Food and Nutrition Sciences, 2011, 2, 868-877
doi:10.4236/fns.2011.28118 Published Online October 2011 (http://www.SciRP.org/journal/fns)

Anti-*Helicobacter* Activity of Certain Food Plant Extracts and Juices and Their Composition *in Vitro*

Anna Babarikina[1,2], Vizma Nikolajeva[2], Dmitry Babarykin[1]

[1]Institute of Innovative Biomedical Technology Ltd., Riga, Latvia; [2]Faculty of Biology, University of Latvia, Riga, Latvia.
Email: vizma.nikolajeva@lu.lv

Received May 4th, 2011; revised July 30th, 2011; accepted August 7th, 2011.

ABSTRACT

Plant material screening was performed to study anti-Helicobacter pylori activity in vitro using an agar diffusion method on Columbia blood agar. 33 substances, juices and plant extracts and 35 of their combinations were tested. Quince (Cydonia oblonga) juice demonstrated the strongest anti-H. pylori activity followed by cranberry juice. Concentrated apple juice, plum, red currant, black chokeberry, raspberry and bilberry juice also showed significant activity. Green tea and apple pomace extract as well as sweet flag rhizome, ginger and wild bergamot extract, cherry syrup, red beet juice and whey did not exhibit anti-Helicobacter activity. Quince juice in combination with bilberry, black chokeberry, red currant juice, green tea, sweet flag rhizome or apple pomace extract as well as cranberry juice in combination with sweet flag rhizome extract demonstrated a synergistic effect on inhibition of H. pylori. The obtained results offer new perspectives for development of functional anti-Helicobacter food product(s) for dietary management of H. pylori infection. The essential components of these products could be the most active juices and extracts like quince and cranberry juice supplemented with a corresponding synergist. Further studies are required to investigate the mechanism of antibacterial action of plant products and their efficacy in vivo.

Keywords: *Helicobacter*, *Antimicrobial Activity*, *Plant Extract*, *Juice*

1. Introduction

Helicobacter pylori is a common bacterium and unique among pathogens. It can persist in the acidic environment of the human stomach. *In vitro*, urease is required for survival at pH 4.0 and below, whereas at higher acidic pH, mechanisms independent of urease are protective [1]. Expression of approximately 7% of the *H. pylori* genome is reproducibly altered by a shift to low pH [2]. A large number of reports have been produced on *H. pylori* and its pathogenetic potential. *H. pylori* infects at least 50% of the world's population [3]. Usually, the infection occurs in early life [4,5] and persists throughout the course of a lifetime. The most likely mode of transmission is from person to person, by either the oral-oral route or the fecal-oral route [6]. The involvement of water and food cannot be excluded as vehicles or sources of infection [7].

The course of treatment against helicobacteriosis is usually based on classic triple therapy including proton pump inhibitors and antibacterial therapy, clarithromycin and amoxicillin. For allergic patients, amoxicillin could be replaced by metrodinazole. In cases of antibiotic resistance, the Bismuth compounds can be applied [8-10]. Currently available first-line anti-*H. pylori* therapies may fail in up to 30% of patients [11] leading to a significant increase of antimicrobial resistance [12-14]. New antimicrobial agents such as a combination of antibiotics with plant extracts and other natural products that possess antimicrobial activity [15,16] are, therefore, being developed to overcome this problem.

Many infections may prove amenable to safe and effective treatment with non-antibiotics [17]. Non-antibiotic therapies, including phytomedicines, probiotics, and antioxidants, have been increasingly investigated for the treatment of *H. pylori* [18]. The consumption of foods that inhibit the growth of bacteria may provide an alternative to current therapies [19] or complement and expedite current treatments [20]. For the present, despite investigations, phytoceuticals are not accepted as a standard treatment for *H. pylori* infection [21].

In general, investigations of natural anti-*Helicobacter* agents can be divided in two groups: 1) investigation of plants used for gastroduodenal disorder treatment in the ethnomedical traditions in different geographic regions [22]; 2) investigation of common food plants and their components. Anti-*Helicobacter* activity has been estimated,

Copyright © 2011 SciRes.

for example, in broccoli sprouts [23], dill, fennel, caraway and cinnamon [20] as well as in several representatives of the *Asteraceae*, *Boraginaceae*, *Crassulaceae*, *Eriocaulaceae*, *Tiliaceae* and *Verbenaceae* families [22]. In our opinion, the largest amount of information describes berries—the cranberry, bilberry, strawberry, black currant and red bilberry [24,25]. The inhibitory effect of the Japanese apricot (*Prunus mume*) on *H. pylori*-related chronic gastritis [26] is also well-known.

Taking into consideration previous findings, the aim of this study was to evaluate the anti-*H. pylori* effect of certain food plant extracts and juices and their composition *in vitro* to enable the production of new functional food product(s) with anti-*Helicobacter* activity.

