Fructooligosaccharide

Department: Technology Dept

Date: 2023.9.3

Introduction to oligosaccharide

●Fructo-oligosaccharide（FOS）, use sucrose as raw material, is also known as Fucto-oligo, it directly enters into large intestine without being digested and absorbed by human body, and in intestine it rapidly promotes reproduction of bididobactirium and other probiotics, so it is also called ″Bifidus Factor″ .It is a good water soluble dietary fiber.

●Widely found in nature, such as chicory, Jerusalem artichoke, garlic, onions, burdock, bananas, wheat, honey, asparagus, etc.

01 Physical and chemical properties

Sweetness

Fructooligosaccharides with a purity of 55% -60% have a sweetness of about 60% that of sucrose, while fructose oligosaccharides with a purity of 95% have a sweetness of about 30% that of sucrose. They possess the pure sweetness of sucrose and have a refreshing and pure taste compared to sucrose, without any aftertaste.

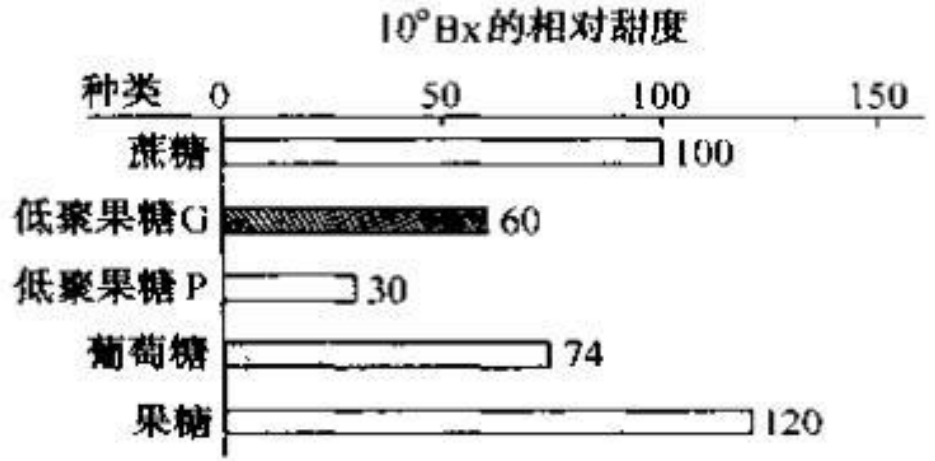


图 4－3　低聚果糖、蔗糖、葡萄糖和果糖的甜度

01 Physical and chemical properties

Appearance and viscosity

Fructooligosaccharide is a colorless transparent liquid, but industrial products are light yellow or yellow in color.

Within the range of 0 ℃ to 70 ℃, the viscosity of fructooligosaccharide is similar to that of isomeric sugars, but decreases with increasing temperature.

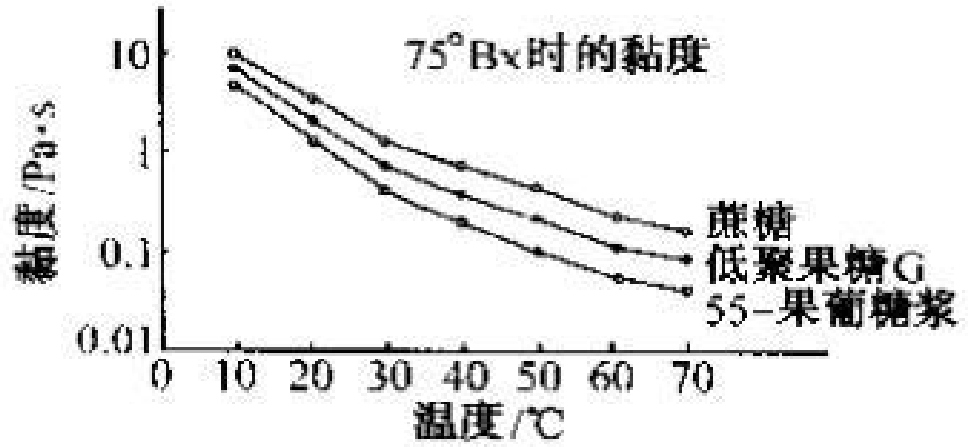


图 4－2　低聚果糖、蔗糖和 55－果葡糖浆在不同温度下的黏度

01 Physical and chemical properties

Water activity

The water activity is similar to sucrose, but fructooligosaccharide is slightly higher.

