Operational Guidelines for the Addition Methods of Fructo-oligosaccharides in Applications

1. General Provisions

1.1 Purpose

To standardize the addition methods, operating procedures, dosage control and quality assurance of fructo-oligosaccharides in various application fields, ensure products meet process requirements, nutritional claims and relevant regulatory standards, improve production efficiency, reduce production risks, guarantee stable product quality, and fully exert the prebiotic and functional properties of fructo-oligosaccharides.

1.2 Scope of Application

This guideline applies to all production processes using fructo-oligosaccharides as a raw material in food, health food, feed and pet food, covering a full range of applications including beverages, dairy products, baked goods, meat products, confectionery, frozen food, condiments, health food, feed/pet food. It is intended for production operators, technicians, quality inspectors and relevant training purposes.

1.3 Reference Standards

Formulated in accordance with *National Food Safety Standard Standard for Uses of Food Additives* (GB 2760-2024), *National Food Safety Standard Dietary Fiber* (GB 28050), *Fructo-oligosaccharides* (GB/T 23528-2019) and production process specifications of related products, combined with the product characteristics of fructo-oligosaccharides.

2. Basic Characteristics of Fructo-oligosaccharides

The core prerequisite for guiding FOS addition is mastering its inherent properties, which determine the addition process, timing and dosage, as detailed below:

2.1 Physicochemical Properties

- **Solubility and Dispersibility**: Freely soluble in water; can be added directly as dry powder or dissolved in warm water. Excellent dispersibility, not easy to clump, shear-resistant, compatible with various food processing techniques such as homogenization, emulsification and mixing. A 10% aqueous solution is colorless and transparent.
- **Thermal and Acid Stability**: High temperature resistance, compatible with baking, sugar cooking, extrusion and high-temperature sterilization (121℃, 30min); extremely high acid resistance, stable in systems with pH≥2.0, suitable for acidic products such as fruit juice, yogurt and fruit vinegar, not easy to decompose and lose efficacy.
- **Basic Parameters**: Degree of polymerization 2–9 (calculated with fructose unit content ≥95%), dietary fiber, calorific value approx. 1.5 kcal/g (1/3 of sucrose, 1/6 of fat), sweetness 0.3–0.6 times that of sucrose, low hygroscopicity, pH of 10% aqueous solution 4.0–7.0, odorless with a clean taste.

2.2 Core Functional Properties

- **Dietary Fiber Fortification**: Serves as a high-quality source of water-soluble dietary fiber, supporting nutritional claims such as "high fiber" and "contains dietary fiber" without affecting product taste and flavor.
- **Texture Modification**: Provides mild thickening, stabilization, moisturization, anti-aging and ice crystal growth inhibition effects, improving product taste and texture, enhancing system stability and extending shelf life.
- **Health Functions**: Low calorie and low sweetness, can replace part of sugar and fat to achieve low-sugar, low-fat and low-calorie product positioning. Core prebiotic function: selectively proliferates beneficial bacteria such as intestinal Bifidobacterium and Lactobacillus, inhibits harmful bacteria, regulates intestinal flora balance, promotes intestinal peristalsis, suitable for functional product development.
- **Process Compatibility**: Strong compatibility, can be compounded with sugar alcohols, sugar substitutes, colloids, starches, probiotics and other raw materials without impairing their functions, suitable for production processes of various foods, health foods and feeds.

2.3 Safety and Compliance Requirements

Fructo-oligosaccharides are a nationally permitted food additive (functional categories: dietary fiber, prebiotic), complying with GB 2760-2024. It may be used appropriately according to production needs with no general limit requirements. It can be used in infant food, health food, ordinary food and feed/pet food. Usage shall comply with the compliance standards of corresponding products, ensure consistency between finished product nutrition labels and actual addition levels. Addition in infant food shall conform to relevant provisions of GB 28050.

3. General Specifications for Addition Process

In all application fields, FOS addition shall follow the general specifications below to ensure uniform addition, full dissolution, no impairment to product quality, and full retention of its prebiotic functions.

3.1 Pretreatment and Dissolution Methods

- **Direct Dry Powder Addition**: Suitable for solid mixed products (e.g., baking flour, solid beverages, compressed tablets, pet pellet feed).

Operating points: Pre-mix FOS evenly with other dry powder raw materials (flour, maltodextrin, sugar substitutes, etc.) in advance to ensure uniform dispersion and avoid local agglomeration before subsequent processing. Pre-mixing time is recommended to be no less than 5 minutes.

- **Aqueous Solution Preparation**: Suitable for liquid and emulsified products (e.g., beverages, dairy products, sauces, ice cream).

