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COMMENTARY

Nanotechnology in Elevation of the Worldwide Impact of Obesity and Obesity-Related Diseases: Potential Roles in Human Health and Disease

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Abstract

Current worldwide data show epidemics of obesity and type 2 diabetes with no real solutions apart from continuous calls to changing lifestyle and food habits. Despite health messages that are communicated by health authorities, the epidemic is growing. More people are affected with health consequences that are usually frightening as more resources are wasted, especially in areas where health care and resources are lacking.

Nanotechnology applications in food industry present practical approaches that help produce more tasty food with little calories, functional foods, and nutritional supplements and alter the fats and sugar contents of our foods with potential for many more applications. Consequently, this opens more windows to better control of many nutritional deficiencies as well as obesity and type 2 diabetes, especially among children and young adults who are addicted to fast food. With such potential, food producers, policy makers, health authorities, food scientists, and governments need to collaborate and make all possible efforts to fund and support research in different areas of food produced using nanotechnology.

So far, consumers are not prepared to accept food produced using nanotechnology, mainly because information on the safety of such products are not enough. This issue needs to be addressed and researched well using suitable risk assessment methodologies. Consumers need to be assured, and involved as well, to avoid the "refusal state" that still exists against many safe products such as genetically modified organisms and irradiated food. There is the possibility that consumers could perceive that they will bear the potential risks posed by nanotechnology applications while the benefits will accrue mainly to others, such as food processors or farmers.

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Biological and nonbiological structures of 100 μm and less have been shown to have unique and novel functional characteristics that were not known before for the same materials at the normal scale. These characteristics are reflected as enhanced functionality whenever nanomaterials are produced. The enhanced functionality of the nonmaterial is the key parameter that can be utilized in production of food as well as different food-related materials.

Food produced using nanotechnology, including nano-delivery systems for nutrients and supplements, with

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enhanced functional characteristics is an excellent candidate for addressing different health- and disease-related issues.[1,2] Nanotechnology-based food, e.g., canola active oil,[3] health food products, and food packaging materials are already available to consumers in some countries, and it is expected that nanotechnology-derived food products will be increasingly available to consumers worldwide.[2]

Obesity and diabetes have been described in the literature as epidemic. It has a huge impact on the life of the affected individual and communities, especially among communities where resources are limited. With no real reduction of the epidemic, global efforts are needed to closely explore the potentials of nanotechnology in controlling obesity and diabetes.

This commentary article represents the opinion of a public health specialist on food produced using nanotechnology and on the results of efforts to reduce the global burden of obesity and diabetes.

Obesity and Diabetes Worldwide

World Health Organization data that relate to obesity and obesity-related diseases, reflected as body mass index (BMI), is horrifying. The categories for BMI and their corresponding values in parentheses are: underweight (<18.5); normal weight (18.5–24.9); and obese (>30).

Table 1 shows the average BMI of population of some countries as illustrated on the home page of the World Health Organization's website.

The figures illustrated in this table are examples of the spread of obesity worldwide. Obesity is a major factor for diabetes, which jeopardizes human health and wellbeing. The consequences of obesity include an endless list of diseases that drive people to drug dependency, loss of resources, and situations that progress and worsen every day. In some countries listed in **Table 1**, the number of obese people account for more than one third of the country's population, and the numbers keep growing. Every few years, more countries report an epidemic of obesity. This situation requires urgent plans and strategies. The calls for changing the lifestyle of populations bring little change, especially among children and young adults. The Diabetes Federation estimates that the number of obese individuals will increase to 333 million by 2025. With no action to defuse this increase, it is estimated that total direct health care expenditure on diabetes worldwide will be between 213 and 396 billion international dollars in 2025. This would mean that the proportion of the world's health care budget spent on diabetes care in 2025 will be between 7% and 13%.[4]

Table 1.
Average Body Mass Index of the Populations of Some Countries as Illustrated at the World Health Organization Home Page

Country	BMI (kg/ht m^2)
USA	33.90
United Arab Emirates	33.74
UK and North Ireland	22.7
Kingdom of Saudi Arabia	35.6
American Samoa	74.6
Bahrain	28.86
Canada	23.1
Egypt	30.3
Greece	22.5
Kuwait	28.75
Mexico	23.60
Malta	20.70
Panama	34.74

Food Production Technology: The Absent Roles in Reduction of Obesity and Diabetes

Food production and the current technology used aim for high profit, which is partially attained through cutting costs and introducing marketing techniques that attract consumers. Unfortunately, the tastes that attract consumers best are still embedded in fats and sugars. Most food companies and producers use these particular food characteristics to enhance the sale. With very little exception, most fast foods are full of calories. It slowly transfers fats from food to human bodies. Food additives are used in food to boost the taste, modify color, increasing volume, make it crunchy, and increase shelf life. With the exception of sweeteners, nothing has really emerged to cut down the calories of the food sold today in most food premises and food courts worldwide. It is amazing how people are getting fat wherever you travel, except in areas where food is scarce. Technologies used in the food industry are not diligently addressing the issue of the huge amounts of calories in the food we consume. The consequence is seen everywhere, despite the heath awareness messages and campaigns that call for healthy food and healthy lifestyle. A new factor needs to be added to these health

messages: consumption of low-calorie foods with more nutrients. As seen through nanotechnology, the production of this type of food is possible, examples include low-fat nanostructured mayonnaise, spreads, and ice creams that claim to be as "creamy" as their full-fat alternatives and, hence, offer a healthier option to the consumer.[5] That means it offers "healthy" food options that can be used to cut down the food calories while providing more nourishing food. This agrees with what has been stated by Kampers that "understandings of processes at the micro- and nano level allow us to re-engineer processes in food industry and to create new products that taste and feel the same."[6]

Possible Roles of Nanotechnology in Reduction of Obesity and Diabetes

The emergence of nanotechnology with possible applications and very high potential in the food industry is the first real approach that needs to be studied from different dimensions to solve the growing epidemic of obesity and type 2 diabetes. Public health strategies aimed at prevention of weight gain and obesity will probably be more cost-effective than treatment of consequences such as diabetes. Food produced using nanotechnology can be used as a powerful public health tool for the provision of low-calorie foods, thus playing major roles in controlling obesity and diabetes.

