Consumers and Food Choice: Quality, Nutrition and Genes

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Abstract

The quantity and quality of food needed for reproduction differs from nutritional needs for health and longevity. The choice of food type and amount is driven by our genetic need for growth and reproduction, not for long term health. So, fast digestible food, rich in energy is searched for. We humans share that drive with almost all animals. The energy carrying nutrients in processed food are more accessible than in the same unprocessed food. That leads to an ever increasing level of processing, and an ever decreasing consumption of raw fruits/vegetables and home cooked meals. In the past, with alternating conditions of food shortage and food abundance, overeating in times of prosperity was a reproductive advantage. However, high energy food becomes a severe nuisance in the age of permanent food abundance. Obesity and heart diseases spread through the developed world. That behaviour is rooted in our genetic instincts. Cultural based sensorial preferences, induced mostly in childhood by an epigenetic mechanism, present a variation around the instinctive rooted preferences. Food choice based on reflective decisions appears of minor importance. Nevertheless, all government campaigns against over-eating appeal to reason, not to instinct. We are faced with a permanent dichotomy between what is good for reproduction and what is good for health. This occurs not only in what and how we eat, but also in all neighbouring areas on the edges of food science, biology, social science, medicine and ethics.

INTRODUCTION

Why do people eat what they eat? What is the relationship between food choice, health, nutrition and genes? Production of our food is mainly targeted at producing mass, harvest time is chosen based upon produce properties that are good for transportation and distribution. Retail outlets are considering product quality and health promoting compounds in our food to convince customers to buy the product again. And finally customers search for tasty food, to suite their budget and their preferences with respect to quality and health. Throughout the food supply chain, health, quality and nutrition are present in one way or another. All players within that supply chain have to deal with these issues to stay competitive, to stay commercially viable and to survive. So, for all players in the chain, from breeding, production, harvest, distribution, retail through to consumption, the question "*Why do people eat what they eat?*" seems rather important. Genetics and genomics are gaining more and more importance. A complete section in this conference is devoted to that. But that only concerns the effects of genes and genomics on the behaviour and properties of products. What about the human consumers of these products? Are they affected by their genes in their daily pattern of eating behaviour?

Over years of evolution, we humans largely share our genetic information with the animals around us. There is strong evidence from decades of study on animal and human feeding behaviour, that the urge to consume energy rich food is driven by the urge to proliferate the genes (survive as a species): reproduction of genes is more important than the health of the individual body. And reproduction of genes is an energy consuming process. It is amazing how much young people eat every day. Energy is the basic driver

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of eating. Processed food delivers about 50% more energy than the same unprocessed raw food, and in a shorter time. Pleasure in eating is the reward evolution has provided to trick individuals to eat more than necessary to maintain the body in good health. It is good for the genes: the human species occupies all corners of our planet.

In our world of permanent food abundance, however, that turns out to be quite hazardous for individuals. Obesity and diseases such as diabetes and coronary diseases, are the logical consequences of the instinctive drive for more and more energetic food. That forces us to rethink the strategies required to combat obesity and over-consumption. Also the consequences for quality perception and food acceptance have to be reconsidered in terms of instinctive food choice and reflective food choice. On a conscious level, we know eating too much food, and too much high energy food, is bad for our health, but the instinctive drive for that food simply results in faster and/or stronger action than reflection. We have already eaten, despite (even before maybe) realising the possible consequences. Joy in eating is immediate, pain from wrong eating takes time to show up. Here the genetically induced drivers of eating will be reviewed, together with the consequences for food choice, acceptance, quality perception and the fight against obesity and food related diseases.

This paper explores an area on the edges of food science, biology, social science, medicine and ethics. Details on the effects of genes on nutritional behaviour in this vast area can be found in Ostan et al. (2009, 2010). Both papers include extensive literature overviews to back-up this viewpoint.

WHY DO WE EAT?

All living creatures have to maintain their body health, their locomotion apparatus, and their reproductive apparatus. That is what we do with our food. Instinctive patterns of behaviour are rooted in the nature of organisms, just like physiological organs (Lorenz, 1937; Tinbergen, 1963). Nature takes care of all needs of individuals, food for maintenance, for well being and for health all alike. This viewpoint is called inclusive fitness (Hamilton, 1964a, b).

