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WASTEWATER MANAGEMENT IN TOMATO FACTORIES

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ABSTRACT: *Tomato (Lycopersicon esculentum) is a globally consumed vegetable with a significant role in the food industry. In 2021, global tomato production exceeded 189.1 million metric tons, emphasizing its economic importance. This research delves into the challenges posed by wastewater generated during tomato processing and explores sustainable strategies for managing it. Case studies were conducted in tomato processing plants in California, Kadawa (Kura LGA, Kano State), and Kumo (Gombe State) to assess their wastewater management practices. The findings revealed a lack of uniform wastewater collection systems in the studied factories, highlighting the need for improved environmental sustainability. As Bauchi State's population and industrialization grow, addressing the wastewater issue becomes increasingly urgent. Inadequate wastewater management can have detrimental effects on human health, water supplies, and the environment. To mitigate these challenges, this study proposes the integration of sustainable techniques in tomato processing factories. The objectives include quantifying wastewater generation, designing a functional factory layout applicable to other food processing industries, and creating a factory design that promotes sustainable water use. Site selection criteria were established, focusing on accessibility, labor availability, utilities, expansion potential, topography, and environmental impact. After a thorough evaluation, a site in Hardawa, Misau Local Government Area of Bauchi State, was identified as the most suitable location for the proposed tomato processing factory. The factory's design brief includes provisions for production facilities, administrative blocks, and worker facilities. Space requirements were determined based on the anticipated activities within each section. The proposed design emphasizes water harvesting and recycling to reduce wastewater generation and promote sustainability. In conclusion, this research underscores the importance of addressing wastewater management in tomato processing factories. By implementing sustainable design principles, factories can minimize environmental impact, enhance operational efficiency, and demonstrate commitment to ethical business practices. The proposed design offers a comprehensive solution to the wastewater challenge, ensuring compliance with environmental standards and safeguarding natural resources. Recommendations include collaboration between factory management and government authorities, the adoption of sustainable design approaches in future tomato processing facilities, and the allocation of resources for ongoing maintenance. Embracing these recommendations will contribute to more responsible and environmentally conscious tomato processing practices.*

KEYWORDS: Wastewater Management, Tomato Factories, Lycopersicon Esculentum

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INTRODUCTION

One of the most widely consumed vegetables worldwide is the tomato (*Lycopersicon esculentum*). The food industry also makes extensive use of it as a raw material for the creation of derivative goods like purees and ketchup (Campbell, 2007). It is also the most popular vegetable in the Mediterranean diet, which is known to be good for one's health, particularly in terms of preventing the onset of chronic degenerative disease. Tomatoes are a good source of antioxidants, which is why they are so healthy, according to Conrad et al. (2016). In 2021, the world produced slightly more than 189.1 million metric tons of tomatoes, according to data compiled and updated by the FAO as of December 2022. This represents a 2% increase over the 184.8 million metric tons harvested in 2020 and a 4% increase over the three-year average (182.7 million metric tons) from 2018 to 2020.

These numbers show that a substantial number of nations' yearly tomato production has reached or surpassed the million-tonne mark. Cameroon and Indonesia produced roughly 1.1 million mT, which is much less than Iran's 3.4 million mT and six times less than Italy's 6.6 million mT. Turkish production (13 million mT) was twice as much as Italian production (11 million mT), but it was barely a fifth of China's crop (67 million mT), which was responsible for roughly 36% of the global harvest (Branthôme 2023).

Nigeria now produces 10.8% of the fresh tomatoes in the continent, making it the second-largest producer (Taofiq, 2017). With 2.3 million tons produced in 2016, the nation ranked as the 14th largest tomato grower globally (Taofiq, 2017). This contributed only slightly (1.2% of the global output in 2016). According to Mapping of Tomato Clusters in Northern Nigeria (MTCNN, 2017), tomatoes may be grown in most of Nigeria, although the Savannah agro-ecological zone is the best because there are less pests and illnesses that affect tomatoes there. The main tomato-growing regions are located between latitudes 7.5oN and 13oN, with temperatures ranging from 25oC to 34oC. These states are Bauchi, Benue, Borno, Kano, Kaduna, Plateau, Jigawa, as well as certain southern states including Delta, Kwara, and Oyo (Ugonna et al., 2015), with Bauchi being the fourth-largest tomato producer in the world. Since they are a warm-season crop, these tomatoes might be damaged by heavy rain or excessive humidity. Thus, in the Northeastern states that produce tomatoes, Bauchi state ranks first, yields are increased in well-drained, sandy loam, and rich in humus soils.

