

## Bioaccessibility and cellular uptake of iron from processed yellow mealworms

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The consumption of insects is expected to have many advantages which have contributed to the current trend to include edible insects in western diets. Edible insects contain high levels of trace elements such as zinc, selenium, and iron. Therefore, their inclusion in human diets might be a strategy to combat nutritional deficiencies such as that of iron. However, little is known about the actual bioavailability of iron from insects.

Here, an *in vitro* digestion/Caco-2 cell culture model is presented to determine bioaccessibility and cellular uptake of iron from freeze-dried larvae of *Tenebrio molitor* (mealworms). The processed mealworms were digested *in vitro*, and iron concentration of the digests was determined by Inductively Coupled Plasma – Mass Spectrometry to assess iron bioaccessibility. Cellular iron uptake was indirectly measured as ferritin synthesis in Caco-2 cells. Values obtained for mealworms were compared to bioaccessibility and cellular iron uptake from digests of minced pork. Furthermore, it was analyzed whether processed mealworms could increase bioaccessibility and cellular uptake of iron in co-digestion with iron sulfate.

The freeze-dried mealworm samples contained approximately 10 times more iron ( $17.7 \pm 4.1$  mg/100 g dm) than minced pork ( $1.6 \pm 0.4$  mg/100 g dm), however, the iron concentration of the bioaccessible iron fraction measured after *in vitro* digestion was only about 2 times higher in the mealworm digests ( $104.0 \pm 44.1$  µg/L) compared to the digests with pork ( $63.4 \pm 20.9$  µg/L). Both digests induced ferritin synthesis in the Caco-2 cells, with a significantly higher cellular uptake for digests from pork.

After digestion of 16753.5 µg/L (300 µM) iron sulfate, only 0.05% of the total iron from the initial digestion mixture was bioaccessible and there was no detectable cellular uptake of iron compared to the control. Co-digestion with mealworms resulted in a higher bioaccessibility of iron (3.1%) and in a significantly increased cellular iron uptake.

Overall, it can be beneficial to incorporate freeze-dried mealworms in human diets, because an enhancing effect on iron bioaccessibility and cellular uptake was observed.