2. Materials and Methods

2.1. Tested Substances, Juices and Extracts

33 substances, juices and plant extracts were tested (**Table 1**). Whey was produced by "Elpa" Ltd. (Latvia). Water extract of green tea and concentrated apple juice were obtained from "Pure Food" Ltd. (Latvia). Berries and juices were obtained from "Lases" (Latvia). Red beets were supplied by "Baldones lauki" Ltd., dried sweet flag rhizome, fresh ginger, dried wild bergamot as well as chemicals—by Kirsch Pharma GmbH (Germany). Ethanol solution of propolis was obtained from Riga Pharmaceutical Plant JSC (Latvia).

All solutions were made with distilled water. Juices were obtained from cranberries, red beets and apples by using a household juicer followed by centrifugation at 3000 rpm for 30 min. 10% extract of apple pomace was obtained after suspending 10 g of commercial apple pomace ("Lases", Latvia) in 100 ml of 90˚C water. All materials were stored in the dark at 2˚C - 8˚C until use.

2.2. Measurement of pH

The pH values were measured using a pH meter pH/Ion 510 (Oakton Instruments, USA).

2.3. Bacteria and Culture Conditions

The strain *Helicobacter pylori* ATCC 43504 was used. *H. pylori* was cultivated on Columbia blood agar (Oxoid, UK) at 37˚C for 72 h. Plates were incubated in anaerobic conditions inside an anaerobic jar HP0011A (Oxoid, UK) containing GasPak™ Plus (Becton, Dickinson, USA).

2.4. Agar Diffusion Method

Antibacterial activity was determined by the agar diffusion method. The agar diffusion test was performed on Columbia blood agar (Oxoid, UK). Inoculum of 10^6 CFU of bacteria per millilitre was used. Aliquots of 85 μl of each test-sample solution were applied into 6.0 mm diameter agar wells. After incubation in anaerobic conditions at 37˚C for 72 h, the diameter of the clear zone (no growth) around the well in the bacterial lawn was measured and was used to express the antimicrobial activity. The inhibition zone diameter was measured in millimeters (mm). The tests were performed in triplicate and the final results were presented as the arithmetic average.

2.5. Statistics

Statistical analysis was done by analysis of variance. $P < 0.05$ was considered statistically significant. Each experiment was repeated three times.

3. Results

3.1. Anti-*Helicobacter* Activity of Certain Substances, Juices and Extracts

The antibacterial activity against *H. pylori* was tested for five organic acids (**Table 1**) in the pH range of 1.18 to 3.11 and for three food preservatives (sorbic acid, potassium sorbate and sodium benzoate). Anti-*Helicobacter* properties were shown only for hydrochloric acid (0.4% solution), acetic acid (1%) and citric acid (2%) but not for ascorbic acid (0.5%) and benzoic acid (0.15%). The selected preservatives did not exhibit antibacterial activity at the tested concentrations permitted in food products.

From other tested components including fruit and berry juices, quince juice showed the greatest antibacterial activity. Its activity exceeded the activity of cranberry juice (**Table 1**) and it was less dependent on dilution than cranberry juice. The antibacterial activity was observed in 10% quince juice while cranberry juice retained some activity only at 20% concentration. Moreover, quince juice recovered the major part of its antibacterial activity even after five years' storage. Equivalent activity was demonstrated by juice of wild and cultivated cranberries, *Vaccinium vitis-idaea* and *V. macrocarpum*, respectively. Experimental increase of pH of quince and cranberry juices with sodium hydrocarbonate or calcium carbonate above pH 4 completely eliminated the anti-*Helicobacter* activity (**Table 2**).

Concentrated apple juice as well as plum, red currant, black chokeberry, raspberry and bilberry juice also demonstrated significant antibacterial activity. Green tea extract and apple pomace extract as well as sweet flag rhizome, ginger and wild bergamot extract, cherry syrup, red beet juice and whey did not possess anti-*Helicobacter* activity (**Table 1**).

In general, the values of pH of the investigated solutions were in the range from 1.18 (0.4% hydrochloric acid, corresponding inhibition zone diameter 10 mm) to 8.80 (10% extract of dried sweet flag rhizome, inhibition zone diameter 0 mm). The highest pH at which antibacterial

Copyright © 2011 SciRes.

Table 1. Anti-*Helicobacter* activity and characteristic of certain solutions, juices and extracts.

No.	Name	Concentration, %	pH	Inhibition Zone Diameter, mm[a]
1	Acetic acid	1	2.91	12
2	Ascorbic acid	0.5	2.93	0
3	Benzoic acid	0.15	3.11	0
		0.06	3.10	0
4	Calcium citrate	2.5	5.76	0
5	Citric acid	2	1.91	17
6	Ethanol	80	-	10
		40	-	0
		16	-	0
		8	-	0
7	Ethanol solution of propolis	30	-	10
		15	-	0
		6	-	0
		3	-	0
8	Hydrochloric acid	0.4	1.18	10
9	Potassium sorbate	0.15	6.74	0
10	Sodium benzoate	0.15	6.25	0
11	Sodium hydrocarbonate	4	8.32	0
12	Sorbic acid	0.15	3.50	0
13	Sucrose	5	4.70	0
14	Acid whey	100	4.36	0
15	Sweet whey	100	6.78	0
16	Water extract of apple (*Malus* sp.) pomace	10	4.11	0
17	Water extract of dried sweet flag rhizome (*Acorus calamus*)	10	8.80	0
18	Water extract of dried wild bergamot (*Monarda fistuloza*)	2	6.80	0
19	Water extract of fresh ginger (*Zingiber officinale*)	2.5	8.08	0
20	Water extract of green tea (*Camellia sinensis*)	5	6.58	0
		2.5	6.82	0
		2.0	5.70	0
		1.5	6.62	0

