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Knowledge, use and perceptions of probiotics and prebiotics in hospitalized patients

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Abstract

Aim: Little is known about inpatient probiotic and prebiotic consumption or beliefs, despite their increase in availability. Therefore, the purpose of this research was to assess inpatient knowledge, use and perceptions of probiotics and prebiotics.

Methods: All subjects were inpatients at two urban medical centers on general medical/surgical floors. Patients were randomly selected to complete a verbally administered questionnaire inquiring about probiotic and prebiotic knowledge, use and perceptions. Patient responses were recorded directly into Survey Monkey (Palo Alto, CA, USA) on a computer.

Results: Patients (n = 200) were 58% women and 56% were Caucasian with a mean age of 56 years. More patients were familiar with the term “probiotic” (43%) compared with “prebiotic” (11%); however, only 20% and 7% could correctly define probiotics and prebiotics, respectively, from a list of responses. More patients were consuming probiotics (53%) than prebiotics (38%). The most common probiotic

and prebiotic products consumed were yogurts (72%) and cereals/granola bars (55%), respectively. Patients believed probiotics and prebiotics most beneficial for "digestion or gut health", but the most common reason to consume these products was "to taste or try" (36% and 43%, respectively). Overall, patients believed probiotics and prebiotics to be safe; however, they also believed that health claims could only somewhat be trusted.

Conclusions: This research found that many patients are consuming probiotic and prebiotic products despite limited awareness of the true meaning of these terms. As probiotic and prebiotic use is more common, it is important that clinicians are aware of increased use and provide patients with recommendations based on recent research.

Keywords: clinical nutrition and dietetics, clinical trials, consumers, dietary intake, food preferences, health beliefs

Introduction

The human gastrointestinal tract is home to trillions of bacteria that have a symbiotic relationship with the host. These bacteria have many important functions including immunity, harvesting energy and altering lipid metabolism. Recognition of these important functions has resulted in development of commercial products that include probiotics and prebiotics. These products are intended to modify gut bacteria to benefit host health.¹

A probiotic is a live microorganism that, when administered in adequate amounts, confers a health benefit on the host.² Probiotics have been recognized as helpful for health for over 100 years; Élie Metchnikoff received the Nobel Prize in Medicine in 1908 for his work with gut microbiota and immune system. Yakult (Yakult Honsha Co., Ltd) is a Japanese dairy probiotic product on the market since 1935. Despite being in existence and recognized for health promotion for over 100 years, probiotics have only recently become popular, with commercially available probiotics such as Yakult and Activia (Dannon). The global market for probiotic products is estimated to be 26 million in 2012 and the market increased by approximately \$1.5 billion in a 5-year period.³ A prebiotic is a selectively fermented ingredient that allows specific changes, both in the composition and/or activity in the gastrointestinal microflora that confer benefits upon host wellbeing and health.⁴ These prebiotic fibers, commonly inulin and fructooligosaccharides (FSO), are fermented in the intestine, so as to stimulate growth of beneficial bacteria already in the gut.⁴

Recent research has examined the effects of probiotics and prebiotics for alleviation of various health conditions. Overall, current research suggests a positive effect of probiotics and prebiotics in gastrointestinal transit time, irritable bowel syndrome and ulcerative colitis.⁵⁻¹⁹ Much research has shown a benefit of probiotics in antibiotic-associated diarrhoea.²⁰⁻²³ However,

a recent large randomized controlled trial showed no benefit of probiotic supplementation in incidence of antibiotic-associated diarrhoea.²⁴ Clarification is needed to determine what dose and which strains are beneficial for different health conditions.

Although a substantial increase in consumption of probiotic- and prebiotic-containing products has been seen in the last decade, the current consumer knowledge, use and perceptions of these products has not been examined. Therefore, the purpose of the present research was to gain a better understanding of how many, which types, and for what purpose hospital patients are taking probiotic and prebiotic products, and to compare differences based on patient demographics.

