Research Article

www.ijrap.net

# IS INFANT FEEDING ON COMPLEMENTARY FOOD REQUIRES ADDITIONAL PREBIOTICS?

Befikadu Tariku[1] , Singh Pragya[2]*
[1]ArbaMinch University, Nursing Department, Post Box No 21 ArbaMinch, Ethiopia
[2]School of Nutrition, Food Science and Technology, Hawassa University, Hawassa, Ethiopia

Received on: 07/08/12 Revised on: 20/10/12 Accepted on: 09/11/12

***Corresponding author**
E-mail: pragyasingh85@yahoo.co.in
**DOI: 10.7897/2277-4343.03632**
Published by Moksha Publishing House. Website www.mokshaph.com


**ABSTRACT**
Bacteria are normal inhabitants of the gastrointestinal tract, where more than 400 bacterial species are found. Bacterial colonization of the gut begins at birth, as newborns are maintained in a sterile status until the delivery begins, and continues throughout life, with notable age-specific changes. Human milk oligosaccharides are complex glycans that are highly abundant in human breast milk. It is generally accepted that human milk oligosaccharides have prebiotic effects, selectively serving as a source of energy and nutrients for desired bacteria to colonize the infant intestine. The concentration and composition of oligosaccharides varied, indicates that the protective ability of breast milk based on human milk oligosaccharides vary. Prebiotic is commonly tested on infants not started complementary food as ingredients in formula and in adults. This review was intended to describe the outcomes of the prebiotic on the infants of complementary feeding age range and their tolerance to it. The study tried to identify articles published on the prebiotic and infants with complementary feeding age range. There were four studies on the complementary feeding age range of infants about the tolerance and effect of prebiotics use. Based on the gastrointestinal symptoms finding of the studies, the addition of the prebiotics were tolerated. All studies were based on the supplementation of the prebiotics to the formula or cereals. There is a need to identify the effect of addition of prebiotics to the infants of breastfeeding during introduction of complementary feeding, both by supplementation and based on the foods containing prebiotics.
**Key words**: prebiotic, probiotic, complementary feeding

## INTRODUCTION

Bacteria are normal inhabitants of the gastrointestinal tract, where more than 400 bacterial species are found[1]. Bacterial colonization of the gut begins at birth, as newborns are maintained in a sterile status until the delivery begins, and continues throughout life, with notable age-specific changes[2]. Normally the stomach contains few bacteria whereas the bacterial concentration increases throughout[1-2]. The total microbiota population outnumbers the cells in the human body and accounts for 35–50% of the volume of the colonic content[3].

Fuller, in 1986 defines probiotic as 'a live microbial feed supplement which beneficially affects the host animal by improving its microbial balance'[4]. Report of a Joint FAO/WHO expert consultation on evaluation of health and nutritional properties of probiotics redefined probiotics as 'live microorganisms which when administered in adequate amounts confer a health benefit on the host'[1]. In humans, commonly used probiotic genera are lactobacilli (e.g., Lactobacillus *acidophilus, L. casei, L. delbruekii)* and bifidobacteria (e.g., Bifidobacterium *adolescentis, B. bifidum, B. longum, B. infantis)*, in addition species of streptococci (e.g., Streptococcus *salivarius* ss. *thermophilus, S. lactis)* also included. These genera are used either as single species or in mixed cultures with bacteria. It has been hypothesized that probiotics administered to humans can have positive effects in a number of biomedical conditions[5]. The composition of this protective flora can be altered by dietary and environmental influences. This alteration of the flora may result in increase the susceptibility of the host to a disease and/or reduces food utilization[4].

A prebiotic is a non-viable food component that confers a health benefit on the host associated with modulation of the microbiota[6]. It also define as a selectively fermented ingredient that allows specific changes, both in the composition and/or activity in the gastrointestinal microbiota that confers benefits upon host wellbeing and health[7]. There are different fibers that may pass the upper gastrointestinal tract. Common prebiotics those fulfill the criteria of prebiotic and those commonly in use include inulins, fructo-oligosaccharides (FOS), galacto-oligosaccharides (GOS), soya-oligosaccharides, xylo-oligosaccharides, pyrodextrins, isomalto-oligosaccharides and lactulose. These food ingredients are resistance to the upper gastrointestinal tract and fermented in the colon, promote the growth of beneficial bacteria[8].

