

Gut bacterial fermentation of food by-products

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Valorization

Societal relevance

Food waste can occur at different levels in the food supply chain, such as during harvesting, storage, processing, packaging and at the consumer's home (1). The term "food by-product" generally refers to edible parts of food that during the processing were discarded, lost, degraded or consumed by pests (1). They are the residual materials from food processing of vegetal (or animal) origin, such as peels, seeds and bagasses (2).

Although food processing technology has brought several positive aspects regarding for instance increasing shelf life of certain food products, the production of ultra-processed foods is linked with several negative effects at distinct levels:

- Food processing is responsible for about 39% of the total food waste generated around the globe (3);
- Production of highly processed foods generates great amounts of underused by-products that contribute to environmental pollution (4);
- Discarding of food by-products means misuse of natural resources like water and soil (5);
- The consumption of ultra-processed foods has negative effects to human health (6). The production of this type of foods includes the addition of artificial preservatives, bulky agents, artificial flavouring and colourings and the removal of important nutrients, such as fibres (7).
- Consumption of ultra-processed foods is contributing to a major global health problem: obesity (7).

At the same time that food industries discard these food by-products, it was estimated that in 2016, 815 million people suffered of undernutrition (8).

In general, fruit and vegetables by-products, such as peels and bagasses are sources of (amongst others) different dietary fibres, which are suitable for human consumption (9). Giving the circumstances mentioned above, their disposal is unacceptable, and reflects the paradox of the current way of living in our society. In summary, food processing generates huge amounts of food by-products. Their disposal in the environment is a source of pollution and at the same time, the wastage of food occurs hand in hand with starvation. Paradoxically, the production of ultra-processed foods is leading to a consumption of poor nutrient diets. Consumption of poor nutrient diets have consequences for health, which includes malnourishment, such as obesity (Figure 1), whereas the food-by products contain nutrients that are required for health, such as fibres and anti-oxidants.

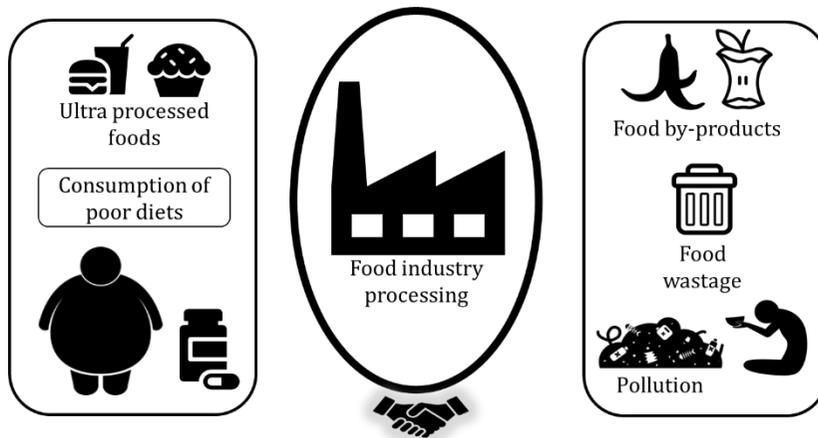


Figure 1: Food products undergo processing, by which the removal of food components generates by-products that are underused – discarded – causing environmental pollution. At the same time, there are people around the world suffering of starvation/undernutrition. The consumption of ultra-processed foods is detrimental to human health, leading to different health problems, including obesity. This is an unfortunate process filled with paradoxes.

There is a necessity to create solutions aiming at a conscious use/destination of food by-products, and scientific research in this field is one way to achieve such demand.

Thus, any attempt to tackle the problem of food by-product underuse is extremely important because it can constitute a beneficial solution that affects both societal health and the environment.

Our work focused on exploring the characteristics of selected Brazilian food by-products and their potential health benefits by investigating their *in vitro* effects on the gut microbiota. Food by-products are very diverse and thus have the potential to be used in several food segments. We have focused on Brazilian by-products generated from starch and flour production of cassava and juice production of oranges and passion fruit, and their beneficial aspect regarding the fibre content and modulation of the gut microbiota in lean and obese people.

The results showed here demonstrate the suitability of the tested by-products in being used as food for humans, and their possible effects related to gut health. Also, our results pave the path for further research on the incorporation of by-products into food products, or their use *per se*, perhaps as a functional food.

