The Impact of Serotonin and Diet on Irritable Bowel Syndrome

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Abstract: This review seeks to explore the numerous studies conducted in order to link Irritable Bowel Syndrome (IBS) with the lack of serotonin production in the body. The evidence associating certain foods with raised tryptophan levels in the body has also been explored and a suitable Indian diet is hypothesized. Serotonin— a neurotransmitter of both the Enteric nervous system (ENS) and the Central nervous system (CNS) is synthesized by the hydroxylation of L-tryptophan to 5-hydroxytryptophan. The Brain-Gut axis exists as a well-established system of communication between the emotion-cognition centers of the brain and our gut. 5-hydroxytryptamine (5-HT), or serotonin, has been associated with the regulation of particle transport and fluid discharge in the Gastrointestinal tract and is found to be a prominent factor in the prevalence of IBS. We reviewed the conventional treatment methods of using drugs, with the recently accredited treatment options like dietary regulation, exercise, meditation, and acupuncture. It was found that the most commonly used drugs exhibited various side effects like nausea, fatigue, rash, and dizziness. Resultantly, an in-depth evaluation of different Indian dietary patterns and their respective effects on tryptophan levels has been highlighted in order to formulate an ideal diet for patients with IBS. This review, in its essence, stresses the crucial need for further research on the dietary implications of common Indian food and their FODMAP (Fermented Oligosaccharides, Disaccharides, Monosaccharides, And Polyols) contents and underscores the benefits of using unconventional and natural methods for the treatment of tryptophan-related Gut disorders. Serotonin, a neurotransmitter of ENS, works with our gut to perform assimilation and absorption. Falling levels of serotonin have been effectively linked to gut disorders like IBS. For treatment, besides medication, techniques like acupuncture along with exercise and a tryptophan-rich diet are proved to be effective against IBS symptoms.

Keywords—Serotonin, Tryptophan, Irritable bowel syndrome, FODMAP.

INTRODUCTION

Serotonin (5-hydroxytryptamine or 5-HT) is a neurotransmitter associated with the Central Nervous System and the Enteric Nervous System (Fig. 1). Serotonin is produced by a biochemical conversion process (Fig. 2) where tryptophan, a component of proteins, combines with tryptophan hydroxylase, a chemical reactor to produce 5-hydroxytryptamine \cite{1}. It is usually called the happy chemical, because it contributes to wellbeing and happiness. Its depletion has been seen in various mental illnesses like depression and anxiety.

Apart from this, Serotonin has another crucial role in Gut and motility. It was established during the early 1950s that a large amount of Serotonin (5-HT) is released from the mucosa at a comparative time as peristalsis happened within the digestive tract \cite{2}. Since then numerous studies have been conducted to analyze the relation between 5-HT and motility.

The microorganisms present in the gut are capable of synthesizing 5-HT but this bacterial production is far exceeded by biosynthesis in Enterochromaffin (EC) Cells. Alternatively, these microbes help regulate the gut and plasma 5-HT levels by providing signals to the host mucosal cells in the form of Tryptophan hydroxylase 1 (TPH1) expression \cite{3}. Moreover, it has been directly affirmed that Enterochromaffin (EC) cells are without a doubt mechanically sensitive and express the mechanosensitive molecule channel, Studies like Tyrode arrangement, utilizing modified Trendelenburg’s strategy were conducted in a confined portion of the lumen in order to study the role of 5-HT in peristaltic reflex \cite{2,4,5,6}. Grider in 1998 illustrated the part of 5-HT4 receptor rising withdrawal and plummeting unwinding within the jejunum of humans, guinea pigs, and rodents. 5HT3 has to be included in motility and discharge \cite{7}. Luminal 5-HT is required for intestinal supplement and water assimilation, and impacts bicarbonate and electrolyte discharge into the lumen \cite{8,9,10}. Through stimulation of 5-HT3 receptors on intestinal vagalafferent nerve endings, EC-cell–derived 5-HT increases postprandial pancreatic protein release, synergistically with cholecystokinin \cite{11}. This, in turn, increases absorption and assimilation of additional luminal secretion. Gastrointestinal 5-HT increases bile activity by increasing the expression of the apical sodium-dependent bile salt transporter \cite{12}. As such, 5-HT may act as a referee of a number of impacts that are credited to both 5-HT and (Glucagon-Like Peptide- 2, 5HT4 receptor rising withdrawal and plummeting unwinding within the jejunum of humans, guinea pigs, and rodents. 5HT3 has to be included in motility and discharge \cite{7}. Luminal 5-HT is required for intestinal supplement and water assimilation, and impacts bicarbonate and electrolyte discharge into the lumen \cite{8,9,10}. Through stimulation of 5-HT3 receptors on intestinal vagalafferent nerve endings, EC-cell–derived 5-HT increases postprandial pancreatic protein release, synergistically with cholecystokinin \cite{11}. This, in turn, increases absorption and assimilation of additional luminal secretion. Gastrointestinal 5-HT increases bile activity by increasing the expression of the apical sodium-dependent bile salt transporter \cite{12}. As such, 5-HT may act as a referee of a number of impacts that are credited to both 5-HT and (Glucagon-Like Peptide- 2,
checking restriction of gastric cleansing and nutrient-stimulated gastric release\textsuperscript{[13][14][15][16]}.

