Impact of some edible plants on buffering gastric juice acidity

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(NJC)

(Received on 25/5/2008) (Accepted for publication 24/8 /2008)

Abstract

The present study deals with the investigation of total acidity, acid-neutralizing capacity (ANC) and mineral contents in some edible plants in order to determine their effect on neutralizing the acidity of gastric juice. The investigated plants are radish, cabbage, carrot, tomato, apricot and banana. The “total acidity” reflects the volume of 0.1 N HCl needed to decrease the pH of 50 ml of each plant syrup by one unit.

The maximum total acidity was 75 ml for apricot, then 54 ml for carrot, 48 ml for cabbage and 38 ml for each of banana and radish. The minimum value was 15 ml for tomato.

Apricot, carrot and cabbage exhibited a relatively high ANC (viz. 6.7, 5.1 and 4.6 ml, respectively), while tomato and radish leaves exhibited a low ANC (viz. 1.3 and 1.8 ml, respectively).

As regards the mineral contents, cabbage had the highest level of Na (viz. 0.99 mg/g dry weight, DW). The richest source of K (viz. 73.5 mg/g DW) was tomato. Apricot showed the highest Ca content (viz. 38 mg/g DW) and Mg content (viz. 24 mg/g DW). Heavy metals showed wide variations. Cu contents ranged between 0.012 (for banana) and 0.0035 mg/g DW (for both carrot and radish). The highest Zn content (viz. 0.112 mg/g DW) and Cd content (viz. 0.004 mg/g DW) was in banana.

The findings suggest that some of the studied plants (viz. apricot, carrot and cabbage) reflect a good buffering effect according to their relatively high total acidity and ANC. In addition, carrot, radish and cabbage may play a good role in reducing gastric juice-acidity since they contain relatively high contents of Mg, which is one of the suitable metals usually used in manufacturing antiacids.

الخلاصة

تهتم الدراسة بتقدير الحامضية الكلية total acidity وسعة معادلة الحموضة acid neutralizing capacity (ANC) ومستوى بعض المعادن لبعض الأغذية النباتية بهدف معرفة تأثيرها في تنظيم حموضة عصارة المعدة. إن الأغذية المستخدمة في هذه الدراسة هي: الفجل ، اللهانة ، الجزر ،الطماطة، المشمش والموز. كانت الحامضية الكلية للمشمش هي الأعلى مقارنة بالأغذية المستخدمة الأخرى حيث بلغت 75 مل، تليها الحامضية الكلية للجزر 54 مل، ثم اللهانة 48 مل، ثم للموز وللفجل 38 مل لكل منهما.

أظهر المشمش والجزر واللهانة مستوى عال من ANC حيث بلغت 6.7 و 5.1 و 4.6 مل على التوالي، في حين أظهرت الطماطة وأوراق الفجل مستوى واطئ نسبيا وكانت 1.3 و 1.8 مل على التوالي.

بالنسبة لمستويات العناصر الفلزية، فقد كان مستوى الصوديوم في اللهانة هو الأعلى حيث بلغ 0.99 ملغم/غم من الوزن الجاف للعصير. وكانت الطماطة هي المصدر الأغنى بالبوتاسيوم حيث بلغ مستواه 73.5 ملغم/غم من الوزن الجاف. لقد أظهر عصير المشمش أعلى مستوى للكالسيوم وكذلك للمغنيسيوم حيث بلغ 38 و 24 ملغم/غم من الوزن الجاف على التوالي.

كانت مستويات العناصر الفلزية الثقيلة متفاوتة كثيرا فتراوحت نسبة النحاس في عصير الاغذية بين 0.012 (للموز) و 0.0035 ملغم/غم من الوزن الجاف (لكل من الجزر والفجل). وأظهر الموز اعلى مستوى للزنك 0.112 ملغم/غم من الوزن الجاف ، والكادميوم 0.004 ملغم/غم من الوزن الجاف.

في ضوء النتائج التي تم التوصل إليها يمكن القول أن لبعض الأغذية النباتية المستخدمة في هذه الدراسة (الموز والجزر واللهانة) قابلية جيدة في تنظيم حموضة عصارة المعدة، إضافة إلى أن كلا من الجزر واللهانة قد تلعب دورا مهما في خفض حموضة عصارة المعدة بسبب احتوائها على مستوى عال نسبيا من المغنيسيوم الذي يعد احد العناصر الفلزية الأكثر ملائمة للاستخدام في صناعة مضادات الحموضة.

Introduction

Since the discovery by William Prout in 1824 that the acidity in the stomach was due to hydrochloric acid, there has been a sustained interest in the mechanisms involved in the formation and secretion of gastric acid[1].

