FRUIT JUICE MATTERS

CRUCIAL LEARNINGS FROM THE LATEST RESEARCH ON FRUIT, FRUIT JUICE AND SUGARS

A summary of the AIJN (European Fruit Juice Association) Scientific Symposium held in Brussels in October 2018



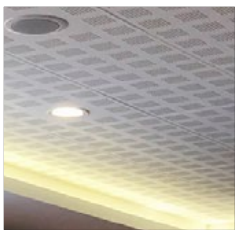




Sugars and fruit juice are at the centre of one of the most polarising public health discussions of our time. Around the world, consumers are being urged to increase consumption of fruit and vegetables while reducing intakes of so-called free sugars — the term the World Health Organisation (WHO) coined to describe "all mono- and disaccharides added to foods by the manufacturer, cook or consumer, plus the sugars naturally present in honey, syrups and fruit juices".

But where does that leave fruit juice? Does this focus on individual foods and nutrients lose sight of the bigger picture of holistic nutrition? And what are the implications for evidence-based public health advice?

Some of the world's leading experts in diet, metabolism and plant bioactives recently met in Brussels to explain, explore and expand on the latest science around the health effects of fruits and 100% fruit juices. Their presentations and discussions highlight the complexity of the issues, challenge some of the assumptions shaping the debate and suggest the benefits of increasing consumption of 100% fruit juice outweigh any potential risks around sugar.



DO FRUIT AND 100% FRUIT JUICE HAVE A SIMILAR OR DIFFERENT ROLE IN CARDIO-METABOLIC HEALTH?

That was the question posed by Professor John Sievenpiper, an expert in nutritional sciences and metabolism, at the University of Toronto — and it goes to the heart of public health conversations around sugar and diet.

Professor John Sievenpiper

After 40 years of advice to reduce saturated fat intakes, the popular media has shifted its focus to carbohydrates and, in particular, sugar. The biologically plausible pathway which suggests fructose is an important factor in obesity has prompted headlines suggesting consumption of fruit juice be restricted, and for some to argue that even fruit should be avoided by those who are obese or have diabetes.

Dietary guidelines around the world continue to recommend consumption of fruit and 100% fruit juice, while advising limiting free sugars, including those from fruit juice, to 10% or even 5% of total calorie intake.[1] However, the link between sugar-sweetened beverages (SSBs) and an increased risk of obesity and type 2 diabetes is reported to be because SSBs provide excess energy, not because of sugar per se.[2] 'Substitution trials', where energy from sugars is exchanged for energy from another source, and 'addition trials' where energy from sugars are in addition to the normal diet, confirm it is excess energy, not the source, which is harmful.[3]

The reality is far more complex than the popular sugar-is-bad mantra suggests. A meta-analysis[4] of 84 cohort studies involving almost 3.9 million people confirms that consumption of SSBs increases the risk of diabetes, while consumption of fruit or fruit juice does not. Similarly, an analysis[5] of 134 studies with more than 5.3 million people shows that SSBs are associated with an increased incidence of coronary heart disease (CHD) and stroke, but fruit was protective against both and 100% fruit juice was protective against stroke. Furthermore, pooled data from 100 studies involving more than 6 million people[6] found that SSBs are associated with an increased risk of dying from cardiovascular disease (CVD), but fruit tended to be protective. Fruit and fruit juice were also associated with a reduced risk of death from CHD and stroke.

In terms of glycemic index, fruit and 100% fruit juice are comparable which may explain why systematic reviews and meta-analyses report that they have similar cardio-metabolic effects. Both have a neutral or beneficial association with risk of type 2 diabetes, hypertension, CVD, CHD and stroke, and both are linked with a lower risk of death from CVD, CHD and stroke. Trials confirm that where fruit and 100% juice do not contribute to excess calories, they have a neutral effect and may even improve a range of

Table: % DALYs attributable to 14 dietary risk factors in Western Europe

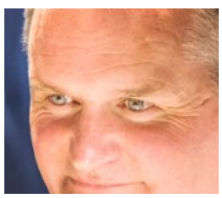
Dietary Risk Factors	% DALYs
1. Low Fruit	2.2%
2. Low Whole Grains	2.1%
3. High Sodium	2.0%
4. Low Nuts & Seeds	1.8%
5. Low Vegetables	1.8%
6. Low Omega-3 Fatty Acids	1.2%
7. High Processed Meat	1.0%
8. Low Fibre	0.6%
9. Low Milk	0.3%
10. High Trans Fatty Acids	0.3%
11. Low PUFA	0.3%
12. Low Calcium	0.3%
13. High Red Meat	0.2%
14. High SSBs	0.1%

Ref: Global Burden of Disease collaborators (2016) Lancet 388: 1659–724.

risk factors for heart disease and diabetes including body weight, glycemic control, blood lipids and blood pressure. Focusing on a single energy source, such as sugar, fails to address the fundamental issue of excess calories and — as we saw with the proliferation of reduced-fat but highly calorific and nutrient-light foods which were produced in response to saturated fats advice — it can also have unintended consequences.

Fruit and vegetable consumption remains too low and is even declining in many countries, yet the Global Burden of Disease Study[7], which examined 79 risk factors, found that the two most important dietary predictors of poor health were a lack of fruit and whole-grains, not high intakes of fat and sugar which did not even feature in the list of top predictors. The table above summarises the findings of this study, which used disability-adjusted life years (DALYs) as a measure of overall disease burden, expressed as the number of years lost due to ill-health, disability or early death. It can be seen that low fruit and low wholegrain consumption accounted for more than 2% of DALYs each. This suggests that increasing intakes of fruit and wholegrains would have a more positive impact on public health than reducing sugar or saturated fats.

When we focus on individual nutrients, such as sugar or fat, important connections in dietary patterns are lost. There is no single 'best' diet, but those with proven health benefits — such as the Mediterranean, DASH and Portfolio dietary patterns — all include higher intakes of vegetables and fruit, including 100% fruit juice.



THE CONCEPT OF MINIMALLY PROCESSED FOODS

Dr Anthony Fardet is a researcher in Preventative and Holistic Diet & Nutrition at INRA, the French National Institute for Agricultural Research. He is also member of the scientific committee of the Siga society. He puts the case for a move away from the reductionist approach of focussing on individual foods or nutrients to a more holistic view based on the degree of processing that foods undergo.

Dr Anthony Fardet

Large population studies show how complex diets which are rich in minimally processed foods — such as the Mediterranean, Okinawa and DASH eating patterns — are better for health and reduce the risk of chronic disease. This supports the case for a more holistic approach to the way we look at food.

The NOVA system of food classification, set out in 2014[8], divided foods into four groupings depending on the degree and purpose of processing. Group one consists of un- and minimally processed foods such as fruit, vegetables, whole-grains, pulses, meat, fish and milk; Group two covers culinary ingredients such as vegetable oils, pasta, salt and sugar. Processed foods, combining Groups 1 and 2, but which contain added ingredients such as stabilisers and preservatives fall into Group 3. Finally, Group 4 consists of ultra-processed foods such as SSBs, confectionery, sugared cereals and mass-produced fast-food. Ultra-processed foods are defined as, "Industrial formulations made from many ingredients and/or additives". These may include sugar, stabilisers and preservatives which are also found in processed foods, but they are first characterised by 'cosmetic' additives and/or purified ingredients which are added to mimic, restore or accentuate the taste, texture or colour of Group 1 foods.

Looking specifically at fruit, fresh, dried and frozen fruits come under NOVA Group 1, including 100% fruit juice, smoothies and purees. Jams, fruit concentrates, and freeze-dried and candied fruits used within other foods are considered to be culinary ingredients and fall into Group 2. Fruit juices made from concentrates with added sugars are in Group 3, along with canned fruits in syrup, while fruit-flavoured drinks and SSBs fall into Group 4.

