ANALYSIS OF SOCIO-ECONOMIC CHARACTERISTICS OF TOMATO (*SOLANUM LYCOPERSICUM*) FARMERS ADOPTERS OF ZERO ENERGY COOLING CHAMBER TECHNOLOGY IN KANO STATE, NIGERIA.

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ABSTRACT

The study conducted to assessed the socio-economic characteristics of tomato farmer adopters of zero energy cooling chamber technology in Kano State, Nigeria. Multi-stage purposive and random sampling technique was used to select 401 respondents from the three Agricultural Zones in the study area. Primary data were collected using structured questionnaire. Descriptivestatisticaltool was to analyse the data. The result revealed that the mean age of the respondents was 43 years and the mean house-hold size was 9 persons. The average farm land was 6 Ha with a mean farming experience of 13 years. The result further revealed that all (100%) the tomato farmers were males and 90.9% were married. Only (31.9%) of the farmers had primary education with mixed cropping (55.3%) as their primary occupation. The result also showed that majority (50.8%) of the farmers are members of cooperative organisation and had contact with extension agents at least twice a month. Majority (60.4%) cultivated UTC tomato variety and 33.9% cultivated Roma VF variety. The average yield obtained in 2019/2020 tomato production season was 480 baskets. Results on types of tomato packaging, handling and storage technology used before Zero Energy Cooling Chamber adoption indicated that the use of crates on the overall was highly effective with a mean value of 3.48. The study concluded that majority of the respondents were all males and fall within economically productive age group. UTC tomato variety was majorly cultivated in the area with a good yield with traditional raffia basket is the most effective method of tomato handling, packaging and storage prior to Zero Energy Cooling Chamber technology adoption. The study recommended that farmers should encourage more on the use of modern production technology and also group formation to enable them have access to both government and non-governmental support.

Keywords: Adopters, farmers,technology, tomato, Zero Energy Cooling Chamber

INTRODUCTION

Fresh fruits and vegetables generally need proper postharvest management to reduce loss and maintain quality. Today, the post harvest handling practices regarding vegetables throughout the production and marketing channels in most developing countries remain either inadequate, inaccessible, costly or not available. The growers have no storage facilities, while the transport and marketing channels also lack storage facilities. As a result, most harvested fruits and vegetables are usually stored in open places, exposed to high temperature and low relative humidity conditions (Asif and Khan, 2019).

The quality of fruits and vegetables and related

shelf life are reduced by the loss of moisture, decay and physiological breakdown and such deterioration is directly related to temperature, relative humidity, air circulation, mechanical damage, and improper postharvest sanitation.
For example, the rate of postharvest loss regarding tomato taken from farmers field to the consumer is as high as 26%. Despite the recent trend toward the increased production of vegetables in Nigeria where the average national per capital consumption of leady vegetables is 23g along

with 89g of non- leafy vegetables and 14g of fruits, the average Nigerian only consumes a total of 126g of fruits and vegetables daily (National Bureau of Statistics {NBS}, 2018). This is far below the minimum daily consumption of 400g of fruits and vegetables as recommended by Food and Agricultural Organization (FAO). World food prices have also recently increased due to natural disasters worldwide. Thus, preserving the fruits and vegetables produced is now a common issue in most developing nations. High food process is a major concern especially for low income food deficit countries that may face problems in financing food imports, and for poor households that spend a large proportion of their income on food (Konineeka and Chandan, 2019). Also, as a result of the global increase in food demand due to increase in world population and particularly of fruits and vegetables, an estimated 500 million small scale farmers are now producing almost 80% of the worlds fruits and vegetables, yet over 40% are never consumed but lost during postharvest handling (Alam, 2022). In 2011, Rockfeller Foundation estimates that in the Sub-saharan Africa, 50% 0f fruits and vegetables are lost due to either during harvest, sorting, handling, transporting and majority coming from storage.