Methods

This was a descriptive, cross-sectional study designed to describe the knowledge, use and perceptions of probiotics and prebiotics of patients at two large urban hospitals in Chicago. Inclusion criteria were adults aged 18 years and over, admitted to the hospital within the previous 72 hours and those who were oriented to person, place and time. Subjects were excluded from the study if they could not speak or understand English, were located on the pediatric, psychiatric, obstetrics/gynecology, oncology or intensive care unit floors, had contact or airborne precautions, or did not give their consent. Ethical approval from the Institutional Review Boards at Rush University Medical Center and Christ Advocate Medical Center was obtained before study initiation and conforms to the provisions of the Declaration of Helsinki.

The questionnaire used in this study was developed without modelling from any previously developed tool. The tool was created to quantitatively and qualitatively measure probiotic and prebiotic knowledge use and perceptions. Ten pilot interviews were performed with nutrition experts to evaluate the content, flow and ease of administering the questionnaire. An additional 10 pilot interviews were completed with patients; as no changes were made to the questionnaire after these pilot interviews, the pilot interviews were included in the final sample.

The questionnaire consisted of 18 questions; questions addressing knowledge of probiotic and prebiotic terms and concepts were asked first. Only patients familiar with the concept of probiotics or prebiotics answered questions about perceptions. Additional questions included beliefs regarding probiotic and prebiotics benefit to health conditions, current or past consumption, and reasons for consuming these products. Questions addressing influences on use and perceptions regarding safety were included. All questions had corresponding handouts with examples of health conditions, probiotic and prebiotic products, and a rating scale (1 = not at all; 2

= a little; 3 = somewhat; 4 = quite a bit; 5 = very much) as a guide for patient response. Probiotic and prebiotic products were chosen for handouts based on products researchers believed to be most accessible to consumers and most commonly consumed. In addition, demographic information was obtained.

Eligible patient units and patients within each unit were randomized using a random numbers table. A maximum of seven questionnaires were completed each data collection day. Enough patients were approached to obtain 100 completed questionnaires at each hospital. After a patient was randomly chosen, the patient was approached, a cognitive assessment was completed, and the patient was provided a letter of introduction. Two study coordinators performed all interviews and directly recorded answers into Survey Monkey. After the interview was completed, patients were offered a handout with information about probiotics and prebiotics as well as examples of products. Patients were not told about this information prior to the interview to avoid response bias.

The Statistical Package for the Social Sciences (SPSS) Version 17.0 (SPSS, Inc., Chicago, IL, USA) was used for data analysis. Descriptive statistics were run for all items; means, standard errors and frequencies were calculated to describe distributions and differences in knowledge and use of probiotics and prebiotics. Differences across gender, age, race and education level were analyzed with chi-squared analysis. Data were normally distributed; therefore, analysis of variance was used to assess differences across demographic characteristics and variables for which a mean could be calculated.

Results

Of the 300 patients that were asked to complete the survey, 100 declined to participate. A total of 200 patients completed the study (67% response). Women comprised 58% of the sample, the mean age of participants was 56 years, and a majority of patients were Caucasian (56%). Most patients (46%) had completed 12 or less years of education, 43% had completed 13–16 years and 12% had completed 17 or more years.

When patients were asked if they were familiar with the term “probiotic” or “prebiotic”, 43% and 11% of patients were familiar with the terms, respectively. From a selection of five definitions, 20% of patients who stated they were familiar with the term chose the correct definition: “probiotics are live bacteria that are helpful to your health when you eat them.” Incorrect definitions of the term “probiotic” offered to patients included natural antibiotics, fibers to help feed good bacteria, cleaning products to kill bacteria and agents to make food taste sweeter. A total of 7% of patients chose the correct definition of a prebiotic: “prebiotics are foods that you eat that help

Table 1. Perceptions of probiotics and prebiotics grouped by medical center patient demographics.^(a)

