Formulating with Fibers

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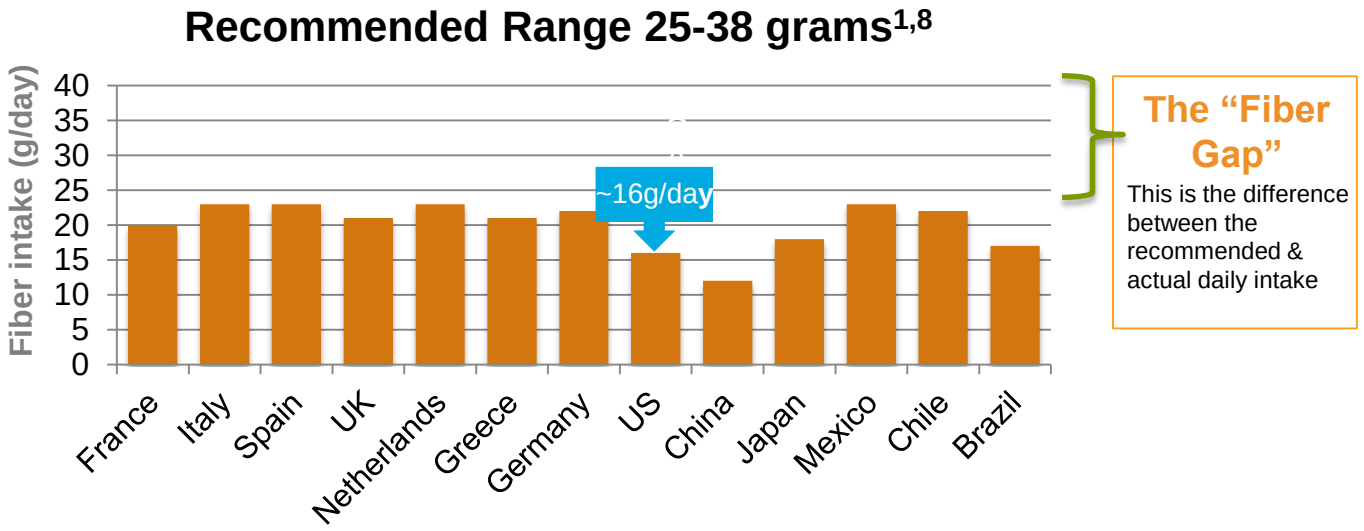
Outline

- ❑ Introduction
- ❑ What is Dietary Fiber?
- ❑ Why use Fibers?
- ❑ Formulating with Fibers
- ❑ Fibers in Sauces & Dressings
- ❑ Summary

INTRODUCTION

The Fiber Gap

Increased recognition that modern diets are below recommendations [1-8]



(1) Gray J. ILSI Europe Dietary fibre Concise Monograph Series. 2006.;(2) Cho SS and M Dreher (eds.). Handbook of Dietary fibre. Marcel Dekker Inc., NY. 2001. (3)Clemens R, Kranz S, Mobley AR, et al. Filling America's fibre intake gap: Summary of a roundtable to probe realistic solutions with a focus on grain-based foods. J Nutr. 2012; 142:1390S-401S. (4)Murphy N, Norat T, Ferrari P, et al. Dietary fibre intake and risks of cancers of the colon and rectum in the European prospective investigation into cancer and nutrition (EPIC). PLoS One. 2012; 7:e39361. (5) King DE, Mainous AG, 3rd, Lambourne CA. Trends in dietary fibre intake in the United States, 1999-2008. J Acad of Nutr Diet. 2012;112(5):642-8. (6) Stookey, JD. Energy density, energy intake and weight status in a large free-living sample of Chinese adults: Exploring the underlying roles of fat, protein, carbohydrate, and fibre and water intakes. EJCN. 2001; 55(5):349-359. (7) Public Health England and Food Standards Agency. National Diet and Nutrition Survey: Results from Years 1-4 (combined) of the Rolling Programme (2008-2009 - 2011-12): Executive Summary. PHE Publications; 2014. (8) Institute of Medicine, Food and Nutrition Board. Dietary Reference Intakes: Energy, Carbohydrates, fibre, Fat, Fatty Acids, Cholesterol, Protein and Amino Acids. Washington, DC: National Academies Press; 2002/2005.

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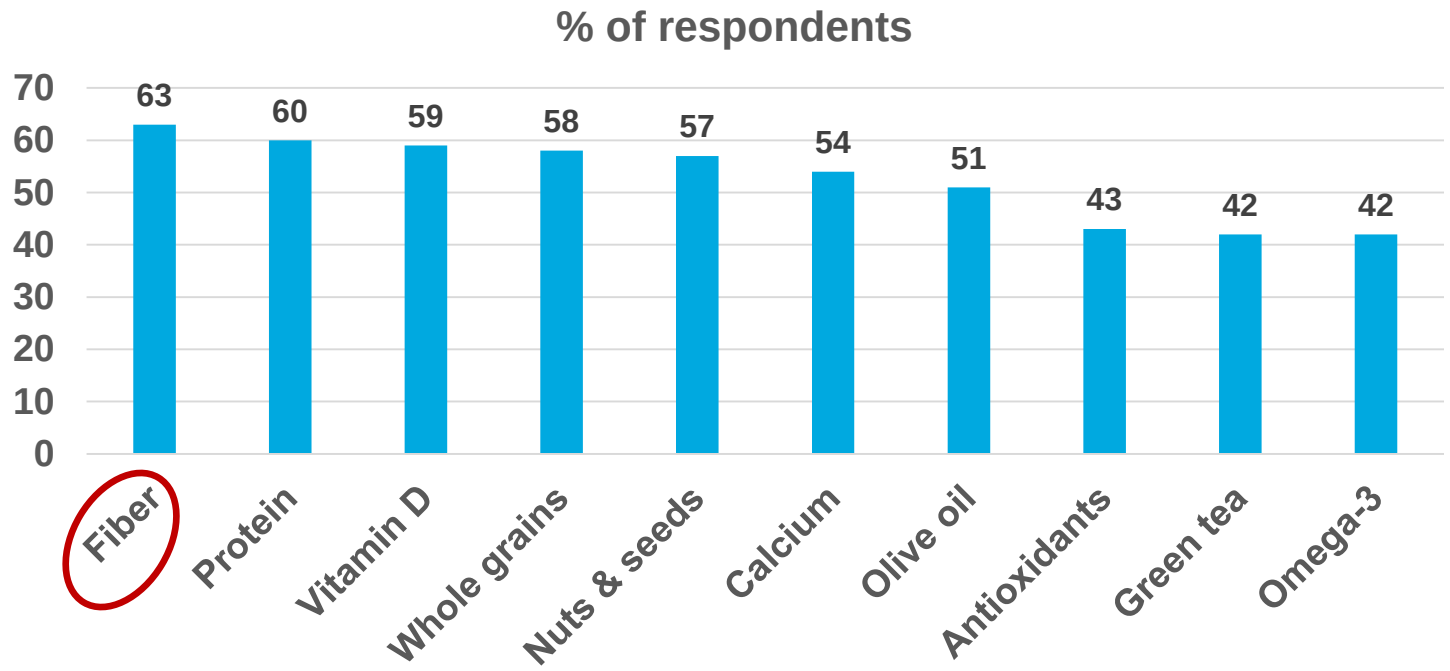
Fiber is the #1 nutrient Americans are adding to their diets*

