

ACNFP Advice on the safety of 3-fucosyllactose (3-FL) as a novel food

Reference Number RP1202

Food Standards Agency (FSA) and Food Standards Scotland (FSS)

Regulated Product Dossier Assessment Version 2.0

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Summary

An application was submitted to the Food Standards Agency (FSA) and Food Standards Scotland (FSS) in July 2021 from Glycom A/S, Denmark (“the applicant”) for the authorisation of 3-fucosyllactose (3-FL) as a novel food.

The novel food is 3-FL which is intended to be used as a source of human identical milk oligosaccharides. 3-FL is manufactured by microbial fermentation using a genetically modified strain of *Escherichia coli* K-12, and then refined to yield the purified novel food.

This new application is seeking to use the novel food within the food following categories: dairy products and analogues, bakery wares, foods for special groups, beverages, and also as a food supplement. Food supplements are not intended to be used if other foods with added 3-FL or breast milk are consumed the same day.

To support the FSA and FSS in their evaluation of the application, the Advisory Committee on Novel Foods and Processes (ACNFP) were asked to review the safety dossier and supplementary information provided by the applicant. The Committee concluded that the applicant had provided sufficient information to assure the novel food, 3-FL, was safe under the proposed conditions of use. The anticipated intake levels and the proposed use in foods and food supplements was not considered to be nutritionally disadvantageous and does not mislead consumers.

1. Introduction

1. To support the risk assessment, the ACNFP provided the advice outlined in this opinion to the FSA and FSS.

2. Following the review by the ACNFP at their meeting in June 2022, further clarification was requested concerning the production process of 3-FL, in order to address information gaps in the dossier. The assessment was completed at the 157th meeting, following the review of the information provided.

3. This document outlines the conclusions of the ACNFP on the safety of 3-FL as a novel food.

2. Assessment

2.1 Identity of novel food

4. The novel food is 3-fucosyllactose (3-FL) which is a purified white to off-white powder or agglomerate containing $\geq 90\%$ 3-FL by dry weight. Due to the presence of other saccharides present in smaller quantities, the total saccharide content of the novel food is $\geq 92\%$ by dry weight.

5. 3-FL is a trisaccharide consisting of D-galactose, D-glucose and L-fucose (see Diagram 1). 3-FL is characterised by the chemical formula: $C_{18}H_{32}O_{15}$; molecular mass: 488.44 g/mol; CAS number: 41312-47-4; IUPAC name: β -D-Galactopyranosyl-(1 \rightarrow 4)-[α -L-fucopyranosyl-(1 \rightarrow 3)]-D-glucose.

Diagram 1: The molecular structure of 3-FL

6. Confirmation that the 3-FL in the novel food, is equivalent to 3-FL found in human breast milk was provided by comparative nuclear magnetic resonance (NMR) spectroscopy: 1H -NMR, ^{13}C -NMR and 2D Nuclear Overhauser Effect spectroscopy (NOESY) analysis.

7. Information to support this characterisation was provided for eight batches of the novel food: four batches of crystallised 3-FL and four batches of non-crystallised 3-FL.

2.2 Production Process

8. The production microorganism used to manufacture the novel food is a genetically modified derivative of *E. coli* K-12 DH1 MDO that functions as a processing aid as defined in Article 3(2)(b) of Regulation (EC) No.1333/2008 on food additives, as retained in UK law. A novel food produced by a GMO does not fall under the remit of the GMO legislation, Regulation (EC) No 1829/2003, as retained in UK law, or Regulation (EC) No 1830/2003, as retained in UK law, when the production microorganism, *E. coli* K-12, is removed during the manufacturing process and therefore no recombinant DNA remains. This has been confirmed in the compositional analysis as detailed below.

9. The novel food is classified as category 1 under the EFSA GMO guidance: chemically defined purified compounds and their mixtures in which both genetically modified microorganisms (GMMs) and newly introduced genes have been removed, under EFSA guidance which categorises GMMs and their products for risk assessment purposes (EFSA GMO Panel, 2011), which the FSA have retained for the purposes of technical review.

10. The microorganism, *E. coli* K-12, has not been adopted into the Qualified Presumption of Safety list; however, other human identical milk oligosaccharides manufactured using the same strain of microorganism are present in the List of Novel Foods, Regulation (EU) 2017/2470, as retained in UK law. This includes 2'-FL, LNnT (Lacto-*N*-neotetraose), 2'-FL/DFL (difucosyllactose), LNT (Lacto-*N*-tetraose), 3'-SL (3'-sialyllactose sodium salt) and 6'-SL (6'-sialyllactose sodium salt).

11. Information on the hazard identification, hazard characterisation, and exposure assessment for the genetically modified derivative of *E. coli* K-12 DH1 MDO was provided in line with EFSA guidance (EFSA GMO Panel, 2011).