	<i>Mean ± SD^(b,c)</i>					
	<i>Probiotics are harmful</i>	<i>Probiotics are safer than prescription drugs</i>	<i>Health claims on probiotic packages can be trusted</i>	<i>Prebiotics are harmful</i>	<i>Prebiotics are safer than prescription drugs</i>	<i>Health claims on prebiotic packages can be trusted</i>
Overall	1.27 ± 0.64	3.29 ± 1.35	2.95 ± 1.10	1.20 ± 0.52	3.29 ± 1.34	3.14 ± 1.08
Gender						
Female	1.25 ± 0.62	3.40 ± 1.37	3.10 ± 1.18	1.24 ± 0.55	3.31 ± 1.34	3.21 ± 1.07
Male	1.30 ± 0.66	3.14 ± 1.32	2.75 ± 0.98	1.14 ± 0.47	3.26 ± 1.35	3.02 ± 1.08
Age group (years)						
45	1.15 ± 0.52 ^x	3.76 ± 1.14 ^x	3.11 ± 0.99 ^x	1.12 ± 0.4 ^x	3.55 ± 1.23 ^x	3.21 ± 1.19
45–65	1.23 ± 0.60	3.13 ± 1.40 ^y	3.15 ± 1.13 ^x	1.09 ± 0.3 ^x	3.43 ± 1.38 ^x	3.30 ± 1.04
65	1.49 ± 0.76 ^y	2.97 ± 1.39 ^y	2.44 ± 1.05 ^y	1.47 ± 0.7 ^y	2.80 ± 1.27 ^y	2.79 ± 0.94
Education (years)						
≤ 12	1.46 ± 0.78 ^x	3.04 ± 1.43	2.88 ± 1.12	1.28 ± 0.62	3.30 ± 1.41	3.15 ± 1.17
13–16	1.12 ± 0.45 ^y	3.61 ± 1.14	2.96 ± 1.11	1.17 ± 0.48	3.33 ± 1.19	3.06 ± 1.00
≥ 17	1.26 ± 0.62	2.96 ± 1.55	3.09 ± 1.08	1.07 ± 0.52	3.13 ± 1.60	3.33 ± 1.05

(a) Based on total number of subjects who responded knowing probiotic (n = 146) or prebiotic concept (n = 103).

(b) Scale: 1 = not at all; 2 = a little; 3 = somewhat; 4 = quite a bit; 5 = very much.

(c) Different letters signify significant differences within demographic: $P < 0.05$ using analysis of variance.

SD, standard deviation.

feed the good bacteria in your body.” Incorrect definitions of the term “prebiotic” offered to patients included live bacteria helpful to health, a type of vitamin, drugs to help lower blood pressure and harmful chemicals. After these, correct definitions were briefly explained; 73% and 52% of the original 200 patients were familiar with the concepts of probiotics and prebiotics, respectively.

Patients with more years of education were more likely to be familiar with the term “probiotic” ($P < 0.000$) than those with less education. Patients who were younger than 45 years of age ($P = 0.011$), and who had more education ($P = 0.001$) were more likely to be familiar with the probiotic concept compared with those older than 45 years of age, or with less education. No significant differences in knowledge of the prebiotic term or concept were found based on demographic characteristics.

Patient perceptions of probiotics and prebiotics are shown in **Table 1**. Overall, patients did not believe that probiotics or prebiotics were harmful, as evidenced by 90% of patients responding with “not at all” or “a little” to the statement “probiotics are harmful.” The majority (95% of patients) chose these responses for prebiotics. Patients aged less than 45 years believed probiotics and prebiotics to be safer than other age groups ($P = 0.039$).

A majority of patients identified both probiotics and prebiotics as benefiting gastrointestinal health (**Table 2**), with the greatest benefit believed to be for both constipation and diarrhea (greater than 87% and 78% believed probiotics and prebiotics benefit these conditions, respectively). This is likely because the majority of advertising for these products is targeted for gastrointestinal health. Use of probiotics and prebiotics for both immune and heart health were also perceived as beneficial.

Table 2. Health conditions for which patients believe probiotics and prebiotics are beneficial and for which patients consume probiotics and prebiotics.