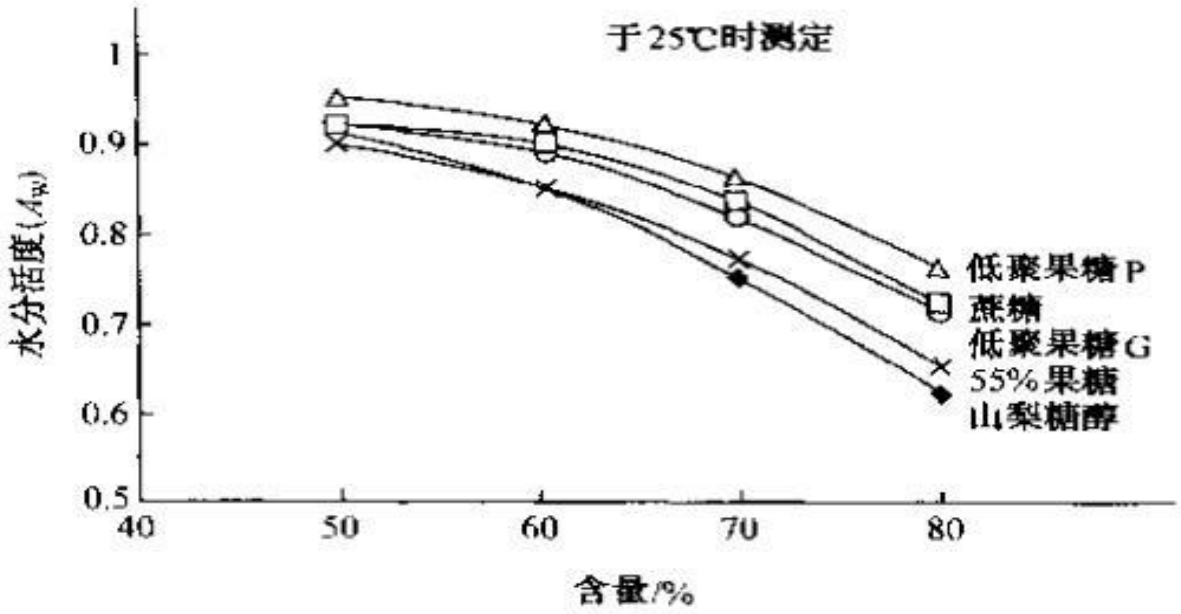


图 4－4 低聚果糖、蔗糖、葡萄糖、55%的果糖和山梨醇的水分活度

Thermal stability

The thermal stability is higher than that of sucrose, and it is very stable at 120 ℃ under neutral conditions. Fructooligosaccharide is stable at 150 ℃ and begins to decompose at 160 ℃.

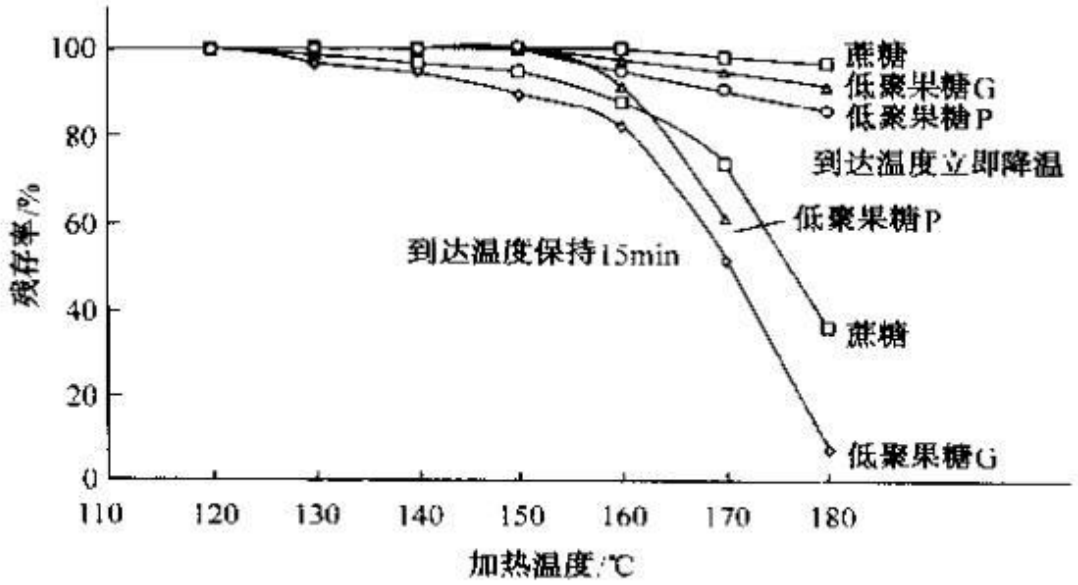


图 4-6 低聚果糖和蔗糖在不同温度下的热稳定性

Acid stability

In an environment with pH>5, heating to 120 ℃ is also relatively stable. However, when heated in an acidic environment with pH<4 at temperatures exceeding 90 ℃, fructooligosaccharide will decompose.

