

**Title:** Perceived acceptability of partial enteral nutrition (PEN) using oral nutritional supplement drinks in adolescent and adult Crohn's Disease outpatients: a feasibility study

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**ABSTRACT**

**Background and aims:** Studies, mainly in Japanese cohorts, have shown that partial enteral nutrition (PEN) including oral nutritional supplement (ONS) drinks can prolong disease remission and increase drug effectiveness in Crohn's disease (CD). Acceptability is a key feasibility parameter to determine whether PEN is a viable treatment option in UK CD patients. We report the results of a single centre cross-sectional feasibility study carried out to investigate perceived acceptability of PEN using ONS drinks and whether ONS preference varies with sex, nutritional status or phenylthiocarbamide (PTC) sensitivity.

**Methods:** Patients with a confirmed CD diagnosis were recruited using convenience sampling from an adult and adolescent gastroenterology outpatient clinic over 3 years. Blind taste testing of 5 polymeric ONS drinks was conducted using a validated 9-point hedonic rating scale followed by completion of the acceptability questionnaire based on the preferred ONS drink. A subset of patients took home the preferred ONS for a 7-day study.

**Results:** 105 CD patients (55 males), aged 34.9 ( $\pm 15.4$ ) years were recruited and 28 patients completed the 7-day ONS study. Overall impression scores did not significantly vary with nutritional status, sex, BMI, handgrip strength (HGS), mid-upper arm circumference (MUAC) or PTC sensitivity. Ensure plus™ milkshake rated highest for overall impression (6.5,  $p < 0.0001$ ) and all other organoleptic properties ( $p < 0.0001$ ). The main perceived benefits of using ONS drinks as PEN related to assurance of nutrient intake (89.3%), convenience (85.7%), and improvement of gut symptoms (84.6%). The main perceived barriers related to reduction in pleasure from eating and drinking (55.6%), struggle with drink storage (53.6%) and increased tiredness than if eating 3 solid meals daily (52.6%). 64.8% of patients would consider using PEN as a maintenance treatment option. 81.0% of patients felt confident about consuming ONS drinks daily as PEN for

three months but this dropped to 63.8% and 37.1% at 6 and 12 months, respectively.

There was a significant drop in perceived ease of use as PEN after the 7-day ONS study (P=0.01).

**Conclusion:** Use of ONS drinks as PEN have high perceived benefits and appear to be a feasible option for short-term use of 3-6 months in CD patients. However, confidence in long-term use of ONS drinks as PEN is low mainly due to the perceived social impact. Future studies should assess longer trial periods and volume of ONS drinks to increase the validity of these findings.

**Key words:** Crohn's disease, partial enteral nutrition, acceptability, long term use, benefits, barriers

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## INTRODUCTION

Crohn's disease (CD) is characterized by chronic gastrointestinal (GI) inflammation of multifactorial aetiology which can affect any part of the GI tract and has no known cure [1, 2, 3]. Medications used to maintain remission control inflammation and suppress the immune system. However, they carry potentially serious side effects that include liver damage, pancreatitis, hair loss, lymphoma, skin cancer, incidence and reactivation of tuberculosis [4]. This has led to an interest in nutritional therapies as alternative treatment option(s) [3].

Exclusive enteral nutrition (EEN) has been shown to induce remission in both children and adults with active CD [5, 6, 7]. The substitution of 35-50% (420-1800 kcal) [8] of food intake with Oral Nutritional Supplement (ONS) drinks, also known as partial enteral nutrition (PEN), has been observed to safely maintain long-term CD remission. PEN has shown similar effectiveness as thiopurines in maintaining remission for up to 2 years without any adverse side-effects [9]. A systematic review of 10 studies concluded that PEN, in polymeric or elemental formulation, significantly increased length of remission and suppressed endoscopic CD activity compared to no PEN [10]. Furthermore, PEN was more effective in remission maintenance than an unrestricted diet in both CD adults and children [11], particularly after EEN therapy [12, 13] with significantly fewer clinical relapses during a 1-year follow-up period [14]. Another systematic review found PEN to be more effective than habitual diet and as effective as some medications in maintaining remission for patients with inactive CD [15].

Compared to habitual diet alone, PEN has been shown to reduce post-operative recurrence [16] during a 3-year follow-up period [17] and does not impair quality of life [18]. As adjunctive therapy to immunosuppressive agents including infliximab, PEN can increase response or reduce drug dose [19, 20, 21, 22] and may be used as salvage therapy for patients who do not respond or lose response to immunosuppressive agents

[23]. Despite the aforementioned benefits of PEN in CD remission, these studies are predominantly from Japanese cohorts and thus lack generalisability internationally. Furthermore, PEN is not currently recommended in any UK based clinical guidelines.

There is no research to date specifically examining the acceptability of ONS drinks as PEN in CD patients for maintenance of remission. Duncan et al. [24] compared efficacy of thiopurines to polymeric feeds as PEN and found efficacy dropped from 6 months in the PEN group and was suggested by the authors this may have been due to lower adherence due to taste fatigue after this time. However, this was not formally assessed.

Predicted challenges in the uptake of PEN in the UK population relate to issues with ONS compliance and acceptability [25, 26], and are influenced by factors including cost, availability, and taste preference [27]. The palatability of ONS drinks can significantly influence long-term compliance [28]. Taste fatigue is a common issue when ONS drinks are taken daily over a long period of time [29], possibly related to low appetite but also due to patients' dislike of certain flavours and/or consistencies, thereby reducing the variety of ONS drinks. It has been hypothesised that genetic differences in the ability to detect bitter tasting compounds, such as phenylthiocarbamide (PTC) could have a role in taste perception and thus influence food preferences and dietary behaviour along with age, sex, as well as individual attitudes and beliefs based on life experiences [30, 31].

In adult CD, compliance has been identified as a potential barrier to using enteral nutrition both for treatment induction as EEN and maintenance therapy as PEN. Potential confounders include poor compliance, poor palatability of feeds and low patient motivation [32]. If these issues can be addressed it may help increase the potential of using PEN as an alternative maintenance treatment option in CD.

To assess whether ONS drinks could be used as PEN among adult and adolescent CD patients, examination of ONS acceptability as PEN by evaluating attitudes and taste preferences should be conducted. Using PEN could reduce the need for

immunosuppressive medications and related side effects, leading to NHS cost savings and improved patient health-related quality of life.

This study aims to assess ONS palatability and preference among CD patients in remission, evaluate current attitudes towards long-term ONS use and whether these vary by key patient characteristics. This will help gain a better understanding of the barriers surrounding long-term ONS use as PEN and inform the feasibility of future clinical trials on the efficacy of PEN in adult and adolescent CD patients.

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## **MATERIALS & METHODS**

### ***Study participants***

A cross-sectional, single-blinded feasibility study was carried out over a 3-year period (2017-2019) using convenience sampling. Participants approached for inclusion had scheduled clinic appointments in the adult and adolescent gastroenterology outpatient clinic of University College London Hospital, UK. Electronic patient records were screened for patient eligibility.

### ***Inclusion and exclusion criteria***

Patients with a confirmed histological diagnosis of CD, in clinical remission as defined by a Harvey Bradshaw Index (HBI) of <5 [33], aged 16-80 years, with no other major medical condition were considered eligible. Patients were excluded if they were above 80 years old, or had a medical condition that affects swallowing function or that may impact normal eating behaviour and therefore invalidate the responses to the questionnaires (e.g. diagnosed eating disorder, current exclusive enteral or parenteral nutrition, coeliac disease, ulcerative colitis or other gastrointestinal condition). Patient information sheets were sent by post to eligible patients for consideration of study participation at least one week prior to their scheduled clinic appointment.

### ***Ethical Approval***

This study was approved by the London-Brent Research Ethics Committee (IRAS ID 2196562).