Dawkins questioned this statement in The Selfish Gene (1976), partly based on the (at that time) very new technology of DNA based information. Life was defined as reproduction of molecules i.e., molecules able to autocatalyse the production of new molecules of the same type (Alberts et al., 1994). That is the main purpose of the existence of life: to duplicate molecules. The central molecule of this type is DNA (and its evolutionary precursor RNA). Reactions between molecules in cells, whether DNA or others, obey the same chemical rules as those of the other material world (Watson and Berry, 2003). In organisms that multiply in a sexual way the genetic information carriers are called genes.

Duplicating complex and quite stable molecules like DNA requires a lot of energy. Having sex is exhausting! Raising kids even more! Growing requires a lot of energy. It is amazing how much young kids can eat in a day! So, nature has provided us with the urge of eating high energy food, and eat it as quickly as possible, to improve the chance of reproduction. And nature has provided us with the pleasure of having sex, and the pleasure of eating. The feeling (afterwards) is called satiety. Yes, we can get satisfaction.

WHAT DO WE EAT?

Since gene reproduction (and cell duplication during growth), is such a high-energy process, all animals search for the highest energy density in food. A long time ago, man found out that in processed food the nutrients are much more accessible. Cooked food has about 50% more energy content than the same food unprocessed (Wrangham et al., 1999) releasing sugars faster in the blood than other forms of food (Holford, 2004; Semolič et al., 2006). At first, processing was limited to heating food (stone-age barbeque), later on with the arrival of the industrial revolution, other forms of food processing such as mincing, cutting and fermentation become available on a large scale. The development of agriculture, instead of gathering and hunting, merely helped to

acquire as much food as possible. The modern development of ever more industrial food processing and ever less cooking at home is a mere developmental stage in that forever ongoing search of more energy rich food, easily digestible with the least of effort in the shortest time.

On top of this genetically (instinctive) and generic (for all humans and animals alike) feeding behaviour, man has the ability to fine tune his menu. Part of that is imposed in our liking mostly at the very early childhood. We like to eat more or less what our parents ate. This induced feeding preference is in a way also mediated by our genes: we share the genes the most with our parents and get their eating habits through the so-called epigenetic mechanism! By this mechanism, the structure of genes does not change, but the state of activation does. This mechanism uses different substances to silence or to activate genes by adding or removing certain groups in complex molecules (Meaney and Szyf, 2005). The best known is a methyl group attached to the DNA structure (cystine unit), which ensures a long lasting preference for certain food types. The epigenetic information can even be passed on genetically to offspring (Frances et al., 1999). This constitutes the culture differences in eating patterns encountered all over the world. In every culture there are highly appreciated food items that are utterly rejected by people from other cultures. These preferences are emotionally based and difficult to change once we get them in our childhood.

The last part of our food preferences is based on reflection: what is good and healthy for my body, without the sexual drive for proliferation and dissemination. Too much high energy food will induce all kinds of diseases and disorders, including heart disease, obesity and diabetes.

The main tendency of the body (phenotype), on the other hand, is to remain functional for as long as possible. According to Dawkins, without taking the effects of genes into account, an organism would take good care of its own health and longevity (a life as long as possible) (Dawkins, 1976). Although the tendency for longevity is also genetically based, for genes it is enough to delay the death of the body for as long as is needed for multiplication (Dawkins, 1976). Therefore, a relatively good health and relative longevity of the body are sufficient for the genes. We have to take care of our food choice for health and longevity based on conscious decisions, more or less against the genetic urge of high energy food.

WHEN DO WE EAT?

During the eons of evolution, many species, animal and human alike, have developed the tendency to eat more in times of food abundance than strictly necessary for maintenance. In that way, individuals could build up food reserves (fat) for times of food shortage. That strategy helped many species to survive in harsh environments. Contrary to many of the great apes, humans adopted that strategy too. That helped our ancestors to move from the rain forest into the savannah, where the food was far less abundant. In these modern times of permanent food abundance in the Western World ("obesigenic environment", Ravussin and Bouchard, 2000) that drive leads, however, inevitably to food related disorders.

On a shorter time scale, we eat when we feel hungry, and stop eating when satiety arrives. So, the generic drive for food, preferably high in energy, is modulated by the biological need or situation of the moment. Satiety, however, also depends strongly on the energy content of the food (van Dijk and Boer, pers. commun.) and the speed of eating. So, even the inhibition of the process of eating (satiety) is related to the energy content of the eaten food.

