Construction of A Potato Slicing Machine For Irish Potato (*Solanumtuberosum*) To Eradicate Damages And Boost Machine Capacity

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ABSTRACT

This study aimed at construction a potato slicing machine for Irish potato (SolanumTuberosum) to eradicate spoilage/losses and damages associated with inadequate storage facilities for Irish potato to boost machine capacity using different cutter blades of sixes 4mm, 5mm, 6mm, and 7mm to obtain a uniform thickness of Irish potato chips produced for uniform drying. A power of 111,19kw (1.5 horsepower) electric motor was used to power the machine. The machine's metallic body in contact with the food product was made of stainless steel (SS410) to avoid food contamination and poisoning. Machine capacity was recorded from performance evaluation results at 490.02kg/hr, the weight of Irish potato measured at 20.75kg, an average slicing time of 2.5minutes (o.042hr, slicing 24 pieces of Irish potato per experiment. A slicing efficiency of 95.18% with a damage efficiency of 4.8% was recorded.

Keywords: *Irish potato slicing machine, machine capacity slicing efficiency, damage efficiency, rotational speed.*

I. INTRODUCTION

Irish potato (*SolanumTuberosum*) belongs to the food class of carbohydrates, and it is mostly consumed as breakfast, eaten at picnics, and consumed by travelers as chips. For large-scale production of potato chips. Producing a slicing machine to ease the processing of potato is apt. Hence, this study is aimed at designing and fabrication a portable potato chips machine with a capacity to cater for both small scale and medium scale production as well as improve on previous cutting mechanisms for potato slicing using a five (5) horsepower (3.728KW) electric motor to power the machine.

Aremu*et al* (2017) constructed an Irish potato slicing machine and evaluating the performance. The machine capacity was recorded at a range of 35.5Kg/hr to 47kg/hr, and machine efficiency was recorded at a range of 39.9% - 83.5% and the frame of the potato slicing machine had a dimension of 45mm x 45mm angle iron bar with a slicing disc of 3mm stainless steel plate of 400mm diameter.

Hoque, M.A., and Saha K.K. (2017) designed and developed a manual potato slicer sliced on a small scale. The slicer was of 360 x 390 x 780 mm dimension. It had a machine capacity of 429.3kg/hour and a slicing efficiency of 88%. The potato slicer was suitable for cottage industries. It sliced using 4 feeding chutes with 3 cutting blades at a slicing time of 7minutes.

II. METHODOLOGY

A. Materials and Methods

A motorized (5hp) potato slicer was designed and fabricated at the Igbinedion University Okada (IUO), Edo State, Nigeria, Engineering workshop in 2019. A number of factors like reciprocating speed, Torque, safety factor, and diameter of cutter blades were designed for and considered in the potato slicing machine's design.

The machine was fabricated using SS406 stainless steel for the feeding chamber to prevent contamination of the potato. Mild steel was used to manufacture the stand of the potato slicer.

The feeding chamber was designed to accommodate the potato tubers. The circumference of the tubers and the diameter of the feeding chamber were considered. Hence, design considerations were made for (1) reciprocating arm speed, Torque, safety factor, and cutter blade using the following formula below
:

B. Design Considerations

Design considerations, when strictly adhered to, will yield a structurally fit machine for usage. Some considerations looked into in this study:

1. Design for reciprocating aim speed
2. Design for Torque
3. Design for the Safety factor
4. Design for cutter blades

a) Determination of reciprocating aim speed

1) $\quad Rs = \frac{2LN}{60}$ ……………….. (1)

Where: Rs = reciprocating arm speed (ms⁻¹)

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L = Length of the Irish potato

N = Number of revolution of the gear motor (r.p.m.)

Where: L =50mm, N =44 r.p.m.

$$\therefore Rs = \frac{2 \times 50 \times 144}{60} = \frac{14,400}{60}$$

2) Determination of Torque

The force the causes rotation (Torque) is expressed as:

$$Torque = \frac{PCO}{Rs\, 2\pi} = \frac{37,285KW \times 60}{0.24 \times 2 \times 3.142}$$

$$= \frac{2,237.1}{1.50891} = 148.3Nm$$

P = power

Torque = 148.3Nm

3) Determination of Safety factor

$$Fg = \frac{Ys}{Ws} = \frac{5 \times 108\ N/m^2}{2 \times 108\ N/m^2} \qquad = 2.5$$