21	Bilberry (*Vaccinium uliginosum*) juice	100	3.52	9
22	Black chokeberry (*Aronia melanocarpa*) juice	100	3.83	10
		20	3.90	0
		10	3.60	0
23	Five-fold concentrated black chokeberry (*Aronia melanocarpa)* juice	100	3.75	12
		50	3.77	10
24	Cherry (*Cerasus* sp.) syrup	70	3.50	0
25	Cultivated cranberry (*Vaccinium macrocarpum*) juice	100	2.52	16
		20	2.58	8
		10	2.62	0
26	Wild cranberry (*Vaccinium vitis-idaea*) juice	100	2.48	16
27	Five-fold concentrated apple (*Malus* sp.) juice	100	3.40	16
28	Plum (*Prunus* sp.) juice	100	3.00	13
		50	2.91	13
		20	3.06	0
		10	3.15	0
29	Quince (*Cydonia oblonga*) juice	100	2.75	19
		50	2.76	12
		33	2.77	9
		20	2.78	10
		10	2.81	11
30	Quince (*Cydonia oblonga*) juice after five years storage	100	2.90	15
31	Raspberries (*Rubus idaeus*) juice	70	2.98	10
32	Red beet (*Beta vulgaris*) juice	100	5.90	0
33	Red currants (*Ribes rubrum*) juice	100	3.05	11
		20	3.09	0
		10	3.22	0

a. 85 µl of each test-sample solution were applied into 6.0 mm diameter agar wells. - not detected.

Copyright © 2011 SciRes.

Table 2. Anti-*Helicobacter* activity and characteristic of different compositions.

No.	Name	Description	pH	Inhibition Zone Diameter, mm[a]
1	100% quince juice: 100% cultivated cranberry juice	1:1	2.53	19
2	100% quince juice: 100% cultivated cranberry juice: 100% black chokeberry juice	1:1:1	2.72	16
3	100% quince juice: 100% cultivated cranberry juice: 100% black chokeberry juice: 100% plum juice	1:1:1:1	2.73	14
4	100% quince juice + $CaCO_3$	5 ml juice + 0.4 mg $CaCO_3$	4.38	0
5	100% quince juice + $NaHCO_3$	5 ml juice + 100 mg $NaHCO_3$	3.58	15
6	50% quince juice + $NaHCO_3$	4 ml juice + 30 mg $NaHCO_3$	3.50	10
7	33% quince juice + $NaHCO_3$	3 ml juice + 15 mg $NaHCO_3$	3.62	8
8	20% quince juice + $NaHCO_3$	5 ml juice +18 mg $NaHCO_3$	3.34	0
9	10% quince juice + $NaHCO_3$	5 ml juice + 18 mg $NaHCO_3$	3.38	0
10	100% quince juice: 100% red beet juice	1:1	3.25	10
11	100% quince juice: 100% black chokeberry juice	1:1	2.94	16
		1:5	3.59	12
		1:1	3.31	14
		2:1	3.16	16
		5:1	3.06	17
12	100% quince juice: 100% bilberry juice	1:1	2.75	15
13	100% quince juice: 100% red currants juice	1:2	2.92	15
		1:5	2.95	15
14	100% quince juice: 2.5% ginger extract	5:1	2.79	14
15	100% quince juice: 5% green tea extract	1:1	2.75	13
16	100% quince juice: 10% dried sweet flag rhizome extract	1:1	2.70	13
17	100% quince juice: 100% cultivated cranberry juice: 100% black chokeberry juice : 100% dried sweet flag rhizome extract	1:1:1:1	2.81	17
18	100% quince juice: 100% wild cranberry juice : 100% black chokeberry juice: 10% dried sweet flag rhizome extract	1:1:1:1	2.85	17
19	100% quince juice: 10% apple pomace extract	1:1	3.00	15
		1:0.2	2.81	19
		1:0.4	2.82	18
		1:0.6	2.86	17
		1:1.4	3.10	12
		1:1.8	3.16	0

