International Journal of Enhanced Research in Science, Technology & Engineering
ISSN: 2319-7463, Vol. 11 Issue 3, March-2022, Impact Factor: 7.957

Oligosaccharides for Good Health: A Review

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ABSTRACT

Oligosaccharides or low molecular weight carbohydrates, containing 3 to 10 sugar moieties i.e., monosaccharides. Oligosaccharide is a carbohydrate polymers comprise three to ten monosaccharides, simple sugars. The linkage among them is an O-glycosidic bond via condensation reaction with an anomeric carbon of a monosaccharide and the other. N-glycosidic linkages can also be formed under particular conditions.These are water soluble and typically 0.3 to 0.6 times as sweet as sucrose.Due to their chemical structure, consumed by limited number of bacteria, they act as pre-biotic. The sweetness decreases with increase in their chain length.Their relative Low sweetness makes them useful in food production with low sugar requirement. These are used as a bulking agent in conjunction with artificial sweeteners.High molecular weight oligosaccharides have increased viscosity, improved body, and mouth feel.Many oligosaccharides or not digested by human (enzyme required to hydrolyze beta links is missing in humans). Their calorific value is 1.5 to 2.0 kcal per gram.

Key words: Oligosaccharides, low-molecular weight, monosaccharides, calorific-value, pre-biotic.

INTRODUCTION

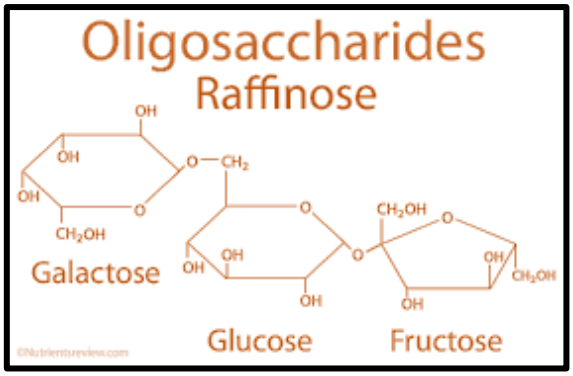
Oligosaccharides can be divided into two types, depending on their digestibility. Milk derived oligosaccharides and non-digestible oligosaccharides. Oligosaccharides derived from milk are of two types i.e.,lactose derivatives and native milk oligosaccharides. On the same pattern, milk oligosaccharides can be divided in to two –acidic oligosaccharides and neutral oligosaccharides. No charged monosaccharide residues are formed in neutral milk oligosaccharides, but one or more residues of Sialic acid are present in acidic milk oligosaccharides.More than 200 milk derived oligosaccharides are investigated.The classification depending on the number of sugar units-Trisaccharide: These types of oligosaccharides are made up of three monosaccharides linked together. Raffinose- a trisaccharidemade up of of glucose, galactose, and fructose.

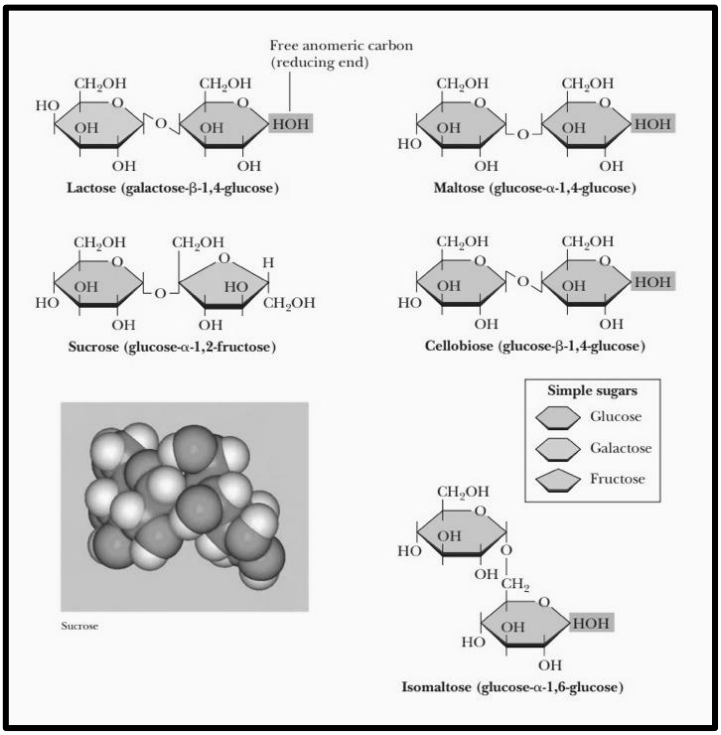
Tetra-saccharides, made of four sugar units. Sesamose, which is made up of four monosaccharides — two galactose units, one glucose unit and one fructose unit.

Penta-saccharides: They are composed of five monosaccharidese.g.,verbascose, with three galactose units, one of glucose and another one of fructose.Hexa-saccharides: with six sugar units.

Oligosaccharides:

- Raffinose from oligosaccharides family:
  Raffinose ($C_{18}H_{32}O_{16}$) a trisaccharide made up of with three sugar units – glucose, fructose, and galactose. With α-galactosidase enzyme, it hydrolyzes to D- Galactose and sucrose.Main sources are – Beetroot, Cabbages, Broccoli, legumes, cabbage, cottonseed, etc.
- Galacto-oligosaccharides (galactose molecules). Present in Human milk oligosaccharides (HMOs). These are derived from lactose. 2′-fucosyllactose, i.e., a trisaccharide composed of glucose, galactose and fucose, contributes 30% of all HMOs.
- Fructo-oligosaccharides (plant-derived oligosaccharides) These are also known as oligofructans and are storage saccharides. These are short chains of fructose residues which are common in plants. E.g., wheat, barley, Agave tequilana, Onion, Helianthus tuberosus, etc. They are commercially used as artificialsweeteners, and food additives for enhancing color and texture.