Also shared with almost all animals is the preference for food stimulants. Apes feast on fermented fruit. Cows can get drunk of apples fermenting in their stomachs. Pigs feast on litter from breweries. And they like it! Liking food stimulants is another trick of the genes to lure us into reproduction. Food stimulants induce a rapid release of energy stored in the body (Holford, 2004), mimicking a similar feeling as feeding. We can take on the world after some good food stimulants like coffee, or alcohol. Also more severe

drugs have quite a similar effect, which is one of the reasons for being liked.

HOW DO WE LIVE? VARIATION IS THE KEY?

Life in its basic definition reduces to multiplication of molecules (DNA). Over millions of years of evolution, nature has found a way (several for that matter) to increase the chance of doing just that: reproduce molecules. But life is also a lottery: you only get once a set of genes, never to be altered. For nature, the power of large numbers completely outweighs the failures that inevitably occur. Elimination of failures is the fundamental process by which evolution works. It is not the individual that is the target of nature, rather it is the vast amount of different copies of DNA. Again, the individual is not important but the genes are. We are just the random carrier of yet another attempt by evolution to adapt to the ever changing environment in which the genes have to act. When we cannot cope with the effects of changes in our environment (e.g., climate change) we will just be eradicated, and live goes on! With another set of genes.

We could consider these generic drivers, common for all people and many animal species, as the mean value of a property that is modulated over a certain variation among individual sets of genes. In Figure 1 this situation is graphically represented. It depicts the effects of the generic drive for high energy food on bodyweight, modulated with a standard deviation over the large number of individuals, all having their own drive strength enforced upon them by their individual gene pattern, their individual cultural based sensorial preferences and their individual nutritional believes.

HOW LONG DO WE LIVE?

From the information provided above, one can easily deduce that the majority of our food is consumed with an inborn urge for speedy consumption of high-energy food. Over thousands of years of evolution, that increased the chance of reproduction. Undernourishment has been shown to delay the onset of puberty (Olshansky and Carnes, 2001), and to cause a "negative psychological and behavioural sequel" (Polivy, 2008). On the other hand, based on numerous studies on animals, it is clear that a limited consumption of food (caloric restriction without undernourishment) will benefit health and longevity. So-called "intermittent fasting" (24 h without food, 24 h food ad libitum) had a similar to effect on longevity in mice as classical caloric restriction (Anson et al., 2003), increasing their lifespan about 60%. This effect on humans needs to be confirmed in studies of long duration, but short term studies seem to indicate an increase in health, well-being and life span or longevity. Some information exists from cultures living at high altitudes (>1700 m, low O_2, low T), like the Hunza in the Himalaya, the Abhaziani in the Caucasus, Vilcabamba and the Bilcabamba in the Andes, mostly very poor, with simple diets with low caloric intake, rich in raw fresh fruit and vegetables, wheat and barley, low in fats and low in animal product content. The elderly in these societies (believed to be well over 100 years old, with very limited, if any medical facilities) live long, still work on the field, are respected and honoured (reduced psycho-stress) and maintain a high level of activity throughout their lifespan (Klatz, 1996).

DO WE ENJOY LIFE?

To ensure a constant intake of high-energy food, necessary to have at least a chance to produce offspring, evolution has provided animals and humans with a pleasure in doing what is necessary for reproduction. Normally, we all enjoy eating, we hate hunger and thirst, when the food is on the table we want to start right away. Sex is marvellous. Food stimulants are marvellous (good wine in good company). Pleasure in food and sex is the reward nature has provided us with to ensure reproduction of the genes (Fanelli and Lauro, 2006). But all these things are known to be not so beneficial for health and longevity. Health is maintained by the genetic system just to a level necessary to ensure a chance of reproduction. After the reproductive phase, life just goes on as it was. We only need less energy intake. The urge to eat and the pleasure in eating, however, still remains. It is simply too expensive for nature to change the system. And to

what end? The reproduction phase is over! Nature did not provide us with pleasure of eating healthy! That is for our reflective mind to decide.