20	100% cultivated cranberry juice : 100% wild cranberry juice	1:1	2.54	19
21	100% cultivated cranberry juice + $CaCO_3$	5 ml juice + 0.2 g $CaCO_3$	3.67	12
22	100% cultivated cranberry juice + $NaHCO_3$	5 ml juice + 200 mg $NaHCO_3$	5.76	0
23	100% cultivated cranberry juice: 100% red beet juice	1:1	3.01	12
24	100% cultivated cranberry juice: 10% dried sweet flag rhizome extract	1:0.2	2.56	11
		1:0.4	2.57	10
		1:0.6	2.59	8
		1:1	2.60	15
		1:3	2.62	16
		1:5	2.65	16
		1:7	2.66	0
		1:9	2.69	0
		1:11	2.94	0
25	100% cultivated cranberry juice: dist. water	1:5	2.63	8
26	100% cultivated cranberry juice: 10% apple pomace extract	5:1	2.48	15
27	100% wild cranberry juice: 10% apple pomace extract	5:1	2.47	15
28	100% wild cranberry juice: 100% bilberry juice	1:1	2.75	12
29	100% black chokeberry juice: 100% bilberry juice	1:1	3.53	11
30	100% black chokeberry juice + $NaHCO_3$	5 ml juice + 100 mg $NaHCO_3$	6.26	0
31	100% black chokeberry juice: 100% red currants juice	1:2	3.32	0
		1:5	3.43	9
32	100% black chokeberry juice: 2.5% ginger extract	1:1	3.61	0
33	100% black chokeberry juice: 1.5% green tea extract	1:5	3.63	0
34	100% plum juice + $CaCO_3$	4 ml juice + 0.2 g $CaCO_3$	5.73	0
35	100% plum juice + $NaHCO_3$	4 ml juice + 100 mg $NaHCO_3$	5.42	0

a. 85 µl of each test-sample solution were applied into 6.0 mm diameter agar wells.

activity was observed corresponded to 3.83 (black chokeberry juice, inhibition zone diameter 10 mm) but all substances, juices and extracts with pH ≥ 3.90 showed no observable activity.

3.2. Anti-*Helicobacter* Activity of Different Compositions

Quince juice in combination with bilberry, black chokeberry, red currant juice, green tea and sweet flag rhizome or apple pomace extracts showed synergistic activity (**Table 2**). For example, quince juice possessed antibacterial activity after dilution with apple pomace water extract (**Figure 1**), but the activity was not observed when this juice was diluted with water. Apple pomace extract itself exhibited no antibacterial effect.

Synergism was observed also for compositions made from cranberry juice and sweet flag rhizome extract (**Figure 2**). Sweet flag rhizome extract alone did not possess the anti-*Helicobacter* activity.

pH values of the investigated compositions fell within the range of 2.47 (wild cranberry juice and apple pomace extract in the ratio 5:1, corresponding inhibition zone

Copyright © 2011 SciRes.

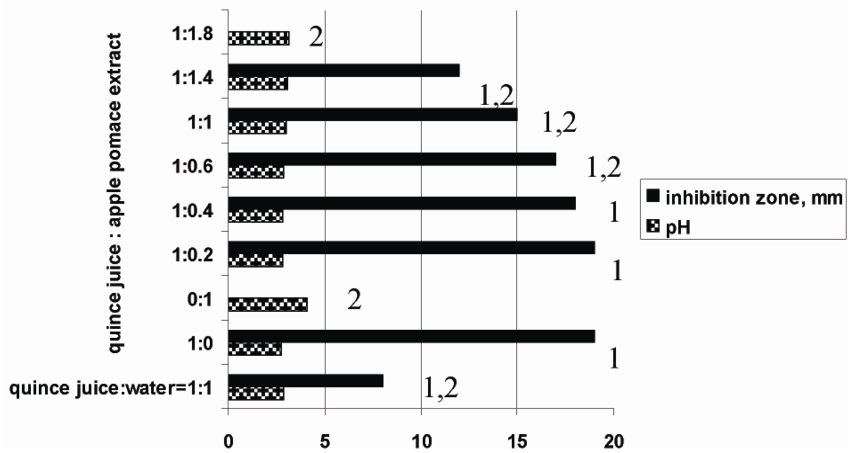

Figure 1. Dilution effect on the quince juice anti-*Helicobacter* activity *in vitro*. The inhibition zone was observed using the agar diffusion method. Aliquots of 85 µl of each test-sample solution were applied into 6.0 mm diameter agar wells. The tests were performed in triplicate and the final results were presented as the arithmetic average. [1]$P < 0.05$ inhibition zone in comparison with apple pomace extract. [2]$P < 0.05$ inhibition zone in comparison with quince juice.