12. Stage 1 of the production process involves the conversion of D-lactose and D-glucose (D-sucrose or glycerol are alternatives to D-glucose) to 3-FL by the adapted cellular metabolism of the production microorganism. Glucose acts as an exclusive energy and carbon source, and lactose as a substrate for the biosynthesis of 3-FL. The 3-FL is released from the *E. coli* K-12 into the fermentation broth. At the end of the fermentation, the *E. coli* K-12 is removed by filtration (see Diagram 2).

Diagram 2: Overview of the Manufacturing Process for 3'-FL

Stage 1 Upstream Processing (USP)

	1	Media Preparation
	2	Propagation
Steps	3	Seed Fermentation
	4	Fermentation Phases
	5	Removal of microorganism*

Stage 2 Downstream Processing (DSP)

	6	Purification/Concentration 1*
	7 ^a	Ion Removal
	8 ^a	Decolourisation
Steps	9	Purification/Concentration 2*
	OP	Crystallisation
	10	Drying
	11	Sampling and Packaging
	12	Quality Control & Batch Release

OP = optional stage

a The order of steps is interchangeable.

* After the marked steps additional sterile filtration (microfiltration) is performed to maintain low microbial load during all times of downstream processing and to ensure high microbial quality of the final ingredient. These steps are further reassurance of absence of the production microorganism in final ingredient.

13. Stage 2 of the production process involves a series of purification and isolation steps to generate the final high-purity ingredient (see Diagram 2). The crystallisation step with acetic acid is optional, but can be used to minimise certain carbohydrate impurities in the finished product.

14. The certificates of analysis for the raw materials and the processing aids used in the manufacture of the novel food are provided. D-Glucose, D-lactose, D-sucrose and glycerol are food grade. The 'glucose' contains $\geq 99.5\%$ glucose. The 'lactose' contains $\geq 99\%$ lactose with lactulose (0.05% maximum) and protein (0.2% maximum). The 'sucrose' contains $\geq 71\%$ sucrose with inverted sugar (0.5% maximum). The 'glycerol' contains $\geq 98\%$ glycerol with moisture content $\leq 5\%$.

15. The novel food is produced in compliance with current Good Manufacturing Practice (cGMP) and the principles of Hazard Analysis Critical Control Point (HACCP). Manufacturing by-products, impurities and contaminants from the fermentation broth are monitored. Analysis from manufacturing batches did not detect significant levels of biogenic amines or amino acids and their metabolites in the final product.

16. The absence of bacteria from the *Enterobacteriaceae* family (ISO 21528-1:2004, MSZ ISO 21528-2:2004) and residual bacterial DNA (*hutC* assay; *marC* assay; 23S assay: LOQ = 4 $\mu\text{g}/\text{kg}$ for all assays) confirms the genetically modified *E. coli* K-12 is not present in the novel food.

17. Analytical data from eight batches of novel food, four batches of non-crystallised 3-FL and four batches of crystallised 3-FL, confirmed the presence of very low levels of microbial endotoxins and proteins (Table 1).

Table 1: Batch results for microbial endotoxins and residual proteins in the novel food

Parameter	Batch 1	Batch 2	Batch 3	Batch 4	Batch 5	Batch 6	Batch 7	Batch 8
Residual endotoxins (EU/mg)	0.0066	0.0122	0.0016	0.0003	0.0498	0.0110	0.0007	0.0077
Residual protein by Bradford assay (w/w %)	0.0017	0.0017	0.0017	0.001	0.0017	0.0017	0.00405	0.0017

Aflatoxin M1 (µg/kg)	0.02	0.02	0.02	NT	0.02	0.02	0.02	NT
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Batches 1 – 4 Non-crystallised 3-FL; Batches 5 – 8 Crystallised 3-FL

NT = not tested

18. The production process has characterised the potential hazards and detailed the corresponding control measures sufficiently.

2.3 Compositional Information

19. Results from eight independent batches of the novel food, four batches of non-crystallised 3-FL and four batches of crystallised 3-FL, demonstrated that the carbohydrate content consistently meets the proposed specification levels (Table 2).