Evidence for direct regulation comes from recent studies on lab-raised and gut microbiome-deficient, germ-free animals. They have high levels of circulating tryptophan and lower levels of serotonin but once gut microbes are introduced, falling levels of circulating tryptophan are observed\textsuperscript{[17]}.

Fasting too fortifies the union and discharge of 5-HT from EC cells in mice due to increased translation of Tph1\textsuperscript{[18]}. Upon detection of low glucose by colonic EC cells, that mirror in vitro fasting conditions, an increase in TPH1 expression, and 5-HT production and release is observed\textsuperscript{[19]}.

Irritable Bowel Syndrome (IBS) is a chronic gastrointestinal disorder that affects 9-23% of the population across the world. It includes a group of symptoms including abdominal pain and changes in the pattern of bowel movements without any evidence of underlying damage. IBS has been divided into 4 types depending on whether diarrhea is common, constipation is common or both are common, or neither (IBS-D, IBS-C, IBS-M, IBS-U).

There is no specific laboratory or imaging test that can be helpful in the diagnosis of IBS. Physicians use 3 sets of diagnostic criteria for IBS which are:

1. **Rome Criteria**: This includes abdominal pain and discomfort lasting on average at least 1 day a week in the last 3 months. Pain and Discomfort are associated with defecation.
2. **Manning Criteria**: This focus on pain relieved by passing stool and on having incomplete bowel movements, mucus in stool and changes in stool consistency.
3. **Type of IBS**: Symptoms according to the type of IBS are observed.

**RELATIONSHIP BETWEEN SEROTONIN AND IRRITABLE BOWEL SYNDROME**

Numerous studies were done to legitimize the relation of Irritable Bowel Syndrome to the lack of serotonin synthesis and release. Gene knockout and Gene transformation were among the best techniques used to study this relationship. Researchers examined that a decrease in the production of intestinal serotonin leads to the weakening of the intestinal lining, which inevitably results in clogging or constipation and an increment in serotonin levels within the gut\textsuperscript{[20]}.

One hypothesis is that the Serotonin Transporter-SERT is deficient in the enterocytes of individuals with IBS. Another hypothesis focuses on diminished numbers of enterochromaffin cells within the GI tract of individuals with IBS.

It was shown that the upregulation of the Indoleamine-pyrole 2,3-dioxygenase activates a metabolic pathway, which is also likely to be associated with the pathogenesis of IBS. Afterward, considerations have shown that both females\textsuperscript{[21]} and males\textsuperscript{[22]} with IBS have extended kynurenine concentrations compared to controls. Therefore, a positive relationship was found between IBS and the kynurenine/tryptophan extent. Those with extraordinary IBS side impacts have extended shunting of tryptophan along the kynurenine pathway which contributes to the unusual serotonergic function.

