Carbohydrates – The Inevitable and The Controversial…

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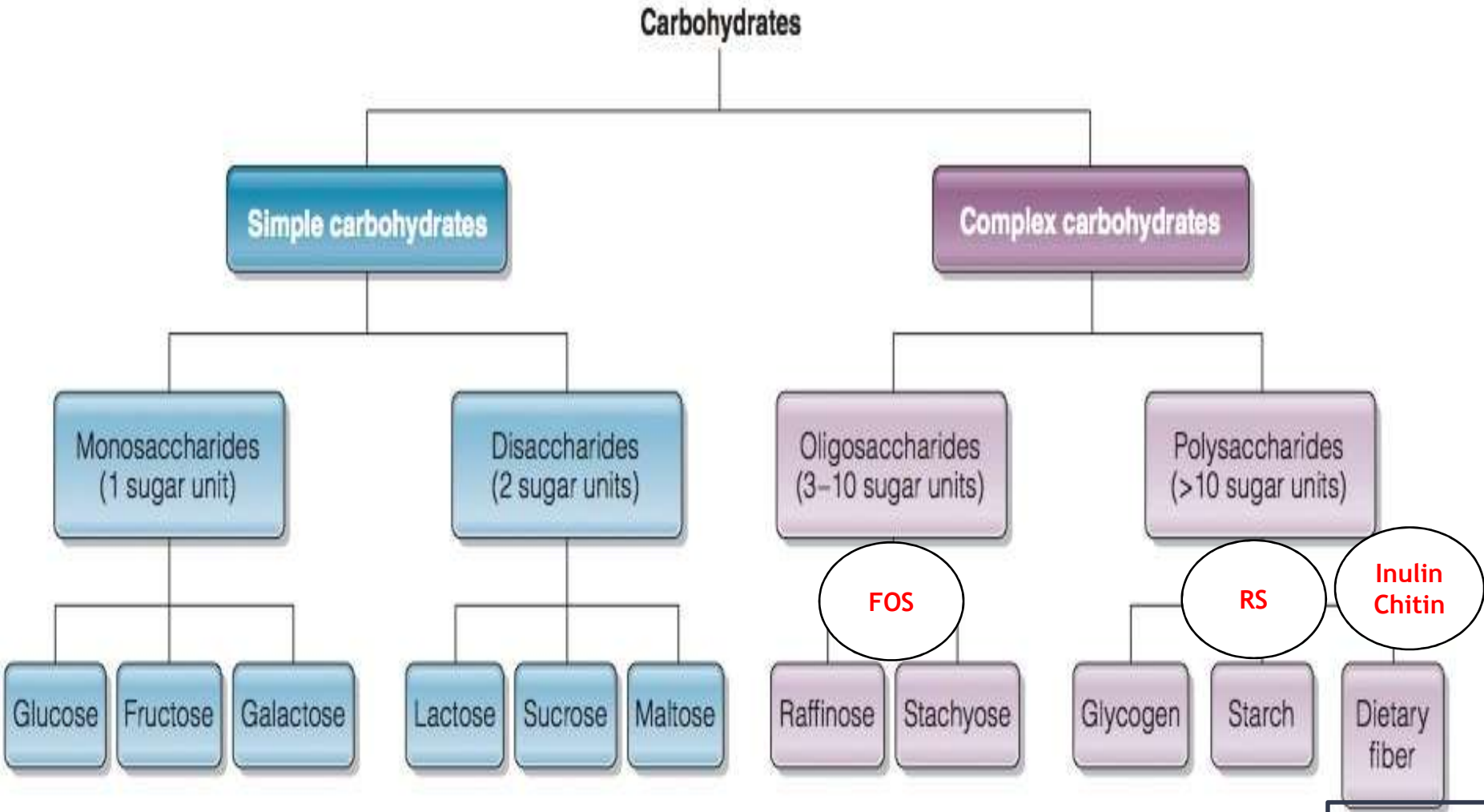

Carbohydrates
Simple carbohydrates
Complex carbohydrates
Monosaccharides (1 sugar unit)
Disaccharides (2 sugar units)
Oligosaccharides (3–10 sugar units)
Polysaccharides (>10 sugar units)
Glucose
Fructose
Galactose
Lactose
Sucrose
Maltose
Raffinose
Stachyose
Glycogen
Starch
Dietary fiber
FOS
RS
Inulin
Chitin

Carbohydrates: The Inevitable Culprit!

