Nutritional and Health Benefits of Inulin and Oligofructose

Effects of Inulin on Lipid Parameters in Humans

Christine M. Williams

Hugh Sinclair Unit of Human Nutrition, Department of Food Science and Technology, University of Reading, Reading, RG6 6AP

ABSTRACT  Convincing lipid-lowering effects of the fructooligosaccharide inulin have been demonstrated in animals, yet attempts to reproduce similar effects in humans have generated conflicting results. This may be because of the much lower doses used in humans as a result of the adverse gastrointestinal symptoms exhibited by most subjects consuming daily doses in excess of 30 g. Two studies that fed either oligofructose (20 g/d) or inulin (14 g/d) observed no effect on fasting total, LDL or HDL cholesterol, or serum triglycerides. Two other studies that fed inulin either in a breakfast cereal (9 g/d) or as a powdered addition to beverages and meals (10 g/d) reported similar reductions in fasting triglycerides (−27 and −19%, respectively). In one of these studies, total and LDL cholesterol concentrations were also modestly reduced (5 and 7%, respectively). Because animal studies have identified inhibition of hepatic fatty acid synthesis as the major site of action for the triglyceride-lowering effects of inulin, and because this pathway is relatively inactive in humans unless a high carbohydrate diet is fed, future attempts to demonstrate lipid-lowering effects of inulin should consider the nature of the background diet as a determinant of response. J. Nutr. 129: 1471S–1473S, 1999.

KEY WORDS: • inulin • triglycerides • human trials

Inulin is a natural storage oligomer of fructose found in many plants, including onion, garlic, leek, chicory and artichoke. Daily intake from these sources is estimated to be in the region of 2–12 g/d in the Western diet (Roberfroid 1993). Oligofructoses (OFS)2 of varying chain lengths can be obtained from inulin by enzymatic hydrolysis. Because of their gelling and thickening properties, both inulin and OFS are useful as food ingredients and have found widespread application in recent years in items such as bread, processed cheese and dairy products (Dysler and Hoffem 1995); in addition, they may hold the promise of health benefits. Dramatic reductions in serum triglycerides have been reported in rats consuming relatively high doses of OFS, although reductions in cholesterol have been seen only with long-term feeding (Delzenne et al. 1993, Fiordaliso et al. 1995). Recent studies have shown the effects on serum triglycerides to be due to reduced secretion of VLDL particles from the liver and to be associated with reduced activity and gene expression of the key regulatory enzyme, fatty acid synthetase (Kok et al. 1996a and 1996b). Although the data obtained from animal studies suggest convincing lipid-lowering properties of OFS, much less information is available from human studies, in which the doses that can be applied are much lower than those that have been used to elicit effects in animals.

Lipid responses to inulin and OFS in subjects with raised blood lipids

Subjects with non insulin-dependent diabetes (NIDDM), who were administered 8 g OFS (Neosugar) in a packed coffee drink or coffee jelly for 14 d exhibited an 8% reduction in total, and a 10% reduction in LDL cholesterol, compared with a control group given sucrose in the same food vehicles (Yamashati et al. 1984). No effects on other serum lipids or on blood glucose concentrations were observed. Similar reductions in blood lipids were reported to have been observed in a group of Japanese subjects with hyperlipidemia (Hidaka et al. 1986), but no data were shown to support this conclusion. More recently, Davidson et al. (1998) in a randomized crossover trial in subjects with modest hyperlipidemia, showed significantly lower total and LDL concentrations during the inulin (Raftiline) phase compared with the placebo phase, but the authors reported no effects on HDL cholesterol or serum triglyceride concentrations.

Lipid responses to inulin and OFS in normal subjects

Although studies conducted in normal subjects are few in number, they are generally well designed and include respectable numbers of subjects. Luo and co-workers (Luo et al. 1996) investigated effects of Neosugar OFS (20 g/d) fed as 100-g cookies in a randomized crossover design with treatment periods of 4 wk. Sucrose was used as placebo. No changes in serum triglycerides, cholesterol or apolipoproteins were ob-

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 Oralfit 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 Abbreviations used: FFA, free fatty acids; NIDDM, noninsulin-dependent diabetes mellitus; OFS, oligofructose.

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erved in either the treatment or placebo periods, although there was a strong trend in the reduction of free fatty acid (FFA) concentrations with OFS. In contrast, Canzi et al. (1995) observed significantly lower triglyceride and cholesterol concentrations in young male volunteers who consumed 9 g inulin (Raftiline) added to a rice breakfast cereal for a period of 4 wk. The study was a randomized sequential design with a placebo period (rice cereal) followed by a test period (rice cereal plus inulin). Total cholesterol and LDL cholesterol levels were reduced by 5 and 7%, respectively, with the inulin treatment compared with the placebo. Fasting triglyceride concentrations were reduced by 27% during inulin treatment and remained significantly lower 4 wk after the end of the inulin phase. In the group as a whole (test and control periods), strong and significant associations were observed between fecal secondary bile acids and serum cholesterol ($P < 0.05$) and, most notably, triglycerides ($P < 0.001$).