<i>Health condition</i>	<i>Believed beneficial</i>		<i>Consumed</i>	
	<i>n^(a)</i>	<i>%^(b)</i>	<i>n^(a)</i>	<i>%^(c)</i>
Probiotics				
Constipation	56	89	14	25
Diarrhoea	55	87	5	9
Overall digestion/gut health	54	86	23	41
Immune health	43	68	6	11
Heart health	38	60	0	0
Overweight/obesity	42	67	3	5
Allergies	35	56	0	0
Mental health/stress	27	43	0	0
To taste/to try ^(d)	–	–	19	34
Prebiotics				
Constipation	22	79	6	18
Diarrhoea	22	79	0	0
Overall digestion/gut health	21	75	7	21
Immune health	20	71	6	18
Heart health	20	71	2	6
Overweight/obesity	15	54	13	39
Allergies	13	46	0	0
Mental health/stress	16	57	0	0
To taste/to try	–	–	13	39

(a) Total number of subjects who indicated probiotics or prebiotics to be helpful for a specific condition or consumed for a condition.

(b) Based on total subjects who responded knowing probiotic ($n = 63$) or prebiotic ($n = 28$) concept; percentage total is greater than 100 because subjects could choose more than one answer.

(c) Based on total subjects who consumed probiotics ($n = 56$) or prebiotics ($n = 33$); percentage total is greater than 100 because subjects could choose more than one answer.

(d) To taste/to try was not included when asked for which health conditions probiotics and prebiotics are beneficial.

Consumption of probiotics and prebiotics for specific health conditions was also assessed (**Table 2**). Similar to what was believed beneficial, patients were most likely to consume probiotics for digestion and gut health, including constipation (25%). On the contrary, patients consumed prebiotics for overweight/obesity and to taste or try.

Health conditions patients believed were most improved by probiotics as indicated on the 5-point scale handout included immune health (3.70 ± 0.99) and digestion/gut health (3.08 ± 1.28). Overall, 34% of patients believed probiotics helped their health "quite a bit" or "very much." Health conditions patients believed were most improved by prebiotics included general health (4.00 ± 0.00), digestion/gut health (3.78 ± 1.26) and immune health (3.31 ± 1.11). Overall, 33% believed prebiotics helped their health "quite a bit" or "very much." It was noted during data collection that many patients stated they were consuming prebiotics for the benefits of fiber, and not the prebiotic properties these products provide. Many patients mentioned their belief that if they had consumed both probiotic and prebiotic products more regularly, they would have seen more health benefits, although this question was not asked formally as part of the survey and was only mentioned by patients during data collection. Therefore, many may have chosen a lower extent of improvement score as they were not taking the products on a regular basis.

Slightly more than half (53%) of patients were consuming or had consumed probiotics (**Table 3**). The most common probiotic was Activia. Female patients ($P = 0.029$) and those who had completed more education ($P < 0.000$) were more likely to consume probiotics than men or those with less education.

Fewer patients (38%) had consumed prebiotics (Table 3). The percentage of patients who were consuming prebiotics may have been higher if more prebiotic products had been listed on the handout, as a wide variety of products contain prebiotics. The most common prebiotic products consumed were Kashi Go Lean Crunch (Kashi Co.) (26% of all prebiotic products consumed), Skinny Cow (Weight Watchers International, Inc.) ice cream sandwiches (26%) and Ensure (Abbott Nutrition) with FOS (20%). Patients who had completed more years of education were more likely to consume prebiotics ($P < 0.000$) than those with less education.

Television or radio most influenced probiotic consumption, with 57% of patients being influenced by these forms of media. Interestingly, dietitians (10%) and the Internet (3%) did not have a large impact on probiotic consumption. Similarly, patients were influenced to consume prebiotics by television or radio (37%), although family or friends had the largest impact (51%). Dietitians (21%) and the Internet (1%) appeared to have a lesser impact on prebiotic consumption.

Table 3. Medical center patient probiotic and prebiotic product consumption.

