MedCrave
Step into the World of Research
Advances in Plants & Agriculture Research

Mini Review

Open Access

CrossMark

Alternate food sources for modification of digestibility of common foods

Volume 9 Issue 1 - 2019

VikonoKsh, Shalini G Rudra, RR Sharma
Division of Food Science and Postharvest Technology, ICAR-Indian Agricultural Research Institute, India

Correspondence: VikonoKsh, Division of Food Science and Postharvest Technology, ICAR-Indian Agricultural Research Institute, New Delhi 110012, India, Email vikonokh@gmail.com

Received: January 02, 2017 | **Published:** January 29, 2019

Introduction

Common foods such as bread, pasta, noodles, etc. are widely consumed by the majority of the world's population. The increase in lifestyle diseases (diabetes, obesity, etc.) coupled with the global awareness on these issues has led to a high demand for foods with lower glycemic index. Glycemic Index (GI) is a number associated with a particular type of food that indicates the food's effect on a person's blood glucose level. A value of 100 represents the standard (pure glucose). Based on the GI, food can be classified as: (Figure 1). One of the best ways of developing food with improved health benefits is by the incorporation of alternate food sources having higher resistant starch fractions such as banana pseudo-stem flour (BPF), sweet potato flour (SPF), barley flour, etc. in the commonly consumed foods. Besides this, the incorporation of newer sources of food leads to enhancement of nutraceutical value of these common foods. For instance, resistant starch (RS) incorporation in food system is becoming increasingly popular as it promotes colon health by the production of short chain fatty acids and reducing pH. RS remains un hydrolyzed even after 16 hour of ingestion and hence acts as a dietary fiber. Knowledge about the complex physicochemical and physiological events that occur in the human gastro-intestinal tract is important when a novel fortified food product is developed. This can be achieved by implementing the various *in vitro* digestion models available. Though not very accurate, *in vitro* digestion models provide an alternative method of screening the food ingredients by mimicking the human digestion process.[1]

Figure 1 Classification of food based on GI.

In this review, we seek to elaborate the methods for *in vitro* digestibility estimation adopted by researchers for low GI foods development. Also some techniques for improvement of quality of these foods through use of hydrocolloids are presented (Figure 2). One such example of incorporation of RS is Nutriose® which is partially hydrolyzed starch from wheat or corn. Having non-viscous soluble nature, Nutriose is gaining acceptability among processors as a RS rich food additive. Lefranc-Millot[2] has reported that during the controlled process of dextrinization, the starch undergoes partial hydrolysis to dextrin, followed by repolymerization which imparts the properties of resistant starch to Nutriose. It is a good source of soluble fiber which has found health benefits in gluten-free bread-making,[3–5] investigated the effect of incorporation of Nutriose® in noodles made from sweet potato flour and sweet potato starch. Regarding this commercial RS, it was reported to have high digestive tolerance, low GI (<25) and good stability. Pale cream fleshed sweet potato (SreeArun) harvested from the Institute farm was used to obtain sweet potato flour (SPF) and sweet potato starch (SPS). Two types each of SPF and SPS based noodles were prepared containing NUTRIOSE® at different levels. The treatment with the lowest glycemic index was further modified by the incorporation of guar gum. The formulation used is summarized in Figure 3. *In vitro* starch digestibility was evaluated as per summarized protocol (Figure 4). Glucose released was quantified by glucose oxidase method (EC1.1.3.4)–PAP method. Cooking loss (CL) was significantly reduced for 10% NUTRIOSE fortified SPF noodles, compared to the control SPF noodles. Significantly higher CL (%) was observed for 20% NUTRIOSE. Swelling index was also the least for the 10% NUTRIOSE fortified SPF noodles. NUTRIOSE might be forming a complex with gluten which then encapsulates the starch granules, so that they undergo only restricted swelling.[6,7] Beyond 10% level, the excess NUTRIOSE might be only forming a loose network, which caused higher swelling on cooking. In the case of SPS noodles, NUTRIOSE addition lead to increased CL probably because of the binding between WPC and NUTRIOSE, leaving the starch to gelatinize freely and leach in the cooking water. GG (0.5–1%) fortification to 5% NUTRIOSE fortified noodles could reduce the CL significantly. Guar gum supplementation (1%) could significantly reduce the swelling index (SI) of 5% NUTRIOSE fortified SPS noodles. Starch digestion kinetics revealed that the digestion preceded very slowly in the test noodles and after 120 min., only 53–68g glucose was released. Further, GG incorporation at 1% level resulted in the drastic reduction in starch digestibility. In case of SPS noodles, *in vitro* starch digestion progressed much slowly than the SPF noodles. NUTRIOSE at 5% and10% level exerted a highly significant effect in reducing the digestible starch, and in increasing the RS in the products. This effect was further complemented by GG addition to a greater extent by 0.5% GG, unlike in the case of SPF noodles, where 1% GG+15% NUTRIOSE, exerted a greater effect in elevating the RS content. The estimated glycemic indices (EGI) was significantly brought down in the SPF noodles by fortifying the SPF with RS rich NUTRIOSE and the least value of 55.23 was obtained for 15% NUTRIOSE. This was further reduced to 54.58 to obtain a truly low glycemic product, by adding 1.0% GG to the 15% NUTRIOSE mix compared to control SPS noodles with EGI of 62.95. Soluble fibres like β glucan primarily from oats and barley can also be used to lower the digestibility of foods besides providing their nutraceutical benefits like hypocholesterolemia. Barley flour usually contains about 2-10% of β-glucan (w/w).[8]