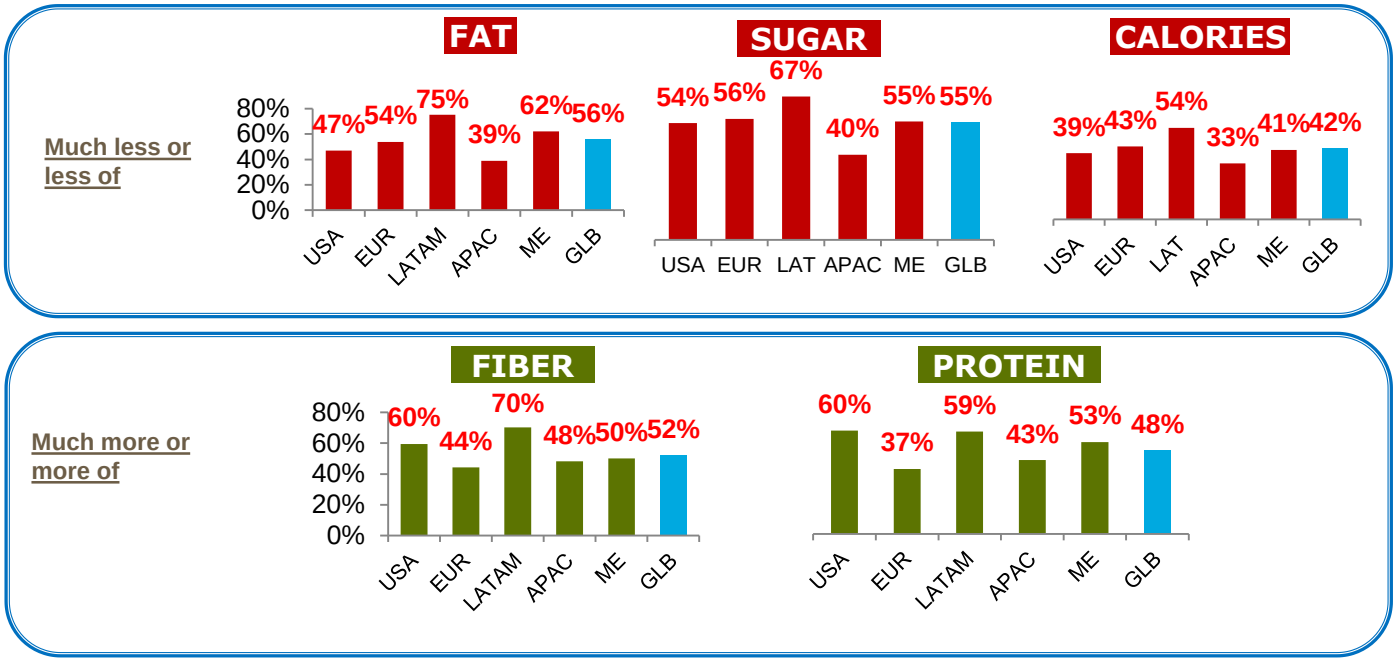


*Hartman 2017 as cited in Sloan, E. (2018) Top 10 functional food trends. Food Technology, pg 26-43

More consumers are trying to eat less sugar worldwide

But they want to eat more fiber and protein

Which nutrients are you trying to eat more or less of?



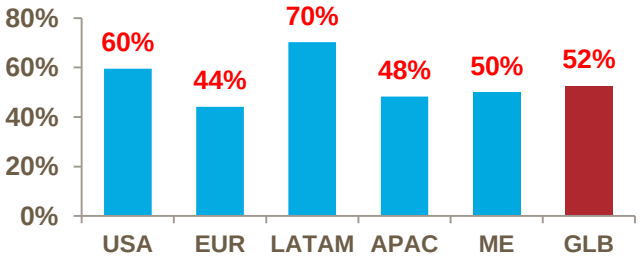
American and LATAM consumers are the most interested in increasing their Fiber and / or protein consumption

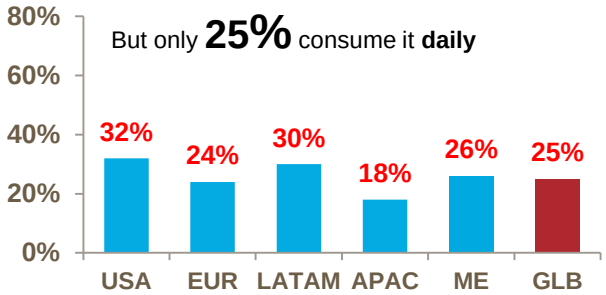
Qualtrics, Tate & Lyle Fibre A&U,11 countries, 8800 respondents, 2015-2016

Consumers want more products with Fiber

High desire for fiber but low consumption

Over **50%** of consumers want **more** Fiber in their diet





Why not consumed more often?

