The effects of regular consumption of short-chain fructo-oligosaccharides on digestive comfort of subjects with minor functional bowel disorders

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A comparative, randomised, double-blind trial was performed in the medical departments of five hospitals to study the effects of regular consumption of short-chain fructo-oligosaccharides (sc-FOS) on the digestive comfort of subjects with minor functional bowel disorders (FBD). In step 1, 2235 subjects were questioned to assess the incidence and intensity of digestive disorders. In step 2, 105 of these patients diagnosed with minor FBD were randomised into two groups to receive either 5 g sc-FOS or 5 g placebo (sucrose and maltodextrins) per d over a 6-week period. The incidence and intensity of digestive disorders were assessed at the end of the treatment period (day 43) using the step 1 questionnaires. A quality-of-life questionnaire was also completed at the start and end of the treatment period to assess potential effects on well-being and social performance. In step 1, 44 % of the subjects questioned presented FBD, of whom 57.1 % suffered from minor FBD. In step 2, on day 43, the intensity of digestive disorders decreased by 43.6 % in the sc-FOS group v. a 13.8 % increase in the placebo group (P=0.026). Symptoms were experienced less frequently by 75.0 % of subjects in the sc-FOS group, while 53.8 % of controls experienced no change (P=0.064). Using the functional digestive disorders quality of life questionnaire, the discomfort item scores increased in the sc-FOS group (P=0.031). However, expressed as change in quality of life (improvement, worsening or unchanged), daily activities were significantly improved in the sc-FOS group (P=0.022). Regular consumption of sc-FOS may improve digestive comfort in a working population not undergoing medical treatment.

Short-chain fructo-oligosaccharides: Quality of life: Functional bowel disorders

Functional bowel disorders (FBD) are diagnosed on the basis of characteristic symptoms in the digestive system persisting for at least 12 weeks over the last 12 months in the absence of any structural or biochemical explanation. The five main symptoms reported by patients are abdominal bloating, rumbling, transit disorders (occasional constipation and/or diarrhoea, possibly alternating), abdominal pains and flatulence. FBD have been reported as being chronic, non-life-threatening conditions, but having a marked impact on daily activities, well-being and social performance, even during symptom-free periods, mainly due to apprehension about impending pain.

These functional disorders, influenced by psychological and environmental factors, are common, with a reported prevalence of up to 61 % in the French population aged over 15 years. Functional disorders thus lead to a high number of general medical and gastroenterology consultations, respectively accounting for 10 and 50 % of all medical consultations. However, two-thirds of subjects with FBD never consult a doctor for their disorder. A nutritional approach therefore appears a good alternative to medication for subjects with minor FBD or individuals rejecting medical therapy. Amongst the few already well-established ingredients recognised as having an impact on the digestive system, short-chain fructo-oligosaccharides (sc-FOS) are known to be fully fermented by the colonic microflora and, above all, to increase colonic bifidobacteria recognised as health

Abbreviations: FBD, functional bowel disorder; FDDQL, functional digestive disorders quality of life; sc-FOS, short-chain fructo-oligosaccharide.

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promoting. Sc-FOS occur in numerous edible plants such as onions, garlic, asparagus, tomatoes and wheat. Bacterial fermentation of sc-FOS increases production of SCFA such as acetate, propionate and butyrate, whose ability to regulate ileal motility has been demonstrated by several studies. As described by Hidaka, sc-FOS improve intestinal function with greater consistency and regularity in stool output.

Thus, while their impact on colonic health has been widely studied, little is as yet known about the impact of sc-FOS on the quality of life of subjects with FBD.

The present study was designed to test the efficacy of sc-FOS in improving digestive comfort among subjects with minor FBD.

**Subjects and methods**

**Subjects**

Subjects were recruited in the occupational medicine departments of five hospitals.

An initial questionnaire designed to assess the incidence and intensity of digestive disorders as well as the number of subjects presenting FBD was completed by 2235 subjects (Fig. 1).

This questionnaire was then analysed by a doctor at each study centre. Of the 2235 patients, 983 were presenting digestive disorders, of whom 57.1% had minor symptoms. A total of 186 subjects met all of the following inclusion criteria: age >18 years, presenting at least two minor FBD symptoms according to the Rome II criteria for at least 12 weeks over the last 12 months, a total intensity score of ≤25 for the symptoms included in the initial questionnaire, an intensity score of ≤5 for ‘discomfort or abdominal pain’, as well as relief following defecation, no major digestive disease and no previous consultation or medication for FBD.