Technologyis one of resources for agricultural production. According to Rotolo *et* al. (2015), classifies technology as an emergent and strong research designs that operationalise central theoretical activity. Technology differ widely, depending on whether the intent is to embrace the totality of human works, in all societies. Adegbola*et al.* (2012) defined technology as the application of knowledge for achieving practical goals in a reproducible way. Technology, according to Asiabaka (2016), is the systematic application of scientific and other organized knowledge for practical goals, including the development of new concepts, ideas, innovations, and materials. A more precise definition of agricultural technology would be the nature, system, and types of inputs that are integrated to carry out agricultural tasks. It may include inputs like seeds, fertilizer, pesticides, and machinery, as well as how these things are put together to carry out agricultural tasks

Zero Energy Cooling Chamber Technology (ZECC) is a technology that was design and developed by IAIR Pusa, New Delhi (Chand and Meena, 2011). It is a technology which can be constructed easily with materials like brick, sand, bamboo, gunny bag etc. It is a technology which increases the quality and reduces deterioration of horticultural produce which takes place immediately after harvest, its principle depends on cooling by evaporation. Its main advantage is that it does not require electricity or power to operate. Simple materials like brick wall structure, sand, bamboo etc available and cheap. It is a double brick wall structure with the cavity filled with sand and walls of the chamber are soaked with water. It can be constructed by using the following steps; identifying an elevated level space having enough water supply, preparing a floor with dimension of 165 cm X 115 cm and layout with bricks, double wall erection of brick at the height of 67.5cm leaving a gap of 7.5cm in between the two walls for filling of river sand after soaking with water and covering of the top with bamboo straw and other locally available materials to protect the chamber from direct

sunlight or rain.ZECC has the advantage of reducing temperature by 10-15% but keeps humidity high. It also helps reduce the distress sales of tomato and other fruits and vegetables, hence provide better marketability of fresh horticultural produce as it helps them retain their nutritive value. ZECC is also environmentally friendly with no pollution (KATARDA and TECHNOSERVE, 2012).

Farmers in Kano State have poor resource available and in the absence of proper storage technique, they usually sell their products just after harvest with little or none to store. Due to lack of sufficient storage and processing facilities in Kano State, considerable amount of tomato is spoiled after harvest, losses occur in both ways ie qualitative and quantitative terms. In Nigeria and specifically the study area- Kano State, most existing empirical studies on issues of post-harvest losses have serious limitations as most studies conducted focus on quantifying the parameters of losses, income reduction due to losses etc with little or no attention given to alternative storage technologies to reduce these losses which is more important to the farmer. Most of the existing effective storage technologies are either costly, capital intensive or not environmentally friendly as compared to ZECC technology which has no complexity, cost effective, time saving, locally produced etc. Also, the dearth of information as to the use of this technology in the study area regarding ZECC technology prompted the research.

Many studies have been conducted on the use of technologies for tomato storage but paid no attention to the level and status of the end users in a systematic way. For instance, Bada (2017) conducted a study to measure the post-harvest loss in tomato. Therefore, in order to fill the information gap and complement other studies conducted on post-harvest losses of tomato, this study has the following specific objectives;

1) describe the socio-economic characteristics of the tomato farmers in the study area,
2) identify tomato varieties planted by the farmers in the study area,
3) identify the tomato storage and handling methods used prior to ZECC adoption and
4) evaluate the effectiveness of other tomato storage and handling prior to ZECC adoption.

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'Nand 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 an annual temperature of 26^0- 30^{0}c (NIMET, 2015). 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; NBS, 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. Other Nationals from different continents of the world are also found in Kano (KNSG, 2006). This brings about different culture, norms, values and preferences as well as different consumption pattern. The State has 44 local Governments Areas and is classified into three agricultural development programme (ADP) zones by Kano State Agricultural and Rural Development Authority (KNARDA, 1995) for the purpose of extension service delivery. The zones are: zones I, zone II and zone III. Each zone comprises of a number of local government areas (LGAs).

Tomato is produced in all the three ADP zones of Kano State. In some of the Local Government Areas (LGAs), availability of irrigation facilities promotes the production of tomato.

Sampling Procedure and Sample size

Multi-stage sampling procedure was used for sample selection for this study. In the first stage, all the eightlocal 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. They are Makoda, Bichi and Kabo in Zone I, Dambatta, Bagwai and DawakinTofa in Zone II with RiminGado and Tofa LGAsin Zone III respectively.

In the second stage, sixteen villages, twofrom each of the identified LGAs were purposively selected based on the concentration of tomato farmers and existence of zero energy cooling chamber technology. The villages were: Makoda and Dogo in Makoda; Bichi and A'awafrom Bichi, with kanya and Gude from Kabo LGAs. Others are Danbatta, and Shiddar from Danbatta, Badodo and Wadan from Bagwai with Jemomi and Dan Itace from DawakinTofa LGAs. From RiminGado-Karofinyashi and Muntsira with Yansabo and Yalwa Karama from Tofa LGAs respectively.