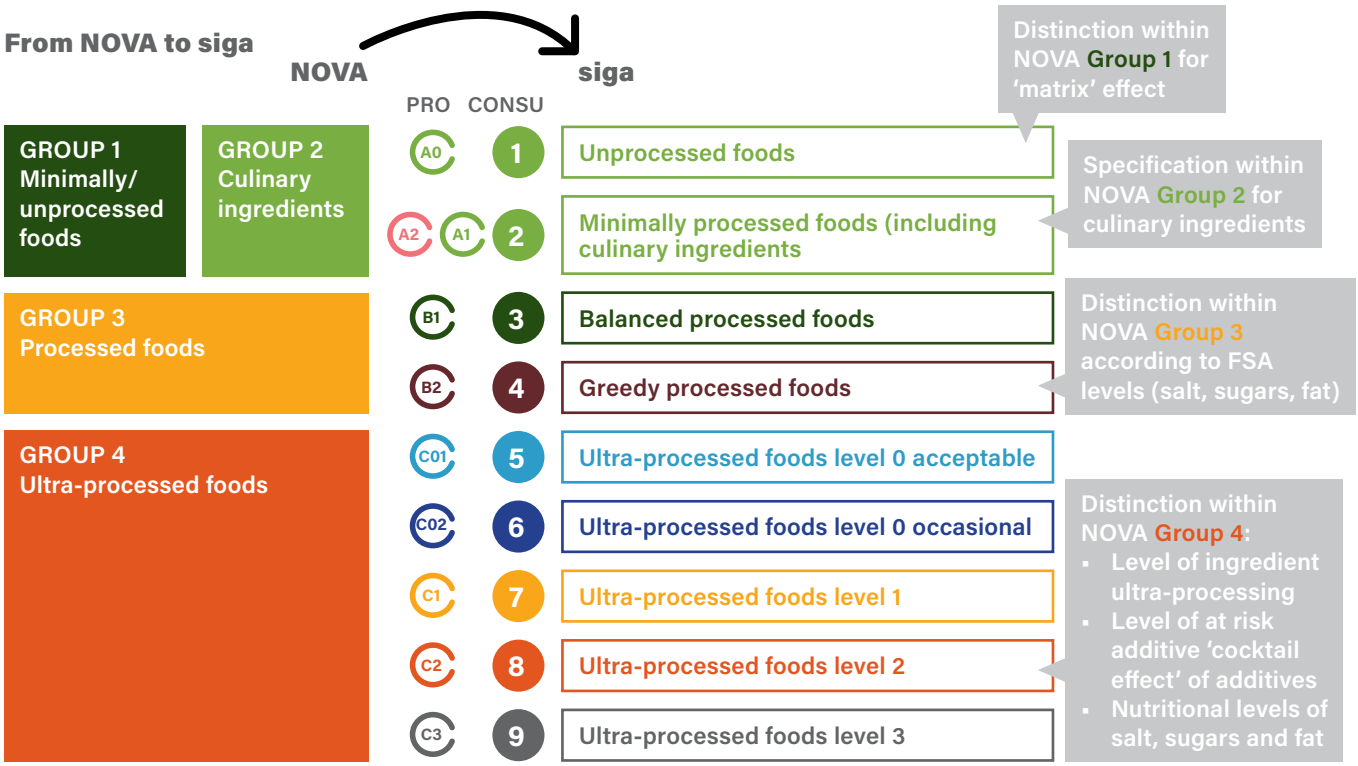
Association is not causation, but there is a significant association between sales of ultra-processed foods and obesity.[9] The degree of processing is also a good marker of diet quality, with higher intakes of ultra-processed foods associated with lower intakes of vitamins, minerals, antioxidants and fibre.

The NOVA classification has been adopted by scientists and public health bodies around the world because it is simple, easy to apply in academic studies, and simple for consumers to understand. However, it does not take account of the 'matrix effect' which greatly impacts the degree of chewing, bioavailability, GI, satiety and gastric emptying — which all increase the health potential of minimally processed food.[10] When comparing fruit and 100% fruit juice, it is assumed that processing breaks down cell walls making the sugars in juice more rapidly absorbed than those in fruit, potentially resulting in less satiety and a different glycemic effect. NOVA also fails to take account of the levels of sugar, salt and fat in processed foods, and the number, as well as the potential health risks, of cosmetic ingredients in ultra-processed foods.

For this reason, the Siga project was developed. Siga is a labelling system that divides the four NOVA food groups into nine, more specific, categories based on the presence of purified cosmetic ingredients/ additives, sugar, salt and fat contents, and the loss of the matrix effect. This creates a distinction between processed foods, which are low in salt, fat and sugar, and those which have higher levels of these less healthy nutrients. It also takes into account the potential additive effect of multiple cosmetic ingredients.

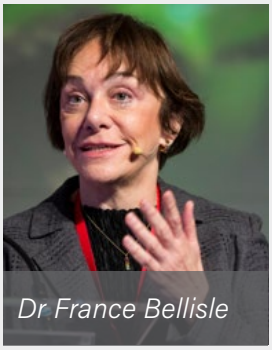
In the case of fruit, analyses of potential health impacts using classifications based on processing show a technological gradient for the health potential of fruit-based products. Fresh and dried fruits appear either neutral or protective, 100% fruit juices have intermediary effects, while a high intake of tinned fruit and sugar-sweetened fruit juice were positively associated with the risk of all-cause mortality and type 2 diabetes, respectively.[11] Finally, minimally processed fruits tend to have a more pronounced impact on satiety, have higher antioxidant potential, and a lower glycemic index.

The Siga project: a holistico-reductionist food classification



THE CONTRIBUTION OF 100% FRUIT JUICES TO THE DIET

Research by Dr France Bellisle, professor at Université Paris 13 Nord, focusses on the psychological, sensory, metabolic and environmental factors which influence our food and drink choices.



Dr France Bellisle

A secondary analysis of the 2016 CREDOC survey[12] in a representative sample of the French population (1,164 children, 318 adolescents and 1,607 adults) reveals that juice consumption increases with income and education and decreases with age, but is not linked to body mass index (BMI), physical activity, smoking or dieting. Half of all juice is consumed at breakfast while orange juice accounts for around 50% of consumption.

In children and adults, there was no association between body weight and juice consumption. Yet people who drank 100% fruit juice also ate more of everything than those who did not. They consumed more calories, more carbohydrates, more free sugars, and as they also ate more fruits, vegetables, dairy products and foods from other categories, they had significantly higher intakes of vitamins, minerals and fibre.

Studies from other parts of the world tend to report associations between fruit juice consumption and lower BMI and weight, or no statistical association, despite juice drinkers typically having higher intakes of calories and sugars. The USA NHANES survey[13] found adults who drank 100% fruit juice (mean intake 200 ml a day) had a lower BMI and waist circumference than non-juice drinkers. In children, there was no difference in weight, but those who drank 100% fruit juice had higher intakes of total energy, vitamins C and A, folates, magnesium and fruit overall.[14] Australian researchers found no association with juice consumption and weight gain in teens[15] while a study in Ireland[16] found that juice intake has a beneficial association with BMI and nutrient intakes.

Table: Differences in energy & nutrient intakes*

Per Day	100% FJ Non-Consumers	100% FJ Consumers
Energy (kcal)	1941	2029
CHO (g)	213	229
Simple sugars (g)	76	94
Free sugars (g)	42	57
Total fats (g)	76	80
Fibre (g)	19	20
Vitamin B9 (µg)	253	298
Vitamin C (µg)	64	101
Vitamin E (µg)	7.9	9
Potassium (mg)	2736	2946
Magnesium (mg)	291	319
Manganese (mg)	2.5	2.8

** Only nutrients where significant differences were noted are presented ($p \leq 0.001$).*

Ref: Bellisle F et al. (2018). Nutrients 10: pii: E459.

In summary, the CREDOC data show that drinking 100% fruit juice is not associated with excess weight, even though 100% fruit juice drinkers eat more overall. Neither were associations found between 100% fruit juice consumption and lifestyle factors such as physical activity and sedentary behaviour. In the French population, free sugars come mainly from solid foods such as cakes and confectionary, rather than beverages (2-3% from juice), which suggests that sugar reduction would be most effective by focusing on these specific food categories. Consumers of 100% fruit juice tend to eat more fruit and vegetables than non-consumers although, in general, most people still fall short of the recommended five a day.[17]

FRUIT JUICE AND DIETARY BEHAVIOURS IN CHILDREN

David Benton, Professor of Psychology at Swansea University, investigates the parallels between nutrition, physiology and psychology.

Professor David Benton

Health concerns around 100% fruit juice focus on five issues: obesity, dental decay and the fears that it displaces fruit, milk and fibre. A leading adviser to the UK Government has argued that 100% fruit juice should not be part of five-a-day recommendations because it contains as much sugar as soft drinks, and that this sugar is so rapidly absorbed that the body cannot tell the difference between 100% fruit juice and cola. It is a simple narrative: Sugar is a major cause of obesity, 100% fruit juice contains sugar, so 100% fruit juice must contribute to obesity.

