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## Effect of Ripeness on Performance of a Motorized Tomato Slicing Machine

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**Abstract** Performance of Motorized Tomato Slicing Machine based on three different levels of ripeness (matured green/unripened tomato=URT), (fairly ripened tomato=FRT), (ripened tomato=RT) was evaluated in order to investigate effect of different levels and to know the best level that produces highest efficiency and output. The result from the evaluation showed that ripeness significantly influences performance of the machine. The following range of values were obtained, 71.43 to 82.19 % for slicing efficiency and 121.19 to 179.04 kg/hour for output capacity. The optimum value of 82.19% slicing efficiency and output capacity of 179.04 kg/hour were achieved while slicing unripened and ripened tomato respectively. In conclusion for best slicing efficiency and output capacity, it is recommended to use the motorized machine for a fairly ripened tomato.

**Keywords** Tomato; Ripeness; Slicing efficiency; Output capacity; Motorized

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### Introduction

Ripening is an activity in fruits development that makes them to be more tasty. In general fruit, becomes sweeter, and softer as it ripens. Fruits that are climacteric experience a series of transformation and some major changes in the course of ripeness which include fruit softness, sweetness, reduced bitterness and colour change. Colour change is as a result of pigments, which is always present in the fruit, becoming visible when chlorophyll is degraded [1]. Although, new pigments are also developed by the fruit as it ripens [2]. The cell wall of fruit generally contained polysaccharides containing pectin. In the course of ripening, a lot of the pectin is converted from water insoluble form to a soluble one by certain degrading enzymes [3]. The enzymes include polygalacturonase [1]. This means that fruit becomes less firm as the structure of the fruit is degraded. Firmness is the property of a fruit which gives it the ability of unyielding to cutting. Different fruits have different ripening stages. In tomatoes the ripening stages are: green (when the surface of the tomato is completely green), fairly ripened which includes: breaker (when less than 10% of the surface is red), turning (when less than 30% of the surface is red but no less than 10%), pink (when less than 60% of the surface is red but no less than 30%), light red (when less than 90% of the surface is red but no less than 60%) and ripened that is red (when the surface is completely red). Tomato has an excellent composition of vitamins A, C and other minerals[4] and one of the major, strong and essential antioxidants, carotene lycopene. Other researches, found lycopene to help protect prostate cancer particularly in cooked tomatoes and it is considered to be good for the heart, among other organs and that results for its acceptance large number of the tribes in the world [5]. Tomato is utilized in both fresh and dried forms for soups/stew making. Tomato farmers and marketers experience a lot of annual posts harvest loss at a disturbing rate of 50 – 70% caused by poor handling, inadequate storage facilities [6] because of the high perishable nature of fresh tomato fruits. To decrease losses and obtain peak use and high profit from tomato, sufficient protection on the part of processing the fruit is required to conserve its quality and enhance shelf life. The traditional method has been found to have low output and efficiency due to the drudgery of the process. It was in recognition of the demand to remove drudgery, injury and associated rigors to the user and to enhance quality, hygiene and efficiency in tomato processing that this research work has been carried out to



develop suitable processing method and equipment of which Tomato slicing machine is a part. Slicing operation is achieved by cutting, which involves the process of pushing, forcing or moving thin sharp blade or knife through the materials resulting in minimum deformation and rupture of the materials [7]. Slicing machine has been designed and developed to reduce the difficulty, low efficiency and output in slicing. The degree of the ripeness of tomatoes affects the performance of slicing operation on this slicing machine. Therefore, this research work is carried out to investigate the effect of tomato ripeness on the performance of a developed motorized tomato slicing machine to determine the best level of ripeness that will give the maximum efficiency and output.