32%
Not enough products

Qualtrics, Tate & Lyle Fibre A&U,11 countries, 8800 respondents, 2015-2016

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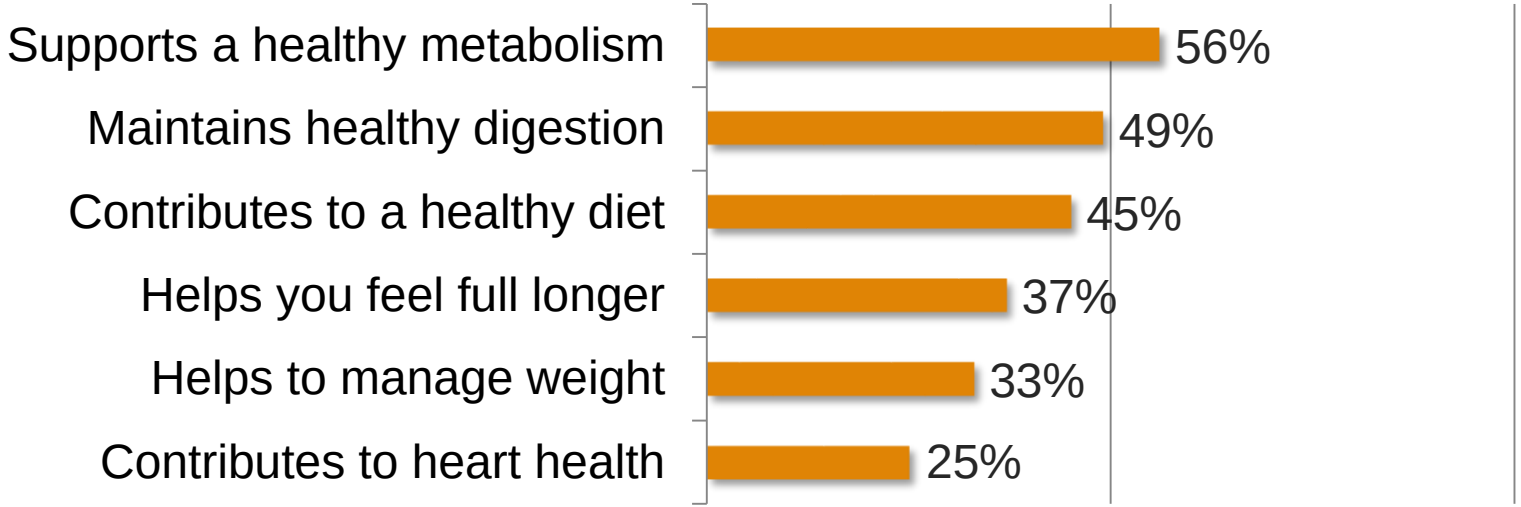
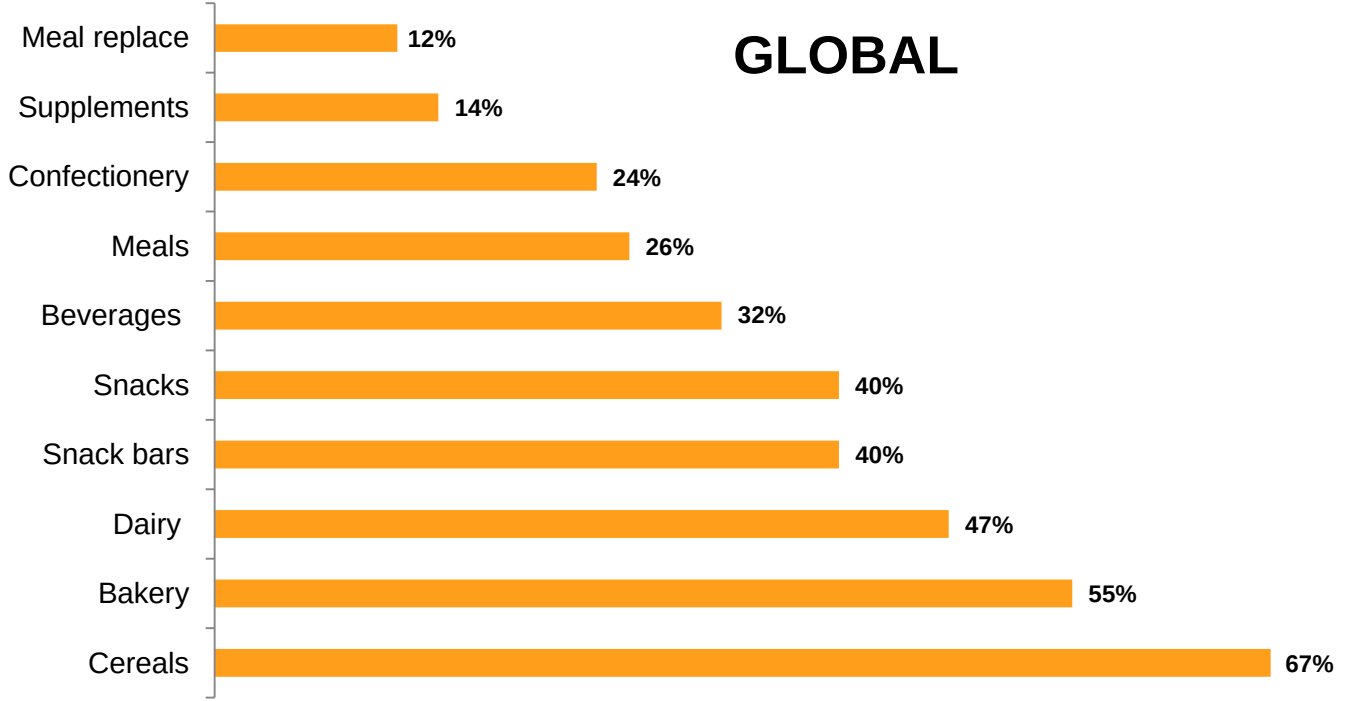
Consumers want Fiber for many reasons



Source: Fiber Study Attitudes and Usage online study conducted by Qualtrics; 2015-2016; N = 800 respondents per eleven countries; % multiple choices 'Reasons why products containing fibers are consumed'

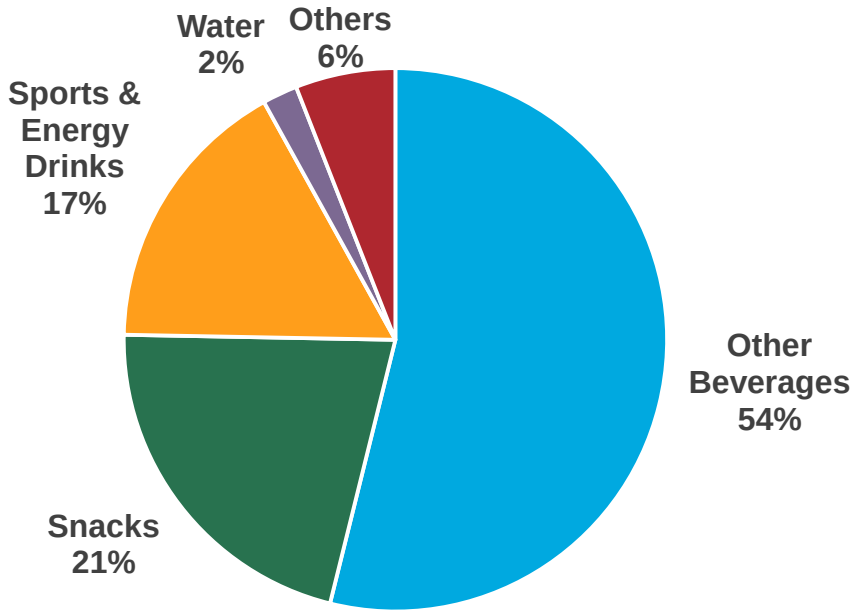
Consumers report that they obtain their Fiber intake primarily from cereals, bakery, and dairy

Key Food & Beverage Categories as Source of Fiber Consumption



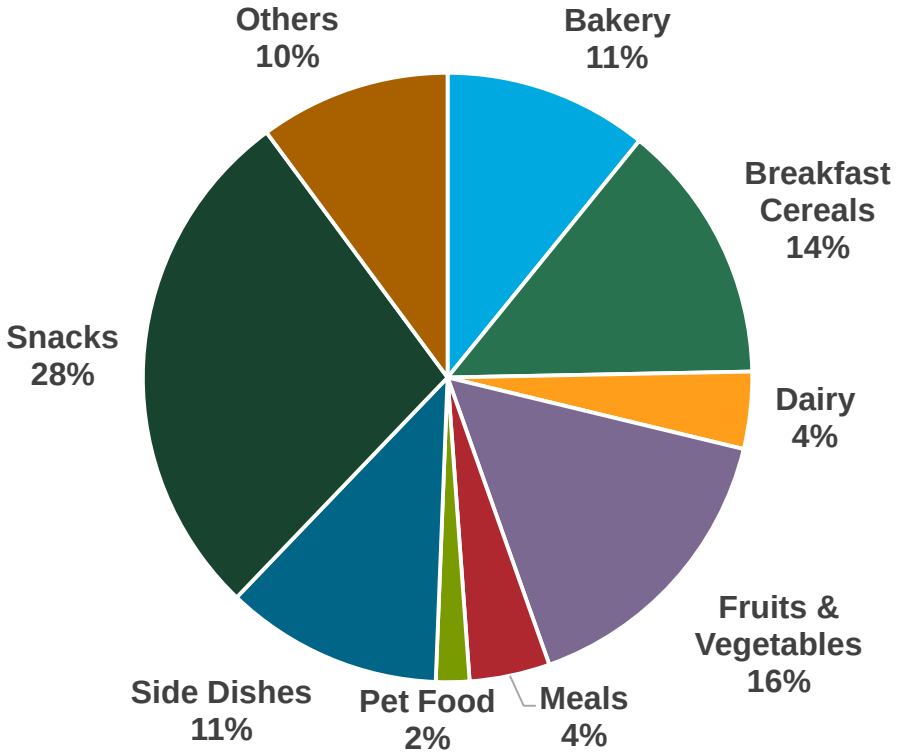
Source: Qualtrics, Tate & Lyle Fibre A&U,11 countries, 8800 respondents, 2015-2016