However, there are flaws with this approach. It reduces the importance of food to a single nutrient; it considers a food or nutrient in isolation from the diet; consumers are portrayed as passive recipients of food and calories; and it ignores the impact of other factors such as education and social background. Diet is dynamic, if you remove calories from one source, the metabolism may adjust or human behaviour seeks to replace them from another source. Individual nutrients may also be nothing more than markers for social background, or a particular type of diet.

Secondary analysis from a British birth cohort study, which enrolled 14,000 pregnant women in 1991 and 1992 and continues to follow the health and development of both parents and children, does not support the juice-equals-sugar narrative.[18] Consumption of 100% fruit juice during pregnancy is associated with having children who are leaner, taller and with a lower BMI. Measurements taken when children were 15 years old showed a dose-dependent association, with those whose mothers drank 100% fruit juice most frequently having the lowest average weight and BMI.

Data collected when the children were 13 years, showed those who drank 100% fruit juice were more likely to eat a range of fruit and vegetables compared with those who drank cola, and as a result they also had higher levels of a range of nutrients including vitamin C, carotene, thiamin, folate, potassium, iron and fibre. Consumption of 100% fruit juice at the age of six years was associated with increased height, weight or BMI, particularly in girls. But by the age of 13, this was reversed, and 100% fruit juice consumption was associated with a lower BMI in girls. The children who drank 100% fruit juice also had better insulin response and fasting blood sugar than those who did not.

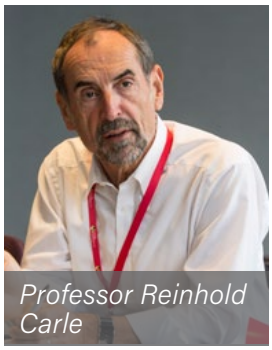
Public health advice is often based on the simple assumption that reducing calories will reduce obesity, and in America this was put to the test when Michelle Obama persuaded 16 corporations responsible for 25% of America's food supply to remove a trillion calories by 2012 and 1.5 trillion calories by 2015. The response was spectacular, with 6.4 trillion calories cut from the American diet by 2012. However, the actions were unsuccessful, with obesity rising despite the fall in calories.[19]

It is not simply a matter of cutting calories, because the impact of calorie reduction is dependent on myriad factors including gender, age, dietary changes, social background and finances. The body is also programmed to replace lost calories, so although excess calories may cause obesity, removing calories on a population levels will not solve it. Physiology will always win unless there is an element of self-efficacy and responsibility for one's own life and health. Any sensible attempt to deal with obesity needs a wide-ranging approach, and this is not something governments can simply impose.

As the American journalist H.L. Mencken said: *"For every complex problem there is an answer that is clear, simple, and wrong."*

IS ORANGE JUICE THE SAME AS SUGAR-SWEETENED BEVERAGES?

Professor Reinhold Carle, Chair of Plant Foodstuff Technology and Analysis at the University of Hohenheim, examined the claim that a glass of orange juice is as unhealthy as a glass of cola.



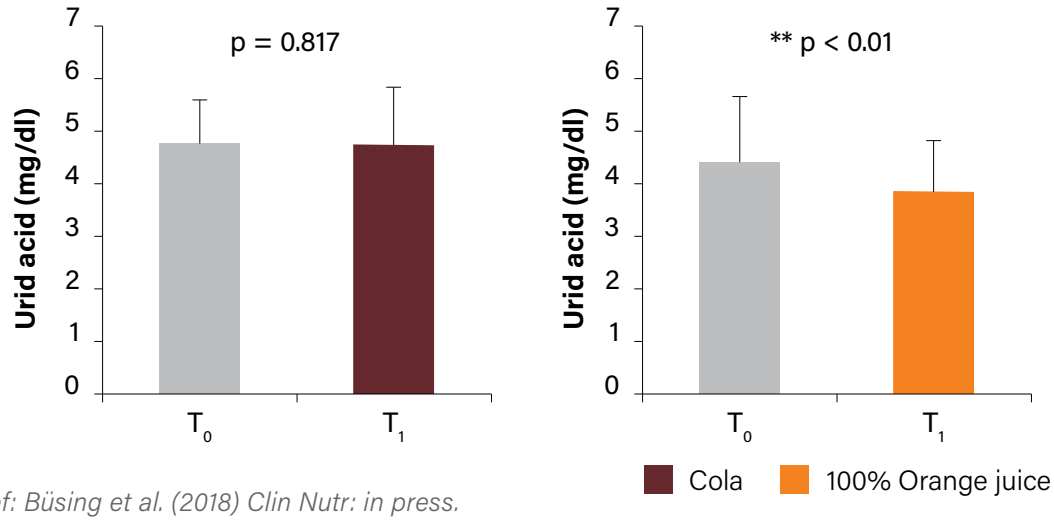
Professor Reinhold Carle

The suggestion that 100% orange juice and SSBs are equally unhealthy puts parents in the difficult position of having to explain to children that oranges are good for them, but orange juice is bad. This is difficult for adults to understand, let alone children — and it is not supported by the evidence.

While there is little difference in the energy provided by a 150 ml glass 100% orange juice and sugar-sweetened cola (61.5 kcal), there is a huge difference in their nutrient compositions, with orange juice providing fewer sugars (12.8 g vs 16.4 g) and significantly more vitamins and minerals, particularly potassium (228 mg vs 1.5 mg), folic acid (32.3 mcg vs none) and vitamin C (54.6 mg vs none). Finally, sugar-sweetened beverages are devoid of citrus polyphenols, such as hesperidin, and they do not contain macromolecular matrix-compounds (i.e. pectin) that can modulate sugar resorption.

Nor do orange juice and cola carry the same metabolic risk. A cross-over study[20] in 26 adults with an average BMI of 23 showed that drinking three glasses of cola between meals caused more pronounced spikes in blood sugar than the same amount of orange juice. Insulin secretion was also significantly higher following orange juice consumption.

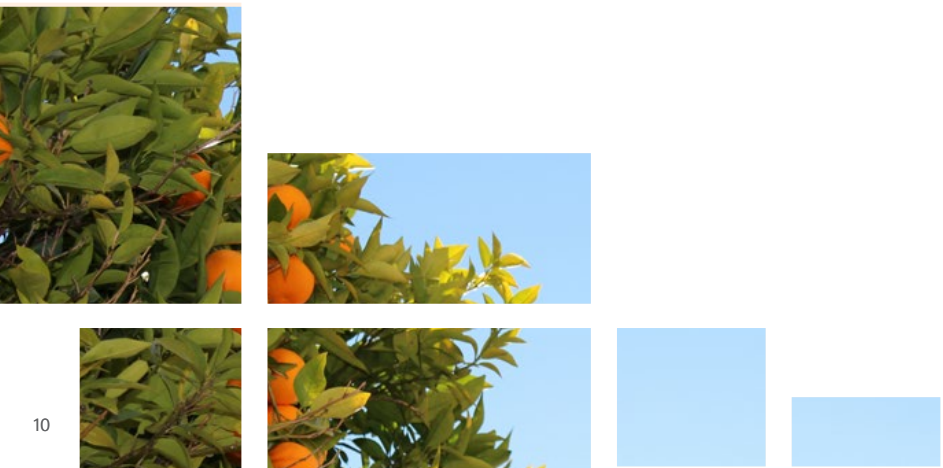
Both drinks contain comparable levels of fructose — which makes up 34% of the sugars in 100% orange juice with pulp, and 39% of the sugars in cola — and fructose is known to raise levels of uric acid which, when consumed in excess, increases the risk of gout. However, unlike cola, 100% orange juice protects against this inflammatory condition, most probably due to hesperedin and vitamin C in juice inhibiting urate formation. This inhibition is also seen in other flavonoids found in fruit and fruit juices, including quercetin (apple, blackcurrant, grapefruit, pineapple, etc), luteolin (apple, orange, cranberry, grapefruit, etc) and -epigallocatechin gallate (apple, grape).[21] In vitro research shows 100% orange juice is a particularly useful source of many plant nutrients as it has higher levels of bio-accessible carotenoids, flavonoids and vitamin C than orange segments or puree.