Among the beneficial bacterial flora of the gut, bifidobacteria and lactobacilli spices are considered as a common probiotics. As described earlier, probiotics affect the health of the individuals in different mechanisms. By colonization resistance, intestinal bacteria protect the host from infection by exogenous pathogens[2, 9] and opportunistic bacteria that are present in the gut[10]. Among components of the microflora, it has been suggested that bifidobacteria and lactobacilli play a role in acting as a barrier against colonization of the gastrointestinal tract by pathogenic bacteria[11]. With this "colonization resistance" wherein the stable ecosystem provided by the commensal bacteria compete for the same nutrients and attachment sites as pathogenic bacteria[3].

Probiotics perform their beneficial effect by producing substances. Some probiotics involves in the production of anti-microbial substances[11]. The production of the anti-microbial substances in the colon by other species of the

endogenous microflora such as bifidobacteria may affect against the potential pathogenic microorganisms that defense the host[8, 11]. Some lactobacillus and bifidobacterial species form substances that are antagonistic to other organisms, such as organic acids, hydrogen peroxide, diacetyl and bacteriocins. Bacteriocin secretion is growth-associated in some species, and is dependent on carbon availability[8].

The commensal microbiota are critical for stimulating the number of immunological barrier provided by the intestinal mucosa. This powerful regulatory influence provided by the intestinal microbiota to the mucosal immune system provides potential therapeutic strategies ranging from heightened host defense and containment of inflammation[3]. In addition, several reports have indicated that bifidobacteria could stimulate the immune system[11].

The role of short-chain fatty acids (SCFAs) have expanded to include their role as nutrients for the colonic epithelium, as modulators of colonic and intracellular pH, cell volume, and other functions associated with ion transport, and as regulators of proliferation, differentiation, and gene expression. Increases in SCFAs result in decreased pH, which indirectly influences the composition of the colonic microflora (eg, reduces potentially pathogenic clostridia when pH is more acidic), decreases solubility of bile acids, increases absorption of minerals, and reduces the ammonia absorption by the protonic dissociation of ammonia and other amines (i.e., the formation of the less diffusible $NH_4^+$ compared with the diffusible $NH_3$)[12].

There are different other functions of probiotics in the colon. Some strains of Bifidobacteria are also known to excrete a range of water soluble vitamins[8]. Several studies in animals and humans have shown positive effects of non-digestible oligosaccharides on mineral metabolism, bone composition, and bone architecture. These effects were not in all cases uniform. Certain experimental or dietary conditions and the physiological characteristics of the target group studied might favor a positive outcome of a study[13]. It is suggested that native resistant starch raised calcium and magnesium absorption because it tended to enhance the solubility of these minerals in ileal and caecal digesta[14].

Human milk is the ideal food for the infant and young children. It fulfills many nutritive and immune-protective functions for infants and children. According to the World Health Organization (WHO) recommendation; breast milk entirely fulfills infants' nutrient requirement up to the age of 6 month[15]. Breastfeeding should continue while gradually introducing complementary food according to the original meaning and intention of the term namely, 'food to complement' the feeding of human milk[16]. Human milk oligosaccharides are complex glycans that are highly abundant in human breast milk[8, 17]. It is generally accepted that human milk oligosaccharides have prebiotic effects, selectively serving as a source of energy and nutrients for desired bacteria to colonize the infant intestine. Beyond these prebiotic effects, human milk oligosaccharides may very likely benefit the breastfed infant through other multiple mechanisms. Human milk oligosaccharides have been shown to be anti-adhesive, mimicking the attachment sites for certain pathogens and blocking their adhesion, colonization, and invasion[17]. The concentration and composition of oligosaccharides varied substantially between individuals and the course of lactation[8, 18]. This indicates that the protective ability of breast milk's prebiotic vary among individuals and during lactation[18].