According to FDA, dietary intake of 3g/day β- glucan can reduce the total cholesterol and the blood glucose level. Many researchers like Moza & Gujral[9] and Soong et al.,[10] have found barley to be a better source of soluble dietary fiber for modifying digestibility of common foods like muffins, breads and cookies. The effect of enrichment of ditalini pasta with barley flour (40%) on the quality characteristics and *in vitro* digestibility has been reported by Montalbano et al.,[11] The elaborate *in vitro* digestion protocol adopted by them has been summarized in Figure 5.[12] Briefly, ditalini pasta (20g) was cooked and separated from cooking water to obtain pasta asciutta. Though the BF-ditalini appeared darker than the control, inclusion of BF did not affect remarkably the pasta quality. The incorporation of BF resulted in a compact starch-protein network that delayed disintegration of the matrix during cooking, thus preserving its quality. With respect to the control, BF-pasta asciutta, having 2.5% β-glucan fiber, caused a decrease of glucose released at 20 min. However, no other significant change was observed thereafter. On the contrary, release of glucose was significantly lower for BF-pasta soup with respect to control soup. These findings indicate that, only BF-soup, containing 5% of β-glucan, significantly decreased the glycemic potency of BF-ditalini.

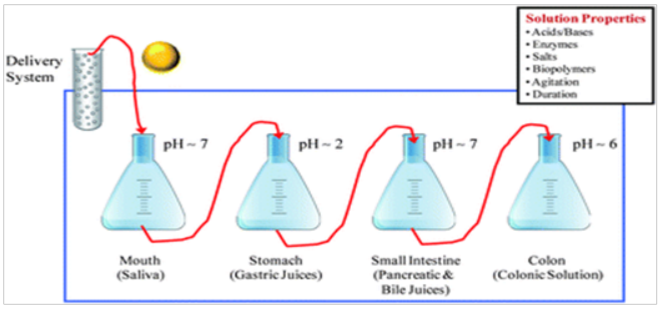

Figure 2 Illustration of *invitro* digestion.

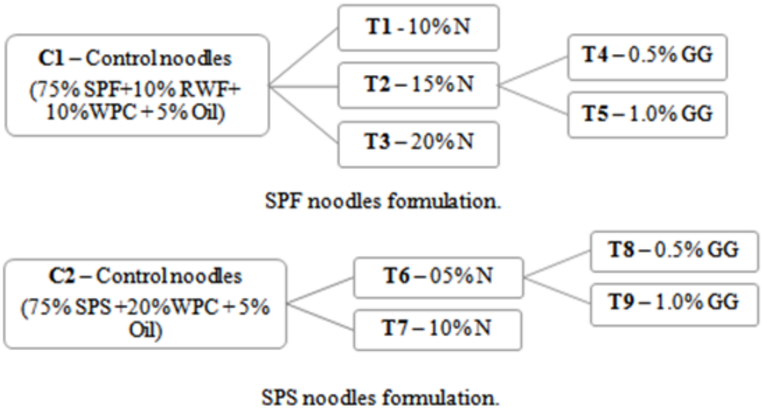

Figure 3 Noodles formulation. C-Control, SPF-Sweet Potato Flour, SPS-Sweet Potato Starch, RWF-Refined Wheat Flour, WPC-Whey Protein Concentrate, T-Treatment, N-Nutriose, GG-Guar Gum.