Carbohydrate requirement

- RDA
- Protein sparing
- Ketosis
- Transition in Quality-Several health implications.

Carbohydrate with Health Implications

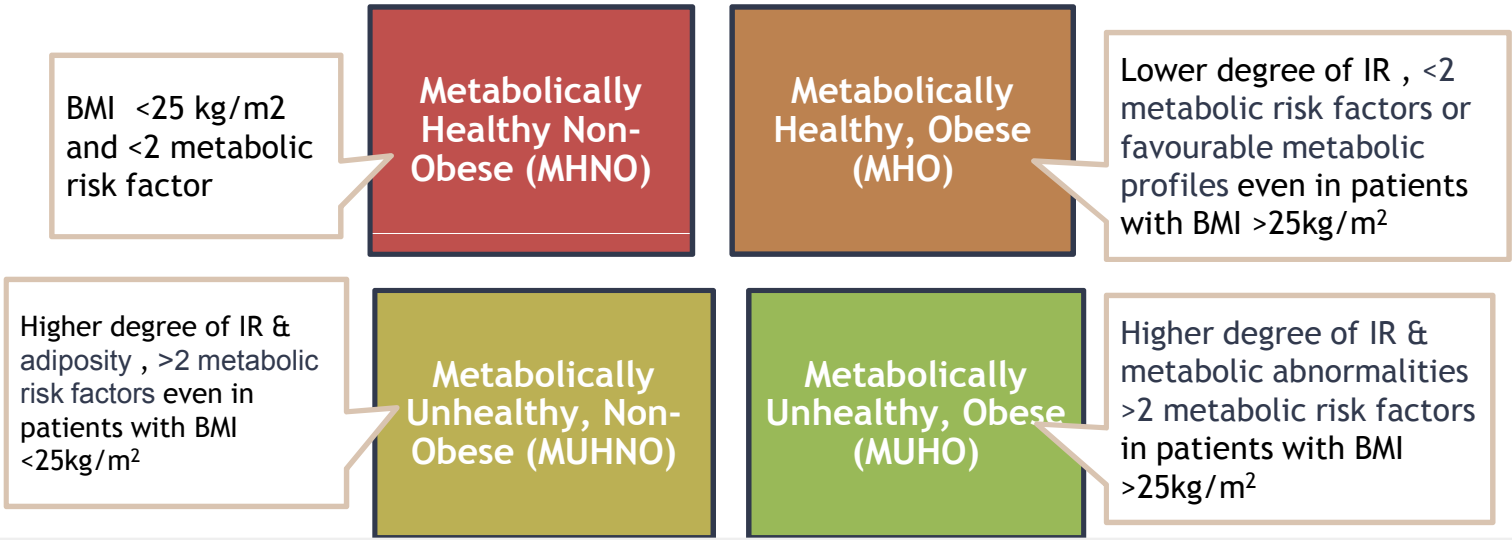
- Fructose
- Free & Added Sugars
- Sugar sweeteners;
- High Fructose Corn Syrup

Carbohydrate in Health & Products

- Dietary Fiber
- Resistant Starch
- Inulin
- Psyllium Husk
- FOS
- Chitin & Chitosan

