

PreScouter

Natural Replacements for Sugar in Beverages

Research Support Service
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Inquiry Question

Which natural replacements for sugar may be applicable in beverages?

Sugar plays an important role in the food and beverages industry due to its sweetness and sensory profile (texture, flavor, color and taste). However, sugar is causing severe negative health consequences in consumers (children and adults) globally; contributing to the increasing rates of obesity, across all age-groups. Sugar-sweetened beverages, in particular, were recently linked to obesity¹ in both children and adults in a study published by the European Association for the Study of Obesity (EASO) that included 250,000 people. Artificial sweeteners are not any better and are increasingly being associated with a long list of equally concerning health claims.^{2,3}

This inquiry highlights potential novel replacements for sugars that are from natural sources, safe, technologically viable and environmentally sustainable to be incorporated into beverages (e.g. soft drinks, juices).

Executive Summary

Well-developed ingredients:

Stevia and **monk fruit** are the most common natural sugar replacers that are currently being used in the food industry. Three key players in this category who have developed natural high-intensity sweeteners that are applicable in beverages are: Tate & Lyle, ED&F Man/Unavoo Food Technologies Ltd and Cargill.

Emerging ingredients:

Chicory root inulin and “**modified**” **sugar** from plant-based sources are the two key innovations in natural sugar-reduced solutions. Chicory root inulin is a low-intensity sweetener, providing up to 50% sweetness in the liquid form. Top players include Cargill, CoSucra and Sensus. Modifying sugar is what Holista Colltech is attempting to do.

Early stage solutions from more basic research:

Studies on the applicability and suitability of **date extract** (syrup) and **date powders** as an alternative to sugar indicated significant potential for use as a natural sweetener ingredient. However, further research is needed.

Executive Summary

Nick Henson, Senior Technical Manager, Food Solutions at Covance, highlighted 4 key considerations when it comes to product reformulation for sugar reduction in beverages: taste, flavor, texture (most challenging) and calorie management. Solutions that met most or all of these considerations have been highlighted. A few examples of companies providing such solutions are presented.

Acknowledgements

We would like to thank Holista Colltech and HEYLO for providing us with supplementary information to complete this report.

WHERE THE FEATURED NATURAL REPLACEMENTS FOR SUGAR COME FROM



A world map with a dark blue background. The United States and Australia are highlighted in a bright red color. A white dot is placed on the US map, connected by a thin white line to the USA information box. Another white dot is placed on the Australian map, connected by a thin white line to the Australia information box.

USA

TATE & LYLE
Monk Fruit Extract

HEYLO
Stevia + Dietary Fiber
















SENSUS
Chicory Root Inulin

CARGILL
Chicory Root Inulin
Stevia

Australia

HOLISTA COLLTECH
Cane Sugar & Beetroot

Natural Replacements for Sugar in Beverages

Product	Source of Raw Ingredient	Sweetness Intensity	Absence of Aftertaste	Suitable for Diabetics	GRAS
Monk Fruit Extract	Monk Fruit	High Intensity			
Stevia	Stevia Plant	High Intensity			
HEYLO	Stevia + Dietary Fibers	Low Intensity			
Cargill EverSweet	Simple sugars fermented by brewer's yeast	High Intensity			
Holista's Low GI-Sugar	Beetroot and sugarcane	Low Intensity		Low-GI validation in progress	
Holista's Reverse Sugar	Beetroot and sugarcane	Low Intensity			
Chicory Root Inulin	Chicory Root	High Intensity			



