Nondigestibility Characteristics of Inulin and Oligofructose in Humans

Henrik B. Andersson, Lars H. Ellegård and Ingvar G. Bosaeus
Department of Clinical Nutrition, Institute of Internal Medicine, Göteborg University, SE 413 45 Göteborg, Sweden

ABSTRACT The ileostomy model is considered to be a reliable model to reflect small bowel absorption. Studies in ileostomy subjects have shown that inulin and oligofructose pass through the small bowel without degradation and without influencing the absorption of nitrogen, fat, starch, calcium, magnesium or zinc. Inulin and oligofructose do not have any considerable effect on cholesterol absorption or bile acid excretion. J. Nutr. 129: 1428S–1430S, 1999.

KEY WORDS: oligofructose, cholesterol, nitrogen, zinc, iron, humans

This review focuses on the effect of different fiber on ileal excretion in ileostomy subjects. It provides a comparison between short-term balance techniques performed with inulin and oligofructose (Ellegård et al. 1997) and five earlier studies using different high fiber products or diets (Bosaeus and Andersson 1987, Bosaeus et al. 1992, Ellegård and Bosaeus 1991, Langkilde et al. 1993, Lia et al. 1995).

Inulin and oligofructose

Ellegård et al. (1997) performed a double blind crossover study with inulin and oligofructose in 10 patients with conventional ileostomy due to ulcerative colitis. The mean serum cholesterol of the subjects was 6.3 mmol/L. Subjects test diets were prepared in a metabolic kitchen for 3 d. The basal diet added sucrose (7 g) compared with a diet fortified with 17 g of inulin, (19.4 g of Raftilose ST) or 17 g of oligofructose (19 g of Raffilose HBP). Inulin and oligofructose were digested only to a small extent in the small intestine. The recovery in the ileostomy effluent amounted to 88% [95% confidence interval (CI), 76–100%] and 89% (64–114%) for inulin and oligofructose, respectively. Similar figures have been reported (Bach Knudsen and Hessov 1995) and are comparable to the recovery of 88% obtained with wheat bran in our earlier ileostomy studies (Sandberg et al. 1981). The nondigestible fructans increased dry matter excretion by nearly 15 g, with an energy content of almost 17 kJ/g, equivalent to the energy value of carbohydrates. No change in the mean daily ileal excretion of nitrogen (2.2, 2.3 and 2.2 g), fat (8.7, 9.6 and 9.3 mmol), or starch (8.8, 9.1 and 8.6 g) occurred in subjects fed the three diets. Moreover, the mean values for the ileal excretion of calcium, magnesium and zinc did not differ among dietary treatments. Mean mineral excretions were 29.3, 30.4 and 31.2 mmol of calcium, 11.1, 10.9 and 10.8 mmol of magnesium and 119, 147 and 116 μmol of zinc per 24 h, respectively. The ileostomy model offers a sensitive method to determine short-term excretion of cholesterol, which averaged 506, 504 and 510 mg per 24 h for the three diets, respectively, and the mean cholesterol absorption, measured with an isotope-labeled cholesterol technique, which averaged 63, 60 and 62%, respectively. No significant differences in bile acid excretion between the three periods were detected (480 mg, 475 mg and 326 mg, respectively). This study suggests that inulin has little or no influence on the absorption of nutrients and minerals in the small bowel. Nevertheless, several questions about this study emerged, including the following: How reliable are these figures? It must be questioned whether the recovery from the ileostomy bags corresponds to the flow from the small to the large bowel. Earlier experience of the sensitivity of excretion figures for sterols in the ileostomy model may provide some clues.

Other dietary fiber studies with the ileostomy model

Although studies in ileostomy subjects have been performed earlier (Werch and Ivy 1940), reliable results of specific analyses of the ileostomy contents could not be obtained until we introduced studies using a controlled diet in the late 1970s that minimized bacterial degradation by frequent collection and immediately freezing of the contents. This is now referred to as the ileostomy model. Advantages and disadvantages have recently been reviewed (Andersson 1992, Andersson and Bosaeus 1993).

The main advantage of the ileostomy model is that the intestinal transit time is so short that the effluent corresponding to one day’s intake is completely excreted before the next morning (Englyst and Cummings 1986, Sandberg et al. 1981). The within-patient, within-diet and day-to-day variations are small, making short-term balance studies feasible. The standard error of the mean for nitrogen and calcium cumulative

1 Presented at the conference Nutritional and Health Benefits of Inulin and Oligofructose held May 18–19, 1998 in Bethesda, MD. This symposium was supported in part by educational grants from the National Institutes of Health Office of Dietary Supplements, the U.S. Department of Agriculture and Oraklif Technical Service. Published as a supplement to The Journal of Nutrition, Guest editors for the symposium publication were John A. Milner, The Pennsylvania State University, and Marcel Roberfroid, Louvain University, Brussels, Belgium.
2 To whom correspondence should be addressed.