According to American dietary Association (ADA), functional foods include whole food, fortified, enriched, or enhanced food, having potentially beneficial effect on health when consumed,ADA supports research to further define health benefits and risks of individual functional foods and their physiologically active components (ADA 2004).

These can be used as low cariogenic substitutes in products like confectionery, chewing gum, and drinks. As these cannot be digested by humans but can be used as sweet low-calorie substitutes in diet food and food for diabetic person.

Some oligosaccharides our quantitatively hydrolyzed in the upper part of GI tract, resulting monosaccharides are transported via portal blood to liver. Such oligosaccharides are essential for health as they serve both as substrates and regulator of major metabolic pathway.

Due to their chemical structure, consumed by limited number of bacteria, they act as pre-biotic.

- Some of significant prebiotic activities are- Growth of bifidobacteria(anaerobic) increases, which inhibits putrefying and pathogenic bacteria (in breastfed baby's intestine).
- Decrease in pH of colon and consequently faeces.
- Produces nutrients like vitamin B one, vitamin B2, vitamin B 12, nicotinic acid, and folic acid.
- Increase in faecal dry weight excretion due to excessive fermentation of non-digestible oligosaccharides.
- Constipation relief due to faecal bulking and effect on intestinal mobility. All effects arelike dietary fiber.
- Inhibition ofdiarrhea by controlling both gram-positive and gram-negative bacteria.
- A protective effect against infection in the gastrointestinal, respiratory, and Urogenital tracts.
- Increase in absorption of minerals- Iron, zinc, calcium, magnesium due to binding capacity of non-digestible oligosaccharides.

- A beneficial effect on the carbohydrate on lipid metabolism.
- Helpsin decreasing triglyceride, cholesterol, phospholipids levels, also reduces risk of obesity and diabetes.
- Changes in concentration of serum cholesterol have been related to changes in intestinal microflora.
- Changes in lipid metabolism due to Short chain fatty acids inhibits absorption of cholesterol through intestinal wall.
- Reduction in cancer especially gut cancer
- Increase in cellular immunity.
- Main faecalphysiological parameters which show decrease are - PH, ammonia, p-cresol, p-insole (all are the risk factors for colon cancer).

Human milk is unique as it contains so many oligosaccharides.Milk contains various oligosaccharides in addition to glycoproteins, glycopeptides, and glycolipidsA growth-promoting factor for Lactobacillus bifidus(***Bifidus factor)*** is present in the whey part of human milk. Lactoferrin plays a role to suppress the growth of bacteria by binding to the iron in milk.Casein and lactose are important nutritional ingredients, while IgA works as a component of transfer immunity for babies.

Food loaded with oligosaccharides: Oligosaccharides are found naturally in many foods and can be added to other foods as a supplement.

Table: Foods rich in oligosaccharides

Legumes	Nuts and Grains	Vegetables	Fruits	Others
Black beans, soya bean, kidney bean, Soya milk, soya flour, Peas, Lentils.	Wheat, rye, barley, Almond, cashews, pistachios	Onions, white onions,garlic, leek, Kale, red and green cabbage, broccoli, scallions	Grapes, plums, prunes, figs, dates, ripe banana, watermelon, raspberry, cherries and pear.	Teas, inulin(chicory root, carob)

Table: Physiological functions of Oligosaccharides.

S. No.	Oligosaccharide	Function	Reference
1.	Lactosucrose	Increase the absorption of calcium by the intestine	Kishino et al., 2006
2.	Xylo-oligosaccharides	Promotes the formation of vitamin B	Alonso et al. 2003
3.	Fructo-oligosaccharides	Enhancement of organic acids production and inhibition of pathogen proliferation in the stomach	Ten Bruggencate et al.,2003
4.	Guar gum hydrolysates	Acts on lipid metabolism and decreases atherogenesis	Suzuki and hara 2004
5.	Galacto-oligosaccharides	Increases the resistance to fractures	Van den Heu vel et al., 2004
6.	Manno oligosaccharides	Reduction of hypertension	Hoshino -takao et al., 2012
7.	Lactulose	Helps in the short chain fatty acids synthesis in humans &decreases serum triacylglycerol levels.	Vogt et al., 2007.
8.	Isomalto-oligosaccharides	Helps in preventing dental caries and relives constipation in elderly people.	Kaneko et al., 1995, chen et al., 2001.
9.	Transgalacto-oligosaccharides	Promotes absorption of calcium in the post-menopausalperiod of women.	Gibson, 2004

Main Functional claims of oligosaccharides are- Bowel function/ constipation, Gastrointestinal discomfort, Defense against pathogens, Reduction in number of specific pathogens, and Reduction in number of gastrointestinal infections.

CONCLUSION

The oligosaccharidesare naturally present in human milk. Around 15 HMOsare identified till date, each with a chain of five basic monosaccharide units. Along with human milk these are also found naturally in various plant foods. These are also added artificially by the food manufacturers to increase texture, prebiotic content, and the flavor. Oligosaccharides can also be used as low-calorie sweetener. These can also be added to glucose syrup to reduce

their sugar content without affecting their sweetness.Pre-biotics feed healthy bacteria present in gut, and oligosaccharides are prebiotic active, these have tremendous benefit in human health. Gut bacteria with prebiotics produce short chain fatty acids. These short chain fatty acids help in lowering gut PH, which in turn, limits the growth of harmful bacteria. Oligosaccharides also strengthen our immune system. Though, there are potential benefits of consuming oligosaccharides, more research is required to make strong conclusions.

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