Metabolic Phenotypes

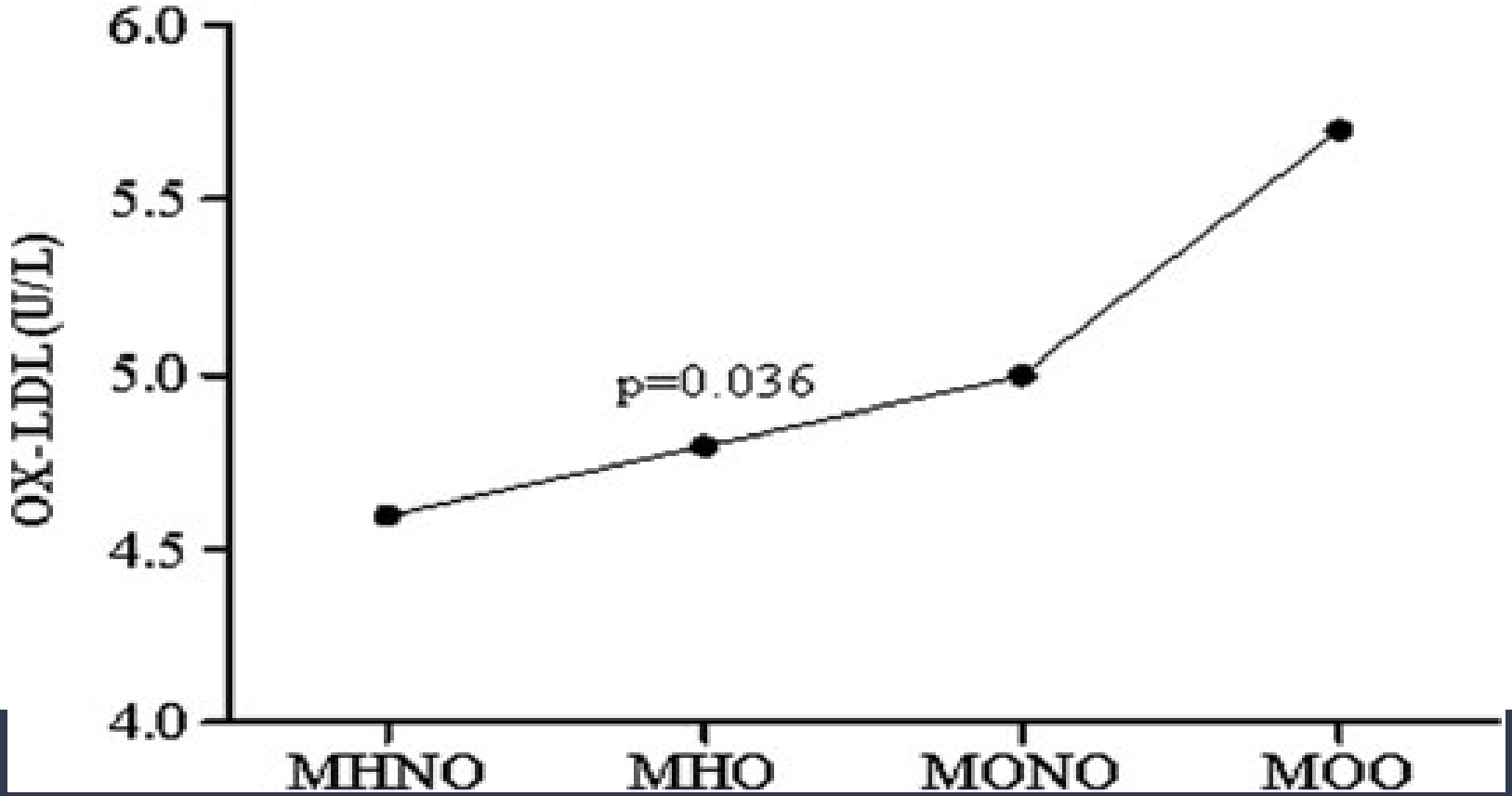
Although many different definitions are used for metabolic health, insulin resistance is regarded as the core pathophysiology



The phenotypes are usually identified using surrogate markers of insulin resistance, the number of metabolic syndrome components, the amount of visceral fat, or the composition of cardiovascular risk factors.

Lee et al. Changes in Metabolic Health Status Over Time and Risk of Developing Type 2 Diabetes. Medicine.2015, Metabolic health and weight: Understanding metabolically unhealthy normal weight or metabolically healthy obese patients. Metabolismclinicalandexperimental65(2016)73–80. **Indulekha et al.** Metabolic Obesity, Adipocytokines, and Inflammatory Markers in Asian Indians—CURES-124

Inflammatory Markers & Metabolic Health



Indulekha et al. Metabolic Obesity, Adipocytokines, and Inflammatory Markers in Asian Indians—CURES-124. DIABETES TECHNOLOGY & THERAPEUTICS Volume 17, Number 2, 2015.

Dietary AGE

Foods **high in** … neat groups
contain 30- ar… est dAGE
level per gram… rs, chips,
and cookies.

High-fat sprea… ls highest in
dAGEs, follow…

Grains, legum… ss
prepared with…

Temperature … ooking.

