



**ASSESSMENT OF THE EFFECTS OF ZERO ENERGY COOLING CHAMBER (ZECC)
TECHNOLOGY ADOPTION OF TOMATO (*SOLANUM LYCOPERSICUM*) AMONG
FARMERS IN KANO STATE, NIGERIA**

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ABSTRACT

The study assessed the effect of zero energy cooling chamber (ZECC) technology among tomato farmers in Kano State, Nigeria. Multi-stage sampling procedure was used to select 401 farmers in the study area. Primary data were collected using structured questionnaire and data were analysed using descriptive statistics and t-test. The result revealed that minimum, maximum and average quantity of tomato spoiled before adoption of ZECC were 11, 45 and 28 baskets of tomatoes, respectively with a standard deviation of 1.081. Also, the results show that the minimum, maximum and average quantity of tomato spoiled after adoption of ZECC were 1, 16 and 5.5 baskets of tomatoes, respectively with a standard deviation of 3.170. Further, result show that minimum, maximum and average quantity of tomato spoiled before adoption of ZECC were 1, 9 and 3 days, respectively with a standard deviation of 0.949. Also, the results show that the minimum, maximum and average quantity of tomato spoiled after adoption of ZECC were 1, 19 and 12 days, respectively with a standard deviation of 1.462. Result on income of tomato production before adoption of ZECC technology revealed that minimum, maximum and mean income obtained by the farmers were ₦23,000.00, ₦55,000.00 and ₦55,2550.00, respectively. While the minimum, maximum and mean income after adoption of ZECC technology were ₦39,000.00, ₦98,000.00 and ₦94,624.00, respectively. Result on paired t-test on the quantity of tomato spoiled, duration of spoilage and income, before and after adoption of ZECC technology revealed that there was significant difference at $P < 0.001$, $P < 0.05$ and $P < 0.01$, respectively. The constraints affecting adoption of ZECC technology were inadequate government support as a severe constraint, pest and disease, among others. The study concludes that there was positive impact on tomato storage using ZECC technology. The study recommends enhancement on training farmers on ZECC technology in order to increase level of adoption which in turn increase life shell of tomatoes and farmers' income in the study area.

Keywords: Adoption, Effect, Energy, Tomato and Technology

INTRODUCTION

About 60% of Africa labour force still derive their livelihood from agriculture, making it the largest employer of labour in most developing countries. Although global food production has increased significantly as a result of adoption of agricultural innovations (improved crops varieties) and other associated technologies such as fertilizer, herbicides and pesticides with sub-Saharan African region making steady rise in agricultural productivity as a result of agricultural technology adoption (Fuglie and Rada, 2013). The need to develop improved varieties and locally available technologies in tomato production and storage that are disease, pest or weed resistant and which can retain its nutritional content; and that can withstand changing weather has been in the

heart of various researchers and institutions (Welch and Graham, 2004). This has become necessary in achieving food security, not only for good quality tomato after storage but also translate to yield increase by the producers but also for improved nutritional quality of crops by way of bio-fortification of some of African's major staples- most importantly tomato (Harvest Plus, 2012). Tomato cultivation is very popular among arable crops farmers in Nigeria particularly Kano State due to its high socio-economic and nutritional value and importance in tackling food insecurity and poverty (Bada, 2017). A number of studies, conducted in various parts of Nigeria suggest some factors (constraints) that are responsible for high postharvest loss include pest, disease, poor storage facilities, transportation cause, mechanical cause among others (Odoemenem and Obinne, 2010; Kudi *et al.*, 2011; Idrisa *et al.*, 2012). Most of the studies conducted on tomato are limited to its output, income generated and scale of production among others and consequently have been unable to employ some of the underlying information regarding on how to improve on its storage to reduce postharvest loss which greatly affect farmers. This suggests that more detailed studies are still required to support existing findings to uncover some factors that have effect and can influence adoption of improved technologies.