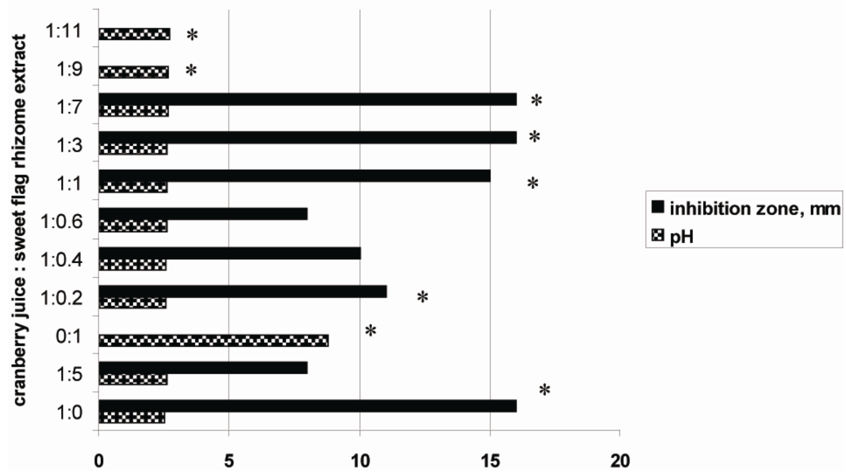

Figure 2. Synergistic effects of cranberry juice and sweet flag rhizome extract on inhibition of *H. pylori*. The inhibition zone was observed using the agar diffusion method. Aliquots of 85 µl of each test-sample solution were applied into 6.0 mm diameter agar wells. The tests were performed in triplicate and the final results were presented as the arithmetic average. *$P < 0.05$ inhibition zone in comparison with cranberry juice diluted with water in the ratio 1:5.

diameter 15 mm) to 5.76 (cranberry juice partly alkalized with $NaHCO_3$, inhibition zone diameter 0 mm). In general, antibacterial activity was observed only for compositions in which pH did not exceed 3.67.

4. Discussion

Anti-*Helicobacter* activity *in vitro* has been estimated in many known botanical extracts—high in *Myristica fragrans* (seed), *Zingiber officinale* (ginger rhizome/root) and *Rosmarinus officinalis* (rosemary leaf); moderate in *Achillea millefolium*, *Foeniculum vulgare* (seed), *Passiflora incarnata* (herb), *Origanum majorana* (herb) and a (1:1) combination of *Curcuma longa* (root) and ginger rhizome; weak in *Carum carvi* (seed), *Elettaria cardamomum* (seed), *Gentiana lutea* (roots), *Juniper communis* (berry), *Lavandula angustifolia* (flowers), *Melissa officinalis* (leaves), *Mentha piperita* (leaves), *Pimpinella anisum* (seed), *Matricaria recutita* (flowers), *Ginkgo biloba* (leaves) [27] etc. Also, the bacteriostatic effect of dill, fennel, caraway and cinnamon extracts against *Helicobacter pylori* has been detected. The presumption was stated that the possible synergistic effects of different dietary combinations of these extracts may be a factor in the possible protection afforded by the traditional Iranian diet against *H. pylori* infection [20].

This study evaluated the anti-*H. pylori* potential of some food-related chemical substances (organic acids and preservatives), plant extracts and juices and ascertained the effectivity of their composition. In general, 33 individual substances, juices and extracts were tested (**Table 1**).

As might be expected, some acid solutions demonstrated anti-*Helicobacter* activity but estimated inhibition zone diameters did not correlate with the pH value. However, we can confirm that pH has significant impact on the growth of *H. pylori*. In our experiments, citric acid solution has a higher pH in comparison with hydrochloric acid solution, but citric acid has a larger inhibition zone diameter than hydrochloric acid (**Table 1**). Probably, the anion, in this case citrate, is also implicated in suppression of bacteria. At least several citrate salts (iron citrate, ammonium iron citrate and sodium ferrous citrate) possess anti-*Helicobacter* activity [28]. However, our experiments with 2.5% calcium citrate remained ineffective. Also, ascorbic acid showed no antibacterial activity, but this fact should be interpreted with caution because this substance is a well-known antioxidant and, therefore, could demonstrate anti-*Helicobacter* activity *in vivo* as have been shown in clinic tests [30,31].

There have been many investigations regarding antibacterial activity of different natural plant products in laboratory experiments as well as *in vivo*. Cranberries are considered the gold standard and they are widely used in various ways [25]. A prospective, randomized, double-blind, placebo-controlled trial conducted in China showed that regular dietary consumption of cranberry juice can suppress *H. pylori* infection [32]. In our experiments, the greatest anti-*Helicobacter* activity was demonstrated by quince and cranberry juice, but significant activity was shown by apple, plum, red currant, black chokeberry, raspberry and bilberry juice (**Table 1**). Although the activity of bilberry and black chokeberry was lower than that of cranberry or quince, their pH was about 0.7 higher. It could be considered an advantage while it decreased the possibility of irritation of mucous membranes.

The antibacterial activity of cranberries and also some other berries usually is attributed to their benzoic acid content. For all that, benzoic acid (0.15%) and sodium benzoate alone did not show anti-*Helicobacter* activity. A high molecular mass constituent of cranberry juice has been shown to inhibit the adhesion of *H. pylori* to human gastric mucus *in vitro* [33]. In our study, the observed activity of quince juice exceeded the activity of cranberries. In the literature, we have found only one research paper [34] in which the authors noted the anti-*Helicobacter* action of quince (*Cydonia oblonga*) juice.