<i>Probiotics</i>	<i>n</i>	<i>%^(a)</i>	<i>Prebiotics</i>	<i>n</i>	<i>%^(b)</i>
Consumption practice			Consumption practice		
Ever consumed probiotics ^(c)	105	53	Ever consumed prebiotics ^(d)	76	38
Currently consuming	83	42	Currently consuming	62	31
Product			Product		
Yogurt	113	72	Kashi Go Lean Crunch	32	26
Activia	93	59	Skinny Cow ice cream sandwiches	32	26
YoPlus Yoplait yogurt	16	10	Ensure with FOS	20	16
GoodBelly yogurt	4	3	Luna bar	19	16
Lowell Polish yogurt	1	1	South Beach Diet bars	16	13
Dairy drink	31	20	Other	2	2
DanActive dairy drink	16	10	Breakstones LiveActive cottage cheese	1	1
Kefir	12	8			
Activia dairy drink	1	1			
Other (unspecified)	1	1			
Pill	11	7			
Florajen	1	1			
Florastor	1	1			
Other (pills unspecified)	9	6			
Cereals	2	1			
Vive Kashi	2	1			
Frequency of consumption			Frequency of consumption		
Once per day	7	5	Once per day	1	1
Daily	63	40	Daily	30	25
2–3 times per week	20	13	Weekly	33	27
Weekly	8	5	Monthly	7	6
Monthly	5	3	Infrequently/rarely	49	40
Infrequently/rarely	54	34	As needed	2	2
Serving size			Serving size		
4 oz	126	80	1 each	62	51
8 oz	14	9	2 each	9	7
>8 oz	6	4	4 each	1	1
1 pill	6	4	≤1 cup	37	30
2 pills	4	3	2 cups	10	8
3 pills	1	1	3+ cups	3	3

(a) Percentage of total based on 157 responses.

(b) Percentage of total based on 122 responses.

(c) Significantly more females were consuming probiotics.

(d) Significant difference found based on education; highest education group had the highest percentage of consumption of prebiotics.

FSO, fructooligosaccharides.

Discussion

At the present time, there is a gap in the literature regarding probiotic and prebiotic knowledge, use and perceptions in a hospitalized patient population as previous studies have used a free-living population. For example, a 2008 survey by the Research Opinion Corporation found that 85% of people interviewed reported knowing "little to nothing" about probiotics; a survey by Kraft foods found similar results revealing 63% of people interviewed were not at all familiar with probiotics.²⁵ In the current study, 57% of patients reported being unfamiliar with the term "probiotic" without any further explanation of the term after the definition was explained; 73% of patients interviewed were familiar with the concept of probiotics compared with only 15% found by the Research Opinion Corporation.²⁵ The higher familiarity found in this study may be due to the fact that the questionnaire was completed 2 years after the previous study and the market and advertising for probiotics has increased dramatically in recent years.²⁶ Kraft foods found that only 13% of those familiar with probiotics could define them accurately compared with 40% in the current study. This discrepancy may be due to differences in questionnaire design or population sampled (hospitalized vs free-living).

A 2007 consumer attitudes survey in a free-living population found 37% of individuals were consuming probiotics for immune health and 41% for digestive health compared with 11% for immunity and 41% for digestion in the current study.²⁷ The consumer attitudes survey found 37% of people were consuming prebiotics for digestion compared with 18% for digestion in the current study; however, 36% were consuming prebiotics for general gut health. In 2009, yoghurt was the most popular mode of administration of probiotics, consistent with the current study where most (66%) probiotic products consumed were a type of yoghurt.²⁸ In 2009, a business analysis company (Datamonitor) reported that 14% of people interviewed thought that probiotic health claims were untrustworthy compared with 40% of patients responding with either "not at all" or "a little" when asked if health claims on probiotic packages can be trusted.²⁶

There are several strengths to this study. This study covered a wide range of questions to help understand probiotic and prebiotic knowledge use, and perceptions. New and novel information was gathered, such as perceived extent of improvement with probiotic and prebiotic intake by health condition, frequency and serving size of consumption, factors influencing consumption, and comparisons by demographic factors. It is valuable to assess these parameters in hospitalized patients as this specific population may differ from the general population because of the potential for their health status to encourage use of dietary means of improving health. Of note, no

probiotic or prebiotic products were offered in the hospital setting; therefore, dietary intake in the hospital likely did not influence responses.