One type of the gastric mucosa cells, viz. parietal cells, are considered to be the source of hydrochloric acid[2]. Parietal cells have three types of basolateral receptors that respond to stimulate acid secretion. They are cholinergic, gastrin and histamine receptors. The binding of acetylcholine, gastrin or histamine leads to the secretion of hydrogen ion into the gastric lumen by the H^+/K^+ ATPase, the final common pathway of acid secretion[3].

Numerous factors; such as cafaein, insulin, protein-rich meals, psychological conditioning, cholinergic drugs and others; increase acid secretion by the stomach[3,5].

Antiacids are alkaline substances that reduce gastric acidity by neutralizing hydrochloric acid, cloning histamine, gastrin or cholinergic receptors or by inhibiting H^+/K^+ ATPase[5,6].

Recently, a resurgence of interest has developed in plants for their possible medicinal values in diets. They have anti-bacterial, hepatoprotective, anticarcinogenic and antiacidic properties. In addition, they provide minerals, fiber, vitamins and essential fatty acids[3,7,8]. According to this fact, many previous studies have investigated minerals and other contents of many plants that have been used as salad and vegetable dishes, in relation to their nutritional or medicinal value[9-13].

The present study deals with the investigation of mineral contents and acid-neutralizing capacity (ANC) of syrup of several edible plants that may play a role in reducing the high acidity of gastric juice, from which a large number of people are suffering.

Materials and Methods

Investigated plants

Six edible plants were investigated in the present study (Table 1). Fresh plants were collected from the local market. They were washed, air-dried, chapped and crushed by a mechanical blender for five minutes. The mashed mixture was filtered through several layers of gauze to remove the residual materials. The filtrate was put in the refrigerator for 6 hours, then it was centrifuged for 15 min. at 3000 g/min and the supernatant was filtered again through a filter paper (Whatmann No. 2) to obtain a clear syrup[12]. The pH and the total acidity of each syrup were checked immediately.

Determination of syrup-pH and total acidity

The pH of each plant syrup was determined by pH-meter (D 8120 Wel). To determine total acidity, 50 ml of each syrup was titrated against 0.1 N HCl, the pH was checked whenever 0.1 or 0.2 ml of HCl was added with shaking, till the syrup-pH decreased by one unit.

A further 50 ml of each syrup was titrated against 0.1 N NaOH till the syrup-pH increased by one unit[14].

Determination of the amount of dry-materials

A dry material of syrup produced from 100 g of each utilized plant was determined after reducing the volume of the clear syrup to about 1/3 by lypholization (using lypholizer from Edwards Company, England), then the produced material was dried in the oven at 50-60 °C in order to obtain a solid material which was stored and kept frozen until ready for chemical analysis.

Determination of ANC

To determine the ANC, a solid sample is more useful in application, so the solid material that was obtained as a result of drying 50 ml of each utilized syrup was used in such investigation. The produced solid material was dissolved again in 50 ml distilled water, then it was titrated against 1 N HCl inorder to decrease syrup-pH by one unit. The pH was checked every time 0.1 or 0.2 ml of HCl was added till the pH decreased by one unit. The stability of pH was checked several times in at least 20 min.[15].

Determination of some mineral concentrations

Mineral concentrations were determined, after digestion of 0.5 g of the dried compound of each utilized syrup, by adding 5 ml of diluted H_2SO_4 (35 ml of conc. H_2SO_4 with 1.84 sp.gr.was diluted to 1 litre) and leaving the mixture for about 24 hours. The solution was diluted to 50 ml by distilled water. The concentrations of K and Na were determined by flame photometer (Corning 400; using natural gas as a flame source) and of heavy metals (viz. Cu, Cd, Zn) by atomic absorption [16,17].The atomic absorption spectrophotometer used was Philips Unicom Model SP9, using air with acetylene as a flame source.

The concentrations of Ca and Mg were determined by titration against EDTA-Na_2. 25 ml of the digested solution was titrated against 0.05 N EDTA-Na_2 in the presence of little amount of murexide (ammonium pupurate) till a brown colour appeared. To determine the concentration of Mg, a further 25 ml of the digested solution was titrated against 0.05 N EDTA-Na_2 in the presence of buffer solution (1 N NH_4Cl 1 N NaOH, 1:5 V/V) and erichrome black T, as indicator. The end point was recognized when the colour of the solution changed from red to blue. The added volume of EDTA-Na_2 was equivalent to both Ca and Mg. To determine the volume of EDTA-Na_2 which was equivalent to Mg, the volume which was equivalent to Ca (produced from the previous step) was substrated from its volume resulting from the present step. Each 1 ml of 0.05 N EDTA-Na_2 is equivalent to 2.008 mg of Ca and 1.216 mg of Mg[18].