Appropriate complementary foods are almost certainly necessary to supply additional energy after 6 months of age. As indicated, infants greater than 6 months of age should start to take additional food with continue breast feeding[19]. The concentration and composition of oligosaccharides varied, indicates that the protective ability of breast milk based on human milk oligosaccharides vary[8, 18]. In addition to this variation on the protection ability; nutritional tradeoff between breastmilk and complementary reduces the intake of breast milk[20]. Complementary feeding is defined as the period during which foods or liquids are provided along with continued breastfeeding[15]. Complementary food is the term used to describe any nutrient-containing foods or liquids, other than breastmilk, that are given to young children prior to weaning[19]. Different researches were done on infants not started complementary food as ingredients in formula and adults about the effect of prebiotic. This review was intended to describe the outcomes of the prebiotic on the infants of complementary feeding age range and their tolerance to it.

## MATERIALS AND METHODS

The study tried to identify articles published on the prebiotic and infants with complementary feeding the age range. Articles selected in the MEDLINE and some key articles were also looked from the citations referred in other papers. This review includes articles published from 2000 to 2012.

## RESULT

There were four studies on the complementary feeding age range of infants about the tolerance and effect of prebiotics use. Even though the publications were not specifically to those infants who started complementary food, but they include these age range. The age ranges of included studies were from 8 weeks to 12 months. The duration of the intervention was from 28 days to 1 year. One of the studies was excluded due to the age range of 1 to 15 years and was done on children of compromised gut function[21]. All articles were published from 2003 to 2011. All articles are based on randomized, blinded and placebo-controlled trials. Some of the articles include infants of breast feeding[22-23], others were not[24] or use breast feeding group of infants as one of the control group [25]. Studies were done in different place. Table 1 shows subjects and type of intervention given for the studies.

## DISCUSSION

One of the study was done on formula fed infants at age when they started to take solid foods (4 to 6 months) with the mean age at the enrolment was 4 months. In this study, 35 infants were included. The GOS/FOS group consisted of 19 infants; the control group consisted of 16 infants[24]. The other was done to assess the tolerance and safety of a formula containing an innovative mixture of oligosaccharides in early infancy. This study was done by randomizing formula fed infants and assigning fully breastfed group without randomization [25]. A study in

Baltimore (USA) was done to evaluate the tolerance and gastrointestinal effects of FOS-supplemented infant cereal used as a daily addition to the diet of healthy infants[23]. A study done in different countries of European (Netherlands, Austria, Switzerland, Italy and Germany) to evaluate the effects of dietary supplementation with the prebiotic oligofructose with and without zinc on the prevalence of diarrhea in a community with a high burden of gastrointestinal and other infections. Both rice- and oat-based cereals were used, with family and child preference determining the allocation of cereal type. During the second trial, zinc (1 mg/15 g cereal) was added to both the oligofructose-supplemented cereal and the non-supplemented cereal[22].

**Table 1: Number of subjects and type of intervention given for the studies**

| Author | Subjects | Intervention vs Control | Study duration |
|---|---|---|---|
| (Duggan *et al.*, 2003)[22] | Infants aged 6–12 mo, start complementary feeding<br>Control- from 141, 122 finish the study<br>Intervention- from 141, 129 finishes the study | Infant cereal supplemented with oligofructose | 6 months |
| (Moore *et al.*, 2003) | - 56 infants aged 4 –12 months involved in the study<br>- 27 experimental group and 29 control group | The intervention group received infant cereal containing 0·03 g FOS/g cereal (0·75 g FOS/25 g serving of cereal).<br>The control group received the same cereal but with 0·03 g maltodextrin in place of FOS/g. | 28 days |
| (Piemontese *et al.*, 2011)[25] | Infants starting 8 weeks was involved<br>414 infants in the prebiotics group and 416 infants in the control group.<br>300 infants assigned to breast feeding group | Intervention -Regular non-hydrolysed cow's milk based formula mixture of neutral short chain GOS and long chain FOS, ratio 9:1<br>Control- regular non-hydrolysed cow's milk based formula without added oligosaccharides | 1 year |
| (Scholtens *et al.*, 2006)[24] | Formula-fed infants aged 4 to 6 months who were about to start consuming solid foods<br>35 infants were included in the study.<br>Intervention group consisted of 19 infants; and control group consisted of 16 infants. | Intervention- receive either weaning products with added GOS/FOS with a ratio of 9:1<br>Control- weaning products with maltodextrin | 6 weeks |