A total of 105 subjects (fifteen men and ninety women; mean age 38.3 years) agreed to take part in the study. All subjects were recruited in the occupational medicine departments of five hospitals.

Subjects were allocated in the form of two packets containing either 2.5 g sc-FOS or a blend of 1:2:5 maltodextrin, promoting. Sc-FOS occur in numerous edible plants such as onions, garlic, asparagus, tomatoes and wheat. Bacterial fermentation of sc-FOS increases production of SCFA such as acetate, propionate and butyrate, whose ability to regulate ileal motility has been demonstrated by several studies. As described by Hidaka, sc-FOS improve intestinal function with greater consistency and regularity in stool output.

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and 1·25 g sucrose (tolerance ± 4 %), depending on the randomisation group. Two packets per d were to be consumed, one at breakfast and one at dinner, either sprinkled over a dessert or diluted in a drink.

Compliance was checked using a form on which subjects kept a daily record of the number of packets consumed and the time of intake. All unused packets were to be returned by the subjects to the investigators at the end of the study.

Statistics
All statistical analyses were conducted using the SAS statistical program (version 8.2; SAS Institute Inc., Cary, NC, USA). All tests comparing the two groups (sc-FOS vs. placebo) were two-tailed with type 1 error set at 0·05, taking into account the two-arm parallel design.

Qualitative variables were expressed in terms of degree and percentage. Both groups were compared for non-ordered qualitative variables using a χ² test, or Fisher’s exact test where size was too small (<5). For ordered qualitative variables, both groups were compared using the Wilcoxon–Mann–Whitney rank-sum test. Quantitative variables were expressed in terms of mean values, standard deviations and ranges. Depending on the results of the normality test (Shapiro–Wilk), the two groups were compared using a Student or Wilcoxon–Mann–Whitney rank-sum test.

Efficacy analysis. Changes in score between days 0 and 43 for each of the eight FDDQL questionnaire items were compared between the two groups using Student’s test. The eight scores were summed and the global scores for days 0 and 43 were compared using Student’s test. The intensity and frequency of symptoms as well as change in these parameters were also compared between the two groups using a Wilcoxon–Mann–Whitney test. Subject satisfaction was analysed using a χ² test or Fisher’s exact test.

Safety analysis. A global analysis was performed for the observed frequencies and the intensity of symptoms occurring during the treatment period.

Results

Step 1
A total of 2235 subjects completed the initial questionnaire. Age ranged from 16 to 75 years (age 36·8 (SD 10·9) years), and 75·7 % of subjects were women. Of these, 983 subjects were presenting digestive disorders, 57·1 % of whom had minor symptoms (i.e. 25·1 % of subjects questioned). According to the symptoms reported, 36·9 % of all subjects questioned presented abdominal discomfort (women, 40·8 %; men, 24·3 %), 25·6 % presented constipation (women, 28·9 %; men, 15·3 %) and 21·9 % presented diarrhoea (women, 22·4 %; men, 20·3 %). Only 186 subjects, mainly presenting abdominal discomfort (96·8 %) or constipation (79·6 %), met all inclusion criteria during checks by the study doctors. Of the ten representative symptoms of FBD, the average number actually presented was 5·1 (SD 1·9), with a global mean intensity of 11·5 (SD 5·9).

Step 2
A total of 105 subjects agreed to participate in the study and were randomised to the sc-FOS (fifty-four subjects) and placebo (fifty-one subjects) groups (Fig. 2).

Characteristics at inclusion. Demographic factors were similar between both groups (Table 1). Women accounted respectively for 83·3 and 85·7 % of subjects in the sc-FOS and placebo groups. The item scores and global score on the FDDQL questionnaire completed at inclusion were comparable for the two groups.

Treatment: compliance and concomitant medication. Treatment compliance was judged satisfactory when the product (two packets of treatment per d) was consumed as instructed throughout the study period (consumption for at least 30 d, consumption of the entire daily dose for at least 27 d and no interruption in intake for more than 4 consecutive days). In terms of these criteria, no significant differences were found in treatment compliance between the two groups (P=0·83). To qualify for inclusion in the per protocol analyses, the date of the final visit also had to be within 10 d of the theoretical date (i.e. between 43 and 53 d after the start of study product intake).