NPD launches in Nutrition category in 2018*



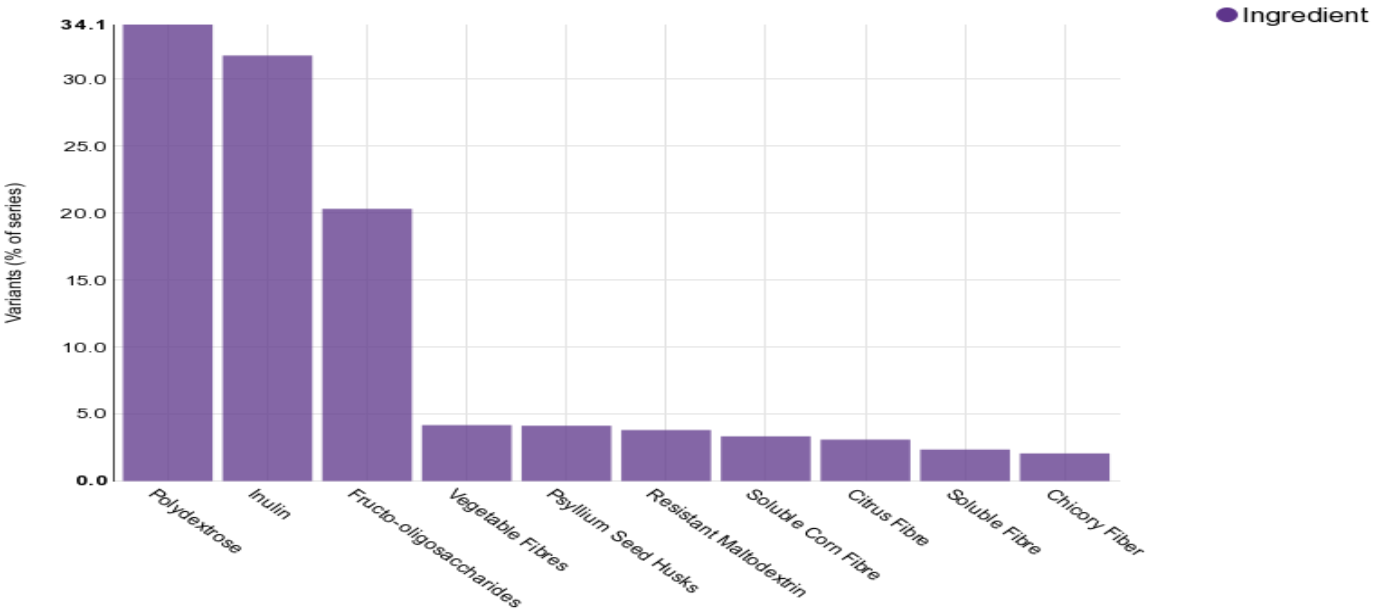
*Mintel NPD database

NPD launches with Fiber Claims in 2018*



*Mintel NPD database

Functional Fiber ingredients in products with low/no/reduced sugar claims (June 2013 - March 2019)*



*Source: Mintel NPD database

WHAT IS DIETARY FIBER?

What is Fiber?

"...Non-digestible soluble and insoluble carbohydrates (with 3 or more monomeric units), and lignin that are intrinsic and intact in plants; isolated or synthetic non-digestible carbohydrates...determined by FDA to have physiological effects that are beneficial to human health." (FDA)

Fibers are

- **Complex carbohydrate structures**
- **Not digested or absorbed**
- **Resistant to digestive enzymes in the small intestine**
- **May be partially or fully fermented in the colon**
- **Have beneficial physiological effects**

As a result, Fibers

- **Have low calorie content**
- **Have digestive health benefits**
- **May have additional health benefits due to adding bulk or being fermented in the colon, prebiotic or gut viscosity effects**

Conventional classification of Fibers based on solubility*

	Chemical constituents	Physiological effects	Examples
Soluble fiber	Non-cellulosic polysaccharides, oligo saccharides, pectins, β-glucans, gums	Delay gastric emptying, fecal bulking, increase gut viscosity and fermentation in the colon leading to blood glucose regulation, lower serum cholesterol levels, increased mineral absorption	Oat and barley beta glucans, pectin, HPMC, guar and locust bean gums, resistant starches, dextrins and maltodextrins
Insoluble fiber	Cellulose, hemicellulose, lignin	Reduce bowel transit time, improve laxation due to fecal bulking, fermentation in the large intestine	Cereal brans, psyllium husk, cellulose

*Li, Y.O. and Komarek, A.R. (2017). Dietary fiber basics. Food Safety and Quality. 1:47

FDA classification of Fibers*

Natural or intrinsic or intact Fibers

- Vegetables, whole grains, fruits, cereal brans, flaked cereals and flours

Isolated or synthetic Fibers

- Beta-glucan soluble fiber, psyllium husk, cellulose, guar gum, pectin, locust bean gum, hydroxypropylmethylcellulose, mixed cell fibers, arabinoxylan, alginate, inulin and inulin-type fractans, high amylose starch (RS2), galactooligosaccharides, polydextrose, resistant maltodextrins/dextrins

*https://www.fda.gov/Food/LabelingNutrition/ucm528582.htm#naturally_occurring_fiber

Chemical classification of Fiber*

Abbreviation	Definition	Examples
HMWDF	High molecular weight dietary Fiber	Cellulose, resistant starch, cereal β-glucan, guar gum and some xylans
IDF	Dietary Fiber insoluble in water	Cellulose, resistant starch and some xylans
SDFP	Dietary Fiber soluble in water and precipitated by 78% ethanol	Cereal β-glucan, guar gum and certain xylans
SDFS	Dietary Fiber soluble in water and soluble in 78% ethanol. This is also known as low molecular weight dietary Fiber (LMWDF) or non-digestible oligosaccharides (NDO)	Fructooligosaccharides (FOS), galactooligosaccharides (GOS), part of polydextrose, inulin and resistant maltodextrins (RMD)

*McLeary et al. 2013. Cereal Chemistry 90(4):396-414

How do we measure Fiber(s)?
Many methods available and validated but none was a ‘complete’ method

Reference method	Lignin	Nonstarch Poly-saccharide	Resistant starch	Inulin	Oligo-Saccharides (e.g. FOS)	Poly-dextrose	Resistant Maltodextrin / Dextrin
AOAC 985.29 and AOAC 991.43							
AOAC 2000.11 (measures %polydextrose)							
AOAC 2001.03							
AOAC 2009.01 or **AOAC 2011,25 (the ‘complete’ method)**							

FDA Fiber Ruling

FDA has defined fiber as isolated or synthetic non-digestible soluble and insoluble carbohydrates (with three or more monomeric units) that have been determined by the FDA to have a physiological effect that is beneficial to human health.