Ys = Yield Strength

Ws = working stress of must steel

The safety factor required for the motor to operate is 2.5

4) Determination of Diameter

The Torque = 148.3Nm

$$N_2 = \frac{N_1 \times D_1}{D_2} = 144\ r.p.m$$

$$d = \frac{Torque}{F} = \frac{143.3}{5.91} = 30.2$$

∴diameter = 30mm

Machine Capacity = 490.25 kg/hr

Table 1: Machine capacity of potato slicing machine

S/N	Weight of sliced Irish Potato (kg)	No of Irish Potato	Slicing Time	Slicing time	Machine Capacity kg/hr
1.	1.722	21	(hr) 0.0350	Mins 2.1	49.10
2.	3.038	20	0.061	3.66	49.81
3.	2.303	27	0.047	2.82	49.00
4.	2.200	26	0.045	2.71	48.91
5.	2.346	27	0.48	2.88	48.89
6.	2.116	25	0.043	2.58	49.22
7.	1.517	20	0.031	1.86	48.96
8.	1.934	24	0.039	2.34	49.61
9.	1.712	21	0.035	2.1	48.90
10.	1.863	23	0.039	2.34	47.76
	Total weight of sliced Irish potato = 20.751kg Average = 2.075kg	Total = 244 Average = 24.4	Total = 0.432hrs Average = 0.042hr	Total = 25.39min Average = 2.5mins	Total = 490.25kg/hr Average = 49.02kg/hr

Average wgt of sliced Irish potato = 2.075kg
Machine capacity = 490.25kg/hr
Average machine capacity = 49.02kg/hr
Average slicing time = 2.5minutes
                    0.042hours
Machine capacity

$$= \frac{Total\ weight\ of\ slicing\ potato\ (kg)}{Slicing\ time\ (hr)} = \frac{20.751kg}{0.432hr}$$
$$= 490.25kg/hr$$

C. Slicing Efficiency

$$Wd\ potato = \frac{Ws/min}{TWsi}$$
$$Slicing\ efficiency = \frac{Wds\ potato}{Tw\ Sposato}$$

Wdspotato = weight of damage sliced Irish potato(kg)
TWspotato = Total weight of sliced Irish potato(Kg)

Table 2: Slicing efficiency of potato slicer

S/N	Weight of sliced Irish	No of Irish Potato	Weight of damaged Irish potato	Slicing efficiency = $\frac{TWS-\ Twd\ x\ 100}{TWS}$
1.	1.722	21	0.0829	0.9518
2.	3.038	30	0.1464	
3.	2.303	27	0.1109	
4.	2.200	26	0.1060	
5.	2.346	27	0.1130	
6.	2.116	25	0.1019	
7.	1.517	20	0.0731	
8.	1.934	24	0.0932	
9.	1.712	21	0.0824	
10.	1.863	23	0.0897	
	Total = 20.751kg Average = 2.07kg		Total = 0.9996 Average = 0.0994	0.9518

Slicing Efficiency = 0.9518 x 100%

$$Sp = 95.18\%$$

Slicing efficiency (%)

$$= \frac{Total\ weight\ of\ slice\ potato - total\ weight\ of\ damaged\ potato}{Total\ seight\ of\ sliced\ potato}$$

(Kingsley-Omoyibo, Q. A. 2019)

$$= \frac{20.751 - 0.9996}{20.751} = 0.9518$$

D. Damage efficiency

$$De = \frac{Damaged\ Irish\ potato}{Total\ weight\ of\ sliced\ Irish\ potato}$$

$$= \frac{0.9996}{20.751} = 0.048$$

% Damage efficiency = (0.048x100)%

$$= 4.8\%$$

Rotational speed of 45.6 r.p.m.

Table 3: Rotational speed of potato slicing machine

S/N	Rotational speed (r.p.m)	Slicing time (Hr)	Slicing Time in mins	Total No. potato sliced	Machine Capacity kg/hr
1.	45.9	0.0350	2.1mins	21	49.19
2.	46.5	0.0610	3.66	30	49.81
3.	44.3	0.0470	2.82	27	49.00
4.	45.2	0.0450	2.71	26	48.91
5.	46.2	0.0480	2.88	27	48.89
6.	46.0	0.0430	2.58	25	49.22
7.	45.4	0.0310	1.86	20	48.96
8.	44.8	0.0390	2,34	24	49.61
9.	46.1	0.0350	2.1	21	48.90
10.	45.7	0.0390	2.34	23	47.76
	Total = 4561r.p.m Average = 45.6r.p.m	Total = 0.432hrs Average = 0.042hr	Total = 25.39mins Average = 2.5mins	Total = 244 Average = 24.4	Total = 490.25kg/hr Average = 49.02kg/hr

The total rotational speed is 456rpm in 2.5minutes. At a rotational speed of 45.9rpm, the slicing Time was recorded at 2.1minutes. At a rotational speed of 45.4rpm, the slicing Time was recorded at 1.86minutes and also at a rotational speed of 45.7rpm, the slicing Time was recorded at 2.34minutes.