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 this selected villages. The final stage involved random selection of 50% of the farmers that are using the technology by the use excel randomisation to come up with a total number of 401 respondents which were used for the study.

Agric Zones	LGAs	Villages	Sampling frame (N)	Sample Size (50% of N)
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**
Zone II Dambatta	Danbatta	Danbatta	56	28
		Shiddar	60	30
	Bagwai	Badodo	60	30
		Wadan	30	15
	DawakinTofa	Jemomi	50	25
		Dan Itace	50	25
Sub-Total			**306**	**153**
Zone III Gaya	RiminGado	Karofin Yashi	50	25
		Muntsira	20	10
	Tofa	Yansabo	70	35
		Yalwa Karama	75	35
Sub-Total			**215**	**105**
Grand Total	**8**	**16**	**802**	**401**

Table 1: Sampling Procedure and Sample Size for Tomato Farmers

Method of Data Collection

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. However, the questionnaire was pre tested on few selected respondents and a Cronbach's Alpha technique was used to test the validity and reliability of the instrument of data collection. Using easy cost-route approach, 2019 tomato season data was collected. Both the researcher and trained enumerators were engaged in data collection. The questionnaire sought information on socio-economic characteristics such as age, sex, education level, marital status, years of tomato farming experience, extension visit etc;

Method of Data Analysis

Descriptive statistical tool was used in analysed the data. Simple descriptive statistics involving the use of frequency counts, percentages, mean and standard deviation were used to present findings from the study.

RESULTS AND DISCUSSIONS

Socio-economic Characteristics of ZECC Technology Adopter Farmers Quantitative Socio-economic characteristics of the farmers

This section presents analysis of results based on the objective of the study. These was to: describe the socio-economic characteristics of the tomato farmers and identify and describe the tomato post-harvest technologies in used before ZECC adoption in the study area. Socio-economic characteristics play an important role in the production of fresh tomatoes. The socio-economic parameters covered in this section

werethose measured quantitatively such as age, household size, farming experience and land size. Socioeconomic characteristics is an economic and sociological combination of total measure of a person's economic and social position relative to others, based on experience, gender, age, marital status, household size, education, among others. These characteristics as they relate to the respondents are presented and discussed in the Table 2. Age of tomato farmers to a certain extent affects their managerial ability and access to land and other inputs. Age factor is also very important in terms of labour supply especially where there are no labour saving technologies. In such situations, one expects the young to be in better position to be more productive ultimately (Bello *et al*., 2016). The result In Table 2 showed that age of tomato farmers in the study area ranged between 22 and 73 with a mean age of 43years. The result indicated that farmers were in their middle ages.This implies that farmers in the study area are at their productive age. This is in line with the findings of Adeoye *et al*., (20017) who reported that majority of the farmers were in the age group of 31 and 40 years. This shows that Tomato production and marketing is dominated by middle aged people in the study area. The dominance of those in their active and productive age has an implication on sustainability of the enterprise as experience is passed on from generation to generation. Labour and productivity has a bearing on age as old people tend to adhere strictly to traditional methods while the young tend to be more willing to adopt new methods in order to increase productivity.

Household size refers to the members of the family living together and feeding from the same pot. Result in Table 2 indicates that majority of tomato producers (48.3%) had household size between 6-10 persons. Few producers (25.4%) had household sizes between 1-5 members. The average household sizes were found to be 9 persons. The minimum household size was 1 and the maximum up to 28 persons. This is in agreement with the findings of Babalola *et al.,* (2010), who reported that the mean average household size of farmers stood at 9. Members of a typical household comprises of the head, his wives, children, daughter in-law, grand children, brothers and their wives, other unrelated dependents living under the same roof and feeding from the same pot. This is a very common practice in the north due to extended family nature and polygamous marriage. In this situation, the family members provide labour to farming and marketing activities in the house.This is so to the extent that even co-tenants help while activities are going on and in return get some remuneration in kind in addition to acquiring skills. This implies that household size has a positive effect on sustainability of Tomato enterprise in the studied location.

land is typically an area devoted to agriculture. The systematic and controlled use of other forms of life- particularly the rearing of livestock and production of crops to produce food for humans and animals. It is usually synonymous with both farmland and cropland as well as pasture or rangeland (FAOSTAT, 2014). Farm size also represents the measure of land that is put under cultivation by farmers for specific farm activity. In traditional African society, it is a measure of wealth, yield and income of a farmer(Abu *et al.,* (2011).The result from Table 2reveals that about 263 tomato farmers (68%) owned a farm size of 2-3 has, 19.9 % and 11.2 % owned have about 0.5-2 and 4-6 ha respectively. The mean farm size was 6 ha with a minimum and maximum farm size of 0.5 and 9ha. This implies that majority of the farmers were operating on a small scale in the study area.

