Potential application of yoghurt, cranberry juice and potato extract as alternative contrast media for computed tomography studies of the gastro-intestinal tract

Rachel Anne San Antonio, Lovelyn Harina, Marvin Magadia, Lourdes Sandoval, Karell Cadampog, Jetro Dilay, and Ruben Talag
Radiologic Technology Department, College of Allied Medical Professions, Lyceum of the Philippines University, Batangas City
onarresluigi8@gmail.com

ABSTRACT: This basic experimental research investigated the feasibility of using food grade materials such as potato juice, cranberry juice and yogurt as alternative oral contrast materials in computed tomography examination of the gastro-intestinal tract. In this study, eight mixtures containing yoghurt, potato extract, and cranberry or their combination were prepared. The mixtures were placed in sample bottles and were scanned using a routine to abdomen contrast computed tompgraphy (CT) protocol. The CT Hounsfield Unit (HU) from each sample were measured and compared from each other. Result of the study indicates that mean HU is strongly dependent on the percentage of potato extract on the mixture. The amount of cranberry and yoghurt on the mixture does significantly affect the CT Hounsfield unit. Results of the study indicate that using potato extract is relatively better than yoghurt and cranberry juice, as alternative contrast medium, in CT studies of the gastro-intestinal tract.

Keywords: contrast media, potato extract, yogurt, cranberry juice, iodine

INTRODUCTION

The increasing use of computed tomography (CT) has been gaining widespread acceptance in routine diagnostic procedures. This imaging modality has become a powerful tool in the identification and diagnosis of diseases (Bushong, 1997).

Computed tomography takes several projections of the region of interest in the body (e.g. Head, Abdomen) and mathematically recreates the anatomic image by taking into account the x-ray absorptions of organs and tissues (Bushong, 2012 pp. 438-439 and Bushberg, et.al. 2012, pp. 324-325). X-ray tissue absorption is quantified in terms of the linear attenuation coefficient. Linear attenuation coefficient is based on the photon-tissue interaction which, in turn, primarily depends on the material's density (Bushberg, et al 2012, pp. 46). Visualizing CT images is represented as pixel grayscale which primarily depends on the computed Hounsfield unit (HU) of the tissue. HU is the ratio of the difference between the average linear attenuation coefficient of the tissue and water (Bushberg, et al 2012, pp. 324).

To delineate tissues from each other, CT depends on the inherent differences in the HU values. Water, for instance, can be fully differentiated from bony structures because of the large difference in the HU values between them. This characteristic, however, is not general for all tissues. Often, adjacent tissue structures have nearly equal HU numbers making a definite delineation an extremely difficult task. To get away with this challenge, the use of a contrast material is normally employed.

Contrast agents are substances that temporarily change the way one visualizes the tissue of interest by increasing the absorption of x-ray photons. These make certain structures in the body appear different on the images and help distinguish selected areas of the body from surrounding tissue thus improving the visibility of specific organs, blood vessels, or tissues.

Contrast agent materials enter the body by swallowing or being administered by enema or injected into a blood vessel. Most common contrast agent is barium sulfate which can be taken through the mouth or through the rectum. It is a radiopaque agent which when taken or administered shows a lighter structure compared to the surrounding tissues. Contrast materials help the physicians see any special conditions that may exist in that part of the body.

The use of barium sulfate, however, may cause unwanted reactions such as hives, itching, red skin, throat tightening, and breathing difficulty. Barium may also cause constipation, intestinal cramping or diarrhea (MedlinePlus). Additionally, barium sulfate has an unpleasant taste making its use, primarily for children, quite challenging.

Nowadays, most commonly used contrast materials are iodine-based. Iodine has a relatively low absorption peak, allowing for a better contrast performance. Iodine possesses three important properties essential in the production of contrast media: high-contrast density, firm binding to the benzene molecule, and and low toxicity (Bettmann MA & Morris TW, 1986).

Using commercially available contrast media, however, makes CT procedures a little more expensive. The high cost is a major concern especially for economically disadvantaged patients. In addition, there are reports that iodine-based contrast causes allergic reactions to hypersensitive individuals (UCSF Radiology Dept., 2016). The need, therefore, for a safer alternative contrast material is of particular importance.

It is widely accepted that several materials, such as potato, cranberry, and yoghurt, are known to contain significant amount of iodine. Aside from their nutritional and medicinal values, these substances could be potentially used as a radiographic contrast media. Additionally, there are no reports indicating that these materials cause allergic reactions, except for lactose intolerance for the case of yoghurt.

In this basic experimental study, the CT Hounsfield unit of different high-iodine fruits juices and their mixture were investigated. The goal of this preliminary study is to identify which among the materials (potato, cranberry, and yoghurt) and their mixtures possesses the highest possible HU values. Although this research is currently limited to the determination of HU values of the above mentioned materials, the end goal of this study is to identify and prepare a future vegetable-based contrast media for CT and general radiography procedures.

MATERIALS AND METHODS

This study is a basic experimental research where the Hounsfield unit (HU) values of several high iodine-content materials are investigated. We prepared seven mixture samples with each one containing different mixtures of potato juice (extract), yoghurt (Nestle Phil), and cranberry (Fontana). The 8th sample used is pure water.

Table 1. Mixtures prepared in this study.