According to Singh *et al.* (2010) Zero Energy Cooling Chamber Technology (ZECC) was established by Roy and Khurdia (1983) at IARI, Pusa, New Delhi for the storage of fruits greatly reduced post-harvest losses and preserved the quality of the produce. Materials like brick, sand, bamboo, gunny bags, etc., it is a technology that is simple to build. It is a technology that improves the quality and lessens the immediate deterioration of agricultural produce after harvest; its basic working principle depends on cooling through evaporation. Its key benefit is that it can function without using any power or energy. Sand, bamboo, a brick wall, and other readily available and inexpensive materials are examples. It is a double-brick construction with a chamber that is water-soaked and has walls that are filled with sand. The steps for building it are as follows: choosing an elevated level area with adequate water supply, laying out a floor of bricks with dimensions of 165 cm by 115 cm, building a double wall of brick at a height of 67.5 cm, leaving a gap of 7.5 cm between the two walls for filling with river sand after soaking in water, and covering the top with bamboo straw and other locally available materials to shield the chamber from direct sunlight or rain.

The advantage of ZECC is that it lowers temperature by 10% to 15% while maintaining high humidity. Additionally, it aids in the reduction of tomato and other fruit and vegetable distress sales, improving the marketability of fresh horticulture goods while preserving their nutritional content. The implementation of the low cost Zero Energy Cooling Chamber (ZECC) for short-term on-farm storage of perishable farm products has enormous potential in light of the severe energy constraint and inadequate cold storage facilities in rural areas. The system will significantly reduce the 40–50% loss of tomatoes produced as a result of inefficient handling, storage, processing, and preservation. One such technique is ZECC, which uses evaporative cooling to extend the shelf life of fresh goods without using any external power. ZECC technology was successfully tested by Lata and Singh (2013) for Gujarati farmers, and they discovered that they were very effective in extending the shelf life of perishable crops. Kumar *et al.* (2014) successfully studied the use of ZECC. The ZECC could maintain a relative humidity of about 95% while lowering the temperature by a range of ten to fifteen degrees (Singh *et al.*, 2010). The specific objectives were to;

- i) Examine the effect of adopting ZECC technology by tomato farmers
- ii) Describe the constraints affecting farmers on adoption of ZECC technology

MATERIALS AND METHODS

The Study Area

This study was conducted in Kano State. Kano state lies in the northern part of Nigeria between latitudes 11° 30' to 12° 37'N and longitude 8° 30' to 9° 35'E. The southern part of the State lies in the Northern Guinea Savannah agro-ecological zone while the remaining northern part is covered by the Sudan Savannah. Kano state shares border with Katsina state to the northwest, Jigawa state to the northeast, Bauchi state to the southeast and Kaduna state to the southwest. The annual rainfall varies from 600-1200mm in the Guinea Savannah to 300-600mm in the Sudan Savannah with a mean value of 897.7mm with and annual temperature of 26⁰- 30⁰C. The length of growing periods (LGP) ranges from 90-150 days in the Sudan and 150-200 days in the Guinea Savannah zone. This allows crops like sorghum, maize, groundnut, cowpea, millet, cassava and sweet potato to flourish well under rain fed agriculture. The production of rice, maize, tomatoes, onions and pepper is increasing as a result of development of irrigation schemes scattered within the state.

The 2006 population census estimates Kano State population at 15,076,892. Using the annual growth rate of 3.2% the projected population of Kano State by the year 2023 could be 20,000,000 (NPC, 2016). Tomato consumption is popular among the teeming population of Kano State. The major tribes are Hausa and Fulani ethnic groups but other ethnic groups inhabiting the state include almost all major and minor tribes in Nigeria. The State has 44 local Governments Areas and is classified into three Agricultural Development Programme (ADP) zones for the purpose of extension service delivery.

Sampling Techniques and Sample size

Multi-stage sampling procedure was used in selecting respondents for this study. In the first stage, all the eight local government areas (LGAs) where the technology was promoted were purposively selected. These LGAs cut across the three agricultural zones under Kano State Agricultural and Rural Development Authority (KNARDA). The LGAs were selected based on the concentration of tomato farmers and presence of existing zero energy cooling chamber technology in those areas. These LGAs are; Makoda, Bichi and Kobo in Zone I, Dambatta, Bagwai and Dawakin Tofa in Zone II with Rimin Gado and Tofa LGAs in Zone III respectively. In the second stage, sixteen villages, two from each of the identified LGAs were purposively selected based on the concentration of tomato farmers and existence of zero energy cooling chamber technology. In the third stage, a list of a total number of 802 farmers who adopted the technology was used as sample frame obtained through key informants and community facilitators from each of the selected villages. The final stage involved random selection of 50% of the farmers that adopted the technology making, a total sample of 401 farmers as shown in Table 1.