Ref: Büsing et al. (2018) Clin Nutr: in press.

Perhaps more importantly, a number of flavonoids found in orange and other juices — hesperedin, naringenin, apigenin, hesperitin (a metabolite of hesperedin) and kaempferol — have been shown to inhibit xanthine oxidase[22], improve insulin resistance[23], reduce free fatty acids and inhibit accumulation of fat.[24] This prompts the question: Do the flavonoids in 100% fruit juice help modulate obesity-related insulin resistance? Studies suggest the answer depends on when they are consumed, since a high intake (1.3 litres) of 100% orange juice was associated with slight fat loss when consumed with meals, and slight fat gain when consumed between meals.[25] Research on more moderate intakes of 100% orange juice is needed to explore these effects.

What is clear, is that the complex matrix of 100% fruit juice means it is not comparable to cola and other SSBs. 100% Orange juice is a valuable source of potassium, folic acid and vitamin C. It contains highly accessible bioactive compounds such as carotenoids and flavonoids and despite having a comparable sugar content, it has a surprisingly low glycemic index (50 vs 63). It is also consumed in far smaller quantities — an average of 7.5 litres per year compared with 75 litres of SSBs.



THE GLYCEMIC IMPACT OF FRUIT AND JUICE SUGARS

Professor Fred Brouns, from the School of Nutrition and Translational Research in Metabolism, at Maastricht University, examined the role of carbohydrates and energy in obesity and diabetes.

Professor Fred Brouns

Obesity and type 2 diabetes are a global health threat, prompting estimates that by 2050 one in three people in Western countries may have type 2 diabetes caused by excess weight. However, this "sugar disease" is not caused by sugar consumption. Focusing only on carbohydrates as a single causal factor and suggesting that cutting these in isolation will prevent overweight and diabetes is incorrect.

Frequent excess energy intake appears to be the most significant factor causing weight gain. The matrix of a food (solid, semi-solid, liquid) can impact on the rate of digestion as well as satiety signals. When consuming energy-containing drinks – whether SSBs, milk or beer – our system does not register all the calories consumed. About 30-40% are missed, leading to a positive energy balance in the absence of sufficient physical activity. This pattern over time contributes to overweight. Accordingly, it is not the type of carbohydrate/sugar that is of concern but overall lifestyle, food matrix and energy intake.[26]

The World Health Organization introduced the term 'free sugars' to include "all mono- and disaccharides added to foods by the manufacturer, cook or consumer, plus sugars naturally present in honey, syrups and fruit juices".[27] The classification has raised questions about its concept and validity. For example, why are natural sugars present in 100% fruit juice considered to be 'free sugars' but the same sugars in fruit not? And why is the sugar present in milk not listed as a 'free sugar'? Moreover, are free sugars worse than exactly the same sugars present in natural foods?

Our gastrointestinal system does not 'see' the sugar source since digestion responds to the presence of molecules in the digestive tract. There is no difference in the absorption and metabolism of monosaccharides derived from either rice or potato, bread, fruits, juices, table sugar, syrups and honey.[28] At equal levels of consumption and in a similar matrix, they all produce similar changes in blood-glucose and insulin release and, once normal metabolism is deranged in type 2 diabetes, they can all be equally problematic.[29]

Some researchers have singled out fructose as being particularly harmful on the premise that all fructose is converted to fat in the liver and increases the risk of metabolic diseases and CVD. It's true that when mice or humans are exposed to calorie overfeeding, excess fructose in the diet leads to weight gain and related health problems.[30] But humans do not consume excess fructose in isolation and data from animals are not representative of the human situation. When consumed together with glucose, as is usually the case in a human diet, the normal metabolic effects are distinct from those of fructose alone. In fact, the majority of fructose consumed is converted to lactic acid and glucose, which are either stored or used in energy metabolism. In this situation, only a small percentage (1-4%) is converted to lipids.

The Glycemic Index is a tool which has been used to consider the impact of different carbohydrates on the extent and duration of raising blood glucose. This is expressed as a figure by comparing the blood glucose response produced by a defined amount of absorbable carbohydrate in food or beverage with that of the same amount of carbohydrate present in a standard control, usually glucose or white bread. In this respect, a GI value of 45 of a 100% fruit juice (supplying 50 g of sugars) means that the blood glucose response is half of that observed after the intake of a standard drink containing 50 g of glucose. At present, there is no international consensus of the value of using GI values in isolation for health recommendations due to various limitations.

One concern is the following line of thought: frequent consumption of sugar sweetened beverages leads to overweight and associated diabetes. Since 100% fruit juices contain similar amounts of sugars, they lead to overweight and diabetes. However, results from five recent systematic reviews and meta-analyses of 13 cohort studies in which the effects of consuming 100% fruit juices have been evaluated, seperately from the consumption of sugar sweetened beverages, show that at observed levels of consumption this is not the case.

This evidence shows that regular consumption of 100% fruit juice is associated with a more favourable body weight and being more insulin sensitive. 100% fruit juice provides a wide range of micronutrients and plant bio-actives known to be supportive for health. Rather than being seen as a thirst quencher, a small glass of 100% fruit juice can be viewed as a meal component that contributes to the nutrient quality of the diet.

Table: GI/GL of typical products

Food item	GI/100 g	GL/portion
White bread	75+2	11/30 g
Whole wheat bread	74+2	7/30 g
Cornflakes	81+6	21/30 g
White rice, boiled	73+4	28/150 g
Apple, raw	36+2	6/120 g
Orange, raw	43+3	4/120 g
Orange juice, medium	50+2	11/250 ml
Orange juice, small	50+2	7/150 ml
Banana, raw	51+3	11/120 g
Potato, boiled	78+4	21/150 g
Sugar-sweetened drinks	63-68	16-23/250 ml

Ref: Atkinson RD et al. (2008) Diabetes Care 31: 2281-2283.

CONTRIBUTION OF ORANGE JUICE AND CITRUS FLAVONOIDS TO REDUCTION OF CARDIO-METABOLIC RISK

Dr Thais Cesar is Associate Professor of Nutrition at Sao Paulo University. Her scientific focus is the nutritional and metabolic properties of citrus fruits.

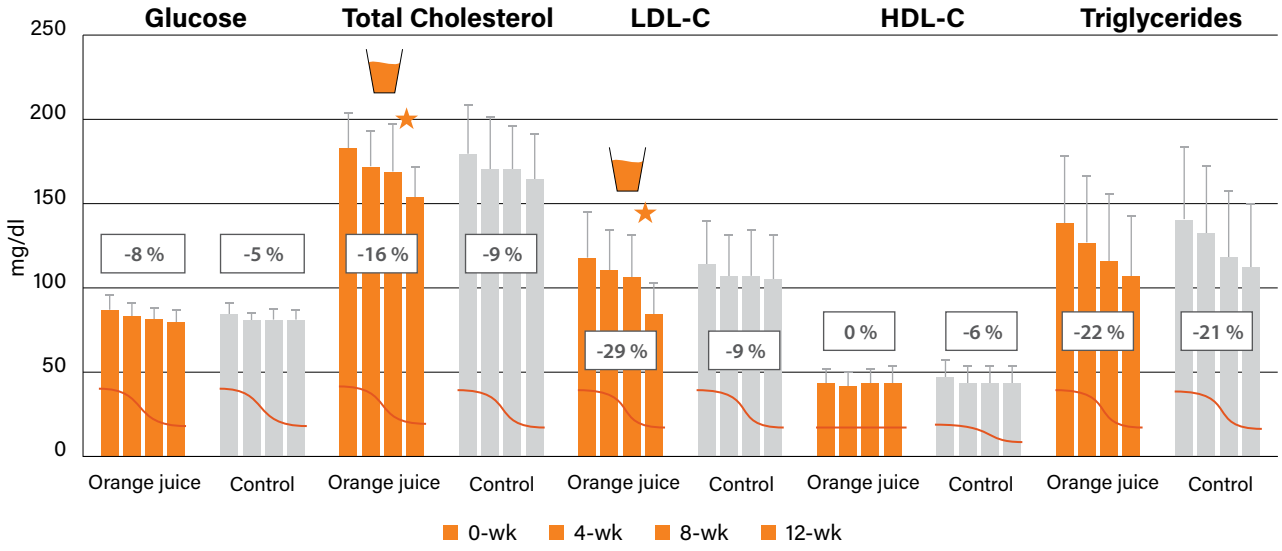
Dr Thais Cesar

One of the biggest threats to human health is metabolic syndrome, a cluster of pathologies — obesity, insulin resistance, hypertension and high blood glucose — which increases the risk of type 2 diabetes and CVD. Foods high in sugar and saturated fat are associated with an increased risk of obesity and metabolic syndrome, while consumption of fruit and vegetables is protective.