Several extracts that did not possess anti-*Helicobacter* activity alone showed significant activity in combination with others components. Such synergism was observed for sweet flag rhizome, green tea and apple pomace extract. However, other investigations have established that sweet flag (*Acorus calamus*) rhizome [35] as well as green tea (*Camellia sinensis*) [36-38] and apple peel extract [39] has antibacterial activity. Cranberry synergies with blueberry, grape seed and oregano extract [39] as well as blackcurrant oil synergy with broccoli sprouts have been reported [19]. Sometimes synergism is already used in practice. Extracts from wild blueberries, strawberries, cranberries, wild bilberries, elderberries and raspberries significantly ($P < 0.05$) inhibited *H. pylori*, compared with controls, and also increased susceptibility of *H. pylori* to clarithromycin, but food supplement OptiBerry, made from a blend of the abovementioned extracts, demonstrated maximal effects [24]. The antibacterial activeity of sweet flag rhizome, green tea and apple pomace extracts also could be expected in *in vivo* conditions.

On the basis of our experiments, the essential components of new functional anti-*Helicobacter* food product(s) could be the most active juices and extracts like quince, black chokeberry and cranberry juice supplemented with one or another synergist. Further studies are required to elucidate the mechanism of antibacterial action of plant juices and extracts and to investigate the efficacy *in vivo*.

REFERENCES

[1] C. C. McGowan, T. L. Cover and M. J. Blaser, "*Helicobacter pylori* and Gastric Acid: Biological and Therapeutic Implications," *Gastroenterology*, Vol. 110, No. 3, 1996, pp. 926-938. doi:10.1053/gast.1996.v110.pm8608904

[2] D. S. Merrell, M. L. Goodrich, G. Otto, L. S. Tompkins and S. Falkow, "pH-Regulated Gene Expression of the Gastric Pathogen *Helicobacter pylori*," *Infection and Immunity*, Vol. 71, No. 6, 2003, pp. 3529-3539. doi:10.1128/IAI.71.6.3529-3539.2003

[3] S. Perry, M. L. Sanchez, S. Yang, T. D. Haggerty, P. Hurst, G. Perez-Perez and J. Parsonnet, "Gastroenteritis and Transmission of *Helicobacter pylori* Infection in Households," *Emerging Infectious Diseases*, Vol. 12, No. 11, 2006, pp. 1701-1708.

[4] H. M. Malaty, A. El-Kasabany, D. Y. Graham, C. C. Miller, S. G. Reddy, S. R. Srinivasan, Y. Yamaoka and G. S. Berenson, "Age at Acquisition of *Helicobacter pylori* Infection: A Follow-Up Study from Infancy to Adulthood," *The Lancet*, Vol. 359, No. 9310, 2002, pp. 931-535. doi:10.1016/S0140-6736(02)08025-X

[5] T. Sabbi, P. de Angelis and L. Dall'Oglio, "*Helicobacter pylori* Infection in Children: Management and Pharmacotherapy," *Expert Opinion on Pharmacotherapy*, Vol. 9, No. 4, 2008, pp. 577-585. doi:10.1517/14656566.9.4.577

[6] L. M. Brown, "*Helicobacter pylori*: Epidemiology and Routes of Transmission," *Epidemiologic Reviews*, Vol. 22, No. 2, 2000, pp. 283-297.

[7] F. F. Vale and J. M. Vitor, "Transmission Pathway of *Helicobacter pylori*: Does Food Play a Role in Rural and Urban Areas?" *International Journal of Food Microbiology*, Vol. 138, No. 1-2, 2010, pp. 1-12. doi:10.1016/j.ijfoodmicro.2010.01.016

[8] L. Fischbach and E. L. Evans, "Meta-Analysis: The Effect

Copyright © 2011 SciRes.

of Antibiotic Resistance Status on the Efficacy of Triple and Quadruple First-Line Therapies for *Helicbacter pylori*," *Alimentary Pharmacology and Therapeutics*, Vol. 26, No. 3, 2007, pp. 343-357. doi:10.1111/j.1365-2036.2007.03386.x

[9] D. Y. Graham and A. Shiotani, "New Concepts of Resistance in the Treatment of *Helicobacter pylori* Infections," *Nature Clinical Practice Gastroenterology and Hepatology*, Vol. 5, No. 6, 2008, pp. 321-331. doi:10.1038/ncpgasthep1138

[10] B. Stenstrom, A. Mendis and B. Marshall, "*Helicobacter pylori*—the Latest in Diagnosis and Treatment," *Australian Family Physician*, Vol. 37, No. 8, 2008, pp. 608-612.

[11] M. P. Della, A. Lavagna, G. Masoero, L. Lombardo, L. Crocella and A. Pera, "Effectiveness of *Helicobacter pylori* Eradication Treatments in a Primary Care Setting in Italy," *Alimentary Pharmacology and Therapeutics*, Vol. 16, No. 7, 2002, pp. 1269-1275. doi:10.1046/j.1365-2036.2002.01244.x

[12] M. Heep, M. Kist, S. Strobel, D. Beck and N. Lehn, "Secondary Resistance among 554 Isolates of *Helicobacter pylori* after Failure of Therapy," *European Journal of Clinical Microbiology and Infectious Diseases*, Vol. 19, No. 7, 2000, pp. 538-541. doi:10.1007/s100960000288