## Materials and Methods

### Motorized Tomato Slicing Machine

The machine consists of a hopper, conveying units, slicing unit (knives arrangement), discharge unit and power unit (electric motor). Tomatoes are feed in the hopper to the conveyor by gravity as a result the tomatoes are conveyed to the cutting unit where the knives arrangement is provided. The whole machine is carried on  $600 \times 580 \times 820$  mm mild steel angle iron frame. The tomato support on the conveyor belt apply force of push on the tomatoes to move against the knives arrangement which is stationary, as the tomatoes comes in contact with the knives due to the force applied by the moving tomato support on the conveyor the tomatoes are sliced and then conveyed into the discharge unit where they are then collected in a container.

### Experimental Design

The rakuta variety was used for the determination of the effect of ripeness on the machine. Matured green/unripened, fairly ripened and ripened tomato samples were obtained at 60, 67 and 74 days respectively after transplanting. The machine speed was allowed to run at constant speed and level of tomato firmness was varied at three (3) levels giving (3×1) treatments. This was considered a factorial concept fitted into a completely randomised design. Each test was replicated four (4) times, giving a total of twelve (12) experimental tests run.



Figure 1: Unliced and Sliced matured green/unripened tomato



Figure 2: Unliced and Sliced fairly ripened tomato





Figure 3: Unliced and Sliced ripe tomato

**Experimental Procedure**

To check and ensure the working condition of the machine. It was switched on and allowed to run without load for some minutes and then 2.5kg of matured green/unripped tomatoes was measured using a weighing balance. The 2.5kg of matured green/unripped tomatoes were fed into the hopper to the conveying unit where it is conveyed to the cutting unit. The time taken to slice the 2.5kg of matured green/unripped tomatoes was taken. The sliced and unliced tomatoes were counted and weighed using the weighing balance. The procedure was replicated/repeated three (3) times for matured green tomatoes. The slicing efficiency (SE) and output capacity (OC) were calculated and recorded. Procedures 1 to 7 were carried out for fairly ripped and ripe tomatoes.

