

POSTHARVEST AND FOOD SAFETY: CONTEMPORARY ISSUES AND A FUTURE DIRECTION FOR THE NIGERIAN FOOD SUPPLY CHAIN

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Abstract

Food safety is essential for the health and well-being of consumers, while food quality is for their satisfaction and nutrition. If quality and safety are to be guaranteed, good practices must be employed from growing, harvesting and postharvest handling of foods, to the processing, packaging, distribution, during storage and preparation before consumption. This has become imperative because foodstuffs undergo progressive deterioration in quality and safety after harvested, gathered, caught or slaughtered with microbes such as bacteria, yeasts, moulds, insects and rodents being in endless competition with man for the supply of his food. These factors together with environment and presence of toxic chemical such as pesticide residues combine to make food either inedible (quality issue) or unsafe (safety issue) for use and/or consumption. There are higher expectations from the 21st century consumers who want their food products to be palatable, have high nutritional value and free from pathogenic and spoilage microorganisms. Hence, preservation and maintenance of safety of food produced as it goes from farm-to-fork and/or from pasture-to-plate remain the number one issue of concern among governments, stakeholders and consumers in many committed countries of the world. Owing to the fact that specific consumer requirement is that foods give them the required nourishment and pose no direct or indirect risk to their health.

Key words: food, safety, quality, post-harvest, supply-chain

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1. INTRODUCTION

Quite a number of postharvest issues are of major concern and include: the quality and safety of food at the time of harvest, potential damages during harvest, and the need for further processing of the harvested foods, time interval between harvest and sale, risk during storage, cost of postharvest technology, emerging technologies as well as regulatory issues. Interestingly, the recent advancement in science and knowledge through research has provided support for the old and new postharvest technologies for ensuring the safety and quality of processed food supply. Also, many studies were been undertaken on postharvest microbiology and technology of foods primarily for the reduction of losses in quality and quantity of foods after harvest and for maintaining safety between harvest and consumption (Kitinoja *et al.*, 2010). These objectives were said to be achieved through growing foods with the required attributes and

extended postharvest quality using a cohesive production systems which maximise yields while not compromising the quality and using efficient postharvest handling techniques for maintaining the quality and safety of foods. Regrettably, the technological tools produced for this purpose are not always available or applied, particularly in less highly industrialized countries like Nigeria. Microbial contamination of food has for long known to have been a serious problem in developed nations, while proactive food safety management system such as HACCP seems to be known only in theory in developing nations, such as Nigeria (Bubl, 2007). This has created an enormous barrier to international trade especially to the local farmers and food producers (Mortimore and Wallace, 2013). This study therefore aim to critically look at various issues related to pre-harvest and post-harvest food safety and give a clear clue on how this could be managed in Nigeria to ensure the protection of lives of the teeming

consumers and promotes international food trade.

2. MATERIALS AND METHODS

This study employed desktop analysis which was conducted by extensive literature review from available documents and reports from current journals, textbooks on pre-harvest and post-harvest food safety programmes of selected developed and developing nations.

3. RESULTS AND DISCUSSION

3.1 Pre-harvest issues

From planting to consumption, there are many opportunities for bacteria, viruses, and parasites to contaminate produce. On the farm, soil, manure, water, animals, equipment, and workers may spread harmful organisms through bad agricultural practises. Produce may be harvested on farm 'A', processed in a different plant, repackaged in another packaging firm, then stored, displayed on the shelves of local and super markets, or served in a home. Each of these channels of handling of foods presents an opportunity for harmful microorganisms to enter the food chain. There is no way to guarantee that everything we grow and consume is free of harmful microbial contamination or any other potential hazards. But, the risk can be effectively managed if preventative steps are taken before green produce and animals leaves the farm to the market. Therefore, food safety begins on the farm by reducing microbial contamination with Good Agricultural Practices (GAPs) right from the time of planting up to the time of harvesting. This can be achieved by using 'clean soil' to grow plant from pathogens-free seeds; use good quality feed and potable water to fatten the animals. Also, use of clean water for irrigation and washing of fresh produce (fruits and vegetables) purposes plays a good role in ensuring food safety on the farm and in the market (Kitinoja and Gorny, 1999; Caprile 2006).