Initial Guidance provided 5/27/2016	Additional Fibers approved 6/14/18	Denied unaccepted fibers 6/14/18	FDA response still pending
• Naturally occurring intact and intrinsic fibers (fruits & vegetables) • Beta-glucan soluble fiber • Psyllium husk • Cellulose • Guar gum • Pectin • Locust bean gum • Hydroxypropyl methylcellulose	• Inulin and inulin-type fructans • High-amylose starch (resistant starch 2) • Polydextrose (1 kcal/g) • Mixed plant cell wall fibers (sugar cane fiber, etc) • Arabinoxylan • Alginate • Galactooligosaccharide • Resistant maltodextrin/dextrin (soluble corn fiber)	• IMO	• CMC • Karaya gum • Pullulan • **RS4 – just approved** • Xanthan gum • XOS

Labelling*

New DV for Dietary Fiber = 28g

Good source of Fiber = 10% of DV

= 2.8g or 3g per serving

Excellent source of Fiber = (20% of DV)

= 6g per serving

*https://www.fda.gov/Food/GuidanceRegulation/GuidanceDocumentsRegulatoryInformation/LabelingNutrition/ucm385663.

WHY USE FIBERS?

Benefits of Fibers

FUNCTIONAL
Sugar / Calorie / Fat reduction
(Bulking, binding, flavor, etc.)

ENRICHMENT
Fiber Content / Functional Claim

Success Criteria:

- BEHAVES the same (process, ease of use, viscosity, etc.)
- TASTES same or better (color, texture, flavor, etc.)
- Cost in use same
- Maximum fibre retention
- Others?

Depending on type of Fiber and content, it may provide variety of health benefits*

Laxation

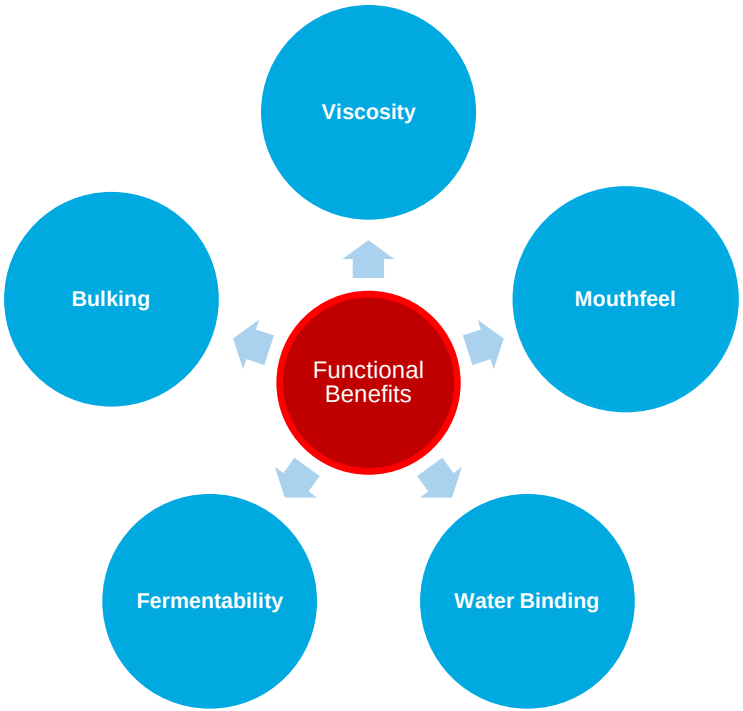
Prebiotic Benefits

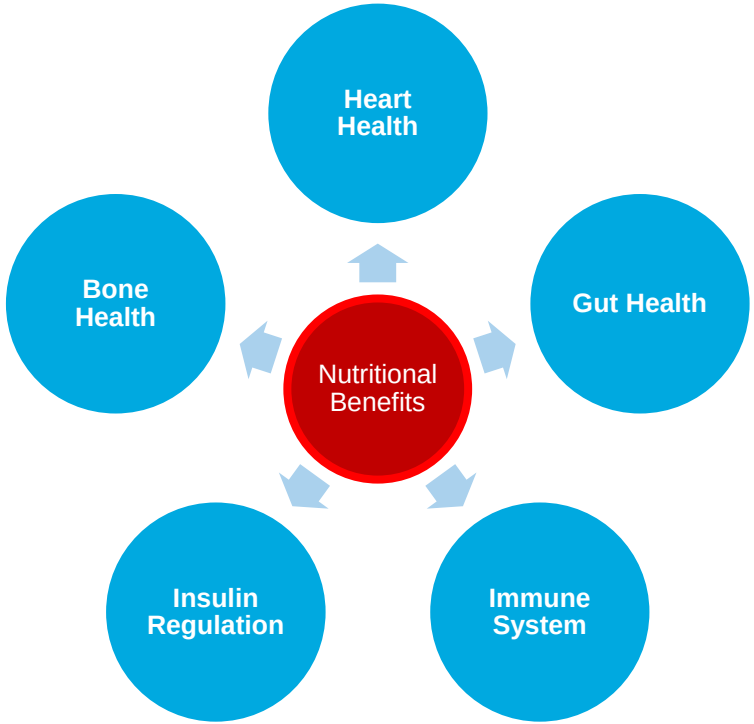
Favorable Blood Glucose/Insulin response

Increases Calcium Absorption

Oat Beta Glucan helps maintain normal cholesterol

Functional & Nutritional Benefits of Fibers





Properties of Dietary Fiber*

Physico-chemical properties	Physiological effect	Functionality in foods
Solubility	Changes in intestinal function	Water binding/holding capacity
Viscosity	Lowering of cholesterol and blood lipids	Fat/oil binding and retention capacity
Density and bulk volume	Modification of glycemic response	Viscosity and rheological property
Surface area characteristics and porosity	Laxation and satiety	Gel forming capacity
Particle size	Fermentation in the colon	Fermentative capacity
Cation exchange capability	Reduction of nutrient availability	Metal ion chelating capacity
Chemical reactivity/interaction with other organic molecules	Enhanced health benefit through synergistic effects with other active ingredients	Thickening, bulking, texture modification, control of sugar crystallization

*Li, Y.O. and Komarek, A.R. (2017). Dietary fiber basics. Food Safety and Quality. 1:47

FORMULATING WITH FIBERS

Factors to consider for selection of Fibers

Content
- Good source of fiber
- Excellent source of fiber

Functionality
- Calorie reduction
- Sugar reduction

Nutrition Claims
- Prebiotic, digestive health
- Hearth health, satiety

Factors to consider for using Fibers in Product Development

- ❑ What is the category
- ❑ What is the food matrix
- ❑ What is the process in the plant
- ❑ What properties are critical for reformulation
- ❑ What is the usage level
- ❑ Which Fiber will be most suitable
- ❑ What other formula adjustments need to be made

Effect of processing on Fiber

Processing can impact the physical and chemical properties of fiber

1. ***Structure*** – complex molecules may be broken down into smaller units
2. ***Solubility*** – potential shift from insoluble to soluble fiber without changes in total dietary fiber composition
3. ***Bulking*** – fibers hold water; the smaller the particle size the greater the water holding capacity. This adds bulk to the food matrix.
4. ***Viscosity*** – because of the ability to bind water, fibers increase viscosity in liquid food systems. Soluble fibers form more viscous systems than insoluble fibers
5. ***Fermentability*** – soluble fibers are more fermentable than insoluble fibers
6. ***Binding*** – fibers are broken down during processing enabling bind with other food components like proteins, starch, non starch polysaccharides and certain minerals

Effect of Fiber addition on processed foods

Effect of processing on Fiber enriched foods depends on

- **Source of Fiber**: grains vs legumes
- **Type of Fiber**: soluble vs insoluble
- **Amount of Fiber**: good source vs excellent source
- **Type of processing**: baking vs extrusion
- **Time and severity of processing**: cold forming vs direct expansion
- **Other components in food**: fat, proteins

Effect of Fiber addition on processed foods

Processing	Impact
Milling	Particle size reduction; increase in surface area
Baking	Decreased expansion, loaf volume, coarse crumb structure
Extrusion	Decreased radial expansion, increased bulk density
Germination	No impact
Puffing	Increase in rapidly digestible starch; decrease in slowly digestible starch

Impact of Fibers impact on end product

Breads
Volume

Crackers
Crunch/Checking

Smoothies
Mouthfeel

Bagels
Shape

Cereals
Bowl life

Clear beverages/soups
Solubility

Snacks
Crunch/texture

Cookies
Spread

Sauces
Consistency/mouthfeel

Which Fibers to use?