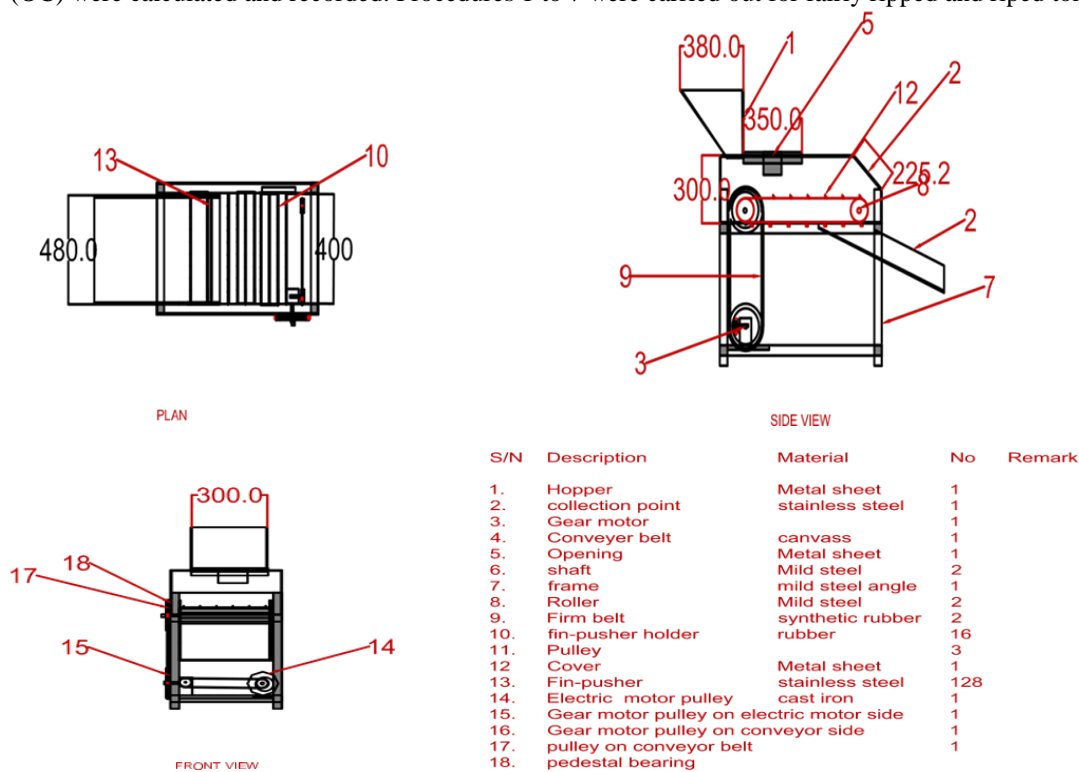


Figure 4: Tomato Slicer Assembly

**Performance Indices**

The performance of the tomato slicing machine was evaluated based on two (2) indices that include slicing efficiency and output capacity.

**Tomato slicing efficiency (SE)**

This measures how effectively the tomato slicing machine slices the tomatoes in a regular size. It can be calculate using the formula given by [8]:

$$SE = \frac{N_{Sliced}}{N_T} \times 100\% \dots \quad (1)$$

Where:

SE = Slicing Efficiency,  $N_{Sliced}$  = Number of sliced tomato,  $N_T$  = Total Number of tomato fed into the machine

**Output capacity (OC)**

This measure the quantity of tomato the slicing machine can handle per unit time. It can be calculate using the formula given by [8]:

$$OC = \frac{W_T}{T} \dots \quad (2)$$

Where:

OC = Output Capacity,  $W_T$  = Total weight of tomato fed into the machine

T = Time taken to slice tomatoes fed into the machine

**Percentage Damage (PE)**

It can be calculate using the formula given by [8]:

$$PE = \frac{N_B}{N_T} \times 100\% \dots \quad (3)$$

Where:

PE = Percentage,  $N_T$  = Total Number of tomato fed into the machine,  $N_B$  = Number of tomato broken

**Results and Discussion****Evaluation of the effect of three levels of tomato ripeness on slicing efficiency**

The results from experimental evaluation of the effect of three levels of tomato ripeness on slicing efficiency of the motorized slicing machine are shown in Table 1.

**Table 1:** Experimental results for slicing efficiency

S/N	Slicing efficiency for unripe tomatoes (%)	Slicing efficiency for fairly ripe tomatoes (%)	Slicing efficiency for ripe tomatoes (%)
1	82.35	83.18	82.14
2	77.80	76.62	78.57
3	86.61	68.76	64.28
4	81.99	77.09	60.71
Mean	82.19	76.41	71.43

The above results shows that the firmer the tomato, the higher the slicing efficiency. This is attributed to the fact that ripened tomato tends to be softer (having less firmness) than the unripened thereby being pressed by slicing knives instead of slicing.

**Table 2:** Descriptive test for effect of tomato ripeness on slicing efficiency

	N	Range	Minimum	Maximum	Mean	Standard error	Standard Deviation	Variance
URT	4	4.55	77.80	82.35	82.19	1.56	3.12	9.72
FRT	4	14.42	68.76	83.18	76.41	2.56	5.12	26.22
RT	4	21.43	60.71	82.14	71.43	4.56	9.11	82.93