The mechanism used by bacteria already present in the gut to maintain their presence in this environment and to avoid colonization of the same intestinal sites by freshly ingested microorganisms, including pathogens . From the identified articles for the infants of complementary feeding age group, only one publication showed that the relation with the microorganism. It showed that by the intake of 4.05 g per day of GOS/FOS, infants of the intervention group show significant increase in the faecal percentage of bifidobacteria after 6 week of intervention. The change in the percentage of the bifidobacteria was significantly different from the change in the control group[24]. The fermentation of dietary carbohydrate to SCFAs represents an important physiological function served by the commensal microbiota[3]. These activities of the bacteria that inhabit the large bowel provide fuels for a wide range of body tissues and appear to be important in a number of metabolic events[26]. Even though it is dependent upon the diet consumed[3, 12], species and amounts of microflora present in the colon and gut transit time[12]; in human the liberation of energy by the intestinal microbiota is estimated approximately 10%[3]. Microbiota in the colon use dietary fiber to produce SCFAs by fermentation process, thereby salvaging important nutrients that would be lost in the feces due to the inability of the human intestine to digest dietary fiber[3, 12]. SCFAs are the principal products of fermentation in the large intestine. They are the predominant anions in the colon, with acetate, propionate and butyrate occurring in greatest amounts[12, 26]. They are rapidly absorbed from the large bowel[12].

There were no significant changes from week 0 to 6 between 2 groups (receipt of prebiotic supplement and control group) on the SCFAs (like acetate, propionate and cumulated proportion of valerate, isovalerate and isobutyrate)[24]. The assessment of the average pH for the infants was no differences between the groups[23-24]. Together with SCFAs, gas formation occurs during fermentation in the colon and the presence of hydrogen, carbon dioxide and methane in the large bowel[8, 26]. During active fermentation, gas is eliminated both through the lungs and expelled as flatus[26]. Excess $H_2$ formation, and osmotic diarrhoea caused by high levels of SCFAs production, provide a barrier to the unfettered use of prebiotics[8, 26]. Gas production by bacteria in the colon can be a source of concern and discomfort to patients with digestive disorders and is a common cause of complaint in medical outpatients. The problem is relatively minor[26]. With respect to GOS, evidence obtained so far from European studies indicates that GOS is safe to add to infant feeds[27].

The identified articles for the infants of complementary feeding age group use different methods of assessment for evaluating the tolerance of prebiotic supplemented diet. Their assessment methods were gastrointestinal symptoms like posse ting, colics[23, 25], flatulence, cramps[23, 25] and vomiting[22-23, 25]. Stool consistency and frequency[22-25], crying[23], and food intake (g cereal/d and g FOS/d)[22-24] were also assessed. The stool consistency was significantly lower in the prebiotics group compared to the control group and closer to the breastfeeding group (Piemontese *et al.*, 2011). In infants, taking the FOS-supplemented cereal had more frequent and softer stools, without any reported diarrhea, in infants taking up to 3.00 g FOS/day. Stool colour was also the same for both groups[23]. The mean intake of GOS/FOS was 4.05 g per day indicated that there is no significant difference b/n the control and the supplement group in the change of stool consistency, but there was small decrease in the stool consistency and in infants receiving weaning foods with added GOS/ FOS[24].

Two studies demonstrated change regarding to the stool frequency. The first indicated that infants in the FOS-supplemented group had a greater frequency of having more stools per day than the control group[23]. The second study showed that there is no significant difference b/n the control and the intervention group in the change of stool frequency, but there was a small increase in stool

frequency in infants receiving weaning foods with added GOS/ FOS [24]. The average daily total intake of cereal per infant was similar in both groups[23]. A more gradual increase of intake was observed[24].