### ***Study design***

The study consisted of two parts: 1) clinical assessment and tasting protocol of ONS drinks, and 2) 7-day sample of preferred ONS drink. Cognitive interviewing techniques

were used to assess the questionnaires for comprehension and appropriateness of answers in 5 CD patients on stable treatment. It is proposed that the characteristics and variables that will contribute to the greater or lesser acceptability of ONS drinks as PEN are as follows (see *Table 1*). These variables and the relationship to each variable will be explored in the current paper.

#### *Clinical assessment*

The study visit was completed on the same day as the scheduled clinic appointment to lessen patient burden in time and cost. Screening took place in a private room within the gastroenterology outpatient clinic. On arrival, participant consent was gained and a screening questionnaire was completed to check patient eligibility (see *Supplementary material 1*). Clinical and demographic data were recorded.

#### *Anthropometric assessment*

Weight and height measurements were taken in minimal clothing and without shoes using an Omron BF500 weighing scale (Omron Healthcare Ltd., Milton Keynes, UK) and a Seca stadiometer (Seca 910, Hamburg, Germany). Body mass index (BMI) was calculated from measurements of weight and height ( $\text{kg}/\text{m}^2$ ). Mid upper arm circumference (MUAC) was obtained with disposable measuring tapes by measuring in cm the circumference of the upper non-dominant arm halfway between the tip of the shoulder and the elbow. Tricep skinfold thickness (TSF) was obtained with a Harpenden skinfold calliper (Holtain Ltd., Crymych, UK) by measuring the back of the triceps of the non-dominant arm halfway between the shoulder and the elbow. The test was repeated twice, and the average of both measurements was recorded in mm. For obtaining HGS measurements, patients were asked to squeeze a Takei TKK 5401 digital dynamometer (Takei Scientific Instruments Co. Ltd., Tokyo, Japan) in a standing position as hard as possible. Two measurements were taken, and the highest value was recorded in kg.



Mid-upper arm muscle circumference (MUAMC) was calculated from MUAC and TSF using the standard formula (MUAC (cm) - (0.314 × TSF (mm)).

### *Tasting Protocol*

The products chosen were all nutritionally complete polymeric ONS drinks including juice and milk style, powdered and low volume clinically lactose free, including one lower and offer two volume styles and flavours to allow for the best range, palatability and patient choice for comparison. Wall et al (2013) suggest that success in use of enteral nutrition as treatment in adults could be increased by offering supplements that are considered more palatable, ideally polymeric formulae. Therefore we propose to further explore the taste perceptions of the commonly used polymeric formulae currently available and used in CD patients in clinical practice.

The following commercially available ONS drinks were used in this study: 1) Ensure plus milkshake style™, 2) Altraplen compact™, 3) Ensure plus juice style™, 4) Fortijuice™ and 5) Modulen IBD™ (for drink composition, see *Table 2*). Modulen IBD™ was offered as a flavoured powder mix to allow for the best comparison to the other supplements as it is offered flavoured in clinical practice. As this is a feasibility study the brand and type of products were chosen to reflect normal clinical practice and the type of products most routinely prescribed in this patient group. Modulen IBD™ powder was made by mixing 6 scoops with 200 ml of water and 3 teaspoons of Nesquik strawberry powder for added flavour in a plastic mixer bottle. All ONS drinks were concealed and labelled from A to E. Patients were given at least two flavour options for each ONS drink in case of flavour aversion. Due to stock issues in Fortijuice™ (June-August 2019) orange was offered instead of apple. ONS samples and water rinses were administered chilled at 4 degrees centigrade using a mini refrigerator in the clinic room. 30 ml of each pre-chilled ONS drink was prepared in transparent 30 ml sized cups. Patients were asked to sample each ONS drink and immediately fill out Questionnaire 1 (see *Supplementary material II*) rating its

appearance, smell, taste, aftertaste, consistency and overall impression using a 9-point hedonic rating scale and repeat the procedure for all five samples. Drinking water was given between each sampling.

The chemical phenylthiocarbamide test (PTC) was used to determine patients taste to bitterness. The PTC test tastes bitter to some individuals but not others, which is determined by genetics. The ability to taste bitterness may affect patients acceptability of ONS drinks. The PTC test involved patients rinsing their mouths with water after the tasting session and placing a PTC test paper strip (Precision Laboratories, Northampton, UK) on their tongues. Their response to tasting bitterness was immediately recorded as “yes” or “no”. Patients were then asked to fill out Questionnaire 2 based on the preferred ONS drink (see *Supplementary material III*).

### **7-day ONS study**

On completion of part one, all participants were offered the option of taking home a 7-day sample of their preferred ONS drink. Those taking part in the 7-day ONS study were asked to drink 1 full bottle per day for 7 consecutive days followed by completion of Questionnaire 3 (see *Supplementary material IV*). Patients were requested to return the completed questionnaire via email or post.

### **Outcome measures**

Questionnaires were used to assess patient preference for a range of ONS drinks currently available. A combination of visual analogue and likert scales were used. Both scales have been used previously to assess taste preference [34, 35, 36]. There was space allocated for free text comments on all questionnaires.

- Questionnaire 1: Taste acceptability “Hedonic rating scale” (completion after each ONS sampling)

- Questionnaire 2: Attitudes and acceptability (completion at the end of stage 1)
- Questionnaire 3: Attitudes, acceptability and tolerance (completion at the end of stage 2)

Questionnaire 1 used a standardised 9-point hedonic rating scale for a range of sensory attributes. The reliability and validity have been approved in food acceptance studies [37, 38] and have been used in similar ONS preference studies [35, 36].

Questionnaire 2 and 3 were non-validated tools intended to establish perceived acceptability and predicted compliance of ONS as PEN defined as consumption of 3 or more bottles per day (35-50% total calorie requirements) to replace one main meal for up to 1 year. Participants were first asked to gauge how long they could consume the drink and the number of bottles daily. Then they were asked specifically on perceived benefits and barriers to long-term consumption as PEN. The tool was designed to gauge patient opinion and attitudes towards use of ONS and potential benefits and barriers towards their long-term use. The questions on attitudes were developed using the food-related quality of life questionnaire in IBD, which is a validated tool measuring the psychosocial impact of food in IBD [39]. Some of the quality of life measures under the domains of: “general food-related QoL” were used including: 1) role limitation-physical, 2) role limitation-emotional, 3) energy/fatigue social functioning, and 4) pain, to devise the questions related to barriers and benefits to help capture the perceived psychosocial impact of following a PEN diet.

Questionnaire 3 had an additional section on ONS tolerance using a 10-point VAS as used in Darmon et al, 2008 [35] (0 indicating no symptoms and 10 constant symptoms) . A summary of the variables explored within the questionnaires are stated in *Table 1*.

### **Statistical Analysis**

A power calculation is not applicable for a feasibility study. The sample size decided upon was based on published feasibility studies. For feasibility studies sample sizes between 24

and 50 have been recommended [40, 41]. We therefore aimed to collect data on a minimum of 24-50 patients who participated in part one and two (7-day ONS study) of the study and returned all completed questionnaires. This led to a higher number of participants that completed part one as we had a high drop-out rate for part two only (73%).

Descriptive statistics were performed on key questionnaire items and data distributions ascertained. Categorical data will be presented as n (%) and continuous data as the mean (SD) or median (interquartile range) for normally and non-normally distributed data respectively. In all tests,  $P < 0.05$  will be considered statistically significant.

Participant demographics were evaluated using means  $\pm$  standard deviation (SD) and frequencies (percentages) in the whole cohort and in the 28 study participants. Differences in characteristics were tested between the whole cohort vs. 7-day ONS study and between those who participated in part one and part two of the study ( $n=77$  and  $28$ , respectively), using Chi-squared tests for categorical variables and independent t-test for normally distributed continuous variables. All questionnaires were scored for internal consistency using Cronbach alpha equation [42]. The Cronbach should be  $>0.7$  to indicate good internal consistency. All questions met Cronbach criterion except the perceived barriers to ONS consumption (Cronbach  $0.498$ ), suggesting the latter results may need to be interpreted with caution.