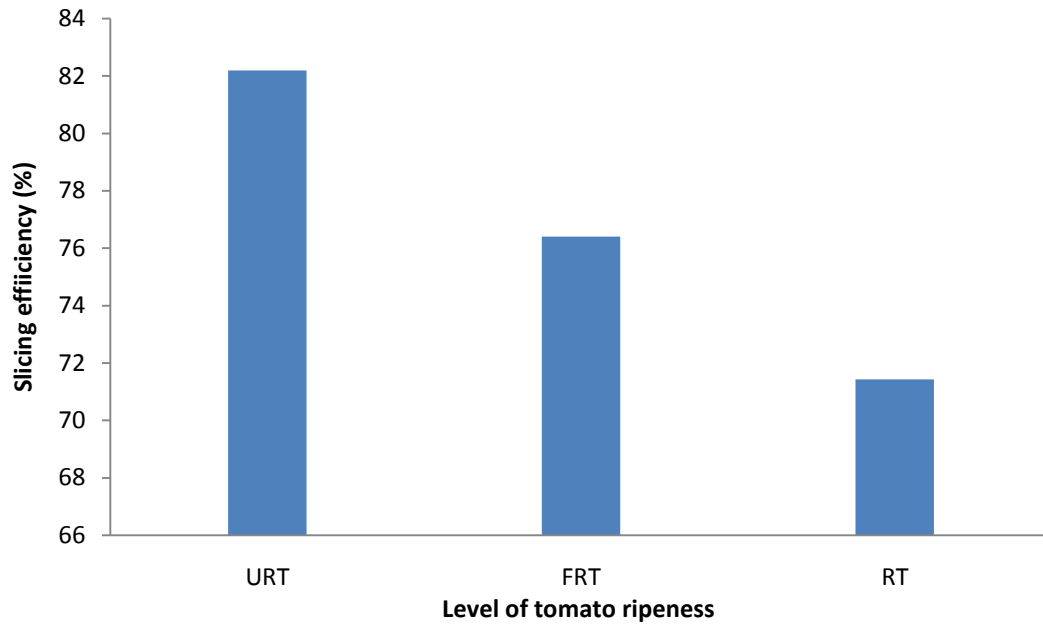


Figure 5: Effect of tomato ripeness on slicing efficiency of motorized tomato slicing machine

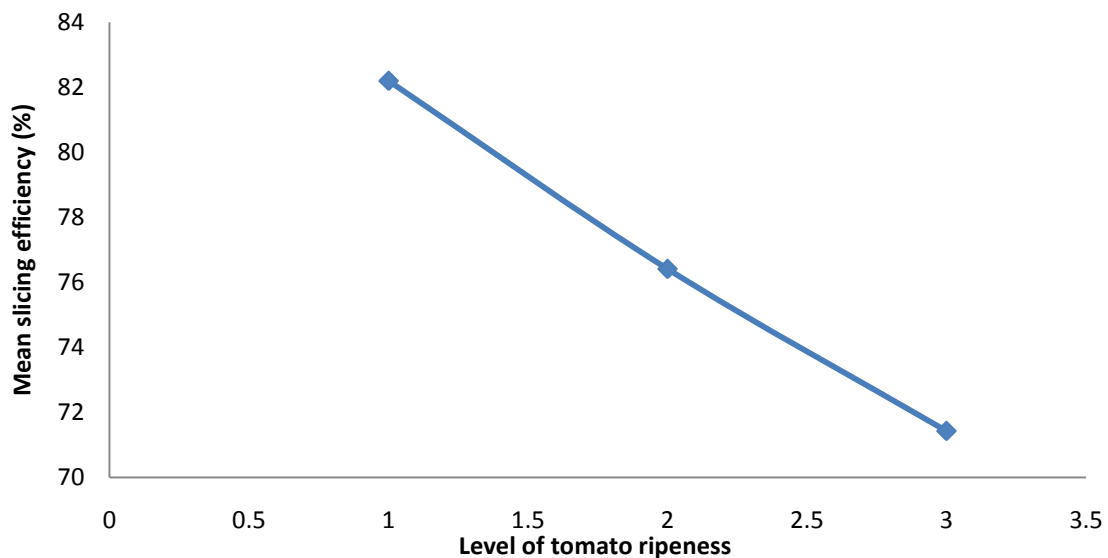


Figure 6: Effect of tomato ripeness on slicing efficiency of motorized tomato slicing machine

### Evaluation of the effect of three levels of tomato ripeness on output capacity

The results from experimental evaluation of the effect of three levels of tomato ripeness on output capacity of the developed tomato slicing machine are as shown in Table 3.

Table 3: Experimental results for output capacity

S/N	Output capacity for unripe tomatoes (Kg/hr)	Output capacity for fairly ripe tomatoes (Kg/hr)	Output capacity for ripe tomatoes (Kg/hr)
1	113.78	119.57	186.67
2	113.24	149.22	175.00
3	136.77	127.30	179.48
4	120.95	145.60	175.00
Mean	121.19	135.42	179.04



Table 4 above shows that the firmer the tomato, the lower the output capacity. This is caused as result of riped tomato which tends to be softer (having less firmness) than the unripped tomato thereby making the passage of slicing knives through riped tomato easier and faster.

