Uncovering the genetic basis for food preferences: the key to personalized nutrition plans?

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It is commonly agreed that nutrition is one of the most important factors influencing human health. In particular, long-term exposure to unhealthy food behaviors may lead to the insurgence of several disorders such as obesity, diabetes and cardiovascular disease. Many studies have shown that even small changes in diet can be extremely helpful not only to prevent but also to improve the outcomes of many common disorders [1]. Thus, there has been a great investment of resources in campaigns aimed at educating people to adopt healthier eating patterns. However, despite these great efforts, results have been weak and obesity or other diet-related diseases are still increasing worldwide [2]. One of the main problems with healthy dietary plans is that their creation has been mostly linked to a medical consideration, neglecting the intrinsic pleasure linked to food. Many studies, however, show that food choices involve the activation of pathways and brain areas linked to pleasure such as the dopaminergic system and the hypothalamus [3]. These studies suggest that if we want to help people change their food choices there is an urgent need to change our approach, taking pleasure into consideration much more than before.

We must consider that our brain responds to different tastes in different ways; if we eat something sweet or umami (the taste of proteins) our brain will translate this into pleasure, while if we eat something bitter, the basic response will be avoidance [4]. This has a distinct evolutionary meaning, since in nature bitterness is linked to toxicity while sweetness and umami are linked to energy. This has been extremely advantageous throughout our history since food was often scarce. In modern times, however, even

in countries where food availability is not an issue anymore, we are still driven to eat as if it were and we still find high-calorie foods pleasurable.

In light of this, it is very important to increase our understanding of the physiological mechanisms that drive food choice and thus its consumption.

Our food choices are shaped by different factors such as culture, learning and age, and evidences indicate that our genes can also determine our preferences for foods [5]. Studies on the impact of genetics in food preferences have shown that the heritability of food preferences vary greatly, ranging between 20% for desserts to 70% for food proteins, while fruit and vegetables show a moderate genetic component (51 and 37%, respectively) [6]. Other studies have shown that variation in some taste receptors may affect the intensity of perceived flavors, such as bitter and sweet [7]. We have also previously demonstrated that these variations may extend from basic taste perception to common food preferences, although not always in expected ways [8]. For example, in a Central Asian population, we have found that variations of the sweet receptor gene *TAS1R2* determine differences in the enjoyment of alcoholic beverages, in particular vodka and white wine [9].

Genetics can therefore have an important impact in helping nutritionists personalize diets beyond what people actually know about their personal food preferences. In many cases, in fact, people can distinguish what they like from what they do not like but they have difficulties understanding why exactly this is.

In a recent study we have shown that a functional variant of one of the bitter recep-

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tor genes (*TAS2R43*) contributes to differences in the enjoyment of coffee: people who perceive stronger bitterness, like coffee more [8]. Although this would seem to contradict the usual paradigm that stronger bitterness results in lower enjoyment, in this specific case further analyses showed that it was caused by differences in caffeine bitterness perception. In other words, people with higher caffeine bitterness perception also liked coffee more in general. This result could not have been as easily inferred by any other method, since people could not express their enjoyment of coffee as linked to their perception of caffeine. In this case, genetics was a vital tool in identifying the role of a specific compound in the preference of a common food such as coffee.

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By extending this approach to other foods, we should be able to understand which compounds make healthy foods unacceptable to some people, thus possibly understanding what changes in their composition or their preparations are necessary to make them more tolerable.

In another study presented at the European Journal of Human Genetics meeting in Milan this year, we identified a variant in the *BNTPI* gene that contributes to differences in preferences for oil or butter on bread [10]. Our preliminary data suggest that the same variation of this gene also predisposes people to differences in total calories, fat and starch intake. Knowing its function will help us to understand why people with this variant have a tendency to eat more and how to tailor a dietary plan closer to each person's particular needs and tastes, thus increasing its effectiveness. Possibly, this could be done by changing the way food is prepared, or by designing specific functional foods according to an individual's genotype. This is already the case for people who cannot eat certain compounds due to specific conditions such as celiac disease or diabetes. However, we should also consider people who cannot eat certain compounds because they find its taste unbearable. We should remember that food preferences are the first factors that drive food choice, and that they have been suggested to be better predictors of health outcomes as compared with common food frequency questionnaires [11].

People develop food preferences early in life [12] and understanding their genetics will help to identify children in need of personalized educational interventions aimed at helping them making healthier food choices.

Another important result expected from this research is that the understanding the biological mechanisms driving taste perception will allow us to find healthy substitutes to not-so-healthy compounds. A clear example of this is salt. Many studies suggest that added salt in food is partly responsible for the increased incidence of hypertension, which affect younger and younger people each year. In a recent study, we have identified a gene that contributes to differences in salt intensity perception and preference [13]. If we consider that so far the taste receptor for salt is still missing, this knowledge, once confirmed, could help to design a salt substitute without the negative health implications on blood pressure. This would translate into an increase in health for all people, and in a huge economic saving for public healthcare systems.

Additionally, identified variants would be extremely helpful in uncovering causal relations between nutrition and health outcomes. Recently, in fact, there has been a lot of attention surrounding a type of study called Mendelian randomization that can suggest, if not prove, the causality between a trait of interest and a health outcome. This approach is based on the use of genetic markers that have a known effect on the studied trait, but not directly on the health outcome. Such markers can then be used to verify the effect of the trait on the health outcome using retrospective data [14]. The genotypes are treated as markers of long-term exposure without the need of actually assessing the trait of interest. If we consider the case of food preferences, given that they can predict food consumption, it may be possible to use garnered genetic knowledge to evaluate the impact of specific foods or food groups on health-related traits.

In conclusion, studies of the genetics of food preferences could have an incredible impact on our understanding of the relationship between nutrition and health status. Helping not only in understanding the mechanisms that regulate food choices and consumption, but also in designing specific actions to improve the quality of peoples' nutrition and more in general health.

Financial & competing interests disclosure

The authors have no relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript. This includes employment, consultancies, honoraria, stock ownership or options, expert testimony, grants or patents received or pending, or royalties.

No writing assistance was utilized in the production of this manuscript.

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