Table 2: The carbohydrate content of the novel food

Parameter	Batch 1	Batch 2	Batch 3	Batch 4	Batch 5	Batch 6	Batch 7	Batch 8
Identification by Retention Time	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Assay (water-free) - Specified saccharides^a [%]	96.2	98.5	96.3	95.4	93.8	95.9	97.4	96.5
Assay (water-free) - 3-FL [%]	93.36	97.45	92.11	94.63	93.23	95.77	97.44	96.51
L-Fucose [%]	0.13	0.16	0.39	0.23	0.11	0.03	0.03	0.03

D-Lactose [%]	2.15	0.29	3.40	0.36	0.30	0.03	0.03	0.03
3-Fucosyl-lactulose [%]	0.57	0.56	0.39	0.18	0.12	0.11	0.03	0.03
Sum of other carbohydrates [%]	0.46	0.73	0.82	1.76	2.70	1.52	0.75	0.98
pH in 5% solution (20°C)	4.6	5.7	5.7	5.5	3.7	3.8	3.9	3.9
Water	3.60	3.23	3.49	2.41	0.14	0.18	0.04	0.01
Sulphated ash	0.01	0.01	0.01	0.10	0.01	0.01	0.01	0.01
Acetic acid ^b	NA	NA	NA	NA	0.5	0.3	0.1	0.1

Batches 1 – 4 Non-crystallised 3-FL; Batches 5 – 8 Crystallised 3-FL

Specification Limits: RT of main component corresponds to RT of standard \pm 3%; Specified saccharides \geq 92.0% w/w; 3-FL \geq 90.0% w/w; L-fucose \leq 1.0% w/w; D-lactose \leq 5.0% w/w; 3-fucosyl-lactulose \leq 1.5% w/w; sum of other carbohydrates \leq 5.0% w/w;; pH in 5% solution (20°C) – 3.2 to 7.0; water \leq 6.0% w/w; sulphated ash \leq 5.0% w/w; acetic acid \leq 1.0% w/w

a Specified saccharides include 3-fucosyllactose, D-lactose, L-fucose and 3-fucosyl-lactulose.

b Relevant only for 3-FL crystallised with acetic acid.

20. L-Fucose and D-lactose are recognised constituents of human breast milk. Consumer exposure to L-fucose is expected to be negligible, and not biologically or nutritionally relevant. The 3-fucosyl-lactulose is formed by a recognised isomerisation reaction in carbohydrates, but the level is considered to be negligible. This particular oligosaccharide is a recognised impurity in other human

identical milk oligosaccharides such as 2'-FL, LNnT, 2'-FL/DFL, LNT, 3'-SL and 6'-SL, which are present in the Union List of Novel Foods, Regulation (EU) 2017/2470, as retained in UK law.

21. The batch results for the non-carbohydrate residues showed that the pH of the crystallised 3-FL is lower than the non-crystallised 3-FL. This is due to the presence of acetic acid residues from recrystallisation and not expected to be a cause for concern under the proposed conditions of use.

22. The fermentation medium contains minerals and trace elements, with trace metals functioning as co-factors for different enzymes. The results from eight independent batches of the novel food, four batches of non-crystallised 3-FL and four batches of 3-FL of the novel food, demonstrated the filtration and purification steps remove these minerals and trace elements to very low levels (Table 3). Analytical data also confirmed the levels of heavy metals were either below the limit of detection or present in very low levels.

Table 3: The content of heavy metals, minerals and trace elements in the novel food

Parameter	Batch 1	Batch 2	Batch 3	Batch 4	Batch 5	Batch 6	Batch 7	Batch 8
Arsenic (mg/kg)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Cadmium (mg/kg)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Mercury (mg/kg)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Copper (mg/kg)	0.2	0.3	0.5	0.1	0.1	0.1	0.1	0.1
Lead (mg/kg)	0.01	0.01	0.01	0.05	0.01	0.01	0.01	0.01

Chloride (w/w%)	0.010	0.001	0.001	0.012	0.009	0.005	0.004	0.004
Iron (mg/kg)	0.5	0.1	0.5	10	0.6	2	0.5	0.5
Potassium (w/w%)	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001
Sodium (w/w%)	0.010	0.006	0.007	0.011	0.003	0.001	0.001	0.001
Sulphate (w/w%)	0.0024	0.0004	0.004	0.0239	0.0051	0.0043	0.004	0.005
Zinc (mg/kg)	0.4	0.1	0.1	0.5	0.2	0.1	0.1	0.1

Batches 1 – 4 Non-crystallised 3-FL; Batches 5 – 8 Crystallised 3-FL

Manganese (0.1 mg/kg); nickel (0.1 mg/kg); ammonium (0.005 w/w%); calcium (0.001 w/w%); magnesium (0.001 w/w%); phosphorous (0.0005 w/w%); molybdenum (0.2 mg/kg); selenium (0.1 mg/kg) – reported values that were below the limit of detection for all batches of the novel food

23. Analytical data concerning the microbiological content from eight independent batches of the novel food, four batches of non-crystallised 3-FL and four batches of 3-FL, of the novel food were reported (Table 4). The results confirm that the novel food consistently meets the proposed specification levels.