3.1.1 Good Agricultural Practices (GAPs)

GAPs are production and farm smooth approaches to ensure the safety of fresh produce for human consumption. GAPs production and post-harvest guidelines are designed to decrease the risk of spoilage and foodborne disease causing microorganisms contaminating the fresh produce. These voluntary techniques can be tailored to any production system. GAP recommendations are directed toward the primary sources of contamination: soil, water, hands, and surfaces (Bourquin, 2009). GAP protocols were developed in response to the increase in the number of outbreaks of foodborne diseases in developed nations, such as the US and UK, resulting from contaminated fresh produce. This is because fresh produce can become contaminated by any of a number of microbes (bacteria, fungi, parasites or viruses) at stages, such as, of production, harvesting, storage, processing, packaging, or marketing (UK Cooperative Extension Service, 2010). GAPs include the use of high quality seeds, treated organic manure, high quality irrigation water and clean soil for growing foods and hygienic approach to animal husbandry. All of which contribute to food safety right from the farm. The food safety pyramid includes GAPs, Good Manufacturing Practises, Standard Operating Procedures and Hazard Analysis and Critical Control Point (HACCP), which will ensure safe food for human consumption (Wilson, 1999).

3.2 Post-harvest issues

3.2.1 HACCP and Food Safety

Implementing an effective food safety management system (FSMS) is critical to the production of safe food from farm to fork (Mortimore and Wallace, 2013). Management systems based on HACCP are the international standard as officially recognised by the Codex Alimentarius Commission in 1993, and guidelines for its application was included as Annex 'A' to the Codex General Principles of Food Hygiene four years later (1997). HACCP systems build upon effectively designed and implemented prerequisite food safety programmes, and focus on three major key

concepts: (a) Identifying significant food safety hazards, (b) Controlling these significant hazards, and (c) Documenting the system (Mortimore and Wallace, 2013). Therefore, HACCP is the process of identifying and assessing product and production related chemical, microbial and physical hazards and the process of controlling and monitoring them. Proper implementation of HACCP system provides the framework to produce foods safely and to prove they were produced safely through proper process documentation (Mortimore and Wallace, 2013).

In a nut shell, HACCP systems: (i) Specifically focus on food safety only, (ii) Are applicable from farm to fork (all phases of food production), (iii) Focus on prevention and control of potential food safety hazards (a preventative approach to food safety), and (iv) Emphasises the use of science and technology to ensure the production of safe food from plough to plate.

However, before HACCP systems can be implemented with success, the food production firm must be operating in accordance with Good Hygiene Practises (GHPs) and Good Manufacturing Practise (GMP). These are regarded as prerequisite programmes (PRPs), and they provide the strong foundation to successful HACCP plan (Mortimore and Wallace, 2013).

3.2.2. The Seven Principles of HACCP

Following the effective completion of HACCP preliminary steps, the team is ready to swing action to apply the laid down HACCP principles. The seven steps processes that would ensure safe production of food include: (1) Hazard analysis; (2) Determining the critical control points (CCPs); (3) Establishing the critical limits; (4) Establishing monitoring procedures for the control of the CCPs; (5) Establishing corrective actions to take when deviation occurs; (6) Establishing verification procedures to determine the effectiveness of the system and, (7) Record keeping and documentation (Mortimore and Wallace, 2013). HACCP is certainly the essence of food safety control in most developed countries, and

it has become the cornerstones of the Global Standard for production of safe food (Kill, 2012).