CHICORY ROOT INULIN

50% sweetness of sugar



HOLISTATECH REVERSE SUGAR

same sweetness as sugar



MONK FRUIT JUICE

10-15 times sweeter
than sugar



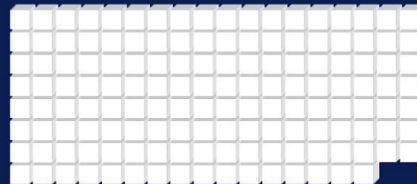
STEVIA + DIETARY FIBERS

10-15 times sweeter
than sugar



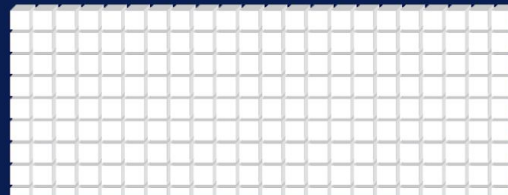
MONK FRUIT EXTRACT

150-200 times sweeter
than sugar



STEVIA

250-300 times sweeter
than sugar



How many sugar cubes are
required to produce the same
level of sweetness as each
natural alternative?

WELL-DEVELOPED INGREDIENTS

The Well-Developed Ingredients

1. **Monk fruit sweetener**, a high intensity sweetener, contains the basic units of triterpene glycosides (mogrosides), and is already present on the worldwide market.
2. **HEYLO sweeteners**, which are already on the market and being utilised by food manufacturers, are constituted of a patented blend of stevia and dietary fibers.
3. **EverSweet™ by Cargill** is a “next-gen” sweetener based on a new fermentation process that can transform simple sugars into some of the better tasting steviol glycosides.

TATE & LYLE



Monk Fruit Sweetener⁴⁻⁷

Monk fruit is classified as a high-intensity sweetener. High-intensity sweeteners are defined as sugar substitutes because they are many times sweeter than sugar but contribute to only a few or no calories when added to foods. **Monk fruit sweetener is generally recognized as safe (GRAS).**

There have been over 800 products, including beverages, containing monk fruit sweetener launched since 2009, as listed on monkfruit.org.

Advantages of Monk fruit sweetener:

- **Monk fruit juice** concentrate is **15-20 times** sweeter than sugar
- **Monk fruit extract** is a powdered fruit extract that is **150–200 times** sweeter than sugar
- Clean-flavor profile

Some suppliers of Monk fruit extract:

- Van Wankum Ingredients
- BioVittoria Ltd: New Zealand
- Blue California
- U.S. Niutang Chemical Inc.



PUREFRUIT™ Monk Fruit Extract can help you deliver low-calorie, premium beverages, with great taste and mouthfeel.

Reported by Kelli Hardin, global category manager of sweeteners and beverages at **Tate & Lyle**, Monk fruit is gaining attention in its application as sugar substitutes in beverages.

Common applications include:

- Dairy and dairy alternative-based beverages (coconut and almond milk)
- Juice
- Flavored water
- Carbonated drinks

Monk fruit performs well in low-acid beverages.

Although, weight-for-weight, monk fruit is more expensive than stevia, cost-in-use continues to decrease as demand and scaling up continues.

Unavoo Food Technologies Ltd is an innovative company that was founded with the purpose to reduce or fully eliminate sugars and artificial sweeteners from food and beverages through better ingredients. Unavoo and ED&F Man partnered in 2016 to develop HEYLO.

HEYLO consists of a patented blend of **organic stevia** (not chemically extracted) and **all-natural dietary fibers** (from the Acacia tree). It is readily available as a B2B solution and will be ready for private consumption in the third quarter of this year.

Characteristics of HEYLO sweetener:

- Clean-label profile
- Prebiotic benefits
- Zero-glycemic index (safe for diabetics) and zero calories
- 10-15 times sweeter than sugar
- No texture or taste trade-offs
- Can tolerate high temperatures and acidity levels

HEYLO has been successfully implemented in many beverage applications such as flavored water, non-carbonated drinks, iced tea, chocolate milk powder, and sodas.

→ According to Lilach Bar Tal, HEYLO's VP Marketing & Strategy, they have had some very successful trials with a few beverage-well-known companies.

Cargill recently announced a 'next-generation' sweetener called EverSweet™. Their technology is based on a new fermentation process that extracts large quantities of Reb M and Reb D (some of the better tasting steviol glycosides) from stevia plants in a sustainable way. Cargill is using 'specially crafted baker's yeast' that can transform simple sugars into steviol glycosides, mimicking the process carried out by the stevia plant.