It has been assumed that because of its sugar content, 100% fruit juice contributes to weight gain and metabolic risk, however a randomised controlled trial (RCT) in 78 obese adults[31] found the opposite to be true. All were put on a reduced calorie diet, and lost weight, but 100% fruit juice consumption was associated with greater reductions in body fat and waist circumference and better preservation of lean mass. Compared with the control group, which had similar mean energy intakes, those who consumed 500 ml of 100% orange juice daily reduced their insulin levels on average by 18%, cholesterol by 24% and C-reactive protein, a marker for inflammation, by 33%. This was accompanied by significantly higher intakes of vitamin C and folate in the juice group.

A new, as yet unpublished, RCT in 187 patients with metabolic syndrome found 500 ml of 100% orange juice drunk as a between-meals snack reduced mean energy intakes and improved diet quality. The 12-week trial revealed that 100% fruit juice consumption was associated with lower intakes of processed and ultra-processed foods and higher intakes of minimally processed foods, and this was reflected in increased intakes of potassium, vitamin C and folate. 100% fruit juice consumption was also associated with improvements in glucose control, HDL cholesterol, inflammation and blood pressure.

It seems likely that flavonoids in 100% fruit juice stimulate production of beneficial short-chain fatty acids and gut bacteria, and this is borne out by preliminary study results which indicate that 100% orange juice may have a prebiotic[32] effect.



Ref: Ribeiro C et al. (2017) Nutrition 38:13-19.

MECHANISMS FOR BENEFIT

Dr Julian Aschoff studied food technology at the University of Hohenheim and now heads the extraction technology department at Dohler Group where he explores the extraction, separation and concentration of plant-based raw materials. He looked at the role of bioactives and their bioavailability in fruit and 100% fruit juices.

Dr Julian Aschoff

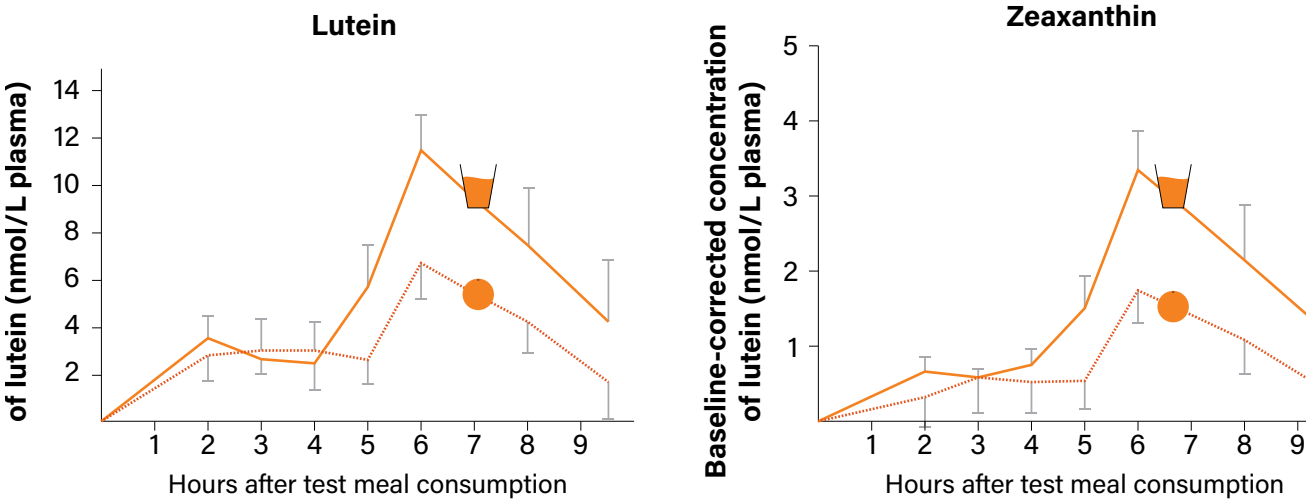
Better hygiene, nutrition and healthcare have seen a rise in average life expectancy in industrialised countries, and with it a rise in lifestyle diseases such as obesity, cancer and CVD. The drivers and mechanisms of these disease are complex, and the focus of on-going research, but free radicals — highly reactive molecules which damage cell DNA — have been identified as a key contributor. Antioxidants, such as vitamins A, C and E and many secondary plant metabolites, are 'first responders' which protect against the oxidative stress caused by free radicals. That's why regular consumption of fruit and vegetables reduces the risk of lifestyle such as type 2 diabetes, CVD and cancer, prompting public health campaigns to encourage consumption.

With all these recommendations, whole fruits or vegetables are presented as the gold standard, but this does not take into account the bioavailability of nutrients, which determines the amounts our bodies can actually use. For example, carrots are rich in vitamin A, but because it is a fat-soluble vitamin, you could eat a kilo of carrots and not absorb any, unless you also consumed a small amount of fat.

Oranges contain antioxidant vitamins and secondary plant metabolites including carotenoids, which support vision and brain development; vitamin C, which supports normal immune function; and flavonoids such as hesperidin which are the focus of ongoing research for cancer prevention, gut health and antibacterial activity. Their food matrix also includes dietary fibres and pectin.

In vitro analyses of raw, fresh orange versus pasteurised juice extracted from the same quantity of fruit suggests that 100% fruit juice has lower levels of secondary plant metabolites: 91% of the vitamin C, 82% of the carotenoids and 12% of the flavonoids.[33] However, the levels of liberated and bio-accessible nutrients in the 100% fruit juice are more than three times higher than those in the fruit. A cross-over study[34] which looked at carotenoid levels in humans confirms that this enhanced bioavailability translates into blood concentrations which are two-fold higher. A similar picture emerges from studies of the flavonoids hesperetin and naringin[35] – and the metabolites produced when they are broken down in the gut — with both fruit and 100% fruit juice providing comparable amounts of usable flavonoids, despite fruit containing 2.3 times more of them.

Bioavailability of carotenoids from oranges vs. pasteurised orange juice



In short, laboratory analysis and studies in people confirm that juicing and pasteurising has minimal effects on levels of vitamin C, but it does improve the bioavailability of a number of beneficial bioactive compounds. It does this by reducing fibre, which inhibits absorption of fat-soluble nutrients, heating during pasteurisation, which releases more carotenoids from plant cells, and juicing, which breaks down cell walls which releases more carotenoids.[36] As a result, drinking a glass of 100% orange juice a day would have a minimal effect on blood sugar levels, but provide significant amounts of vitamin C, carotenoids and flavonoids.

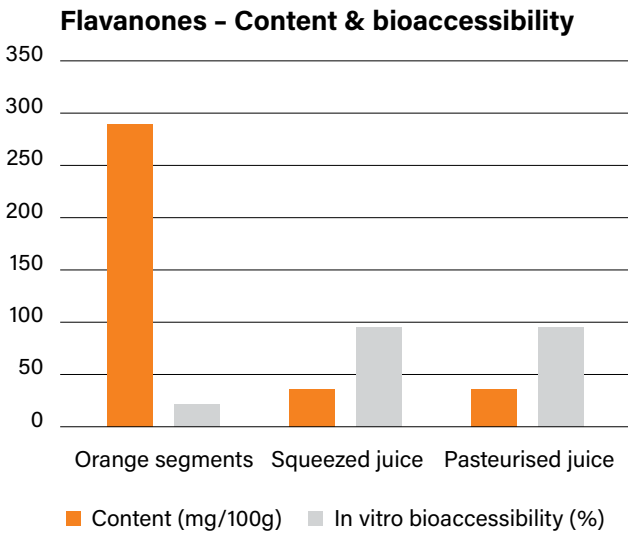
Ref: Aschoff JK et al. (2015) Mol Nutr Food Res 59: 1896-1904.

IMPACT OF PROCESSING ON CITRUS FRUIT BIOACTIVES BENEFICIAL FOR CARDIOVASCULAR HEALTH

Dr Christine Morand, Research Director at INRA, the French National Institute for Agricultural Research is an expert in diet, plant-food bioactives and vascular health.

