Colon-targeted delivery of probiotics through millet-pulse based synbiotic nutrisnacks using an encapsulation-3D printing approach

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Objective:
Probiotics can support a healthy life when administered in an adequate amount. It can be delivered as food and supplements, are generally considered as functional foods. The focus of this research was to study the feasibility of delivering the probiotics through a synergistic approach of encapsulation and 3D printing processes.

Methods:
Probiotics were encapsulated using a spray-freeze drying (SFD) method with prebiotics. Further, the synbiotic powders were mixed with protein-fiber-rich composite flour and 3D printed as synbiotic-composite flour nutrisnacks and then treated post-processed using freeze drying (FD) method. The probiotics' viability after 3D printing and post-processing was assessed for both raw and roasted composite flour matrix to analyze the impact of pre-treatment on the viability of probiotics and starch digestibility. The delivery of encapsulated probiotics was validated using an engineered dynamic in vitro digestion model ARK® and compared with the simulated static in vitro digestion process.

Results:
Roasting pre-treatment of composite flour does not have any significant implications on probiotics viability during printing and post-processing. Whereas, the post-processing method has a significant effect on probiotics viability. The roasted composite flour snacks had a higher starch digestibility index (13.77%) as compared with raw composite flour snacks (8.11%). It indicates that the digestibility of synbiotic flour made with 3D printing snacks was improved by the implementation of roasting process. The results of comparative analysis of static and dynamic digestion showed significant differences. In each digestion method, a significant difference was found between SFD and free cells, but no significance was found in terms of roasted and raw composite flour.

Conclusions:
Overall, a synergistic approach of encapsulation and 3D printing processes resulted in higher viability (8.18±0.28 log10CFU/ml) and better survivability (79%) of probiotics. In the dynamic digestion study, the stability of administered probiotics till the termination of the ileum section in the small intestine showed the targeted delivery of probiotics. Thus the results showed a synergistic approach of encapsulation and 3D printing processes promising the delivery of probiotics at a targeted site of action.