SERT expression is seen to be diminished in IBS patients\textsuperscript{[23]}. On the other hand, SSRI administration increases colonic motility and high-amplitude compressions related to stomach cramping\textsuperscript{[24]}. Chronic treatment of mice with the particular serotonin reuptake inhibitor (SSRI) paroxetine, diminished stool yield, and postponed upper GI tract movement\textsuperscript{[25]}. These discoveries propose that changed mucosal 5-HT signaling seems to contribute to the indications of IBS.

**IBS and Its Subtypes**

There are three major subtypes of IBS. IBS-D is associated primarily with diarrhea. IBS-C is concerned with Constipation and lastly, the third subtype deals with mixed symptoms of both constipation and diarrhea There have been studies that were conducted to compare the SERT-P polymorphism in IBS patients and sound individuals. This polymorphism comes about in a long (L) and a brief (S) allele. It can occur as homozygous (S/S) genotypes, heterozygous (L/S) SERT genotypes, and homozygous long (L/L) genotypes.

This study demonstrated that the SERT-P polymorphism was related to IBS-C within the Indian populace. The recurrence of the SERT-P S/S genotype was higher in IBS-C patients than in normal individuals\textsuperscript{[26]}. In IBS-D, there has been no identified contrast in the basal or fortified mucosal 5-HT release, in spite of the finding that both mucosal 5-HT secretion and Tph1 mRNA levels are decreased\textsuperscript{[27]}. Postprandial 5-HT levels are elevated in platelet-poor plasma tests from IBS-D\textsuperscript{[28][29][30]} or post-infectious IBS patients, but they have been reduced or unchanged in IBS-C.

**IBS and Mental illness**

IBS and its symptoms largely impact daily activities and body image and are a cause of worry to patients. IBS is usually related to disgrace, and patients are stigmatized as ‘frequent fliers’ or ‘somatisers’.

Cognitive behavior therapy (CBT) could be a psychological or ‘talking’ therapy, which can be significantly helpful for patients with IBS. Fifty to 90% of IBS patients have a co-existing psychological condition, reminiscent of anxiety or depression [TABLE 1]. Researchers have found high levels of reported sexual and emotional abuse among patients with IBS. Somatization disorder (SD), a psychiatric disorder has a prevalence of around 25% in patients with IBS, compared with around 1% among the overall population\textsuperscript{[31]}.

**TREATMENT OF IRRITABLE BOWEL SYNDROME**

**Conventional Method**

Drugs are the most common treatment options for patients with gut disorders like IBS.
In cases of IBS-D and pain-predominant IBS, antispasmodics are used as the first-line treatments, and include calcium channel blockers and neurokinin-type 2 receptor antagonists. Rifaximin is deemed to be the best second-line treatment for IBS-D. For patients with IBS-C, besides fiber and laxatives, the most plausible option as a second-line treatment is linacotide.\textsuperscript{[32]}

Alternative/complementary treatment

Besides the conventional use of drugs to treat IBS, studies have also focused on many alternative treatments. For instance, meditation was recently linked with an increase in dopamine levels. A study by Perreau-Linck and colleagues was among the first to show that self-induced changes in mood can affect one’s serotonin production. Another approach used in elevating serotonin levels is exposure to bright light.

In a study that assessed measurements of the serotonin metabolite 5-hydroxyindoleacetic acid (5-HIAA) in the venous outflow from the brain, a direct relation was observed between the duration of bright sunlight and the rate of serotonin synthesis. Similarly, serotonin levels are higher in the postmortem-brain of humans who died during summers, as compared to those who died during winters. In rats, the highest serotonin levels are observed during the light part of the light-dark cycle. In humans, the effect of tryptophan deficiency on the mood of healthy individuals was seen to be highly diminished under bright light, as opposed to dim light.