In contrast to fresh tomatoes, processing tomatoes are quickly processed into paste, diced tomatoes, juice, ketchup, and other value-added goods after being collected (Canned tomato products, 2016). Products from commercial tomato processing are offered to consumers as completed items or as bulk materials to other food processors. When tomatoes are processed, over 70% of them become paste. Once tomatoes are delivered from the field, the primary processes for making paste are washing, crushing, pressing, condensing, packaging, and industrial sterilizing (Gould, 1992). Reducing the amount of water transferred from location to location allows for more efficient tomato transportation by concentrating tomato juice into paste. To produce the sauce or juice they want, processors might add back water.

Wastewater is a byproduct of several production operations, regardless of the final product. Wash water, flume water used to transport tomatoes around the processing facility, condensate from juice evaporation, and cooling water used after products have been heat sterilized are some of the sources of wastewater. A settling pond located outside the plant is where all of these wastewater sources are gathered. Heavier sediment sinks to the bottom of the pond.

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Following that, the water is moved through irrigation ditches and released onto fields of forage crops outside the processing complex. Larger facilities in California deal with several hundred million gallons of wastewater each season, and treating and/or discharging it can cost hundreds of thousands of dollars (Amón et al., 2018; Mannapperuma et al., 1993; Water Resource Control Board, 2020b). The process water has been characterized and found to have a high biological oxygen demand (BOD), nitrates, salinity, and low pH. As a result, careful monitoring is needed while discharging this substance onto land. The soil fertility may be decreased if these elements are released into the soil repeatedly. Process water leaking into groundwater can cause runoff into rivers, which will eventually lead to drinking water. Given these environmental issues, it is necessary to enhance the current land-discharge management techniques in order to reduce the negative effects on natural resources and preserve the best possible growing conditions for the agricultural sector (Noukeu et al., 2016). There are several possibilities for the reuse or disposal of wastewater. For a specific process, like washing or boiler blowdown, industrial water must meet certain quality requirements. If the process water complies with those specifications, it may be circulated inside the building (Mahoney et al., 2018).

Due to its high organic content, industrial effluent typically has a high Chemical Oxygen Demand (COD) value. Olive mill effluent, for instance, has a COD content of 48,500 mg/L, while wastewater from the production of potato chips has a COD value of 2,800 mg/L. According to Yuliani and Akkas (2017), the effluent from the ketchup business contains 2,935.4 mg/L of Biological Oxygen Demand (BOD) and 610 mg/L of Total Suspended Solid (TSS). Due to the low waste biodegradability, high toxicity, and hazardous by-products caused by the high concentration of pollutants, industrial wastewater treatment encounters some operational issues (Abdelwahab et al., 2009). Industrial wastewater treatment already uses a variety of alternatives (Niazmand et al., 2020). Alternative technologies include chemical precipitation (Cosgrove et al., 2019), adsorption (Kofa et al., 2017: Kirisits et al., 2019), biotechnology (Albergamo et al., 2018), reverse (Dura & Breslin 2019; Liu et al., 2020), ion exchange (Al-Amshawee et al., 2019), electrodialysis (Al-Hamdi et al., 2017).

Before being processed into a final product, field-harvested tomatoes are washed, rinsed, and sanitized using water, one of the most crucial raw materials in tomato processing factories. Large amounts of wastewater are produced during tomato factory operations, and this is now a major global concern (Fritsch, 2017). Urbanization has made it difficult for tomato companies to discover ways to reuse the vast amounts of wastewater produced during the washing and sanitation of tomatoes (Florida Tomato Committee, 2007), which must be disposed of in an environmentally responsible manner. Urban water recycling management, the use of rainwater tanks, the reuse of treated wastewater to regulate water runoff, and keeping the water where it falls as much as possible have all been improved over time. This increases environmental sustainability. Peels, seeds, fibrous components, and pulp leftovers are among the other waste products created during the manufacturing of tomato paste in factories.