The years of experience affects the managerial ability and decision on farm operation of farmers (Idah*et ai.*, 2017). Although years of experience could positively affect the managerial ability and decision making in the enterprise, it could also hinder adoption of improved technologies. Majority (55.1&) of tomato farmers had from 1-10 years of experience while 35.9% had 11-20 years of

experience. This is line with the findings of Abimbola (2014)who reported that majority of the farmers (52.3%) in Ogbomosho had between 1 and 10 years of farming experience. Few (6.34%) of the farmers had experience of over 30 years. On the average, the year of experience of tomato farmers was 12 years. This indicates that majority of the respondents were well experienced in their business which would influence their efficiency due to knowledge about local conditions. It is also expected that this experience could reduce post-harvest losses among producers.

Table 2: Quantitative Socio-economic Characteristics of Tomato Farmers ZECC Tech. Adopters

Variable	Freq	%Min	Max	Mean	SD	
Age (yrs)						
22-31	51	12.7	22	73	43	10.053
32-41	166	41.3				
42-51	109	27.1				
52-61	59	14.7				
62-71	14	3.4				
≥72	2	0.8				
Household Size (no.)						
1-5	102	25.4	1	26	9	4.90
6-10	194	48.3				
11-15	61	15.2				
16-20	31	7.7				
21-25	11	2.7				
26 and above	1	0.7				
Land Size (Ha)						
0.5-2.5	72	19.9	0.5	9	6	14.033
2.6-4.6	273	68				
4.7-6.7	45	11.2				
6.8-8.8	1	0.9				
Farming Experience						
1-10	221	16.7	1	50	13	7.085
11-20	144	28.9				
21-30	29	33.3				
31-40	6	16.7				
41-50	1	4.4				
Total	90	100%				

Source: Field survey, 2022

Qualitative socio-economic characteristics of the farmers

Sex refers to the natural segregation of the human race into males and females and represents the sex of the tomato producers. Tomato production was found to be dominated by males. The results from Table 3 indicated that all (100%) the producers were found to be males. This isbecause tomato production and marketing are dominated by men all over the north probably due to the nature of the activities involved and cultural setting of the area. This is in line with the findings of Bada (2017) who found out that traditionally, gender segregation gives room for the division and assignment of responsibilities among people. The author added that, this has led to the categorization of jobs and activities as males tend to undertake more tedious and outdoor jobs while females were left with simpler and indoor activities.

Marriage makes an individual more responsible and takes relatively technical decisions more accurately. Results from Table 3 indicated that a high proportion (90.9%) of tomato producers were being married. Only a small proportion 1.9% of the producers were single. This implies that majority of the respondents were responsible men, can take technical decisions on their own and can put more effort to sustain domestic household demand. This finding is in consistent with the findings of Bada (2017) who reported that majority (86.4%) of the tomato farmers in Kano State were married. This could have implication on post-harvest losses in tomato production since; married farmers are likely to have access to more family labour especially for harvesting.

Education is one of the factors that affect production in a business. Akinola, (2014) defined education as a means of managerial skills. It enables an individual to appreciate the need for changes and facilitate the process of departure from traditional ways of production and marketing to modern methods. Formal education has influence on better understanding and adoption of new technologies among producers and marketers of tomatoes in addition to improving the enterprise through proper record keeping. From Table 3, a reasonable number of the producers (31.9%) had primary education while 19.7% had no formal education while 20.1%, 13.2%, 12.7 % and 2.4% of the producers had junior, tertiary and secondary education. This could affect the degree or level of acceptance and subsequent adoption of improved technologies. This is in agreement with the findings of Ayandiji and Adeniyi (2011) who reported that 82.95% of farmers have no formal education; those with secondary education are 15.91% and for those with post-secondary education were 1.14% respondents. This resulted in high adoption of ZECC technology which translated to low and contributed to low post-harvest losses in tomato production because of their level of education, knowledge and ability to read and write can appreciate and use most of the post-harvest technologies available. This situation is very common among rural communities all over the north due to as a result of awareness creation on the importance of formal education and adoption and use of modern agricultural technologies. This on the other hand, will go a long way to reduce poverty and improve the livelihood of farmers predominantly leaving in rural areas in Nigeria. This showed majority had formal education, are skilled in their production and marketing activities which implied that there would be easy, effective and efficient utilization of credit facilities, adoption of improved technology and so on.