Mixture	Cranberry Juice	Yogurt	Potato Juice	Water
Mixture 1	0 mL	0 mL	50	0
Mixture 2	5 mL	5 mL	40	0
Mixture 3	10 mL	10 mL	30	0
Mixture 4	15 mL	15 mL	20	0
Mixture 5	20 mL	20 mL	10	0
Mixture 6	50 mL	0 mL	0	0
Mixture 7	0 mL	50 mL	0	0
Mixture 8	0 mL	0 mL	0	50

Table 1 shows the component of each mixture. The mixtures are poured on a 50 mL empty contrast bottle.

The mixture-filled contrast bottles are placed on a couch of the CT scan machine (Two-slice Siemen Somatom Spirit CT, Siemens Germany). The figure below is a representation of the set-up.

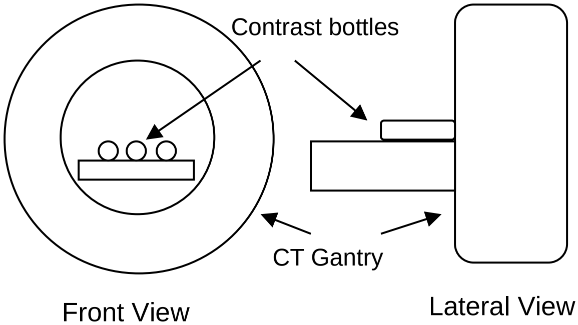

Figure 1. Schematic of the set –up for HU values measurement.

Scan Protocol

The standard abdomen contrast CT helical scan protocol (table 2) was employed in this study. The tube voltage used is fixed at 130 kVp, 60 effective mAs, a one second scan time per rotation, and 1.6 pitch factor.

Table 2. Contrast Abdomen CT scan protocol

Tube Voltage	130 kVp
Effective mAs	60 mAs
Scan time/rotation	1.0 s
Pitch	1.6

The analysis tools included in the Syngo computer program used in the Siemens CT is used to measure the HU and the HU standard deviation.

RESULTS and DISCUSSION

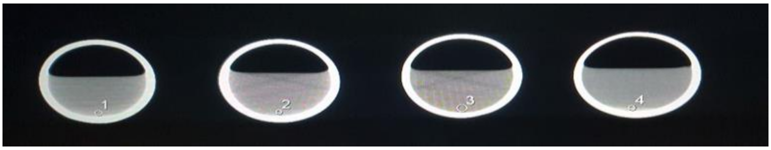

Figure 2 .Sample CT images of the mixtures.

The CT images of the mixtures are shown in figure 2.

The mean HU numbers and its standard deviation are measured for each CT images. The results of the measurements are shown in table 1. Close inspection of the data shows that the mean HU number is strongly dependent on the percentage (by volume) of the potato extract present. For instance, mixture 1, which is purely potato extract, has the largest HU number.

HU values, on the other hand, do not depend on the amount of yoghurt nor of cranberry. For instance, the HU number of pure cranberry is just 58.4, a little smaller than the mean HU for pure yoghurt. These HU range is comparable to the HU values of parenchymal tissues (Bushberg, 2012 pp.325).

Table 3. Mean HU numbers and standard deviation calculated from the mixture

Mixture	Mean HU	SD
Mixture 1	233.4	6.2
Mixture 2	179	14.9
Mixture 3	104.8	23.1
Mixture 4	103.3	41.1
Mixture 5	96.6	14.4
Mixture 6	58.4	7.1
Mixture 7	99.4	10.2
Mixture 8	0.0	8.2

To fully understand how the amount of potato juice affects the HU values of the mixtures, the mean HU is plotted against the percentage of potato extract present. Figure 3 shows the plot of this curve.

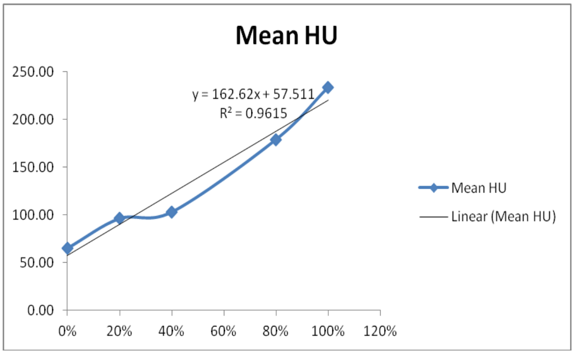

Figure 3. A strong linear relationship exist between mean HU number and percent potato extract

The plot shows that there exist a very strong linear relationship (r2 = 0.96) between mean HU and the amount of potato extract. This result appears to agree with the result of Laohawiriyakamol, et al (n.d). This result means potato extract absorbed more x-ray photons compared to cranberry and yoghurt (Bushberg, 2012 pp. 325). This is due to the presence of starch in potato.

CONCLUSION

As a preliminary study in exploring food-grade materials as alternative contrast media, this basic research was able to show that among yoghurt, cranberry, and potato extract, potato has the highest mean HU number. On the other hand, it appears that HU does not depend on yoghurt and cranberry. These would imply that further research on the development of food-grade contrast materials should focus more on starchy materials such as potato. We expect that incorporating potato starch with other commercially available contrast material would be an acceptable contrast material at a much lower cost.

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