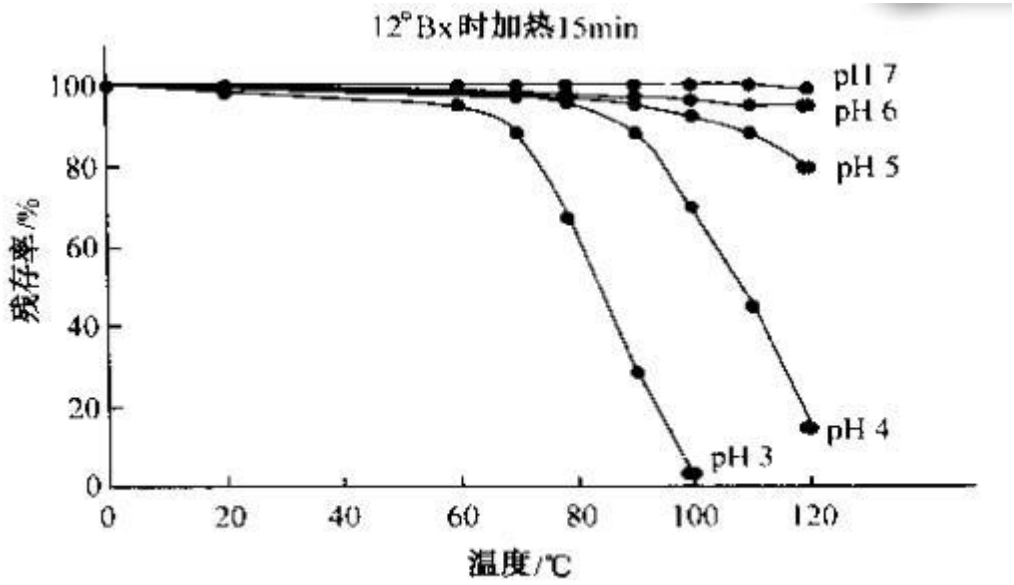


图 4－7　低聚果糖在不同 pH 时的热稳定性

Moisturizing properties

The moisturizing properties of fructooligosaccharide are similar to those of sorbitol and maltose, with higher moisturizing properties than sucrose. Even in low temperature environments, it will not significantly reduce its quality due to drying like granulated sugar. It has excellent water retention ability and is suitable for foods with long moisturizing time to ensure their shelf life; Good anti mold performance, which can extend the shelf life of feed.

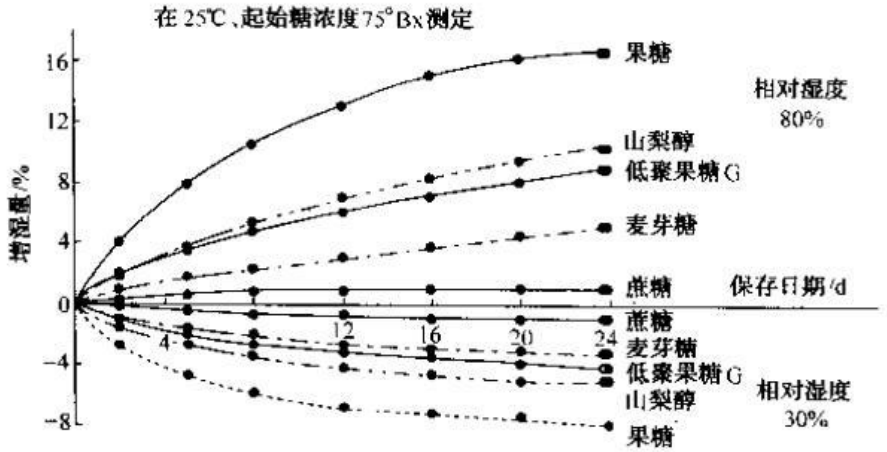


图 4－5 低聚果糖、果糖、山梨醇、麦芽糖和蔗糖在不同相对湿度下的水分含量

Storage stability

The stability of 12 ° Bx fructooligosaccharide under acidic conditions of pH 3 and pH 4 for 3 months at -25 ℃ to 40 ℃ is as follows. As shown in the figure, the stability of 12 ° Bx oligofructose is also very stable under pH 3 and pH 4 conditions for 3 months at temperatures below 20 ℃.

