THE ETHICAL IMPLICATION OF NANOTECHNOLOGY IN THE FOOD INDUSTRY

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Abstract. The intensity to salvage the inadequacy of food production bothers on the relentless effort to upgrade the food science so as to meet the growing needs of the global population. Climate change, population growth, post-harvest losses and food insecurity are among the factors that have impeded the quality and availability of necessary foods. It becomes necessary for the emerging food science to collaborate with nanotechnology in order to measure up with the contemporary demands. One of such promising fields is nanotechnology, which has drawn considerable attention as a result of its wide pertinence and transformative potential across the various domains of human endeavours. Nanotechnology is often considered as the viable and expeditious approach because of its plausibility in all spheres of life. It operates at the molecular and atomic levels, resulting into abundant advantage to the food industry. The use of nanoparticles in the food industry as additives, preservatives and packaging materials has shown earthshaking impact. It promotes packaging by increasing the food hygiene, preventing microbial contamination and lengthening the shelf-life of the consumers' foods. Nano-encapsulation techniques improve nutrient delivery, give the varieties to enhancing the flavour of the foods and increase the possible minerals and vitamins, which may contribute positively to consumers' health and well-being. As reasonable as this may sound, does that mean nanotechnology is completely free of challenges? Despite the numerous heart-breaking benefits of nanotechnology, there are implicit hazards and pitfalls involved. The crux of this paper is to examine how nanotechnology can be employed in the food industry; its necessary benefits as well as discussing the ethical challenges the use of nanotechnology could possibly pose.
Keywords: *nano, nanotechnology, nano particles, food industry, food processing*

Introduction

The revolutionary effect of nanotechnology anywhere it is employed is often compared to the mystical result that often springs from a magical wand. Hardly would one think of any field that nanotechnology is not evading. The revolutionary powers of nanotechnology in the food industry include the encapsulation and delivery of substances in targeted sites, introducing antibacterial nanoparticles into food, intensification of shelf life, detecting contamination in processed food, advanced food storage, tracking, tracing and brand protection. Nano food packet materials extends food life as a result of its high blockade packaging which increases food safety by creating awareness for the consumers when the food is contaminated or spoiled. These packet materials repair tears in packaging, and even release preservatives to extend the life of the food in the package (Chellaram et al., 2014). The technology uses the materials, whose external dimensions ranges in between 1nm to 100 nm. Hence, these materials are known as nano-materials (Kaur et al., 2023). The array of adulterated food packaging in the developing countries especially in Africa has necessitated the need to call for the introduction of nanotechnology in the food industry. There are instances of food being adulterated in Nigeria in which the outcome of the adulteration could either be malignant or benign or merely soothing. All these would have been discovered and

many lives would have been saved in cases of malignant adulteration, if nano food packets had been used. There is no gain-saying that Nigeria is facing an endemic of fake products where buyers are overwhelmed with the number of fake goods, most of which are dejectedly conceded as the real deal. It becomes imperative therefore to have a knowledge of the most counterfeited products in the markets through having the firsthand knowledge of the goods or scanning the barcode whenever the possibility rears its head. Better still, we can engage the use of nanotechnology if the technology of the country has advanced to that height.

This paper therefore intends to examine the nature of nanotechnology as it applies to the food industry. We shall consider the meaning of nanotechnology in relation to its relevance in the modern world, by focusing on its application in the food industry. As plausible as this may sound, we shall critically discuss the possible ethical issues that may be inherent in the use of nanotechnology in the food industry.