Table 4: The microbiological analysis of the novel food

Parameter	Batch 1	Batch 2	Batch 3	Batch 4	Batch 5	Batch 6	Batch 7	Batch 8
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Aerobic mesophilic total plate count ($\leq 1,000$ CFU/g)	10	10	10	10	10	10	10	10
Enterobacteriaceae (absent in 10g)	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
<i>Salmonella</i> (absent in 25 g)	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Yeasts (≤ 100 CFU/g)	10	10	10	10	10	10	10	10
Moulds (≤ 100 CFU/g)	10	10	10	10	10	10	10	10
<i>Bacillus cereus</i> (≤ 50 cfu/g)	10	10	10	10	10	10	10	10
<i>Listeria</i> <i>monocytogenes</i> (absent in 25g)	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
<i>Cronobacter spp.</i> (absent in 10g)	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent

Batches 1 - 4 Non-crystallised 3-FL; Batches 5 - 8 Crystallised 3-FL

24. Certification was provided to demonstrate that the contract laboratories were accredited to perform these analytical studies. Where in-house analysis was used, full methodology and supporting validation documentation was provided.

25. The data presented indicate the novel food can be consistently produced within the proposed specification.

2.4 Stability

26. The stability of the novel food was assessed under real-time conditions (25°C and 60% relative humidity) in two batches, one crystallised and one non-crystallised over a period of eighteen months. Results showed that the novel food meets the specification criteria for saccharide content and microbiological quality over this time period. Data for a further two batches of the novel food under ambient temperature and humidity, one batch covering 22 months and the second batch covering 24 months, were provided following the same parameters. Both batches met the specification limits.

27. The stability of the novel food was assessed under accelerated conditions in two batches of non-crystallised 3-FL over a period of 18 months. Results confirmed that the novel food meets the specification criteria for saccharide content and microbiological quality over this time period.

28. Results from a stability study of powdered infant formula containing the novel food under various environmental conditions (5°C; 25°C and 60% RH; 30°C and 65% RH; 40°C and 70% RH) over a period of 12 months confirmed, that the 3-FL content and microbiological quality of the novel food, is stable over this time period. Additional supporting evidence from a published study by Christensen *et al.* (2020) reported that 3-FL is stable in UHT milk (3 months), whole milk, and yoghurt (up to 36 days). Based on its structure, the stability of 3-FL is anticipated to be similar to those of 2'-FL, LNT, and LNnT, which have been approved as food ingredients in the List of Novel Foods, Regulation (EU) 2017/2470, as retained in UK law.

29. The data provided supports the stability of the novel food for a time period of at least 12 months.

2.5 Specification

30. The specification parameters reported in Table 5 were assessed using internationally recognised methods or determined using internally developed and validated methods.

Table 5: Specification of the novel food

Description

3-Fucosyllactose is a purified carbohydrate powder or agglomerate obtained from microbial fermentation with a genetically modified strain of *Escherichia coli* K-12 DH1 containing at least 90% of 3-fucosyllactose of dry matter.

Parameter	Specification	Method
Appearance	Powder, agglomerates, powder with agglomerates	ISO 6658
Colour	White, white to off-white, off-white	ISO 6658
Assay (water-free) – Specified saccharides ^a	≥ 92.0 w/w %	Glycom method HPLC-402-4C4-001, HPAEC-HMO-021, and HPLC-3FL-003
Assay (water-free) – 3'-FL	≥ 90.0 w/w %	Glycom method HPLC-402-4C4-001
L-Fucose	≤ 1.0 w/w %	Glycom method HPLC-3FL-002 or HPLC-3FL-003
D-Lactose	≤ 5.0 w/w %	Glycom method HPAEC-HMO-021
3-fucosyllactulose	≤ 1.5 w/w %	Glycom method HPAEC-HMO-021

Sum of other carbohydrates	≤ 5.0 w/w %	Glycom method HPAEC-HMO-021 + HPLC-3FL-003
pH in 5% solution (20°C)	3.2-7.0	Ph. Eur. 9.2 2.2.3 (07/2016:20203)
Water	≤ 6.0 w/w %	Glycom method KF-001
Ash, sulphated	≤ 0.5 w/w %	Ph. Eur. 2.4.14
Acetic acid	≤ 1.0 w/w %	Megazyme K-ACETRM
Residual protein by Bradford assay	≤ 0.01 w/w %	Glycom method UV-001
Residual endotoxins	≤ 10 EU/mg	Ph. Eur 2.6.14 (LAL kinetic chromogenic assay)
Lead	≤ 0.1 mg/kg	EN 13805; EPA-6020A
Arsenic	≤ 0.2 mg/kg	EN 13805; EPA-6020A
Aflatoxin M1	0.025 μ g/kg	LC-MS/MS Internal method Neutron 2015 Rev 1
Aerobic mesophilic total plate count	$\leq 1,000$ CFU/g	ISO 4833-1 or ISO-4833-2
Enterobacteriaceae	Absent in 10g	ISO 21528-2

