Abstract for general public

Antioxidant and calcium bioaccessibility of freeze-dried apples impregnated with sea buckthorn juice and calcium lactate: An *in vitro* digestion study

The United Nations has declared 17 Sustainable Development Goals (SDGs), which are the urgent call for action by all countries to achieve sustainable development in 2030. Two of the SDGs are highlighted in this research: a) Goal number 2, which is to end hunger, achieve food security and improved nutrition, and promote sustainable agriculture, and b) Goal number 3, which is ensuring healthy lives and promoting well-being for all at all ages. Goal number 3 is targeting to reduce by one-third premature mortality from non-communicable diseases, such as osteoporosis and calcium deficiency, through prevention and treatment and to promote mental health and well-being.

Recent studies have reported that besides exercising, consuming food products that contain high calcium and antioxidant contents is recommended to be one of the effective solutions to prevent calcium deficiency and osteoporosis. Researchers are developing various functional food products, some of which are based on local commodities which are then in line with goal number 2, concerning food security.

Sea buckthorn (*Hippophae rhamnoides*) and apple (*Malus domestica*) are two among all fruits that are available and rich in antioxidants. Sea buckthorn fruits grow well in Asia and North-Western Europe, and even the cultivation development of sea buckthorn has been financially supported by government and Food and Agriculture Organization of the United Nations (FAO). Thanks to sea buckthorn's phenolic and carotenoid compounds, some studies reported the health benefits of sea buckthorn in both *in vitro* and *in vivo* studies. The same advantages have been found in apple. Noting that apples are widely consumed by the majority of the population and can be grown in various regions in the world, apple has potential to impact significant bioactive compounds intake of population. Although apple was reported by prior studies to have antioxidant activities and is beneficial for health, apple still lacks calcium.

Besides improving the shelf life by reducing the water content of the product, osmotic dehydration and impregnation processes are effective to increase the bioactive compounds in fruits and vegetables, especially when non-thermal technologies such as vacuum impregnation and ultrasound-assisted impregnation were applied. Using sea buckthorn juice and calcium as the impregnation agent might be adapted to the apple to improve the Ca and antioxidant contents. In conducted preliminary studies (unpublished data), optimization of atmospheric, vacuum, and ultrasound-assisted impregnation of apple flesh using sea buckthorn juice and calcium lactate was conducted. The treated freeze-dried apples exhibited antioxidant activities and increased calcium content. However, to confirm its potency, *in vivo* studies should be conducted, noting that the actions of calcium and antioxidants are altered during digestion process and may affect their biological activity. As *in vivo* study is costly, time-consuming, and may cause ethical issues, *in vitro* gastrointestinal digestion model is recommended as a tool to evaluate the stability or bioaccessibility of antioxidants and other bioactive compounds in food products. The controlled conditions in this model mimic the conditions and processes in *in vivo* study. The results obtained from this digestion model can be the guide to future *in vivo* research and can also predict the intake or portion recommendation.

In this proposed study, the optimized freeze-dried apples mentioned above will be subjected to this *in vitro* digestion model that simulates oral mastication, gastric digestion, and intestinal – duodenum, jejunum, ileum digestion. The aims of this study are a) to evaluate the bioaccessibility of calcium, total polyphenol content, and antioxidant activity of treated freeze-dried apple based on preliminary study after each stage of *in vitro* gastrointestinal digestion model, and b) to evaluate the phenolic and carotenoid composition of treated freeze-dried apple after *in vitro* gastrointestinal digestion model. This research result can contribute to the development of a new functional food alternative that is based on local resources, in order to reduce the risk of osteoporosis and calcium deficiency in the population.

Keywords: antioxidants, bioaccessibility, calcium, *in vitro* digestion model, osteoporosis