### ***Overall impression and hedonic characteristics***

Overall impression is defined as the average overall impression of all ONS drinks. In all analyses, overall impression was used as a continuous variable. Means (SD) were used to evaluate the overall impression of the five ONS drinks. Average scores of hedonic characteristics and overall impression of ONS drinks were obtained and compared using one-way analyses of variance (ANOVA). Pearson correlations were used to examine the

association between overall impression and individual hedonic characteristics in all patients and in a sub-group of patients who reported that they could tolerate 3 or more ONS drinks (n=40). Individual hedonic characteristic scores (appearance, rating, smell, taste, aftertaste and consistency) were examined by each ONS drink. Differences between individual hedonic characteristic scores were tested using ANOVA test.

### ***Hedonic ratings and key patient characteristics***

Correlations between average overall impression, overall impression for milk-based supplements, and overall impression for juice-based supplements with TSF, HGS, MUAC, age category, sex, medications and smoking were explored.

Differences in mean (SD) in overall hedonic rating score by strata of i) sex (female, male);

ii) age categories (adolescent vs adult; 15-24, 25-34, 35-44, 45-54, 55-64, 65-74yr

groups); iii) CD medication use (yes, no); iv) smoking (yes, no); v) BMI categories

(underweight, healthy, overweight, obese); vi) HGS (weaker, stronger) and vii) MUAC

(lower <23cm in women and <25cm in men, and higher MUAC  $\geq 23$  in women and  $\geq 25$  in

men) using paired t-tests for binary variables and ANOVA for multiple strata variables.

### ***PTC sensitivity***

PTC sensitivity was evaluated by frequencies (proportions). Differences in mean (SD) overall hedonic rating by PTC sensitivity was evaluated using independent t-test.

### ***Attitudes to long-term ONS consumption and perceived barriers and benefits***

Attitudes, perceived barriers and benefits of ONS are presented as frequencies (proportions) and were examined by age and sex strata, and differences tested using Chi-squared test. Pearson correlations and cross-tabulations were used to test the association between predicted compliance of ONS over a 12-month period and the number of ONS bottles patients perceived they could consume daily. Frequencies (proportions) and corresponding Chi-squared test were used to examine differences between perceived ease of use and the maximum volume drinks patients predicted they could consume daily (<3 vs. ≥3 bottles). In this paper we report several key comments made by study participants. The full set of specific patient comments will be analysed in a future report as it is not within the scope of this paper.

#### ***Patient attitudes and reported GI symptoms following 7-day ONS study***

Differences in attitudes, perceived benefits and barriers, perceived ease of use and acceptability towards ONS usage after completing the 7-day ONS study compared to immediately after the tasting session were presented as frequencies (proportions) and tested using Chi-squared test. Spearman correlations were used to examine the associations between product ease of use and likeability, feeling well after drinking ONS, and whether ONS fitted in well with their current routine. Mean differences were tested using paired t-tests for pre- and post- ONS usage for likeability of ONS and the maximum number of drinks prediction. Median (IQR) were used to present reported GI symptoms following the 7-day ONS study.

All P-Values <0.05 were considered statistically significant. Statistical analyses were conducted using IBM SPSS Version 25 and STATA version 15 [Statacorp, Texas, USA].

## RESULTS

### ***Participant demographics***

A total of 105 male (n=55) and female (n=50) patients aged  $34.9 \pm 15.4$  years were included in the study. Key demographics are shown in Table 3. In this study sample, most patients were of a healthy BMI ( $24.3 \pm 4.9$ ), were white British (73%), and had a sedentary occupation (71%). Forty-seven participants (48%) had previously undergone surgery for CD and most patients reported to take regular CD medications (84%). Similar findings for demographic factors were also reported for the 28 study patients (see Table 3). There were no significant differences between characteristics by participants who took part in just the tasting session and in the 7-day ONS study except for ethnicity (lower proportion of 'other' ethnic group in part one vs. part two of study: 1 vs. 5%,  $P < 0.01$ ).

### ***Overall preference and hedonic ratings of the five ONS drinks***

The average scores for each hedonic characteristic of each ONS drink is shown in Figure 1. Appearance was the highest rated hedonic characteristic with an average score of 5.8 followed by smell and consistency, both with an average score of 5.5. The least rated hedonic characteristic was aftertaste with an average score of 4.8.

Significant positive correlations ( $P < 0.0001$ ) were observed for all hedonic characteristics and overall impression (for all drinks, milk-based and juice-based ONS drinks- see Table 4). Factors such as consistency and taste were found to be the strongest correlations when the associations were examined in a subgroup of patients who reported that they could consume three or more supplement drinks per day.

Ensure plus milkshake rated highest for all individual characteristics including overall impression (see Figure 1) compared to other supplements. The average overall

impression score for milk-based ONS (Ensure plus milkshake style™ and Altraplen compact™) was 6.0, while the average overall impression score for the two juice-based ONS (Ensure plus juice style™ and Fortijuice™) was 5.1 (see *Figure 2*). The powder-based supplement, Modulen IBD™, was rated lowest for taste (4.2) aftertaste (4.2) and overall impression (4.4). The only low volume supplement, Altraplen compact™, rated second lowest for consistency (5.2). Milk-based ONS drinks were rated more positively than juice-based drinks.

### ***Hedonic ratings and key patient characteristics***

There were no significant associations between overall impression score with participant characteristics (age, gender, exercise, cigarette smoking status, use of CD medications) and nutritional status (BMI, MUAC and HGS- see *Table 5*). When overall impression was examined by categories of each key variable, some non-significant trends were observed. For instance, there was a non-significant trend towards higher overall impression score with i) adolescents compared to adults, ii) higher BMI categories, iii) men than women, iv) stronger compared to weaker HGS (see *Table 5*). There were no significant findings for overall impression score for Modulen IBD™ or juice-based supplements with participant demographics and nutritional variables.

### ***PTC sensitivity***

Of the 101 participants who took the PTC sensitivity test, 46 (46%) reported to detect a bitter taste, while the remaining 55 (54%) reported to not detect any bitter taste. There was no significant difference between PTC sensitivity type and overall impression of overall or individual ONS drinks.

### ***Attitudes to long-term ONS consumption and perceived barriers and benefits***



The majority of participants reported that they felt confident to very confident that they could drink ONS on a daily basis for 3 months (82%) and for 6 months (79%; see *Figure 3*). However, when asked how confident they felt to consume ONS drinks for 9 or 12 months, this dropped to 61% and 43%, respectively.

The proportion of participants who predicted that they would be able to drink ONS on a daily basis decreased with increasing number of supplements: 1 bottle (n=33, 32%), 2 bottles (n=31, 30%), 3 bottles (n=27, 26%), and only 13 (13%) of participants predicted they could drink 4 or more bottles per day.

The proportion of participants reporting they were either confident or very confident that they could consume 1, 2, 3 or 4 or more bottles per day were 70%, 94%, 78%, 85.% at 3 months; 49%, 65%, 70%, 85% at 6 months; 46%, 39%, 63%, 54% at 9 months; and 36%, 29%, 52%, 31% at 12 months, respectively. Interestingly, at 3 months those who predicted they could consume 2 bottles per day had higher confidence than those who predicted they could consume 1 bottle per day. Free text comments included: that they would only drink ONS for 3-6 months if “it was required for medical purposes” and if “it was beneficial to my health.” As for consuming these products for 9-12 months, participants reported that they would “get bored of taking them for so long” and “would probably miss taking some.” Another participant stated that ONS drinks are “fairly unpalatable to take for such a long time” and that they have a “negative psychological association.” Participants who reported being able to consume ONS drinks for 3-6 months reported that they are “pleasing to the palate so would have no problem” and that “one a day would be okay.”