**Table 4:** Descriptive test for effect of tomato ripeness on slicing output capacity

	N	Range	Minimum	Maximum	Mean	Standard error	Standard Deviation	Variance
URT	4	23.53	113.24	136.77	121.19	4.75	9.50	90.23
FRT	4	29.65	119.57	149.22	135.42	6.18	12.36	152.81
RT	4	11.67	175.00	186.67	179.04	2.39	4.77	22.76

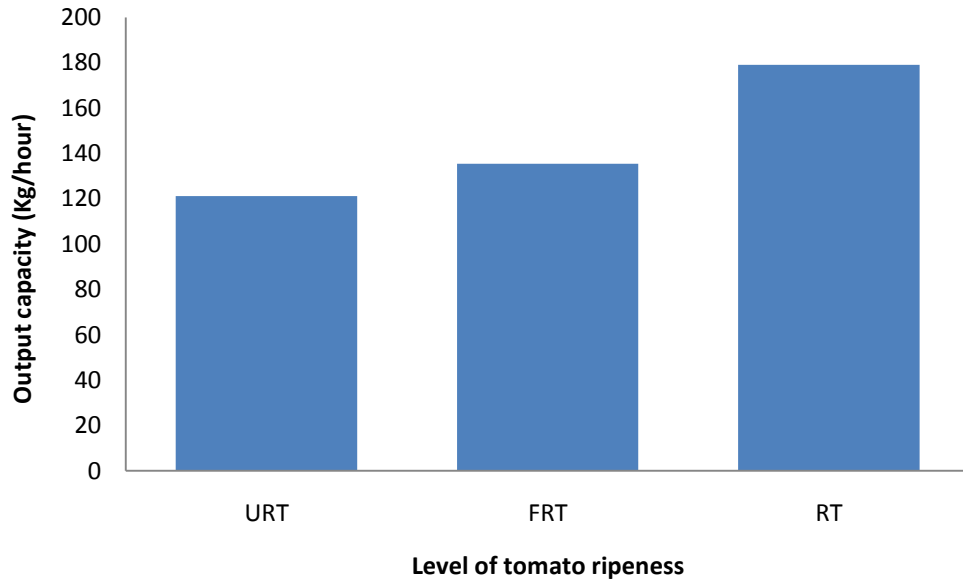


Figure 7: Effect of tomato ripeness on output capacity of motorized tomato slicing machine