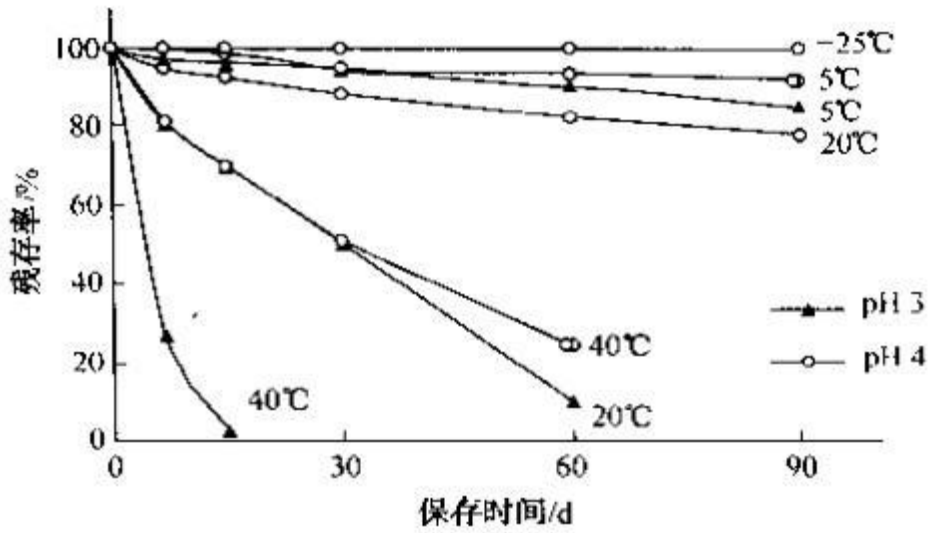


图 4－8　12°Bx 糖浆在酸性条件下的保存稳定性

01 Physical and chemical properties

Low calorie

Fructooligosaccharides are not broken down by α-amylase, sucrose invertase and maltase in the human body, and can not be used as energy by the human body and will not increase the blood sugar. Each gram of fructooligosaccharide contains only 1-2 Kcal/g of calories, so it is very suitable for diabetes patients and obese people to eat.

表 2　常见功能糖和糖醇的热量值

Table 2　Caloric value example of common functional sugars & alditols

名称	热量/(kcal/g)	名称	热量/(kcal/g)
山梨醇	2.4 ~ 3.3	甘露糖	2 ~ 4
木糖醇	1.0 ~ 3.5	低聚果糖	1 ~ 2
麦芽糖醇	2.0 ~ 2.8	葡萄糖	4
乳糖醇	1.2 ~ 2.2	低聚乳果糖	1.3
甘露醇	1.6	麦芽糖	3.3
异麦芽酮糖醇	2	蔗糖	3.89
赤藓糖醇	0.4	乳糖	3.6
氢化淀粉糖浆	2.8 ~ 3.2	异麦芽酮糖	4
棉子糖	1.4 ~ 1.5	大豆低聚糖	2
塔格糖	1.5	果糖	4

功能糖和糖醇的特性与应用

01 Physical and chemical properties

Reductivity (Maillard reaction)

The Maillard reaction has low chromaticity value and weak colorability.