Limitations to this study include a small sample size. Our sample was taken from two urban medical centers and therefore, results cannot be generalized to free-living populations outside of this geographical environment. This study likely does not offer a comprehensive description of probiotic and prebiotic consumption because of the limited number of products on the handouts used in the study. It is likely that this is especially true for prebiotics because of the large variety of products containing prebiotics. The type of products (e.g. yoghurts, bars, dairy drinks) reported to be consumed may have also been influenced by the type of products on the handout. While we saw differences in probiotic and prebiotic knowledge and intake by education level, our ability to compare these groups is limited because of the differences in samples sizes between groups. In addition, information related to past medical history information was not collected; the health status of patients may have influenced whether patients consumed probiotics or prebiotics and for which health conditions they were consumed.

In conclusion, this study demonstrated that many patients at two large, urban medical centers are consuming products containing probiotics and prebiotics despite not understanding the true meaning of these terms. Probiotics are much better recognized by inpatients compared with prebiotics. Inpatients are consuming probiotics mostly for gastrointestinal concerns and prebiotics to help reduce overweight and obesity. In light of these findings, it is important that healthcare professionals, including dietitians, are aware of patient probiotic and prebiotic consumption. This consumption provides cause for dietitians to inquire about use and to provide patient education to ensure that both probiotics and prebiotics are being consumed safely and for health conditions supported by research.

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Authorship — MB and AU were responsible for the acquisition and analysis of data, as well as drafting and revising the paper. HR was responsible for conception and design of the study and critical revision of the paper. MG, CV and GW all made valuable contributions to the design, analysis and documentation of this research.

References

- 1 Steer T, Carpenter H, Tuohy K, Glenn GR. Perspectives on the role of the human gut microbiota and its modulation by pro- and prebiotics. *Nutr Res Rev* 2000; **13**: 229–54.
- 2 Food and Agriculture Organization/World Health Organization. *Joint FAO/WHO expert consultation on evaluation of health and nutritional properties of probiotics in food including powder milk with live lactic acid bacteria*, 2001. <ftp://ftp.fao.org/docrep/fao/009/a0512e/a0512e00.pdf> accessed 12 October 2011
- 3 Markets and Markets. *Probiotic market- advanced Technologies and global market (2009–2014)*, 2009. <http://www.marketsandmarkets.com> accessed 1 October 2009
- 4 Gibson GR, Probert HM, Loo JV, Rastall RA, Roberfroid MB. Dietary modulation of the human colonic microbiota: updating the concept of prebiotics. *Nutr Res Rev* 2004; **17**: 259–75.
- 5 Bouvier M, Meance S, Bouley C, Berta JL, Grimaud JC. Effects of consumption of a fermented milk by the probiotic strain *Bifidobacterium animalis* DN-173 010 on the colonic transit times in healthy humans. *Biosci Microflora* 2001; **20**: 43–48.
- 6 Marteau P, Cuillerier E, Meance S *et al.* *Bifidobacterium animalis* strain DN-173 010 shortens the colonic transit time in healthy women: a double-blind, randomised, controlled study. *Aliment Pharmacol Ther* 2002; **16**: 587–93.
- 7 Meance S, Cayuela C, Raimondi A, Turchet P, Lucas C, Antoine JM. Recent advances in the use of functional foods: effects of the commercial fermented milk with *Bifidobacterium animalis* strain DN-173 010 and yoghurt strains on gut transit time in the elderly. *Microb Ecol Health Dis* 2003; **15**: 15–22.
- 8 Kleessen B, Sykura B, Zunft HJ, Blaut M. Effects of inulin and lactose on fecal microflora, microbial activity, and bowel habit in elderly constipated persons. *Am J Clin Nutr* 1997; **65**: 1397–402.
- 9 Guyonnet D, Chassany O, Ducrotte P *et al.* Effect of a fermented milk containing *Bifidobacterium animalis* DN-173 010 on the health-related quality of life and symptoms in irritable bowel syndrome in adults in primary care: a multicentre, randomised, double-blind, controlled trial. *Aliment Pharmacol Ther* 2007; **26**: 475–86.
- 10 Sinn DH, Song JH, Kim HJ *et al.* Effect of *Lactobacillus acidophilus*-SDC 2012, 2013 in patients with irritable bowel syndrome. *Dig Dis Sci* 2008; **53**: 2714–18.
- 11 Parisi G, Bottona E, Carrara M *et al.* Treatment effects of partially hydrolyzed guar gum on symptoms and quality of life of patients with irritable bowel syndrome. A multicenter randomised open trial. *Dig Dis Sci* 2005; **50**: 1107–12.
- 12 Olesen M, Gudmand-Hoyer E. Efficacy, safety, and tolerability of fructooligosaccharides in the treatment of irritable bowel syndrome. *Am J Clin Nutr* 2000; **72**: 1570–75.
- 13 Kim HJ, Vazquez Roque MI, Camilleri M *et al.* A randomised controlled trial of a probiotic combination VSL# 3 and placebo in irritable bowel syndrome with bloating. *Neurogastroenterol Motil* 2005; **17**: 687–96.