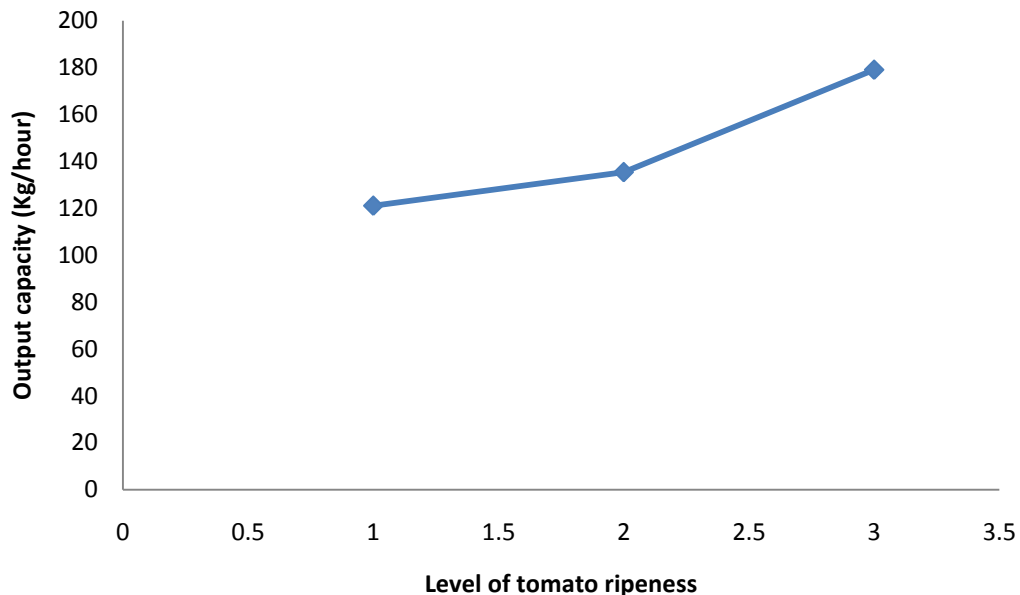


Figure 8: Effect of ripeness on output capacity of motorized tomato slicing machine





### Evaluation of the effect of three levels of tomato ripeness on percentage damage

Effect of three levels of tomato ripeness on percentage damage of the developed tomato slicing machine are as shown in Table 5.

**Table 5:** Experimental results for percentage damage

S/N	Percentage damage for unripe tomatoes (%)	Percentage damage for fairly ripe tomatoes (%)	Percentage damage for ripe tomatoes (%)
1	0	2.46	3.94
2	0.27	4.28	7.17
3	0.5	4.09	7.78
4	0	2.14	5.84
Mean	0.19	3.24	6.18

These results above shows that the firmer the tomato, the lower the percentage damage. This is caused as a result of riped tomato which tends to be softer (having less firmness) than the unripped tomato thereby making the passage of slicing knives through riped tomato easier and faster thus resulting to more damage.

**Table 6:** Descriptive test for percentage damage

	N	Range	Minimum	Maximum	Mean	Standard error	Standard Deviation	Variance
URT	4	0.50	0.00	0.50	0.19	0.08	0.16	0.03
FRT	4	2.14	2.14	4.28	3.24	0.48	0.95	0.91
RT	4	3.84	3.94	7.78	6.18	0.74	1.47	2.17

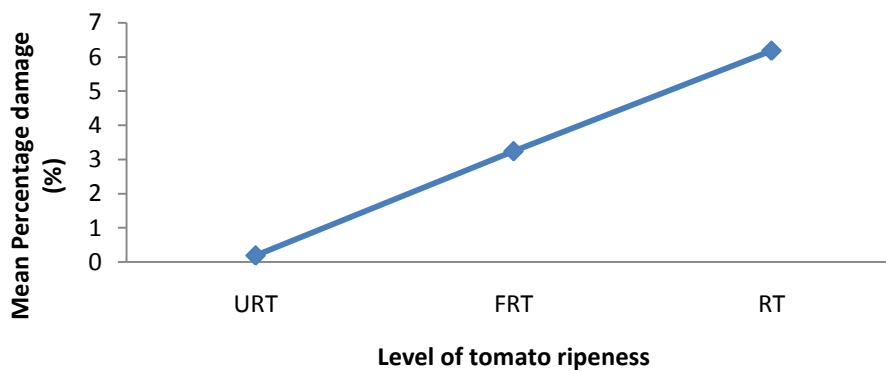


Figure 9: Effect of ripeness on percentage damage of motorized tomato slicing machine

