European Journal of Clinical Nutrition (2003) 57, 701–705
 0954–3007/03 $25.00
www.nature.com/ejcn

ORIGINAL COMMUNICATION

Tolerance of symptomatic lactose malabsorbers to lactose in milk chocolate

RMK Järvinen[1]*, M Loukaskorpi[1] and MIJ Uusitupa[1,2]

[1]*Department of Clinical Nutrition, University of Kuopio, Kuopio, Finland; and* [2]*Kuopio University Hospital, Kuopio, Finland*

Objective: To study tolerance to lactose in milk chocolate among symptomatic lactose maldigesters.
Design: Randomized cross-over study.
Subjects: Twenty-seven adult lactose maldigesters with symptomatic lactose intolerance.
Methods: A 100 g chocolate sample prepared with whole milk (12 g lactose), whole-milk powder (12 g lactose), low-lactose milk powder (2 g lactose) or lactose-free milk powder was eaten after an overnight fast. Gastrointestinal symptoms (flatulence, abdominal bloating, abdominal pain, borgorygmi and nausea) were recorded in a questionnaire during the following 8 h. Bowel movements and stool consistency were also registered during the test day.
Results: The numbers of persons reporting different gastrointestinal symptoms or any of the symptoms did not differ significantly after eating the chocolate samples. No statistical differences were found in the estimated strength of the different symptoms or the total strength of all symptoms combined. Differences in the bowel frequency and stool consistency were also non-significant.
Conclusions: Lactose malabsorbers with self-reported lactose intolerence did not differ in their response to milk chocolate samples containing different amounts of lactose.
European Journal of Clinical Nutrition (2003) **57,** 701 – 705. doi:10.1038/sj.ejcn.1601600

Keywords: lactose; lactose intolerance; lactose malabsorption; milk chocolate; adults

Introduction

Lactose intolerance is a common gastrointestinal disorder which is associated with incomplete digestion of lactose. Prevalence of primary adult-type hypolactasia is very high worldwide though there is great variation between different races and populations (Sahi, 1994). Sensitivity to lactose, however, varies greatly and depends both on personal and circumstantial factors (Vesa *et al*, 2000). Although the majority of lactose malabsorbers develop gastrointestinal symptoms including flatulence, abdominal pain and diarrhea after ingestion of a large single dose of lactose such as the amount equivalent of 1 l of milk, a considerable number of lactose malabsorbers can consume one cup (240 ml) of milk without appreciable symptoms (Suarez *et al*, 1995b). It has been suggested that lactose can be better tolerated by lactose malabsorbers when it is ingested with a meal or solid food (Solomons *et al*, 1985; Martini & Savaiano, 1988). Furthermore, tolerance to lactose can be increased due to intestinal adaptation to the amounts of lactose ingested (Hertzler & Savaiano, 1996; Pribila *et al*, 2000).

Lactose is a sugar naturally occurring only in milk; however, it is a common constituent in other foods where milk or lactose have been added. Besides milk and milk products, tolerance to lactose in other foods has rarely been investigated. Milk chocolate is a non-dairy product which contains about the same amount of lactose in a 100 g sample that is found in a cup (240 ml) of milk. This study was carried out in order to demonstrate the effects of lactose in milk chocolate on the gastrointestinal symptoms of subjects with lactose malabsorption.

Subjects and methods

Subjects

Subjects were volunteers who were selected among the students and staff of the University of Kuopio and the

*Correspondence: R Järvinen, Department of Clinical Nutrition, University of Kuopio, PO Box 1627, FIN-70211 Kuopio, Finland.
E-mail: Ritva.Jarvinen@uku.fi
Guarantor: R Järvinen.
Contributors: MU was responsible for the study design. ML completed the experimental work and carried out the statistical analyses. RJ prepared the manuscript. All authors contributed to interpreting the data.
Accepted 19 July 2002

Kuopio University Hospital. Persons who had experienced gastrointestinal symptoms after drinking milk or food containing lactose, with or without previous diagnosis of lactose malabsorption, were invited to participate in the study. Those with no previous diagnosis of lactose malabsorption by a health care professional took part in an oral lactose load test (Arola, 1994). Lactose malabsorption was diagnosed if the maximum rise in blood glucose was less than 1.1 mmol/l within 1 h after ingestion of 50 g of lactose dissolved in 400 ml of water. In total, 44 persons were willing to participate; however, 15 of these were excluded from the study since lactose malabsorption could not be verified by an oral lactose load test. Symptom records for two of those who participated in the tests remained deficient. The final study group included 25 women and two men, aged between 16 and 55 y.