→ This technology was developed in partnership with Evolva.

EverSweet Properties:

- Sweetness characteristics: high intensity, fast onset, well-rounded and robust
- Improved sweetness quality: No bitterness or aftertaste most commonly associated with using stevia leaf extracts at high concentrations.
- Zero-calorie and safe for diabetics
- Clean label

Some applications in beverages:

- | | | |
|---------------|------------------------|-------------------|
| • Soft drinks | • Functional beverages | • Flavored waters |
| • Iced tea | • Energy drinks | • Chocolate milk |

EMERGING INGREDIENTS

The Emerging Ingredients

1. **Holista CollTech**, an Australian biotechnology startup has filed a patent for the first low GI-sugar with all natural ingredients. They are also working on a reverse-sugar sweetener, expected to hit the market in mid 2018.
2. **Chicory root inulin** sounds promising as it can be used in the following products:
 - a) Smoothies due to its creaminess profile
 - b) Soy drinks and flavored water due to its high solubility

It is available in liquid form, so it is compatible for beverages. Products from **Sensus** and **Cargill** are highlighted.



Australian (Perth-based) biotech company, known as Holista CollTech is the result of the merger between Holista Biotech of Malaysia and CollTech Australia. The company is working on two very promising sugar alternatives, both of plant origin (beetroot and sugarcane):

1) **Holista's Reverse Sugar Sweetener:**

- ✓ Sensory profile completed, to hit market in June 2018.
- ✓ Can be used in all applications as a 1 to 1 replacement with no aftertaste.
- ✓ Has no effect on metabolism and passes through the body undigested. Thus, it is a zero-calorie sweetener and suitable for diabetics.

2) **Holista's Low-GI Sugar:**

- ✓ Patent filed for the world's first low GI-sugar made completely of all-natural ingredients.
- ✓ Mimics nature; when consumed, it reduces the rate that glucose is digested throughout the body.
- ✓ Can be used in all applications as a 1 to 1.2 replacement with no aftertaste.
- ✓ Early sensory testing completed, validation of GI studies in progress. Preliminary results will be available in June 2018.

As reported by Dr. Rajen Manikka, CEO of Holista, both of these sugar replacement innovations are physically sugar and have the functionality of sugar. They can be cooked, baked, heated, chilled, etc.

The company is working on obtaining a GRAS label for both.

Holista is looking to approach various sugar companies with a B2B strategy and open to partnerships from all over the world.

- Both innovations present a natural, clean-label alternative to sugar and artificial sweeteners for beverages. The only minor drawback may be price, where early estimates for the reverse sugar product may be 3-5 times the price of white sugar. However, costs will drop with the scaling up of production.

Sensus is a company in the Netherlands that produces and markets healthy food ingredients called **Frutafit inulin** and **Frutalose oligofructose**, both derived from natural chicory root.

They are sources of inulin, a soluble dietary fiber which comes from the root of the chicory plant. It has a beneficial prebiotic effect on human health.

Sensus also reported¹⁴ that:

"As a soluble fiber, inulin, is a perfect ingredient for instant beverages, soy drinks, and flavored waters, particularly those that could be classified as 'functional'. Inulin is completely soluble and also gives beverages extra body. Its neutral to sweet taste can strengthen the sweetness of high intensity sweeteners while masking any after taste. But, inulin is also an ideal sugar replacer in low-calorie beverages."

Oliggo–Fiber® Chicory Root, developed by CoSucra and distributed in the North American market by Cargill, helps beverage manufacturers capitalize on key consumer trends, such as clean label ingredients and sugar reduction, without impacting the taste of the final food product.

Applications:

- Functional and flavored waters
- Powdered beverages
- Smoothies
- Chilled juices

Benefits:

- Can be used as a bulking agent in reduced sugar applications
- Modulates flavor of some high intensity sweeteners
- Soluble fiber source
- Adds creaminess, increases body and mouthfeel

Cargill has provided a product portfolio, please refer to this [link](#).