Meat and mea…
broiling, grilli…

Traditional co… at high
temperatures…

Food item	AGE content
Fats	
Almonds, roasted	66.5 kU/g
Oil, olive	120 kU/g
Butter	265 kU/g
Mayonnaise	94 kU/g
Proteins	
Chicken, broiled (15 min)	58 kU/g
Chicken, fried (15 min)	61 kU/g
Beef, boiled (60 min)	22 kU/g
Beef, broiled (15 min)	60 kU/g
Tuna, roasted (40 min)	6 kU/g
Tuna, broiled (10 min)	51 kU/g
Cheese, American	87 kU/g
Cheese, brie	56 kU/g
Tofu, raw	8 kU/g
Tofu, broiled	41 kU/g
Carbohydrates	
Bread, whole wheat	0.5 kU/g
Pancakes, homemade	10 kU/g
Apples	0.13 kU/g
Bananas	0.01 kU/g
Carrots	0.1 kU/g
Green beans	0.2 kU/g

URIBARRI et al.: DIET-DERIVEI…
Clinical Nutrition (2017); Sharma et al. Advanced glycation End-products (AGEs): an emerging concern for processed food industries. J Food Sci Technol (December 2015) 52(12):7561-7576

Reducing AGE

Table 1 Advanced glycation end-products (AGEs): At a Glance

Advanced glycation end-products (AGEs)	•Protein modifications such as altering their structure and function called "Advanced glycation end-products"
Dietary intake of AGEs	•Depends on the thermal treatment of food incurred •Amount varies even within the same type of food
Mitigation in food	•Glycation reactions are responsible for desired flavour, colour etc. Thus, considerable attention must be paid to the beneficial aspects of the Maillard reaction.
Toxicity of AGEs	•Promote oxidative stress and inflammation related diseases like atherosclerosis, diabetes, acute vascular injury and chronic kidney disease •Associated with age-related and diabetic complications like cataract, joint stiffening •Increased stiffness of the collagen network in the bone, resulted in increase in skeletal fragility and fracture risk •Accumulation of glycation compounds in the plasma and tissues represent an important class of "uremic toxins" •AGEs and RAGE can profoundly be involved in cardiovascular diseases through regulation of atherogenesis, angiogenic response, vascular injury and inflammatory response
Medications	•Intake of antioxidant rich diets like vitamin E, vitamin C, alpha lipoic acid, taurine etc. •Agents like aminoguanidine, metformin, benfotiamine and pyridoxamine can prevent AGEs formation. •Use of AGEs crosslink breakers like ALT 711 or alagebrium drug •Lower cooking temperature •Addition of acids (vinegar, lemon juice) lowers AGEs level

Uribarri et al. Dietary AGEs in disease. Adv Nutr 2015; Sharma et al. Advanced glycation End-products (AGEs): an emerging concernfor processed food industries. J Food Sci Technol (December 2015) 52(12):7561-7576

Carbohydrates: Where are we?

Traditionally carbohydrates were considered as a source of energy or as nondigestible bulk associated with dietary fiber.

Emerging areas of consideration include:

- Glycemic effects
- Fermentable carbohydrates and bowel health & its impact on gut health
- Presence of physiologically active phytochemicals that may be involved in lowering the risk of chronic disease
- Role of carbohydrates in food intake regulation & energy balance

Barbara O. Schneeman. Carbohydrate: Friend or Foe? Summary of Research Needs J. Nutr. 131: 2764S–2765S, 2001

RS Content in Indian Foods

Food Sample	RS (g/100g)
Basmati Rice	20.22
Kolam Rice	27.67
Whole Wheat Flour	0.50
Refined Wheat Flour	0.65
Whole Moong	4.52
Kabuli Chana	1.93
Chana Flour	1.98

Freshly Cooked/ Processed Food Sample	RS (g/100g)	SD
Pressure Cooked Basmati Rice	0.47	0.028
Pressure Cooked Kolam Rice	0.46	0.021
Pulao	0.55	0.035
Khichadi	0.78	0.014
Chapatti	0.49	0.021
Paratha	0.61	0.035
Puri	0.47	0.021
Bhatura	0.54	0.007
Germinated (sprouted) moong	0.79	0.057
Germinated (sprouted) moong usal	0.87	0.042
Soaked Kabuli Channa	0.73	0.007
Chhole	2.38	0.297
Pithale	0.09	0.012

Nigudkar, *Curr. Res. Nutr Food Sci Jour.*, Vol. 2(2), 73-83 (2014)

Resistant Starch

Objective: To examine the influence of **increased Resistant Starch content** of the diet on selected **anthropometric measurements, fecal microflora and biochemical parameters**

Intervention:Experimental diet was provided for **14 days.**
Ø Cereals and millets such as Brown Rice and Jowar (Bhakri) with relatively higher RS content were selected.
Ø Dhal / Pulse preparation incorporated in all three meals
Ø Extensive use of Green Banana and Raw Carrot in daily menu .
Ø RS content of the diet was approximately **1g / 100 kcal**