Chocolate samples

Four different milk chocolate samples were tested. The first sample consisted of usual milk chocolate drawn from the commercial production (Milk Chocolate, Fazer Chocolates Ltd, Vantaa, Finland). The second sample was prepared using whole milk powder instead of whole milk, the third sample was prepared using lactose-hydrolyzed milk powder, and the fourth sample was chocolate prepared using totally lactose-free milk powder from which lactose had been removed chromatographically. Lactose removed from the lactose-free milk was replaced with sucrose in order to maintain similar amounts of sugars and total carbohydrates in the test samples. The amount of cocoa butter and cocoa bulk were also slightly adjusted in chocolate samples 3 and 4 in order to equalize the carbohydrate and dry matter content of the samples. Data on the composition of the chocolate samples are presented in Table 1.

Study design

The study was a blinded cross-over study where four chocolate samples were offered to each participant in randomized order. The study design was accepted by the Ethics Committee of the University of Kuopio and the Kuopio University Hospital. The participants gave their informed consent before the study. There were at least 2 days between the test days, and the tests were not carried out during any acute illness or menstruation. Occasional use of drugs such as aspirin for headache was prohibited during the test days.

A 100 g chocolate sample was eaten in the morning between 8 and 10 o'clock after an overnight fast (10 h). The subjects were allowed to drink a glass (2 dl) of water after the test meal, but otherwise the fasting state was continued for 5 h. The test meals were eaten at a clinical research unit where the participants stayed for 1 h. The subjects had oral and written instructions for the test day. They were advised not to eat or drink any lactose-containing food or other foods likely to induce gastrointestinal symptoms. They were also asked to keep a food diary until 10 a.m. of the test day. Gastrointestinal symptoms including flatulence, abdominal bloating, abdominal pain, borgorygmi and nausea were recorded on a questionnaire with a scale ranging from 0 (no symptoms) to 10 (very severe symptoms disturbing normal life) once every hour for the first 3 h and then two more times (at 4–6 and 7–8 h) until 8 h had elapsed since the test meal. In addition, there was one line for recording symptoms during later hours of the test day, however, in the analyses only the symptoms occurring within 8 h were taken into account. The number of bowel movements and consistency of stools were also recorded during the test day. The symptom questionnaire was kindly supplied by Dr Riitta Korpela (Foundation for Nutrition Research, Helsinki, Finland).

Statistical analyses

Frequencies of the persons reporting gastrointestinal symptoms at different hours and for the whole 8 h period following the test meal were calculated. In order to estimate the severity of the symptoms resulting from different chocolate meals, the individual scores for a given symptom were combined over the 8 h period. Finally the grand sum of all scores for different symptoms was calculated. Total numbers of bowel frequencies as well as numbers of bowel frequencies with different stool consistency during the test days were calculated. Non-parametric Kruskall–Wallis test was used to analyse the differences for the degree of the severity of the symptoms perceived by the subjects after eating different

Table 1 The sugar and carbohydrate composition of the four milk chocolate samples, and the proportions of cocoa butter and cocoa bulk in the samples

Component	*Chocolate 1 (fresh milk)*	*Chocolate 2 (milk powder)*	*Chocolate 3 (low-lactose milk powder)*	*Chocolate 4 (lactose-free milk powder)*
Lactose (%)	12	12	2	0
Galactose (%)	—	—	5	—
Glucose (%)	—	—	5	—
Sucrose (%)	35.8	35.8	32.1	44.1
Total carbohydrates (%)	49.5	49.5	49.5	49.5
Cocoa butter (%)	19.2	19.2	21.0	21.0
Cocoa bulk (%)	12.1	12.1	13.9	13.9

chocolate samples. Differences between the numbers of individuals with gastrointestinal symptoms and differences between the bowel movement frequencies were tested using chi-square test. Statistical analyses were carried out using the SPSS statistical program for Windows (version 7.5, SPSS Inc., Chicago, IL, USA).

Results

Flatulence and abdominal bloating were the most often recorded gastrointestinal symptoms (Table 2). Approximately four in five of the participants reported the occurrence of flatulence after eating different chocolate meals. The total number of subjects who reported any of the symptoms after eating different chocolate meals varied between 19 and 25. Accordingly, a considerable proportion of the participants reported the occurrence of some gastrointestinal symptoms; however, the symptoms were mostly mild. The numbers of individuals reporting different gastrointestinal symptoms or any of the symptoms following test meals did not differ significantly after eating the four chocolate samples. Differences in the numbers of persons with gastrointestinal symptoms at different hours after eating the chocolate samples were also non-significant (data not shown).