3.3. Economic losses

Developing countries lost roughly 40% of their food harvest, especially fruits and vegetables, to spoilage and infestations on its journey to the ultimate consumer (Kitinoja *et al.* 2011). In developing countries, such as Nigeria, where tropical weather and poorly developed infrastructure contribute to the problem, losses are sometimes of shocking proportions if valued to Naira. Losses occur in all operations from harvesting through handling, storage, processing and marketing. The losses vary according to the influence of factors such as the perishability of the commodity; ambient temperature and relative humidity which determine the natural course of deterioration; bacterial and fungal spoilage; damage by pests (insects), rodents and birds; the length of time between harvesting and consumption; and practices of postharvest handling, storage and processing. In fact, most often, postharvest losses are a symptom rather than the problem. Therefore, knowledge of their cause is essential for deciding measures to prevent them. Such measures may have to be taken by the small farmer, the private trader, a cooperative, other operator, food handlers and transporters, wholesale and retail markets [Food and Agricultural Organisation (FAO), 1996].

In contrast, in the developed nations fruits and vegetables are packaged in Hammock pack and Polyethylene to reduce moisture loss, fresh meat is sold in vacuum packaged pack to extend its shelf life, cereals are distributed in Polyethylene and other suitable packages (Cantwell 2011; Grebitus *et al.* 2013). This is to contain and present these foodstuffs to consumers safely and to prevent food contamination in the distribution chain (Cantwell 2011). Conversely, in Nigeria, foodstuffs are still sold in the markets without any packaging exposing them to all sorts of organisms (pathogenic and non-pathogenic) and other damaging environmental factors,

such as sunlight, dust, flies and human activities (Personal Communication, 2013).

4. HIGHLIGHTS AND DISCUSSION

In the developed nations, farmers and traders of food are fully aware that it is a collective responsibility to ensure food safety and quality in the food supply chain (FAO 2006). Time has come when such system have to be embraced in Nigeria. This is because the market is becoming competitive; also educated and probing customers are demanding for fresh and processed foods that are safe for consumption. Also, if Nigerian foods must be accepted for international trading, a robust National Food Control System (NFCS) must be put in place, and monitored by suitable and qualified personnel, which is the major approach that could ensure accommodation of our local produce into the international food supply chain (Kitinoja *et al.* 2011). Government agencies (at Federal, States and Local government levels) are responsible for establishing and managing an enabling institutional, policy and regulatory framework for food safety, and carrying out food control activities that protect consumers from risks arising from unsafe food and fraudulent practices (FAO 2006). Thus, the capacity of a NFCS relates to its ability to perform appropriate functions effectively, efficiently and sustainably in order to provide safe and quality food for domestic consumption and export (FAO 2006).

Also, postharvest research and extension (PR&E) has long been neglected in Nigeria. There should be a survey of the current human, physical, and financial resources allocated to PR&E activities in every state and local governments in Nigeria and the results should be used to develop an action plan for establishing an effective PR&E programme to serve the needs of all levels of government. In most cases, solutions to existing problems in the postharvest handling system require the use of available information and implementation of existing appropriate traditional and modern technologies. Thus it is extremely important to

strengthen the link between researchers and extension officers to ensure the smooth transfer of relevant information to those who need it. And it has been opined that the most successful model is that where PR&E officers belong to the same organisation and are co-located for maximum local and international interactions and collaborations (Kitinoja *et al.* 2011).

Furthermore, establishing a Postharvest Working Group in each state and local governments of Nigeria can be very useful in providing a forum for communications among all those concerned with postharvest technology, and PR&E. The next step is to establish a link among the various Postharvest Working Groups in each state to facilitate exchange of information and regional collaboration on training and other areas of mutual interest. Funding for PR&E efforts should be enhanced and sustained by the three tiers of government and stakeholders. Although reducing postharvest losses of already produced food is more sustainable than increasing production to compensate for these losses, insufficient amount of money is usually allocated for funding of agricultural research globally. This status quo must be changed to reach a better balance in allocation of resources between efforts towards increased production and those towards reducing postharvest losses in the world (Kitinoja *et al.* 2011).

