

# Reduction of Food Cravings Utilizing a Novel Probiotic Containing Akkermansia

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## INTRODUCTION

Glucagon-like peptide 1 (GLP-1) is a hormone naturally produced by the human intestinal epithelial L-cells in response to nutrient ingestion (Holst 2007). GLP-1 is well studied and is shown to have important gastrointestinal, metabolic, and neurological functions in humans (Shah & Vella 2014). GLP-1's actions include the following: suppressing secretion of the hormone glucagon (which normally stimulates glucose release by the liver), serving to normalize blood glucose, slowing gastric emptying with the effect of prolonging satiety and enhancing nutrient digestion and absorption, and signaling through the vagus nerve and interacting with neuronal receptors in the brain to activate pathways that control appetite (Richards et al. 2014). There is emerging evidence that ingestion of specific nutrients or dietary supplements can be used to naturally stimulate GLP-1 within the gut, thereby influencing appetite, promoting satiety, and reducing food cravings. Certain probiotic species and strains may be leveraged for this purpose, as they have been shown to increase the GLP-1 secreted in the gut. GLP-1 Probiotic used in this consumer survey includes three strains commonly found in the healthy human gut, which are equipped to increase GLP-1 production by the following means:

- **Akkermansia muciniphila** WB-STR-0001 lives in the mucus layer that forms part of the gut barrier. These bacteria consume mucins, stimulating a thicker mucus layer and fortifying the gut barrier overall (Pellegrino et al. 2023). The bacteria also release a protein called p9 that increases GLP-1 secretion, accounting for some of the beneficial effects on insulin sensitivity and dyslipidemia (Yoon et al. 2021).
- **Clostridium butyricum** WB-STR-0006 is a probiotic strain that is genetically equipped for efficient production of the short-chain fatty acid butyrate. In animal models, scientists have shown that *C. butyricum* supplementation increases GLP-1 because its conversion of dietary fibers to butyrate in the colon stimulates GLP-1 production by the intestinal L-cells (Stoeva et al. 2021).
- **Bifidobacterium infantis** Bi-26™ contributes to higher GLP-1 levels in the gut by producing acetate and lactate, which are consumed by other bacteria within the gut microbial ecosystem (including *A. muciniphila* and *C. butyricum*) to produce butyrate (Groeger et al. 2013). The butyrate then triggers increased GLP-1 production by the L-cells.

## AIM

The primary aim of the consumer survey was to explore how the supplementation of GLP-1 Probiotic (*Akkermansia muciniphila* WB-STR-0001, *Clostridium butyricum* WB-STR-0006, and *Bifidobacterium infantis* Bi-26™) affected participants' perceived food cravings over a period of six weeks using a validated questionnaire called the Food-Craving Inventory II (FCI-II).

## METHOD

The consumer survey involved a convenience sample from the general population with participants volunteering in response to an email invitation or to posts on LinkedIn or Instagram. The participants indicated they were willing to consume the product for at least six weeks. The current investigation was an exploratory open-label consumer survey designed without a control group or placebo that took place over a period of approximately four months, from November 2023 to February 2024.

Investigators assessed food cravings at baseline using a validated questionnaire called the Food-Craving Inventory II (FCI-II) (White et al. 2002), which presented participants with a 28-item food list and asked them to indicate how often they had experienced a craving for that food over the past month. The questionnaire provided a clear definition of a craving: "an intense desire to consume a particular food (or food type) that is difficult to resist."

Each participant rated the frequency of their cravings for individual food items using a 5-point Likert scale (Never, Rarely, Sometimes, Often, or Always). For scoring purposes, overall food cravings were assessed as well as four sub-categories: Sweets (with foods such as cinnamon rolls and chocolate), High Fats (with foods such as bacon and gravy), Carbohydrates/Starches (with foods such as baked potatoes and pasta), and Fast Food Fats (with foods such as pizza and french fries).

All questionnaires were administered online using the Qualtrics survey tool.

## DISCUSSION

The results of this consumer survey suggest that dietary supplement reduces food cravings in the general population, potentially decreasing overall food intake. Food cravings were reduced across four subcategories of commonly craved foods – Sweets, Fast Food Fats, Carbs/Starches, and High Fats. This observation is consistent with the concept that a general GLP-1 related mechanism (affecting overall appetite control) is involved, rather than a more specific mechanism that would only affect one category of foods such as sweets.

Individuals who scored higher on total cravings at baseline experienced a greater reduction of cravings after six weeks of supplementation, suggesting a homeostatic or normalizing effect on appetite. This finding of greater reductions with higher baseline cravings held true within most of the food subcategories.

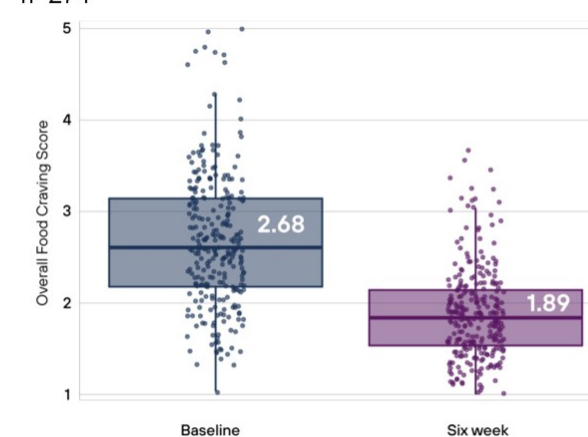
The results of this exploratory consumer survey support the idea that the probiotic helps individuals in the general population moderate their cravings and food intake.

