

Basic Research

Radio Opacity of Honey: A Unique Physical Property with The Potential of A Radio Contrast Media

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Abstract

Background: Honey is known for its various physical properties, chemical contents and as a topical therapeutic agent. However its potential use in diagnostic radiology has not been reported.

Aims: To establish radio opacity of honey as its unique physical property, to establish its relationship with other physical properties, chemical contents and to determine if honey has any potential as diagnostic contrast media.

Material and Methods: CT scanner was used to calculate radio density in Hounsfield Unit (HU) on six honey samples, honey samples of different dilutions, Iopamidol, 25% glucose and agents containing Calcium, Iron, Magnesium and Potassium. Plain X-ray was obtained on honey samples, honey filled plastic tubes, and honey impregnated cotton gauze. Radio density of honey samples was compared with four selected physical properties of honey.

Results: Radio density of six honey samples ranged between 287±3.4 HU and 329±5.3 HU. Radio density of 2% Iopamidol, a commonly used radio contrast agent was 341±8.2 HU. Compared to honey, 25% glucose had low radio density and 15% Potassium chloride had high radio density. Radio density of six honey samples were compared with corresponding density ($p=0.0003$), specific gravity ($p=0.0002$), refractive index ($p=0.0001$) and dynamic viscosity ($p=0.10$). Plain X-ray images of honey samples showed marked radio opacity.

Conclusion: Radio opacity of honey is probably related to its high carbohydrate and potassium content. Honey's anti-bacterial & healing benefit will offer dual therapeutic and diagnostic advantage with concomitant use as a topical radio contrast agent.

Key Words: Honey, Physical property, Radio density.

Introduction

Honey is produced by bees for nectar collection and long term food storage as honey.¹ Honey is used in cooking, baking, desserts, and as addition to various beverages such as tea².

In USA honey is graded on its color and optical density by USDA standards and on the Pfund scale which ranges from zero for water white honey to more than 114 for dark amber honey³.

Most commercially available honey is a mixture of two or more honeys differing in floral source, color, flavor, density or geographic origin⁴.

Physical and chemical properties of honey vary depending on water content, the type of flora used to produce it, temperatures, and proportion of specific sugars it contains⁵. Honey contains varieties of organic and inorganic substances. Carbohydrates comprise about 82% of honey. They are monosaccharide like fructose (38.2%), glucose (31%) and rest are disaccharides and oligosaccharides.

Each 100 Gram of honey contains approximately 20.3 mg of Calcium, 1.4 mg of Iron, 6.8 mg of Magnesium, 13.6 mg of Phosphorous, 176 mg of Potassium, 13.6 mg of Sodium and negligible amount of Zinc, Copper, Manganese, Selenium and Fluoride etc⁶.

One study observed quantities of minerals in different honeys (in ppm) as follows: Potassium (298.60 – 491.40), Magnesium (80.70), Calcium (60.75 - 99.95), Phosphorous (21.10 - 33.29) and Sodium (15.69 - 26.93), Iron (67.18 - 98.13), Iodine (12.61), Manganese (4.15 - 6.04), Zinc (3.44 - 5.72) and small amount of Cobalt, Nickel, Lead and Cadmium⁷.

Honey has a density of around 1.36 Kg/L and it is 36% denser than water³. Specific gravity of honey is dependent on water content⁸. The melting point of crystallized honey is between 40°C and 50°C depending on its components⁹.

Viscosity (dynamic) of honey expressed as mPa.S (millipascal seconds) is affected by both temperature and water content¹⁰.

Refractive index of honey is altered by variations in water content. Water content can be measured by the combined formula developed by Wedmore using refractive index and tables developed by Chataway^{11,12}. Typically the refractive index for honey ranges from 1.504 at 13% water content to 1.474 at 25% water content.

Because honey contains electrolytes in the form of acids and minerals, it exhibits various degrees of electrical conductivity indicating quality of honey in terms of its ash content¹².

Radio opacity (or radio density) refers to relative inability of electromagnetic radiation particularly X-rays to pass through a particular material and it can be quantified according to Hounsfield scale¹³. This principle is central to X-ray Computerized Tomography (CT) scan applications where radio density is expressed as Hounsfield Unit (HU)¹⁴.

Literatures on physical properties of honey have described specific gravity, density, viscosity, refractive index, electrical conductivity, thermal and optical properties of honey¹². However there is no report on radio density of honey on current literature search. In our study honey has been observed to have significantly high radio density worthy of further investigation.

Objective

Objectives of our study was: (1) to establish high radio density of honey as a newly reported physical property, (2) to determine if this characteristics is attributed to any chemical content of honey, (3) to determine if this property is related to other physical properties of honey; and (4) to determine if this unique property has any potential for diagnostic use.

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Materials and Methods

This was a prospective observational study carried out between Aug 2016 and April 2017 at a local hospital and at a local university.