Beside the reduction of calories in food, another nano-approach for fighting obesity has been suggested by Kim at the International Nanofood Research Society in Seoul, South Korea.[7] The summary of this approach is to make people feel full before they overeat by delaying the emulsion's breakdown until it reaches the ileum, where it triggers the "ileal brake," the mechanism that makes a people feel full. The field of nanobiosensors could also have a profound impact on obesity and energy balance issues. Such sensors often use nanomanipulation of surface properties to make their active elements sensitive to the presence of specific molecules or cells. Understanding and manipulating the interface between living matter such as cells or biomolecules such as proteins and enzymes and the nonliving matter of sensor receptors could lead to development of *in situ* sensors for monitoring markers that establish nutritive or metabolic state. Sensors of this type could also be used at the organ level to provide *in vivo* monitoring and perhaps even neural stimulation in some controlled feedback loops in obesity applications.[8]

Our knowledge so far with food produced using nanotechnology provides information that the major characteristics of any food product are enhanced. Products go more functional on their main surface characteristics. Sweeteners go sweeter, creams go creamier, and pesticides go more efficient in their toxicity against the targeted population and of course with far less dose. The functional brick units and composition of such characteristics can be selected and enhanced through the nanotechnology as well as other scientific methods available today. The final product will be chemically and functionally defined. Enhancement of major characteristics means that the amount needed to cause a specific effect is much reduced. To the extreme, a barrel of soft drink can be sweetened with one spoonful of sugar, or a double strength delicious ice cream milk shake will have no calories but still have the traditional taste and flavor.

Food Nanoparticles: Is It Really New? Is It Really Risky?

Food at the nano scale is not new to the human body. Food and nonfood nanoparticles enter our bodies through different ports:[9] nose, eyes, mouth, and skin. Foods, once broken down and digested, are absorbed at different levels of the alimentary canal at molecular scale size and, of course, enter the different cells at submolecular and nano sizes. It has been noted that there is a clear difference between naturally occurring nanoparticles and those that are man-made. Naturally occurring nanoparticles are short-lived and show a strong tendency for agglomeration, i.e., forming larger particles—changing from nanoparticles to microparticles—and acquiring different properties.[10] However, in the normal dynamic cellular and tissue fluids, the agglomeration process just described is not always attained. That means nanoparticles, whether natural or artificial, continue within the body or are excreted with urine or sweat or even removed by the macrophages, or used as biological materials needed by the different organs for different normal body processes and functions. It is clear that more research is needed to know the exact processes and behavior of different food particles (whatever their size is) once inside the different cells.

Nanotechnology-based food and health food products and food packaging materials are already available to consumers in some countries, and additional products and applications are currently in the research and development stage. That is also the case for food contact surfaces, packaging materials,[2] cosmetics, pharmaceuticals, and refrigerators utilizing silver nanoparticles to enhance food-keeping qualities. Silver has antibacterial properties[11]

and, in the nanometer size range, is a potent antibacterial agent. There are no reports of toxicity or adverse reactions related to these products.

Regarding acceptance of food produced using nanotechnology, the results of a mail survey in Switzerland to examine lay people's (N = 337) perceptions of 19 nanotechnology applications showed that the importance of naturalness in food products and trust were significant factors influencing the perceived risk and the perceived benefit of nanotechnology foods and nanotechnology food packaging.[12] Consumers need to be assured, and involved as well, to avoid the "refusal state" that still exists against many safe products such as genetically modified organisms and irradiated food. There is the possibility that consumers could perceive that they will bear the potential risks posed by nanotechnology applications while the benefits will accrue mainly to others, such as food processors or farmers.[13]

The list of current and projected nanotechnology applications in the food and agriculture sector[2] are indicators of how far this technology can go. But still, the assessment of risk has to continue in such ways to address the valid issues. To do that, there is a clear need to develop methods or models for measuring the shelf life and fate of the different nanoparticles (whether natural or man-made) within tissues and cells. Such studies need to be encouraged and funded by different mega food groups, industries, and governments as well. Examples of expected outcomes of these studies are: better life quality for consumers, safe and better food taste, less medical expenditures regarding diet-related diseases, more profit for the industry, more efficient functional foods, effective drugs with far less doses, and more healthy communities.

Conclusion

Regarding obesity and diabetes—and with the tempting tastes of fat and sugar—especially among children, adolescents, and young adults, nanotechnology can play major roles in producing food items with reduced calories in fats and sugars. Examples of such products are already available, such as ice cream and chocolates.

Global data show an increase in obesity and the diabetes epidemic[14–18] despite the efforts and practices currently in place. This fact should encourage more scientists, public health specialists, medical personnel, researchers, as well as consumers to closely explore the potential of nanotechnology produced food in control of obesity and diabetes.

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