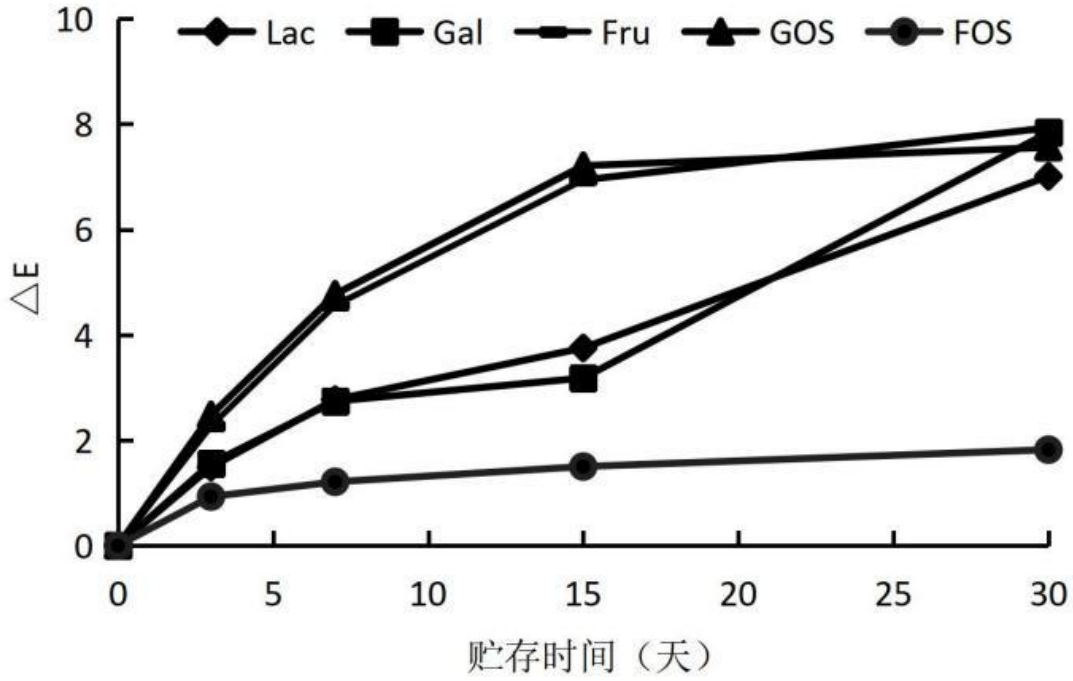


图 1- 7 WPI 与糖模拟美拉德反应体系总色差值变化

乳制品中常见单糖和低聚糖的美拉德反应 特性比较研究

01 Physical and chemical properties

Crystallinity

Difficult to crystallize, and when used in combination with other sugars, it also has the effect of preventing crystallization.

Nutritional

It is not hydrolyzed by human digestive enzymes and is non digestible and insulin independent. Fructooligosaccharide intake can effectively reduce the fasting blood glucose level, so it is very suitable for diabetes patients and obese people.

Anti caries teeth

FOS cannot be mutated as a fermentation substrate to generate insoluble glucans, and does not provide a place for oral microbial deposition, acid production, and corrosion (tartar). The amount of lactic acid generated by it is less than 50% of sucrose. Therefore, FOS is a functional sweetener with low corrosion and anti caries properties.

Shape forming, alkali resistance and aging resistance.

02 Physiologic function

1.Regulating the balance of the body's microbiota and promoting the proliferation of efficient bifidobacteria. Fructooligosaccharides are internationally recognized as a popular super bifid factor. Experiments have shown that after ingesting a certain amount of oligofructose, the number of beneficial bacteria in the human body, Bifidobacterium, can proliferate by 10-100 times. At the same time, organic acids such as acetic acid, lactic acid, propionic acid, butyric acid, etc. produced reduce the pH value in the intestine, inhibit the growth and reproduction of exogenous pathogenic bacteria and inherent spoilage bacteria in the intestine, reduce the growth and accumulation of spoilage substances in the intestine, improve the intestinal environment, promote intestinal peristalsis, and prevent constipation and diarrhea.

02 Physiologic function

2.Reduce blood lipids and cholesterol. FOS is an excellent water-soluble dietary fiber. Through the action of intestinal bifidobacteria, FOS can ferment to produce propionic acid, hinder cholesterol synthesis, promote cholesterol conversion to bile acid, increase bile acid excretion, and effectively reduce the amount of serum cholesterol, triglycerides, and free fatty acids. It has a good improvement effect on a series of cardiovascular diseases such as hypertension and arteriosclerosis caused by high blood lipids.

02 Physiologic function

3.Promote the synthesis of vitamins and enhance immunity.

FOS can promote the natural formation of various vitamins and folate, produce a large amount of immune substances such as S-TGA immune protein, effectively prevent bacteria from attaching to the host's intestinal mucosal tissue. A large amount of bifidobacteria can also strongly stimulate intestinal immune cells, increase the number of anti body cells, activate macrophage activity, and strengthen the human immune system.

02 Physiologic function

4.Protect the liver.

After absorbing fructooligosaccharide, bifidobacteria rapidly proliferate, inhibiting the formation of spoilage bacteria such as Escherichia coli, Salmonella, and Clostridium, reducing the generation of toxic metabolites, and rapidly expelling toxic metabolites from the body, reducing the burden on the liver and protecting the liver.

Moreover, ingesting oligofructose does not cause an increase in blood sugar and insulin levels;

02 Physiologic function

5.Promote the absorption of minerals and the elimination of toxic waste in the intestine.

Fructooligosaccharide has the function of combining dietary fiber with metal ions. In the acidic environment of the large intestine, the solubility of minerals such as calcium, magnesium, and zinc increases, and its bioavailability also improves. Fructooligosaccharides can maintain the water content of the intestinal wall, increase the moisture and acidity of the intestinal contents, and cultivate bifidobacterium intestinal wall to form a membrane protective barrier, thereby accelerating intestinal peristalsis and producing defecation reflex, which is conducive to the elimination of carcinogenic toxic waste such as indole and sentinel amines in the intestine.

6.Prevent dental caries.