The necessity for an appropriate and effective waste management system is becoming increasingly pressing as Bauchi State's population and industrialization grow. If improperly handled or disposed of, the wastewater produced by these enterprises could be dangerous to human health. By using sustainable wastewater management techniques, manufacturers can demonstrate their dedication to moral and ethical business practices as well as their compliance with environmental standards. For enterprises to reduce their environmental effect and guarantee regulatory compliance, wastewater management is crucial. In order to avoid

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pollution and save our natural resources, it entails the proper treatment and disposal of water used in industrial operations. The host communities of these companies are at risk for environmental health due to the inadequate management of wastewater by factories, particularly in Bauchi State. This may contaminate the water supplies in the towns, draw insects and rodents, and cause respiratory illnesses, skin, nose, and eye irritation, gastrointestinal problems, exhaustion, migraines, and psychological problems, as well as allergies.

This study aims at integrating some sustainable techniques in tomato processing factories. This will be achieved through the following objectives: to determine the typical quantity of waste water generated from tomato processing factory; to determine the functional layout of a tomato processing factory that can be adoptable for other food processing; and to design a tomato processing factory that will aid sustainable use of water.

METHODOLOGY

Data was gathered for this study through three tomato processing plants (Manto Processing Company, Kumo Gombe State, Dangote Tomato Processing Factory, Kura Local Government, Kano State, and Morning Star Tomato Processing Factory, Florida). This was done to allow for extensive consultation and to obtain enough data directly from the research's intended audience. An in-depth case study was used as the major data collection tool (Inuwa, 2014). In order to gather the necessary information through photographs, observations, and a checklist, the selected cases were visited and were led by the tour-guide working in the selected cases.

The proposed site's features, characteristics, geography, and vegetation, among other things, are some of the primary sources of the data that were gathered. Site visits helped achieve this. Case studies helped the researcher gather data on the production procedures involved in the design, noting the conditions of various case studies of existing facilities linked to the project, which gave a basis for producing an evaluation in accordance with that basis (Yin, 2009). A description of the case's physical details served as the basis for the case study. In order to get the information required for analyses, the chosen cases were visited, and assistance with a guided tour of the factory was arranged.

RESULTS AND DISCUSSION

Table 1: Cross Case analyses of Manto, Dangote, and Morning Star Companies

SN	List	Manto	Dangote	Morning Star
1	Inspection/weighing unit	+	+	+
2	Processing unit	+	+	+
3	Laboratory unit	+	+	+
4	Utilities unit	+	+	+
5	Farm workshop and maintenance unit	-	+	+
6	Administrative block	+	+	+
7	Accounting section	+	+	+
8	Worker’s facilities e.g., canteen, kitchen	+	+	+
9	Staff quarters	-	-	+

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10	Generator house	+	+	+
11	Clinic	-	-	+
12	Reservoir	+	+	+
13	Tools making unit (about 60% of the machine part are been produced by the unit)	-	-	+
14	Landscape	-	-	+
15	Adequate natural ventilation	+	+	-
16	Adequate natural lightening	+	+	-

According to this study, the Manto tomato company makes around 27,000 tonnes of tomato paste annually, and during the production process, 25,000 to 30,000 liters of waste water are produced weekly from washing, rinsing, and sanitizing. A multipurpose production line owned by the company makes mango, tomato juice, and tomato paste. Because mango and tomato trees bear fruit at different times of the year, the business can operate all year long. The factory lacks a wastewater collection system for water harvesting. The plant has a reservoir that gathers waste water from the production area; however, because the business lacks a system for recycling waste water, once the reservoir is full, the leftover waste water is diverted to the outside environment.

According to AfricaBusinessCommunities.com, the Dangote tomato processing plant processes roughly 500,000 kg of tomatoes per day. This enormous quantity of tomatoes requires a lot of water to wash, rinse, and sanitize them before processing. By the end of the week, 30,000–40,000 liters of water (or roughly 6,000 liters per day) have been used to clean these tomatoes. Although the firm has already built an irrigation farm to assist in managing the amount of wastewater discharged into the surrounding area. The enterprise has a single production line that solely makes tomato paste. It also gathers water from roof tops, has a reservoir to catch production-related waste water, and channels the rest outside.

