World Journal of Biology Pharmacy and Health Sciences
eISSN: 2582-5542
Cross Ref DOI: 10.30574/wjbphs
Journal homepage: https://wjbphs.com/

(Research Article)

PROPOSED VEGETABLES PRESERVATION CENTRE, MBAUKWU: ADOPTING A PRESERVATION PLATFORM TO CURB POST-HARVEST WASTE OF VEGETABLES AND ENSURE THEIR CULTIVATION FOR ECONOMIC PURPOSE

Peter Chukwubuikem Okekeaji *

Department of Architecture, Faculty of Environmental Sciences, Chukwuemeka Odumegwu Ojukwu University, Anambra State, Nigeria.
* Corresponding Author

ORCID Details
Peter Chukwubuikem Okekeaji: https://orcid.org/0009-0008-4320-9177

World Journal of Biology Pharmacy and Health Sciences, 2026, 27(03), 020–024

Publication history: Received on 12 July 2026; revised on 07 September 2026; accepted on 09 September 2026

Article DOI: https://doi.org/10.30574/wjbphs.2026.27.3.0464

ABSTRACT

The high post-harvest loss of vegetables, largely due to limited preservation capacity, is a major concern in developing countries where seasonal food shortages and nutritional deficiencies persist. This study proposes the design and establishment of a Vegetable Preservation Centre in Mbaukwu, Awka South Local Government Area of Anambra State, Nigeria, to mitigate post-harvest wastage and promote economic cultivation. A mixed-methods research design was employed, integrating primary data from observations and interviews with secondary data from architectural and agricultural case studies across India and Ghana. The proposed design adopts a clustered site concept and an I-line (linear) production flow layout to ensure seamless processing from raw material reception to packaging and cold storage. Additionally, sustainable architectural solutions, such as the Integrated Waste Treatment Plant (Biofil Digester) and courtyard systems for optimal natural ventilation, were incorporated into the spatial planning. The facility is programmed to process 25 metric tonnes of various vegetables daily, supported by a projected workforce of 1,824 production staff and 99 administrative personnel. The establishment of this centre will provide a sustainable platform to extend the shelf-life of vegetables, ensure food security, generate employment, and boost the exportation revenue of Anambra State.

Keywords: Vegetable Preservation; Post-Harvest Loss; Industrial Architecture; Food Security; Mbaukwu; Sustainable Design

1 INTRODUCTION

Vegetables are succulent herbaceous plants characterized by high moisture content (often 75% or more) and are essential sources of minerals, vitamins, and dietary fibre [1]. Despite their nutritional and economic value, vegetables are highly perishable, resulting in alarming post-harvest losses. In Nigeria, food waste is estimated at $750 billion annually, with approximately 80% of food wasted nationwide compared to the global average of 33% [2]. Furthermore, the Agricultural Fresh Produce Growers and Exporters Association of Nigeria (AFPGEAN) estimates that between 55% and 72% of fresh fruits and vegetables grown in the country perish before consumption [3].

This high rate of spoilage is primarily driven by a lack of refrigerated storage, inadequate processing facilities, and erratic electricity supply. The environmental footprint of this wastage is also significant, as decomposing food releases greenhouse gases into the atmosphere [2]. In Anambra State, which boasts rich agricultural lands across the tropical rainforest and savannah belts, vegetable wastage is estimated at 30% to 35% [4]. The state government has identified several local government areas, including Awka South (where Mbaukwu is located), as major hubs for vegetable production.

To address this deficit and support the state's drive to legally export indigenous vegetables (such as bitter leaf, scent leaf, and pumpkin leaf) to international markets, there is an urgent need for specialized industrial infrastructure. The aim of this project is to design a Vegetable Preservation Centre that will serve as an industrial hub for processing, packaging, and storing vegetables. The objectives include providing properly zoned spaces for all preservation operations, adopting sustainable construction materials, and meeting stringent industrial and public building regulations.

2 LITERATURE REVIEW

2.1 Industrial Building Design and Layout

The architectural design of industrial buildings is fundamentally utilitarian, prioritizing operational efficiency, adaptability, and spatial flow. Factory layouts are generally categorized into several types based on the production process:

- Product Line Layout: Arranges equipment according to the sequence of operations, minimizing material handling costs and production time. Variations include the I-Line (straight line), U-Line (allowing multi-machine handling by operators), S-Line (for exceptionally long production sequences), and L-Line [5].
- Process (Functional) Layout: Groups similar machines together, which is suitable for non-repetitive jobs and offers greater flexibility.
- Fixed Position and Mixed Layouts: Used when the product is too heavy to move, or combining linear and functional setups for complex manufacturing.