	Breads/Cookies/ Crackers	Cereals/Snacks	Dairy / Ice creams	Beverages	Sauces/Dressings
Sugar reduction	SDF/IDF	SDF/IDF	SDF	SDF	SDF
Calorie reduction	SDF/IDF	SDF/IDF	SDF	SDF	SDF
Fiber enrichment	SDF/IDF	SDF/IDF	SDF	SDF	SDF
Flavour improvement	SDF	SDF	SDF	SDF	SDF
Mouthfeel/texture	SDF	SDF	SDF	SDF	SDF
Binding/cohesion	SDF	SDF			
Thickening			SDF	SDF	SDF

SDF = Soluble Dietary Fiber; IDF = Insoluble Dietary Fiber

FORMULATING SAUCES & DRESSINGS WITH FIBERS

Fibers in Dressings and Sauces – Retail Examples

Polydextrose

Polydextrose

Citrus Fiber

Carrot Fiber

Citrus Fibers

Chicory Fiber

Chicory Fiber

Carrot Fiber

Role of Fibers in Sauces & Dressings

Functional Benefit

- Viscosity
- Thickener
- Water-binding capacity
- Texturant/gum replacer

Clean Label

- Friendly ingredients
- Natural and clean label appeal

Nutrition Claims

- Good source/excellent source
- L/N/R sugar
- No fat/low fat
- Low calorie

What Must the Developer Consider when Choosing and Formulating with Fiber

Clean Taste

Functional Properties

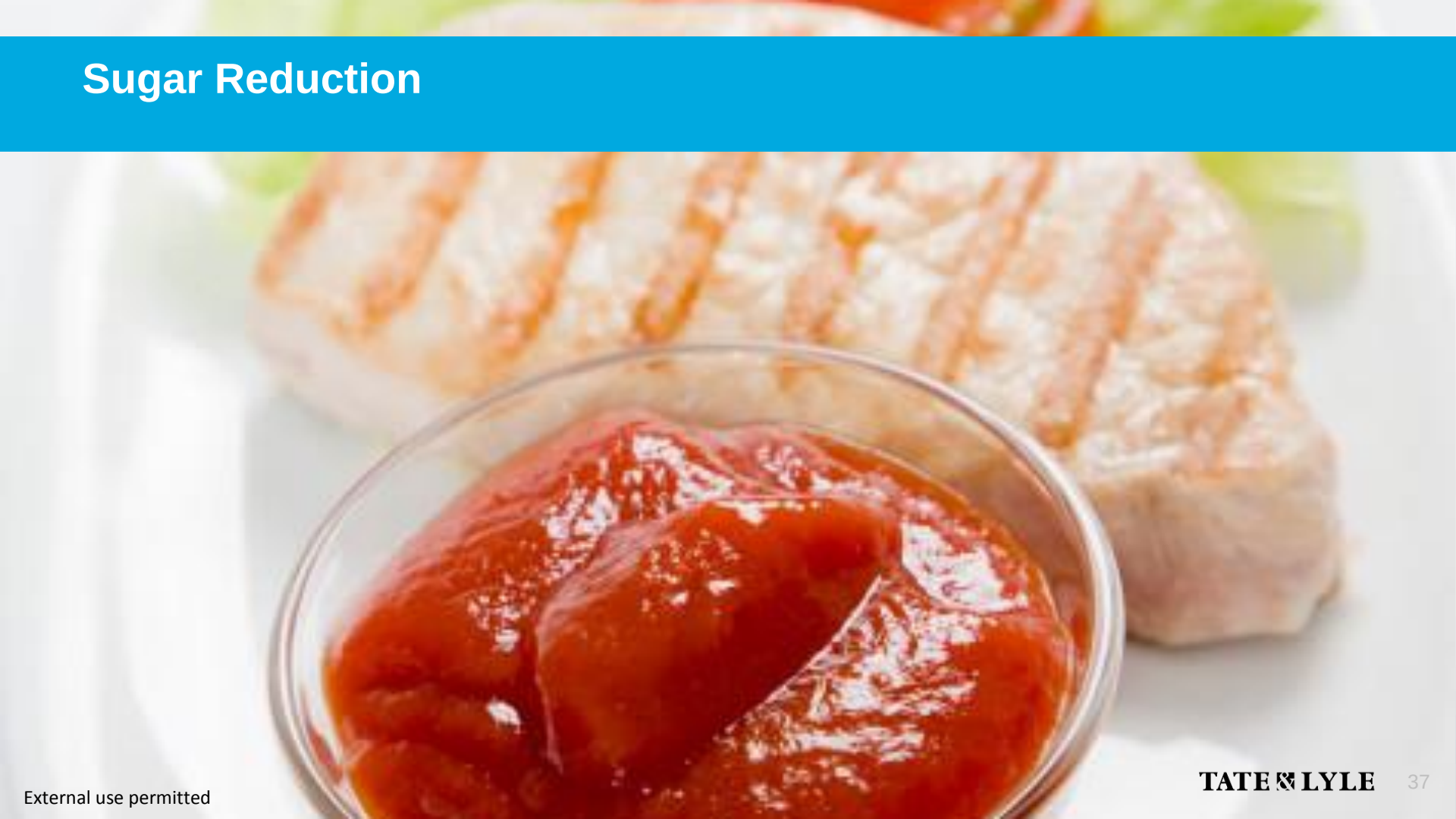
Process Stability

Friendly Label

Digestive Tolerance

Nutrition and Health Claims

Sugar Reduction



No Sugar Added Dipping Sauce

High quality dipping sauce with the texture, colour, and flavour of a regular full sugar version but with

NO added sugar

50% FEWER calories

And NO change in processing

No sugar added Dipping Suace - Formulation

Ingredients	Standard (%)	No Sugar Added (%)
Water	42.3	45.08
Tomato Paste	28	28
Vinegar	13.5	13.5
Sucrose	14	0
Polydextrose	0	11.2
Salt	2	2
Spices	0.2	0.2
Sucralose	0	0.0175
Total	*100.00*	*100.00*

- **Provides texture so no starch is needed**
- **Lower level of polydextrose needed to compensate for mouthfeel**

No sugar added Dipping Sauce – Product Attributes

Parameters		Standard	No Added Sugar
pH		3.7	3.8
Water Activity		0.958	0.967
Color	L*	24.99	24.91
	a*	29.95	29.3
	b*	27.26	25.63
Viscosity* Brookfield 20 rpm		10000 cPs 12000 cPs	9000 cPs 10000 cPs