<i>Salmonella</i>	Absent in 25 g	ISO 6579 or AFNOR BRD 07/11-12/05
<i>Bacillus cereus</i>	≤ 50 CFU/g	ISO 7932
<i>Listeria monocytogenes</i>	absent in 25g	ISO 11290-1
<i>Cronobacter spp.</i>	absent in 10g	ISO 22964
Yeasts	≤ 100 CFU/g	ISO 21527-2
Moulds	≤ 100 CFU/g	ISO 21527-2

a Specified saccharides include 3-fucosyllactose, D-lactose, L-fucose and 3-fucosyl-lactulose.

b Relevant only for crystallised 3-FL

31. The information provided is sufficient for the specification of 3-FL, and appropriately characterises the novel food seeking authorisation.

2.6 History of Use

32. There is no evidence for a history of use for 3-FL as a food ingredient.

33. Human breast milk contains a family of structurally related oligosaccharides, known as human milk oligosaccharides (HMOs), as the third largest solid components (Kunz and Rudloff, 1993; Bode, 2012; Newburg, 2013). The concentrations of HMOs in human colostrum are 20 to 25 g/L, whereas in mature human milk, the concentrations are 5 to 20 g/L (Bode, 2012). A wide variability has been reported in these values,, depending on the individual, lactation period and genotype of the mother. Although there are over 140 known HMOs (Urashima *et al.*, 2011; Chen, 2015; Remoroza *et al.*, 2020), the five most abundant HMOs, on average, account for nearly half of the oligosaccharide fraction by mass. These are 2'-FL, LNFP-I, lacto-*N*-difucohexaose I (LNDFH-I), LNT, and the novel food, 3-fucosyllactose (3-FL) (Thurl *et al.*, 2017; Molnar-Gabor *et al.*, 2019).

34. A literature review of the quantitative data for 3-FL in human breast milk from forty-one publications reported that mean concentrations vary from 0.02 g 3-FL/L (van Niekerk *et al.*, 2014) to 3.43 g 3-FL/L (Lefebvre *et al.*, 2020). Using the reported standard deviations, the values reported by Gabrielli *et al.* (2011) represented the highest extrapolated 95% confidence limit (CL) at 4.72 g 3-FL/L. The estimated highest mean and highest 95% CL intake levels of 3-FL from human breast milk are reported in Table 6.

Table 6: Highest Intakes of 3-FL from 800ml and 1200ml of Breast milk for 6.7kg Infant ^a

Human Milk Oligosaccharide	Estimated highest intake for 800ml ^b milk (mg/kg bw/day)	Estimated highest intake for 1200ml ^b milk (mg/kg bw/day)
3-FL		
Highest Mean (based on 3.43 g/L)	410	614
Highest 95% CL (based on 4.72 g/L)	564	845

a EFSA SC, 2012

b EFSA NDA Panel, 2013

35. The history of use data did not indicate any further areas for evaluation.

2.7 Proposed Use and Anticipated Intake

36. Infants, children, and adults, including pregnant and lactating women, were identified as the target population of the novel food. The proposed food categories and maximum use levels are listed in Table 7.

Table 7: Food Categories and Use Levels for 3-FL from the novel food

Food Category Name**Proposed Maximum Use Level****Dairy Products and Analogues**

Unflavoured pasteurised and unflavoured sterilised (including UHT) milk

2.0 g/L

Unflavoured fermented milk-based products

2.0 g/L (beverages)

4.0 g/kg (products other than beverages)

Flavoured fermented milk-based products including heat-treated products

2.0 g/L (beverages)

12.0 g/kg (products other than beverages)

Bakery wares

Fine bakery wares. Cereal bars only

25.0 g/kg

Foods for Special Groups (FSG)**Foods for infants and young children**

Infant formula as defined in Regulation (EU) No 609/2013

2.0 g/L in the final product ready for use, marketed as such or reconstituted as instructed by the manufacturer

Follow-on formula as defined in Regulation (EU) No 609/2013

2.0 g/L in the final product ready for use, marketed as such or reconstituted as instructed by the manufacturer

Milk-based drinks and similar products intended for young children	2.0 g/L (beverages) in the final product ready for use, marketed as such or reconstituted as instructed by the manufacturer
	12 g/kg (products other than beverages)

Foods for special medical purposes as defined in Regulation (EU) No 609/2013

Foods for special medical purposes as defined in Regulation (EU) No 609/2013	In accordance with the particular nutritional requirements of the persons for whom the products are intended
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Total diet replacement for weight control as defined in Regulation (EU) No 609/2013

Total diet replacement for weight control as defined in Regulation (EU) No 609/2013	2.0 g/L (beverages)
	25.0 g/kg (products other than beverages)