Exercise is also believed to increase serotonin function in the brain. Major studies in this matter were initiated under the hypothesis that the fatigue caused by exercise leads to increased plasma tryptophan and diminished levels of branched-chain amino acids (BCAAs) leucine, isoleucine, and valine. This causes a significant increase in tryptophan availability as BCCAs can hinder tryptophan transport to the brain. Post and colleagues assessed the biogenic amine metabolites in cerebrospinal fluid (CSF) of clinically depressed patients before and after an elevation in their physical activity.\textsuperscript{[33]} Patrick and Ames in 2015, studied the effects of aerobic exercise on brain serotonin levels. Exercise has the potential to increase tryptophan’s chances of crossing the blood-brain barrier by muscular-uptake of competitive amino acids.\textsuperscript{[34]} Regular exercise (30 min of swimming daily, 4 weeks) was seen to increase serotonin metabolism and production in the brainstem and cerebral cortex but decrease hippocampal serotonin levels.

In another study, the introduction of a low-to-moderate intensity exercise regimen significantly improved IBS symptoms, and this improvement remained considerable even 60 days post-training. However, signs of inflammation, oxidative stress, antioxidants, and other IBS symptoms were observed 8 weeks post-training. This led to the conclusion that a regular exercise routine is essential in order to conserve the benefits of exercise training.

Another well-known factor is diet. Foods that are rich in tryptophan are often believed to be associated with elevated serotonin levels. Since the early 1970s, nutritional research developments show that brain function is influenced by the availability of various nutrients in the diet. In the mid-1970s, Gessa et al demonstrated that acute administration of a mixture of essential amino acids lacking Tryptophan (Trp-free mixture) produced a specific and long-lasting reduction of brain tryptophan and serotonin levels in rats.\textsuperscript{[35]}

Administration of this Trp-free amino acid mixture in rats produced a sharp drop in the concentration of serum tryptophan associated with a decrease in brain tryptophan, serotonin (5-HT), and 5-hydroxyindoleacetic acid (5-HIAA) levels in rats.

Ingestion of only proteins diminishes rat brain Tryptophan and 5-HT because all of the amino acids compete with tryptophan for transportation across the blood-brain barrier. Conversely, carbohydrate consumption increases Trp and 5-HT levels in the brain as ingestion of carbohydrates increases blood insulin levels which in turn increases the uptake of branched-chain amino acids into muscles, thus decreases their plasmic concentration and competition at the blood-brain barrier.

A minor component of milk, α-Lactalbumin, contains relatively more tryptophan than most proteins. In small quantities, the ingestion of α-lactalbumin is seen to improve mood and cognition under certain circumstances, probably owing to elevated serotonin.\textsuperscript{[36]}

Dietary fiber is a safe and cheap way to improve IBS. As an example, bran is proved to be a natural bulking agent.\textsuperscript{[37]} Peppermint oil is a common remedy for IBS and abdominal pain. It counters spasmodic movements by the transport of calcium ions across the cell membrane.

More about IBS and the Indian diet is given in the results and discussion of this review.

Techniques like Acupuncture and Colon Hydroscopy are also considered to be helpful in relieving abdominal distress. It has been indicated that several acupoints have distinguished effects on D-IBS, C-IBS, and abdominal irritation. It is known to exhibit certain gut responses that lead to inhibited acid output, reduced rectal hypersensitivity, and normalized motility. However, this effect is not always observed. Nevertheless, the National Institute for Health and Care Excellence (NICE) guidelines do promote the use of acupuncture to treat IBS.

Colon hydrotherapy (CHT) is a minimal access technique widely adopted to treat bowel inconsistencies. However, several side effects such as perforation, rectal bleeding, and pelvic abscess have been reported.\textsuperscript{[38]}

**REVIEW RESULTS**

The relationship between Serotonin and Gut has been stated in various research papers including various Gut-related disorders like Irritable Bowel Syndrome (IBS) and their treatments along with detailed information of Serotonin-rich drugs to improve bodily functions but most of these studies
include data based on populations of the countries in the west. Through this review paper, we have tried to discuss such disorders in the context of India’s population and dietary routines including food items commonly consumed in different regions of India along with their Tryptophan content and hence formulated an ideal diet (as per the data) which in future, can be introduced to various IBS patients to check its effectiveness in improving their condition.

DISCUSSION

It has been well established that a tryptophan-rich and FODMAP low diet can aid in alleviating the symptoms of IBS. However, such dietary intervention has mostly been hypothesized for a western diet. In this review, we have discussed a diet based on the daily food intake of an average Indian individual. The daily L-tryptophan requirement for a normal human is 900-1000 mg [39].