[13] F. Bazzoli, P. Pozzato and T. Rokkas, "*Helicobacter pylori*: The Challenge in Therapy," *Helicobacter*, Vol. 7, Suppl. 1, 2002, pp. 43-49. doi:10.1046/j.1523-5378.7.s1.7.x

[14] A. Qasim and C. A. O'Morain, "Review Article: Treatment of *Helicobacter pylori* Infection and Factors Influencing Eradication," *Alimentary Pharmacology and Therapeutics*, Vol. 16, 2002, pp. 24-30. doi:10.1046/j.1365-2036.2002.0160s1024.x

[15] R. N. Ndip, A. E. M. Tarkang, C. M. Echakachi, A. Malongue, J.-F. T. K. Akoachere, L. M. Ndip and H. N. Luma, "*In vitro* Antimicrobial Activity of Selected Honeys on Clinical Isolates of *Helicobacter pylori*," *African Health Sciences*, Vol. 7, No. 4, 2007, pp. 228-231.

[16] R. N. Ndip, A. E. M. Tarkang, S. M. Mbullah, H. N. Luma, A. Malongue, L. M. Ndip, K. Nyongbela, C. Wirmum and S. M. N. Efange, "*In Vitro* Anti-*Helicobacter pylori* Activity of Extracts of Selected Medicinal Plants from North West Cameroon," *Journal of Ethnopharmacology*, Vol. 114, No. 3, 2007, pp. 452-457. doi:10.1016/j.jep.2007.08.037

[17] C. F. Carson and T. V. Riley, "Non-Antibiotic Therapies for Infectious Diseases," *Communicable Diseases Intelligence*, Vol. 27, 2003, pp. S143-146.

[18] M. M. Kamiji and R. B. Oliveira, "Non-Antibiotic Therapies for *Helicobacter pylori* Infection," *European Journal of Gastroenterology and Hepatology*, Vol. 17, No. 9, 2005, pp. 973-981. doi:10.1097/00042737-200509000-00014

[19] J. I. Keenan, N. Salm, M. B. Hampton and A. J. Wallace, "Individual and Combined Effects of Foods on *Helicobacter pylori* Growth," *Phytotherapy Research*, Vol. 24, No. 8, 2010, pp. 1229-1233.

[20] S. Sadeghian, T. R. Neyestani, M. H. Shirazi and P. Ranjbarian, "Bacteriostatic Effect of Dill, Fennel, Caraway and Cinnamon Extracts against *Helicobacter pylori*," *Journal of Nutritional and Environmental Medicine*, Vol. 15, No. 2-3, 2005, pp. 47-55. doi:10.1080/13590840500535313

[21] S. Y. Lee, Y. W. Shin and K. B. Hahm, "Phytoceuticals: Mighty but Ignored Weapons against *Helicobacter pylori* Infection," *Journal of Digestive Diseases*, Vol. 9, No. 3, 2008, pp. 129-139. doi:10.1111/j.1751-2980.2008.00334.x

[22] H. S. Falcao, I. R. Mariath, M. F. Diniz, L. M. Batista and J. M. Barbosa-Filho, "Plants of the American Continent with Antiulcer Activity," *Phytomedicine*, Vol. 15, No. 1-2, 2008, pp. 132-146. doi:10.1016/j.phymed.2007.07.057

[23] A. Yanaka, J. W. Fahey, A. Fukumoto, M. Nakayama, S. Inoue, S. Zhang, M. Tauchi, H. Suzuki, I. Hyodo and M. Yamamoto, "Dietary Sulforaphane-Rich Broccoli Sprouts Reduce Colonization and Attenuate Gastritis in *Helicobacter pylori*—Infected Mice and Humans," *Cancer Prevention Research*, Vol. 2, No. 4, 2009, pp. 353-360.

[24] A. Chatterjee, T. Yasmin, D. Bagchi and S. J. Stohs, "Inhibition of *Helicobacter pylori in vitro* by Various Berry Extracts, with Enhanced Susceptibility to Clarithromycin," *Molecular and Cellular Biochemistry*, Vol. 265, No. 1-2, 2004, pp. 19-26. doi:10.1023/B:MCBI.0000044310.92444.ec

[25] H. Shmuely, J. Yahav, Z. Samra, G. Chodick, R. Koren, Y. Niv and I. Ofek, "Effect of Cranberry Juice on Eradication of *Helicobacter pylori* in Patients Treated with Antibiotics and a Proton Pump Inhibitor," *Molecular Nutrition and Food Research*, Vol. 51, No. 6, 2007, pp. 746-751. doi:10.1002/mnfr.200600281

[26] S. Enomoto, K. Yanaoka, H. Utsunomiya, T. Niwa, K. Inada, H. Deguchi, K. Ueda, C. Mukoubayashi, I. Inoue, T. Maekita, K. Nakazawa, M. Iguchi, K. Arii, H. Tamai, N. Yoshimura, M. Fujishiro, M. Oka and M. Ichinose, "Inhibitory Effects of Japanese Apricot (*Prunus mume* Siebold et Zucc.; Ume) on *Helicobacter pylori*-Related Chronic Gastritis," *European Journal of Clinical Nutrition*, Vol. 64, No. 7, 2010, pp. 714-719. doi:10.1038/ejcn.2010.70