Petersen et al. (1997) reported no effect on blood lipids of a daily intake of 14 g inulin added to a low fat spread for a period of 4 wk. The study was a double-blind randomized cross over design in 66 young healthy women. Although HDL cholesterol and the LDL-HDL cholesterol ratio were lower at the end of both the control and test (inulin) periods, there were no significant differences in blood lipids between placebo and inulin. Although this was a rigorously designed study, the fact that subjects were required to consume 40 g of spread per day (30 g/d of fat) (approximately twice the normal level of spread intake and 50% of total fat intake for young women) may have contributed to the negative findings observed in this group. As discussed below, triglyceride-lowering with inulin may be more likely if the background diet is high in carbohydrate rather than fat.

In a recently conducted study, 58 middle-aged subjects with moderately raised blood lipid concentrations consumed 10 g/d of inulin (Raftiline) or placebo in a powdered form that could be added to beverages, soups or cereal (Jackson et al. 1998). The study was a double-blind parallel control design with equal numbers of subjects allocated to placebo and inulin groups using stratified randomization. Subjects consumed the inulin or placebo products for 8 wk with fasting blood samples collected at baseline, 4 and 8 wk of intervention and 4 wk after the end of feeding. There were no significant changes in total, LDL or HDL cholesterol or apolipoproteins B and A in either of the groups over the 8-wk intervention, although 4 wk after the intervention, total and LDL cholesterol levels were lower than at baseline in the placebo group. Serum triglycerides were 19% lower at 8 wk than at baseline in the inulin-treated group (Fig. 1) and values were significantly lower than in controls ($P < 0.05$). Baseline triglyceride values were identical in the two groups and did not contribute to the lower values found in the inulin group at 8 wk. Serum triglycerides returned to baseline values 4 wk after treatment ended. A number of factors may have contributed to the positive findings for effects of inulin on serum triglycerides in this study. Subjects were chosen for their modestly raised triglyceride values at baseline, and the study was conducted over a longer period than any of the previous human studies. This appears to be of particular importance because, like the other studies, no significant differences in fasting serum lipids were seen at 4 wk, but significantly lower triglyceride values were observed at 8 wk. The method of dietary intervention used was simple, designed to ensure optimal compliance and to prevent confounding changes in intake of other nutrients or foods that might complicate the interpretation of the findings. Although there were important changes in serum triglycerides in the group as a whole, it should be noted that not all subjects showed a positive response to inulin feeding; in ~25% of subjects, there were no alterations in serum triglycerides, either at 4 or 8 wk. This lack of response may reflect individual differences in responsiveness to inulin, variations in background diet or lack of compliance to the product. Individual variation may also explain why, in a subgroup of subjects who undertook evaluation of postprandial lipid and glucose responses to standard meals, there were no significant differences in postprandial plasma triglycerides at 8 wk compared with baseline in inulin-treated subjects. Fasting and postprandial FFA levels were significantly lower 8 wk after inulin treatment compared with baseline. However, lower fasting (but not postprandial) FFA were also observed at 8 wk in the placebo group.

**Mechanism of lipid-lowering in response to OFS and inulin in humans**

Further studies are required to determine whether there are consistent lipid-lowering effects of inulin and OFS in humans. Present data suggest that in subjects with hyperlipidemia, any effects that do occur result primarily in reductions in cholesterol, whereas in normal subjects, effects on serum triglycerides are the dominant feature. This latter response is similar to that observed in animals, in which effects of cholesterol are small, and has been suggested to reflect reduced secretion of VLDL particles secondary to inhibition of de novo fatty acid synthesis. If this mechanism is also the effect that operates in humans and is responsible for the reduced triglyceride concentration observed in the two human studies reported above, it may also explain why such effects are difficult to demonstrate in humans. The high levels of fat present in the diet of most humans mean that rates of de novo fatty acid synthesis are low or nonexistent because exogenous dietary fatty acids are used as the substrate for triglyceride VLDL synthesis (Aarsland et al. 1996). In humans, drugs and dietary fatty acids that reduce serum triglycerides appear to increase triglyceride clearance and fatty acid oxidation; they also divert fatty acids into hepatic phospholipid synthesis, rather than inhibit de novo
fatty acid synthesis. These observations suggest that attempts to address the putative triglyceride-lowering properties of inulin and OFS should use subjects consuming a high background dietary carbohydrate intake. Investigations conducted in subjects with NIDDM would be of particular value because in these individuals, triglyceride rather than cholesterol is the primary lipid abnormality seen, and a high carbohydrate diet is used as a standard dietary approach in the treatment of NIDDM.

**CONCLUSION**

Although convincing lipid-lowering effects of inulin and OFS have been observed in animals, the studies have used relatively high levels; equivalent doses could not be used in humans because of known adverse gastrointestinal side effects at intake levels >30 g/d. Studies that have investigated effects of inulin and OFS in humans are few in number, although those that have been conducted are well designed and include relatively large numbers of subjects. The studies used varying levels of supplementation; (9–20 g/d) with a variety of inulin-enriched foods used to increase daily intakes. In studies conducted in normal subjects, two reported no effects of inulin or OFS on serum lipids, whereas two others reported significant reductions in serum triglycerides (−19 and −27%) with more modest changes in serum total and LDL cholesterol. Future studies that aim to investigate effects of inulin or OFS on serum lipids should consider the choice of subjects, the duration of the study and the levels of fat and carbohydrate in the background diet as important variables that may influence outcome.

**LITERATURE CITED**