Primary occupation refers to the main economic activity which a person or group of persons engage in over a certain period of time taking into cognisance the type of activity they are engaged in such as farming, trading etc as a means of livelihood. The result from Table 3 shows that majority (55.3%) of the farmers were engaged in mixed croppingand tomato farming

with 39.6% only were engaged in other activities. This is in consistent with the findings of Adeoye *et al*., (2017) who reported that 69% of the farmers are mostly engaged in only farming only. It also in agreement with the findings of Mustapha *et al.,* (2015) who opined that an additional advantage to adopt technology by farmers is directly related to his main means of livelihood. This implies and signifies the high level of adoption of ZECC technology and its subsequent sustainability since the predominant activity engaged in the area is farming.

Table 3: Qualitative Socio-economic Characteristics of Tomato Farmer ZECC Tech. Adopters

Variable	Frequency	Percentage (%)
Sex		
Male	401	100
Sub-Total	401	100
Marital Status		
Single	8	1.9
Married	393	90.9
Sub-Total	401	100
Educational Status		
No formal education	79	19.7
Primary	128	31.9
Junior Sec. school	81	20.1
Senior Sec. School	51	12.7
Tertiary	53	13.2
Others	9	2.4
Sub-Total	401	100
Primary Occupation		
Tomato Farming only	159	39.6
Mixed cropping	217	55.3
Vegetable farming	6	1.4
Trading	5	1.3
Civil servant	10	2.4
Sub-Total	401	100
Total	401	100%

Source: Field survey, 2022

Membership of Association and Contac with Extension Agents

Association is formed when an individual recognises common and desirable needs among themselves. These farmer's organisation is normally formed to provide certain services that assist members of the group to improve production and have easy access to all production inputs (Idah *et al.*, 2017). As shown in Table 4, majority (50.8%) of fresh Tomato producers were members of either tomato or other farmers association. About49.2% were not members of the association. This is as a result of the dispersed nature of the farmers in their

various dealings and their behaviours. This implies that the producers have access to information on production of tomatoes. The result suggest that tomato farmers are likely to take advantage of benefits derived from association(Orifah, 2021).

Contact with extension agents by farmers avail them with the opportunity to learn, know and improve their farming techniques in doing that, they will increase their income and better their living standard. Result from Table 4 indicated that 42.3% of the respondents reported hadcontact with extension agents twice in a month. Only 23.6% and 20.4 % indicated that they had contact with extension agents three times and once in a month respectively. This implies that the farmers feel the presence of extension agents on transfer of technologies.Babatunde *et al.,* (2017) reported that that extension provides information on new technologies for farming communities that, when adopted, can improve production, incomes, and living standards. Extension service providers make an innovation known to farm households, act as a catalyst to speed up the adoption rate, control change, and attempt to prevent some individuals in the system from discontinuing the diffusion process. This also agreed with the findings of (Musa, 2014)in a study on impact of IITA on farmer's improvement in level of production in Yobe State who reported that majority of intervention received by farmer's which translate to an increase in production are associated with frequent contact with extension agents.

Table 4: Association of membership and Contact with Extension Agents

Membership of association		
Yes	204	50.8
No	197	49.2
Access to EAs, NGOs		
Yes	401	100
Contact with EAs (No/Month)		
Once	82	20.4
Twice	170	42.3
Thrice	95	23.6
Four times	54	13.7
Min. contact	1	
Max. contact	4	

Source : Field Survey, 2021

Tomato Variety Planted and Yield

Result in Table 5 above showed majority (60.4%) of the farmers planted UTC variety due to some varietal characteristics preferred by the farmers such as its large size, early maturing, has a less seed gel, more marketable and good for processing into sauce and paste. This variety also undergone intensive breeding program to become one of the leading tomato seed variety. This was followed by Roma VF variety (33.9%) due to its fleshy, juicy and almost seedless fruits with a delicious flavour thus making it an excellent variety for eating it fresh and next to UTC. This implies that farmers used tomato variety with low perishability, more market value and early maturing. The result further

showed that Beef steak (3.2%) and cherry (2.5%) varieties have low acceptability in the study area. This implies that tomato farmers in the study area had a good knowledge of tomato varieties in terms of identification, agronomic practices, shelf life and market demand. This result agrees with that of Samuel *et al.,*(2011) that tomato farmers were knowledgeable in the identification and storage ability of tomato varieties. A short shelf life has been reported by authors to be one of the major constraints to tomato farming, so knowledge of how long it takes for a tomato variety to spoil is important to mitigate this constraint. The result also indicated that Beefsteak, Plum, Grape and Campari were not produced in the study area as they are suitable to southern part of the country.