[27] G. B. Mahady, S. L. Pendland, A. Stoia, F. A. Hamill, D. Fabricant, B. M. Dietz and L. R. Chadwick, "*In Vitro* Susceptibility of *Helicobacter pylori* to Botanical Extracts Used Traditionally for the Treatment of Gastrointestinal Disorders," *Phytotherapy Research*, Vol. 19, No. 11, 2005, pp. 988-991. doi:10.1002/ptr.1776

[28] Otsuka Pharmaceutical Co., Ltd (JP), Inventors: M. Kikuchi, H. Takiza, H. Wakebe, F. Mukai, S. Shimizu, H. Okamatsu, T. Saito, S. Yamadaira, H. Kimura and K. Sasaki, "Composition, Antimicrobial Agent, Infection Preventive, and Food against *Helicobacter pylori*," WIPO Patent Application WO/1998/009652, Application Number: PCT/JP/1997/ 003100. 1997.09.04.

[29] M. Tabak, R. Armon, G. Rosenblat, E. Stermer and I. Neeman, "Diverse Effects of Ascorbic Acid and Palmitoyl Ascorbate on *Helicobacter Pylori* Survival and Growth," *FEMS Microbiology Letters*, Vol. 224, No. 2, pp. 247-253. doi:10.1016/S0378-1097(03)00439-7

[30] C. H. Chuang, B. S. Sheu, A. W. Kao, H. C. Cheng, A. H. Huang, H. B. Yang and J. J. Wu, "Adjuvant Effect of Vitamin C on Omeprazole-Amoxicillin-Clarithromycin Triple Therapy for *Helicobacter pylori* Eradication," *Hepato-Gastroenterology*, Vol. 54, No. 73, 2007, pp. 320-324.

[31] L. Zhang, J. Ma, K. Pan, V. L. Go, J. Chen and W. C. You, "Efficacy of Cranberry Juice on *Helicobacter pylori* Infection: Randomised Placebo-Controlled Trial," *Helicobacter*, Vol. 10, No. 2, 2005, pp. 139-145. doi:10.1111/j.1523-5378.2005.00301.x

[32] O. Burger, I. Ofek, M. Tabak, E. Weiss, N. Sharon and I. Neeman, "A High Molecular Mass Constituent of Cranberry Juice Inhibits *Helicobacter pylori* Adhesion to Human Gastric Mucus," *FEMS Immunology and Medical Microbiology*, Vol. 29, No. 4, 2000, pp. 295-301. doi:10.1111/j.1574-695X.2000.tb01537.x

[33] S. Fattouch, P. Caboni, V. Coroneo, C. I. G. Tuberoso, A. Angioni, S. Dessi, N. Marzouki and P. Cabras, "Antimicrobial Activity of Tunisian Quince (*Cydonia oblonga* Miller) Pulp and Peel Polyphenolic Extracts," *Journal of Agricultural and Food Chemistry*, Vol. 55, No. 3, 2007, pp. 963-969. doi:10.1021/jf062614e

[34] F. Aquil and I. Ahmad, "Antibacterial Properties of Traditionally Used Indian Medicinal Plants," *Methods and Findings in Experimental and Clinical Pharmacology*, Vol. 29, No. 2, 2007, pp. 79-92. doi:10.1358/mf.2007.29.2.1075347

[35] H. C. Lee, A. M. Jenner, C. S. Low and Y. K. Lee, "Effect of Tea Phenolics and their Aromatic Fecal Bacterial Metabolites on Intestinal Microbiota," *Research in Microbiology*, Vol. 157, No. 9, 2006, pp. 876-884. doi:10.1016/j.resmic.2006.07.004

[36] A. Rocco and G. Nardone, "Diet, *H. pylori* Infection and Gastric Cancer: Evidence and Controversies," *World Journal of Gastroenterology*, Vol. 13, No. 21, 2007, pp. 2901-2912.

[37] C. Stoicov, R. Saffari and J. Houghton, "Green Tea Inhibits *Helicobacter* Growth *in Vivo* and *in Vitro*," *International Journal of Antimicrobial Agents*, Vol. 33, No. 5, 2009, pp. 473-478. doi:10.1016/j.ijantimicag.2008.10.032

[38] E. Pastene, H. Speisky, M. Troncoso, J. Alarcon and G. Figueroa, "*In vitro* Inhibitory Effect of Apple Peel Extract on the Growth of *Helicobacter pylori* and Respiratory Burst Induced on Human Neutrophils," *Journal of Agricultural and Food Chemistry*, Vol. 57, No. 17, 2009, pp. 7743-7749. doi:10.1021/jf9006592

[39] D. A. Vattem, Y. T. Lin, R. Ghaedian and K. Shetty, "Cranberry Synergies for Dietary Management of *Helicobacter pylori* Infections," *Process Biochemistry*, Vol. 40, No. 5, 2005, pp. 1583-1592. doi:10.1016/j.procbio.2004.06.024

Copyright © 2011 SciRes.