OVERVIEW OF THE SITUATION

So, we end up with a very ambiguous situation. What is good for reproduction is not really beneficial for our health although it is beneficial for our well-feeling. What is good for the reproduction (survival and proliferation of the species as a whole), is often not so good for the individual person. That is reflected in a dichotomy within ourselves: what we do is very often not what we would like to have done upon reflection. That can be heard in many proverbs in all societies like: "*remorse comes after the sin*", and "*the mind is strong but the flesh is week*". We keep bumping our nose against that dichotomy, not only in food choice but also in all aspects of ethics as the dichotomy of good for all (others), or good for the individual.

The drive for food is acting on three different levels simultaneously:

1. The genetic drive for fast and high energy food acts on an instinctive level (sexual drive).
2. The epigenetic drive determines largely our individual preferences. It acts on an intermediate level, but close to instinctive (cultural drive).
3. The drive for well-feeling and pleasure is a direct consequence of the first two drives (social drive).
4. The drive for health and longevity is emotional (instinctive and epigenetic) but less powerful and slower than the instinctive drive for reproduction favourable food. It has to be enforced by will power, more or less against the dominant (reproductive) instinctive drives (medical drive).

Reflection processes (we have to think about it) take more time than instinctive processes. Moreover, we have already eaten, in spite of (even maybe before) realising the possible consequences. Joy in eating is immediate, pain from wrong eating takes time to show up.

In our search for high energy and easy to digest foods, the intensity of processing and the amount of processed products has steadily increased from the stone-age barbeque over fermentation to the sophisticated contemporary techniques. The ultimate "successes" of this development are food supplements and functional foods, which provide (at least claim to provide) instant health in small bottles and pills. Not always for the best health, as can be taken from the recent article that indicates that prolonged high doses of anti-oxidants (food supplements) actually promote cancer (Schafer et al., 2009).

So, we are stuck with a permanent dichotomy in our feeding behaviour going back and forth between beneficiary for reproduction and growth on the one hand and health and longevity on the other. It is the same dichotomy as found in "good for all" and "good for the individual".

All these generic drives and reasons for feeding patterns (for all humans and animals), are of course modulated to the liking and genetic building of individual consumers. We are not all the same! Some people are more sensitive to these drivers, and/or to the consequences of them (see Fig. 1). That is very frequently genetically determined also.

CONSEQUENCES

For Food Processors

Food processing keeps growing to be more important than home made food. McDonalds are all over the world. Fast food can be found on every street corner. Some resistance exists as "slow food" actions, but these are outnumbered severely. Nevertheless, the health of individuals may be endangered, both by the mere properties of processed food (high and easily available energy and nutrients, overeating) and the ever present danger of processing errors and fraud (as we can take from the recent milk scandals in China, and some years ago the dioxin crisis in Belgium). Processing

companies are also faced with that same dichotomy as individuals: what is good for all (good manufacturing practice) and what is good for the company (profits)? Moreover there is a definite effect of the use of processed food on social structure and behaviour. The large contingent of out-of-house-working females has been made possible by the availability of processed foods, increasing thereby the production of even more processed food products. Convenience foods come at the cost of social behaviour. Family life seems to be disintegrating by lack of shared meal sessions (just grab something out of the frig). At the same time, the food processing industry plays at the conscience of consumers by offering "lite" products, to counterbalance (in principle) too much and too easily acquired energy.

This development will most probably continue towards a real food intake in form of tablets and concentrated drinks. The drive for fast easy food with high energy content, originating from our genetic heritage, will make that feasible. Somehow the food processing industry has to take responsibility for the health of individuals, each in their own state of development, each with its own needs and drawbacks. Personalising diets will become the corner stone of future feeding patterns and research on nutrition and medicine.

For the Supply Chain

A similar situation exists for the fresh fruit and vegetable supply chain. Coupled to the ever increasing processing level, the amount of fresh product offered directly to consumers will probably decrease steadily, as has been happening already for quite some time. Traditional fruits and vegetables are increasingly replaced by exotic products from the other end of the world, just to please the consumers with new fresh products without any (at least not too much) consideration for local employment or global energy consumption. Soy bean production is quite a good example of this dichotomy: it delivers high energy food, at a reasonable price all over the world. But it is quite detrimental for the local farmers both in the buying (developed) countries as in the producing countries.

More and more the supply chain will adapt to the demands of the processing industry and the large supermarkets. This spiral development is more or less a self fulfilling prophecy: with less consumers buying fresh produce, less of these will be offered on the market.

