits, stress or sleeping habits. All of these factors may contribute to the abnormalities in the urine pH reading as they may lead to disruption of the normal acid-base balance regulation. Further study need to be done solely regarding these factors as to make a clearer justification how these factors may or may not influence one's urine pH.

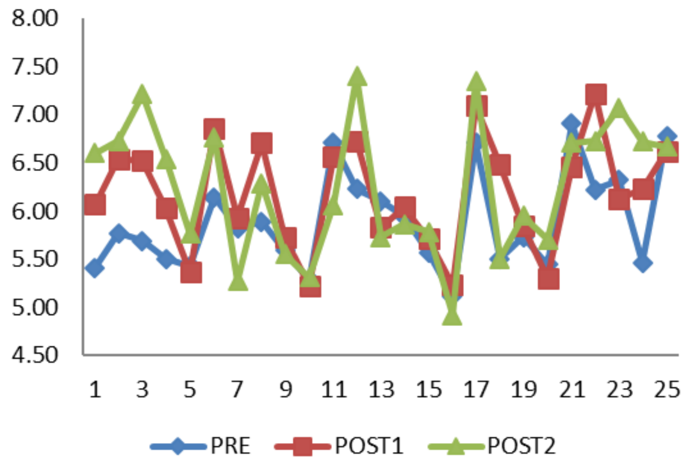

Fig. 3: Relation between fibre meal and urine pH for pre, post 1 and post 2 urine samples

3.4. Protein

Paired T test was used to analyze the mean of data collected and a line graph is plotted. Based on (Table- 1), Pair 1 was the comparison of mean of pH of urine sample between pre and post 1 while Pair 2 was the comparison of mean of pH urine sample between post 1 and post 2. The mean pH for pre, post 1 and post 2 are 5.73, 6.44, and 5.99 respectively. Based on the fig. 4, there were total of 24 respondents who showed an increase in pH from pre to post 1 and 1 respondents decreased in result whereas there were 3 respondents showed increase in urine pH from post 1 to post 2 and 22 respondents decreased in result. This aligned with the assumption that we made in which there will be increase in urine pH from pre to post 1 while decrease in urine pH from post 1 to post 2 reading. For individual results assessment, most of the respondents showed normal and moderate changes in urine pH from pre to post 1 and post 2 and aligned with our assumption but some respondents showed a slight difference like respondent 9, the urine pH reading decreases from pre straight to post 2; respondent number 2 and 22 showed increase in pH from post 1 to post 2. From the result obtained in figure 7, the pH of the urine increased from pre sample towards post 1 and decreased back when post 2 were taken; proportional to our hypothesis. The increase in the urine pH from pre to post one was due to the over-secretion of HCl by parietal cells in the stomach to convert the precursor pepsinogen to a smaller molecule known as pepsin, which is its active form. Pepsin, the protease in the stomach is most active at a pH of 2.0 to 3.0 and inactive if more than 5.0. Hydrochloric acid (HCl) secreted by parietal cells is originally at the pH 0.8 but after mixing with the stomach contents and other secretion from the glands of the stomach, the pH then average around the optimum and favourable acidity for the activity of pepsin. Thus, protein diet causes a high amount of HCl to be secreted in the stomach in order for digestion of protein to occur. The acid also elicits additional enteric nervous reflexes to enhance the original nervous signals to chief cells or peptic cells, stimulating the release of pepsinogen; and this occur indirectly to digest protein in the stomach[1]. Thus, pepsinogen secretion by the chief cells in the gastric gland of the stomach is strongly influenced by the amount of acid in the stomach. Pepsin brings about 10 to 20% of total protein digestion, initiating the process of protein digestion by converting the protein to proteoses, peptones and some polypeptides via hydrolysis at the peptide linkage between amino acids.