Delimitation of nanotechnology

Hardly in another field would you see scholars agreeing on a univocal definition of a particular concept. Every scholar considers the definition of a concept from his perspective and the area he specializes in. There are currently lots of definitions of what nanotechnology is or what it could be. Be that as it may, the divergent definitions in most cases are seen to be pointing towards the same purpose only from different perspectives. Therefore, having a deep understanding of nanotechnology may be laden with some controversial underpinnings especially when one wants to break down the scientific components that may be inherent in its analysis. For the sake of this write-up, we shall try to approach the delineation devoid of the possible scientific jargon, and we shall attempt to be down to earth without losing the originality in the definition. Before delving into the meaning of nanotechnology, it is important to state that the concept is used to mean both the basic and applied scientific research. The understanding of nanotechnology as a basic science goes beyond the mere theoretical approach as it is often considered in the times past. Nanotechnology as a basic science requires the use of tools and practices that are fundamentally technological. The activities of engineering which involve the creation of machines and other devices are considered as essential explorations into the system of nature. It would not be out of place therefore to say that nanotechnology is a synergy of science and technology.

The word nanotechnology can be broken into two separate words, where the prefix would be nano and the suffix, *technology*. On one hand, the prefix nano has its etymology in the Greek word for "dwarf." We can therefore interpret the word to ordinarily mean 'very small or minute.' The suffix *technology* on the other hand is taken as the application of knowledge for achieving practical goals. When the prefix and suffix are combined, nanotechnology can be interpreted to mean the application of very small matter for scientific advancement in different spheres of life such as medicine, production of goods, energy and manufacturing sectors, among others. Having understood the concept from the literary perspective, it will not be out of place to examine it from a professional point of view. Nanotechnology is the field that focuses on the use of materials on the nanoscale. By nanoscale, it simply means the research and technology development at the atomic, molecular, or macromolecular levels, in the length scale of approximately 1-100 nanometer range, creating and using structures, devices, and systems that have novel properties and functions because of their small size and the ability to manipulate on the atomic scale (Samal, 2017). In food, nanoparticles

are used as additives such as preservatives, flavoring agents, antimicrobial sensors and packaging substances. Nanotechnology provides a huge collection of opportunities for the development of new products and applications in food systems. It is on this note that Kiplagat sees nanotechnology as:

> *"The study, design, creation, synthesis, manipulation, and application of functional materials, devices, and systems through control of matter at the nanometer scale. It can be harnessed to address some of the world's most critical developmental problems, such as food insecurity, environmental pollution, inefficient energy production/consumption and affordable healthcare."*
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> (Kiplagat, 2022).

The position of Kiplagat shares a resemblance with the assertion who see nanotechnology as a novel scientific approach involving the use of materials and equipment capable of manipulating the physical as well as chemical properties of a substance at molecular levels. Nanotechnology appears to make the ordinary look extraordinary in terms of production output and result. It is loaded with the possibilities of revolutionizing the food industry with new tools for the molecular management of diseases and better productivity in plants and animals. Nanotechnology is a field of science and technology that deals with the manipulation and control of matter on an extremely small scale, generally at the nanometer position. A nanometer is one billionth of a cadence, which is about the size of several titles or motes. Nanotechnology involves designing, structuring, and manipulating structures and biases at the Nanoscale to produce new functionalities and parcels that are not set up in larger systems. This technology has operations in colorful fields similar to medicine, electronics, material science, and energy production (Chaudhary et al., 2014). To develop and advance freely that will lead to inventions in areas similar to medicine delivery systems, nanotechnology needs to be given a special place. In the field of medicine for instance, nanotechnology is being used to produce targeted medicine delivery systems that can deliver specifics directly to specific cells in the body, minimizing reactions and perfecting treatment effectiveness. In electronics, nanotechnology has led to the development of lower and more effective biases like Nanoscale transistors and memory storehouse factors. likewise, nanomaterials with unique parcels, such as increased strength, inflexibility, or conductivity, are being employed in manufacturing processes to produce lighter and more durable products (Samal, 2017).

One of the crucial advantages of nanotechnology is its eventuality to revise coluorful diligence by enabling scientists and masterminds to design and manipulate materials at the molecular position. This precise control over the structure and parcels of materials opens up new possibilities for creating high-performance products with enhanced functionalities. Overall, nanotechnology holds a great pledge to drive scientific improvements and technological advancements in the coming times. Experimenters continue to explore the possibilities of this fleetly evolving field, seeking to harness the unique parcels of nanoscale materials for a wide range of operations that could transfigure diligence and ameliorate the quality of life.