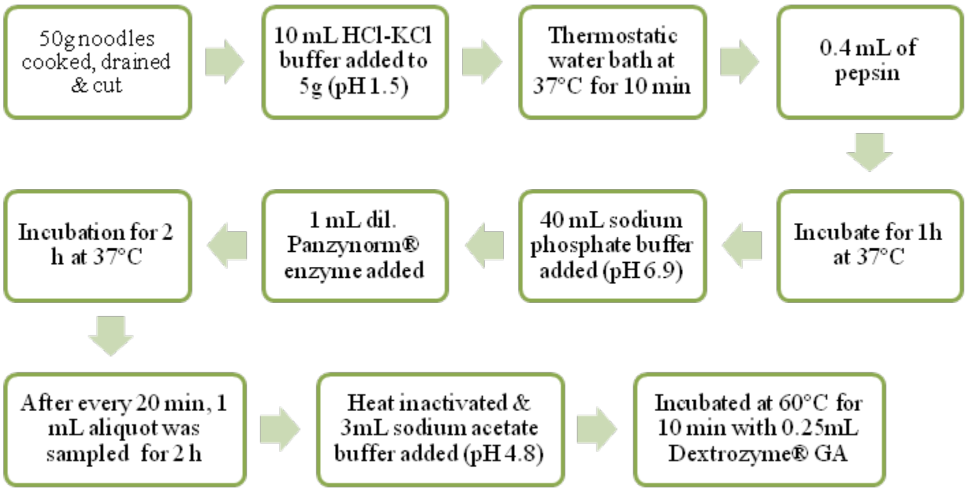

Figure 4 In vitro digestion protocol (Menonet al., 2015). Panzynorm®- 10,000 U lipase, 9000 U α-amylase, 500 U protease. Dextrozyme®- glucose amylase (intestinal enzyme).

Delay in the starch hydrolysis of pasta added with soluble fiber can be attributed to changes in its microstructure and to hydration of the polysaccharide matrix which hinders encapsulation of the protein-starch matrix until the later stages of digestion (Figure 6). Banana and its by-products are increasingly being used as rich sources of dietry fiber. Banana flour has been successfully incorporated in bread-making,[13] pastas[14] while banana pseudostem flour has been incorporated in cookies.[15] Having high fibre content,[16] Banana pseudostem flour (BPF) can be used as an alternative food source for improving the health benefits of common foods such as bread. BPF has been found to be a good source of macro minerals such as K, Na, Ca, Mg and P.[17–19] However, incorporation of BPF leads to gluten dilution which has a negative impact on the bread quality. Hydrocolloids such as xanthenes gum and sodium carboxyl-methyl cellulose (CMC) at 0.8% levels were employed to alleviate these effects. The *in vitro* starch digestibility of the samples was carried out according to the procedure proposed by Goñi *et al*. (1997). The composite breads were found to contain higher amount of Na, Ca, P, K, Mg, Fe and Mn as

Citation: VikonoKsh, Rudra SG, Sharma RR. Alternate food sources for modification of digestibility of common foods. *Adv Plants Agric Res.* 2019;9(1):178–181. DOI: 10.15406/apar.2019.09.00432

compared to the control bread. The composite breads had lower total starch content (75-79%). In general, RS in bread samples were found to increase in the presence of hydrocolloids. In breads with CMC along with BPF, the RS content increased to 14.98% as compared with BCtr due to the presence of Na CMC, a soluble cellulose derivative. The interaction between the added fibers and the biopolymers may have resulted in a compact structure in the bread crumb which resulted in the entrapment of starch and thus reducing its accessibility by the enzymes and hence its liberation. *In vitro* starch hydrolysis showed that the composite breads had lower glycemic response (0.3-2.6%). Addition of different hydrocolloids resulted in a decrease in GI by 68-77% because hydrocolloids are capable of retarding the enzymatic hydrolysis by coating the surface of the starch granules. These act as a physical barrier to the enzyme attack as well as to the release of hydrolysis products.