The diet of an IBS patient should be developed, keeping in mind the following aspects-

1. **Water-soluble fiber**- Dietary fiber increases stool bulk by stimulating colonic mucosa. However, consuming water-insoluble fiber, like bran, may further cause abnormal bloating and intestinal discomfort whereas water-soluble fiber like psyllium often aids in relieving symptoms of GI tract disorders [40].

2. **Low fat**- Patients with IBS are often subjected to gas retention (bloating), nausea, and distension caused by the intraluminal fat in the small intestine. They exhibit abnormal lipid dependent motor dysfunction and increased rectal hypersensitivity. Thus, few patients associate IBS with fat-intake. However, regular differences in dietary fat consumption levels have not been found between sound individuals and IBS patients [41].

3. **Gluten-free**- Gluten is a mixture of proteins-gliadin and glutenin. It increases intestinal permeability by changing the function of the mucosal barrier. A gluten-free diet would ultimately lead to decreased permeability and reduced bowel frequency in IBS-D patients. This would also cause a reduced intake of FODMAPS which would ultimately aid in relieving IBS symptoms.

4. **Low FODMAPs**- FODMAPs (Fermented Oligosaccharides, Disaccharides, Monosaccharides, and Polysols), are a group of short-chain carbohydrates that are digested and absorbed poorly in the GI tract. Some examples include fructose, raffinose, nystose, and kestose. A low FODMAP diet has been effectively proven to be effective against IBS symptoms in numerous clinical trials. However, studies are still required for the determination of FODMAP contents in common Indian foods and the tolerance levels in an Asian setting.

5. **Tryptophan-rich diet**—Elevated serotonin levels are often associated with tryptophan-rich food consumption. There have been studies that observed a drop in 5-HT serum concentration and reduction in brain-tryptophan, upon administration of a tryptophan-free amino acid mixture.

Diversity in eating habits, patterns, food items, occurs when we move from north to south or east to west India, due to cultural differences, local vegetation, climate differences, social issues, religious beliefs, resources availability, differences in abiotic factors like soil etc. Many food items, predominant in the Indian diet, possess these qualities and have been listed in (Table 2) [42][43]. As an example, the above data has been used to formulate an ideal diet for IBS patients in (Table 3) which will fulfill the daily tryptophan requirements.

CONCLUSION AND LIMITATION

The interconnection of all bodily functions is evident when we examine the ‘Happy hormone’—serotonin and trace its functioning from acting as a neurotransmitter to being an important aspect in the development of gastrointestinal disorders like Irritable bowel syndrome. Our dietary intake plays a key role in the regulation of IBS, and this information has been utilized to narrow down on food items in the Indian diet which possess all five qualities of being gluten free, low in fat, low in FODMAP content, rich in tryptophan, and possessing water-soluble fibers.

A limitation of this study would be the absence of a professionally prescribed diet. The regime mentioned in the results of this review is concluded on the basis of readings and analysis of existing literature and is derived from previously-concluded trials.

FIGURES AND TABLES

Fig. 1. Gut-Brain Axis
The gut-brain axis is a bidirectional communication between the central and the enteric nervous system, linking emotional and cognitive centres of the brain with peripheral intestinal functions.
Tryptophan is a substrate for the large neutral amino acid transporter system and competes for transport with several other amino acids essential for brain function. Once in the CNS, L-tryptophan is hydroxylated to 5-hydroxytryptophan by the enzyme tryptophan hydroxylase type 2, the rate-limiting step in the brain serotonin synthesis. This is followed by subsequent decarboxylation involving the enzyme L-aromatic acid decarboxylase to serotonin (5-hydroxytryptamine, 5-HT).

Fig. 2. Tryptophan Metabolism

Tryptophan is a substrate for the large neutral amino acid transporter system and competes for transport with several other amino acids essential for brain function. Once in the CNS, L-tryptophan is hydroxylated to 5-hydroxytryptophan by the enzyme tryptophan hydroxylase type 2, the rate-limiting step in the brain serotonin synthesis. This is followed by subsequent decarboxylation involving the enzyme L-aromatic acid decarboxylase to serotonin (5-hydroxytryptamine, 5-HT).