Compliance was good for fifty subjects (consumption during respectively 40·9 (SD 1·9) d in the sc-FOS group (twenty-four subjects) and 41·3 (SD 1·4) d in the placebo group (twenty-six subjects)), but less satisfactory for the other forty-seven subjects. Eight subjects (four in each group) dropped out before the final medical visit.

As regards concomitant medication, nine subjects took a treatment having a potential minor influence on FBD (respectively four and five subjects in the sc-FOS and placebo groups).
Furthermore, the occurrence of gastroenteritis in one subject may have had a minor effect on FBD.

Safety analysis

In the ninety-seven subjects in the intent-to-treat group, twenty-seven adverse events were seen, concerning respectively eleven (22·9 %) and sixteen (32·6 %) subjects in the sc-FOS and placebo groups. Severity of these adverse events was distributed as follows: nine were reported as light (two under sc-FOS and seven under placebo), fifteen as mild (seven sc-FOS and eight placebo) and three as severe (two sc-FOS and one placebo). Five adverse events comprised infectious diseases such as angina, bronchitis, sinusitis or gastroenteritis (two sc-FOS and three placebo), ten comprised gastrointestinal symptoms such as diarrhoea, constipation, abdominal pain, vomiting or nausea (six sc-FOS and four placebo), twelve comprised painful symptoms including headache or lower back pain (five sc-FOS and seven placebo) and six comprised other symptoms (for example, anxiety, weight loss). Of the three adverse events reported as severe, respectively two (abdominal pain and nausea (same subject), spots on the chest, back and arms) and one (unwarranted anxiety) were seen in the sc-FOS and placebo groups. Two patients had symptoms diagnosed as linked to sc-FOS consumption (possible or probable association); these were diarrhoea, and abdominal pain and nausea (same subject). Eight subjects definitively stopped consuming the product after the occurrence of an adverse event.

Change in symptom intensity (initial questionnaire)

At the beginning of the study, the sc-FOS and placebo groups showed similar intensity of digestive disorders (sc-FOS, 3·6 (SD 1·8); placebo, 3·4 (SD 2·1); P=0·565). Sc-FOS ingestion for 6 weeks significantly reduced symptom intensity by 43·6 % (2·1·6 (SD 2·1); P=0·026, FOS v. placebo); the placebo group experienced a 13·8 % increase (see Fig. 3 and Table 2).

Change in frequency of digestive disorders (consultation questionnaire)

The frequency of digestive disorders was assessed over the 4 weeks preceding the start of the study and at the end of the study. Over the 4 weeks preceding the start of the study (day 0), the various symptoms of digestive disorders occurred once per week in both groups (per protocol population) (Table 3): 41·7 and 38·5 % of subjects in the sc-FOS and placebo groups, respectively. On day 43, a reduced frequency was noted in the sc-FOS group, with 20·8 % for the mixed items ‘more than once per week’ and ‘every day’, whereas the frequency in the placebo group remained higher, at 42·3 % for the same mixed items. None of these changes were statistically significant.

At 6 weeks later, symptoms were experienced less frequently by 75·0 % of subjects in the sc-FOS group (29·2 % much less frequently; 45·8 % rather less frequently) compared with control subjects, 53·8 % of whom experienced no change, as shown in Fig. 4 (P=0·064).

Table 1. Characteristics of patients in the intent-to-treat group with baseline intensity of symptoms related to minor functional bowel disorders (FBD)