In a nut shell, increasing investments in postharvest technology is long overdue in Nigeria, and can have a major impact on reducing waste and increasing the food supply, leading to improved incomes without increasing production and wasting the expenditures on all the inputs required. The most useful technological changes in production, harvesting, and postharvest handling systems for perishables have resulted from interdisciplinary team approaches in PR&E programmes. Maintaining quality and ensuring safety by avoiding chemical, and microbial contamination, must be the focus of future PR&E activities in Nigeria. Therefore, capacity-building efforts undertaken in postharvest technology and PR&E in Nigeria must be comprehensive, and include technical

knowledge on handling practices, research skills, access to tools and supplies, cost and benefit information, extension skill development, such as training needs assessment, teaching methods, and advocacy. Also, a central site for conducting PR&E and offering local extension programmes such as a 'Postharvest Training and Services Centre' is recommended for each state and local government in Nigeria. The centre could serve as a place where local PR&E personnel could meet and conduct practical adaptive research aimed at testing innovations under local conditions, identifying issues regarding practicality, costs, potential economic benefits, providing demonstrations of those innovations determined to be feasible (both financially and technically), providing comprehensive, practical training on improved postharvest practices, and providing information of practical use to people involved in postharvest research and technology.

5. FUTURE DIRECTION FOR NIGERIA FOOD SUPPLY CHAIN

Food safety cannot be ensured for consumers if the government do not care and do not even know what is happening in the food supply chain (on the farm and in the market). Specific agencies should be established to monitor and enforce regulations on the safety aspects of Nigerian food chain; hence a Food Safety Agency of Nigeria (FSAN) should be established and funded by the three levels of the government and food production firms to ensure safety of foods in the country. The FSAN can have its functions spread out to cover states and local governments in form of local authorities to ensure food safety at grassroots level from farm to fork. The proposed agency (FSAN) should be given autonomy to deal and handle food safety issues in Nigeria. This is because the management of Postharvest can be achieved through an organised Food Safety Management System (FSMS) which include core control and assurance activities (Kirezieva *et al.* 2013). The

core control activities include the design of preventive measures, such as HACCP, and intervention processes, monitoring system and actual operation of control strategies; while the core assurance activities consist of system identification, validation, verification and record keeping (Luning *et al.* 2008; Kirezieva *et al.* 2013).

5.1. Food Legislation

Food control systems should be developed and operated in accordance with certain fundamental principles including a food chain approach, risk analysis, transparency and the involvement of all the concerned stakeholders including the governmental and non-governmental organisations. Moreover, achieving food safety is a shared responsibility and involves different types of stakeholders including government, farmers, the food industry, consumers and their organizations, academic and scientific institutions (FAO 2006), which is aimed at protecting public health, increasing and ensuring economic viability and sustainability, harmonizing well-being and stimulating fair trade on foods within and between nations are the main aims of food regulation that assure a safe supply of food commodities and aspire to eliminate unwholesome and fraudulent practices (Lin and Yamao 2012).

5.2. Policy and Plan

Effective food control systems require policy and operational coordination at the national level (Sartera 2009). Nigerian government has established the National Agency for Food and Drug Administration & Control (NAFDAC) as the highest level policy making body for food matters. NAFDAC is established and designed by the government to protect the consumers in Nigeria, but it is has to be streamlined and redefined and it has to integrate an effective policy on food safety in Nigeria in collaboration with FSAN.

