Storability of vegetable carotene severely affected by oxygen in air

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The shelf life of vegetable carotenoids when stored in powdered form is severely affected by oxygen in the storage environment—an effect that has a big impact on the food industry, but that can be dramatically

reduced by implementing optimized production processes. This is the clear finding of an elaborate study using the know-how and equipment of EQ BOKU, a facility that provides precision scientific instrumentation and expertise to members of the University of

Natural Resources and Life Sciences, Vienna, as well as to external clients. The research, supported by the world's leading manufacturer of coloring plant concentrates, compared different processes and formulations in the production of pigment-rich carrot concentrate powder, and tested their effects on storability. The results are of major significance to the food industry, since coloring concentrates from fruits and vegetables are increasingly being used as an alternative to artificial colorings. The results of the study have now been published in *Food Research International*.

Vegetable concentrates instead of artificial colors

Carrot concentrates are rich in valuable carotenoids (special pigments with antioxidant effects), and highly sought after in the food industry for use as colorings. But in order for the rich orange color in carrots to be transferred to food and drink preparations, the structure of the natural pigments must be preserved, and contact with oxygen avoided until they are used. A team led by Professor Henry Jäger from the Institute of Food Technology at the University of Natural Resources and Life Sciences, Vienna (BOKU), has investigated how this can now be better achieved for powder products through optimized production processes. For the investigation, they used the cutting edge equipment available at EQ BOKU, which enables analysis of food technology process steps along entire production cycles.

The team made new discoveries concerning the way oxygen can infiltrate them. These insights will enable the shelf life of carotenoids in stored end products to be greatly increased. But it is important to take

advantage of the opportunities to influence the structure of the material for storage right at the beginning of the production process for vegetable concentrate powders. "The infiltration of oxygen present in the air into pigment-rich powder particles is actually the biggest factor influencing the shelf life of coloring that we identified," explained Klara Haas, a researcher from the working group. "But with delicate management of the drying process in production, the shape of the powder particles can be determined in order to greatly reduce diffusion of oxygen into the stored goods."

A key role is played here by so-called "carrier materials," which are used in production to ensure that powders have a stable structure. In the study—which has now been published—maltodextrin, which is often employed as a carrier material, was replaced by gum arabic or modified starch. There were good reasons for this, as the research results showed: "The carrier material can enclose a large proportion of carotene and so shield it from oxygen, but a certain amount remains on the surface and is exposed to the oxygen," explained Professor Jäger. "We discovered that when maltodextrin is used, after one drying stage over a third of the sensitive carotene is found on the surface of the powder particles, unprotected. This is reduced to just a quarter or a fifth when modified starch or gum arabic is used. This means that both are carrier materials that provide better protection against oxygen." The method of powder manufacture also has an enormous influence on storability—with the physical barriers to oxygen again proving decisive. If the powder is produced by means of freeze drying, powder particles contain micropores and nanopores that allow oxygen to penetrate quickly. But by using an optimized spray drying process, which produces denser particles with lower surface area, oxygen diffusion during storage is reduced and the stability of the plant-based coloring concentrate is massively increased. The ideal size for particles is up to a little over 90 micrometres." "Larger particles mean that there is a greater proportion of carotenoids inside the particles compared to that on the surface, so

there is greater protection against oxygen," explained Professor Jäger.

To a certain extent, the oxidation of vegetable carotenoids can also be reduced by adding antioxidants such as tocopherol, ascorbyl palmitate and sodium ascorbate. However, the new findings reveal the limitations of these costly measures, as Klara Haas asserted: "Of course the antioxidants help, but if the powder particles do not have an appropriate microstructure, their effect is limited. These additives can only develop their full protective capabilities when the structure physically obstructs the diffusion of oxygen through the powder. In a particle with the right structure, the antioxidants that are already present from the carrot are sufficient to protect the carotenoids."

In summary, the findings show that the shelf life of vegetable coloring concentrates when stored in powdered form can be markedly increased if an optimized drying process is used in production and modified starch or gum arabic is employed. Without these measures, in extreme cases almost 90 percent of carotene is lost within three months; with optimized production, this was reduced to less than 10 percent. Precise analysis of the storability of natural carotenoids and differing production variants was made possible by EQ BOKU's comprehensive range of equipment. This allows alternative production processes to be carried out at pilot scale, and results to be directly evaluated using state-of-the-art analysis equipment.

More information: Klara Haas et al. Stabilization of Crystalline Carotenoids in Carrot Concentrate Powders: Effects of Drying Technology, Carrier Material, and Antioxidants, *Foods* (2019). DOI: 10.3390/foods8080285

Klara Haas et al. Impact of powder particle structure on the oxidation stability and color of encapsulated crystalline and emulsified carotenoids in carrot concentrate powders, *Journal of Food Engineering* (2019). DOI:

10.1016/j.jfoodeng.2019.07.025