(Mean values and standard deviations)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>sc-FOS group (n=48)</th>
<th>Placebo group (n=49)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>39·5 (11·9)</td>
<td>37·6 (10·9)</td>
<td>0·397</td>
</tr>
<tr>
<td>Age range (years)</td>
<td>20–59</td>
<td>20–55</td>
<td>0·746</td>
</tr>
<tr>
<td>Females (n)</td>
<td>40</td>
<td>42</td>
<td>0·898</td>
</tr>
<tr>
<td>Symptoms related to minor FBD (n)*</td>
<td>5·6 (1·8)</td>
<td>5·5 (1·8)</td>
<td>0·898</td>
</tr>
<tr>
<td>Symptoms related to minor FBD range (n)*</td>
<td>2–9</td>
<td>2–10</td>
<td>0·898</td>
</tr>
<tr>
<td>Abdominal pain†</td>
<td>3·6 (1·8)</td>
<td>3·4 (2·1)</td>
<td>0·566</td>
</tr>
<tr>
<td>Abdominal fullness†</td>
<td>3·7 (2·4)</td>
<td>4·0 (2·1)</td>
<td>0·528</td>
</tr>
<tr>
<td>Feeling of incomplete bowel movement†</td>
<td>1·7 (2·4)</td>
<td>1·6 (2·2)</td>
<td>0·800</td>
</tr>
<tr>
<td>Urgency†</td>
<td>1·8 (2·6)</td>
<td>2·1 (2·7)</td>
<td>0·628</td>
</tr>
<tr>
<td>Straining at stool†</td>
<td>2·9 (3·1)</td>
<td>3·1 (2·9)</td>
<td>0·694</td>
</tr>
<tr>
<td>Global intensity of symptoms†</td>
<td>13·4 (7·0)</td>
<td>13·7 (6·9)</td>
<td>0·857</td>
</tr>
<tr>
<td>Item scores on FDDQL for day 0 questionnaire Activities‡</td>
<td>80·9 (14·7)</td>
<td>80·5 (17·3)</td>
<td>0·723</td>
</tr>
<tr>
<td>Anxiety‡</td>
<td>64·3 (24·4)</td>
<td>67·3 (24·1)</td>
<td>0·454</td>
</tr>
<tr>
<td>Diet‡</td>
<td>64·2 (17·2)</td>
<td>64·5 (21·7)</td>
<td>0·628</td>
</tr>
<tr>
<td>Sleep‡</td>
<td>78·5 (18·3)</td>
<td>71·8 (20·9)</td>
<td>0·125</td>
</tr>
<tr>
<td>Discomfort‡</td>
<td>46·1 (15·2)</td>
<td>44·2 (19·9)</td>
<td>0·694</td>
</tr>
<tr>
<td>Coping with disease‡</td>
<td>71·5 (14·9)</td>
<td>70·0 (17·2)</td>
<td>0·645</td>
</tr>
<tr>
<td>Control of disease‡</td>
<td>56·7 (24·9)</td>
<td>48·5 (26·3)</td>
<td>0·118</td>
</tr>
<tr>
<td>Impact of stress‡</td>
<td>32·8 (27·4)</td>
<td>30·8 (23·8)</td>
<td>0·890</td>
</tr>
<tr>
<td>Global score on FDDQL for day 0 questionnaire‡</td>
<td>66·0 (9·4)</td>
<td>63·8 (13·8)</td>
<td>0·700</td>
</tr>
</tbody>
</table>

sc-FOS, short-chain fructo-oligosaccharides; FDDQL, functional digestive disorders quality of life.

* Number of symptoms between 1 and 11 experienced during the previous 12 months.
† On a scale of 1–10.
‡ On a scale of 0–100, where 0 = poor quality of life and 100 = excellent quality of life.
Change in quality of life after 6 weeks of short-chain fructo-oligosaccharide consumption

The FDDQL questionnaire item scores were compared between day 0 and day 43 for both groups (Table 4). As regards the per protocol population, the discomfort item scores appeared to have significantly increased in the sc-FOS group after 6 weeks of consumption of the study product compared with the placebo (sc-FOS, 20·1 (SD 14·2); placebo, 12·1 (SD 19·6); \( P = 0.031 \)). The differences between the sc-FOS and placebo groups regarding the other item scores were not significant.

Change in quality of life was also analysed in terms of improvement (i.e. item score on day 43 \( \leq \) day 0), worsening (i.e. item score on day 43 \( > \) day 0) and no change in comfort (i.e. item score on day 43 = day 0). As shown in Fig. 5, digestive comfort tended to increase (\( P = 0.071 \)) and daily activities were significantly improved (\( P = 0.022 \)). These increases respectively concerned 95·8 and 83·3 % of subjects in the sc-FOS group.

Activity scores on day 43 also differed significantly between the sc-FOS and placebo groups (sc-FOS, 95·0 (SD 5·3); placebo, 82·7 (SD 19·7); \( P = 0.011 \)). Subjects consuming sc-FOS were therefore less disturbed by their digestive symptoms in performance of their daily activities.

Discussion

The patients enrolled in the present study were screened using the Rome II criteria \(^{24} \). They are representative of the female population generally known to present FBD \(^{26} \). However, compared with previous FBD data for the French population \(^{6} \), the prevalence detected in the present study was lower (44 v. 61 %), which could be due to a lower mean age in the present study, as well as different socio-cultural makeup of the populations. This last factor is a consequence of the method of recruiting the subjects, who were mainly hospital staff members. Age, socio-economic status and culture are indeed recognised as important factors that can have a bearing on FBD \(^{26} \).