Applications of nanotechnology in Africa

The use of nanotechnology is imperative in all facets of life. Africa as a content should not be left out in the race for adopting the use of nanotechnology. For workable

growth in Africa to be advocated for, there has to be among others, upgraded yield in agriculture, complete shake-up of health delivery systems as well as water management. It is the applications of biotechnologies and nanotechnologies as well as indigenous technologies that will greatly assist in the accomplishment of this noble sustainability goal. Our discussion shall concentrate on some areas where nanotechnology can be of most benefit for Africa's developmental agenda, and these include water, energy, health, mining and minerals' extraction and manufacturing. Numerous African countries have made great advances in harnessing nanotech applications in various socio-economic areas in the last few years (Kiplagat, 2022). For the sake of emphasis, a few African countries will be considered. South African is believed to be one of the topmost African countries that has achieved a reasonable landmark in the application of nanotechnology. The research in nanotechnology in South Africa currently focuses on social development and industrial growth, which include the development of cheaper solar cells, nano-membrane technology for water purification and fuel-cell development, among others. The South African Nanotechnology Initiative was developed in 2003, with the aim of building science councils and industrial companies that will concentrate on the aforementioned areas of nanotechnology.

Despite the huge reliance of Nigeria on importations, efforts have been made by the academia, research institute and the government to create awareness and interest in nanotechnology. The concerted energy has been channeled on capacity building, research and development. The collaborative work of the scientists, technologists and entrepreneurs in the areas of medicine, agriculture, energy and water purification has left so much to be desired. Hardly would it be possible to come by any African country without a reasonable attempt to be nano-technologically inclined. As it were, there is the possibility that in the near future no country would be able to escape the relevance of researching and developing this type of technology. Every country wants to ensure the safety of the food the general masses consume, and nanotechnology has been deemed the leeway towards achieving this feat.

The use of nanotechnology in the food industry

As earlier mentioned, hardly would any walks of life be discussed without a mention of the use of technology. Here, we shall consider some of the grey areas that nanotechnology has been employed in the food industry. The raw materials or ingredients are good for consumption when they are processed into food and other forms so as to make them marketable and with shelf life. When food is processed, toxin is removed; it is prevented from pathogens and helps in improving the consistency of foods for better marketing and distribution. Processed foods are usually less inclined to early degeneration than fresh foods and are better suited for long distance transportation from the source to the consumer. All these are the effects of nanotechnology in the food industry (Chellaram et al., 2014). Nanofoods are the foods that have been produced, processed and packaged with the aid of nontechnology. We can therefore consider food processing as the practice of preserving the food by different methods and techniques in order to transform the food to a consumable state with the techniques that are designed in such a way that the flavor and quality are kept intact and the food is protected against micro-organisms (Samal, 2017). Again, the term 'nanofood' is the food that has been refined, shaped, handled or packaged using nanotechnological techniques or tools, or to which nanomaterials have been added. As part of the human food processing, nano capsules have adopted as nano-sized ingredients, additives and nutritional supplements.

It has been reported that nano encapsulation of food ingredients and additives have been carried out to provide protective barriers, flavor and taste masking, controlled release, and better dispensability for water-insoluble food ingredients and additives. The intention of these efforts is to develop improved tastes, reduce the amount of salt, sugar, fat and preservatives, address food-related illnesses (e.g. obesity and diabetes), develop targeted nutrition for different lifestyles and aging population, and maintain sustainability of food production, processing and food safety (Samal, 2017).