* Viscosity development is dependent on the quality of homogenization step

No sugar added Dipping Sauce – Nutritional Information

Nutrition facts	Serving (15g)	
	Standard	No Added Sugar
CALORIES (Kcal)	13	5.8
PROTEINS (g)	0.2	0.2
CARBOHYDRATES	3.1	1
of which sugars (g)	2.6	0.5
FAT (g)	_	_
of which saturates (g)	0	0
FIBER (g)	0.2	1.5
SODIUM (mg)	122	122

50% calorie reduction

No added sugar

7.5 times increase in fiber

Fiber Enrichment

Pourable Salad Dressing – Good Source of Fiber

Pourable Salad Dressing with the texture, colour, and flavour of a regular full sugar version but with

60% LESS added sugar

3g Fiber per serving

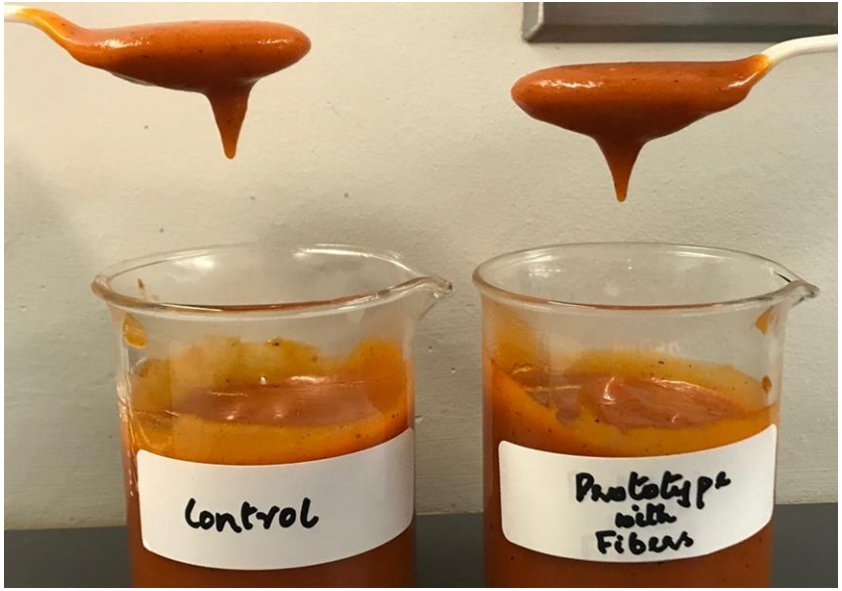
And NO change in process

Reduced Sugar Pourable Salad Dressing - Formulation

Ingredients	Control (%)	Reduced Sugar (%)
Vegetable Oil	25	25
Sucrose	23	10
Tomato Paste	14	14
Vinegar	7.4	7.4
Water	26.6	27.485
Spices	2	2
Salt	1	1
Thickeners	0.8	0.9
Preservatives	0.2	0.2
Soluble Corn Fiber	0	12
Sucralose	0	0.015
Total	*100*	*100*

- Provides texture
- Provides the body
- Compensates for the mouthfeel loss

Reduced Sugar Pourable Salad Dressing - Comparison



- Similar Color
- Similar Texture
- Similar mounting on the spoon
- Similar taste profile

Reduced Sugar Pourable Salad Dressing – Product Attributes

Parameters		Control	Reduced Sugar
pH		3.5	3.4
Water Activity		0.954	0.961
Color	L*	24.99	24.91
	a*	29.95	29.3
	b*	27.26	25.63
Viscosity* Brookfield 10 rpm		2000 cPs 3000 cPs	2000 cPs 3000 cPs

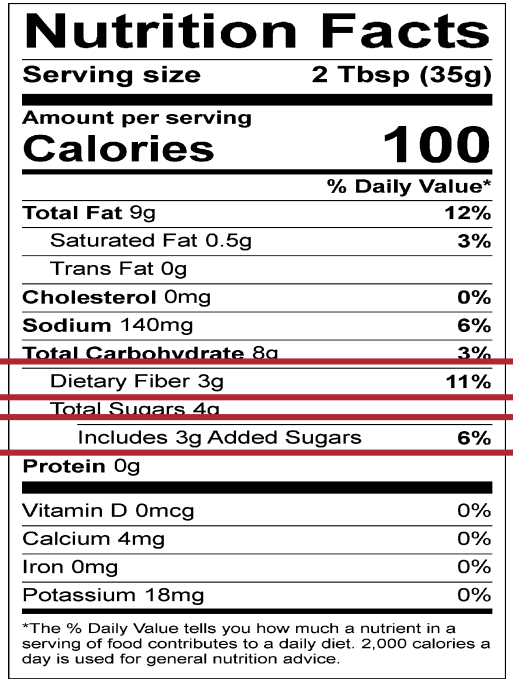
Reduced Sugar Pourable Salad Dressing - Nutritional Information

Nutrition Facts

Serving size	**2 Tbsp (35g)**
Amount per serving	
Calories	**120**
	% Daily Value*
Total Fat 9g	**12%**
Saturated Fat 0.5g	**3%**
Trans Fat 0g	
Cholesterol 0mg	**0%**
Sodium 140mg	**6%**
Total Carbohydrate 10g	**4%**
Dietary Fiber 0g	**0%**
Total Sugars 8g	
Includes 8g Added Sugars	**16%**
Protein 0g	
Vitamin D 0mcg	0%
Calcium 4mg	0%
Iron 0mg	0%
Potassium 18mg	0%

*The % Daily Value tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

Control



Nutrition Facts

Serving size	**2 Tbsp (35g)**
Amount per serving	
Calories	**100**
	% Daily Value*
Total Fat 9g	**12%**
Saturated Fat 0.5g	**3%**
Trans Fat 0g	
Cholesterol 0mg	**0%**
Sodium 140mg	**6%**
Total Carbohydrate 8g	**3%**
Dietary Fiber 3g	**11%**
Total Sugars 4g	
Includes 3g Added Sugars	**6%**
Protein 0g	
Vitamin D 0mcg	0%
Calcium 4mg	0%
Iron 0mg	0%
Potassium 18mg	0%

*The % Daily Value tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

Reduced Sugar

- **3 grams of fiber per serving**
- **60% reduction in added sugar**

Clean Label

Fiber as Gum Replacer in Spoonable Salad Dressing

Spoonable Salad Dressing without Gums in the formulation. Provides similar texture, colour, glossiness, mouthfeel and flavour.