64 participants reported they could tolerate a maximum of 1-2 bottles per day compared to 40 participants who reported they could consume  $\geq 3$  bottles per day. Perceived ease of use

was not statistically significant between these groups ( $P$ -value=0.38). Despite this, 68 (65%) would still consider taking ONS drinks as an alternative to their maintenance medication and 53 participants (52%) perceived that using ONS drinks as PEN would be easy to very easy.

#### *Main perceived benefits*

Responses to each perceived benefit and barrier of long-term use of ONS drinks as PEN are shown in *Supplementary Figures 1 and 2*, respectively. The three main perceived benefits were the following: i) “I would feel more assured that I am getting all of the nutrients my body needs which I currently struggle to obtain from food alone” (85%); ii) “Taking these drinks would fit in well with my current daily routine” ( $n=86\%$ ); and iii) “Taking these drinks daily may help improve my gut symptoms by eating less food that possibly upsets me ” (85%). Comments related to these perceived benefits included some participants reporting that using ONS drinks as PEN would fit in “very well” with their current activities during the day, and that they are convenient as it involves “no cooking.” One patient reported that fitting these drinks into their routine “could be done reluctantly.”

#### *Main perceived barriers*

The three main perceived barriers were the following: i) “I would be unable to get the full pleasure from eating and drinking” (56%); ii) “I would struggle to find space to store the drinks in my house ” (54%); and iii) “I would feel more tired and have less energy than if I eat 3 solid meals daily ” (52%). Participants reported that it would not fit in well with their current routine as “it disrupts the cooking plan for the rest of the family” and it would “impact eating with family or partner.”

The patients’ gender and age in relation to the perceived benefits and barriers were assessed and there was no significant difference between gender or age for each

question. However, the 15-24 age category had the highest percentage of participants; therefore, cross comparisons should be interpreted with caution.

### ***Patient attitudes and reported GI symptoms following 7-day ONS study***

Twenty-eight patients in total completed the 7-day ONS study of their preferred ONS and returned the feedback questionnaire. After the 7-day ONS study, 27 patients reported they could consume the drink all (78%), most (11%) and some (11%) of the time.

### *Likelihood of choosing ONS over medication*

Hypothetical views regarding the likelihood of patients choosing to use PEN as an alternative to current maintenance medication was 65% for all 105 patients. For the 28 patients who took the 7-day ONS study this was 82% pre- and 68% post 7-day ONS study, which did not reach statistical significance ( $p=0.82$ ).

### *Confidence in drinking ONS over different time periods*

Reported confidence in drinking the supplement drinks daily for 3, 6, 9 and 12 months declined as time intervals increased. Post 7-day ONS study, those reporting that they were confident to very confident in taking supplements was 82%, 64%, 50%, 39% at 3, 6, 9 and 12 months respectively.

### *Perceived benefits and barriers*

Of the perceived benefits the following was observed to be significantly different pre- and post- 7-day ONS study: "I currently find it hard to consume 3 meals per day and would prefer to replace one meal with the drinks" (30% to 43%,  $P<0.05$ ). Of the perceived barriers, a significant difference was seen for "I would be unable to get the full pleasure from eating and drinking" (56% vs. 63%,  $P<0.01$ ), and I would struggle to afford the cost of

monthly GP fees (32% vs. 15%,  $P<0.05$ ). No other barriers reached statistical significance pre- and post- 7-day ONS study.

#### *Perceived ease of use (PEOU)*

The PEOU of using ONS drinks as PEN significantly reduced after the 7-day ONS study ( $p=0.015$ ; see *Figure 4*). The proportion of patients reporting that they would find it difficult to very difficult increased from 18% pre- to 32% post- 7-day ONS study. Similarly, those reporting it would be easy to very easy, reduced from 71% to 50% post 7-day study. PEOU post 7-day study was significantly correlated with the likeness of drinks ( $r=0.59$ ,  $P<0.01$ ) and feeling well after drinking the drinks ( $r=0.56$ ,  $P<0.01$ ). PEOU and taking these drinks fitted in well with my current routine ( $r=0.53$ ,  $P<0.01$ ).

#### *Maximum number of ONS drinks that could be consumed daily*

When asked about the maximum volume of ONS that could be consumed daily, there was a clinically significant mean difference post- 7-day ONS study ( $P<0.05$ ). There was a trend toward decreased ONS use in both pre- and post- 7-day ONS study questionnaire responses. The average maximum number of bottles participants predicted they could consume per day was 2.5 pre- and 2.1 ( $P=0.05$ ) post- 7-day study. Post 7-day ONS study, there was a decreasing trend in patients reporting how many ONS drinks could be consumed daily (32%, 32%, 29%, 7% reported they could take 1, 2, 3, and 4 or more bottles daily, compared to baseline: 18%, 29%, 39%, 14%, respectively).

#### *Likeability of the drinks*

There was a significant decline in likeness score pre- and post- 7-day ONS study (8.1 and 6.1 respectively,  $p<0.02$ ).

### *Patient-reported GI symptoms following the 7-day ONS study*

The majority of participants reported no gut symptoms after the 7-day ONS study (0 indicating no symptoms and 10-constant symptoms): the median score for nausea, vomiting, reflux, bloating, abdominal pain was 0. However, the patients did report that they were hungry (median 5, IQR 1.5-7) and patients generally felt well after consuming the ONS drinks (median score 8, IQR: 5.3-9.4). The median reported consistency of stools (0-very liquid and 10 very hard), was 6 (IQR 6-8).

## **DISCUSSION**

To our knowledge, this is the first study to assess the perceived acceptability of using ONS drinks as PEN in CD patients. Previous research examining ONS drinks acceptability and palatability has mainly been conducted amongst oncological and other disease cohorts.

### ***Overall preference and hedonic ratings of ONS drinks***

Milk-based ONS drinks were preferred to juice-based ONS, with taste, aftertaste and consistency being most strongly correlated with overall impression. Ensure plus milkshake style™ was the highest rated ONS for all hedonic characteristics and overall impression, and generally milk-based ONS were rated more positively than juice-based ones. These findings are corroborated in the SUSTAIN trial of healthy volunteers [36] and other studies using different methods in cancer and malnourished patients [34, 35, 43]. Brown et al (44) compared the liking of four different ONS drinks between thoracic cancer patients and healthy volunteers and found that patients rated fresh milk and milk-style supplements higher than juice or yoghurt styles. Our study did not test fresh milk-based supplements, as lactose intolerance is common in CD.

Acidity in juice-based ONS drinks may explain the lower preference, compared to milk-based ONS. This may be due to taste evolution, where salt and sweet tastes reflect

nutrient-rich foods, whilst bitter and sour tastes indicate perished or harmful foods [45].

Although there is an innate preference for salty and sweet tastes and a dislike for sour and bitter ones [46], liking for sour and bitter tastes can be learnt.

Food and drink appearance set hedonic and sensory expectations, which are pivotal in defining the final tasting experience and product likeness degree, even prior to consumption [47]. Preference towards milk-based ONS may be due to sensory appeal.

Our study participants had the opportunity to see each ONS before tasting, therefore it is likely that the appearance of each drink generated taste expectations. Studies suggest that more concentrated colouring to a food-drink product can lead to individuals rating taste as more intense [48, 49] partly explaining why Ensure plus juice style™ (dark amber) and Fortijuice™ (bright yellow), which are darker and more intensely coloured than the other ONS, were more negatively rated for appearance and most hedonic characteristics.

Olfactory and gustatory cues may have influenced ONS first impression, possibly causing a distorted perception of the remaining hedonic characteristics. All factors could have had a synergistic effect towards a lower preference to juice-based ONS.

