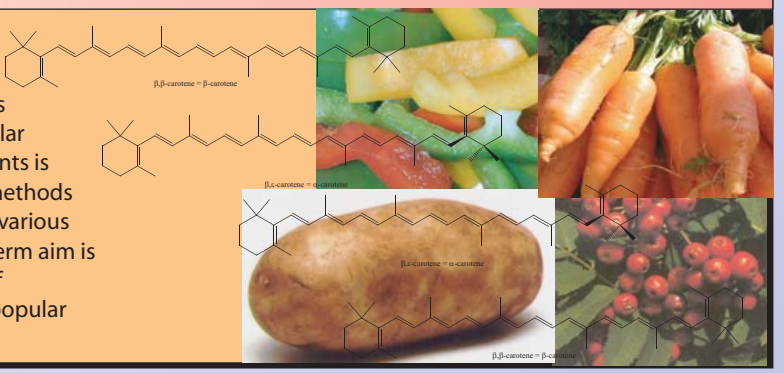
Developing methods for measuring carotenoid bioavailability

KIRSTIN BANNON
HARRIS ACADEMY, DUNDEE Placement at Scottish Crop Research Institute, Invergowrie, Dundee
Mentors: Drs Gordon J McDougall and Derek Stewart, Quality, Health and Nutrition; email- gmcdou@scri.sari.ac.uk

Scottish Crop Research Institute

Introduction

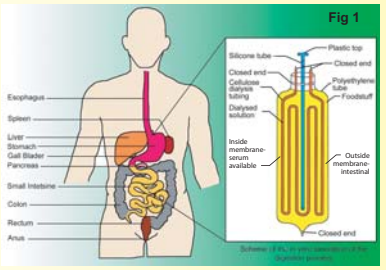
Carotenoids are essential for human health. These hydrophobic isoprenoid derivatives are precursors for Vitamin A (retinol) and deficiency of dietary carotenoids can lead to health problems such as age-related macular degeneration and enhanced risk of cardiovascular problems (1). The uptake and stability of these essential micro-nutrients is not well defined. The objective of this project is to develop in vitro methods to assess the bioavailability and stability of dietary carotenoids from various fruits and vegetables in the human gastro-intestinal tract. The long term aim is to select potato varieties with elevated levels of bioavailable forms of carotenoids for accelerated breeding programmes - to provide the popular potato with extra nutrient appeal.

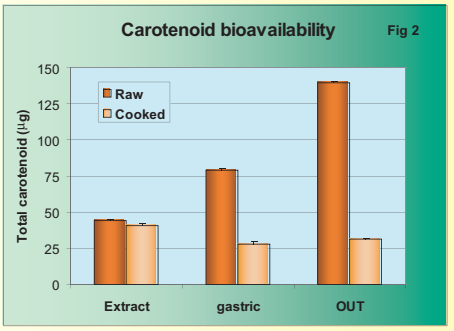


Results

Bioavailability of carotenoids

The bioavailability of carotenoids was assessed using a model system (2) that mimicked the digestive processes of the human gastrointestinal tract (Fig. 1). The carotenoids from raw and cooked carrots were studied to validate the procedure (Fig. 2). Roughly equal amounts of carotenoids were present in the original extracts of raw and cooked carrots. However, less carotenoids in the cooked carrots survived the gastric and intestinal digestions than the raw carrots. This is probably due to the increased release of carotenoids from the raw carrots during digestion.

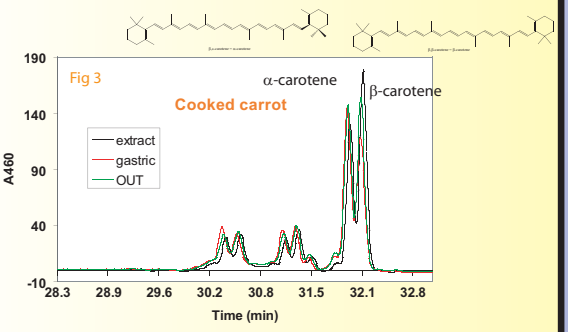


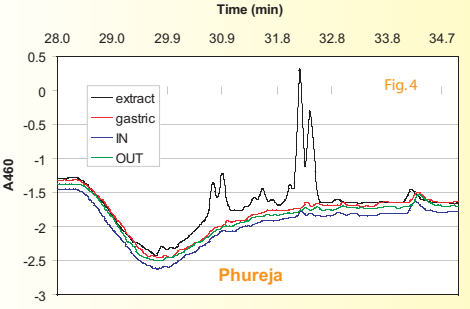


No carotenoids were detected in the IN samples suggesting that these hydrophobic compounds did not penetrate the dialysis membrane. Analysis of the carrot samples by reverse phase high performance liquid chromatography reveled the presence of two main peaks which can be assigned to α-carotene and β-carotene (Fig 3). The carotene levels in each fraction tallied with the total amount of carotenoids which validates the use of this in vitro digestion procedure for carrot carotenoids. The cooked sampes contained small peaks of other carotenoid-like material (Fig. 2) which eluted before the carotenes and are probably thermal/oxidative degradation products of the carotenes formed during cooking.

Identification of carotenoids by HPLC

In vitro digestion studies were carried out using cooked tubers of Solanum phureja. The total carotenoid levels in these relatives of the potato were fifty times lower than the carrot samples. The recovery values for the gastric, IN and OUT samples were not accurate due to the low carotenoid content and interference by yellow contaminants in the extracts. However, carotenoids could be detected in the original extract by HPLC (Fig. 4) but not in any of the in vitro digestion samples. The carotenoid profile of the Phureja sample is similar to previous studies but further work is required to identify the individual carotenoids.





Conclusions

The in vitro digestion procedure used can assess the bioavailability of carotenoids in samples that contain appreciable amounts of carotenoids such as carrot and tomato. However, improvements are required if the method is be to used to assess the bioavailablilty of carotenoids in lower yielding samples such as potatoes and Solanum phureja. The method was applied to Rowan berries but although a carotenoid HPLC profile was obtained, the levels were too low to assess changes in recovery. Nevertheless, the pattern of bioavailability of polyphenols from the rowans was very similar to previous results suggesting there was no fault in the execution of the method.

Improvements could be made by increasing the sample size to increase the carotenoid content or employing different sampling methods to extract and/or concentrate or analyse the soluble carotenoids (3).

References

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3. D.A. Garrett, M.L. Failla and R.J. Sarama (2000) Estimation of carotenoid bioavailability from fresh stir-fried vegetables using an in vitro digestion/Caco-2 cell culture method. Journal of Nutritional Biochemistry 11, 574-580.