Operating points: Dissolve FOS in warm water at 40–50℃ at a ratio of 1:2.5–3.2 (FOS: softened water), stir for 15–25 minutes until the solution is completely clear, filter through 80–120 mesh before use to remove undissolved particles and impurities and avoid affecting product taste and appearance.

- **Compounding Principles**: Prioritize compounding with sugar alcohols (sorbitol, maltitol), sugar substitutes (steviol glycosides), colloids (xanthan gum, pectin) to enhance functional effects and system stability. Avoid direct contact with strong oxidants and high-concentration heavy metal ions. In strongly

acidic systems with pH<3.0, verify FOS stability in advance; adjust pH or use refined-grade products if necessary.

3.2 General Key Points for Addition Procedures

- **Addition Timing**: Select appropriate addition nodes according to product process characteristics. The core principle is "ensure full dissolution/dispersion and avoid functional loss caused by prolonged high-temperature heating". For probiotic products, addition at low-temperature stages is recommended.
- **Stirring Requirements**: Stir thoroughly after addition. Stirring speed for liquid systems: 800–1200 r/min. Stir solid systems until no obvious clumping and uniform mixing to ensure consistent FOS distribution in the system.
- **Metering Requirements**: Use precise metering equipment (electronic scales, metering pumps, etc.) to strictly control addition levels per formula, avoiding product quality anomalies, inconsistent nutritional claims or insufficient prebiotic functions caused by metering deviations.

3.3 General Quality Control Standards

- **Solubility**: Dissolved solution is clear and transparent without precipitation or visible particles. No FOS agglomeration in solid products; mixing uniformity complies with relevant standards.
- **Sensory Requirements**: Does not affect original product flavor and color, no off-odors or abnormal color changes, and may moderately enhance clean mouthfeel.
- **Nutritional Control**: Finished product dietary fiber content meets formula requirements and nutrition label specifications. Prebiotic products shall ensure effective FOS content meets standards, guaranteeing authentic and valid claims such as "high fiber", "contains dietary fiber" and "prebiotic".

4. Field-Specific Addition Process Guidance

Based on product characteristics and production processes in each field, clear FOS addition levels, procedures, operating points and functional objectives are defined to ensure direct implementation and full utilization of its prebiotic and functional value.

4.1 Beverages (Liquid & Solid Beverages)

4.1.1 Applicable Products

Fruit juice drinks, carbonated drinks, sports drinks, functional drinks, solid beverages, meal replacement powders, fruit vinegar drinks, etc.

4.1.2 Addition Levels

Liquid beverages: 0.8%–5%; solid beverages: 6%–25% (based on total formula mass). May be appropriately increased to 3%–8% for prebiotic functional drinks.

4.1.3 Addition Procedures & Operating Points

- **Liquid beverages**: Add during batching. Dissolve FOS in warm water at 40–50℃ at 1:2.5–3.2, filter and add to batching tank, mix evenly with sweeteners, stabilizers, flavors, fruit juice and other raw materials. Homogenize at 18–28 MPa before sterilization (pasteurization or UHT). UHT temperature ≤135℃,

duration ≤5 seconds to avoid prebiotic degradation from prolonged heating.

- **Solid beverages**: Add during dry mixing. Pre-mix FOS evenly with maltodextrin, sugar substitutes, vitamins, minerals and other dry powders for at least 5 minutes before granulation, drying, tableting or other processes to ensure good solubility, no clumping and no precipitation after reconstitution.

4.1.4 Functional Objectives & Notes

- **Objectives**: Fortify dietary fiber, exert prebiotic effects, improve beverage taste (enhance cleanliness), reduce calorie and sweetness, support "sugar-free/low-sugar" and "prebiotic" positioning, improve system stability.
- **Notes**: Complete FOS dissolution before carbonation in carbonated drinks to avoid affecting aeration and taste. Use refined-grade FOS for acidic drinks (pH<3.0) to prevent sour taste or functional loss. Control sterilization temperature and time for prebiotic drinks to maximize FOS activity retention.

4.2 Dairy Products (Liquid Milk, Yogurt, Milk Powder, Soy Milk)

4.2.1 Applicable Products

Pure milk, flavored milk, fermented yogurt, yogurt drinks, infant milk powder, middle-aged and elderly milk powder, soy milk, cheese, etc.

4.2.2 Addition Levels

0.8%–6% (based on total formula mass). Infant milk powder: 1%–3%; fermented yogurt: up to 3%–8%.