Beverages

Flavoured drinks	1.25 g/L
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Food supplements

Food supplements (infants and young children)	2 g/day
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Food supplements

(other children, adolescents and adults) 4 g/day

37. The anticipated intake for 3-FL in children up to the age of 16 weeks is estimated to be 520 mg/kg body weight/day, equivalent to 3.48 g/day for a 6.7 kg infant. This value was calculated from the use of 3-FL in infant formula (2.0 g/L) at a high consumption level of 260 ml/kg body weight/day, as established by the EFSA Scientific Committee (EFSA SC, 2017). This value does not exceed the estimated intake for 3-FL at the highest 95% CL for breast milk (see Table 6).

38. An intake assessment using the summary statistics of consumption from the dietary surveys in the EFSA Comprehensive database was conducted by matching the proposed conditions of use with the FoodEx2 categories. The estimated mean and high-level intakes of 3-FL from the proposed conditions of use for each sub-population are presented in Table 8.

Table 8: Estimated daily intake of 3-FL from proposed food uses

Population Group	Mean Intakes of 3-FL (mg/day)	High Level Intakes of 3-FL (mg/day)	Mean Intakes of 3-FL (mg/kg bw/day)	High Level Intakes of 3-FL ^a (mg/kg bw/day)
Infants (≤ 11 months)	377 to 1,148	1,352 to 3,028	44 to 196	155 to 499
Young children (12 to 35 months)	473 to 1,189	983 to 2,373	38 to 119	92 to 231
Other children (3 to 9 years)	395 to 1,262	883 to 2,002	13 to 66	34 to 116

Adolescents (10 to 17 years)	185 to 1,326	716 to 2,381	3 to 25	16 to 49
Adults (18 to 64 years)	157 to 967	697 to 2,176	2 to 13	11 to 29
Pregnant and lactating women	326 to 907	906 to 1,789	5 to 13	12 to 28
Elderly (65 to 74 years)	151 to 777	605 to 2,195	2 to 10	10 to 27
Very elderly (75+ years)	117 to 835	737 to 1,487	2 to 11	13 to 20

a Results are not presented that were not statistically reliable (n 60).

39. On a body weight basis, the highest intakes of 3-FL were observed in infants and young children. Higher intakes in these age groups are expected given the relatively high intake of foods and beverages on a body weight basis compared to the other population groups, where the intake levels are significantly lower. The wide range of high intake levels for 3-FL in infants and young children represent the variability in the national survey data, and the assumption that all the proposed foods will be consumed at the maximum proposed intake levels. This represents an extremely unlikely scenario.

40. A comparison of the estimated mean and high level intake of 3-FL (based on all infants) against the highest mean and upper confidence limit exposures from breast milk for 3-FL on a body weight basis (EFSA NDA Panel, 2013), are shown in Table 9. This data indicates that the estimated intake of 3-FL, in the most sensitive population group (infants), is not expected to exceed the levels found in human breast milk, for which there is a history of safe use.

Table 9: Highest Intakes of 3-FL from Breast Milk versus Highest Level of Exposure from Proposed Uses in Infants

Dietary Source	Estimated Daily Intake for 3-FL (mg/kg bw/day)
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Mean Intake of Human Milk (800 ml) for 6.7 kg infant

Highest Mean (based on 3.43 g/L ^a)	410
Highest 95% CL (based on 4.72 g/L ^a)	564
Highest Mean Consumption from Proposed Uses ^b	196

Mean Intake of Human Milk (1200 ml) for 6.7 kg infant

Highest Mean (based on 3.43 g/L ^b)	614
Highest 95% CL (based on 4.72 g/L ^b)	845
Highest 95% Percentile Consumption from Proposed Uses ^b	499

a Calculated using quantitative analytical data for oligosaccharides in breast milk

b Estimated intake for all infants.

41. The use level for 3-FL in food supplements is 2 g/day for infants and young children, and 4 g/day for all other population sub-groups. Food supplements are not intended to be used if other foods with the novel food are consumed on the same day. For infants and young children, food supplements are not intended to be used if breast milk or other foods with added 3-FL are consumed on the same day.

42. The estimated intake for 3-FL in food supplements on a body weight basis for all population groups at the proposed use levels is presented in Table 10.

Table 10: Estimated daily intake of 3-FL from food supplements

Proposed use level (g/day)	Population Group	Mean Body Weight (kg) ^a	Estimated intake (mg/kg bw/day) ^b
2.0	Infants (\leq 11 months)	6.7	299
2.0	Young children (12 to 35 months)	11.9	168
	Other children (3 to 9 years)		
4.0	Adolescents (10 - 17 years)	23.1	173
		43.4	92
	Adults (18 - 64 years)	73.9	54
	Elderly (65 - 74 years)	76.0	53
		71.2	56
	Very Elderly (\geq 75 years)		

a EFSA SC 2012

b Calculation: [Proposed Use Level (g/day) / Mean Body Weights] x 1,000.