Fructooligosaccharide cannot be used as a fermentation substrate by Streptococcus mutans to produce insoluble glucan, providing a place for oral microbial deposition, acid production, and corrosion (tartar). The lactic acid produced by oral acid producing bacteria when fermenting oligofructose is also much lower than that produced by fermenting sucrose. Therefore, it can prevent dental caries.

02 Physiologic function

7.Prevent obesity.

The three sugars and four sugars in sugarcane oligosaccharides are not hydrolyzed by enzymes in human saliva and digestive enzymes in the small intestine, making them difficult to digest and absorb, and have low calorific value. Therefore, intake of oligofructose does not cause obesity.

In addition to the above functions, oligofructose can also prevent facial sores, black spots, freckles, acne, and age-related spots, making the skin bright, aging slower, and having a cosmetic effect.

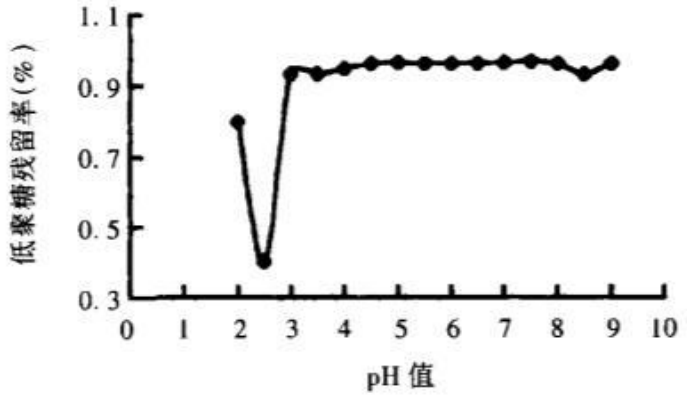
03 Effect of Acid Heat Conditions on the Stability of Fructooligosaccharides

Ultra high temperature instantaneous sterilization (135 ℃, 10-25 s) heat treatment has little effect on functional oligosaccharides under acidic, neutral, or alkaline conditions, making it a preferred process for adding oligosaccharide products for thermal sterilization.

The total functional oligosaccharide retention rate in oligofructose was 0.92 after heat treatment at 85 ℃ for 5-30 minutes using the pasteurization process.

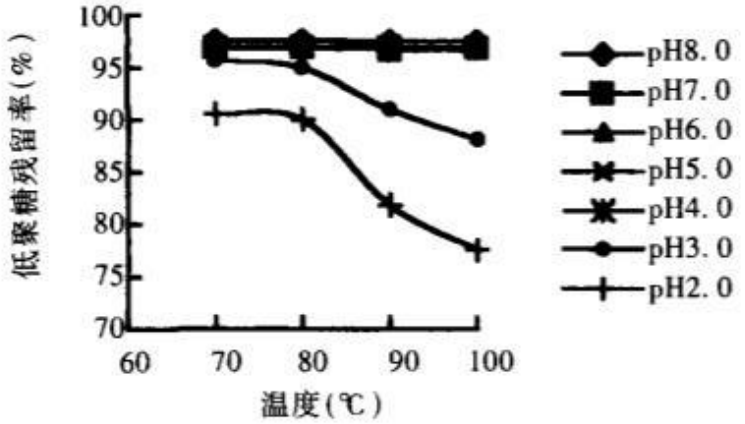
The high-temperature long-term sterilization (121 ℃, 10-25 minutes) heat treatment process may have a significant impact on the stability of oligosaccharides. After heat treatment at 121 ℃ for 25 minutes, under acidic conditions, the total functional oligosaccharide content in oligofructose decreased from 58% of the total sugar to 16%, with a retention rate of 0.27.

03 Effect of Acid Heat Conditions on the Stability of Fructooligosaccharides



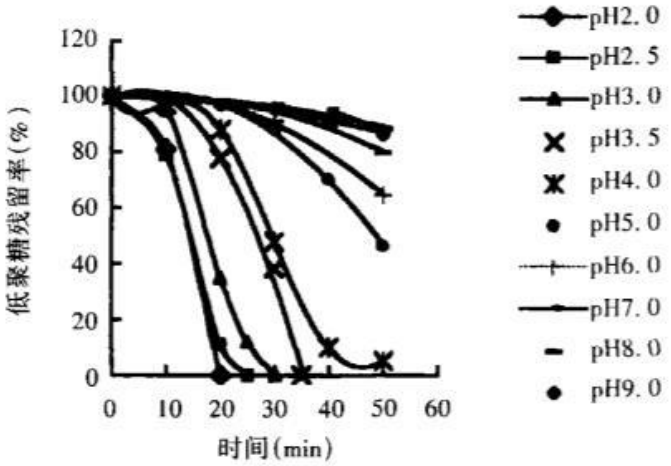
注：溶液低聚果糖浓度 12%，采用磷酸氢化钠－柠檬酸缓冲液（0.1mol/L）或磷酸氢二钠－磷酸二氢钾缓冲液（1/15mol/L）控制在 pH2～9 之间，巴氏杀菌：温度 62.5℃加热 30min