Dr Christine Morand

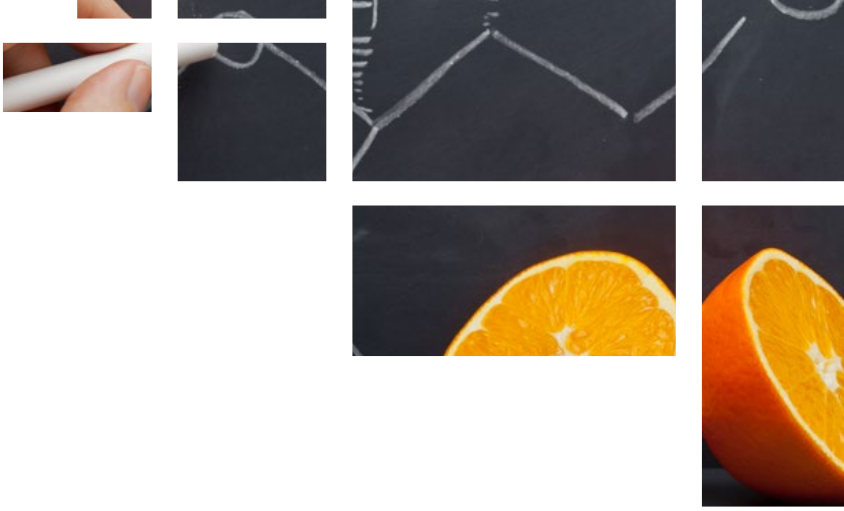
Citrus is a valuable source of nutrients including fibre, vitamin C and calcium, as well as certain bioactive compounds, especially polyphenols with a content higher than 1g/100g, and, to a lesser extent, carotenoids which are precursors of vitamin A. However, the exposure of the human body to citrus phytochemicals is much more complex as revealed by the use of untargeted metabolomics to analyse the urine profile of subjects drinking citrus juice. Even if the wide range of the metabolites released is still not fully identified, proline betain and flavanone glucuronides have been already identified as biomarkers of citrus juice consumption.[37] Further metabolomics work is required to identify more of the absorbed metabolites, potentially the beneficial bioactives of citrus, and to determine the impact of processing on these compounds.



Ref: Aschoff JK et al. (2016) Mol Nutr Food Res 60: 2602-2610.

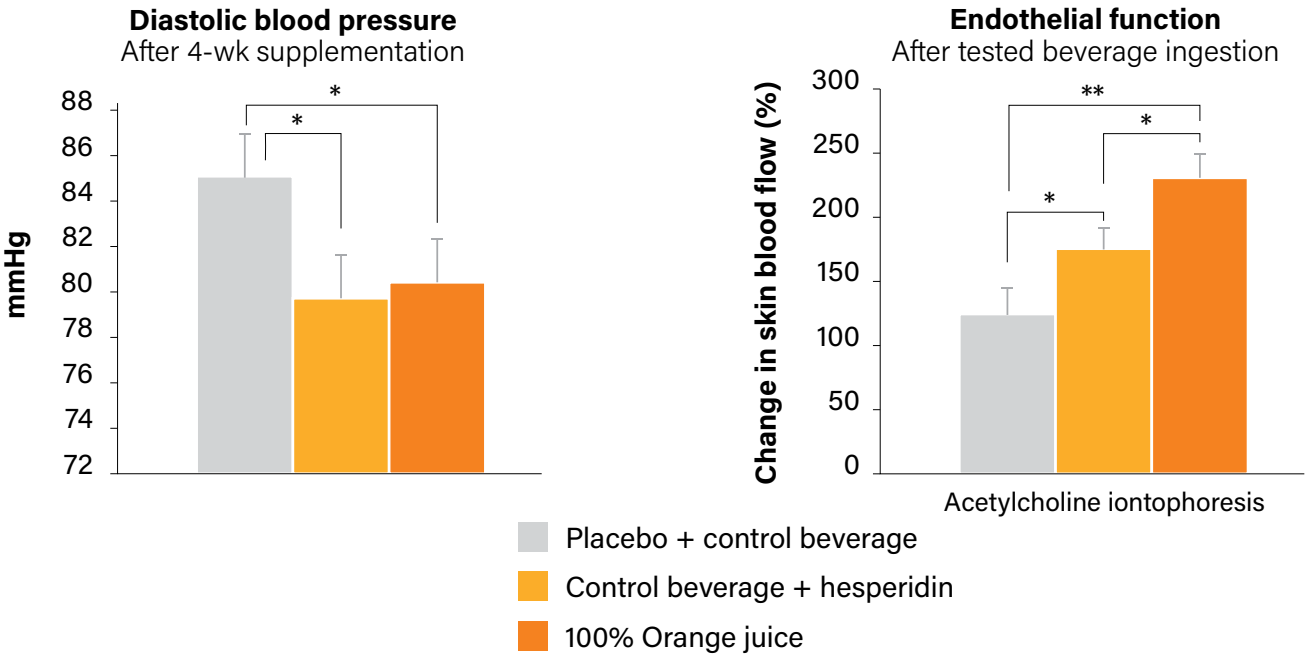
We know that approximately 20% of carotenoids in 100% fruit juice are lost during pasteurisation, however this process also increases the bioavailability. Juicing also increases the bioavailability of two beneficial flavanones unique to citrus: hesperetin, which is predominant in oranges and clementines, and naringenin, which is found in grapefruit. In fruits or 100% fruit juices, these flavanones are present as glycosides, hesperidin and naringin. Large long-term population studies, such as the Iowa Women's Health Study[38] of 34,492 postmenopausal women and the Nurses' Health Cohort[39] of 69,622 women, report that citrus flavanones protect against coronary heart disease and stroke and suggest a daily serving of citrus juice provides enough of these flavanones to reduce the risk of both.

Most of these flavanones are found in the solid parts of the fruit (membrane and albedo), consequently the consumption of the fruit provides at least 8-fold more flavanones than 100% fruit juice. However, because the solubility (directly linked to bioaccessibility) of flavanones present in 100% fruit juice is markedly higher than in fruits (92% vs. 20%) this impacts their level of bioavailability and, ultimately, the amounts of usable flavanones in fruit and 100% fruit juice are quite comparable. Urinary analysis confirms it is the solubility of flavanones rather than their concentration that determines the level of bioavailability. Studies show that bioavailability can vary dramatically between individuals consuming fruit or 100% fruit juice. It is proposed that gut bacteria, which are a key player in the deglycosylation of flavanones prior to their absorption, could also be responsible for this inter-individual variability. Nevertheless, consuming fruits or 100% fruit juices leads to the production of comparable flavanone metabolites in the body.



Fourteen RCTs have examined the impact of flavanones on different aspects of cardiovascular health and these have produced varying results, probably due to differences in study design, dose and participant characteristics. Clinical effectiveness is seen at intakes of 200-300mg/day citrus flavanones in chronic studies. A randomised crossover trial[40] in 24 healthy men which compared a placebo drink, a control beverage containing hesperidin, and 100% orange juice (a natural source of hesperidin) showed that both 100% orange juice and the hesperidin-fortified beverage significantly lowered diastolic blood pressure, improved the elasticity of blood vessels and modulated the gene expression profile of circulating immune cells.

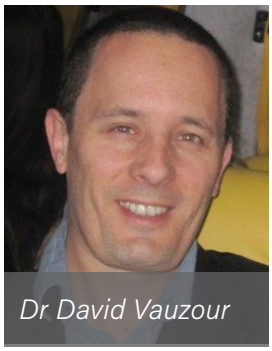
The observed changes in gene expression suggest hesperidin inhibits inflammation and fat deposits in the arteries, which could protect against vascular damage and offer a mechanism for the growing body of evidence suggesting hesperidin is driving the cardiovascular benefits associated with citrus foods.



Ref: Morand C et al. (2011) Am J Clin Nutr 93: 73–8.

MECHANISMS AND IMPACT OF CITRUS FLAVONOIDS ON COGNITIVE FUNCTIONS

Dr David Vauzour's research at the Universities of Reading and East Anglia has focussed on the correlation between diets rich in fruit and vegetables and a decreased risk of neurodegenerative disorders.