5.3. Food safety and Traceability

Systems of food production and distribution are becoming more interdependent, integrated

and globalised. Concurrently, escalating and heavily publicised outbreak of foodborne illness around the world has raised the awareness of the need to ensure food safety and quality (Karippacheril and Srivastava 2011). Therefore in order to ensure food safety, improve product quality and sustain a competitive advantage in the market, many food producers are turning to 'supply chain traceability' (Barratt and Oke 2007). Traceability is the ability to trace the origin (supplier), movement (transporter), and destination (retailer and consumer) of foodstuffs (fresh and processed) along the supply chain, and it has been associated with improvements in operational performance, inventory optimisation, product quality and food safety (Bertolini *et al.* 2006; Bachini *et al.* 2008; Institute of Food Technology 2011). Increasingly, producers, retailers, customers, suppliers, regulators and consumers are encouraging food producers to be able to trace the origin of ingredients and products 'one step forward and one step back' along the food supply chain. In parallel with this trend, recent technological developments, such as Radio Frequency Identification (RFID), have enabled food producers to trace and track foodstuffs and products using real time data (Bechini *et al.* 2008).

5.4. Enhancement of technical assistance and capacity building in food safety

While NAFDAC is responsible for protecting much of the food supply marketed in Nigeria, it is equally important for NAFDAC to coordinate its food safety capacity-building activities in collaboration with FSAN, Ministry of Agriculture, Ministry of Health and all stakeholders in the food supply chain, ranging from farmers to food processors and retailers. It is also important to harness synergies with other countries that have common food safety requirements and offer or support similar trainings.

This will help to minimize duplication of effort and inefficient use of resources [United States, Food and Drug Administration (USFDA), 2013].

5.5. Partnership with the global food safety community

With the globalization of the food supply chain, the responsibility for food safety has also become global. No country can alone assure the safety of its food supply chain (USFDA, 2013). Having agreed with this reality, it is important to be aware of the roles and responsibilities of each player in the food supply chain. While FSAN embraces its role in building food safety capacity in collaboration with NAFDAC and other stakeholders, it should recognise that many other types of entities including food safety experts, funding organisations, development leaders, food processors, manufacturers, researchers, and trainers, can all contribute in building food safety capacity for Nigeria.

5.6. Training requirements from experts

Ensuring that foods are safely delivered to Nigerian consumers requires NAFDAC and FSAN to cooperate with foreign counterparts by providing information about applicable and universally recognised food safety laws and regulations and the scientific basis for such requirements (USFDA, 2013).

5.7. Information, Education and Communication

Education, information, and communication (EIC) can be used by governments to enlighten consumers about food safety and quality, and encourage farmers, food processors and food retailers to adopt GAPs, GMP, GHPs and Good Handling Practices (FAO 2006). Sharing education, information, and advice among stakeholders across the farm to table continuum is essential to ensure the success of food safety programmes.

It has been opined that EIC play an important role in an effective food control system by increasing awareness and knowledge about food safety and quality issues among consumers and their organisations, food producers, processors, traders, food enterprises and industry associations, and empowering them to enhance food safety and quality in the food supply chain (FAO 2006).

6. CONCLUSIONS

The overall objective of this study was to gain an insight into the various issues related to postharvest and food safety in Nigeria, and to highlight a clear hint on how to effectively manage them through sound scientific approach in this modern time. This is to protect public health and promote international trade between Nigeria and other nations. Several recent studies were reviewed and important points were highlighted, discussed and summarised. It is crystal clear that food safety issues are yet to take off in Nigeria. A lot of efforts are still concentrated on Food quality; it is time for Nigerian government and stakeholders to embark on a fresh journey of FSMS and NFCS as practised in all developed and some developing nations because dedicated governments of all world are intensifying efforts to improve food safety in their respective territory to ensure the protection of public health (Jacxsens *et al.* 2009; Lin and Yamao, 2012), and Nigeria should not be an exception.

7. CONTRIBUTORS

Sirajo Mohammed Funtua and Ismail Balarabe Bilya wrote the first draft of this manuscript after detailed discussion with each other during their MSc programme in the University of Greenwich, United Kingdom; also Isah Gimba Kutigi was involved in the final draft. The three authors contributed to draft revisions and accepted for publishing the final version of this paper.

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