图 1　不同 pH 值溶液体系中低聚果糖在巴氏杀菌过程中的降解作用



注：溶液低聚果糖浓度 12%，采用缓冲液控制样品 pH2～9，加热时间 15min

图 2　不同 pH 值溶液体系中低聚果糖在常压——高温加热过程中的降解作用



注：12% 低聚果糖溶液，控制 pH2.0～9.0，在高压蒸汽消毒器内控制压力 1kg/cm²，加热 10～50min。

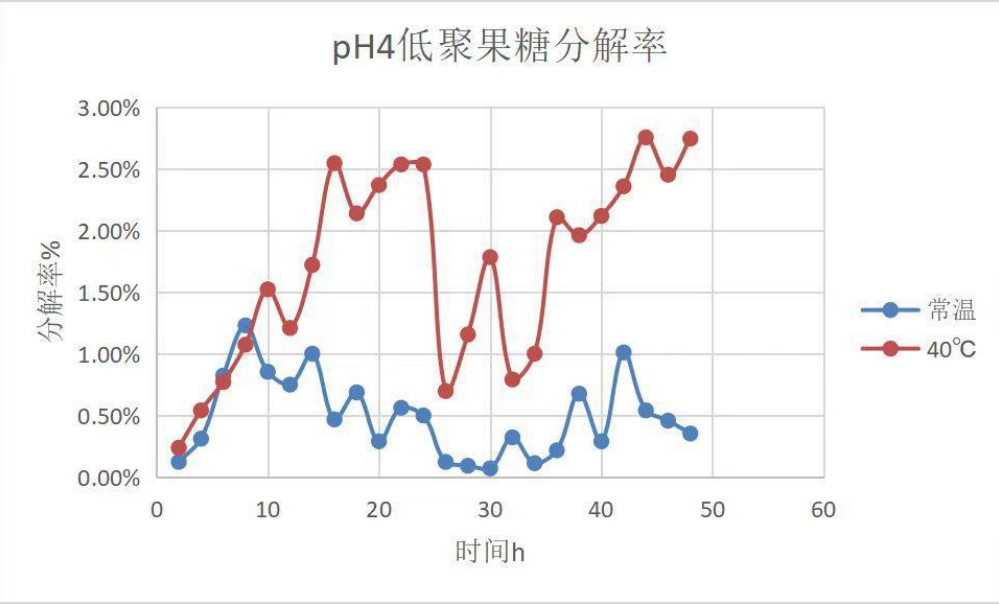
图 3　121℃杀菌过程中低聚果糖的降解作用

This study focuses on the stability of oligofructose during bread baking.

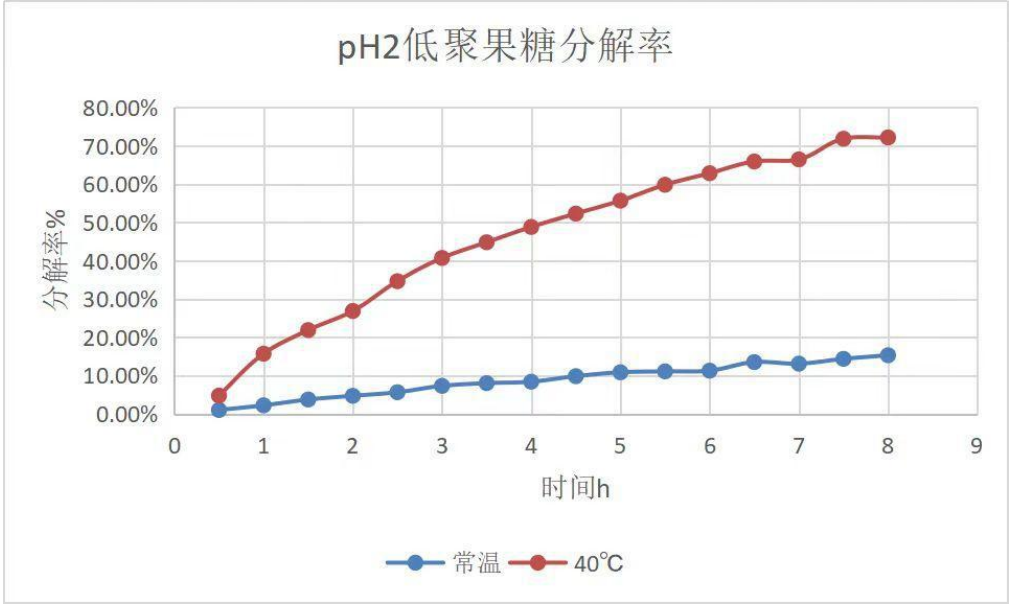
For pasteurization, oligofructose in a pH>3.0 solution system has good stability, and is highly unstable between pH 2 and 3; For high-temperature short-term treatment (70-100 ℃/0.25-15 min), the degradation rate of oligofructose in the pH 4-8 solution system is generally less than 3%. When pH<4, the stability significantly decreases with the increase of heating temperature and system acidity; For high-pressure sterilization (121 ℃/10-50min), the oligofructose in the solution is degraded to varying degrees within the pH 2-9 range. The stability of oligofructose is poor within the pH 2-4 range, and almost all of it is degraded after 20-50min. A considerable portion of it is also degraded in the pH 4-9 system.