### ***Hedonic ratings and patient characteristics***

A strength of our study is the examination of factors known to impact taste and its perception. However, similar to previous research amongst hospitalised patients, we did not find that overall impression ratings were significantly influenced by sex, nutritional status, smoking, alcohol or age [50]. Although nutritional status has been associated with ONS preference, most previous studies primarily involve cancer patients, where treatment-associated taste changes are common [34, 51, 52] which is not comparable to CD patients in remission. However, there was a non-significant trend between higher BMI and MUAC and overall impression. Although age was not associated with hedonic characteristics, the overall impression score was slightly higher in adolescents compared to adults. Hoffman et al. [53] conducted a systematic review which found that sweet taste preference decreases

with age, unlike bitter and sour tastes. However, the olfactory system is often stated to have peaked in early adulthood, where each individual undergoes a baseline rate of olfactory receptor apoptosis [54], and with contributing neurodegenerative diseases and cumulative environmental insults age-related olfactory losses are greater [55]. Often, alcohol and smoking can impact taste and smell threshold and, when combined with advancing age, we would expect to see changes in compliance rates.

### ***PTC sensitivity***

PTC sensitivity is a genetic marker of bitter taste perception and can affect food preference [56] and has also been associated with sweet taste perceptions [57]. PTC sensitivity and ONS overall impression scores were, however, not associated in this study, which is consistent with previous research [58]. Another study amongst dietitians, found no significant difference between PTC sensitivity and ONS overall impression scores [59], suggesting that environmental factors may outweigh genetic predisposition to specific food preferences.

### ***Perceived barriers, benefits, and attitudes to long-term ONS consumption***

One of the main perceived barriers reported with PEN consumption was the inability to obtain full pleasure from a normal diet. Participants expressed that drinking ONS daily would upset their social life “on some occasions” and that they may feel excluded as it is “important that family are together” while having the same meal. Others explained that they would not feel excluded as it is their “choice to drink them” and that they would “expect some flexibility” by consuming them. These findings confirm that ONS intake is highly influenced by environmental factors. Food restrictions and disease exacerbations impact the social lives of IBD patients, potentially resulting in anxiety, stress, and social isolation [39, 60]. Conversely, if one or more main meals are replaced with ONS, eating

with family may help with ONS compliance. It has been observed that meal size can increase [61] and even be perceived as tasting better [62] if eaten in the presence of others. However, the applicability of this to ONS remains unknown; the ONS psychosocial impact in CD patients should be further investigated.

Participants were advised to base all answers on their preferred ONS drink. It is known that taste fatigue occurs most often in ONS drinks that are deemed least palatable from the outset [28]. Dietary monotony can decrease food intake whereas food variety can stimulate intake and decrease taste fatigue [63]. Taste fatigue was rated by 44% of individuals as a barrier. Some patients stated that they would not get bored of ONS drinks as the “tolerable taste helps” and that they “could have different flavours”. ESPEN guidelines support this notion, stating that ONS variety and alternating taste are important for achieving increased nutrient and energy intake [64]. ONS volume may also determine acceptability.

The success of ONS as PEN depends on the patient’s ability to drink sufficient quantities of ONS drinks over an extended period of time [34, 65]. Most participants predicted that they would be able to drink one or two bottles daily which may not equate to PEN, which is defined as 35-50% of total calorie requirements daily [8]. Despite perceived benefits, only 65% of the patients would consider replacing their maintenance medication with ONS. These findings may indicate patient beliefs that medications are more effective or lack of awareness of ONS as PEN to maintain remission. Following the taste test, 81% of participants felt confident they could consume ONS for three months, although this did decline for longer durations. Confidence may increase if patients are better informed of the clinical benefits of ONS drinks as PEN.

### ***Patient attitudes and ONS tolerability following 7-day ONS study***



We also tested ONS tolerability during a real-life application. ONS likeness declined over the week, despite the fact that most patients did not report having GI symptoms. In addition, a longer ONS study (i.e. 1 month vs. 7 days) with a greater volume to reflect the definition of PEN (see *Methods*) would have strengthened the applicability of these findings.

## **CONCLUSION**

Our study confirmed that ONS overall are well tolerated and accepted by CD patients, with a higher preference towards milk than juice-based ONS. Patient awareness of ONS drinks health benefits was high and some would consider using ONS drinks as PEN to replace their current CD maintenance medications. ONS use as PEN for three to six months seems to be a feasible option for CD patients, though feasibility for longer durations has yet to be confirmed. Future studies should consider larger samples with longer trial periods to determine PEN feasibility as a maintenance therapy in CD patients. These results can be used to inform a future clinical trial to assess the efficacy of PEN for maintenance of remission in CD patients.

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**Conflict of Interest**

There were no conflicts of interest for this study

**Author Contributions**

KK: conceptualisation, methodology, provision of resources, data curation, writing draft (original and review), supervision of research activity

ND: conceptualisation

ML: conceptualisation, writing review and editing

PP: formal analysis, data curation, writing review and editing

KF: formal analysis, validation of reproducibility of results, data curation

NR: Investigation, provision of resources

BK: Investigation, provision of resources, writing original draft

HK: Investigation, provision of resources, writing original draft and review

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### **Supplementary material**

Supplementary material I: Screening questionnaire

Supplementary material II: Hedonic rating scale acceptability questionnaire

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**Supplementary Tables and Figures**

- Supplementary Figure 1 Perceived barriers of ONS consumption  
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**TABLES****Table 1. Model of acceptability of ONS**

<b>Background and environmental variables</b>	<b>Acceptability of organoleptic properties</b>	<b>Perceived ease of use (benefits and barriers)</b>	<b>Perceived negative/positive health benefits of consumption (benefits and barriers)</b>
Age	<i>Taste characteristics:</i> Appearance	Ease of preparation	Energy levels
Gender	Smell Taste	Prescription costs	Fatigue
Education status	Consistency Overall impression	Volume required to consume and length of time	Maintain good nutritional status
Nutritional status (anthropometric measures)	Perceived taste fatigue  Overall likeness of product	Ease of storage  Psychosocial factors: Exclusion at mealtimes  Enjoyment of eating  Effect on social life	Ability to meet nutritional requirements  Effect of gut symptoms  Effect on disease status

Table presents the characteristics and variables that contribute to acceptability of ONS consumption.

**Table 2. Commercially available ONS drinks used in the study**

ONS drink	Volume (ml)	Energy (kcal)	Energy distribution (g)			Flavours
			<i>Protein</i>	<i>Carbohydrate</i>	<i>Fat</i>	
Ensure plus milkshake	220	330	13.8	44.4	10.8	Strawberry or vanilla
Altraplen compact	125	300	12	36	12	Strawberry or vanilla
Ensure plus juce	220	330	10.6	71.9	0	Strawberry or apple
Fortijuce	200	300	7.8	67	0	Strawberry, apple or orange
Modulen IBD	250	250	9	27	11.5	Strawberry or vanilla

Table presents commercially available ONS drinks (product name, volume, nutritional value and flavours) used in the present study.