43. The estimated mean and high-level intake of 3-FL in food supplements (based on infants) against the highest mean and upper confidence limit exposures from breast milk for 3-FL on a body weight basis is shown in Table 11. The results confirm that the estimated intake of 3-FL in food supplements is not be expected to exceed the levels found in human breast milk, for which there is a history of

safe use.

Table 11: Highest Intakes of 3-FL from Breast Milk versus Highest Level of Exposure from Food Supplements Consumed by 6.7kg infant

Highest mean intake based on 800 ml breast milk	Highest 95% CL intake based on 800 ml breast milk	Highest mean intake based on 1200ml breast milk	Highest 95% CL intake based on 1200ml breast milk	Highest intake at 95% percentile from proposed use as a food supplement at 2 g/day
410	564	614	845	299
mg/kg bw/day	mg/kg bw/day	mg/kg bw/day	mg/kg bw/day	mg/kg bw/day

Highest Mean (based on 3.43 g/L)

Highest 95% CL (based on 4.72 g/L)

2.8 Absorption, Distribution, Metabolism and Excretion (ADME)

44. The 3-FL oligosaccharide in the novel food has the same structure as the naturally occurring counterpart in human breast milk.

45. Most human milk oligosaccharides are reported to undergo limited oral absorption intact. Human milk oligosaccharides do not undergo significant digestion in the upper gastrointestinal tract but can undergo fermentation in the colon. Human milk oligosaccharides are predominantly excreted unchanged in the faeces, with a small proportion excreted unchanged in the urine.

46. The absorption of 3-FL from consumption of the novel food is not expected to differ from the intake of human milk oligosaccharides following infant consumption of breast milk. Therefore, this was not expected to pose a safety concern for infants or other age groups.

47. Committee members noted that oligosaccharides are usually considered prebiotic and can cause bloating in high doses. Consequently, it was highlighted

that risk managers may wish to consider whether there was a need for foods containing 3-FL to be labelled on this basis.

48. The ADME of human milk oligosaccharides are well understood and the information does not indicate any further areas of concern.

2.9 Nutritional information

49. The novel food is mainly composed of the oligosaccharide, 3-FL, which is structurally identical to the naturally occurring counterpart in human breast milk. Consumption of the novel food at the proposed use levels is not expected to be nutritionally disadvantageous for consumers.

2.10 Toxicological information

50. Toxicological studies were performed with 3-FL to support the safety assessment of the novel food. The respective study reports are unpublished and claimed as proprietary data. They were considered essential in the assessment the safety of the novel food and were reviewed by the ACNFP.

51. *In vitro* genotoxicity testing of 3-FL was conducted under Good Laboratory Practice (GLP) conditions and according to the following OECD guidelines: *in vitro* bacterial reverse mutation test (OECD TG 471) and *in vitro* mammalian cell micronucleus test (OECD TG 487). This approach is recommended by the UK Committee on Mutagenicity , and is also the basis of guidance on the preparation and submission of an application for authorisation of a novel food in the context of Regulation (EU) 2015/2283, as retained in UK law.

52. The *in vitro* bacterial reverse mutation test (Gilby, 2020a) demonstrated that 3-FL is non-mutagenic, in the absence or presence of metabolic activation.

53. The *in vitro* mammalian cell micronucleus test (Gilby, 2020b) demonstrated that 3-FL is non-clastogenic and non-aneugenic in the absence or presence of metabolic activation.

54. The results from these *in vitro* studies support the conclusion that the novel food is not genotoxic.

55. Repeated Dose 90-Day Oral Toxicity Study in Rodents (Stannard, 2020) was conducted under GLP conditions according to OECD TG 408 guidelines as recommended by the Guidance on the preparation and submission of an application for authorisation of a novel food in the context of Regulation (EU) 2015/2283, as retained in UK law. The aim of the study was to identify any

adverse effects following the consumption of 3-FL.

56. In this 90-day feeding study, each group consisted of 10 female and 10 male rats which were fed 0 (control - vehicle only [water]), 1,000, 3,000 or 4,000 mg/kg bw/day of 3-FL by oral gavage. A reference control group consisting of the same number of animals was fed oligofructose (4,000 mg/kg bw/day). Additionally, satellite groups consisting of 5 female rats and 5 male rats for the control and high dose treatment, and the reference control treatment were used as recovery groups.