Conclusion: Significant decrease was observed in weight, body mass index, waist circumference and hip circumference & fasting blood glucose post intervention. Fecal samples showed a significant increase in **Bifidobacteria, Lactobacilli, E. coli count and a significant decrease in Salmonella count post intervention.**

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RESEARCH PAPER
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Effect of diet rich in resistant starch on fecal microflora, anthropometric and biochemical parameters in healthy adults

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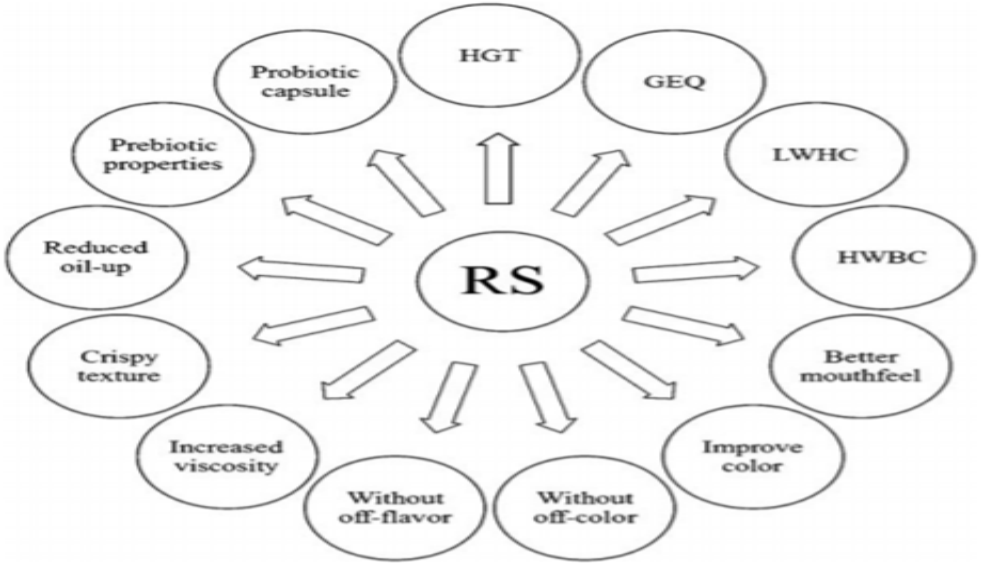
ABSTRACT

Short duration effect of consumption of Resistant Starch (RS) as a supplement in improving animal and human health has been documented using single food based approach. Effect of composite diet rich in resistant starch on human health needs to be studied. The objective was to examine the influence of increased Resistant Starch content of the diet on selected anthropometric measurements, fecal microflora and biochemical parameters. Ten healthy adults in the age group 25-45 years participated in the study. Habitual energy, macronutrients and RS intake was calculated using 7 day food diary. Subjects were then provided with an experimental diet for an intervention period of 14 days. Experimental diet was designed using Indian preparations with foods relatively rich in RS. Recording of anthropometric measurements, collection of fecal and blood samples was done pre and post intervention. Bacterial count as log colony forming units (cfu) was measured in fecal samples. Serum lipid profile and fasting blood glucose was estimated. The experimental diet provided approximately 1g RS/100 kcal which was approximately three times higher than the amount consumed habitually. Significant decrease was observed in weight, body mass index, waist circumference and hip circumference post intervention. Fecal samples showed a significant increase in *Bifidobacteria, Lactobacilli, E. coli* count and a significant decrease in Salmonella count post intervention. Fasting blood glucose decreased significantly post intervention. The food based approach to increase resistant starch content of the diet showed a beneficial effect on gut microflora and anthropometric parameters in healthy adults

Applications of Resistant Starch

The unique characteristics of RS, such as its natural sources, gentle bland flavor, white color, low water holding capacity, etc. have made it a valuable supplement in the formulation of wide range of functional foods, even in microencapsulation of probiotics.



HGT: High Gelatinisation temperature
GEQ:Good extrusion qualities
LWHC:Lower Water Binding Capacity
HWBC:Higher Water Binding Capacity

Homayouni et al. Resistant starch in food industry: A changing outlook for consumer and producer. Starch *2013*

Dietary Fibre

Inulin

Inulin is a type of **soluble fiber** found in many plants. It is a **polyfructan**

Design:

Systematic review and meta-analysis with **20 RCTs with 607 adult participants**

Intervention

Supplementation of Inulin type fructans on lipid profile, fasting glucose and insulin

Findings & Conclusion

The use of ITF has benefits for **LDL-C reduction across all study populations**, whereas **HDL-C improvement and glucose control** were seen only in the **T2DM subgroup**. Overall, ITF supplementation may provide a novel direction for improving the lipid profile and glucose metabolism.