“At the March’s Natural Products Expo West trade show, Cargill in the USA, sampled a new food prototype: a vegan, reduced-sugar, non-GMO hazelnut spread. The company created this sample to demonstrate how it thinks one particular star ingredient, chicory root fiber, can play a greater role in the sugar-reduction movement.”

Their aim is to promote chicory root fiber as a clean-label ingredient, said Taylor Halstead, production line manager, Cargill.

He added by saying:

“It’s multifunctional. It provides texture and it can provide some sweetness as well to some formulations...Chicory root fiber can help with sugar reduction, although it cannot achieve a total zero-sugar product.

EARLY STAGE SOLUTIONS FROM MORE BASIC RESEARCH

What is the applicability and suitability of date extract (syrup) as an alternative natural sweetener ingredient?

To answer this question, the liquid sugar extraction from date palm (*Phoenix dactylifera* L.) fruits was investigated. The study¹⁸ looked at whether date extract (syrup) can be utilised in food industries, such as soft drinks, candy and bakery products, to replace imported and exported expensive sucrose.

The Riziz date variety was used in this study. The research data indicated a significant potential to use date syrup in product development and the following conclusions were made:

- Total sugar contents = 83%
- Use of date pulp to water ratio (D/W:1/3) with ultrasonic process at power 25% gave the highest recovery (**please refer to Figure 1**).
- Glucose and fructose were the major sugars present in the date syrup.
- Organoleptic evaluation of the date syrups was desirable (**please refer to Table 1**).