The mean values of the total scores for the strength of different symptoms and the sum of all scores combined during the eight-hour period following the test meals are shown in Table 3. The highest total scores were found for flatulence and abdominal bloating. However, when compared to the total maximum score values the mean ratings were low indicating that the perceived symptoms were mostly very mild. The mean values for the sum of any given symptom as well as for the sum of all symptoms combined were slightly lower after eating chocolate sample 4, prepared with totally lactose-free milk; the score values did not, however, differ significantly between the four chocolate samples.

The total number of bowel movements reported by 27 participants during the test days varied between 23 and 29 and the consistency of the stools was mostly reported to be normal. Twenty-four subjects reported 29 bowel movements after eating chocolate sample 1, 19 subjects reported 24 bowel movements after eating chocolate sample 2, 25 subjects reported 28 bowel movements after eating chocolate sample 3, and 18 subjects reported 23 bowel movements after eating chocolate sample 4. The total number of bowel movements with loose stool consistency was four after chocolate sample 1, six after chocolate sample 2, five after chocolate sample 3, and five after eating chocolate sample 4. There were no significant differences in the total number of bowel movements or bowel movements with loose stool consistency after eating different chocolate samples (data not shown).

Discussion

In this randomized cross-over study on lactose malabsorbers, we did not find any significant differences in the gastrointestinal symptoms or bowel movements and stool consistency after eating milk chocolate samples containing different amounts of lactose. This finding indicates that, in general, the symptoms attributed by lactose intolerants to milk chocolate apparently cannot not be ascribed directly to the lactose content of the chocolate.

A 100 g sample of milk chocolate used in the present study contains 12 g of lactose, an amount comparable to that detected in one cup (240 ml) of milk. This amount is considerably lower than that used in an oral lactose load test (50 g of lactose), and therefore can also be considered to produce less gastric complaints. In previous studies mainly carried out using lactose dissolved in milk or water, the tolerance of lactose malabsorbers to these amounts of lactose has been shown to be variable (Vesa *et al*, 2000). In controlled cross-over studies, nonsignificant differences in the severity of gastrointestinal symptoms have been reported after ingestion of lactose doses up to 6 or 7 g dissolved in milk or water (Hertzler *et al*, 1996; Vesa *et al*, 1996); however, the intensity of abdominal pain was greater after consumption of a 12 g dose of lactose than after a 6 g lactose dose (Hertzler *et al*, 1996). Lactose in chocolate may be better tolerated, since in the present study gastrointestinal symptoms after eating chocolate samples with 12 g of lactose did not differ significantly from those arising after eating lactose-free or low-lactose samples.

Table 2 The number of subjects who reported different gastrointestinal symptoms and any of the symptoms during 8 h after eating the chocolate samples ($n = 27$)

Symptom	*Chocolate 1 (fresh milk)*	*Chocolate 2 (milk powder)*	*Chocolate 3 (low-lactose milk powder)*	*Chocolate 4 (lactose-free milk powder)*	P-*value*[a]
Flatulence	22	21	18	19	0.48
Abdominal bloating	19	19	17	16	0.80
Abdominal pain	10	10	8	8	0.88
Borgorygmi	11	9	10	9	0.93
Nausea	10	8	12	6	0.29
Any symptom	25	23	22	19	0.21

[a]Chi-square test.

Table 3 The mean ± s.d. and interquartile range of the scores given for different gastrointestinal symptoms and the sum of all symptoms during 8 h after eating the chocolate samples ($n = 27$)

	Chocolate 1 (fresh milk)		*Chocolate 2 (milk powder)*		*Chocolate 3 (low-lactose milk powder)*		*Chocolate 4 (lactose-free milk powder)*		
Symptom[a]	*Mean s.d.*	*Range*[c]	*Mean s.d.*	*Range*[c]	*Mean s.d.*	*Range*[c]	*Mean s.d.*	*Range*[c]	P-*value*[b]
Flatulence	6.0 ± 6.4	1–8	5.2 ± 5.4	1–10	5.1 ± 5.8	0–10	4.4 ± 4.6	0–9	0.75
Abdominal bloating	5.0 ± 5.7	0–9	5.3 ± 5.7	0–9	5.6 ± 6.3	0–12	4.6 ± 5.5	0–8	0.93
Abdominal pain	3.6 ± 6.6	0–4	2.9 ± 5.5	0–4	2.3 ± 4.5	0–2	2.3 ± 5.2	0–3	0.85
Borgorygmi	3.4 ± 5.8	0–5	2.1 ± 3.8	0–4	1.9 ± 3.2	0–3	1.3 ± 2.3	0–2	0.80
Nausca	1.5 ± 2.5	0–3	1.9 ± 3.8	0–2	1.8 ± 2.8	0–2	1.0 ± 2.5	0–0	0.43
Sum of all symptoms	19.5 ± 20.8	3–28	17.5 ± 18.6	2–29	16.6 ± 16.2	2–32	13.5 ± 15.8	0–23	0.59