Based on the outcomes, there was no significant difference in the number of days with diarrhea between the treatment groups in either study[22-23]. There were no significant differences between the treatment groups in study in the numbers of days of severe diarrhea, dysentery, or vomiting or in the frequency with which diarrheal pathogens were isolated[22]. In addition, there were no differences in the mean number of days per infant that these symptoms were 'more than usual' for crying, spitting-up or colic. There were no differences in flatus and colic and/or abdominal cramps according to the parents[23].

## CONCLUSION

Based on the gastrointestinal symptoms finding of the studies, the addition of the prebiotics were well tolerated. The amount of the prebiotics was different based on the age of the infants. All studies were based on the supplementation of the prebiotics to the formula or cereals. This review has been generally been limited to small numbers of articles and the articles studies were done on different age groups and different form of supplementation and outcome measurements. There is a need to identify the effect of addition of prebiotics to the infants of breastfeeding during introduction of complementary feeding, both by supplementation and based on the foods containing prebiotics.

## REFERENCES


1. FAO/WHO. Health and Nutritional Properties of Probiotics in Food including Powder Milk with Live Lactic Acid Bacteria, Report of a Joint FAO/WHO Expert Consultation 2001.
2. Mitsuoka T. Intestinal flora and ageing. Nutrition Review. 1992; 50: 438-446. http://dx.doi.org/10.1111/j.1753-4887.1992.tb02499.x
3. Tappenden KA, Deutsch AS. The Physiological Relevance of the Intestinal Microbiota- Contributions to Human Health. Journal of the American College of Nutrition. 2007; 26 (6): 679S–683S. PMid:18187433
4. Fuller R. Probiotics in man and animals. Journal of Applied Bacteriology. 1989; 66: 365-378. http://dx.doi.org/10.1111/j.1365-2672.1989.tb05105.x PMid:2666378
5. Gibson GR, Roberfroid MB. Dietary Modulation of the Human Colonie Microbiota: Introducing the Concept of Prebiotics. Journal of Nutrition 1995; 125: 1401-1412. PMid:7782892
6. FAO. FAO Technical Meeting on PREBIOTICS: Food Quality and Standards Service: Food and Agriculture Organization of the United Nations;2007.
7. Gibson GR, Probert HM, Loo JV, Rastall RA, Roberfroid MB. Dietary modulation of the human colonic microbiota: updating the concept of prebiotics. Nutrition Research Reviews. 2004; 17: 259-275. http://dx.doi.org/10.1079/NRR200479 PMid:19079930
8. Macfarlane GT, Steed H, Macfarlane S. Bacterial metabolism and health-related effects of galacto-oligosaccharides and other prebiotics. Journal of Applied Microbiology. 2008; 104 (2): 305-344. PMid:18215222
9. Tancrede C. Role of human microflora in health and disease. European Journal of Clinical Microbiological and Infectious Diseases. 1992; 11: 1012–1015. http://dx.doi.org/10.1007/BF01967791
10. Guarner F. Enteric flora in health and disease. Digestion. 2006; 73: 5–12. http://dx.doi.org/10.1159/000089775 PMid:16498248
11. Liévin V, PeiVer I, Hudault S, et al. Bifidobacterium strains from resident infant human gastrointestinal microflora exert antimicrobial activity. Gut. 2000; 47: 646–652. http://dx.doi.org/10.1136/gut.47.5.646 PMid:11034580 PMCid:1728100
12. Wong JMW, Souza Rld, Kendall CWC, Emam A, Jenkins DJA. Colonic Health: Fermentation and Short Chain Fatty Acids. Journal of Clinical Gastroenterology. 2006; 40 (3): 235-243. http://dx.doi.org/10.1097/00004836-200603000-00015 PMid:16633129