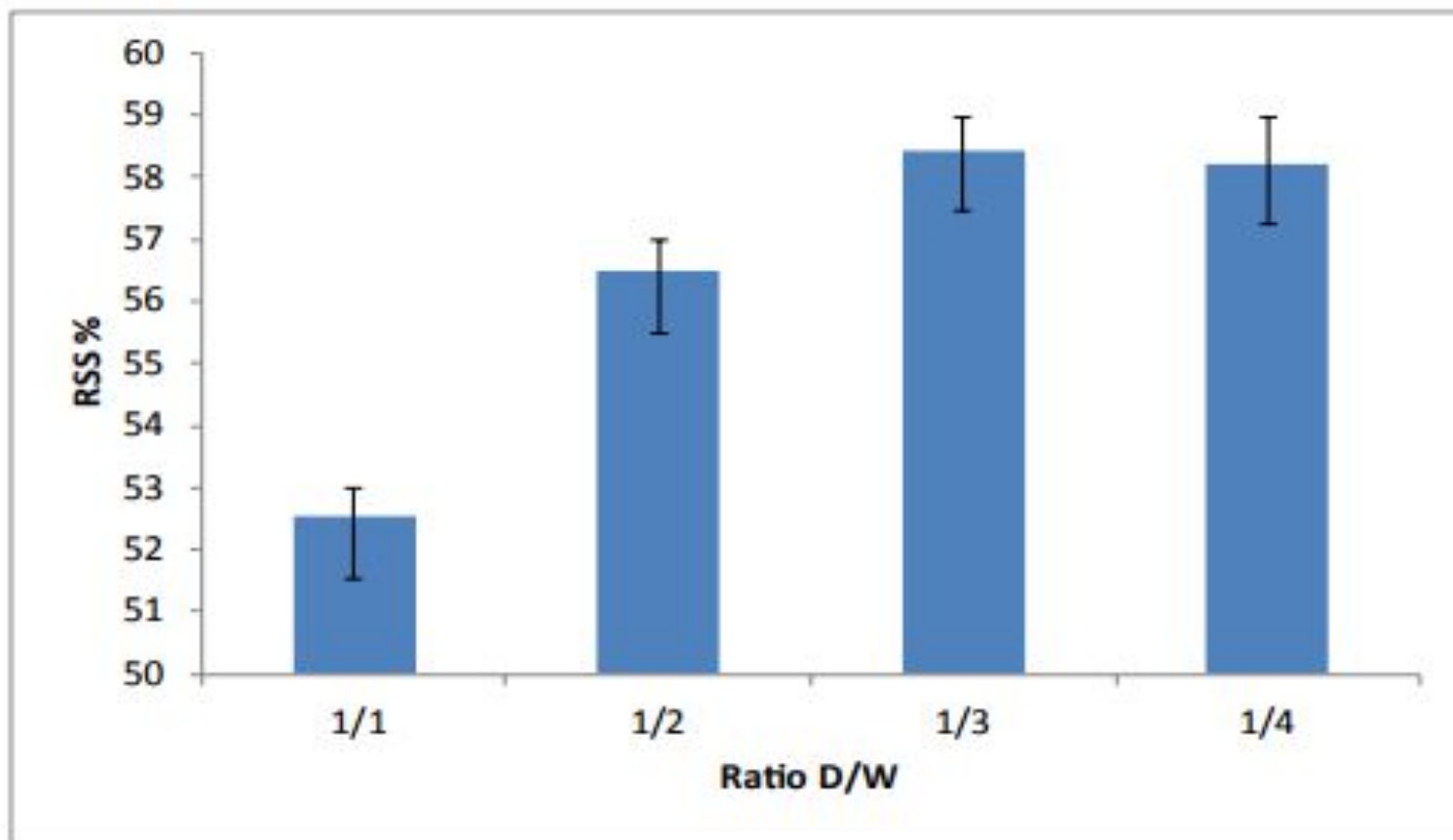


Figure 1. Effect of date / water ratio (D/W) on the extraction yield (RSS %) of soluble solids from Reziz date fruit.

Syrup	Color	Texture	Taste	Flavor	Overall quality
1 *	7.78 ±0.43 ^c	7.56±0.51 ^b	7.53±0.55 ^c	7.39±0.53 ^c	7.14±0.45 ^c
2 **	8.25±0.60 ^b	8.28±0.43 ^a	8.28±0.39 ^b	8.28±0.43 ^b	7.89±0.21 ^b
3***	8.64±0.38 ^a	8.53±0.32 ^a	8.64±0.33 ^a	8.56±0.34 ^a	8.61±0.32 ^a
Khalas control	7.06± 0.34 ^d	6.78±0.39 ^c	6.69±0.39 ^d	6.97±0.36 ^d	6.75±0.31 ^d

Table 1: Analysis of variance for organoleptic evaluation of date syrup (at ratio 1/3 D/W)

Within same column, means with the same letter are not significantly different *Date Syrup ** Date Syrup with enzymes 1.0% *** Date Syrup with Sonication 25%

What is the possibility of using date powders as a sucrose replacement in soft drinks' production?

Sugar plays an important role in the development of beverages, such as soft drinks. Owing to the worldwide increasing rate of obesity, industries must seek alternative to lower the sugar content or find natural alternatives that mimic the sweetness presented by sucrose. Therefore, **this study aimed at looking at the possibility to use date powders from Algerian varieties as a replacement of sucrose during the production of soft drinks.**

Four different varieties¹⁹ were selected to obtain date powders as seen in Table 2. The *H'llowa* variety was selected to be incorporated in soft drinks (**please refer to Table 3**) based on the following qualities:

- Yield
- Optical density (a parameter that analyses browning effect of the product)
- Moisture
- Total and reducing sugars
- Rehydration power
- Sensitivity in temperature
- Organoleptic/rheological properties
- Nutritional quality

Sensory Characteristics	Date Varieties	Good	Acceptable	Poor	Bad
Color	Tefezouine	50	36	14	/
	Timjouhart	14	50	22	14
	H'loua	79	14	7	/
	H'mira	14	22	43	21
Taste	Tefezouine	43	36	21	/
	Timjouhart	21	44	21	14
	H'loua	57	36	7	/
	H'mira	7	14	43	36
Texture	Tefezouine	57	29	14	/
	Timjouhart	36	43	21	/
	H'loua	71	21	8	/
	H'mira	21	57	22	/

Table 2: Sensory evaluation of date powders of the 4 date varieties studied.