Table 1: Sampling Procedure and Sample Size

| Agric Zones | LGAs | Villages | Sampling frame | Sample Size (50%) | |
|------------------|----------|-----------|----------------|-------------------|-----|
| Zone I Rano | Makoda | Makoda | 60 | 30 | |
| | | Dogo | 60 | 30 | |
| | Bichi | A’awa | 50 | 25 | |
| | | Bichi | 20 | 10 | |
| | Kabo | Kanye | 50 | 24 | |
| | | Gude | 50 | 25 | |
| | | Sub-Total | | 290 | 144 |
| Agric Zones | LGAs | Villages | Sampling frame | Sample Size (50%) | |
| Zone II Dambatta | Danbatta | Danbatta | 56 | 28 | |
| | | Shiddar | 60 | 30 | |
| | Bagwai | Badodo | 60 | 30 | |
| | | Wadan | 30 | 15 | |
| | Dawakin | Jemomi | 50 | 25 | |
| | | Tofa | | | |
| | | Dan Itace | 50 | 25 | |
| Sub-Total | | 306 | 153 | | |
| Zone III Gaya | Rimin | Karofin | 50 | 25 | |
| | | Gado | | | |
| | Tofa | Yashi | | | |
| | | Muntsira | 20 | 10 | |
| | | Yansabo | 70 | 35 | |
| | | Yalwa | 75 | 35 | |
| | | Karama | | | |
| Sub-Total | | 215 | 105 | | |
| Grand Total | 8 | 16 | 802 | 401 | |

Source: Reconnaissance Survey, 2019

Method of Data Collection and Analysis

Primary data was used for the study. Primary data were obtained from the respondent through the use of structured open and close-ended questionnaire complemented with interview schedule. Descriptive statistical tools comprising percentage, mean, standard deviation and inferential statistic (Paired sample T-Test) was used to analyze objectives.

T-test

T-test was used by comparing the means difference between quantities of tomato spoiled, days of tomato spoiled and income of tomato production before and after adopting ZECC technology. The formula for calculating t-test is specified as follows:

a) Quantity of Tomato Spoiled:

$$t = \frac{\bar{X}_{QTSA} - \bar{X}_{QTSB}}{SED} \quad \dots (1)$$

Where,

t = t – calculated

\bar{X}_{TSA} = Mean Quantity of Tomato Spoiled After ZECC Technology Adoption in Baskets
 \bar{X}_{TSB} = Mean Quantity of Tomato Spoiled Before ZECC Technology Adoption in Baskets
 SED = Standard error of mean quantity differences

b) Days of Tomato Spoiled:

$$t = \frac{\bar{X}_{DTSA} - \bar{X}_{DTSB}}{SED} \quad \dots (2)$$

Where,

t = t – calculated
 \bar{X}_{DTSA} = Mean Days of Tomato Spoiled After ZECC Technology Adoption
 \bar{X}_{DTSB} = Mean Days of Tomato Spoiled Before ZECC Technology Adoption
 SED = Standard error of mean days differences

c) Income of Tomato Production:

$$t = \frac{\bar{X}_{ITPA} - \bar{X}_{ITPB}}{SED} \quad \dots (3)$$

Where,

t = t – calculated
 \bar{X}_{ITPA} = Mean Income of Tomato Production After ZECC Technology Adoption
 \bar{X}_{ITPB} = Mean Income of Tomato Production Before ZECC Technology Adoption
 SED = Standard error of mean income differences