Each study sample of honey and other study liquids were kept in 10 cc plastic syringes at room temperature and appropriately labeled before use. We obtained radio density of the study samples (Fig 1, 2 & 3; Table 1, 2 & 3) calculated in HU by using a CT scanner (SIEMENS Model – SOMATOM Definition AS + slice 128).

We used SIEMENS 1000 MA digital X-ray machine to obtain X-ray images of designated study samples.

We randomly chose six different samples of honey obtained from a local supermarket (Table 1 A-F). Samples A & E, samples B, C & D and sample F were from Australia, Bangladesh and Saudi Arabia respectively.

We estimated radio density of six honey samples (Table 1 A-F). We estimated radio density of Iopamidol 370 (undiluted and 02.0% soln.) which is an intravenous radio contrast agent used by radiologists at our imaging center, sample B honey of four different strengths (100%, 75%, 50%, 25% in water), 25% Glucose (Table 2 a-g.). Then we estimated radio density of 10% Calcium gluconate solution, 4% Magnesium Sulphate solution, 2% Iron Sucrose solution and 15% Potassium Chloride solution (Table 3 I-IV).

We obtained X-ray images of study samples in 10 CC plastic syringes mentioned in Table 2 a-g.

We obtained X-ray images of a sample of honey contained in a plastic syringe, a honey filled plastic tube, a plastic tube filled with honey and air bubbles, and a piece of cotton gauze impregnated with honey.

Density and specific gravity of study samples (A - F) of honey were measured simultaneously with an Anton Paar (Model DMA 5000) vibrating-tube density meter at 25°C¹⁵. Refractive indices of study samples (A - F) were measured at 25°C using Anton Paar Abbemat-350 automated refractometer¹⁶.

We used Ostwald viscometer¹⁷ to measure dynamic viscosity of study samples (A - F) at 22.0°C.

Results of radio density of study samples (A - F) were compared with density, specific gravity, refractive index and viscosity of corresponding samples. The data were analyzed by using SPSS version-20. Radio density of honey expressed in HU was considered as dependent variable and density (expressed in gm /cubic cm), specific gravity, refractive index and viscosity (expressed in mpa.s) were considered as independent variables. One sample T test was used to observe the level of significance. *P*-value <0.05 was considered as statistically significant.

Results

Radio density of study samples A - F calculated by plain CT scanner in HU (Mean ± SD) are shown at Table 1 A - F and with corresponding CT axial image at Fig 1 A - F.

Table 2 a - g and Fig 2 a - g show radio density of designated study samples described in materials and methods with corresponding CT axial image.

Table 3 I - IV and Fig 3 I - IV and show radio density of four different intra venous therapeutic agents containing Calcium, Magnesium, Iron and Potassium respectively with corresponding CT axial image as described in materials and methods.

Table 4 shows radio density of sample A to F compared with density, specific gravity, refractive index and dynamic viscosity with mean \pm SD and calculated *p* value for each set of physical properties.

Fig 4 shows X-ray images of 100% Iopamidol 370, 2% Iopamidol 370, four concentrations of sample B honey and 25% glucose (see Table 2 a - g) arranged from above down.

Fig 5 shows X-ray image of a sample of honey filled plastic syringe (a), honey filled plastic tube (b), plastic tube filled with honey and air bubbles (c), and a piece of cotton gauze impregnated with honey (d).

Discussion

We have studied six honey samples (A - F) all locally procured (both native and foreign origin). All these samples showed radio density ranging from 287 ± 3.4 HU to 329 ± 5.3 HU (Table 1 A - F). We also observed that 2% Iopamidol 370 which is a intravenous contrast media used in our study hospital with a radio density of 341 ± 8.2 HU (Table 2 b). So radio density of 2% Iopamidol is comparable to radio density of honey samples used in our study.

Carbohydrates comprise about 82% of honey according to different literature⁵. Out of them Fructose (38.2%) and glucose (31%) are the most abundant.

25% Glucose has a radio density of 52.3 ± 10.3 HU (Table 2 g) and 25% honey has radio density of 63.1 ± 4.7 HU (Table 2 f). So it can be hypothesized that fructose (radio density not measured) and glucose together may contribute to overall radio density of honey.

As honey contains significant amount of Potassium, Calcium, Iron and Magnesium, we examined four different therapeutic intravenous agents mentioned in Table 3 I - IV. 15% Potassium chloride soln. was found to have significantly high radio density of 372.9 ± 9.6 HU and it is comparable to that of honey. According to literature, Potassium is the most abundant mineral (one third of mineral content of honey) observed in honey^{18,19}. So it can be hypothesized that significant Potassium content could also be responsible for the radio opacity of honey.