57. No deaths, test item-related clinical abnormalities, ocular changes, or differences in food consumption and bodyweight between test groups were reported. There were no statistically significant dose dependent changes in haematology, blood chemistry, urinalysis, serum hormone levels, or organ weights. In addition, no dose related abnormalities were noted during the necropsy or histopathological evaluation. Therefore, the no observable adverse effect level (NOAEL) for 3-FL was considered to be the high-dose of 4,000 mg/kg bw/day.

2.11 Allergenicity

58. The protein content of the novel food is reported as 0.01% w/w. The potential allergenicity of the introduced proteins expressed in *E. coli* K-12 (Allergen Online tool, version 21 - University of Nebraska) was assessed. None of the proteins was predicted to be an allergen.

59. The novel food is unlikely to trigger allergic reactions in the target population under the proposed conditions of use.

3. Discussion

60. The novel food is a human identical milk trisaccharide containing $\geq 90.0\%$ dry weight of 3-FL, which is manufactured by microbial fermentation using a genetically modified strain of *Escherichia coli* K-12. The total saccharide content of the novel food is up to 92% dry weight including of other saccharides present in smaller quantities.

61. 3-FL is intended to be used in dairy products and analogues, bakery wares, beverages, foods for infants and young children, foods for special medical purposes, total diet replacement for weight control, and food supplements. Infants, children, and adults, including pregnant and lactating women, are identified as the target population of the novel food.

62. Analysis confirms that the novel food is structurally identical to the 3-FL found naturally in human milk. Exposure to 3-FL relates solely to breastfeeding infants as there is no recognised history of use for this milk oligosaccharide as an ingredient in foods or food supplements.

63. In the Repeated Dose 90-Day Oral Toxicity Study in Rodents, the NOAEL for 3-FL was 4,000 mg/kg bw/day, the highest dose tested. When this NOAEL is compared with the highest estimated exposure in each population category, the margins of exposure range from 8 to 148. Given that the 3-FL in the novel food is equivalent to 3-FL found in human breast milk, these margins of exposure are acceptable with respect to the highest estimated daily intakes in the intended population.

64. Moreover, the anticipated daily intake of the novel food in all population groups, including children up to the age of 16 weeks using infant formula alone, is not expected to exceed the highest intake level of 3-FL in breastfed infants on a body weight basis

65. The use level of 3-FL in food supplements (2 g/day for infants and young children, and 4 g/day for all other population sub-groups) is not expected to exceed the highest intake level of 3-FL in breastfed infants on a body weight basis. Food supplements are not intended to be used if other foods containing the novel food, including breast milk or other foods for infants and young children, are consumed on the same day. It is noted that the concurrent use of 3-FL in foods and food supplements by adolescents and adults would not be expected to exceed the intake levels of 3-FL in breastfed infants on a bodyweight basis.

4. Conclusions

66. The ACNFP have undertaken the assessment of 3-FL and concluded that the composition of the novel food is safe under the proposed conditions of use and does not pose a safety risk to human health.

67. These conclusions were based on the information in the novel food dossier submitted by the applicant plus the supplementary information and could not have been reached without the following data claimed as proprietary by the applicant:

- annexes to the dossier which relate to the identity of the novel food, the production process, composition, stability, history of use, and the anticipated intake of the novel food.

- bacterial reverse mutation test (Gilby, 2021a [unpublished]), *in vitro* micronucleus test (Gilby, 2021b [unpublished]), 14-day dose range finding study (Stannard, 2021a [unpublished]) and 90-day repeat dose feeding study with the novel food (Stannard, 2021b [unpublished]) including the summary table of statistically significant observations in the toxicity studies (Appendix B.3).

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Abbreviations

3-FL	3'-fucosyllactose
ACNFP	Advisory Committee on Novel Foods and Processes
ADME	Absorption, Distribution, Metabolism and Excretion
AFNOR	Association Francaise de Normalisation
bw	body weight
CL	confidence limit
CAS	Chemical Abstracts Service
CFU	Colony Forming Unit
cGMP	Current Good Manufacturing Practice
DNA	Deoxyribonucleic acid
EC	European Commission
EFSA	European Food Safety Agency
EPA	Environmental Protection Agency
EU	European Union
EU/mg	Endotoxin units per milligram
GLP	Good Laboratory Practice
HACCP	Hazards Analysis and Critical Control Points
HPAEC	High-performance anion exchange chromatography
HPLC	High-performance liquid chromatography
ISO	International Organisation for Standardization
KF	Karl Fisher
LC-MS/MS	Liquid chromatography-tandem mass spectroscopy
LOQ	limit of quantification
NMKL	Nordisk Metodikkomite for Levnedsmidler

NOAEL	No Observable Adverse Effect Level
NT	Not tested
OECD	Organisation for Economic Co-operation and Development
Ph. Eur.	European Pharmacopoeia
RT	retention time
UHT	ultra-high temperature
UV	ultra-violet