Structure & role of different prebiotics

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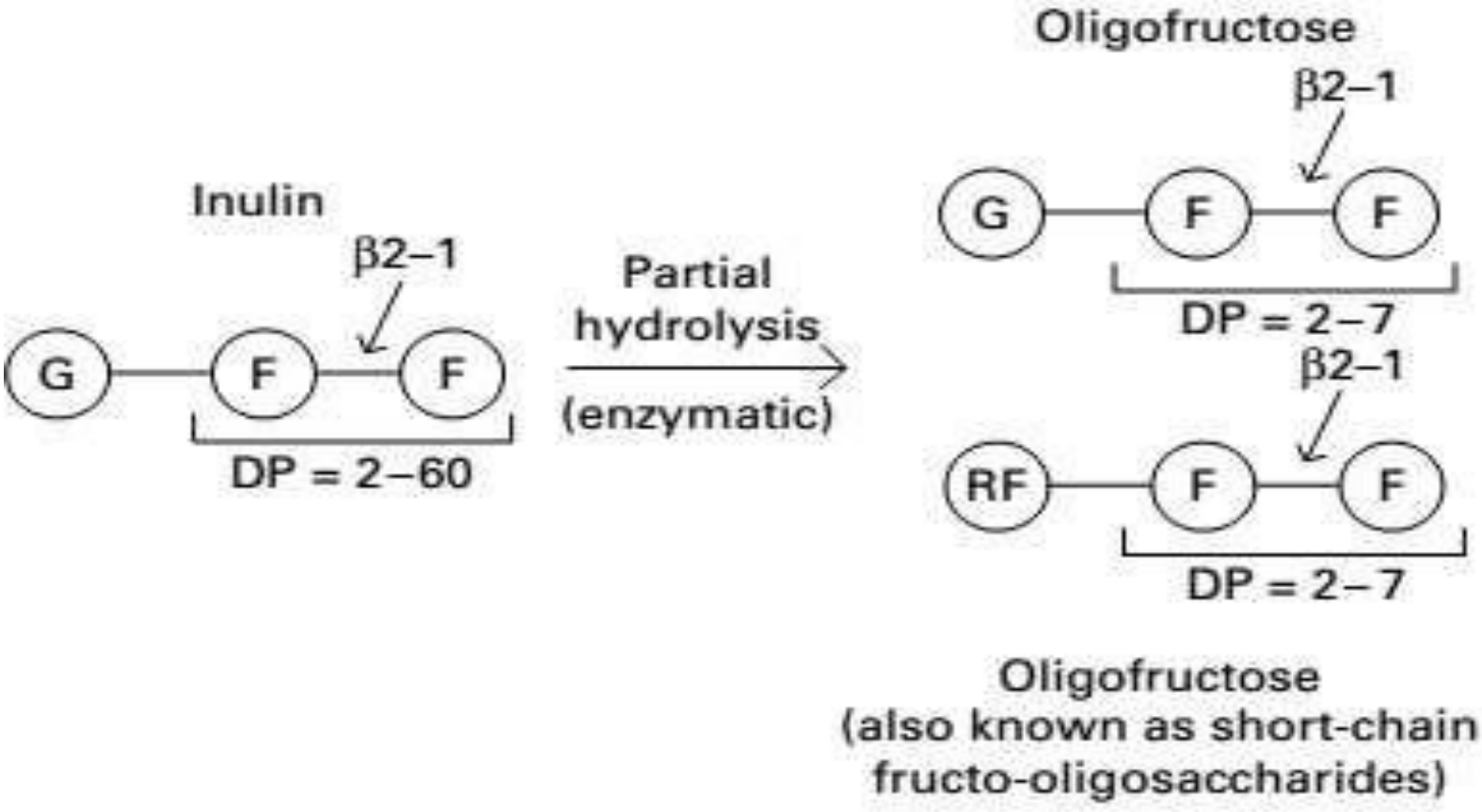
- β2-1 Fructans, which include inulin (IN) and fructo-oligosaccharides (FOS), fulfil the criteria for prebiotics. (Gibson, et al.,2004).

- According to Roberfroid, 2007, only two particular prebiotics then fully met the refined definition of prebiotics: Inulin(IN) and Trans-galactooligosaccharide (TOS).

INULIN:

- Inulin is the most common type of FOS.
- IN is a linear carbohydrate molecule which contains β-(2→1) fructosyl–fructose linkages with a terminal glucose.
- IN may contain between two and sixty fructose residues with an average of twelve. (fig.1)
- Partial enzymatic hydrolysis of IN yields a FOS known as oligofructose(OF), which can have a terminal glucose or fructose residue (fig.1)
- In OF there can be two to eight (average five) fructose residues with a terminal glucose residue or a chain of three to eight (average five) fructose residues.

FIG.1:


Inulin
β2–1
G
F
F
DP = 2–60
Partial
hydrolysis
(enzymatic)
Oligofructose
β2–1
G
F
F
DP = 2–7
β2–1
RF
F
F
DP = 2–7
Oligofructose
(also known as short-chain
fructo-oligosaccharides)

Dietary Source of Inulin (IN):

- IN is found naturally in a variety of plant foods such as bananas, barley, chicory, garlic, artichoke, leeks, onions and wheat.

- Oligosaccharides, including some believed to be prebiotics, are present in human breast milk.

- The presence of oligosaccharides in large amounts in breast milk suggests that these compounds may play an important role in early infant development, perhaps of the gut, its microbiotia and the immune system.