<table>
<thead>
<tr>
<th>Study</th>
<th>Number of Patients</th>
<th>Percentage of patients with psychological illness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blanchard et al (2007)</td>
<td>210</td>
<td>66.6% (DSM-IV Axis type-1 disorder)</td>
</tr>
<tr>
<td>Kennedy et al (2005)</td>
<td>149</td>
<td>43% (Any psychological disorder in the past year)</td>
</tr>
<tr>
<td>Payne and Blanchard (1995)</td>
<td>34</td>
<td>85% (DSM-IV Axis type-1 disorder)</td>
</tr>
<tr>
<td>Tkachuk et al (2003)</td>
<td>28</td>
<td>68% (DSM-IV Axis type-1 disorder)</td>
</tr>
</tbody>
</table>

Table 1. IBS Patients with co-existing Mental illness studies. Deficiency of serotonin is common in IBS and as well as in many mental disorders. Many studies were done to study the existence of mental illness in IBS patients, here are enlisted some of the studies with percentage of IBS patients with psychological illness. [3,13]

<table>
<thead>
<tr>
<th>Food items with High FODMAP</th>
<th>Tryptophan Content (g) (per 100 g of food item)</th>
<th>Water-soluble Dietary Fibre (g) (per 100 g of food item)</th>
<th>Food items with Low FODMAP</th>
<th>Tryptophan Content (g) (per 100 g of food item)</th>
<th>Water-soluble Dietary Fibre (g) (per 100 g of food item)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple</td>
<td>0.0030</td>
<td>2.44</td>
<td>Banana</td>
<td>0.0118</td>
<td>1.04</td>
</tr>
<tr>
<td>Mango</td>
<td>0.0056</td>
<td>1.10</td>
<td>Orange</td>
<td>0.0003</td>
<td>0.56</td>
</tr>
<tr>
<td>Wheat</td>
<td>0.1168</td>
<td>4.67</td>
<td>Maize</td>
<td>0.0632</td>
<td>0.94</td>
</tr>
<tr>
<td>Barley</td>
<td>0.2080</td>
<td>3.01</td>
<td>Rice</td>
<td>0.0860</td>
<td>0.82</td>
</tr>
<tr>
<td>Rye</td>
<td>0.1080</td>
<td>15.1</td>
<td>Ragi</td>
<td>0.0664</td>
<td>1.67</td>
</tr>
<tr>
<td>Cabbage</td>
<td>0.0230</td>
<td>2.47</td>
<td>Brinjal</td>
<td>0.0156</td>
<td>1.20</td>
</tr>
<tr>
<td>Cauliflower</td>
<td>0.0291</td>
<td>2.51</td>
<td>Capsicum</td>
<td>0.0124</td>
<td>0.73</td>
</tr>
<tr>
<td>Cashew</td>
<td>0.2226</td>
<td>3.30</td>
<td>Almond</td>
<td>0.1851</td>
<td>2.52</td>
</tr>
<tr>
<td>Pistachio</td>
<td>0.2811</td>
<td>10.3</td>
<td>Walnut</td>
<td>0.1622</td>
<td>0.65</td>
</tr>
<tr>
<td>Cheese</td>
<td>0.2002</td>
<td>0.00</td>
<td>Yogurt</td>
<td>0.1550</td>
<td>0.00</td>
</tr>
<tr>
<td>Milk</td>
<td>0.0452</td>
<td>0.00</td>
<td>Oats</td>
<td>0.1785</td>
<td>3.81</td>
</tr>
<tr>
<td>Honey</td>
<td>0.0042</td>
<td>0.23</td>
<td>Kidney Beans</td>
<td>0.2790</td>
<td>2.62</td>
</tr>
<tr>
<td>Mushroom</td>
<td>0.0356</td>
<td>1.02</td>
<td>Bitter Gourd</td>
<td>0.0204</td>
<td>3.10</td>
</tr>
<tr>
<td>Beetroot</td>
<td>0.0142</td>
<td>2.84</td>
<td>Lady Finger</td>
<td>0.0093</td>
<td>1.33</td>
</tr>
</tbody>
</table>