The average rotational speed was recorded at 45.6rpm at 2.5minutes.

Table 4: Comparison of results with the previous author

Evaluation	
Aremu*et al.* (2017)	Kingsley-Omoyibo Q.A. (2019)
Machine capacity 355kg/hr	Machine capacity 490.02kg/hr
Slicing efficiency 83.5%	Slicing efficiency 95.18%
Damage efficiency 57%	Damage efficiency 4.8%

The machine capacity of Aremu*et al*. (2017) was improved upon from 355kg/hr to 490.02kg/hour in this study. The splicing efficiency was also improved from 83.5% to 95.18% in this study. A very low damage efficiency of 4.8% was recorded in this study as against 57% for Aremu*et al*. in 2017.

Table 4 shows the bill of engineering materials used and the evaluation.

Table 4: Bill of Engineering Measurement and

S/N	Component	Material	Dimensions (mm)	Qty	Unit Cost (₦)	Total Cost (₦)
1	Electric motor	Cast iron	5hp	1	15,000	15,000
2	Ball Bearing	Stainless Steel	Dia:20mm	2	1000	2000
3	V-Belt	Rubber	A37	1	500	500
4	Pulley	Cast iron	Dia.50mm	1	1500	1500
			Dia.100mm	1	2000	2000
5	Solid Shaft	Stainless Steel (ASTM A36)	Length: 3feet Dia: 20mm	1	3000	3000
7	Angle bar	Mild Steel (ASTM A36)	Length: 7500 50x50x3mm	2	3500	3500
8	Stainless Plate	Galvanized metal	(SS410)	1	50000	50000
11	Bolt & Nut	Mild Steel (ASTM A36)		12	50	600
					Total	78,100 ≈$200

Evaluation (BEME)

III. EXPERIMENTAL PROCEDURE

The potato slicer was set up using a 5horse power motor to drive the pulley.

An average of 24 potatoes was loaded into the loading chamber and sliced using a 7mm cutter blade. A machine capacity of 490.25kg was recorded at an average of 2.5mins slicing time. The damaged potato sliced was recorded at a damage efficiency of 4.8% (low) with a slicing efficiency of 95.18%. The machine was tested with load and without load. A test for proper assembly with load and without load to test for the potato slicer's proper functioning was carried out.

The potato slicer sliced efficiently with a very low damaged efficiency of 4.8% and can slice for both small and medium scale.

IV. CONCLUSION

1. Damage losses were eliminated as very low damage of 4.8% was achieved.
2. A machine capacity of 490.25kg/hr was established
3. A slicing time of 2.5minutes for an average of 24 potatoes was established
4. A safety factor of 2.5 was established
5. A slicing efficiency of 95.18% was established

The newly constructed potato slicing machine is efficient and slices with reduced damages.

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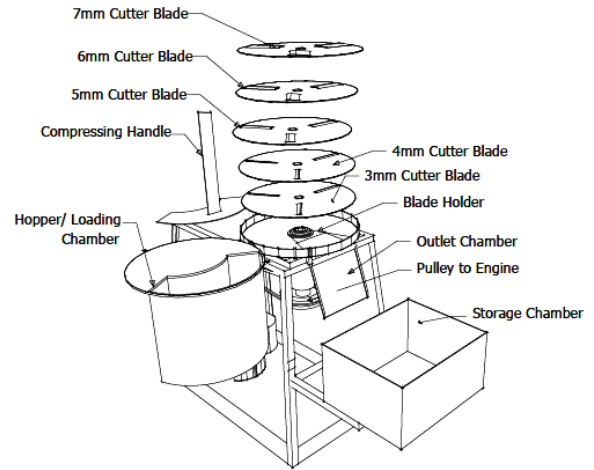
A 3D exploded view of the potato slicing machine, an isometric view of the potato slicing machine is shown below:

EXPLODED VIEW

FRONT VIEW