[a]The maximum possible score for each of the symptoms was 50 and for the sum of all symptoms 250.
[b]Kruskal–Wallis test.
[c]Interquartile range.

In a previous study investigating the effect of lactose ingested as a chocolate milk formula in lactose intolerants, the addition of cocoa was found to significantly reduce both the breath hydrogen level as well as gastrointestinal symptoms, thus suggesting that the alleviation may be due to cocoa supplementation (Lee & Hardy, 1989). In another study chocolate milk with 18 g of lactose reduced total breath hydrogen production (Dehkordi *et al*, 1995). Accordingly, cocoa may alleviate the effects of lactose in milk chocolate. Since solid consistency and high energy content of food delays gastric emptying (Moore *et al*, 1984; Notivol *et al*, 1984; Marciani *et al*, 2001), lactose eaten in milk chocolate may even induce fewer symptoms than the respective amount of lactose in chocolate milk. It has been previously demonstrated that consuming milk or lactose with a meal or other foods produces less breath hydrogen and gastrointestinal symptoms (Solomons *et al*, 1985; Martini & Savaiano, 1988; Dehkordi *et al*, 1995).

The basic compositions of the four chocolate samples were equalized as far as possible. In order to keep the total amount of carbohydrates and sugars at similar levels, the lactose removed from the lactose-free chocolate was replaced by sucrose. Because both lactose and sucrose are disaccharides, their effect on gastric osmolality is similar. The osmotic impact of low-lactose chocolate was apparently slightly increased due to the prior hydrolysis of lactose into glucose and galactose. It has been demonstrated that gastric emptying is slower after a glucose-galactose solution than a lactose solution in lactose maldigesters (Troncon *et al*, 1983). Therefore, the gastric effect of the low-lactose chocolate (sample 3) may have been slightly different from those of the others. Otherwise, the differences in the composition of the test chocolates were minimal.

The majority of the participants of the present study were women. This unequal gender distribution of the study subjects was due to the fact, that the majority of the staff and students among whom the participants were selected, were women. Although there appears to be no gender difference in the prevalence of lactose malabsorption (Rao *et al*, 1994), the responses of men and women to lactose could be different. Men with lactose malabsorption could react more readily to ingested lactose due to their faster gastric emptying (Notivol *et al*, 1984; Hermansson & Sivertsson, 1996). On the other hand, women seem to experience stronger gastrointestinal complaints after lactose ingestion (Krause *et al*, 1996). The importance of gender on the results of this kind of study testing subjective symptoms is therefore difficult to estimate. In general, previous studies testing tolerance to lactose have paid little attention to the gender of their study subjects.

The participants in the present study were selected to represent those lactose malabsorbers who would most likely experience symptoms after ingesting lactose, and who apparently would also benefit from the availability of low-lactose or lactose-free products. However, recent studies have shown that specification of lactose intolerance associated with lactose maldigestion may be cumbersome (Peuhkuri *et al*, 2000). A considerable proportion of those who have self-diagnosed lactose intolerance cannot be diagnosed as lactose malabsorbers (Johnson *et al*, 1993; Suarez *et al*, 1995a). In the present study, the specification of lactose intolerance was based not only on self-reported lactose intolerance but also on a diagnosis of lactose malabsorption, as determined by blood glucose measurement after an oral lactose load test. It may be possible that even among the defined group of symptomatic lactose maldigesters, some of the symptoms were due to underlying irritable bowel syndrome. In a previous study, irritable bowel syndrome was found in 15% of both lactose absorbers as well as lactose malabsorbers (Vesa *et al*, 1998).

Our results suggest that 12 g of lactose present in milk chocolate is well tolerated by symptomatic lactose

malabsorbers. Ingestion of milk chocolate produced only minor gastrointestinal complaints, which did not differ significantly from those after eating lactose free chocolate. Apparently no specific restriction in the diet of lactose intolerants is needed as far as a moderate amount of milk chocolate is concerned.

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