13. Scholz-Ahrens KE, PeterAde, Marten B, et al. Prebiotics, Probiotics, and Synbiotics Affect Mineral Absorption, Bone Mineral Content, and Bone Structure. The Journal of Nutrition. 2007; 137: 838S–846S. PMid:17311984
14. Schulz AGM, Amelsvoort JMMV, Beynen AC. Dietary Native Resistant Starch but Not Retrograded Resistant Starch Raises Magnesium and Calcium Absorption in Rats. Journal of Nutrition. 1993; 123: 1724-1731. PMid:8410364
15. PAHO/WHO. Guiding Principles for Complementary Feeding of the Breastfed Child. Division of Health Promotion and Protection. Food and Nutrition Program:Washington, DC.2003.
16. Przyrembel H. Timing of Introduction of Complementary Food: Short- and Long-Term Health Consequences. Annals of Nutrition and Metabolism. 2012; 60 (suppl 2): 8–20. http://dx.doi.org/10.1159/000336287 PMid:22555185
17. Bode L. Human milk oligosaccharides: prebiotics and beyond. Nutrition Reviews. 2009; 67 (Suppl. 2): S183–S191. http://dx.doi.org/10.1111/j.1753-4887.2009.00239.x PMid:19906222
18. Chaturvedi P, Warren CD, Altaye M, et al. Fucosylated human milk oligosaccharides vary between individuals and over the course of lactation. Glycobiology. 2001; 11: 365-372. http://dx.doi.org/10.1093/glycob/11.5.365 PMid:11425797
19. WHO. Complementary feeding of young children in developing countries: a review of current scientific knowledge. WHO/NUT/98.1. Geneva: WHO1998.
20. Dewey KG, Brown KH. Update on technical issues concerning complementary feeding of young children in developing countries and implications for intervention programs. Food and Nutrition Bulletin. 2003; 24 (1): 5-28. PMid:12664525
21. Khoshoo V, Sun SS, Storm H. Tolerance of an Enteral Formula with Insoluble and Prebiotic Fiber in Children with Compromised Gastrointestinal Function. Journal of the American Dietetic Association. 2010; 110: 1728-1733. http://dx.doi.org/10.1016/j.jada.2010.08.011 PMid:21034888
22. Duggan C, Penny ME, Hibberd P, et al. Oligofructose-supplemented infant cereal: 2 randomized, blinded, community-based trials in Peruvian infants. American Journal of Clinical Nutrition. 2003; 77: 937–942. PMid:12663295
23. Moore N, Chao C, Yang L-P, Storm H, Oliva-Hemker M, Saavedra JM. Effects of fructo-oligosaccharide-supplemented infant cereal: a double-blind, randomized trial. British Journal of Nutrition. 2003; 90: 581–587. http://dx.doi.org/10.1079/BJN2003950 PMid:13129464
24. Scholtens PAMJ, Alles MS, Bindels JG, Linde EGMvd, Tolboom JJM, Knol J. Bifidogenic Effects of Solid Weaning Foods with Added Prebiotic Oligosaccharides: A Randomised Controlled Clinical Trial. Journal of Pediatric Gastroenterology and Nutrition. 2006; 42: 553-559. http://dx.doi.org/ 10.1097/01.mpg.0000221887.28877.c7 PMid:16707980
25. Piemontese P, Giannı ML, Braegger CP, et al. Tolerance and Safety Evaluation in a Large Cohort of Healthy Infants Fed an Innovative Prebiotic Formula: A Randomized Controlled Trial. PLoS ONE. 2011; 6 (11): http://dx.doi.org/10.1371/journal.pone.0028010
26. Cummings JH, Macfarlane GT. The control and consequences of bacterial fermentation in the human colon. Journal of Applied Bacteriology. 1991; 70: 443-459. http://dx.doi.org/10.1111/j.1365-2672.1991.tb02739.x
27. Moro GE, Arslanoglu S, Stahl B, Jelinek U, Wahn U, Boehm G. A mixture of prebiotic oligosaccharides reduces the incidence of atopic dermatitis during the first six months of age. Arch Dis Child. 2006; 91: 814–819. http://dx.doi.org/10.1136/adc.2006.098251 PMid:16873437 PMCid:2066015


**Cite this article as:**
Befikadu Tarikul, Singh Pragya. Is infant feeding on complementary food requires additional prebiotics?. Int. J. Res. Ayur. Pharm. 2012; 3(6):837-840

Source of support: Nil, Conflict of interest: None Declared