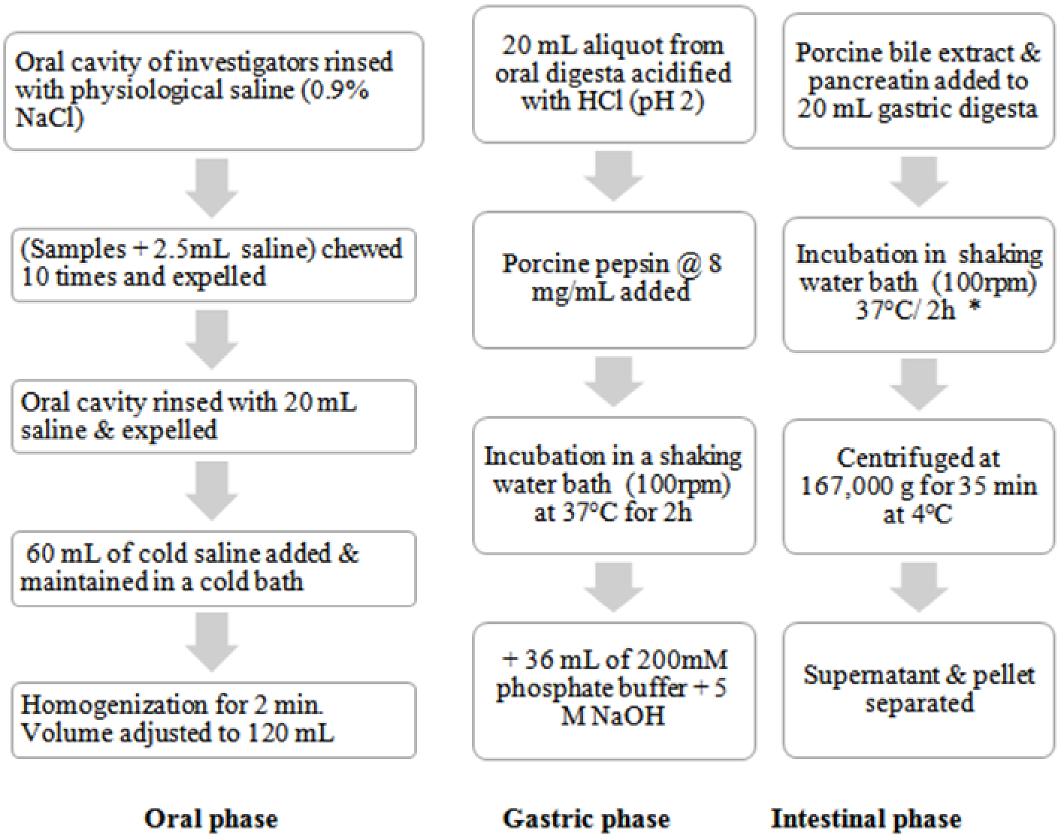

Figure 5 In vitro digestion (Tesoriereet al.2008).

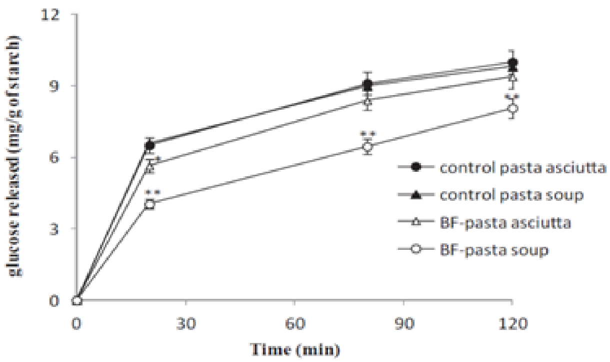

Figure 6 Kinetic of glucose release during in vitro intestinal digestion of BF-ditalini, asciutta and soup, in comparison to control.

Future thrust

Further research needs to be conducted on the alternative food sources and their utilization in improving the health of the consumers. The use of alternate food sources is fairly a new concept and hence, very limited literature regarding the toxicological and anti-nutritional factors is available. This need to be established for such sources. Technological interventions to improve the quality of common foods containing resistant starch or slowly digestible starch require urgent attention.

Acknowledgments

None.