03 Effect of Acid Heat Conditions on the Stability of Fructooligosaccharides

fructooligosaccharide decomposition rate(pH4)



fructooligosaccharide decomposition rate(pH2)



04 Application of fructooligosaccharide

Fructooligosaccharides have been widely used in food industries such as dairy products, health products, functional beverages, solid beverage candies, biscuits, bread, jelly, etc., as well as in the feed industry, pharmaceutical, beauty, and other industries.

In Japan, Fructooligosaccharides has been used as a swelling agent, sweetener, freshener, and wetting agent, and France has also approved the use of oligofructose as an additive in pig and rabbit feed.

Kurs Biotechnology Company in the United States has also partnered with Meiji Fruit Company in Japan to produce and sell oligofructose to meet the high demand of consumers.

04 Application of fructooligosaccharide

1.As a bifidobacterium growth promoting factor, applied in dairy products

In Taiwan, Japan, and other places, FOS is widely used in dairy products. This not only adds the function of oligofructose to the product, but also overcomes certain defects of the original product, making it more perfect.Adding fructooligosaccharide to lactobacillus milk and grain products can prolong the shelf life of the products; Enhance the good taste and flavor of dairy products, promote the absorption of nutrients in dairy products by the human body.

04 Application of fructooligosaccharide

2.Applied to health products.

Adding fructooligosaccharide to nourishing foods that enhance human immunity can not only enhance the efficacy of the product, but also reduce its internal heat.

Adding fructooligosaccharide to foods and health products that lower blood pressure and regulate blood lipids can not only improve the efficacy of the product, but also improve the taste and grade of the product.

04 Application of fructooligosaccharide

3.Applied to food for infants, young children, middle-aged and elderly people

After weaning, the number of bifidobacteria in the body of infants and young children will sharply decrease, leading to symptoms such as fever, constipation, diarrhea, and anorexia. Adding an appropriate amount of FOS to infant food can greatly improve this adverse phenomenon and also promote the absorption of nutrients by infants and young children;

04 Application of fructooligosaccharide

4.Functional beverages and wine, sake, and other fruit wine series.

As a unique low sugar, low calorific value, and difficult to digest sweetener, adding it to food can not only improve the taste of the product, reduce the calorific value of the food, but also extend the shelf life of the product.Adding oligofructose to weight loss foods can greatly reduce the calorific value of the product; In low sugar foods, oligofructose is less likely to cause an increase in blood sugar; Adding oligofructose to fruit flavored beverages and tea beverages can make the product taste more delicate, soft, and refreshing;Adding FOS to alcoholic products can adjust the taste of the product to eliminate acidity, bitterness, and astringency, improve clarity, and completely or partially replace sucrose and honey. At the same time, it can increase the functionality of the product, improve its efficacy and grade.

04 Application of fructooligosaccharide

5.Application in the feed industry

Safe feed additives and green feed additives will become hot and key areas of industry development. At present, oligosaccharides are mainly used as food ingredients, and their application as additives in feed has only recently emerged.A large number of research results have shown that oligofructose plays an important role in promoting animal growth, improving feed utilization, enhancing immunity, preventing diseases, improving animal fertility, and improving the environment.

04 Application of fructooligosaccharide

5.Other applications

In addition to the above applications, the value of oligofructose has gradually been reflected in the development of various industries: adding it as an adjunct to throat wetting sugar products can play a general sugar effect and prevent dental caries;As a beauty factor added to beauty foods and skincare products, it can enhance the beauty and skincare effects of the product; Adding oligofructose to baked foods can enhance product color, improve brittleness, and facilitate puffing;In addition, there has been some research and development in the application of medicine.