Going further deep into the mechanism of HCl production and secretion by the parietal cells in the gastric glands of the stomach, carbon dioxide from the blood streams enter the parietal cell across the basal membrane which will be combines with hydroxyl ions from the dissociation of water to form bicarbonate ion with the help of an enzyme called carbonic anhydrase. The bicarbonate ions diffuse out of the parietal cell into extracellular fluid exchanging with the chloride ions entering the parietal cells from the extracellular fluid the later will be secreted into the canaliculus to combine with hydrogen ion to form hydrochloric acid[8]. The diffusion of the bicarbonate ion into the extracellular fluid during metabolism lead to a condition called as the alkaline tide phenomenon because of increase of bicarbonate in the blood resulting into a alkaline condition of the extracellular fluid; increasing the systemic blood pH. Although there is a bicarbonate buffer system which is the most important extracellular buffer, but in this study, we discussed on how the kidney are involved in the digestion of food in the stomach which may lead to pH changes in the urine. In alkalosis, the loss of bicarbonate helps return the plasma pH to normal. The basic mechanism occurring in all parts of the renal tubules except in the descending and ascending limbs of loop of Henle is that for each bicarbonate ion reabsorbed, a hydrogen ion must be secreted. The compensatory reactions to alkalosis are opposite to those occurring in acidosis as the tubular secretion of hydrogen ions is decreased and excretion of bicarbonate ions increases. The net effect of increase ratio of bicarbonate to hydrogen in the renal tubular fluid gives a sign of excess of bicarbonate and thus cannot be reabsorbed from the tubules and thus excreted in the urine; removing the bicarbonate from the extracellular fluid via renal excretion, having the same effect as adding an hydrogen ion into the extracellular fluid, returning the concentration of hydrogen ion and pH back to normal; easing the alkalosis and causes the rise of the urine pH[4]. From post 1 to post 2, the results showed that most of the urine pH obtained from the respondents drop due to the absence of food in the stomach to be digested and no further stimulation of the secretion of HCl in the stomach and leading to only basal HCl secretion in the stomach and thus the urine pH decreases due to the drop of bicarbonate diffusing out from parietal cells into the extracellular fluid and thus leading to a decrease bicarbonate excretion via urine. For some of the respondents like respondent number 2 and 22, an increase of post 2 urine pH may be due to the 'conditioned reflex, a reflex that stimulate HCl secretion in the stomach result from the sight, smell and thought of food which brought by parasympathetic nerve fibre; vagus nerve leading to 30% of gastric secretion; as part of the cephalic phase of gastric secretion. This happens because the respondents were asked not to eat or drink anything until they submit the last urine sample at 2.30 pm except for drinking plain water and this makes them feel hungry. For respondent number nine, there may be certain causes related to the respondent's lifestyle and environment conditions based on the questionnaire answered. On the questionnaire, it showed that respondent 9 does not play any sport and she doesn't even exercise in her daily routine which may affect her body metabolism and digestion processes; despite the fact that she drank high amount of water (10 times) thus does not correlate with respondent 21 and 12 mentioned in carbohydrate due to dehydration that may affect their digestion. Previous study shown the effect of exercise on digestion and metabolism of food on donkeys and ponies were done and it summarized that there were on slight effect on exercise in which the exercising ponies have higher digestibility coefficient than the donkeys who were not put to exercise, but the results were not significant[5]. It may or may not relate with respondent 9 situation but further studies need to be done on this to support our study findings. Further study need to be done solely regarding these factors as to make a clearer justification how these factors may or may not influence ones' urine pH as said in fibre discussion. It showed the total mean of urine pH for all meal type for each pre, post 1 and post 2 and protein showed a very steep increase from the pH of pre urine sample to post1. Thus, this support very well the points discussed due to the alkaline tide phenomenon which lead to the increase of bicarbonate excretion and thus increases the urine pH; and from post 1 to post 2 showed a very drastic drop of urine pH which also proves the theory discussed before decreasing the urine pH indicating the extracellular is returning back to its normal pH value as the HCl secretion decrease to its basal secretion.

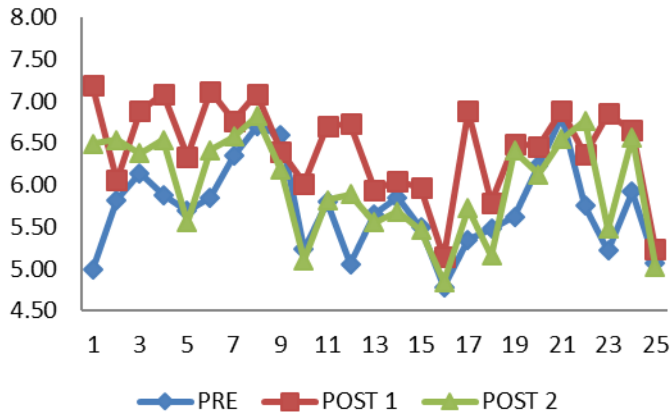

Fig. 4: Relation between protein meal and urine pH for pre, post 1 and post 2 urine samples