**Table 3. Demographic data of study participants**

<b>Variable</b>	<b>Total cohort (n=105)</b>	<b>Trial patients (n=28)</b>
Age (age)	34.9±15.4	35.9±14.3
Weight (kg)	70.9±16.6	71.0±17.7
BMI (kg/m <sup>2</sup> )	24.3±4.9	25.1±6.0
MUAC (cm)	29.9±5.5	30.4±8.1
MUAMC (cm)	24.7±5.2	25.2±7.8
HGS (kg)	31.4±13.2	30.1±10.4
TSF (mm)	16.6±7.6	16.6±7.6
<b>Age group, n (%)</b>		
Adolescent (13-18 years)	11 (10)	2 (7)
Adult (> 18 years)	94 (90)	26 (93)
<b>Sex, n (%)</b>		
Female	50 (48)	15 (54)
<b>Ethnicity, n (%)</b>		
White	75 (73)	16 (59)
Mixed	6 (6)	3 (11)
Asian	8 (8)	1 (4)
Black	8 (8)	2 (7)
Other	6 (6)	5 (19)
<b>Education, n (%)</b>		
School leaver	10 (10)	2 (8)
NVQ/BTEC	8 (8)	7 (29)
A/O Levels	32 (33)	10 (42)
Bachelors	30 (31)	4 (17)
Masters	12 (12)	1 (4)
PhD	5 (5)	
<b>Type of occupation, n (%)</b>		
Sedentary	70 (71)	21 (81)
Standing	22 (22)	5 (19)
Manual	6 (6)	
<b>Exercise, n (%)</b>		
None	19 (18)	7 (26)
Light	33 (32)	7 (26)
Moderate	40 (39)	11 (41)
Vigorous	11 (11)	2 (7)
<b>Smoking, n (%)</b>		
Yes	12 (11)	4 (14)
<b>Cigarettes, n (%)</b>		
0 cigarettes/day	93 (98)	28 (100)

1-3 cigarettes/day	1 (1)	0 (0)
4-6 cigarettes/day	0 (0)	0 (0)
7 or more cigarettes/day	1 (1)	0 (0)
<b>Alcohol, n (%)</b>		
Yes	59 (56)	17 (61)
<b>Units per week, n (%)</b>		
0 units/week	50 (51)	12 (46)
1-3 units/week	28 (28)	11 (42)
4-6 units/week	12 (12)	2 (8)
7-10 units/week	6 (6)	1 (4)
> 10 units/week	3 (3)	0 (0)
<b>Previous CD surgery, n (%)</b>		
Yes	47 (48)	13 (46)
<b>CD medication, n (%)</b>		
Yes	88 (84)	24 (86)
<b>PTC sensitivity, n (%)</b>		
Yes	46 (46)	11 (39)
Demographic and patient characteristics of the cohort (n=105) and the trial patients (n=28) are presented using means (SD) and frequencies (proportions).		

**Table 4. Correlations between overall impression and individual hedonic characteristics, in the total cohort (n=105) and for patients who predicted they could tolerate 3 or more ONS drinks daily (n=40)**

<b>Total Cohort (n=105)</b>			
Hedonic characteristic	All ONS	Milk-based ONS	Juice-based ONS
Consistency	0.72***	0.62***	0.56***
Appearance	0.49***	0.40***	0.47***
Smell	0.63***	0.51***	0.56***
Taste	0.87***	0.70***	0.73***
Aftertaste	0.77***	0.59***	0.66***
<b>Participants who report they can tolerate 3 or more ONS drinks (n=40)</b>			
Hedonic characteristic	All ONS	Milk-based ONS	Juice-based ONS
Consistency	0.67***	0.62***	0.58***
Appearance	0.36*	0.33*	0.46*
Smell	0.52**	0.50*	0.52**
Taste	0.85***	0.67***	0.79***
Aftertaste	0.77***	0.51**	0.69***
Values represent Pearson correlation coefficients between overall impression and individual hedonic individual characteristics in all patients and in a sub-group of patients who reported that they could tolerate 3 or more ONS drinks (n=40).			
P-Values are denoted by asterisk(s), *** $\leq 0.0001$ , ** $\leq 0.01$ , and * $\leq 0.05$ .			



**Table 5. Overall impression score by key patient characteristics**

<b>Variable</b>	<b>n</b>	<b>Overall impression score</b>		<b>P-value</b>
		<b>Mean</b>	<b>SD</b>	
<b>Age</b>				NS
Adolescent	11	5.45	1.13	
Adult	93	5.04	1.17	
<b>Sex</b>				NS
Female	50	5.02	1.20	
Male	54	5.15	1.14	
<b>BMI</b>				NS
Underweight	7	5.29	1.38	
Healthy weight	63	4.97	1.11	
Overweight	21	5.24	1.26	
Obese	13	5.31	1.25	
<b>CD medication use</b>				NS
No	16	5.25	1.00	
Yes	88	5.06	1.20	
<b>HGS</b>				NS
Weak	28	5.07	1.30	
Strong	76	5.09	1.12	
<b>MUAC</b>				NS
Low	29	4.83	1.23	
High	75	5.19	1.14	
<b>Smoking</b>				NS
No	92	5.04	1.20	
Yes	12	5.42	0.79	
<b>Cigarettes</b>				NS
No cigarettes	92	5.04	1.20	
1-3 cigarettes	1	6.00	0.00	
>7 cigarettes	1	5.00	0.00	
<b>Exercise</b>				NS

None	19	4.89	1.37	
Light	33	4.94	1.30	
Moderate	40	5.33	1.02	
Vigorous	10	5.10	0.88	

Overall impression score by key patient characteristics. Values are presented using means (SD) and frequencies (proportions) and differences are tested using paired t-test and Chi-squared tests. P-values <0.05 are considered statistically significant.

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**Figure 1. Overall impression and individual hedonic characteristic scores by each ONS drink**