4.2.3 Addition Procedures & Operating Points

- **Liquid milk/soy milk**: Add during batching. Dissolve FOS and add to batching tank, mix evenly with milk/soy milk, stabilizers and sweeteners. Homogenize at 22–32 MPa, sterilize (≤121℃, ≤30 min) and fill.
- **Yogurt/yogurt drinks**: Prefer post-fermentation addition. Mix dissolved FOS with yogurt after fermentation, homogenize and fill to avoid affecting probiotic activity. If added before fermentation, limit dosage to ≤5% and add separately from starter cultures to reduce impact on fermentation efficiency.
- **Milk powder**: Add during dry mixing. Pre-mix FOS evenly with milk powder, maltodextrin, nutrients and test mixing uniformity before packaging to prevent moisture absorption and clumping.

4.2.4 Functional Objectives & Notes

- **Objectives**: Synergize with probiotics to regulate intestinal health, fortify dietary fiber, enhance nutrition label value, improve dairy taste (reduce cloying sweetness) and stability, extend shelf life, support "prebiotic" and "high fiber" positioning.
- **Notes**: Limit pre-fermentation FOS to ≤5% to avoid affecting fermentation and viscosity. Test mixing uniformity after pre-mixing in milk powder production. Strictly follow GB 28050 and infant food standards for infant formula.

4.3 Baked Goods (Bread, Pastry, Biscuits, Dried Noodles)

4.3.1 Applicable Products

Toast, cakes, biscuits, mooncakes, dried noodles, steamed buns, pastry fillings, etc.

4.3.2 Addition Levels

0.8%–12% (based on flour mass), replacing 6%–22% of flour or sugar. Pastry fillings: 8%–15%.

4.3.3 Addition Procedures & Operating Points

- **Bread/cake**: Add during dry mixing. Pre-mix FOS with flour, yeast, sugar, oil, then add water and egg liquid for dough mixing at 28–32℃. Fermentation time may be shortened by 10%–15%. Bake at 170–210℃, adjust time by product size to avoid prolonged high heat.
- **Biscuits**: Add during dry mixing. Pre-mix FOS with flour, butter, sugar, leavening agents, add small amount of water to form dough, rest, sheet and mold. Bake at 150–170℃ to ensure crispness; avoid excessive addition causing softness.
- **Dried noodles**: Pre-mix FOS with flour and starch, add water to form dough, calendar, cut and dry to improve toughness, reduce breakage and pasting during cooking.

4.3.4 Functional Objectives & Notes

- **Objectives**: Improve dough water retention and fermentation, soften finished products, delay staling, extend shelf life; reduce calories and sweetness, fortify dietary fiber, improve texture, support “low-sugar” and “high fiber” positioning.
- **Notes**: Adjust water volume and mixing time if addition exceeds 12%. Compounding with colloids improves crispness in biscuits. Baking temperature ≤220℃ to prevent caramelization.

4.4 Meat Products (Ham, Sausage, Canned Meat, Fillings)

4.4.1 Applicable Products

Low-temperature ham, high-temperature sausage, canned meat, meatballs, dumpling fillings, bun fillings, etc.

4.4.2 Addition Levels

3%–22% (based on meat emulsion mass). Up to 25% as fat replacer. Fillings: 5%–15%.

4.4.3 Addition Procedures & Operating Points

- **Ham/sausage**: Add during chopping/emulsification. Chop meat emulsion to viscous consistency at medium-high speed, add dissolved FOS and continue chopping 6–12 minutes for full emulsification. Add seasonings, mix, encase and sterilize (≤121℃).
- **Canned meat/meatballs**: Add during emulsification. Mix meat emulsion, FOS, starch and salt, emulsify, mold and cook to reduce water loss and improve tenderness.
- **Fillings**: Mix FOS with meat, vegetables, starch and water to improve water retention and moldability, reduce exudation during cooking.

4.4.4 Functional Objectives & Notes

- **Objectives**: Act as water-retaining agent and fat replacer, reduce moisture and fat loss during cooking/freezing, improve tenderness and yield, achieve low-fat positioning; fortify dietary fiber and provide mild prebiotic effects.
- **Notes**: Control chopping temperature ≤10℃ to prevent spoilage. Adjust dosage based on fat content. Avoid prolonged sterilization.

4.5 Confectionery & Chocolate (Hard Candy, Soft Candy, Gum Base, Chocolate)

4.5.1 Applicable Products

Hard candy, soft candy, nougat, chewing gum base, chocolate, jelly, etc.

4.5.2 Addition Levels

Hard/soft candy: 3%–12%; gum base/jelly: 10%–15%; chocolate: 6%–12%. Sugar-free candy: up to 8%–15%.