Although the Morning Star factory produces 40% of the industrial paste used in the US, it lacks a typical wastewater harvesting system. According to Dala Kasler, the firm was assessed a fine of $1.5 million in 2016 for breaking wastewater discharge restrictions due to the production of 3,534 liters of wastewater per day without the use of a typical harvesting device. The company has two production lines to make tomato paste and diced tomatoes.

The three case studies (Table 1) demonstrate that the three businesses lack a uniform wastewater collection system, which should be investigated to increase environmental sustainability.

At the end of the study, a proposed design was made by employing some sustainable techniques to serve as a solution to the problem identified. Pursuant to that, a proposed site was located in Hardawa community, Misau Local Government Area of Bauchi state. The choice of the community is influenced by so many criteria.

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Site Selection Criteria

The analysis must be carefully done bearing in mind the conditions laid down for such a site selection. For the tomato processing factory, the analysis sites are all in Bauchi State and therefore only one that has the most advantage over the other shall be considered for the project.

Therefore, the selection criteria was focused on the following:

1. **Accessibility**: Accessibility to sources of raw materials, accessibility to market area of the finished product. Also, proximity from the immediate neighborhood.
2. **Labour**: Labour force is the backbone of every factory. Proximity to both skilled and unskilled labor will be favored.
3. **Utilities**: Public utilities such as water, electricity and telephone must be present. Water and electricity are of paramount importance.
4. **Expansion**: Factory site should be able to expand in due course, site with good expansion potential was considered.
5. **Topography**: The gradient of the site, drainage system of the site was noted. Relatively flat ground surface is best for good industry's flow.
6. **Impact on environment**: It is important to assess the impact of the proposed factory on the surrounding area in terms of noise, vibration and efficient disposal. Nature of surroundings and tend of future development.

Site Selection

Two (2) sites were objectively compared based on the above criteria to select the most suitable for the design, the sites were compared to get the best assessment.

Fig. 1 and 2: Google earth image of site "A, B" showing the immediate neighborhood

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Fig. 3: Google earth image of site "C" showing the immediate neighborhood

Site A

Site A is located in Hardawa, Misau Local Government Area of Bauchi state. By careful analysis the following site potentials were observed.

1. The land is large enough to accommodate the factory with future expansion. There is access to major roads to ease transportation.
2. The site is located within the view of interstate and local routes.
3. The soil is of high load bearing capacity which can withstand or support construction.
4. Availability of infrastructure like water, electricity, and other services.
5. There is also availability of skilled and unskilled labor around.
6. Most importantly, the site is close to the available tomato farms which makes it easy to access.

Site B

Site B is located in Mainari of Misau Local Government Area, Bauchi state. The site is a gentle slope; the vegetation is bound by farming activities. The vegetation there is mostly grasses and shrubs with few trees around (Fig. 23).

a) The site is also large enough to accommodate the factory building for further expansion.

b) There is access to major roads.

c) There is the presence of water bodies.

d) Absence of labor force, especially skilled labor.

e) Poor telecommunication services.

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Site C

Site C is located in Bagel, Dass Local Government Area of Bauchi state. By careful analysis, the following site potentials were observed.

1. The land is large enough to accommodate the factory with future expansion. There is access to major roads to ease transportation.

2. Availability of infrastructure like water, electricity, and other services.

3. There is also availability of skilled and unskilled labor around.

4. The level of tomato production in the local Government area is very low due to soil variation.

Site Location

Based on the above selection process, all the factors/criteria have been carefully assessed and studied at the end of which site A, located within Hardawa in Misau Local Government Area was selected as the most suitable and compliant with the site criteria set. The site for the tomato factory is located in Hardawa, Misau Local Government Area. The community lies a few kilometers away from Misau, the headquarter of Misau Local Government area of Bauchi State. Apart from the production of tomato, Misau is well known for farming watermelon and mango fruit. These fruits can be found in the neighboring areas of Misau LGA. All these fruits are of varying seasons and when these are merged in the tomato factory, it will enable the factory to be in production all year.