Table 2: Tryptophan Content in food items with Low-FODMAP

strategy for symptom control in patients with IBS. A reason that contributes to poor absorption of FODMAPs include the absence of luminal enzyme capable of hydrolysing glycocisic bonds present in complex carbohydrates and absence or low activity of brush border enzymes such as GLUT-2 and GLUT-5. [2,13]

<table>
<thead>
<tr>
<th>Breakfast</th>
<th>Mid Snack</th>
<th>Lunch</th>
<th>Mid Snack</th>
<th>Dinner</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 bowl of Greek Yogurt Oat Meal</td>
<td>1 cup Nuts ½ cup Almonds (0.0925g Trp and 1.26g DF)</td>
<td>1 serving Rice (0.1075g Trp and 1.025g DF)</td>
<td>1 cup Rajma (0.1743g Trp and 1.63g DF)</td>
<td>2 Medium Sized Oranges (0.00084g Trp and 0.784g DF)</td>
</tr>
<tr>
<td>1 cup Oats (0.1785g Trp and 3.81 g DF) + 1 Banana (0.0139g Trp and 1.227g DF) + 1 cup water + ¼ cup Greek yogurt (0.0949g Trp and 0g DF)</td>
<td>½ cup Walnuts (0.1054g Trp and 0.42g DF)</td>
<td>1 cup Rajma (0.1743g Trp and 1.63g DF)</td>
<td>0g DF</td>
<td></td>
</tr>
<tr>
<td>½ cup Greek yogurt (0.0949g Trp and 0g DF) + ½ cup water</td>
<td>½ cup Walnuts (0.1054g Trp and 0.42g DF)</td>
<td>1 cup Rajma (0.1743g Trp and 1.63g DF)</td>
<td>0g DF</td>
<td></td>
</tr>
<tr>
<td>1,205g DF + Trp and 5,037g DF</td>
<td>1,205g DF + Trp and 5,037g DF</td>
<td>1,205g DF + Trp and 5,037g DF</td>
<td>1,205g DF + Trp and 5,037g DF</td>
<td></td>
</tr>
<tr>
<td>Total=0.2846g DF + Trp and 5,037g DF</td>
<td>Total=0.1979g DF + Trp and 1,680g DF</td>
<td>Total=0.3879g DF + Trp and 2,655g DF</td>
<td>Total=0.2846g DF + Trp and 5,037g DF</td>
<td></td>
</tr>
<tr>
<td>2 Medium Sized Oranges (0.00084g Trp and 0.784g DF)</td>
<td>2 Medium Sized Oranges (0.00084g Trp and 0.784g DF)</td>
<td>2 Medium Sized Oranges (0.00084g Trp and 0.784g DF)</td>
<td>2 Medium Sized Oranges (0.00084g Trp and 0.784g DF)</td>
<td></td>
</tr>
</tbody>
</table>

Table 3: An example of Indian ideal diet for IBS patient.

This an example of Indian ideal diet for IBS patient which fulfil the daily requirements for tryptophan (900-1000mg) and dietary fibre (15-20g) while keeping the low and high FODMAPs food items in balance.

ACKNOWLEDGMENT

We would like to express our special thanks and gratitude to our professor and mentor Dr. Bhawana Sharma, for her constant support and guidance throughout the course of this review paper. We would also wish to thank our institution ‘Shaheed Rajguru College of Applied Sciences for women, University of Delhi’, for providing us with opportunities and shaping us into able individuals.

REFERENCES

Bicomboter variant: Analysis in relation to intestinal inhibition of gastric emptying. via cAMP—

http://www.ijert.org

Published by:

International Journal of Engineering Research & Technology (IJERT)

ISSN: 2278-0181

Vol. 9 Issue 08, August-2020

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Actually, I'm not sure how the bicomboter variant relates to the inhibition of gastric emptying. The data seems to be focused on gut medication, irritable bowel syndrome, and serotonin metabolism in irritable bowel syndrome. Could you provide more context or clarify the question?