The easiest means of transporting the processed food lies with the way it is being packaged. Food packaging gives protection to the product by resisting against unnecessary tampering with the content, either physically or chemically. In the modern economy, the relevance of packaging dwells on the effective delivery and conservation of food and other consumer products. It facilitates the end-use expediency and communication at the purchaser levels. It is a way of showing how the product is labeled to display any nutritional information on the food being consumed, the date of the production, the composition of the production and the shelf-life date of the product. The packing has a great significance in preserving the food to make it marketable and enticing to the intending customers. Packaging of food serves as a response to the advancement of material science and technology, and as a way of bettering consumers' lifestyle. Packaging is not only essential in effective distribution and preservation of food and other consumer products in today's global economy, but helps to facilitate their end-use convenience and communication. These important functions in food packaging have made food packaging become the third largest industry in the world (Han, 2005; Robertson, 2005). Packaging offers restraint and protects food products during distribution and storage from external and internal unfavorable conditions, such as water vapour, microorganism, gases, orders, dust, and mechanical shock and vibrations (Samal, 2017). Packaging of food is captured under nanoencapsulation. Nanoencapsulation is taken to mean the technology to pack substances in miniature making use of techniques such as nanocomposite (two or more phases of composite materials) and nanoemulsification (for active pharmaceutical ingredients). The addition of Nanoparticles to many foods improve the flow properties, colour and stability during processing, as well as increasing the shelf life. For example, *aluminosillcate* materials are commonly used as anticaking agents in granular or powdered processed foods, while *anatase titanium* dioxide is a common food whitener and brightener additive, used in confectionery, some cheeses and sauces (Alfadul and Elneshwy, 2010). There are myriads of other materials that are easily adopted in increasing the shelf life of products and the nutritional values.

The materials used in the food industry are the products of agricultural activities, and the availability of these products bother on how the farm products turn out. There is the need to employ the use of nanotechnology in agriculture and food production in the form of nanosensors, for monitoring crop growth and pest control by early identification of animal or plant diseases. These nanosensors help to enhance production and improve food safety. The sensors function as external monitoring devices (Raliya et al., 2013). Nanomaterials can also be introduced in or on the food which boost the output in terms of safety and general volume of the production. Another point worth mentioning in the application of nanotechnology in food industry has to do with functional foods. By functional foods, we mean any food or food ingredient that may provide a health benefit outside the traditional nutrients it contains. This definition is considered to be a problematic one because the phrase "traditional nutrients" refers only to vitamins and

minerals. The reason is that these are considered essential to the diet and responsible for deficiency disease. For instance, in our regular diet, it has been observed over time that vitamin C corrects scurvy, vitamin D alleviates rickets. Medical foods that are formulated to be consumed under the supervision of a physician can easily be included in this category. Diseases such as diabetes require that the patient being placed under diet control. With the use of medical foods, the condition of the patient can be managed with distinctive nutritional requirements (Paul and Dewangan, 2015).

Ethical analysis of nanotechnology

As plausible as the use of nanotechnology may appear, there is every tendency for us to close our eyes to the possible pitfalls that may be inherent in the procedure. The plausibility is not a condition for us to lose sight of the possibility of the presence of nanoparticles in some products which may be concealed from the consumers. This is made lucid in the words of Paul and Dewangan, who succinctly stated that nanoparticles and nano capsules contained in several foods are currently available for purchase without indicating the presence of these nano materials on their packaging (Paul and Dewangan, 2015). We could recall that we had noted that one of the requirements of packaging is to indicate the composition of the product and the nutritional values the consumers tend to gain. Should this be the case, why would the presence of nanoparticles be concealed on the package? Are the substances part of the controlled products that should not be made available to the general public? Could that be tantamount to hiding the likely hazard that may be imminent with the consumption? These and many more are the questions begging for answers that the concealment of that needed information could raise in the mind of anyone who may be privileged to it. It is to be noted that consumers have the right to know if nanotechnology is used in their food products. Utmost transparency is required in the use of nano-materials, including labeling requirements which may activate the informed decision-making and consumer acceptance. It is a common knowledge that no consumer would voluntarily choose to settle for a product that will improve his health condition. At the same time, we cannot undermine the fact that some individuals might as well go for some substances they feel would benefit them in terms of soothing their mood which may eventually cause some damages to the whole well-being. Be that as it may, it is expected that every consumer desires that he gets satisfaction from the products he uses, with the assurance that the safety to his health is assured. It is suspected that there is a lack of comprehensive research on the long-term health impacts of consuming nanoparticles. It is essential to ensure that nano-materials used in food products do not pose risks to human health. When researches are not concluded on particular nano-particle, it should not be introduced for human consumption.