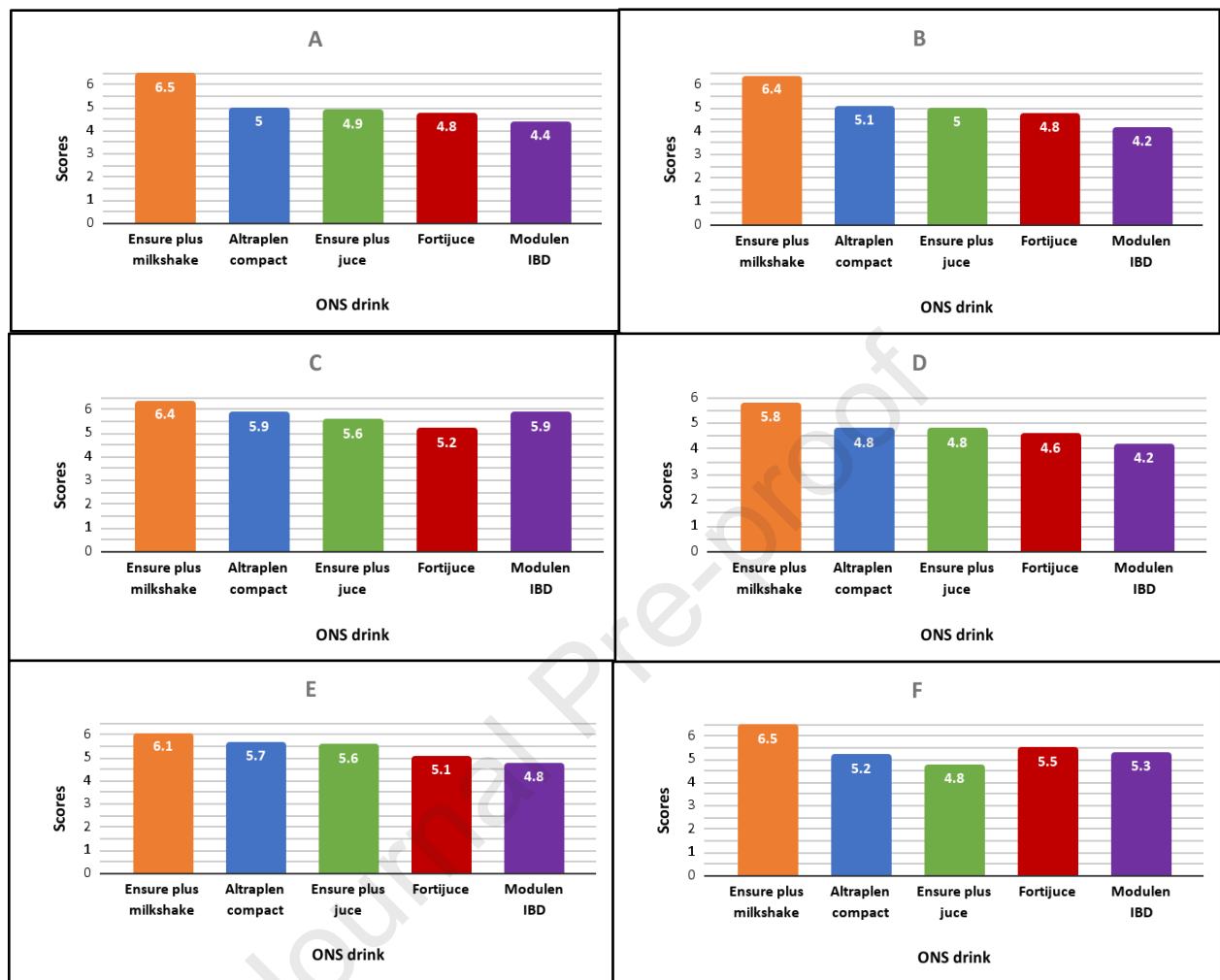


Figure Panels (A-F): A) overall impression score, B) taste score, C) appearance, D) after taste score, E) smell and F) consistency scores by each ONS drink (Ensure plus milkshake™, Altraplen compact™, Ensure plus juice™, Fortijuice™, Modulen IBD™).

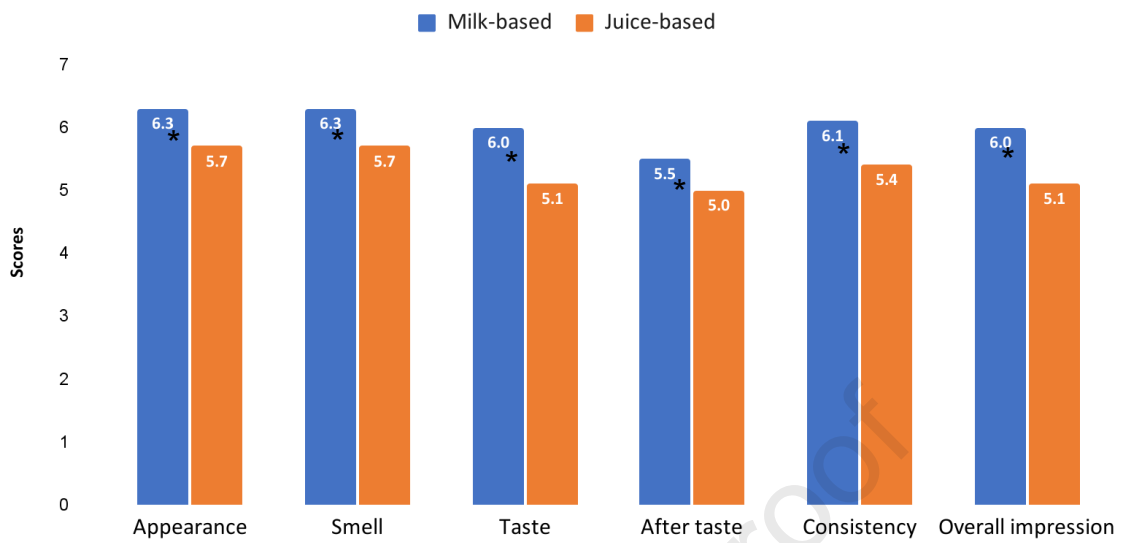
**Figure 2. Scores of sensory attributes between milk-based and juice-based ONS drinks**

Figure shows individual hedonistic characteristic scores for sensory attributes by appearance, smell, taste, after taste, consistency and overall impression by milk-based vs. juice-based ONS drinks. Significant differences between time points are denoted by \* $<0.05$ , \*\* $0.01$ , \*\*\* $<0.0001$ .

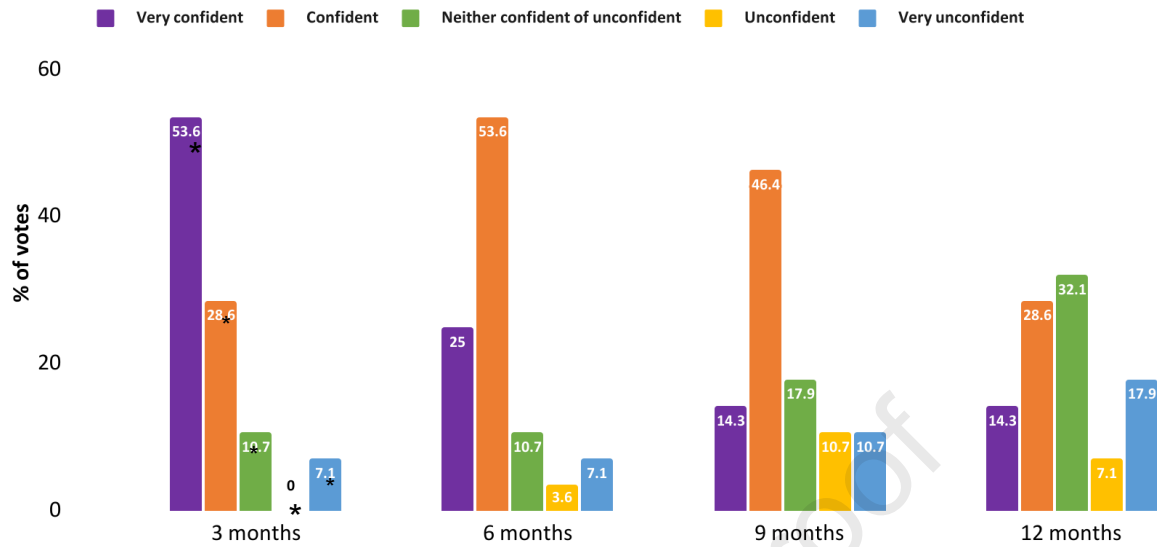
**Figure 3. Confidence levels to consume ONS drinks for 3, 6, 9 and 12 months**

Figure shows proportions of patients reporting confidence in consuming drinks at 3, 6, 9 and 12 months.

Significant differences between time points are denoted by \* $<0.05$ , \*\* $0.01$ , \*\*\* $<0.0001$ .

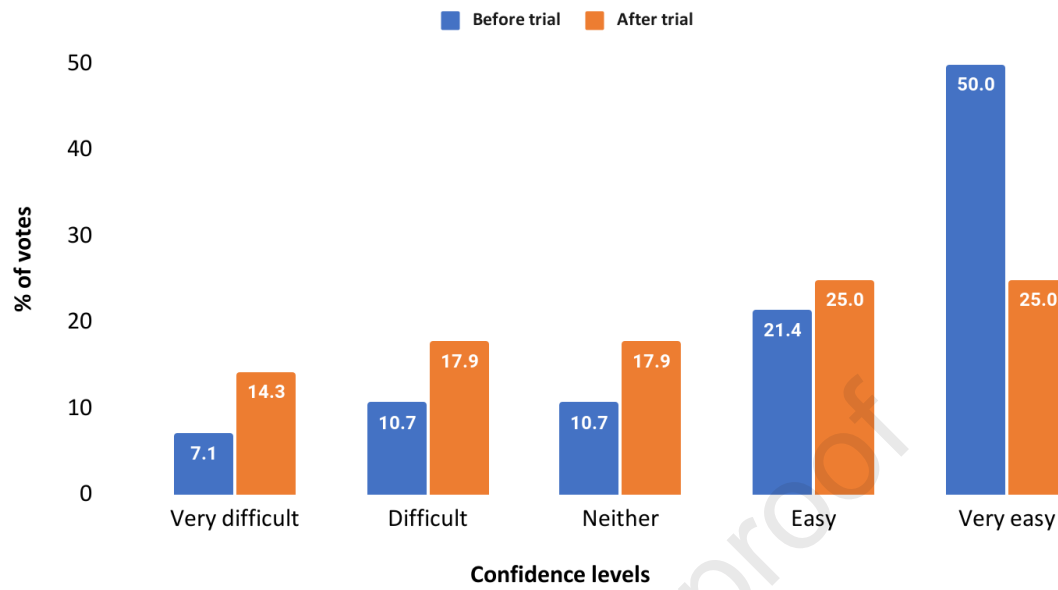
**Figure 4. Perceived ease of using ONS as a replacement before and after the 1-week trial**

Figure shows the perceived ease of using ONS drinks as a replacement before and after the 1-week ONS trial.