Fig 1: Analysis of site conditions and surroundings, climate and other relevant parameters

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Design Brief

The State Government has expressed its desire to establish a Tomato processing factory towards employing the concept of water harvesting to achieve sustainability. Being aware of the problem of tomato wastes when it is in season. The Government intends to establish ways to tackle this wastewater in an environmentally sustainable way.

To achieve this, the factory is expected to provide space solution for:

1. Factory:

1. Production hall
2. Maintenance workshop
3. Raw material storage
4. Finished product storage
5. Loading and off-loading bay
6. Changing room
7. Labs

2. Administrative Block

1. Management office
2. Clinic
3. Canteen
4. Retail outlet/showroom
5. Security outpost

3.2 Schedule of Accommodation

To achieve the required space solution for the design, the following schedule of accommodation is provided:

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Table 2: Administrative Block

Activity	**No of Users**	**Total Floor Area (M^2)**
Reception/Waiting	8	43.20
Sales Manager	1	36.00
Marketing Department	2	42.00
General Manager	1	42.00
Personal Manager	1	36.00
Secretary to General Manager	1	36.00
General Staff Officer	3	36.00
Agric Officer	3	36.00
Acct. Dept.	2	36.00
Board Room	17	60.00
General Store	1	36.00
Asst. G. M's Office	1	36.00
Display Room	2	35.25
Total		**510.25m^2**

Table 3: Workers Facilities

Activities	**No. of Users**	**Total Floor Area (M^2)**
Raw Material Reception	5	900.00
Processing Hall	17	1134.00
Store	1	225.00
Quality Control	2	18.00
Laboratory	2	15.50
Tool Room	3	9.00
Empty Can Store	1	9.00
Packaging	2	9.00
Technical Officer	1	9.00
Processing Engr.	1	9.00
Control Room	1	9.00
Clinic	1	18.00
Total		**2,364.5m^2**

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CONCLUSION AND RECOMMENDATION

This study's conduct and its subsequent conclusions were motivated by the hopes for a long-term solution to the identified problem. Case studies were carried out in California, Kadawa in the Kura LGA of Kano state, and Kumo in Gombe state. Variables were used to evaluate each tomato processing plant's performance.

The case studies show that most businesses do not adopt the principle of water harvested and recycling as a sustainable architectural design that will aid in an essential part of sustainable construction, contrary to the study's attempt to view the issue of water harvesting as a sustainable design principle. However, when compared to expectations, the overall performance of the three (3) tomato processing factories on which case studies were presented falls short of the required standard. The findings aid in mitigating the methods and effects of sustained human change of the natural environment. The two local case studies fell short in terms of sustainable techniques, construction components, and building aspects. In this context, the idea of sustainable approaches is used to address the issue of waste water in the factory and prevent costs from being spent during the production process. The size of the reservoirs for collecting water and other liquid wastes makes this apparent in the suggested design.

Issues have been found and used design to address them in the area of our research findings. Thus, in order to decrease the amount of waste water generated in factories, it is advised that the tomato processing factory be built in accordance with the sustainability principle, with an emphasis on the topic of water harvesting and recycling. There should be significant cooperation between the management of the factories and the government authorities because some tomato processing factories are deteriorating as a result of neglect by the relevant authorities. This can be accomplished by hiring personnel for building maintenance who will be in charge of maintaining the factory.

Finally, this study makes the recommendation that the design approach presented here be accepted and thereafter applied whenever it is necessary to build a factory for processing tomatoes in order to reduce waste water.

REFERENCES

Abdelwahab, O., Amin, N. K., & El-Ashtoukhy, E.-S. Z. (2009). Electrochemical removal of phenol from oil refinery wastewater. *Journal of Hazardous Materials*, *163*, 711–716.

Al-Amshawee, S., Yunus, M. Y. B. M., Azoddein, A. A. M., Hassell, D. G., Dakhil, I. H., & Hasan, H. A. (2019). Electrodialysis desalination for water and wastewater: A review. *Chemical Engineering Journal, 380*.