Soluble Oat Fiber as a Gum replacer

Clean Label Appeal

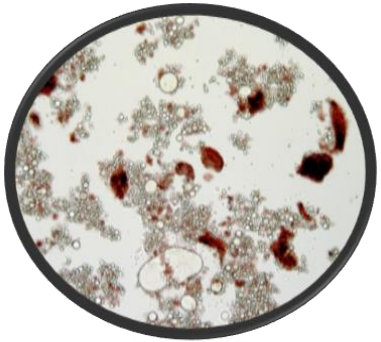
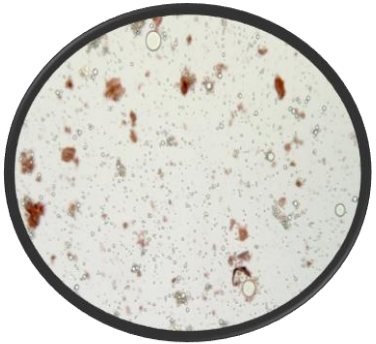
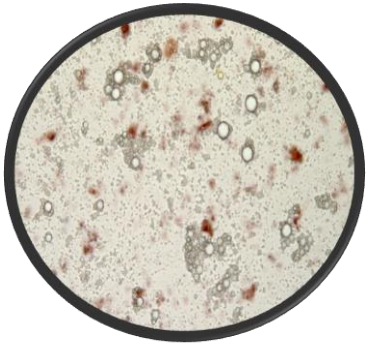
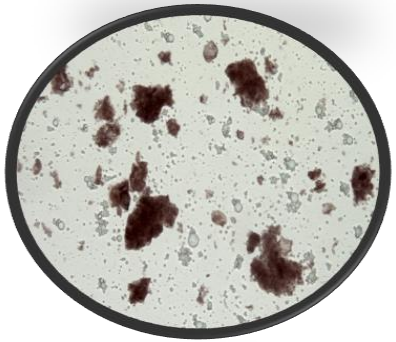
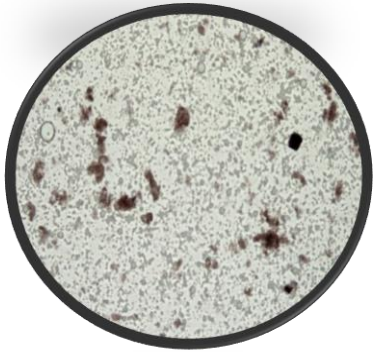
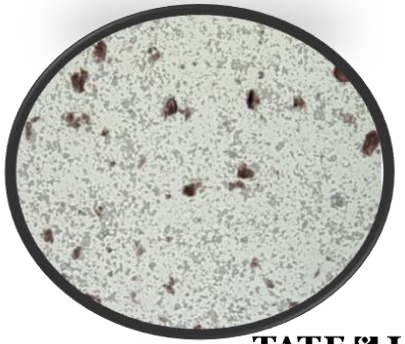
And NO change in process

Spoonable Dressing with Fibers - Formulation

Ingredients	No Fiber/Gum (%)	With Guar Gum(%)	With Fiber (%)
Water	39.815	39.735	39.315
Soybean Oil	35	35	35
Vinegar	7	7	7
Egg yolk, pasteurized, frozen, 10% salt	5	5	5
Corn Starch	4.5	4.5	4.5
Mustard Flour	0.3	0.3	0.3
Salt	2.25	2.25	2.25
Sugar	6	6	6
EDTA	0.005	0.005	0.005
Potassium Sorbate	0.13	0.13	0.13
Guar Gum	0	0.08	0
Soluble Oat Fiber	0	0	0.5
Total	*100*	*100*	*100*

Soluble Oat Fiber used at a higher dosage than Guar Gum

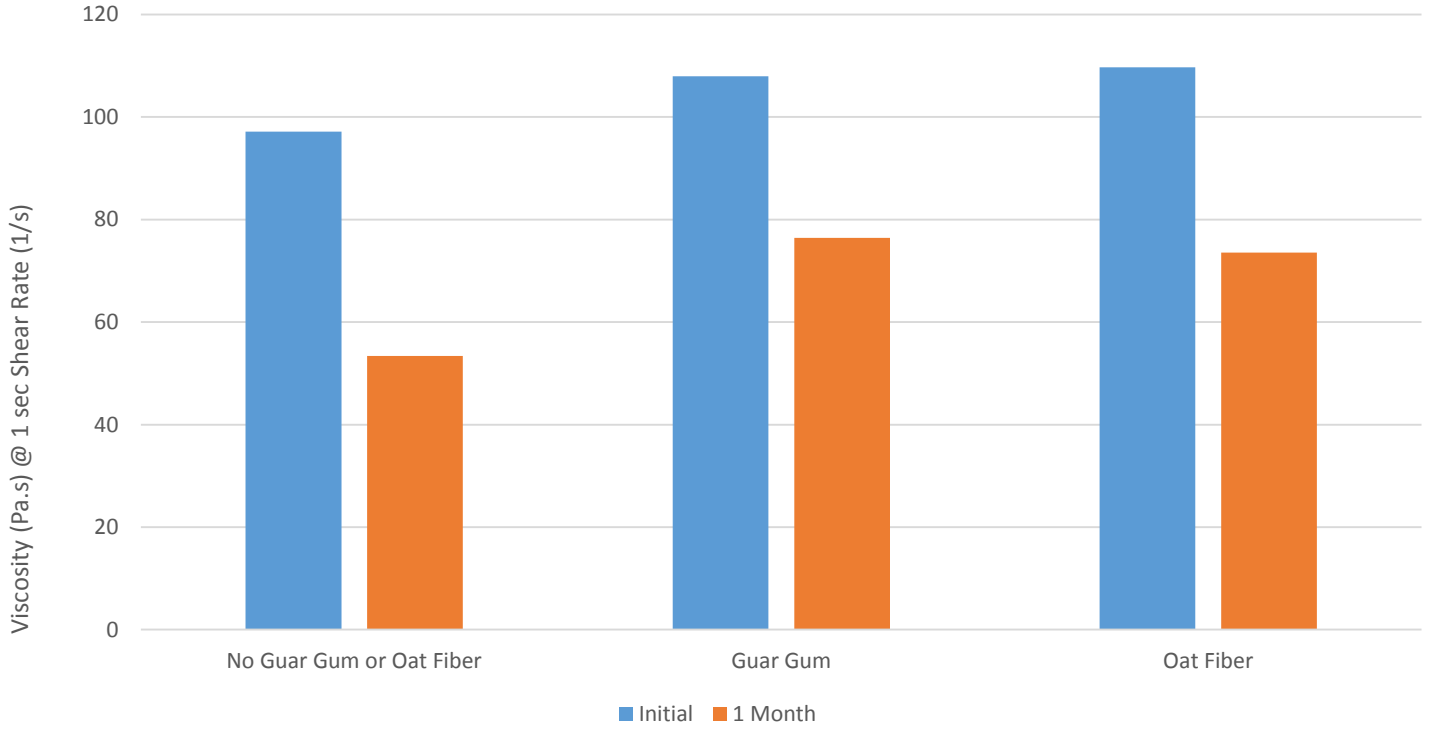
Spoonable Dressing with Fibers - Microscope Images

	No Fiber or Guar	Guar Gum	Oat fiber
Initial			
1 month			

Spoonable Dressing with Fibers – Product Attributes

Attributes	No Fiber/Guar Gum	Guar Gum	Oat Fiber
pH	3.4 -3.6	3.4 – 3.6	3.4 – 3.6
Viscosity* Brookfield 20 rpm	15000 cPS 12500 cPS	15000 cPs 14000 cPs	15000 cPs 13500 cPs

Spoonable Dressing with Fiber - Rheology



Spoonable Dressing with Fibers - Comparison

No Fiber or Guar Gum

Guar Gum

Oat fiber

Similar spoonability, texture, mouthfeel, flavor and color

SUMMARY

Summary

- Consumers are not getting enough fiber in their diets; however, they recognize fiber is needed for healthy living
- Fibers have beneficial physiological effects
- There are many types of fibers from different sources
- Formulating with fibers can impact process conditions and formula adjustments may be needed
- Fibers can be used to add texture and bulk, and reduce the fat and sugar content in sauces and dressings.
- Fibers can be a valuable tool to formulate clean label products.