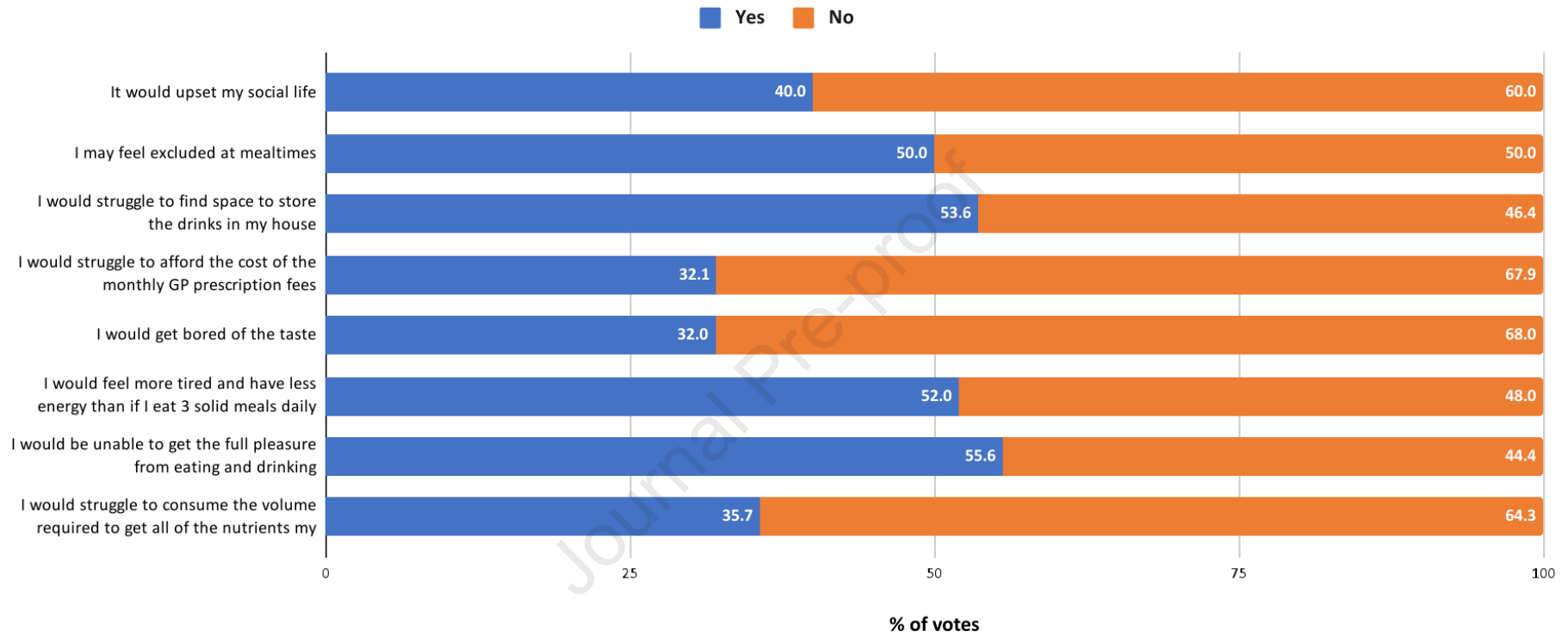
**Supplementary Figure 1. Perceived barriers of ONS consumption**

Figure shows the proportion of patients reporting yes and no to perceived barriers to ONS consumption.

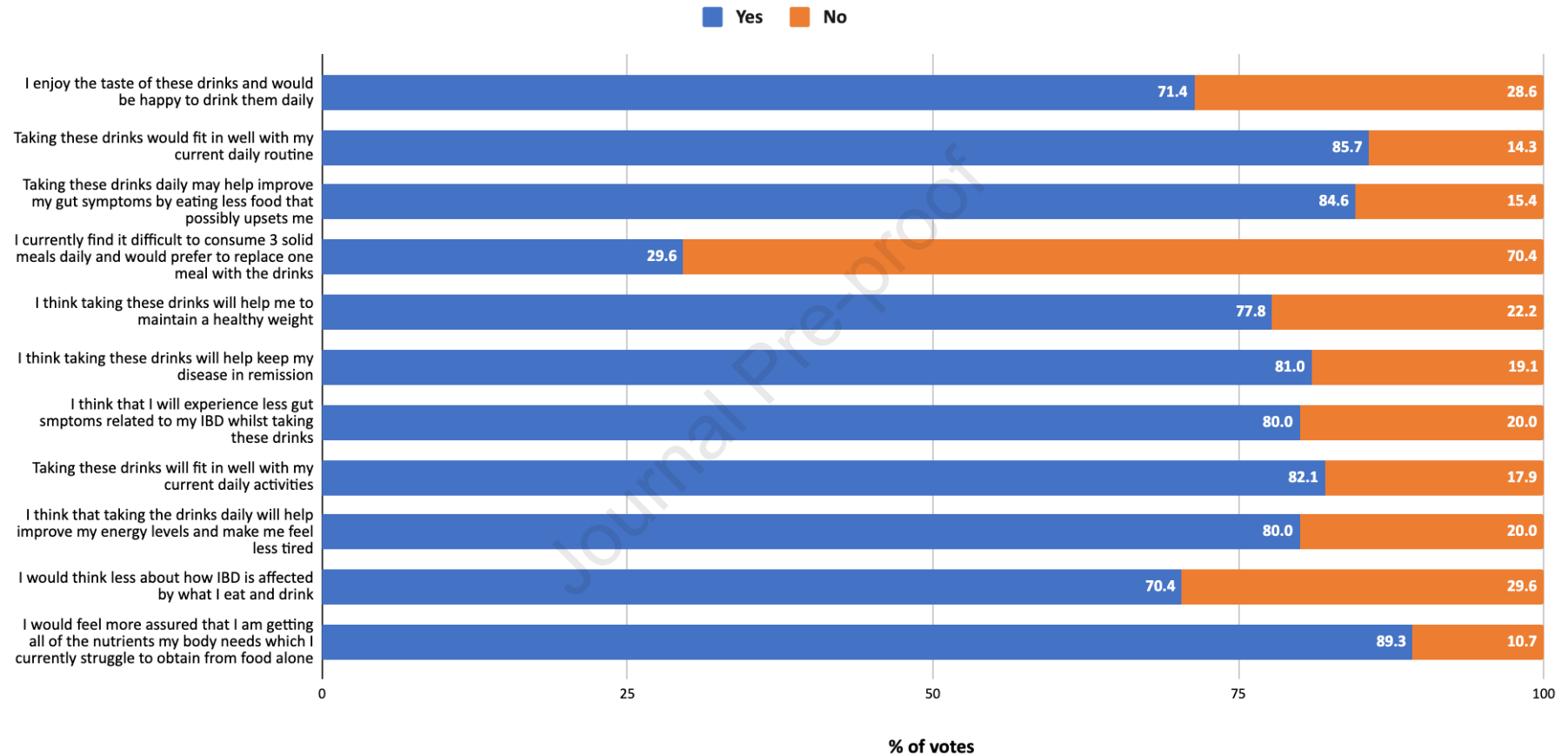
**Supplementary Figure 2. Perceived benefits of ONS consumption**

Figure shows the proportion of patients reporting yes and no to perceived benefits to ONS consumption.