The uproar the use of technology may generate is determined by the environment it is being put to use. If the environment is well-embedded with the practice of nanotechnology, the people would have become so accustomed with the products that emanate through its use. It would not be out of place therefore to say that the public perceptions and attitudes towards nanotechnology may arise within the context of the society in which they are rooted. Support for nanotechnology can be won over through the creation of public awareness. Engaging the public in dialogues about nanotechnology in the food industry is crucial for building trust and addressing ethical concerns. Open communication, education, and participatory processes can help ensure that diverse. When this is done, it would assist in resolving the problem of informed

consent which may generate a serious ethical controversy. Accessing new technology in every clime involves fair distribution and the availability of funds. There is a growing concern that the benefits of nanotechnology in food production may not be equally distributed. It is important to consider how this technology can be used to address food security and equity issues, especially in developing countries. The stratification of the society would give those who fall into the upper echelon and at the same time, close to the corridor of power the most advantaged position in terms of accessibility. Those on the lowest rung of the societal ladder may not have the enablement to access the nano-products even when they so much desire them. The Government needs to improvise as a way of subsidizing the available nano-materials so as to make everyone benefit. It is foreseen that the introduction of nanotechnology in food production could widen existing disparities in access to safe and nutritious food. Ensuring that nanotechnology benefits are accessible to all populations, including marginalized communities, is crucial for addressing equity concerns.

It is envisaged that the use of nanotechnology may generate some anxieties due to the obvious exciting results it brings. The landmark output may necessarily draw our attention in finding out the inherent risk that may be present in the procedure. The plausibility would push us to investigate the potential for such foods to pose new health risk. The need urgently arises for regulatory systems saddled with the responsibility of managing any risks associated with nanofoods and the use of nanotechnologies in food industry. Government needs to ensure a thorough supervision of the procedures of nanotechnologies in terms of economic, civil liberties and ethical challenges. The European Union regulations for food and food packaging for instance, recommends that specific safety standards and testing procedures are required for the introduction of new nanotechnology. In the United States, it is regulated by the body known as United States Food and Drug Administration (USFDA) (Alfadul and Elneshwy, 2010). In Nigeria, the National Agency for Food and Drug Administration (NAFDAC) is saddled with that responsibility. There is a risk that nanotechnology in the food industry could be misused for purposes such as food fraud or adulteration. It is crucial to establish protocols and safeguards to prevent misuse and ensure the right use of nanotechnology in food production.

Conclusion

There is no gain-saying the fact that the increasing rate of human population necessarily increases the number of mouth to be fed. In meeting up with this, improved strategies need to be put in place to commensurate the anticipated intention. The pressing demand to satisfy the nutritional, healthy and fresh diet of the consumers puts the food processing industry under a serious pressure. Be that as it may, do we need to close our eyes to the procedures engaged by the food industry in meeting up with these huge demands? The answer obviously cannot be given with an affirmation because the good intention of meeting the high demands of feeding many mouths should not be tainted with a procedure that might probably pose some risks to the people the procedure claims to help. Therefore, the important measure to be adopted today is the regulation of activities in the field of nanotechnology. The regulation of nanotechnology is confronted with some difficulties due to the fact that the procedure is employed in various sectors of the economy. Efforts should be made to apply a uniform definition of nanomaterial, which will facilitate the validation of the methods, the instrumentation for

detection and analysis of the likely hazards that may be inherent in the nanomaterials, in guaranteeing the safety consumption by the consumers.

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Conflict of interest

The authors confirm that there is no conflict of interest involve with any parties in this research study.

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