2.2 Structural Systems and Materials

Industrial buildings require structural systems capable of supporting wide spans and heavy loads. Common systems include:

- Portal Frames: Widely used for combining structural efficiency with functional application, allowing for open, unobstructed floor spaces [6].
- Lattice Trusses: Ideal for long-span buildings, offering high stiffness and load-bearing resistance while minimizing material use.
- Materials: Steel structures (hot-rolled I-sections, cold-formed profiles) are preferred for production areas due to their adaptability. Roof and wall claddings often utilize composite or sandwich panels featuring foam insulation layers to provide necessary fire resistance and acoustic control [6].

2.3 Principles of Vegetable Preservation

Food preservation techniques date back to prehistoric times but have evolved into precise industrial processes. Key preservation methods for vegetables include:

- Freezing: Slows enzyme activity and prevents microbial growth. Vegetables must be blanched prior to freezing to deactivate enzymes and prevent flavour degradation [7].
- Dehydration (Drying): Removes moisture to prevent decay. Industrial methods utilize controlled cabinets (dehydrators) with regulated heat (typically around 140°F) and forced air circulation to prevent "case hardening" or scorching [8].
- Blanching: An essential pre-treatment involving steam, hot water, or microwaves. Steam blanching is heavily favoured in industrial settings as it retains water-soluble nutrients better than water scalding [9].

3 RESEARCH METHODOLOGY

This study utilized a mixed-methods approach to gather relevant architectural and operational data for designing the preservation centre [10].

- Primary Data Collection: Data was collected via direct site observations in Mbaukwu, photographic documentation, and personal interviews with key stakeholders, including the Anambra State Commissioner for Agriculture, the Programme Manager, and logistics directors involved in agro-exports.
- Secondary Data Collection: Gathered from architectural design manuals (e.g., Time-Saver Standards, Architects' Data), academic journals, and online databases.
- Case Studies: Five functional industrial facilities were studied to deduce best practices:
    - Tasa Foods Private Limited (India): Highlighted the use of an I-line production flow, lattice truss roofing, and clear zoning, though it lacked adequate emergency exits.
    - Fruits and Flavour Limited (Ghana): Demonstrated good drainage and proximity to water sources, but suffered from poor spatial linkages and open production halls susceptible to pests.
    - Papso Ghana Limited (Ghana): Featured well-screened service areas but poor ventilation and inadequate raw material storage.
    - Bomarts Farms Limited (Ghana): Showcased good integration between the storage facility and production floor.
    - Tomato Processing Factory (Tema, Ghana): Highlighted the importance of proximity to labour and markets, despite poorly defined parking areas.

4 ANALYSIS, FINDINGS, AND DISCUSSION

4.1 Site Analysis

The proposed site is located in Mbaukwu, Awka South Local Government Area, Anambra State. The site's physical and climatic features dictate several architectural interventions:

- Temperature and Humidity: Mbaukwu experiences warm temperatures (averaging 29.0°C in March) and high relative humidity (up to 79.7% in July). Design Solution: Implementation of damp-proof membranes and maximum cross-ventilation to prevent interior moisture buildup.
- Rainfall and Wind: September records the highest rainfall (306 mm), accompanied by prevailing South-West trade winds. Design Solution: Use of deep eaves (minimum 600mm) and operable fenestrations to manage windward and leeward pressures.
- Topography and Soil: The gently sloping terrain features evenly compacted subsoil, which possesses a good load-bearing capacity, reducing the risk of uneven structural settlement.

4.2 The Vegetable Processing Workflow

The architectural layout of the production hall is strictly dictated by the processing sequence. The automated line includes:

- Harvesting and Weighing: Raw vegetables arrive via truck, are stored temporarily, and then loaded onto a weighing belt equipped with load cells.
- Preparation and Slicing: Produce moves to a preparation table (VBT-3/4 standard) featuring ergonomic workstations and a three-belt system to separate waste. A belt slicer then cuts the vegetables to specified dimensions.
- Washing: An automated washing machine utilizing an air injection system and electrolyzed water cleans the produce while eliminating pesticide residues and microorganisms.
- Treatment (Blanching): Vegetables are transferred via crane and wire mesh sieves into steam-jacketed kettles to deactivate enzymes.
- Dewatering and Quality Control: Mesh dewatering belts remove excess surface water before the product undergoes rigorous laboratory sampling to ensure compliance with export standards (MRLs).
- Drying and Packaging: Dehydrator machines dry the vegetables until they achieve the required brittleness. A multi-head weigher then packages the products for storage in modular walk-in industrial freezers.

4.3 Space and Workforce Allocation

The facility is zoned into two distinct areas:

- Administrative Section: Adopting a courtyard system for optimal natural lighting, this section houses executive offices, research laboratories, clinics, welfare units, and libraries. The workforce analysis projects 99 personnel across administrative, security, and maintenance roles.
- Production/Processing Section: Adopting an I-line (linear) product layout for maximum efficiency, this massive hall accommodates the processing of 25 metric tonnes of vegetables daily per product type. Operating across 6 different vegetable types, the required production workforce totals 1,824 individuals (including inspectors, machine operators, and janitors).