Results

The pH of the syrup of each of the utilized plants is reported in Table 2. The highest pH value (viz. 6.18) was found in radish leaves-syrup and the lowest (viz. 3.33) in apricot fruit-syrup. The dry material that was produced from the syrup of 100 g of each plant varied depending on the plant (Table 2).

The total acidity of each utilized plant syrup is given in Table 3 which shows that the volume of 0.1 N HCl needed to decrease the pH of 50 ml syrup, by one unit, varied with different plants. The maximum volume (viz. 75 ml) was obtained for apricot syrup while tomato syrup needed the minimum volume (viz. 15 ml). On the other hand, the volume of 0.1 N NaOH needed to increase the syrup-pH by one unit exhibited the maximum volume (viz. 50 ml) for apricot syrup but the minimum volume (viz. 6 ml) for radish leaves-syrup.

Table 4 shows the ANC and the pH of the solution produced from re-dissolving the lypholized-dried material in 50 ml distilled water. The pH values was found to be relatively higher than that of the syrup before lypholization.

The table also shows the volume of 1 N HCl needed to decrease the pH of the reconstituted lypholized-material by one unit which reflected its ANC. Apricot, carrot and cabbage needed relatively higher volumes (viz. 6.7, 5.1 and 4.6 ml, respectively) compared with other plants such as tomato and radish leaves (viz. 1.3 and 1.8 ml, respectively).

The concentration of studied minerals are presented in Table 5. Cabbage had the highest concentration of Na (viz. 0.99 mg/g DW) followed by banana then carrot (0.75 and 0.74 mg/g DW respectively). Radish-P had the lowest concentration (viz. 0.28 mg/g DW). With regard to K, the richest source was tomato followed by apricot then radish-P (viz. 73.5, 48 and 43.5 mg/g DW, respectively). Radish-C had the lowest concentration (viz. 21.9 mg/g DW). Apricot and banana species showed higher Ca contents (38 and 33 mg/g DW, respectively) than tomato, radish-P and C, carrot and cabbage (viz. 24, 23. 22. 17 and 14 mg/g DW, respectively). Furthermore, apricot and banana had higher contents of Mg (viz. 24 and 16.8 mg/g DW, respectively) than the others; carrot, radish-P and C, cabbage and tomato had 11.4, 11, 8.5, 6.8 and 5.6 mg/g DW, respectively.

Heavy, metals in the utilized species varied widely in their contents. The Cu contents ranged between 0.012 (for banana) and 0.0035 mg/g DW (for carrot and radish-C). The highest Zn content (viz. 0.112 mg/g DW) was in banana, whereas, tomato and cabbage had the lowest Zn content (viz. 0.045 mg/g DW). Banana had the highest level of Cd (viz. 0.004 mg/g DW). The Cd contents in radish-C and tomato were the same (viz. 0.0016 mg/g DW) and cabbage had the lowest level (viz. 0.0013 mg/g DW).

Discussion

To interpret the capability of the utilized plants listed in Table 1 (radish, cabbage, tomato, apricot and banana) to reduce the gastric juice-acidity, the pH values of such plant-syrups were determined, they were all acidic but their pH values were not less than 3.33. It has been stated that control of stomach acidity is achieved by several approaches: neutralization of the existing acid, inhibition of acid secretion, enhancement of natural protective processes and treatment of H. Pylori infection[6,19]. During active secretion, the gastric juice has a pH value of 1 or less[6,20]. Although the syrup-pH was acidic, it still had buffering capability because its value was more than 1, therefore, such plants may reduce the gastric-juice acidity according to the neutralization effect. In addition, most of the utilized plant-syrups needed a relatively large volume of HCl to reduce its pH, and needed a small volume of NaOH to increase its pH which reflects a good buffering effect[7]. It is known that the volume of gastric juice is 20-100 ml[20].

One of the parameters that reflect the efficiency of drugs to reduce the gastric juice acidity is ANC; the higher the ANC the more effective the drug. Table 6 shows the ANC of some available antiacid-drugs[15] and according to the results listed in Table 4, apricot, carrot and cabbage (and, to some extent radish-P and banana) had ANC which mimicked that drugs as Maalox and Mg-trisilicate.