Importantly, consumers are becoming more aware about the consequences their food choices can have, not only regarding the individual aspect, such as health, but also considering the collective or societal effects. Sticking to a sustainable

diet is perhaps the most crucial step that a responsible consumer can do in their daily lives. This topic is discussed in the next section.

Sustainable diet and sustainable food system

A sustainable development (of food use) guarantees that the needs of the current generation are achieved without compromising the ability of future generations to achieve their own needs (10). In this context, it is acknowledged that both a healthy diet and a diet that leads to less food wastage reduce the negative impact on the environment, leading to the notion of sustainable diets (11). The term “sustainable diets” was defined by the Food and Agricultural Organization (FAO) as *“diets with low environmental impacts, which contribute to food and nutrition security and to healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimising natural and human resources”* (12).

“A sustainable food system is a food system that ensures food security and nutrition for all in such a way that the economic, social and environmental bases to generate food security and nutrition of future generations are not compromised” (11)

The results presented in this thesis contribute to two aspects regarding sustainability. The first relates to sustainable diets. Results shown here demonstrate the potential health benefits that the consumption of food by-products might bring, especially regarding gut health through the gut microbiota. The by-products tested are natural, rich in fibres and the product of food processing that would otherwise be discarded. Thus, as previously mentioned, the consumption of a healthy diet including these by-products reduces the detrimental impact on the environment. The composition of the diet chosen by consumers has the capacity to drive the demand of specific food products, or specific ways of manufacturing, which has a social, economic and environmental effect (11). In this regard, consumers have the power to push food companies to a sustainable manner of production. For that, information about sustainable diets is crucial.

The second aspect is associated with a sustainable food system. The use of food by-products contributes to a sustainable food system, decreasing the negative

impact that their disposal would have on the environment. Additionally, utilization of the food product as a whole is a responsible use of natural resources that were employed for plants cultivation, such as soil and water, as well as the human labour that was applied (11).

Target group - overweight and obese individuals

Obesity is characterized by abnormal or excessive body fat accumulation that might impair an individual's health. In adults, overweight is equivalent to body mass index (BMI) between 25-30 kg/m², while obesity is defined by a BMI higher than 30 kg/m² (13). Increased BMI is a risk factor for several diseases associated with obesity, such as diabetes, cardiovascular diseases and cancer (14).

Obesity has almost tripled since 1975 around the globe, and in 2016, almost 2 billion adults were overweight, while 650 million were obese (14). There are many factors that contribute to the onset of overweight and obesity, such as bad eating habits essentially due to increased intake of ultra-processed foods which are dense in energy and poor in nutrients (empty calories), and physical inactivity (13). However, it has been hypothesized that these factors cannot solely explain the pandemic of obesity. It has been suggested that a disturbed gut microbiota (dysbiosis) can have a role in obesity (15,16).

Modern life style is causing changes in the gut microbiota (Figure 2) and may explain not only the pandemic of obesity, but also the increased incidence in others diseases, such as asthma, inflammatory bowel disease, autism, food allergies and many others (17).

Although the role of the gut microbiota on host metabolism and obesity is not completely understood, a balanced diet, which includes the consumption of fibres and/or prebiotics, can have a positive effect on the gut microbiota, and consequently on health.

Our results have shown that the use of food by-products can lead to a healthier profile of the gut microbiota, especially the microbiota originating from obese individuals.

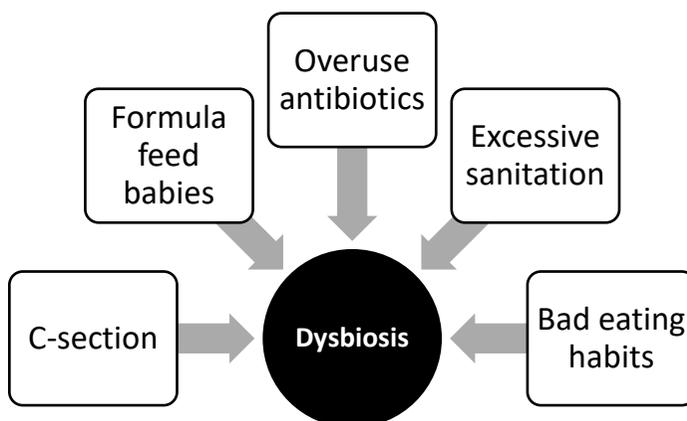


Figure 2: Modern life factors that are causing dysbiosis in the gut microbiota, with consequences to health. It is known that all the points cited have a detrimental consequence on the composition of the gut microbiota. And this starts very early in life, for instance by the way of delivery (C-section) and the excessive use of antibiotics, the use of infant formula to feed babies instead of breast feeding, excessive sanitation, and bad eating habits with lack of fibre consumption as one of the main consequences (17). These early impacts on the gut microbiota may lead to disease and disorder later in life, e.g. obesity (18).