RESULTS AND DISCUSSION

Quantity of Tomato Spoiled Before and After ZECC Technology Adoption in Baskets

The result in Table 2 revealed that minimum, maximum and average quantity of tomato spoiled before adoption of ZECC were 11, 45 and 28 baskets of tomatoes, respectively with a standard deviation of 1.081. Also, the results show that the minimum, maximum and average quantity of tomato spoiled after adoption of ZECC were 1, 16 and 5.5 baskets of tomatoes, respectively with a standard deviation of 3.170. This implies that after adopting ZECC technology by farmers, there was average decrease of tomato loss of 22.5 baskets with constituted about 64.3% decrease of tomato spoilage. Bada (2017) reported that post-harvest losses can be attributed to poor storage facilities, poor transportation networks, inadequate modern tomato value addition trends, disease infestation, and inability to acquire better and higher-quality seeds. This suggests that ZECC use on the farm may help lower some post-harvest losses for the reasons mentioned. The result is in agreement with the findings of Idah *et al.* (2017) that improper storage conditions and vibration caused on by undulation and abnormalities during road transit can increase tomato waste. Also, the result is in line with the findings of Sharma and Singh (2011) who report that at harvest there was greatest losses in tomato, onion, pea, potato, radish, pepper, and cabbage due to poor post management practices.

Table 2: Quantity of Tomato Spoiled Before and After ZECC Technology Adoption in Baskets

| Tomato Quantity Spoiled Before ZECC Adoption | Freq. | % | Min. | Max. | Mean | S.D |
|--|-------|------|------|------|------|-------|
| 11-17 | 19 | 4.7 | 11 | 45 | 28 | 1.081 |
| 18-24 | 189 | 47.1 | | | | |
| 25-31 | 92 | 23 | | | | |
| 32-38 | 61 | 15.2 | | | | |
| 39-45 | 40 | 10 | | | | |
| Tomato Quantity Spoiled After ZECC Adoption | | | | | | |
| 1-4 | 170 | 42.3 | 1 | 16 | 5.5 | 3.170 |
| 5-8 | 161 | 40.2 | | | | |
| 9-12 | 57 | 14.3 | | | | |
| 13-16 | 13 | 3.2 | | | | |

Source: Field Survey, 2021

Days Tomato Spoiled Before and After ZECC Technology Adoption

Table 3 shows minimum, maximum and average quantity of tomato spoiled before adoption of ZECC were 1, 9 and 3 days, respectively with a standard deviation of 0.949. Also, the results show that the minimum, maximum and average quantity of tomato spoiled after adoption of ZECC were 1, 19 and 12 days, respectively with a standard deviation of 1.462. This implies that after adopting ZECC technology by farmers, there was average increase of 9 days before tomato starts spoiling. Thus, ZECC technology has increase the shelf life of tomatoes. This result is in conformity with the findings of Krishi *et al.* (2018) that Cabbage, broccoli, and tomatoes had increased shelf life of 5 days, 2 days, and 7 days, respectively, in the trial stage. This finding is consistent with that of Ahmed (2018), who reported that various tomato varietal characteristics, such as thick flesh, a lot of seeds, smooth skin, shape, and size, increase the perishability of tomatoes and so lengthen the time it takes for tomatoes to spoil after harvest.

Table 3: Days Tomato Spoiled Before and After ZECC Technology Adoption

| Tomato Spoilage Before ZECC Adoption | Freq. | % | Min | Max | Mean | S.D |
|--|-------|------|-----|-----|------|-------|
| 1-2 | 119 | 29.7 | 1 | 9 | 3 | 0.949 |
| 3-4 | 268 | 66.8 | | | | |
| 5-6 | 13 | 3.3 | | | | |
| >9 | 1 | 0.2 | | | | |
| Tomato Spoilage After ZECC Adoption | | | | | | |
| 7-9 | 32 | 8.1 | 1 | 19 | 12 | 1.462 |
| 10-12 | 257 | 64.1 | | | | |
| 13-15 | 110 | 27.4 | | | | |
| 16-18 | 1 | 0.2 | | | | |
| >19 | 1 | 0.2 | | | | |

Source: Field Survey, 2021

Income of Tomato Production Before and After ZECC Adoption (₦)

The income of tomato production before and after of ZECC technology was shown in Table 4. The results revealed that majority (58.3%) earned between ₦29,000.00 and ₦34,000.00. The minimum, maximum and mean income obtained by the farmers were ₦23,000.00, ₦55,000.00 and ₦55,2550.00, respectively before adoption of ZECC technology. Similarly, the minimum, maximum and mean income realised after adoption of ZECC technology were ₦39,000.00, ₦98,000.00 and ₦94,624.00, respectively. The local farmers' annual farm revenue was too low to support significant agricultural development. This implies there was an increase in income after adoption ZECC technology. Also, the findings revealed that tomato farmers were operating on small scale production in the study area. This result is in conformity with that of Oni and Obiako (2022), who estimated that tomato growers earned an average monthly income of ₦30,916.67. Similarly, Jondhale *et al.* (2000) adoption of groundnut farming practices was found to have an increase in the annual revenue.