The Pendulum researchers did not attempt to isolate the effects of the probiotic blend from the inulin contained in the dietary supplement. In previous studies, inulin is associated with reduced food cravings, yet the dose of inulin required to achieve reduced cravings is generally accepted to be around 5g per day. The daily dose (211 mg) of inulin in the probiotic blend was considered to be too low to have a significant effect.

## RESULTS

### Reduction in Overall Food Craving

n=274

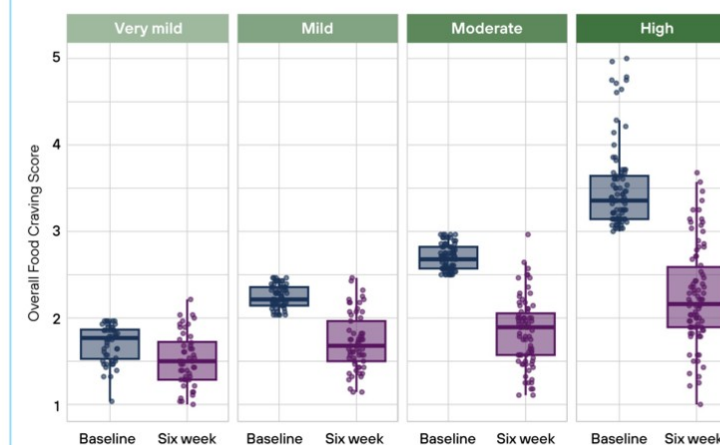


**Results showed that 91% of participants experienced a reduction in overall food cravings.**

The group's total FCI-II mean score at baseline was **2.68** (SEM = 0.04), and at six weeks was **1.89** (SEM = 0.03). This result shows a significant decrease in participants' reported total food cravings from baseline to six weeks ( $p < 0.001$ ).

A significant reduction in FCI-II scores was observed despite the fact that the food craving scores reported at baseline were not especially high. A typical participant reported "rarely" or "sometimes" experiencing food cravings at baseline, yet a clear reduction in scores was evident from the six-week FCI-II questionnaire.

### Reduction in Overall Food Cravings Categorized by Baseline Score



For the statistical analysis, baseline FCI-II scores were categorized into four groups (based on the distribution of scores) as follows:

- Very mild = 1 - 1.99 (never to rarely)
- Mild = 2 - 2.49 (rarely to occasionally)
- Moderate = 2.5 - 2.99 (occasionally to sometimes)
- High = 3 - 5 (sometimes to often to always)

Each participant's score fell into a single (non-overlapping) bin.

Data showed the individuals experiencing higher food cravings at baseline had a greater reduction in their scores at the six-week mark of the consumer study ( $p < 0.001$ ).

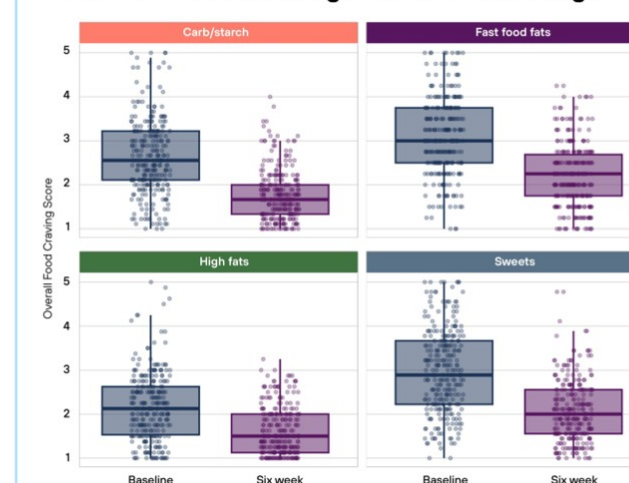
## ADHERENCE

Six weeks after baseline, 274 participants self-reported their adherence to the recommended dietary supplementation. When asked to report how frequently they took the supplement, 93% of participants (n=256/274) said they consumed the probiotic supplement five or more days per week.

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### Reduction in Food Cravings Across All Subcategories



When the specific food subcategories assessed in the questionnaire were analyzed separately, mean food craving scores were significantly reduced from baseline to six weeks in all four subcategories:

- Sweets
- Fast Food Fats
- Carbs/Starches
- High Fats

No single subcategory unduly influenced the total FCI-II mean scores. When considering each category of foods separately, the majority of individual participants in the consumer study group experienced a reduction in food craving score for that category.

**The percentage of individuals showing improved food cravings for each food subcategory is as follows:**

- Sweets – 88% of individuals
- Fast Food Fats – 85% of individuals
- Carbs/Starches – 87% of individuals
- High Fats – 82% of individuals

## DISCLOSURE

Poster authors are employees of Pendulum Therapeutics, Inc.

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