Result from Table 6 above indicated that the minimum and maximum tomato yield per hectar measured in basket was 35 and 920 baskets/ha. The average yield was 480 baskets with a standard deviation of 261.3 respectively. This implies that tomato production in the above study area is flourishing. This result agrees with that of Ajagbe*et al.,* (2016) who reported that the tomato farmers record high yield especially during its peak period at harvest as more farmers produce it in large quantity. The result also goes in line with that of Adebola (2021) that variety preferred among tomato farmers was the beaf steak, Beefsteak, Plum, Grape and Campari in Oyo state, Nigeria with average yield of 550 basket by farmers.

Table 5: Tomato variety planted by tomato farmers

Tomato variety planted	Freq.	%
Roma VF	136	33.9
UTC	242	60.4
Beaf steak	13	3.2
Cherry	10	2.5
Total	401	100

Source: Field survey, 2022

Table 6: Tomato Yield in 2019/2020 Season

Yield in 2019/2020 season (basket)	Freq.	%	Min.	Max.	Mean	S.D
35-200	80	19.1	35	920	480	261.386
201-365	69	18.2				
366-531	130	32.4				
532-697	22	6.4				
698-863	21	4.2				
864-1000	79	19.7				

Source: Field survey, 2022

Types of tomato storage and handling in use prior to ZECC technology

Post-harvest quality of tomato cannot be enhanced by any technology but it can be maintained to increase shelf-life (Bello *et al.*, 2016). As far as tomato is concerned all effort on post-harvest losses is geared towards reduction of Ethylene production from damaging fruits and diseases fruits which can affect adjacent fruits (Issac, *et.al*., 2016).

The result in Table 7 shows that respondents available post-harvest technologies in use prior to adoption of ZECC technology. The variables were analysed using a binomial scale of yes or no against some technologies used in the storage of tomato. From the result above, it showed that respondents were mostly familiar with the use of raffia basket (74.5%), followed by woven jute sacks (67.3%) because most of the farmers prefer the packaging of their tomatos inside woven bags. The result further showed that about 57.1% of the farmers are using plastic crates with only about 17.9% used sacks for tomato storage. The result showed that the respondents were mostly familiar with raffia basket as handling method after harvesting of tomato. This is because most of the farmers prefer the packing of their tomato inside basket of various sizes because it's cheaper and more accessible with only few (2.45%) using modified atmospheric storage. This agrees with the findings of Issac, *et.al.* (2016) who revealed that the use of raffia basket and crates (85.5%) were also used by farmers because they are simple practice in most rural communities as it does not require specialized training. His result further showed that refrigeration (9.8%) was not mostly used by the farmers. Refrigeration storage helps to reduce poor appearance of quality attributes like texture, nutrition, aroma and flavor at 10-15^{0}C and relative humidity of 85-95% but requires energy and capital. The above finding is also in line with the findings of Hussaini (2020) and Bello *et al.,* (2016) that most of the tomato farmers were not using modern post-harvest technologies for tomato storage. The result is also in line with study conducted by KARI (Idah *et al., 2017*) who reported that Bungoma District still relies on traditional ways of storing tomato produce, thus incurring high post harvest losses.