4.5.3 Addition Procedures & Operating Points

- **Hard/soft candy**: Add during sugar cooking. Boil sugar and water, add FOS and sugar alcohols, cook to target temperature (hard candy 145–155℃, soft candy 105–115℃), mix, cool and mold to inhibit crystallization and improve transparency.
- **Gum base**: Add after softening. Heat gum base to 60–80℃, mix with FOS, sweeteners and flavors, sheet and mold to improve chewiness and clean taste.
- **Chocolate**: Add after cocoa butter melting. Mix cocoa butter, cocoa powder, sugar and FOS, homogenize, temper, mold and cool to replace part of fat and sugar, reduce calories and improve smoothness.

4.5.4 Functional Objectives & Notes

- **Objectives**: Inhibit sugar crystallization, improve texture (chewiness, smoothness, cleanliness), reduce sweetness and calories, fortify dietary fiber, support “sugar-free/low-sugar” and “prebiotic” positioning.
- **Notes**: Cooking temperature ≤160℃ to avoid caramelization. Ensure full dissolution in chocolate. Compounding with pectin improves gel stability in soft candy.

4.6 Frozen Food (Ice Cream, Sorbet, Frozen Dough)

4.6.1 Applicable Products

Ice cream, sorbet, frozen glutinous rice balls, frozen dumplings, frozen bread dough, etc.

4.6.2 Addition Levels

0.8%–6% (based on total formula mass). Ice cream: 3%–8%; frozen dough: 1%–5%.

4.6.3 Addition Procedures & Operating Points

- **Ice cream/sorbet**: Add during batching. Dissolve FOS and mix with milk, cream, sugar and stabilizers, homogenize (18–28 MPa), sterilize, cool, age (4–6℃, 4–8 h), freeze and store to inhibit ice crystals and improve smoothness.
- **Frozen dough**: Add during dry mixing. Pre-mix FOS with flour, yeast, sugar and oil, add water to form dough, mold and quick-freeze (≤-18℃) to improve water retention and fermentation performance after thawing.

4.6.4 Functional Objectives & Notes

- **Objectives**: Inhibit ice crystal growth, improve smoothness, reduce quality loss during freezing/thawing, extend shelf life; reduce fat for low-fat positioning, fortify dietary fiber and provide prebiotic effects.
- **Notes**: Ensure sufficient aging time. Frozen dough storage ≤-18℃, avoid repeated thawing. Compounding with stabilizers enhances stability.

4.7 Condiments (Sauces, Hot Pot Base, Soup Mix, Soy Sauce)

4.7.1 Applicable Products

Tomato sauce, salad dressing, hot pot base, soup packets, soy sauce, oyster sauce, condiment pastes, etc.

4.7.2 Addition Levels

6%–18% (based on total formula mass). Soup packets/soy sauce: 5%–12%; hot pot base: 10%–20%.

4.7.3 Addition Procedures & Operating Points

- **Sauces/hot pot base**: Add during emulsification. Emulsify oil, water and base at medium-high speed, add dissolved FOS and emulsify 12–18 minutes, add seasonings, sterilize (≤121℃) and fill.
- **Soup/soy sauce**: Add during batching. Dissolve FOS and add to mixing or fermentation tank, mix, cook, filter, sterilize and package to enhance flavor and reduce salty cloying.

4.7.4 Functional Objectives & Notes

- **Objectives**: Thicken and stabilize systems, improve water retention and cling, reduce salty cloying, fortify dietary fiber, enhance health attributes and extend shelf life.
- **Notes**: Control emulsification temperature and speed to prevent separation. Add post-fermentation for fermented products. Compounding with colloids improves viscosity in hot pot base.

4.8 Health Food (Capsules, Tablets, Granules, Oral Liquids)

4.8.1 Applicable Products

Dietary fiber capsules/tablets, meal replacement granules, intestinal health oral liquids, prebiotic preparations, etc.

4.8.2 Addition Levels

0.8%–60% (based on total formula mass). Daily intake: 3–10 g. Prebiotic preparations: 40%–60%.

4.8.3 Addition Procedures & Operating Points

- **Capsules/tablets**: Add during dry mixing. Pre-mix FOS with microcrystalline cellulose, magnesium stearate, etc., granulate, dry, tablet or encapsulate to ensure good moldability and qualified disintegration time.
- **Granules/oral liquids**: Granules follow solid beverage process. Oral liquids: dissolve and filter FOS, mix with functional ingredients (probiotics, vitamins), homogenize, sterilize (≤100℃) and fill to protect active components.