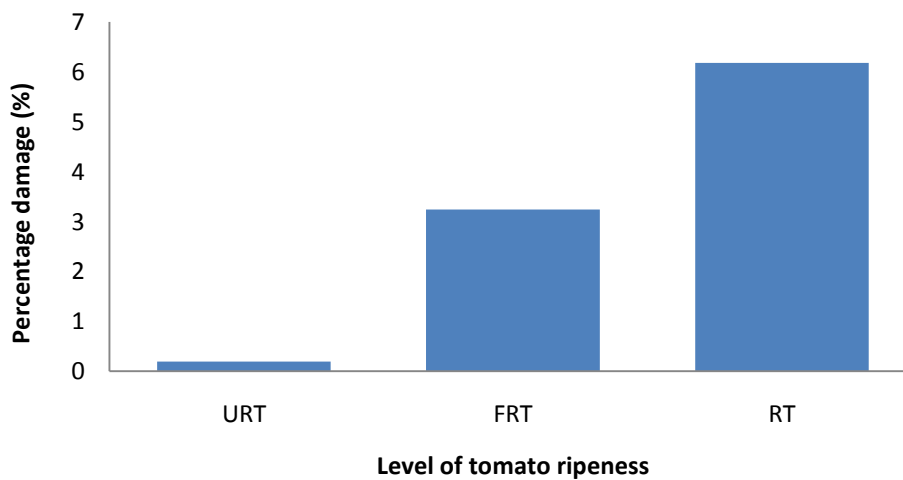


Figure 10: Effect of ripeness on percentage damage of motorized tomato slicing machine



Note: FRT = fairly riped tomato  
RT = riped tomato  
URT = unripped tomato

## **Discussion**

### **Slicing Efficiency**

Descriptive statistics was used for the analysis and the analysed result are given in table 2. It can be observed from the descriptive statistics evaluation that the average value for slicing efficiency of unripped tomato is bigger than that of a fairly riped and significantly bigger than that of riped ones and that is additionally illustrated by figure 5 and 6. This clearly shows that the unripped tomatoes are more compacted or hard than the fairly and riped. Finally, it could be deduced that the harder and more compacted the tomato, the better the slicing efficiency and vice versa and that is as a result of the fact that riped tomato is likely to be softer (having less hardness and compaction) than the riped, thus being squeezed down by the slicing knives rather than being properly sliced[9, 10].

### **Output Capacity**

For the output capacity given in Table 4 it is observed that the mean value from descriptive statistics of the output capacity of riped tomato is larger than that of fairly and appreciably larger than that of the unripped and This is was also demonstrated using graph as shown in figure 7 and figure 8. This suggests that riped tomatoes are less hard and compacted than unripped and fairly riped. From the result, it can be affirmed that the harder and compacted the tomato, the lesser the output capacity. This is due to the fact that riped tomato is prone to be more softer (having less firmness) than the unripped, hence making easier and faster slicing operation [10].

### **Percentage Damage**

Table 5 shows the descriptive statistics evaluation of the percentage damage. From the table, it can be noticed that the average percentage damage for riped tomato is more than that of fairly and greatly more than that of the unripped ones and this was again displayed by graphs in figure 9 and 10. It could be finally revealed that the more harder and compacted the tomato, the lesser the percentage damage which maybe as a result of the riped tomato softness, that causes the machine to damage the tomato instead of performing effectively with hard and compacted ones[10].

### **Recommendations**

The following are suggested for further study

- The effect of different varieties of tomato on the slicing efficiency and output capacity should be carried out.
- The effect of different sizes of tomato on the slicing efficiency and output capacity should also be investigated.

### **Conclusion**

A machine for slicing tomatoes was evaluated. The level of tomato firmness affects the slicing efficiency and output capacity because the amount of resistance offered by the tomato varies with the different level of firmness. The motorized tomato slicing machine was used to determine the influence of the levels of tomato hardness on its slicing efficiency and output capacity. From the result of the evaluation, the slicing efficiency and output capacity of the machine were in the range of 71.43 to 82.19 %, and 121.19 to 179.04 kg/hour respectively. The best slicing efficiency of 82.19% was obtained using unripped tomato while highest output capacity of 179.04 kg/hour was obtained using riped tomato. It was discovered that slicing using unripped (matured green) tomatoes requires more force to be applied by the knives thus requiring more energy and power while fairly riped tomatoes and riped tomatoes requires less compared to unripped tomatoes. Considering the slicing efficiency, output capacity, power and energy requirement and the level at which tomatoes can be used, it is recommended to slice tomatoes when they are fairly riped.





### Acknowledgment

Acknowledgement is hereby accorded to Department of Agricultural and Bioresource Engineering, Abubakar Tafawa Balewa University, ATBU, Bauchi, Nigeria, for their support and contributions.

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