Beyond the prevalence of FBD, the study also provided information concerning the impact of FBD on quality of life.
lifestyle. Contrary to previous studies, a specific quality-of-life questionnaire devoted to functional digestive disorders was used to assess each patient's own evaluation of his or her health status. This is currently the most relevant, valid and responsive questionnaire available to assess the impact of FBD status on quality of life as perceived by the patient. Other questionnaires, such as the 'medical outcomes study 36-item short form', the sickness impact profile, and the psychological general wellbeing scale, are generic instruments designed to compare health status scores among subjects with various diseases but do not focus on the specific impact of a particular symptom on their quality of life. They were therefore less likely to detect small but clinically important changes induced by the treatment used during the present study.

For example, problems largely experienced by patients with irritable bowel syndrome such as abdominal pain or urgency would not be singled out by the above-mentioned questionnaires.

Furthermore, the present study is the first dealing with FBD to be carried out in a working population not undergoing medical treatment. To date, no randomised, placebo-controlled clinical trials have been performed introducing a dietary ingredient for the treatment of minor FBD symptoms and using relevant evaluation methods to quantify the results. For subjects presenting these symptoms, which while not severe cause discomfort in all daily activities, dietary change could have a significant impact on wellbeing as well as working capacity and may thus have potential benefits for healthcare spending.

A recent study showed that sc-FOS are bifidogenic and well tolerated at doses ranging from 2.5 to 10 g/d with a dose–response relationship in healthy volunteers. Studies with higher dosages of sc-FOS did not show any further increase in Bifidobacteria count but excessive flatus occurred in some cases. In another threshold study evaluating symptomatic response to varying levels of sc-FOS ingested regularly by fourteen healthy volunteers, excessive flatus and borborygms were recorded by about 10% of volunteers at 10 g/d. We therefore chose to test a 5 g/d dose rather than 10 g/d in our trial in subjects with FBD, particularly as subjects with irritable bowel syndrome are more sensitive and could present more pronounced gastrointestinal side effects than healthy subjects for a given dose.

An improvement in digestive comfort (close to significance) and in performance of daily activities (significant) was observed under sc-FOS compared with placebo. Other items related to quality of life (anxiety, diet, sleep, control of disease, coping with disease and stress) showed no significant change compared with placebo. No significant change in intensity of symptoms was noticed with sc-FOS consumption except for digestive disorders and abdominal pain, which were significantly lower compared with placebo. In the present study, the placebo effect appeared remarkably high. The influence of psychological and environmental factors on these symptoms is well known, but this could also explain why several statistical tendencies were obtained rather than solid statistical effects.

This double-blind, placebo-controlled study was carried out to assess the effect of regular and moderate sc-FOS consumption on the quality of life of subjects presenting untreated minor FBD. It was initially assumed that these dietary fibres could reduce symptoms linked with FBD and therefore improve the quality of life of such subjects. Finally, we showed that 6 weeks’ consumption of 5 g sc-FOS/d led to a significant decrease in the intensity of digestive disorders. Improvement was also noted in digestive comfort and in daily activities. On the basis of these findings, we conclude that regular consumption of 5 g sc-FOS/d may improve digestive comfort in subjects with minor FBD, thereby improving quality of life as well as social performance.

It would also be useful to study the effect of sc-FOS consumption on irritable bowel syndrome, a particular form of functional bowel disorder. Referring to the Rome III...
criteria, irritable bowel syndrome is in fact characterised by abdominal pain and discomfort associated with defecation disorders. Throughout the world, about 10–20% of adults and adolescents have symptoms consistent with irritable bowel syndrome, which is slightly less than the level found in the subjects initially questioned in the present study (Fig. 1); these symptoms are frequently associated with impaired quality of life and high healthcare costs. The impact of sc-FOS on Crohn’s disease is another interesting area for investigation. A recent study proved that 3 weeks' consumption of 15 g fructans reduces the activity of Crohn’s disease. Increased levels of faecal bifidobacteria, modification of mucosal dendritic cell function and production of butyrate with its anti-inflammatory properties could all be involved in this effect. Further justification for such studies lies in the fact that no efficient treatment is yet available despite a prevalence of 25–150 per 100,000 worldwide.

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References

10. Aliment Pharmacol Ther 21, 499–508.