

Nutrients in 100% fruit juice are bioavailable and processed has edge over fresh for bioactives



100% fruit juice (100%FJ) has nothing added or taken away, which is why it reflects the nutrient content of the fruit from which it is made.

The nutrient composition of 100% orange juice (100%OJ) is shown below per 100g. Values in red represent 'source' claims that can be made on pack.

Energy	41 kcal
Calcium	11 mg
Iron	0.2 mg
Magnesium	9.5 mg
Phosphorus	15.3 mg
Potassium	152 mg
Zinc	0.06 mg
Vitamin C	36.4 mg
Thiamin	0.08 mg
Riboflavin	0.02 mg
Niacin	0.29 mg
Folate	21.5 µg
Vitamin B6	0.07 mg
Vitamin B12	0.02 mg
Vitamin A	4.1 µg
Vitamin D	0.0 µg
Vitamin E	0.8 mg
Vitamin K	0.08 µg

As well as these nutrients, 100%FJ contains bioactive substances such as carotenoids (mainly luteins and cryptoxanthins), polyphenols (hesperidin and narirutin which are within the flavanone group) and pectin (fibre).

In clinical trials, therapeutic effects for hesperidin have been noted for neurological disorders, psychiatric disorders, and cardiovascular disease¹. The impact on brain health may be due to the fact that citrus flavanone can traverse

the blood-brain barrier thus increasing their usefulness as promising candidates to help prevent neurodegeneration². Other emerging effects of hesperidin include antioxidant and anti-allergic effects, immuno-modulatory activity, alleviation of hormonal disorders, anti-ulcer activity and potential wound healing³.

What is bioavailability?

Bioavailability means how accessible to the body are the nutrients in a food. For example, there is plenty of iron in spinach but, due to other natural compounds, such as oxalic acid, less than 10% of it is absorbed⁴. Interestingly, having a glass of 100%FJ with your spinach can optimise iron absorption!

Are nutrients in 100%FJ bioavailable?

The bioavailability of 100%OJ polyphenols was measured in 12 adults who ate a low polyphenol diet for 2 days before being given 250ml pulp-enriched 100%OJ or a placebo drink, following a 2-week washout⁵. The 100%OJ contained 584 mmol of polyphenols, mostly as flavanones.

24-hour urine sampling showed that metabolites of flavanone were appearing 2-10 hours after consumption which is consistent with the accepted view that flavanones are absorbed in both the small and large intestines. Flavanone catabolites (produced during breakdown) were seen in large quantities, equivalent to 88% of what had been consumed. These findings suggest that polyphenols in 100%OJ appear to be much more bioavailable than previously thought.

A longer term study⁶ examined the bioavailability of nutrients and bioactive substances in 100%OJ. For 3 weeks, 13 healthy, normal weight adults drank 236 ml juice daily which provided 256 mg vitamin C, 229 mg hesperidin, 6 mg carotenoids, and 160 µg folate.

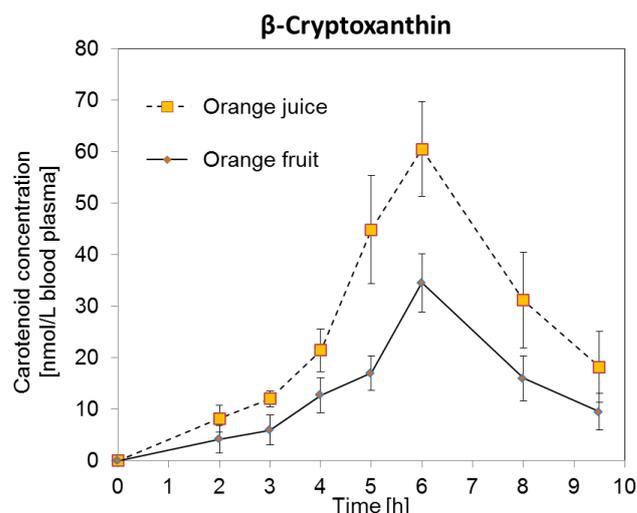
Compared with baseline, blood sampling revealed a significant increase in nutrient levels i.e. vitamin C and folate levels increased by around 50% while the flavanone levels were boosted 8-times. Carotenoid levels increased by 22%. Urine results confirmed a 9-times excretion of flavanones which returned to baseline levels within 2 weeks of stopping the juice consumption.

Interestingly, subjects' weight did not change during the study and the participants reported a lower intake of snacks and smaller portion sizes of meals.

How do juices compare with whole fruit?

Aschoff et al. (2015)⁷ compared the bioavailability of β-cryptoxanthin, lutein, zeaxanthin and zeinoxanthin from fresh oranges (400g) versus pasteurized 100%OJ (719g). Using a randomised cross-over design in 12 participants, a known amount of β-cryptoxanthin was provided in both test conditions. Blood samples were taken hourly for the next 10 hours.