- 14 Ishikawa H, Akedo I, Umesaki Y, Tanaka R, Imaoka A, Otani T. Randomised controlled trial of the effect of bifidobacteria-fermented milk on ulcerative colitis. *J Am Coll Nutr* 2003; **22**: 56–63.
- 15 Kruis W, Schutz E, Fric P, Fixa B, Judmaier G, Stolte M. Double-blind comparison of an oral *Escherichia coli* preparation and mesalazine in maintaining remission of ulcerative colitis. *Aliment Pharmacol Ther* 1997; **11**: 853–58.
- 16 Rembacken BJ, Snelling AM, Hawkey PM, Chalmers DM, Axon AT. Non-pathogenic *Escherichia coli* versus mesalazine for the treatment of ulcerative colitis: a randomised trial. *Lancet* 1999; **354**: 635–39.
- 17 Bibiloni R, Fedorak RN, Tannock GW *et al.* VSL#3 probiotic mixture induces remission in patients with active ulcerative colitis. *Am J Gastroenterol* 2005; **100**: 1539–46.
- 18 Guslandi M, Giollo P, Testoni PA. A pilot trial of *Saccharomyces boulardii* in ulcerative colitis. *Eur J Gastroenterol Hepatol* 2003; **15**: 697–98.
- 19 Hafer A, Kramer S, Duncker S, Kruger M, Manns MP, Bischoff SC. Effect of oral lactulose on clinical and immunohistochemical parameters in patients with inflammatory bowel disease: a pilot study. *BMC Gastroenterol* 2007; **7**: 36.
- 20 Duman DG, Bor S, Ozutemiz O *et al.* Efficacy and safety of *Saccharomyces boulardii* in prevention of antibiotic-associated diarrhoea due to helicobacterpylori eradication. *Eur J Gastroenterol Hepatol* 2005; **17**: 1357–61.
- 21 Cremonini F, Di Caro S, Covino M *et al.* Effect of different probiotic preparations on anti-helicobacter pylori therapy-related side effects: a parallel group, triple blind, placebo-controlled study. *Am J Gastroenterol* 2002; **97**: 2744–49.
- 22 Beniwal RS, Arena VC, Thomas L *et al.* A randomised trial of yogurt for prevention of antibiotic-associated diarrhoea. *Dig Dis Sci* 2003; **48**: 2077–82.
- 23 Lewis S, Burmeister S, Brazier J. Effect of the prebiotic oligofructose on relapse of *Clostridium difficile*-associated diarrhoea: a randomised, controlled study. *Clin Gastroenterol Hepatol* 2005; **3**: 442–48.
- 24 Allen S, Wareham K, Wang D *et al.* *Lactobacilli* and *Bifidobacteria* in the prevention of antibiotic-associated diarrhoea and *Clostridium difficile* diarrhoea in older inpatients (PLACIDE): A randomised, double-blind, placebo-controlled, multicentre trial. *Lancet* 2013; **382**: 1249–57.
- 25 Lorraine H. *Americans warming to probiotics, says datamonitor*, 2009. <http://nutraingredients-usa.com>
- 26 Datamonitor. *Opportunities in digestive and immunity health: consumer attitudes and behaviors*. 2009.
- 27 International Food Information Council. *Consumer attitudes toward functional foods/foods for health*. 2007.
- 28 Hailu G, Boecker A, Henson S, Cranfield J. Consumer valuation of functional foods and nutraceuticals in Canada. A conjoint study using probiotics. *Appetite* 2009; **52**: 257–65.