4.8.4 Functional Objectives & Notes

- **Objectives**: Supplement dietary fiber, exert prebiotic effects, regulate intestinal health, assist glycemic and lipid control, support intestinal motility, fit dietary fiber and intestinal health positioning.
- **Notes**: Control daily intake to avoid intestinal discomfort. Adjust dosage for tablet hardness and disintegration. Avoid direct mixing with strong acids.

4.9 Feed & Pet Food (Pellet Feed, Dry & Wet Pet Food)

4.9.1 Applicable Products

Livestock and poultry pellet feed, aquafeed, dry pet food, wet pet food, pet snacks, etc.

4.9.2 Addition Levels

1.5%–12% (based on total formula mass). Livestock feed: 1.5%–8%; pet food: 5%–12%.

4.9.3 Addition Procedures & Operating Points

- **Pellet feed**: Add during dry mixing. Pre-mix FOS with corn flour, soybean meal, fish meal, extrude at 120–150℃ and dry to improve pellet moldability and moisture resistance.
- **Pet dry/wet food**: Dry food follows pellet feed process. Wet food: dissolve FOS during batching, mix with meat, vegetables and nutrients, sterilize (≤121℃) and fill.

4.9.4 Functional Objectives & Notes

- **Objectives**: Supplement dietary fiber, improve intestinal health, digestibility and immunity; act as binder to improve moldability and shelf life; enhance palatability for sensitive pets.
- **Notes**: Ensure uniform mixing. Control dosage in wet food to avoid diarrhea. Use water-resistant FOS in aquafeed.

5. Common Problems & Solutions

5.1 Incomplete Dissolution, Precipitation/Particles

- Causes: Low water temperature, insufficient stirring, direct addition without pre-mixing, raw material impurities, improper dissolution ratio.
- Solutions: Use 40–50°C water, stir 15–25 minutes; pre-mix solids, filter liquids through 80–120 mesh; adjust ratio to 1:2.5–3.2 (FOS: water).

5.2 Sour Taste or Off-Odor

- Causes: Regular-grade FOS, excessively low pH, excessive dosage, incompatible raw materials.
- Solutions: Use refined-grade FOS; adjust pH to 4.0–7.0; compound with sweeteners; reduce dosage.

5.3 Abnormal Texture (Hard, Soft, Sticky)

- Causes: Improper dosage, no compounding with colloids/starch, unsuitable process parameters.
- Solutions: Optimize dosage; compound with colloids/starch; adjust temperature, time and shear speed.

5.4 Inconsistent Nutrition Label & Claims

- Causes: Metering deviation, insufficient addition, testing errors, substandard raw material purity.
- Solutions: Use precise metering; use purity ≥95% FOS; test finished products; calibrate equipment regularly.

5.5 Phase Separation or Syneresis During Shelf Life

- Causes: Uneven dispersion, insufficient homogenization, insufficient stabilizers, improper storage.
- Solutions: Ensure full dissolution/dispersion; optimize homogenization; increase stabilizers; control temperature and humidity.

5.6 Insufficient Prebiotic Function

- Causes: Prolonged high heat, insufficient addition, expired raw materials, contact with oxidants.
- Solutions: Control sterilization conditions; ensure full dosage; use within shelf life; avoid oxidants.

6. Storage & Transportation Requirements

6.1 Storage Requirements

- Store sealed in cool, dry, ventilated warehouse: temperature ≤25°C, relative humidity ≤60%, avoid moisture, sunlight and high temperature (clumping above 30°C).
- Separate from toxic, harmful and odorous materials to prevent contamination. Stack height limited; keep ≥10 cm from floor and walls.
- Shelf life: 18–24 months (unopened). Expired materials prohibited. Use within 1 month after opening; reseal to prevent moisture absorption.

6.2 Transportation Requirements

- Avoid sunlight, rain and moisture; transport at 5–30℃ to prevent package damage.
- Use clean, dry, odorless vehicles; separate from hazardous materials.
- Handle gently during loading/unloading; avoid impact, extrusion and dust emission.

7. Operational Safety Requirements

- Operators must wear PPE (mask, gloves, work clothes, cap) before work to avoid dust inhalation and skin contact. In case of inhalation, leave the scene, gargle and receive oxygen if needed.
- Maintain good ventilation during dissolution and stirring; prevent burns when operating high-temperature equipment with heat-resistant gloves and goggles.
- Take anti-static measures (anti-static clothing, grounding) due to flammable FOS dust.
- Dispose of waste (undissolved particles, packaging) per environmental regulations.
- Follow equipment operating procedures; stop and report malfunctions or abnormal raw materials (clumping, odor, discoloration).