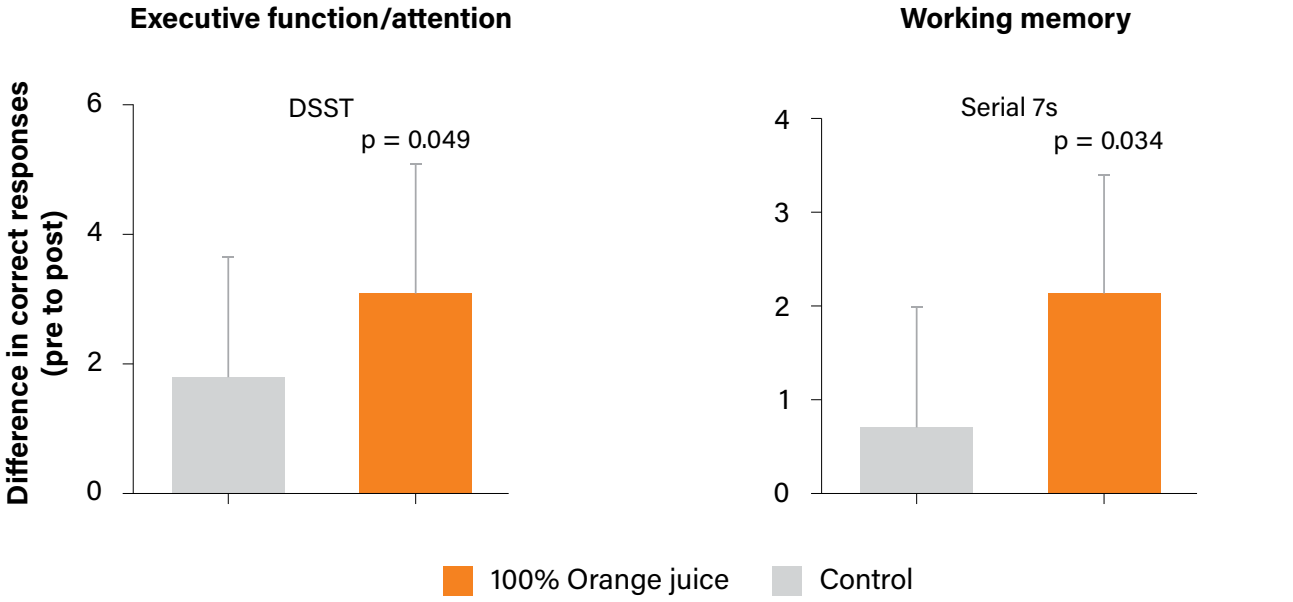
Dr David Vauzour

An ageing population is driving a steady rise in dementia, with the number of people diagnosed expected to almost double every 20 years. Diet is an important, and modifiable, risk factor and there is a growing body of opinion that lifestyle changes offer the best protection against cognitive decline. A number of nutrients, including the flavonoids found in fruit and vegetables, omega-3 fatty acids, and B-vitamins are known to have an effect on brain functions and biology.

The evidence for flavonoids is supported by studies linking increased daily intakes with a reduction in cognitive decline, and trials showing 100% orange juice — which is high in flavanones such as hesperidin and naringin — provides short- and longer-term benefits. A study[41] in 24 adults aged 30 to 65 given 240 ml of 100% orange juice or a placebo with an equivalent amount of sugar, found that those who drank the 100% orange juice had significantly higher global cognition (Fig. A) and alertness (Fig. B) two and six hours later respectively. A similar trial[42], where 37 healthy adults aged 60 to 81 were given 250 ml of 100% orange juice or a placebo daily for eight weeks reported a greater than two-fold improvement in global cognitive function (Fig. C) and a significant rise in executive function (Fig. D).

At least four mechanisms appear to be driving these benefits: improved cell signalling, better blood supply in the brain, better synaptic performance and reduced inflammation. Metabolites produced when citrus flavonoids are broken down are able to cross the blood-brain barrier and are found in the highest concentrations the hippocampus, the brain's memory centre, and the cortex, which receives and processes information.

Chronic improvements in cognitive function following OJ (250 ml/day for 8 weeks)

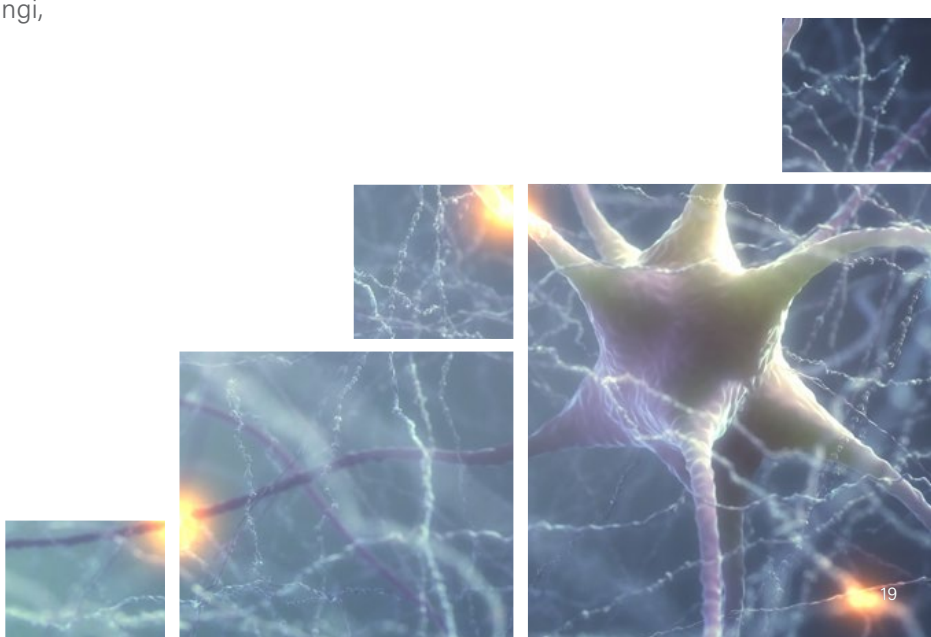


At least four mechanisms appear to be driving these benefits: improved cell signalling, better blood supply in the brain, better synaptic performance and reduced inflammation. Metabolites produced when citrus flavonoids are broken down are able to cross the blood-brain barrier and are found in the highest concentrations in the hippocampus, the brain's memory centre, and the cortex, which receives and processes information.

They influence a number of signalling pathways within the brain and in vitro studies confirm hesperetin protects against neuronal injury caused by oxidative stress and inhibits cell death.[43] Naringenin, another flavanone found in 100% orange juice, inhibits inflammatory damage to the microglial cells which encase and protect the brain.[44] MRI scans show that flavonoid-rich 100% orange juice can dilate blood vessels in the brain, which improves blood supply and reduces blood pressure — a known risk factor for cognitive decline. Perhaps more importantly, these vascular benefits are observed in areas of the brain relating to memory formation.[45]

Gut microbiota play an important part in the way our bodies access these flavonoids, and the composition of this collection of bacteria, fungi, protozoa and other organisms — known as the microbiome — is unique to each of us, just like fingerprints. More than 1,000 different bacterial species have been identified, but each of us has only 150 to 170. More than three million genes can be found in our microbiome — 150 times more than the number found in the human genome. Animal studies show hesperetin activates beneficial changes in the microbiome via a number of signalling pathways, which increase bile acid production and levels of short-chain fatty acids in the gut. These changes inhibit fat deposits within liver cells and protect against non-alcoholic fatty liver disease, a key characteristic of metabolic syndrome.

Further research is needed to learn more about these mechanisms and the impact our exposome — all the environmental and lifestyle factors we are exposed to — has on the microbiome, but these mechanisms suggest we may be able to use flavonoids to produce beneficial changes to the microbiome which will protect cognitive function.



OPPORTUNITIES PRESENTED BY THE SYNERGY OF PHYTOCHEMICALS IN FRUITS AND 100% FRUIT JUICES

Dr Rui Hai Liu is a Professor in the Department of Food Science at Cornell University whose research focus is the effect of functional foods and bioactive compounds on chronic disease.