Table 7: Types of tomato storage methods and technology used by farmers before ZECC

Technology	Frequency	Percentage
Crates	229	57.1
Ground spraying	171	42.6
Plastic container	183	45.6
Raffia basket	299	74.5
Refrigerator	72	17.9
Sacks	72	17.9
Woven jute sacks	270	67.3
Warehouse	45	11.2
Hermetic technology	40	9.4
Modifies atmospheric package	10	2.4

Source; Field Survey, 2021

**: Multiple response exist.

As depicted in table 7 on the respondents' available posts harvest methods/technologies on storage of tomato prior to ZECC adoption.The variables were analyzed using a binomial scale of yes or no against some technologies in the storage of tomato, where respondents can select more than method. Post harvest quality of tomato cannot be enhanced by any technology but it can be maintained to increase shelf-life. As far as tomato is concerned all effort on post harvest losses is geared towards reduction of Ethylene production from damaging fruits and diseases fruits which can affect adjacent fruits (Issac, *et.al*, 2016). The result It showed that majority (299) of the respondents were mostly familiar with crates followed by plastic containers (183). This is because most of the farmers prefer the packing of their tomato inside crates, plastic containers or basket of various sizes. Refrigeration Storage was also (59.2%) The refrigeration storage was also used as it helps to reduce nonappearance of quality attributes like texture, nutrition, aroma and flavor at 10-15^{0}C and relative humidity of 85-95% but however low (Issac, *et.al*, 2016). They were also aware of Warehousing (9.9%), Controlled Atmosphere and Hermetic Technology (2.4%) revealing low usage possibly they were not within the knowledge of the tomato farmers in the study area. This is in line with the submission of Hussieni (2020) that most of the tomato farmers were not aware of current post harvest technologies on tomato.

Effectiveness of other tomato storage and handling in use prior to ZECC technology

The result from Table 8 shows that majority (40.9%) of the respondents indicated that plastic containers with a mean value of 3.97 as a method of packaging and handling tomato on the overall is highly effective as compared to other packaging and handling methods and reducing tomato post-harvest lost due to its easy flow of air through the containers thus reducing spoilage. This is so because the farmers prefer to store harvested tomatoes in plastic containers. Crates packaging and handling was ranked very effective (27.2%) with a mean value of 2.53. The result further revealed that raffia basket (66%) was rated effective with a mean value of 2.87, sacks was rated moderately effective (27.7) with a mean score of 2.91 and woven bags (35.8%) was rated not effective on the overall with a mean scorer of 3.25 respectively. This is in agreement with the findings of Bello*et al.* (2016) who showed that farmers rated cleaning and disinfecting as highly effective (x= 3) for tomato storage and handling. This is because proper hygiene practices is essential to avoid tomato spoilage, post harvest diseases like Salmonella, Cryptosporidium, Cyclospora and Hepatitis A virus emanating from fruits to human. Also, farmers rated pre-cooling practices effective (55.8%) because it results in preserving tomato for quite number of days after putting them under shed at good temperature. Other practices such as post harvest treatment (32.5%) was rated moderately effective, , use of MAP (14.2%), $CaCL_2$ (12.5%), Warehousing (10.0%), Controlled Atmosphere and Hermetic Technology (7.5%) were rated highly effective also.

Table 8: Information on the effectiveness of other Post-harvest methods used by farmers before ZECC adoption

Technology	Effectiveness					X	S.D
	HE	VE	E	ME	NE		
Raffia Basket	45(11.3)	70(17.4)	284(66.0)	23 (5.3)	9(2.1)	2.87	0.805
Crates	110 (25.6)	117(27.2)	48(11.2)	105(24.4)	20(4.7)	2.53	1.286
Plastic Cont.	176(40.9)	7(1.6)	146(34)	1(0.2)	63(14.7)	3.97	0.807
Woven bags	4(0.9)	80(18.6)	25(5.8)	138(32.1)	154(35.8	3.25	0.879
Sacks	109(25.3)	70(16.3)	49(11.4)	119(27.7)	49(11.4)	2.91	1.365

Source: Field Survey, 2021

Mean score threshold: > 3= Highly effective, 2-3= Effective, < 2= Not effective

HE= Highly effective, VE= Very Effective, E= Effective, ME= Moderately effective, NE= Not effective, X= Mean Score, S. D= Standard deviation

Conclusion and Recommendations

The study concluded that all the respondent in the study area fall within economically productive active age group which means that the respondents in the study area have the capacity and ability to embark on tomato production which can lead to high potential for technology adoption. Also, the type of tomato storage technology used prior to ZECC adoption showed that most of the farmers used woven jute bags, plastic containers and raffia basket. Also, on the effectiveness of the storage technologies in used before ZECC, raffia basket was found to be effective. Also, result on level of awareness on ZECC technology, almost all respondents were aware on different aspect of ZECC from its construction, to operations and reduction in tomato spoilage and adding market value to tomato. It was study recommended that farmers should encourage more on the use of modern production technology. Also, farmers should be encouraged on group formation to enable them have access to both government and non-governmental

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