The results showed that β-cryptoxanthin was 1.8-times more bioavailable in 100%OJ than in whole oranges. Based on a separate *in vitro* method, β-cryptoxanthin was 5-times more bioaccessible in 100%OJ versus whole oranges (see chart below for β-cryptoxanthin; there was also a similar although non-statistically significant trend for lutein):



The differences may be due to high pectin levels in the whole fruit inhibiting absorption, or the disruption of cell walls in 100%OJ leading to a greater release of β-cryptoxanthin. Other work⁸ has found that a higher proportion of carotenoids in 100%OJ are present in droplets which may explain why absorption from juice is superior.

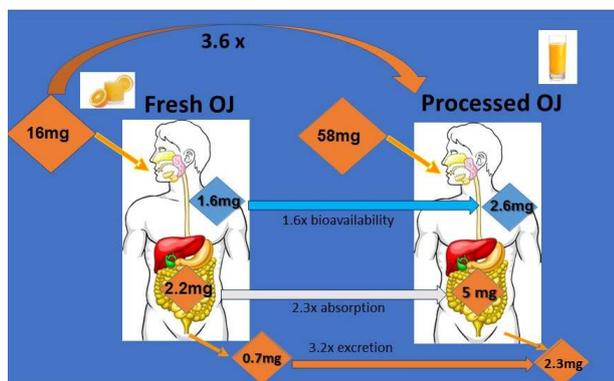
A second similar study⁹ examined the bioavailability of the flavanones, hesperidin and narirutin, in 100%OJ versus whole oranges. This was done by tracking the excretion of a known amount of flavanones in urine. Despite the hesperetin content of whole oranges being 2.4-times higher than 100%OJ, 24-hour urine excretion was similar.

This could mean that absorption and metabolism of dietary flavanones is saturated when intake exceeds a certain limit, perhaps due to poor solubility or limitations of transport mechanisms in the gut. Or, it could mean that flavanones in the whole fruit are not very bioavailable due to the fibre content. Dietary fibre in oranges is 16-times higher than in 100%OJ.

Fresh juice versus processed juice

As commercially-produced juice often contains lower levels of vitamins, due to the impact of shelf life, there is an assumption that it is less useful nutritionally than freshly squeezed juice.

This was investigated for 100%OJ in a randomised crossover trial in 24 adults¹⁰ where the two types of juice were given for 2 days each separated by a 30-day washout. Blood and urine sampling revealed no statistical differences in the metabolism of the flavanones, hesperidin and narirutin coming from processed or fresh 100%OJ. However, due to differences in the flavanone content (58 mg processed vs. 16 mg fresh), gut absorption and urinary excretion were significantly higher following consumption of the processed 100%OJ. Overall, this resulted in an increased 1.6-times bioavailability (see diagram below):



Flavanones are known to be soluble compounds which sit within the juice cloud, rather than in the cell wall material. The authors proposed that the rich flavonoid content of 100%OJ may be responsible for some of the health effects seen in studies, i.e. anti-oxidative and anti-inflammatory responses.

In other work¹¹, the focus on vitamin C degradation in heat-treated foodstuffs may be missing the point as health outcomes may be driven by complex mixtures of phytochemicals rather than a single

antioxidant. As one example, vitamin C provides only 0.4% of the total antioxidant activity of apples with the remaining activity driven by phenolics, flavonoids, and anthocyanins. Therefore, a broad spectrum of bioactive substances in food should be considered in future studies, as well as the water content which can influence the concentration of nutrients.

Role of bioactives in the body

Various studies have confirmed the potential health impact of the bioactives found in 100%FJ. In a controlled trial in diabetic participants, hesperidin lowered oxidative DNA damage and lipid peroxidation¹². In another trial β -cryptoxanthin lowered total, LDL and HDL cholesterol and positively modified bone turnover markers¹³. Lutein and zeaxanthin have been found in clinical trials to improve vision in people with age-related macular degeneration¹⁴, while citrus flavonoids may be protective against neurodegenerative diseases¹⁵. As yet, there are no authorised EU health claims for any fruit bioactives.

Bioavailability and ageing

It is recognised that the availability and metabolism of nutrients is affected by ageing. Good examples are vitamin D and vitamin B12. An observational study¹⁶ of 2118 women (aged 35-74 years) from six European countries examined blood levels of carotenoids and tocopherol (a form of vitamin E). Older women had lower levels of carotenoids but higher levels of tocopherol. As older women had higher intakes of fruit and fruit juice (both excellent sources of carotenoids), it is likely that the age-related differences were due to a lower bioavailability or different storage patterns in the body. If this were the case, higher intakes of fruit and fruit juice could be an important way to prevent a significant decline in carotenoid status in older people.

Conclusion

This collection of studies shows that:

- 100%FJ, especially 100% OJ, is a valuable source of nutrients and bioactives linked with health;
- These bioactives, such as carotenoids and flavanones, are bioavailable in 100%FJ;
- Processed 100%FJ has a similar bioavailability of flavanones to whole fruit but a higher carotenoids bioavailability;
- Processed 100%FJ compares well to freshly squeezed juice in terms of flavanones absorption and metabolism, suggesting that it has an equivalent nutritional value for bioactives.

Disclaimer: Every effort has been made to ensure that the information contained in this document is reliable and has been verified. The information is intended for non-commercial communication to healthcare professionals only. The information given in this dossier does not constitute dietary advice.

References

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