Even though more studies are necessary, the results shown here are promising with regard to the use of a natural food-product that commonly are discarded, to tackle overweight and obesity.

References

1. Parfitt J, Barthel M, Macnaughton S. Food waste within food supply chains: quantification and potential for change to 2050. *Philos Trans R Soc London B Biol Sci.* 2010;365(1554):3065–81.
2. Helkar P, Sahoo A, Patil N. Review: food industry by-products used as a functional food ingredients. *Int J Waste Resour.* 2016;6(3):1–6.
3. Mirabella N, Castellani V, Sala S. Current options for the valorization of food manufacturing waste: a review. *J Clean Prod.* 2014;65(Supplement C):28–41.
4. Sharma SK, Bansal S, Mangal M, Dixit AK, Gupta RK, Mangal AK. Utilization of food processing by-products as dietary, functional, and novel fiber: a review. *Crit Rev Food Sci Nutr.* 2016 Jul 26;56(10):1647–61.
5. Spiker ML, Hiza HAB, Siddiqi SM, Neff RA. Wasted food, wasted nutrients: nutrient loss from wasted food in the United States and comparison to gaps in dietary intake. *J Acad Nutr Diet.* 2017 Jul;117(7):1031–1040.e22.
6. Juul F, Hemmingsson E. Trends in consumption of ultra-processed foods and obesity in Sweden between 1960 and 2010. *Public Health Nutr.* 2015 Dec;18(17):3096–107.
7. Louzada ML da C, Baraldi LG, Steele EM, Martins APB, Canella DS, Moubarac J-C, et al. Consumption of ultra-processed foods and obesity in Brazilian adolescents and adults. *Prev Med (Baltim).* 2015 Dec;81:9–15.
8. FAO, IFAD, UNICEF, WFP, WHO. The state of food security and nutrition in the world 2017. Building resilience for peace and food security. Rome; 2017.
9. Martins ZE, Pinho O, Ferreira I. Food industry by-products used as functional ingredients of bakery products. *Trends Food Sci Technol.* 2017;67:106–28.
10. Berry EM, Dernini S, Burlingame B, Meybeck A, Conforti P. Food security and sustainability: can one exist without the other? *Public Health Nutr.* 2015 Sep;18(13):2293–302.
11. Meybeck A, Gitz V. Sustainable diets within sustainable food systems. *Proc Nutr Soc.* 2017 Feb;76(1):1–11.
12. Burlingame B, Dernini S. Sustainable Diets and Biodiversity: Directions and Solutions for Policy, Research and Action. In: *Sustainable Diets and Biodiversity: Directions and Solutions for Policy, Research and Action International Scientific Symposium, Biodiversity and Sustainable Diets United Against Hunger*, FAO Headquarters, Rome, Italy, 3-5 November 2010. Food and Agriculture Organization of the United Nations (FAO); 2012.
13. Meldrum DR, Morris MA, Gambone JC. Obesity pandemic: causes, consequences, and solutions-but do we have the will? *Fertil Steril.* 2017 Apr;107(4):833–9.
14. WHO. Obesity and Overweight - Fact sheet n. 311. 2017.
15. Cox LM, Yamanishi S, Sohn J, Alekseyenko A V., Leung JM, Cho I, et al. Altering the intestinal microbiota during a critical developmental window

- has lasting metabolic consequences. *Cell*. 2014 Aug 14;158(4):705–21.
16. Ley RE, Turnbaugh PJ, Klein S, Gordon JI. Microbial ecology: human gut microbes associated with obesity. *Nature*. 2006 Dec;444(7122):1022–3.
 17. Blaser MJ. The theory of disappearing microbiota and the epidemics of chronic diseases. *Nat Rev Immunol*. 2017 Jul;17(8):461–3.
 18. Stanislowski MA, Dabelea D, Wagner BD, Iszatt N, Dahl C, Sontag MK, et al. Gut microbiota in the first 2 years of life and the association with body mass index at age 12 in a Norwegian birth cohort. *MBio*. 2018 Oct;9(5).