0222-3166/99 $3.00 © 1999 American Society for Nutritional Sciences.
balances, was similar for a 4-d balance period in ileostomy subjects (1.5 and 1.0 mmol/24 h, respectively) compared with that for 52 d in subjects with an intact large bowel (1.5 and 1.9 mmol/24 h, respectively) (Tornquist et al. 1986). The CV between days for dry matter excretion in ileostomy subjects is ~5% (Ellegård and Bosaeus 1991).

Collection of ileostomy contents is relatively easy to perform for ileostomy subjects because handling of ileostomy excreta is a routine matter for these subjects. In contrast, constant supervision and encouragement are needed to obtain complete fecal collections from normal healthy persons. The ileostomy model could be criticized because ileostomy subjects have lost the ileocecal valve together with a minimal part of the distal ileum. Furthermore, the bacterial flora differ from those of the normal distal ileum. The number of bacteria in the terminal ileum of ileostomy subjects has been estimated to be $10^7$–$10^8$ per gram compared with $10^5$–$10^6$ per gram in the normal ileum (Finegold et al. 1970).

A number of studies, however, support the idea that there is only a small microbial degradation in the ileostomy bags when they are handled properly. Thus, degradation of bile acids and neutral steroids is minimal (Bosaeus et al. 1986, Bosaeus and Andersson 1987). Furthermore, there is no or minimal degradation of non-starch polysaccharides (NSP) components from pectin, bran or starch foods (Englyst and Cummings 1987, Englyst and Kingman 1990, Schweizer et al. 1990). Less than 5 mmol/L of short-chain fatty acids are found in ileal samples (Cummings and Englyst 1991). The pH of the ileostomy content is generally in the range of 7–8. Moreover, to determine whether significant fermentation occurs in the terminal ileum, two ileostomy subjects have been studied both with and without the antibiotic Metronidazole (Englyst and Cummings 1987). No significant difference was observed in the recovery of non-starch polysaccharides (NSP), starch or resistant starch with or without the antibiotic. Consequently, the ileostomy model can be used for determination of small-intestinal digestion of carbohydrates without interference from any substantial bacteriological degradation.

It could also be questioned whether the transit through the small bowel in the proctocolectomized subject differs from that of the normal subject. However, transit time through the stomach and small intestine of ileostomy subjects is similar to that observed in healthy subjects (Holgate and Read 1983, Malagelada et al. 1984). Moreover, the so-called ileal brake, whereby fat in the terminal ileum may influence gastric emptying rate and the intestinal transit time, also seems to be operative in ileostomy subjects (Soper et al. 1990).

The function of the distal ileum seems to remain intact in patients in whom there is only a small resection of the distal ileum, as after proctocolectomy for ulcerative colitis. Ileal excretion from patients operated for Crohn’s disease does not differ in ileostomy subjects (Soper et al. 1990). The CV between days for dry matter excretion in ileostomy subjects is ~5% (Ellegård and Bosaeus 1991).

Collection of ileostomy contents is relatively easy to perform for ileostomy subjects because handling of ileostomy excreta is a routine matter for these subjects. In contrast, constant supervision and encouragement are needed to obtain complete fecal collections from normal healthy persons. The ileostomy model could be criticized because ileostomy subjects have lost the ileocecal valve together with a minimal part of the distal ileum. Furthermore, the bacterial flora differ from those of the normal distal ileum. The number of bacteria in the terminal ileum of ileostomy subjects has been estimated to be $10^7$–$10^8$ per gram compared with $10^5$–$10^6$ per gram in the normal ileum (Finegold et al. 1970).

CONCLUSION

From our study performed on inulin and oligofructose in ileostomy subjects (Ellegård et al. 1997), in relation to our earlier experience with ileostomy subjects, three conclusions can be reached. First, inulin or oligofructose passes through the small bowel without degradation and without influencing the absorption of nutrients or minerals (calcium, magnesium and zinc). Second, inulin and oligofructose do not appear to have any considerable effect on cholesterol and bile acid excretion in the small bowel. Finally, one of the physiologic effects of inulin and oligofructose is to supply substrate for fermentation in the colon.

LITERATURE CITED


creases cholesterol and reduces bile acid excretion from the small bowel.
(β-glucan) increases bile acid excretion and a fiber-rich barley fraction increases
Malagelada, J. R., Robertson, J. S., Brown, M. L., Remington, M., Duenes, J. A.,
Experimental model for in vivo determination of dietary fibre and its effect on the
(1990) Nutrients excreted in ileostomy effluents after consumption of mixed
Nutr. 44: 567–575.
Zhang, J.-X., Hallmans, G., Andersson, H., Bosaues, I., Áman, P., Tidehag, P.,
Zhang, J.-X., Lundin, E., Andersson, H., Bosaues, I., Dahlgren, S., Hallmans,
and fecal sterol excretion in human subject with ileostomies. J. Nutr. 121:
778–784.