Sensory Characteristics	Soft Drinks	Good	Acceptable	Poor	Bad
Color	Control (250ml water, 125g sucrose, 1.5ml aroma, 075g citric acid, 0g date powders)	65	20	15	/
	A (250ml water, 0g sucrose, 1.5ml aroma, 075g citric acid, 125g date powders)	55	25	5	15
	B (250ml water, 62.5g sucrose, 1.5ml aroma, 075g citric acid, 62.5g date powders)	75	15	10	/
	C (250ml water, 62.5g sucrose, 0ml aroma, 075g citric acid, 62.5g date powders)	70	15	15	/
Taste	Control (250ml water, 125g sucrose, 1.5ml aroma, 075g citric acid, 0g date powders)	65	20	15	/
	A (250ml water, 0g sucrose, 1.5ml aroma, 075g citric acid, 125g date powders)	50	15	15	20
	B (250ml water, 62.5g sucrose, 1.5ml aroma, 075g citric acid, 62.5g date powders)	70	15	15	/
	C (250ml water, 62.5g sucrose, 0ml aroma, 075g citric acid, 62.5g date powders)	75	20	5	/
Acidity	Control (250ml water, 125g sucrose, 1.5ml aroma, 075g citric acid, 0g date powders)	55	20	15	10
	A (250ml water, 0g sucrose, 1.5ml aroma, 075g citric acid, 125g date powders)	80	10	10	/
	B (250ml water, 62.5g sucrose, 1.5ml aroma, 075g citric acid, 62.5g date powders)	60	20	15	5
	C (250ml water, 62.5g sucrose, 0ml aroma, 075g citric acid, 62.5g date powders)	75	15	10	/

Table 3: The results of the sensory evaluation carried out for soft drinks.

Supplementary Information

A comparison of natural sugar substitutes and their sweetness level²⁰

Natural sugar substitutes	Potency [Times sweeter than sucrose (by weight)]	Potency [Times sweeter than sucrose (by food energy)]	Energy density of sucrose
Brazzein	800	-	-
Curculin	550	-	-
Erythritol	0.7	14	0.05
Glycyrrhizin	50	-	-
Glycerol	0.6	0.55	1.075
Hydrogenated starch hydrolysates	0.4-0.9	0.5-1.2	0.75
Inulin	-	-	-
Isomalt	0.45–0.65	0.9–1.3	0.5
Lactitol	0.4	0.8	0.5
Lo Han Guo	300	-	-
Mabinlin	100	-	-
Maltitol	0.9	1.7	0.525
Maltooligosaccharide	-	-	-
Mannitol	0.5	1.2	0.4
Miraculin	Does not taste sweet by itself, but modifies taste receptors to make sour things taste sweet temporarily		
Monatin	Naturally-occurring sweetener isolated from the plant <i>Sclerochiton ilicifolius</i>		
Monellin	3000	-	-
Pentadin	500	-	-
Sorbitol	0.6	0.9	0.65
Stevia	250	-	-
Tagatose	0.92	0.24	0.38
Thaumatococin	2000	-	-
Xylitol	1	1.7	0.6

The aim of this review article was to explore the health controversy over perceived benefits of sugar substitutes.

A list of natural sugar substitutes was gathered and presented in this inquiry. A summary can be seen in the adjacent table.

Research Conducted on the Suitability of Natural Sweeteners in Beverages

Authors	Contact Info	Article	Journal/Weblink	Year
Heylo Revolution	Industry contact	Say goodbye to sugar and its old alternatives	http://www.heylosweet.com/	2017
ED&F MAN	Contact HEYLO	ED&F Man and Unavoo launch natural sweetener	http://www.edfman.com/news/894-ed-f-man-and-unavoo	2017
Holista CollTech	Industry contact	Holista CollTech Collaborates with Nobel Prize Nominee to File Patent for World's First Low GI-Sugar With All-Natural Ingredients	https://www.asx.com.au/asxpdf/20170106/pdf/43f5dn27yq98q8.pdf	2017