Role of Inulin on immunity:

- The effect of β2-1 fructans upon macrophage number and function has been studied, with the results suggesting that macrophage functions are enhanced by the addition of β2-1 fructans to the diet.

- Peritoneal macrophage phagocytic activity was increased in rodents given IN or OF for varying periods of time (Kelly-Quaglian *et al.*,2003).

- In rats, OF-enriched IN (100g/kg) increased caecal secretory IgA concentrations(Roller *et al*., 2004).

- The number of T cells in the MLN of rats was increased upon 10% OF or IN supplementation and also the blood IL-2 and IL-4 concentrations were increased upon the supplementation for 4 months (Trushina *et al.*, 2005).

- A study shows the percentage of blood B cells (defined as CD19+) was increased in young male adults after consumption of a bread containing IN (Seidel *et al*., 2007).

REFERENCE	Prebiotics dose used	Animal studied	Immune effect
Stillie et al, 2005	Inulin (4·8 % w/w diet)	Rats (21 d old, male & female); diabetes resistant or diabetes prone	**In diabetes-resistant rats;** ↑Small intestine length ↓ Number of splenocytes ↑CD8+ Lymphocytes in PP ↑ Proliferation of splenocytes and MLN cells to mitogens ↓Production of IL-4 and ↑ production of IL-10 by stimulated splenocytes **In diabetes-prone rats;** ↓Number of splenocytes ↑IgA+ cells in jejunal lamina propria ↑B lymphocytes in PP ↓Production of IL-4 and ↑production of IL-10 by stimulated splenocyte

FRUCTOOLIGOSACCHARIDES (FOS):

STRUCTURE:

- FOS consists of several β(1-2) or β(1-6) linked fructose units which may be linked to glucose residues.

DIETARY SOURCE:

- They can be found naturally in some cereal crops as well as fruits and vegetables such as bananas, onions, chicory root, garlic, asparagus, onion and leeks.

Role of FOS on immunity:

- They stimulate the growth of bifido bacteria and to inhibit growth and multiplication of potentially pathogenic bacteria such as enterobacteria, clostridia and salmonella.

- Fermentation of FOS leads to the production of short chain fatty acids, which is substrate for energy metabolism in the colonic mucosa stimulating epithelial cell growth.

- Short chain FOS can enhance IgA content and thus play a major role in immunity.

- A **study** conducted by Bourgot *et al*.,2014 says that maternal scFOS supplementation modified the intestinal immune functions in piglets in association with increased colostral immunity.

- Thirty-four sows received a standard or a scFOS supplemented diet (10 g scFOS/d) for the last 4 weeks of gestation and the 4 weeks of lactation.

- Colostrum and milk immunoglobulins (Ig) and TGFβ1 concentrations were evaluated on the day of delivery and at d 6 and d 21 postpartum.

- Colostral IgA ($P<0.05$) significantly increased because of scFOS and TGFβ1 concentrations tended to improve ($P<0.1$).

- Such results underline the key role of maternal nutrition in supporting the postnatal development of mucosal immunity.

Another study shows dietary supplement of FOS to the Caspian roach (*Rutilus rutilus*) fry increase the serum Ig levels, lysozyme activity and alternative complement activity (ACH50) and thus improving the innate immune response (Soleimani et al.,2012).

TRANS-GALACTOOLIGOSACCHARIDES (TOS):

STRUCTURE:

- **Galacto-oligosaccharides** (GOS), also known as oligogalactosyllactose, oligogalactose, oligolactose or **transgalactooligosaccharides (TOS),** belong to the group of prebiotics.

- GOS/TOS generally comprise a chain of galactose units that arise through consecutive transgalactosylation reactions, with a terminal glucose unit. However, where a terminal galactose unit is indicated, hydrolysis of GOS formed at an earlier stage in the process has occurred.

- The degree of polymerization of GOS/TOS can vary quite markedly, ranging from 2 to 8 monomeric units.

Role of TOS/GOS on immunity:

- Galactooligosaccharides, GOS can positively influence the immune system—indirectly through the production of antimicrobial substances as the result of galactooligosaccharide fermentation, that can reduce the proliferation of pathogenic bacteria, and directly by interaction with immune cells.

- In infants the usage of GOS has been shown to have a potential role in allergy prevention and reduction of infectious diseases.

- Several studies have shown that GOS and FOS fermentation can lead to the production of **butyrate**, the principal fuel for colonic epithelial cells. This SCFA also stimulates apoptosis (Rowland 1998) and may be a protective factor in carcinogenesis (Scheppach and Weiler 2004).

- **Propionate** is also produced from GOS, and has been shown to be anti-inflammatory with respect to colon cancer cells (Nurmi et al. 2005).

Role of TOS/GOS on Mucosal Immune System:

- The intestinal mucosa contains large amounts of sIgA which has a protective role against adherence and invasion by harmful bacteria and viruses.
- Levels of sIgA in faeces have been found to correlate with an increased ability to neutralize and clear viruses.
- Infants have an immature immune system, and because of the lack of transfer of immunoglobulins from breast milk, formula-fed babies have low levels of sIgA, which can lead to increased risk of gastrointestinal infection.
- Thus, the addition of prebiotics such as GOS alone or in combination with probiotic bifidobacteria or lactobacilli with immunomodulatory abilities that are able to utilize the substrate, has potential to increase production of sIgA in the body.