The therapeutic efficiency of the antiacids neutralizing HCl and their adverse effects depend on the metallic ion as well as the base with which it combined; usually sodium, magnesium or aluminum is used[4]. Table 5 shows a high content of Na for cabbage, banana and carrot which may play an important role in neutralizing HCl[4]. In addition, the table shows the highest content of K for tomato, which may make it less capable of neutralizing HCl because K is important for insulin function[21] which in turn is recognized as one factor for increasing HCl secretion in the stomach.[3] Regarding Mg, it showed a higher concentration in apricot than in banana but the content of Ca for both of them was also high and it has been stated that Ca-carbonate causes rebound acid secretion, therefore Ca has largely been a banded for the neutralization of gastric acidity[4]. Carrot, radish and cabbage may be more effective in reducing the acidic feeling due to their relatively high contents of Mg (a suitable metal in a number of antiacid drugs) and low contents of Ca.

Some heavy metals are essential at low levels but toxic at elevated levels[22]. The presence of heavy metals (e.g. Cu, Zn and Cd) in the diet may play a role in reducing the gastric juice-acidity by inhibiting some enzymes that have a direct role in acid secretion by the stomach such as carbonic anhydrase or H^+/K^+ ATPase[20,23,24]. Therefore, the relatively high content of Cd, Zn and Cu in banana, apricot and radish-P may, in the case of application, give them a chance to neutralize gastric juice.

Finally, in addition to the role of metals and ANC in neutralizing gastric juice-acidity, the utilized plants may contain other effective compounds (e.g. glucagon-like peptide 2, GLP-2) that inhibit gastric acid secretion[25], or compounds that clone the cholinergic, gastrin and histamine receptors[3,5]. The utilized plant-components may form a protective layer on the stomach content and prevent the passage of acid to the pharynx through the aperture between the esophagus and the stomach. These assumptions need further studies to be proved or refuted.

Table (1): Investigated plants and their edible parts

Scientific name	Common name	Edible parts*
Raphanus sativa	Radish	L,C,P
Brassia oleracea	Cabbage	L
Daucuso carata	Carrot	R
Lyopersicum esculentum	Tomato	C
Prunus armeniaca	Apricot	F
Musa paradisiaca	Banana	F

* Edible parts: L, leaves; C, core; P, peel; R, root and F, fruit

Table (2): Dry material-content and the syrup-pH of utilized plants

Species	Dry material (g/100 g)	Syrup-pH
Radish		
L	1.60	6.18
C	4.67	5.46
P	1.02	5.2
Cabbage, L	11.33	4.17
Carrot, R	10.63	4.47
Tomato, C	2.08	4.24
Apricot, F		3.33
Banana, F	8.26	4.33

Table (3): Volume of 0.1 N HCl and 0.1 N NaOH needed to decrease and increase the pH of 50 ml syrup by one unit (total acidity)

Utilized syrup	Vol. of 0.1 N HCl for decreasing pH by one unit (ml)	Vol. of 0.1 N NaOH for increasing pH by one unit (ml)
Radish		
L	20	6
C	26	15
P	38	26
Cabbage	48	44
Carrot	54	28
Tomato	15	19.5
Apricot	75	50
Banana	38	12

Table (4): Volume of 1 N HCl needed for the estimation of acid-neutralizing capacity (ANC)

Soln. of dry material obtained by drying 50 ml syrup of	Soln. pH	Vol. of 1 N HCl needed for ANC (ml)
Radish		
L	6.57	1.8
C	6.02	2.4
P	5.80	3.5
Cabbage	4.92	4.6
Carrot	4.83	5.1
Tomato	4.65	1.3
Apricot	3.81	6.7
Banana	4.85	3.5

Table (5): The mineral content of the utilized plant-syrup

Dry material of the syrup of	Concentration of minerals (mg/g DW)						
	Na	K	Ca	Mg	Cu	Zn	Cd
Radish							
C	0.42	21.9	22	8.5	0.0035	0.072	0.0016
P	0.28	43.5	23	11	0.0044	0.058	0.0017
Cabbage	0.99	27.8	14	6.8	0.0036	0.045	0.0013
Carrot	0.74	31.5	17	11.4	0.0035	0.054	0.0014
Tomato	0.37	73.5	24	5.6	0.0044	0.045	0.0016
Apricot	0.62	48	38	24	0.013	0.056	0.002
Banana	0.75	24	33	16.8	0.012	0.112	0.004

Table (6): The ANC of one tablet of some available antiacids[15]

Antiacids	Vol. of 1 N HCl (ml) (ANC)
Maalox	4.0
Mg trisilicate	4.5
Actal	8.9
Nulacin	9.3
Polycrol	10.0

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