For Quality and Product Acceptance

In the viewpoint on quality and product acceptance, as described by Sloof et al. (1996), only reflective aspects were included. That means that consumers were thought to decide upon purchase or eating (acceptance) solely on knowledge of product properties, the economic market situation and the socio-psychological circumstances of the consumer. The possibility of instinctive decisions was completely ignored. Based on the information of current studies, this viewpoint has to be adapted to include the generic and instinctive drive as described above. How this will be implemented is yet not known. Most probably the speed of decision making will have to play a crucial role in the adapted viewpoint on quality and acceptance.

For Governmental Campaigns against Obesity

For quite some years now, the problem of overweight and obesity has steadily increased in the Western world. Even half of our pets (dogs and cats) are overweight (Vidic, 2008)! We live in the age of permanent food abundance, at the highest level of energy content. We feed that to ourselves and to our pets. Several governmental campaigns are in operation to tackle this problem. As far as we know these campaigns are based on educating the consumer making them conscious of the consequences of eating patterns. For decades, food labelling on packed products (of course processed), has been a legal requirement. It provides individual consumers with information on content, compounds and energy present. It is up to the individual consumer to decide. More specific campaigns are now running to specifically fight obesity, mainly by making

people aware of the benefits of physical exercise, and by warning against junk food. Especially at schools, this is of utmost importance since the epigenetic mechanism also works here: what we learn in childhood is very hard to change later. But all these efforts are appealing to the reflective capacities of individuals. They consequently neglect (probably by not realising) the generic drive for that kind of (unhealthy) behaviour (Wanchek, 2007).

For Food Science

What the "solutions" are for this problem, we do not know. But from the information provided in this paper, it should be clear that the generic and genetic drives should be taken into account much more.

Food research should take the dichotomy between good for health/longevity and good for reproduction into account. Defining which target a study aims at seems therefore to be crucial. Each of these targets seems to result in different solutions.

What has also to be taken into account in the search for solutions to this nutritional problem is that food preferences and nutritional satisfaction are dominant driver in the choice of consumers. Some consumers regulate their nutrition mostly on reflection, but they seem to be in greatly outnumbered. At the end of the 1980s a large survey in the USA revealed that less than 3% of the population followed a diet that conformed to official nutritional guidelines (Milton, 1998). Despite most people being aware of the risks of overweight, the problem has been growing steadily. The problem of obesity has become a "global epidemic" (WHO, 1997).

The solutions now proposed by nutritional science and the strategies chosen by governments and food suppliers do not reflect the behaviour of the majority of the population. They act more on sensations than on rationality. So, the task for nutritional science seems to be to find diets that give not less enjoyment than present unhealthy diets. To say it simply: let's find enjoyable healthy food for our pets. They don't think at all, and are a far easier study subject than humans. If it works for them, it will probably work for humans as well.

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Figures

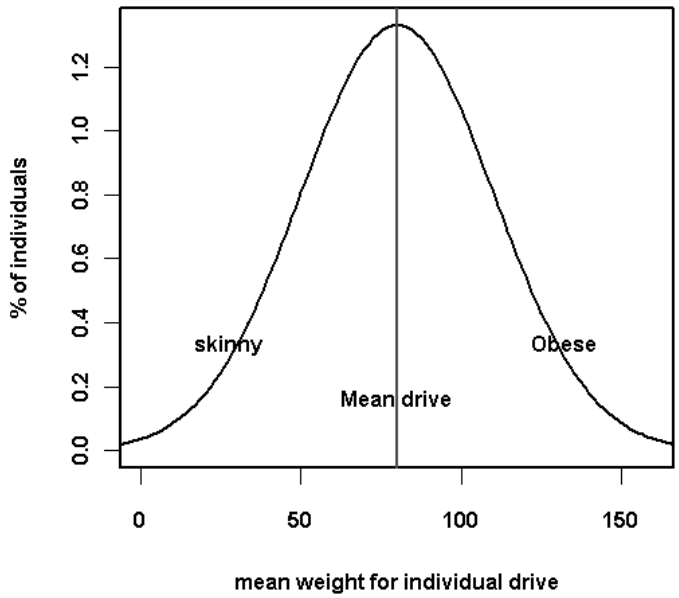

Fig. 1. Distribution of weight (mean 80 kg, standard deviation 30 kg) with variation in drive for high energy food. The parameters are completely arbitrary.