We chose density, specific gravity, refractive index and dynamic viscosity and we compared the results of these four

physical properties of all six honey samples (A - F) with respective radio density. We observed that radio density of all the study samples were positively correlated with density, specific gravity, refractive index with significantly low *p* value (.0003, .0002, .0001 respectively) with the exception of dynamic viscosity (*p* = 0.10). (Table 4)

Lastly we examined X-ray images of honey filled plastic syringes (Fig 4; also note Fig 2 & Table 2), honey filled plastic tube, plastic tube containing honey with air bubbles, honey impregnated cotton gauze (Fig 5 a b c d). These images indicate that honey has significant radio density on plain X-ray.

We believe that honey has the potential to be used by radiologists for imaging sinus, fistula, outlining salivary duct, and urethra etc. Honey impregnated cotton gauze can also be used by surgeons to pack external wounds and internal cavities (like peritoneal cavity) during operative procedures. The location of the packing is expected to be visualized and confirmed by plain X-ray. Similarly if honey is injected into bursa, cysts, etc. dimensions of cavities is expected to be outlined by plain X-ray.

Various literatures describe abundant therapeutic benefits of honey. Honey promotes healing of wound dehiscence²⁰. It prevents formation of biofilm and is superior to antimicrobial dressing²¹. It promotes debridement of wounds and accelerates wound closure²². It has broad spectrum antimicrobial activities and clears severely infected skin wounds²³. Honey enhances healing in burn wounds²⁴.

Conclusion

It can be concluded that honey as a topical radio contrast agent, has dual application potential both therapeutic and diagnostic. Our study is a preliminary study. So combination of therapeutic application of honey in healing of lesions as outlined in the previous paragraph together with the diagnostic potential of X-ray and CT imaging of the some lesions will open up potentially vast areas of research. We also conclude that radio opacity of honey is a newly identified physical property which needs further study to determine more accurately its relationship with its various physical properties and chemical contents.

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Table-I

	Mean HU ± SD
A Ausie bee	288.2± 21.3
B Dabur honey	294.1±9.7
C AP honey Sundar ban	322.4±3.0
D Haradighi	287.8±3.4
E Capilano	328.7±3.4
F AlShifa acacia honey	329.0±5.3

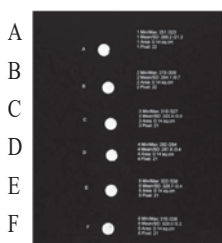


Fig 1

Table-2

	Mean HU ± SD
a 100% Iopamidol 370	3071±0.0
b 02% Iopamidol 370	341.0±8.2
c 100% honey	305.1±18.3
d 75% honey	243.2±12.4
e 50% honey	152.9±9.4
f 25% honey	63.1±4.7
g 25% glucose	52.3±10.3

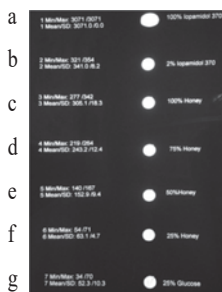


Fig 1

Table-3

	Mean HU ± SD
I 10% Calcium gluconate soln.	67.8±10.5
II 4% Magnesium Sulphate soln.	17.5±5.5
III Iron Sucrose solution	252.1±9.3
IV 15% Potassium Chloride soln.	372.9± 9.6

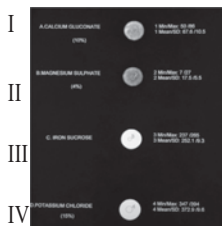


Fig 3



Fig 4

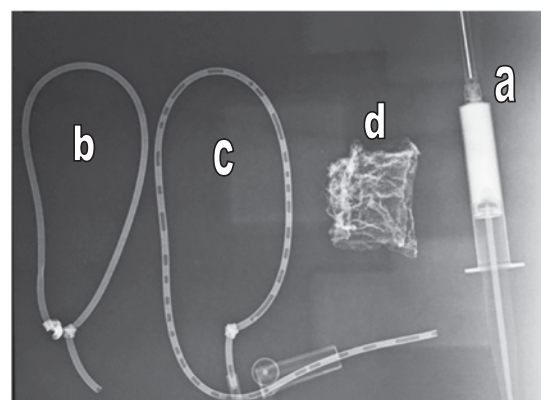


Fig 5

Table-4

Study samples of honey	Radio density HU: Mean ±SD	Density gm/ cm3	P value	Specific gravity	P value	Refractive index	P value	Viscosity <i>mpa.s</i>	P value
A	288.2 ± 213	1.41412		1.41053		1.489760		2519.87	
B	294.1 ± 9.7	1.40715		1.40715		1.489130		2098.18	
C	322.4 ± 3.0	1.41021		1.411440		1.489260		3409.14	
D	287.8 ± 3.4	1.218		1.222		1.474750		355.76	
E	328.0 ± 3.4	1.41907		1.422390		1.493500		5672.30	
F	329.0 ± 5.3	1.42159		1.42581		1.492630		4693.04	
			.0003		.0002		.0001		.010

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