European Journal of Clinical Nutrition (2017) **71**, 9–20

www.nature.com/ejcn

REVIEW

Effect of inulin-type fructans on blood lipid profile and glucose level: a systematic review and meta-analysis of randomized controlled trials

F Liu[1], M Prabhakar[1], J Ju[2], H Long[1] and H-W Zhou[1,3]

BACKGROUND/OBJECTIVES: This systematic review and meta-analysis was performed to assess the effects of inulin-type fructans (ITF) on human blood lipids and glucose homeostasis associated with metabolic abnormalities, including dyslipidemia, overweight or obesity, and type-2 diabetes mellitus (T2DM).

SUBJECTS/METHODS: The MEDLINE, EMBASE and Cochrane Library databases were systematically searched for randomized controlled trials (RCTs) before January 2016. Human trials that investigated the effects of ITF supplementation on the lipid profile, fasting glucose and insulin were included using Review Manager 5.3.

RESULTS: Twenty RCTs with 607 adult participants were included in this systematic review and meta-analysis. In the overall analysis, the supplementation of ITF reduced only the low density lipoprotein-cholesterol (LDL-c) (mean difference (MD): −0.15; 95% confidence interval (CI): −0.29, −0.02; $P=0.03$) without affecting the other endpoints. Within the T2DM subgroup analysis, ITF supplementation was positively associated with a decreased fasting insulin concentration (MD: −4.01; 95% CI: −5.92, −2.09; $P<0.0001$) and increased high density lipoprotein-cholesterol (HDL-c) (MD: 0.07; 95% CI: 0, 0.14; $P=0.05$). Moreover, a reduced fasting glucose tendency was identified only in the T2DM subgroup (MD: −0.42; 95% CI: −0.90, 0.06; $P=0.09$). There was a potential publication bias, and few trials were available for the T2DM subgroup analysis.

CONCLUSIONS: In summary, the use of ITF may have benefits for LDL-c reduction across all study populations, whereas HDL-c improvement and glucose control were demonstrated only in the T2DM subgroup. Thus, additional, well-powered, long-term, randomized clinical trials are required for a definitive conclusion. Overall, ITF supplementation may provide a novel direction for improving the lipid profile and glucose metabolism.

European Journal of Clinical Nutrition (2017) **71**, 9–20; doi:10.1038/ejcn.2016.156; published online 14 September 2016

Shoaib et al. **Inulin: Properties, health benefits and food applications. Carbohydrate Polymers 2016**

Dietary Fibre

Fructooligosaccharides (FOS)

Methods

Barley was cooked and fermented with buttermilk, followed by **addition of FOS, flavors** (rose, khus, chocolate and salt-jeera) and **colors. Sensory evaluation** was done using composite score method, for the four drinks in triplicates.

Findings & Conclusion

No aftertaste or bad mouthfeel was reported in any of the products.Locally available **functional ingredients** can be used to develop **functional foods in form of foods and beverages. FOS as a prebiotic** can be added to foods without affecting their sensory attributes. **Development of such value added products shall also fulfil the increasing demand of health foods by the consumers.**