Table 4: Income from Tomato Production Before and After ZECC Technology Adoption

| Income from tomato sales before ZECC adoption (₦) | Freq. | % | Min. | Max. | Mean |
|---|-------|------|-----------|-----------|-----------|
| 23000-28000 | 115 | 28.7 | 23,000.00 | 55,000.00 | 58,255.00 |
| 29000-34000 | 234 | 58.3 | | | |
| 35000-40000 | 20 | 4.9 | | | |
| 41000-46000 | 17 | 4.3 | | | |
| 47000-52000 | 9 | 2.3 | | | |
| 53000-55000 | 6 | 1.5 | | | |
| Income from tomato sales after ZECC adoption (₦) | | | | | |
| 39000-48000 | 115 | 28.7 | 39,000.00 | 98,000.00 | 94,624.00 |
| 49000-58000 | 115 | 28.7 | | | |
| 59000-68000 | 77 | 19.2 | | | |
| 69000-78000 | 28 | 7.0 | | | |
| 79000-88000 | 38 | 9.4 | | | |
| 89000-98000 | 28 | 7.0 | | | |

Source: Field Survey, 2021

Effect of ZECC Technology Adoption by Tomato Farmers

T-test is a useful technique for comparing mean values of two sets of observations in order to evaluating whether there is statistically significant difference between the two means or not. The quantity of tomato spoiled before and after ZECC adoption, number of days for tomato to spoil before and after ZECC adoption. Also, the income of the farmers on tomato production before and after ZECC adoption were discussed. Result on t-test in Table 5 on the effect of ZECC technology on the quantity of tomato spoiled before and after ZECC adoption indicates that there was significant difference at $P < 0.001$. The mean quantity spoiled before and after adoption of ZECC technology were 28 and 5.5 baskets respectively. This implied that quantity of tomato spoiled after ZECC adoption was highly reduced which indicated a strong effect of ZECC technology. This agrees with the findings of Kandji *et al.* (2016) reported that one of the reasons why tomato farmers

in most African countries are willing to adopt improved technologies such as new variety, chemical fertilizers, and improved technology was due to high return on their investments.

Table 5: Paired T-Test Comparison between Quantity of Tomato Spoiled in Basket Before and After ZECC Technology Adoption

| Variable | Mean | S.E | Df | Mean Difference | t-ratio | p-value | Remark |
|------------------|------|-------|-----|-----------------|---------|---------|-------------|
| Qty. before ZECC | 28.0 | 1.081 | 412 | -2.089 | -8.946 | 0.000 | Significant |
| Qty. After ZECC | 5.5 | 3.170 | | | | | |

Source: Field Survey, 2021 N= 401, Qty. = Quantity, df = Degree of freedom

Result in Table 6 revealed that average days of tomato spoilage before and after adoption of ZECC technology were 3 and 12 days, respectively with a mean difference of 2.5 days. The calculated t-value was 6.2171 and significant at $P < 0.001$. This implied that there was a significant increase in number of days it took for tomato to start rotting. Krishi *et al.* (2018) reported that 80% of the farmers expand their farm land for tomato production as a result of adopting improved seed varieties and storage technology.

Table 6: Paired T-Test Comparison of Tomato Spoilage by Days Before and After ZECC Technology Adoption

| Variable | Mean | S.E | Df | Mean Difference | t-ratio | p-value | Remark |
|------------------|------|-------|-----|-----------------|---------|---------|-------------|
| Days Before ZECC | 3 | 0.949 | 216 | 2.411 | 6.2171 | 0.051 | Significant |
| Days After ZECC | 12 | 1.462 | | | | | |

Source: Field Survey, 2021 N= 401, df = Degree of freedom,

Result on t-test in Table 7 on the effect of ZECC on the income of farmers before and after ZECC adoption is presented in Table 7. The result show that the mean income of tomato production before and after ZECC technology were ₦58,255.00 and ₦94,624.00. The calculated t-value was 11.234 and significant at $P < 0.001$. This implies that there was an increase in income as a result of adopting ZECC technology.