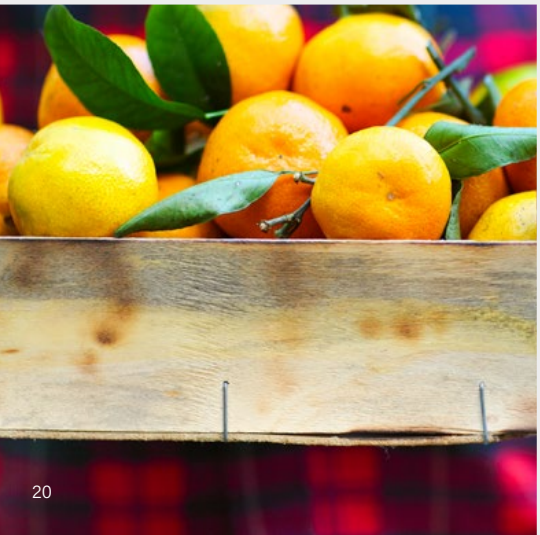
Dr Rui Hai Liu

We know plant-based foods reduce the risk of CVD and cancer and while there is still much to learn about the thousands of bioactive compounds in these foods, the evidence suggests it is better to have a little of everything, rather than supplements containing high doses of specific compounds. This can be seen in the effect of hesperetin which inhibits growth of breast cancer cells in small doses, but is toxic at large ones. Hesperetin has also been shown to adjust the volume of dozens of genes which influence the structure and function of breast cancer cells, as well as genes regulating inflammation and natural cell death.

However, studies of compounds in apples reveal a synergistic effect which makes these bioactives more potent in combination. For instance, apples contain the flavanol quercetin and individually both apples and quercetin will reduce the growth of breast cancer cells, but this effect is more than doubled when the two are combined.[46] Similar amplification can be seen in combinations of apple with ursolic acid, and apple with resveratrol.

The benefits of a whole-food approach are confirmed by studies using C. elegans, an experimental model of ageing, which report that extracts of apple and blueberry both deliver dose-dependent extensions in lifespan and protection from oxidative stress.[47,48]

The take-home message is that whole foods are healthier than individual dietary supplements and consumers should obtain a range of antioxidants by consuming a wide variety of plant foods, including fruits, 100% fruit juices, vegetables and whole-grains on a daily basis.



THE ROLE OF FRUIT JUICE IN ACHIEVING FIVE-A-DAY

On behalf of fellow Swansea University academic, Dr Hayley Young, Professor David Benton presented the findings of a study into strategies for increasing fruit and vegetable intakes.

The justification for removing 100% fruit juice from five-a-day recommendations is based on three assumptions: the specific role that sugar, particularly fructose, plays in obesity; the fact that juicing removes fibre; and the suggestion that 100% fruit juice is not as filling as fruit and may encourage over-consumption of energy.

However, there is nothing special about fructose. The calories it contains are no different from the calories in other foods; concerns around fibre are only relevant if 100% fruit juice is replacing whole fruits or vegetables; and worries about excessive energy intakes are not supported by patterns of consumption.

Perhaps unsurprisingly, there are significant differences in national guidelines on 100% fuit juice, despite universal agreement on the importance of eating more fruits and vegetables. However, advice on 100% fruit juice should be considered in the context of current consumption of fruit and vegetables, and this is woefully low. It is estimated that inadequate intakes account for between 5.6 and 7.8 premature deaths each year[49], yet surveys report that the vast majority of Europeans do not consume the recommended five-a-day.[50]

This is not as a result of poor awareness. The term five-a-day is so familiar there is no need to mention fruit or vegetables and the health benefits of increased consumption are widely known. Health educators have been incredibly successful at spreading the five-a-day message, but rather unsuccessful at translating it into behavioural change.

We clearly need a new approach, and it should focus on understanding why people are not eating fruit and vegetables and addressing the barriers to increased consumption. Consumer research has identified six key challenges: fruit and vegetables take effort to prepare; they can be messy because they create waste or leave hands feeling sticky; their short shelf life requires frequent shopping; they are bulky and heavy to transport; they are often more expensive than less healthy foods, and many consumers don't know how to add more fruit and vegetables to their diets.

As the influential Canadian psychologist Albert Bandura pointed out: "People's beliefs about their abilities have a profound effect on those abilities." In other words, believing we can do something increases the chance of success, while lack of belief increases the odds of failure. To increase intakes of fruit and vegetables, we must alter this mindset and address the challenges to consumption — and 100% fruit juice provides a simple solution to the six barriers identified by consumer surveys. It takes no effort to prepare; there is no mess; it can be purchased in bulk and stored at home or purchased in small easy-to-carry quantities; it is inexpensive and is simple to add to our diet.

Consumption of fruit and vegetables has a direct impact on life expectancy, but 25 years after the World Health Organisation introduced its five-a-day recommendation only four out of 19 EU countries have average intakes which achieve this target . In the UK, almost half the population eats less than three portions a day and overall the average is 3.8 portions a day when 100% fruit juice is included, and only 3.2 portions if not.[52]

Adding a single portion of 100% fruit juice every day would have such a positive impact on consumption it would reduce the risk of death from all causes by 3.9%. In terms of public health advice, it is the definition of low-hanging fruit.

CONCLUSION

This symposium uniquely brought together a wide range of evidence on 100% fruit juice. The key findings were:

- Fruits and 100% fruit juices both appear to have protective cardiometabolic effects, such as lowering blood pressure and improving insulin sensitivity. The mechanisms probably involve bioactive compounds, such as hesperidin and carotenoids which are bioavailable in both fresh and pasteurised juices, as well as potassium, vitamin C and folate.
- When considering associations with cardiovascular disease risk, 100% fruit juices are more similar to fruit (i.e. neutral or positive health impacts) than to sugar-sweetened beverages. In randomised controlled studies, the short-term metabolic impact of daily 100% fruit juice is different from that of sugar-sweetened beverages, for example uric acid levels. Thus, it does not make sense to categorise 100% fruit juices simply on the basis of their sugar content.
- There is adequate justification that 100% fruit juices should be considered complementary to public health campaigns aimed at improving population consumption of fruit and vegetables. For example, consumers of 100% fruit juices tend to consume more fruit and vegetables, have a more nutrient-dense dietary pattern, and often have a lower body mass index than non-consumers.
- There is emerging evidence that citrus flavanones are important to brain health and cognitive function.

Considering where 100% fruit juices fit into dietary guidelines is a more complex issue given the current focus on macronutrients, such as saturated fat and free sugars. 100% fruit juices have been categorised as a source of free sugars by WHO which, by default, places them in the same grouping as sugar-sweetened beverages, confectionery, desserts, cakes and biscuits which are generally considered as less desirable dietary choices.

Yet, as this symposium has demonstrated, 100% fruit juices are, in fact, much more complex than the highly processed foods and drinks which provide similar levels of free sugars. This is due to the natural matrix of 100% fruit juices (they have a low glycemic index (GI) compared with sugar-sweetened beverages) and their nutrient density, which includes micronutrients and bioactives, has demonstrable effects on animal and human health.

- The NOVA classification, and related systems such as SIGA, may be one way forward as these aim to group foods and drinks based on their level of processing, rather than their macronutrient content. In the NOVA classification, 100% fruit juices fall within the 'minimally processed category' – which is considered more beneficial than processed and ultra processed categories.
- 100% fruit juices can also be classified as part of the Fruit & Vegetable category which forms the key pillar of most food-based dietary recommendations. In several European countries, a daily glass of 100% fruit juice is viewed as a step towards the fruit and vegetable target. There is evidence that including 100% fruit juice as an option supports self-efficacy and increases the likelihood of the fruit and vegetable target being met.
- Given the low GI of 100% fruit juice, and the low glycemic load of a typical 150 ml glass, 100% fruit juice may be included in dietary guidelines based on GI – a system that is used in Australia, for example.
- The similarity to fruit and the minimal processing has led 100% fruit juice to be included in 'prescribed' diets, such as the PREDIMED or DASH diets which have been shown to lower the risk of cardiovascular disease, type 2 diabetes and breast cancer.

Further debate is required to determine where 100% fruit juice best fits within dietary recommendations and what level of consumption is optimal. National guidelines for a serving of 100% fruit juice vary from 150 ml (UK) to 240 ml (USA), while long-term randomised controlled trials have reported benefits at daily intakes ranging from 200 ml to more than 500 ml. What is clear, however, is the lack of justification for a simplistic "single silver bullet" logic of macronutrients and single endpoint research paradigms. Diets and, indeed, consumers are more complex than this and there is more merit to a holistic system.

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