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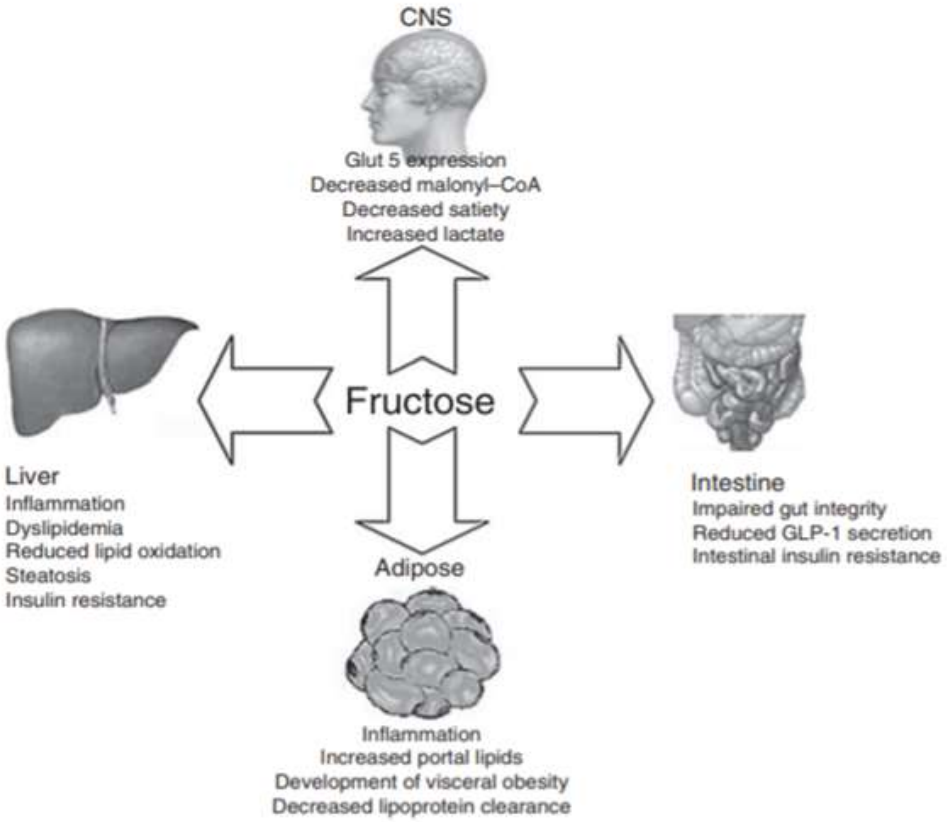
Development and sensory analysis of a buttermilk based fermented drink using barley and fructooligosaccharide as functional ingredients

Mini Sheth, Harsha Hirdyani

Abstract
Background: Functional foods are getting popularity in the world, due to tremendous health benefits conferred by specific components of these foods. During the last few decades the interest and demand for both healthy food and value added beverages has increased and its demand is expected to rise in the future.
Objective: The present study was done to develop a buttermilk based fermented drink using barley and fructooligosaccharide (FOS) as functional ingredients.
Materials and methods: Barley was cooked and fermented with buttermilk, followed by addition of FOS, flavors (rose, khus, chocolate and salt-jeera) and colors. Three successive trials were conducted to screen the panellists using threshold test. Sensory evaluation was done using composite score method, for the four drinks in triplicates. An internal panel of 24 semi trained members evaluated the products for color and appearance, mouthfeel, texture, taste, after taste, and overall acceptability.
Results: A significant difference was observed among drinks with different flavors. Salt-jeera flavor was liked most by all the panel members followed by rose. No after taste or bad mouthfeel was reported in any of the products.
Conclusion: Thus it can be concluded that locally available functional ingredients can be used to develop functional foods in form of foods and beverages. Addition of FOS as a prebiotic can be added to foods without affecting their sensory attributes. Development of such value added products shall also fulfil the increasing demand of health foods by the consumers.

Khanvilkar et al. Fructooligosaccharides: applications and health benefits. Agro FOOD Industry Hi Tech - vol. 26(6) - November/December 2015

Metabolic Effects of Fructose



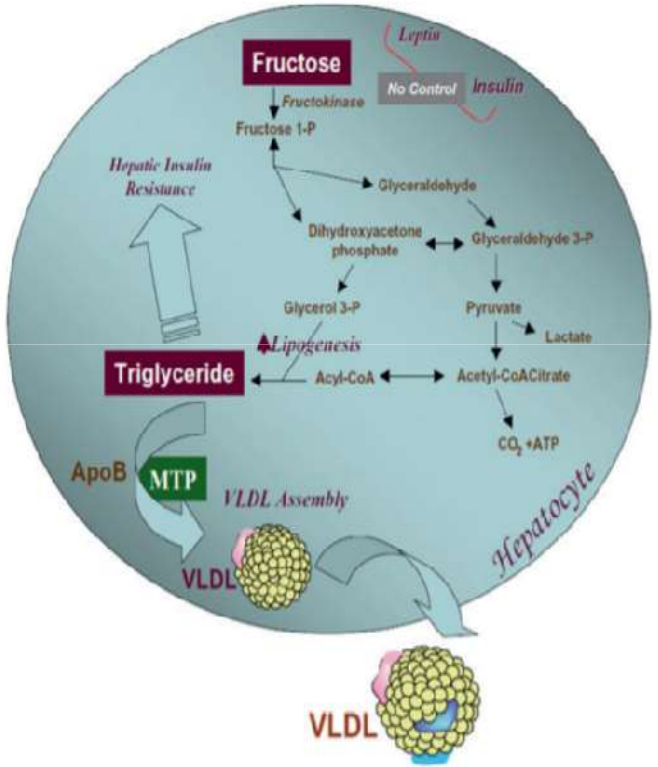


Fig. 1 Hepatic fructose metabolism: A highly lipogenic pathway [67]