Table 7: Paired T-Test Comparison of Farmers Income from Tomato Sales Before and After ZECC Technology Adoption

| Variable | Mean | S.E | Df | Mean Difference | t-ratio | p-value | Remark |
|--------------------|-------|-------|-----|-----------------|---------|---------|-------------|
| Income Before ZECC | 58225 | 0.933 | 186 | 35399 | 11.234 | 0.012 | significant |
| Income After ZECC | 94624 | | | | | | |

N= 401, df = Degree of freedom,

Source: Field Survey, 2021

Constraints to the Adoption of ZECC Technology in the Study Area

The difficulties tomato farmers had on adoption of ZECC technologies is presented in Table 8. The result revealed that inadequate government support was found to be the serious constraint affecting the farmers with a mean score of 3.66. This was followed by problem of pests and diseases with a mean score of 3.04. Other constraints affecting farmers were inadequate improved seeds and inadequate training on ZECC technology with mean scores of 2.19 and 2.03, respectively. This suggests that the majority of farmers complained on institutional factors rather than technological factors. This result is in agreement with the findings of Komolafe *et al.* (2014) reported that majority of the farmers identified similar constraints affecting adoption of agricultural initiatives and programmes in Niger and Ondo States. Also, Asgedom *et al.* (2010) reported that the main obstacles on tomato storage were lack of infrastructure, limited funding, outdated equipment, and low literacy among tomato producers.

Table 8: Constraints faced by Farmers in Adoption of ZECC Technology

| Constraint | VS | S | NS | Mean | Rank |
|-------------------------------------|-----------|-----------|-----------|------|------------------|
| Inadequate Government support | 36(8.9) | 191(47) | 350(87.2) | 3.66 | 1 st |
| Pest and diseases | 209(52) | 117(29.1) | 260(64.8) | 3.04 | 2 nd |
| Inadequate credit facilities/source | 164(40.1) | 119(29.6) | 118(29.4) | 1.88 | 8 th |
| Poor market after storage | 106(26.4) | 159(39.6) | 129(32.1) | 2.02 | 6 th |
| Inadequate improve seed varieties | 113(28.1) | 74(18.4) | 207(51.6) | 2.19 | 3 rd |
| High cost of materials | 155(38.6) | 177(44.1) | 62(15.4) | 1.73 | 9 th |
| Poor soil to construct ZECC | 147(36.6) | 92(22.9) | 157(39.1) | 2.00 | 7 th |
| Technicality involved in ZECC | 13(3.2) | 222(55.3) | 45(11.2) | 1.47 | 11 th |
| It consumes time | 162(40.3) | 209(52.1) | 24(5.9) | 1.62 | 10 th |
| Inadequate training on ZECC | 25(6.2) | 313(78.0) | 61(15.2) | 2.07 | 4 th |
| Poor Information network | 30(7.4) | 322(80.2) | 48(11.9) | 2.03 | 5 th |
| Poor climatic condition | 204(50.8) | 105(6.1) | 52(12.9) | 1.42 | 12 th |
| Poor Communication channel | 163(40.6) | 177(44.1) | 59(14.7) | 1.73 | 9 th |

Figures in parenthesis are percentages, VS= Very severe, S= Severe, NS= Not severe

Source: Field Survey, 2021

CONCLUSION AND RECOMMENDATIONS



The study examined the impact of ZECC technology on tomato storage for a long number of days with less postharvest loss. The study concluded that ZECC has positive effect on tomato storage in the study area. The findings indicate a significant reduction of tomato quantity spoiled and there was increased in income after adoption of ZECC technology. Based on the findings of the study, the following recommendations were made:

- i) Enhancement on training farmers on ZECC technology in order to increase life shell of tomatoes. This could be done by working with development partners to build as many tomato storage facilities as possible using various materials.
- ii) Farmers should be encouraged to patronize various market outlets in order to generate high income.
- iii) Despite the fact that the majority of the technology was only used in tomato growing areas, it must now be scaled up to other regions in order to guarantee a year-round supply of such perishable goods.

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