Albergamo, V., Blankert, B., Cornelissen, E., Hofs, B., Knibbe, W.-J., van der Meer, W., & de Voogt, P. (2018). Removal of polar organic micropollutants by pilot-scale reverse osmosis drinking water treatment. *Water Research*, *148*, 535-545.

Al-Hamdi, A. M., Rinner, U., & Sillanpää, M. (2017). Tin dioxide as a photocatalyst for water treatment: A review. *Process Safety and Environmental Protection, 107,* 190–205.

Campbell, J. K., Engelmann, N. J., Lila, M. A., & Erdman, J. W. Jr. (2007). Phytoene, Phytofluene, and Lycopene from Tomato Powder Differentially Accumulate in Tissues of Male Fisher 344 Rats. *Nutrition Research, 27*(12), 794–801.

Article DOI: 10.52589/AJENSR-NOIFZUQO
DOI URL: https://doi.org/10.52589/AJENSR-NOIFZUQO

Conrad, A. C., & Mathabatha, M. F. (2016). Elucidating Variable Traits of Flower Pigments in Clivian Plants' Species. *Vegetos, 29*, 4–15.

Cosgrove, S., Jeferson, B., & Jarvis, P. (2019). Pesticide removal from drinking water sources by adsorption: A review. *Environmental Technology Review, 8*, 1–24.

Dura, A., & Breslin, C. B. (2019). The removal of phosphates using electrocoagulation with Al–Mg anodes. *Journal of Electroanalytical Chemistry, 846*.

Florida Tomato Committee. (2007). Taskforce on Operation for Utilization of Tomato packing house waste and waste water. University of Florida.

François-Xavier Branthôme. (2023). Worldwide (total fresh) tomato production in 2021. [URL]

Fritsch, C., Staebler, A., Happel, A., Márquez, M. A. C., Aguiló-Aguayo, I., Abadias, M., ... Belotti, G. (2017). Processing, Valorization and Application of Bio-Waste Derived Compounds from Potato, Tomato, Olive and Cereals: A Review. *Sustainability, 9*(1492), 1–46. doi:10.3390/su9081492.

Hamdan, S. S., & El-Naas, M. H. (2014). An electrocoagulation column (ECC) for groundwater purification. *Journal of Water Process Engineering, 4*, 25–30.

Hashim, K. S., Kot, P., Zubaidi, S. L., Alwash, R., Al Khaddar, R., Shaw, A., ... Aljefery, M. H. (2020). Energy efficient electrocoagulation using baffle-plates electrodes for efficient Escherichia coli removal from wastewater. *Journal of Water Process Engineering, 33*.

Kirisits, M. J., Emelko, M. B., & Pinto, A. J. (2019). Applying biotechnology for drinking water biofiltration: Advancing science and practice. *Current Opinion in Biotechnology, 57*, 197–204.

Kofa, G. P., Gomdje, V. H., Telegang, C., & Koungou, S. N. (2017). Removal of fluoride from water by adsorption onto fired clay pots: Kinetics and equilibrium studies. *Journal of Applied Chemistry, 2017*, 1–7.

Liu, Z., Lompe, K. M., Mohseni, M., Bérubé, P. R., Sauvé, S., & Barbeau, B. (2020). Biological ion exchange as an alternative to biological activated carbon for drinking water treatment. *Water Research, 168*.

Noukeu, N. A., Inocent, G., Priso, Richard, Din, Ndongo, Taffouo, Victor, Dibong, S. D., & Ekodeck, Georges. (2016). Characterization of Effluent from Food Processing Industries and Stillage Treatment Trial with Eichhornia crassipes (Mart.) and Panicum maximum (Jacq.). *Water Resources and Industry, 16*.

Taofiq, O. (2017). Trend Analysis of Tomato Production in Nigeria (2010 – 2014).

Ugonna, C. U., Jolaoso, M. A., & Onwualu, A. P. (2015). Tomato Value Chain in Nigeria: Issues, Challenges and Strategies. *Journal of Scientific Research & Reports, 7*(7), 501–515. doi:10.9734/JSRR/2015/16921.

Article DOI: 10.52589/AJENSR-NOIFZUQO
DOI URL: https://doi.org/10.52589/AJENSR-NOIFZUQO