4.4 Sustainable Design Concepts

The project integrates several sustainable architectural and technological concepts:

- Cluster Site Concept: Facilities are grouped based on adjacency needs to ensure smooth pedestrian and vehicular circulation.
- Integrated Waste Treatment Plant (IWTP): A Biofil Digester system is proposed to mimic natural aerobic decomposition. This achieves zero-discharge of wastewater, generates biogas for energy, and provides nutrient-rich filtered water for site landscaping and adjacent experimental farms.

5 CONCLUSION

The high rate of vegetable spoilage in Nigeria—driven by poor storage, inadequate processing facilities, and erratic power supply—poses a massive threat to food security and economic growth. The establishment of the Vegetable Preservation Centre in Mbaukwu serves as a comprehensive architectural and industrial solution to this crisis. By integrating an efficient I-line processing layout, state-of-the-art dehydration and freezing technologies, and sustainable waste management systems, the facility will drastically reduce post-harvest losses. Furthermore, the centre aligns with the Anambra State Government's objective to legalize and expand the exportation of indigenous vegetables, thereby generating substantial rural and urban employment, boosting state revenue, and improving farmers' livelihoods.

Recommendations

Based on the architectural and operational findings, the following recommendations are proposed:

- Structural Adaptability: Industrial buildings must be designed for general-purpose use with maximum flexibility for future expansion. Single-storey production halls should utilize wide-spanning portal frames or lattice trusses to provide unobstructed floor space.
- Strict Zoning: There must be a clear separation between noisy, heavy-duty production zones and quiet administrative/research zones to ensure acoustic comfort and worker productivity.
- Sustainable Waste Management: The implementation of Integrated Waste Treatment Plants (such as the Biofil Digester) should be mandated for agro-industrial facilities to ensure safe, zero-emission disposal of organic waste and wastewater.
- Export Compliance: The centre must consistently utilize electrolyzed water washing and precise steam blanching to ensure all processed vegetables meet European maximum residue levels (MRLs) and international phytosanitary standards.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

Acknowledgments

The author expresses unalloyed appreciation to the Almighty God for inspiration. Profound gratitude is extended to the research supervisor, Arc. (Mrs) O.C. Ifebi, and other faculty members including Arc. Dr. K. Ezeji, Arc. C.T.N.M Madubuko, Arc. Dr. B.O. Agoha, Arc. P.O.C. Osunkwo, Arc. B.S.A. Okoye, and Arc. A.I.V. Maduabum for their tireless guidance and contributions to the success of this project. Sincere thanks are also extended to Mr. and Mrs. A.S. Okekeaji, siblings, and friends (Uzoeghelu Kenechukwu, Dona-Ezennaka Izuchukwu, and Obiakor Nnamdi) for their unwavering support.

Disclosure of conflict of interest

The author declares that this work is a product of original research and has not been presented elsewhere for the award of a degree or certificate. All sources have been distinguished and appropriately acknowledged, and no competing financial interests exist.

Statement of ethical approval

This dissertation was examined and formally approved for the degree of Master of Science in Architecture by the Department of Architecture and the School of Post Graduate Studies, Chukwuemeka Odumegwu Ojukwu University.

Statement of informed consent

Informed consent was obtained from all individual participants and stakeholders interviewed for this study.

REFERENCES

[1] Uzo J. Vegetable Production and Breeding within the Green Revolution Programme. Paper Presented at the 6TH National Horticultural Conference. University of Nigeria Nsukka; 1989.

[2] Agro Nigeria. Nigeria food waste at 750bn yearly. Agro Nigeria; 2016. Available from: https://agronigeria.com.ng/

[3] PremiumTimes. 55 per cent Nigeria's fruits vegetables perish consumption. PremiumTimes; 2016. Available from: https://www.premiumtimesng.com/

[4] Iwuora EO. The need for a Vegetable Preservation Centre. Unpublished Author's Field Work; 2018.

[5] Christoph R. Line Layout Strategies – Part 2: I-, U-, S-, and L-Lines. AllAboutLean.com; 2016.

[6] The Steel Construction Institute (SCI). Best Practice in Steel Construction - Industrial Buildings. Technische Universität Dortmund, Germany: The Steel Construction Institute; 2008.

[7] Fellows P. Guidelines for Small-scale Fruit and Vegetable Processors, Issue 127. New York: Food and Agriculture Organization of the United Nations; 1997.

[8] Henneman A, Malone N. Drying Vegetables. Utah State University Extension; 1994.

[9] Greg SC. Investigating methods of conditioning fresh vegetables in retail establishments. Ohio State University; 2014.

[10] Kothari C. Research Methodology Methods and Techniques. New Delhi: New Age International (P) Ltd., Publishers; 2004.