Conflicts of interest

The authors declared there is no conflict of interest.

References

1. Coles LT, Moughan PJ, Darragh AJ. *In vitro* digestion and fermentation methods, including gas production techniques, as applied to nutritive evaluation of foods in the hindgut of humans and other simple-stomached animals. *Animal Food Science and Technology*. 2005;123-124(1):421–444.
2. Lefranc Millot C. NUTRIOSE® 06: a useful soluble dietary fibre for added nutritional value. *Nutrition Bulletin*. 2008;33(3):234–239.
3. Martínez MM, Díaz Á, Gómez M. Effect of different micro structural features of soluble and insoluble fibres on gluten-free dough rheology and bread-making. *Journal of Food Engineering*. 2014;142:49–56.

4. Menon R, Padmaja G, Sajeev MS. Cooking behavior and starch digestibility of Nutriose® (resistant starch) enriched noodles from sweet potato flour and starch. *Food Chem*. 2015;182:217–223.

5. Menon R, Padmaja G, Sajeev MS. Ultrastructural and starch digestibility characteristics of sweet potato spaghetti: Effects of edible gums and fibers. *International Journal of Food Properties*. 2015;18(6):1231–1247.

6. Colonna P, Barry JL, Cloarec D, et al. Enzymic susceptibility of starch from pasta. *Journal of cereal science*. 1990;11(1):59–70.

7. Fardet A, Hoebler C, Bouchet B, et al. Involvement of the protein network in the in vitro degradation of starch from spaghetti. *Reprod Nutr Dev*.1997;37(3):351–352.

8. Bamforth CW. Barley β-glucans: their role in malting and brewing. *Brewers Digest*. 1982;57(6):22–27.

9. Moza J, Gujral HS. Starch digestibility and bioactivity of high altitude hulless barley. *Food Chem*. 2016;194:561–568.

10. Soong YY, Tan SP, Leong LP, et al. Total antioxidant capacity and starch digestibility of muffins baked with rice, wheat, oat, corn and barley flour. *Food Chem*. 2014;164:462–469.

11. Montalbano A, Tesorerie L, Diana P, et al. Quality characteristics and *in vitro* digestibility study of barley flour ditalini pasta. *LWT – Food Science and Technology*. 2016;72:223–238.

12. Tesoriere L, Fazzari M, Angileri F, et al. In vitro digestion of betalainic foods. Stability and bioaccessibility of betaxanthins and betacyanins and antioxidative potential of food digesta. *J Agric Food Chem*. 2008;56(22):10487–10492.

13. Juarez-Garcia E, Agama-Acevedo E, Sáyago-Ayerdi SG, et al. Composition, digestibility and application in breadmaking of banana flour. *Plant Foods Hum Nutr*. 2006;61(3):131–137.

14. Ovando-Martinez M, Sáyago-Ayerdi S, Agama-Acevedo E, et al. Unripe banana flour as an ingredient to increase the undigestible carbohydrates of pasta. *Food Chemistry*. 2009;113(1):121–126.

15. Ambrose DCP, Lekshman R. Quality attributes of cookies from banana centre core flour incorporated in wheat and refined flour. *Food Science Research Journal*. 2016;7(2):141–147.

16. Abdul Aziz NA, Ho LH, Azahari B, et al. Chemical and functional properties of the native banana (*Musa acuminata x balbisianaColla cv. Awak*) pseudostem and pseudostem tender core flours. *Food Chemistry*. 2011;128:748–753.

17. Ho LH, Aziah AA, Bhat R. Mineral composition and pasting properties of banana pseudo-stem flour from *Musa acuminata X balbisiana cv. Awak* grown locally in Perak, Malaysia. *International Food Research Journal*. 2012;19(4): 1479–1485.

18. Ho LH, Aziz NAA, Azahari B. Physico-chemical characteristics and sensory evaluation of wheat bread partially substituted with banana (*Musa acuminata X balbisiana cv. Awak*) pseudo-stem flour. *Food Chem*. 2013;139(1):532–539.

19. Ho LH, Tan TC, Aziz NA, et al. *In vitro* starch digestibility of bread with banana (*Musa acuminate* X *balbisiana*ABB cv. Awak) pseudo-stem flour and hydrocolloids. *Food Bioscience*. 2015;12(1):10–17.