Research Conducted on the suitability of natural sweeteners in beverages

Authors	Contact Info	Article	Journal/Weblink	Year
Sensus	info@sensus.nl +31 165 582 578	Discover the benefits of inulin	https://www.inspiredbyinulin.com/applications-of-inulin/beverages.html	2017
Cargill	1-800-227-4455	Oliggo-Fiber® Chicory Root Fiber	https://www.cargill.com/food-bev/na/oliggo-fiber-chicory-root-fiber	2017
		Eversweet™	https://www.cargill.com/food-bev/na/eversweet-sweetener	2018
Tate & Lyle	Industry contact	Tate & Lyle Launches PUREFRUIT™ Monk Fruit Extract, the First Fruit-Based Calorie-Free Sweetening Solution	https://www.tateandlyle.com/news/tate-lyle-launches-purefruit-monk-fruit-extract-first-fruit-based-calorie-free-sweetening	2011

Research conducted on the suitability of natural sweeteners in beverages

Authors	Contact Info	Article	Journal/Weblink	Year
Hariri A, Ouis, N and Bouhadi, D	haririahmed@yahoo.fr	Effect of substitution of sugars by date powders variety H'lowa on the quality of the soft drinks	Journal of Applied Biotechnology & Bioengineering	2017
Sami Ghnimi*, Syed Umer, Azharul Karim, Afaf Kamal-Eldin	Sami_ghnimi@uaeu.ac.ae	Date fruit: An underutilised food seeking industrial valorization	NFS Journal	2017
Roger A. Clemens*, Julie M. Jones, Mark Kern, Soo-Yeun Lee, Emily J. Mayhew, Joanne L. Slavin, Svetlana Zivanovic	clemens@usc.edu	Functionality of sugars in foods and health	Comprehensive Reviews in Food Science and Food Safety	2016

Research conducted on the suitability of natural sweeteners in beverages

Authors	Contact Info	Article	Journal/Weblink	Year
Gamal A El-Sharnouby*, Salah M Aleid, Mutlag M Al-Otaibi	gelsharnoby@kfu. edu.sa	Liquid sugar extraction from date palm fruits	Journal of Food Processing & Technology	2014
Kirtida R. Tandel	ni.oc.oohay@ledn ataditrikrd	Sugar substitutes: Health controversy over perceived benefits	Journal of Pharmacology & Pharmacotherapeutics	2011

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15. <https://www.cargill.com/food-bev/na/oliggo-fiber-chicory-root-fiber>
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18. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3198517/>

About the Authors



Vasambal Manikkam

Victoria University (Australia)

Professional Summary:

Vasambal is a PhD qualified Nutritional Food Scientist, committed to improving people's health through education, research and product development. She is currently a member of the Global Scholar Program at PreScouter.

Research Background:

Vasambal completed her PhD in Food Science and Technology at Victoria University. Her research described the novel work on endogenous enzymatic degradation of excess or wasted fish proteins from Australian fish species, to develop bioactive peptides, with specific antioxidant and metal-chelating properties.

Scientific Interests:

- Food safety & quality across the food & beverages industry
- Food security and minimising food wastage
- The effects of food products on gut microbiome/brain axis and metabolic diseases prevention.
- Functional foods to prevent/manage obesity, hypertension and oxidative stress
- Functional properties of plant-based foods.

About the Authors



Rachel Murkett

University of Cambridge (UK)

Professional Summary:

Rachel is one of PreScouter's Project Architects. She specializes in the food & beverage industry.

Research Background:

Rachel completed her PhD in Chemistry at the University of Cambridge. Her research was focused around Photobiology, with research themes including the development of fluorescent proteins for biomedical imaging applications and the formulation of lutein as a nutritional supplement.

Scientific Interests:

Molecular biology, protein expression and purification, protein and small molecule biophysics, large scale assays (liquid handling robots), structural characterisation techniques and data analysis.

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