The result also showed that pre urine pH was not significantly correlated to types of meals ($p>0.05$) and the relationship between these variables is medium ($r = 0.345$) (Table- 2). On the other hand, post 1 urine pH was significantly correlated to types of meals ($p < 0.05$) and the relationship between these variables was very strong ($r = 0.982$). Whereas post 2 urine pH was not significantly related to types of meals ($p>0.05$) and the relationship between these variables was medium ($r = 0.462$). Relation between male gender and urine pH based on the types of meal consumed (Fig. 5) and the relation between female gender and urine pH based on the types of meal (Fig. 6) were shown. For fig. 5, male gender had more fluctuation on the pH of the urine samples for pre, post 1 and post 2. The graph showed that the urine PH from pre to post 1 significantly increase and slightly increase for protein, and fat and fibre respectively; and the urine pH drop from post 1 to post 2 for all three meals which is align with our assumption based on the theory discussed. While carbohydrate results showed very minimal changes and the pH was rather constant from pre to post 2. For fig. 6, it showed that protein and fat has similar pattern as the ones in the figure 2, but carbohydrate and fibre showed increase in urine pH from pre straight to post 2. This may be due to hormonal changes and hydration factors that affect the difference in results for male and female as female usually undergoes menstruation once a month but further study need to be done to prove this problem; moreover, there may be some effects by lifestyle like exercises, allergies and normal diet but to support this further study need to be done on the effect of hormones and lifestyle on urine pH.

Table- 2: Correlation between type of meals and urine pH

Urine pH	Pearson correlation (r)	Significant
Pre urine pH	**0.345**	**0.655**
Post 1 urine pH	**0.982**	**0.018**
Post 2 urine pH	**0.462**	**0.538**

Data is presented as mean. Correlation is significant at the 0.05 level (2-tailed).

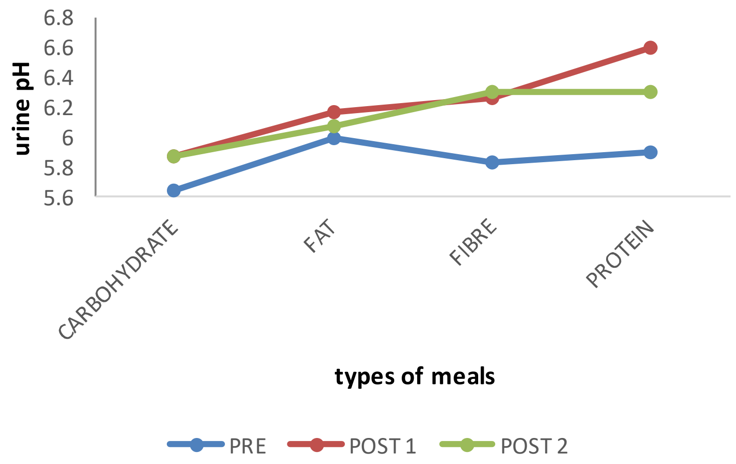

Fig. 5: The Relationship between different types of meals on urine pH sample for pre, post 1 and post 2 in male

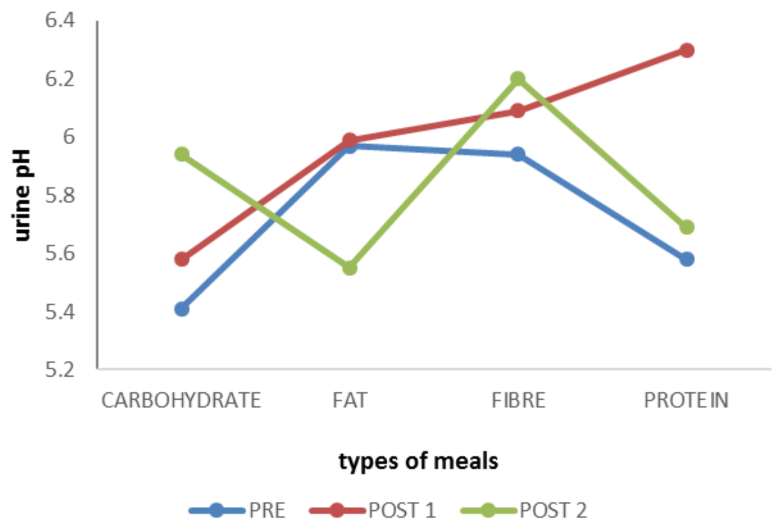

Fig. 6: The relationship between different types of meals on urine pH sample for pre, post 1 and post 2 in female.

4. CONCLUSION

From this study, we can infer that among the four types of meals tested against their influence on urine pH, protein has the strongest influence, followed by fat, carbohydrate and dietary fiber. Consumption diet rich in protein tends to produce extreme high pH as protein have tendency to highly stimulate the HCL secretion in the stomach during its metabolism. Fats fall to second in influencing the HCL secretion during its ingestion as its stimulation is not as strong as in protein but it does bring significant changes to urine pH. Both carbohydrates and dietary have about the same level of influence towards urine pH. Their changes are not due to HCL secretion but a different mechanism which eventually lead to the changes in acid-base balance of the extracellular fluid.

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