Jha et al. Dietary Fiber and Human Health: An Introduction. Dietary Fiber for the Prevention of Cardiovascular Disease. 2017

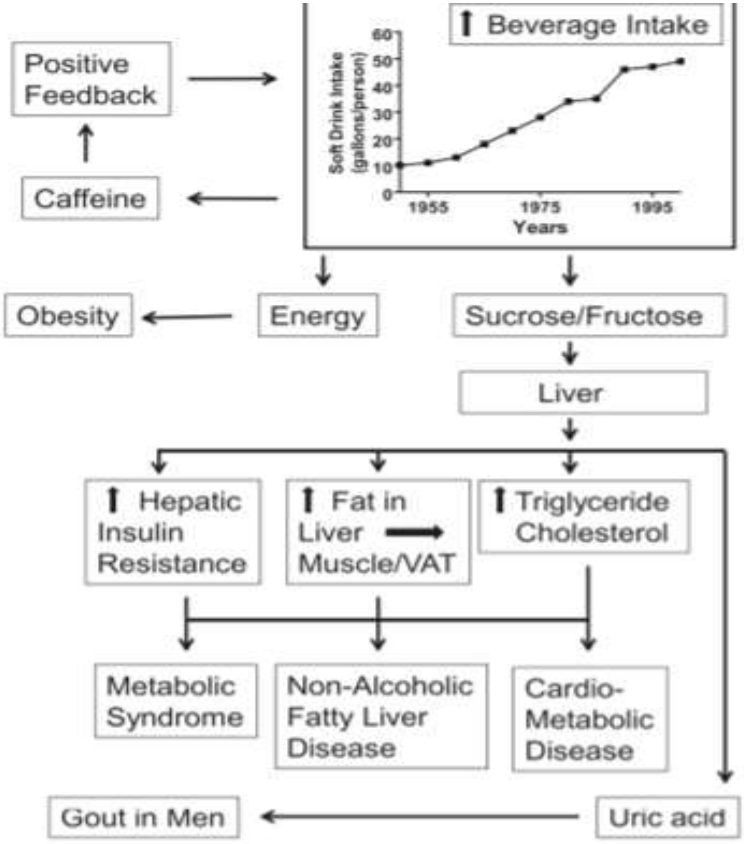
JM 2019

High Fructose Corn Syrup & Metabolic Health

High Fructose corn syrup is used as a sweetener used in **Sugar Sweetened Beverages, candies, Cola beverages and frozen and canned foods.**

Chronic excessive intake disrupts **metabolic health and induces inflammation.**

Chronic fructose consumption promotes mechanisms that **up- regulate the hepatic lipogenesis program leading to NAFLD**



Madan et al. High Fructose Intake, HCFS And Metabolic Syndrome – Should We Be On Guard? The Indian Practitioner. 2018; George Bray, American Diabetes Association. 2013

Use of Carbohydrates in Food Industry: An Overview

Category of Food	Type of Carbohydrate
Beverages	Added Sugars, Sugar Sweeteners,Lactose
Meal Replacers	FOS, Inulin, Psyllium husk, Sugar sweeteners, Added sugars
Cold pressed Juices	Sugar Sweeteners, Added sugars
Breads & Bakery foods	Resistant Starch, Inulin, Psyllium husk, FOS, Bran
Dairy Products	Sugar, Fructose, Lactose
Granola Bars	Dietary Fiber, FOS, Sugar alcohols, added sugars, guar gum, Oat/Cereal Fiber, Inulin
Probiotic Drinks	Sugars, added sugars
Processed Cereals	Psyllium husk, Sugar sweeteners, Bran

Key Messages

- India needs Carbohydrates and Wholesomeness of Food
- Type of carbohydrate – Quantity and Quality.
- Processing of food to minimize Advanced Glycated End products (AGE) in Food.
- Maximizing on the physiological benefits of the carbohydrates for metabolic health.
- Innovation in Good Quality Carbohydrate ,Fibre Dense, Functional Nutrient Dense Products in a defined caloric intake in each category of Food.

THANK YOU