

ORIGINAL RESEARCH

Cutting resistance assessment for three varieties of cassava roots

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Abstract

In this study, a model has been developed to assess the peel and root resistance to cutting. The evaluation was done with knife thicknesses of 1.0 mm, 1.5 mm and 2.0 mm using *Duade kpakpa*, *Dudze* and *Sika bankye* cassava varieties as experimental samples for three postharvest delays. The knife penetrated the tuber at 50 mm, 100 mm and 150 mm away from the proximal end. An average peel thickness obtained was in the range of 1.81 mm – 3.01 mm. The average diameters recorded ranged from 52.52 mm to 60.40 mm. The cutting resistance assessed for the *Duade kpakpa*, *Sika bankye* and *Dudze* cassava peels were 44.85 N, 50.01 N and 53.53 N, respectively with no significant differences ($p < 0.05$). The penetration resistance of the tuber decreased with increasing postharvest delay and increased with increasing knife thickness. The effect of the treatments on the response variables evaluated by factorial analysis showed that significant differences generally decrease with increasing interaction. Comparing the results, cutting resistances of 229.02 N, 223.09 N and 204.43 N in maximum were obtained for the *Dudze*, *Sika bankye* and *Duade kpakpa* cassava roots, respectively. The quantitative assessment by the PLSR model under the knife thicknesses ($R^2 = 0.9689$; RMSE = 2.1020) was significantly better than the PLSR model under postharvest delay ($R^2 = 0.7845$; RMSE = 4.0183). The technique employed in assessing the cutting resistance emphasized the cultivar differences and provided a measuring sequence and outstanding quantitative analysis.

Keywords: Slicing, Processing, Postharvest Delay, Knife Thickness, Penetration Resistance

Introduction

Cassava is a root crop with vast applications both domestically and industrially. Apart from being a staple crop in countries in subtropical and tropical Africa, Latin America and Asia, it is also an important ingredient for the textile, paper, plywood and pharmaceutical industries (Ibegbulem and Chikezie, 2018). In Ghana, it is the most cultivated root and tuber crop and can be grown commercially in almost all agroecological zones of the country (Aidoo *et al.*, 2019). In 2021, Ghana produced about 22.68 million tonnes of cassava by cultivating about 1.01 million hectares (FAOSTAT, 2023). It is a drought-resistant crop and can withstand harsh climatic and poor soil conditions. It is also more resistant to pests and diseases than many other crops. This makes cassava the most important root and tuber crop for the Ghanaian farmer and the economy since it contributes significantly (about one-fifth) to the agricultural gross domestic product of the country (Darko-Koomson *et al.*, 2019).

Cassava however cannot be stored for a long period after harvesting due to its high perishability. Preservation of cassava is best done after processing to reduce the level of moisture in the roots. Cassava processing involves several operations depending on the final product being considered. Mechanised processing of cassava just like other agricultural products is affected by crop factors such as shape, size, moisture content, postharvest delay (days after harvest) and variety (Olukunle and Akinuli, 2013). Operations like peeling, chipping, and slicing involve the use of knives or cutting blades.

The performance of knives for cutting has been identified to be influenced in terms of cutting properties and energy re-

quirement by crop variety, species, diameter, moisture content, stage of maturity, cellular structure and cutting blade type (Pekitkan *et al.*, 2019). Some of the parameters of concern with respect to the cutting force and energy of knives are knife edge angle, approach angle, tip radius and cutting velocity (Vu *et al.*, 2020; Pekitkan *et al.*, 2019; Schuldt *et al.*, 2016).

Studies on the determination of cutting force for biological materials are needed for the design and operation of efficient processing equipment. Optimising the cutting force ensures compact mechanical parts and results in energy-efficient chopping devices (Vu *et al.*, 2020). Penetration resistance indicates the opposing force exhibited by materials to devices like knives or cylindrical probes placed on them. This study, therefore, determined the penetration resistance of three varieties of cassava on different days after harvest and positions on the cassava root using knives with different thicknesses.

Materials and Methods

Description of the study area and sampling

The mechanical model used for the penetration force assessment was developed at the Department of Agricultural and Biosystem Engineering workshop of the Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, located in the Ashanti Region of Ghana. Three cassava cultivars namely *Duade kpakpa*, *Sika bankye* and *Dudze* were used as experimental samples. The samples were harvested from KNUST experimental farm at Anwomaso in the Ashanti Region of Ghana. Cassava roots of comparable sizes for each cultivar, were selected for the experiment.

Development of the cutting blade model

The developed cutting knife opening force assessment model consists of a square base frame, four legs vertically inclined frame with a smaller square top frame that supports a pressure shaft (Figure 1). The turning of a horizontal arm fixed on top of the shaft provided linear motion to the shaft. This linear motion caused a cutting blade attached to the lower end of the shaft by means of a flange bearing (F204) to move downwards. A sensory scale was installed on the square base frame to enable

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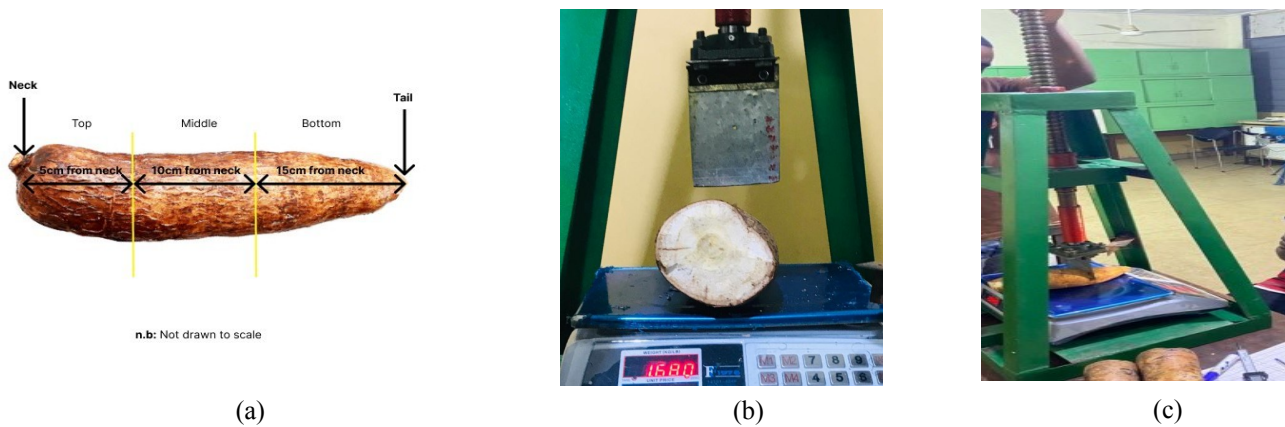


Figure 1 Measuring processes showing (a) cassava root, (b) sample positioning, and (c) cutting of cassava root

Table 1 Experimental design with independent variables and respective levels

Independent variable	Levels
Thickness of Cutting knife	1.0 mm, 1.5 mm and 2.0 mm
Cassava root variety	<i>Duade kpakpa</i> , <i>Sika bankye</i> and <i>Dudze</i>
Postharvest delay	1-Day, 2-Days and 3-Days after harvest
Cutting positions away from the stock	50 mm, 100 mm and 150 mm

measurement of the cutting resistance. The mechanical model has an overall dimension of 1040 × 640 × 470 mm.

Assessment of cutting resistance

Freshly harvested cassava roots for the three cultivars were transported from the Experimental Farm at KNUST, Ghana without any damage for the measurement of different physical and mechanical properties. Subsequently, ten (10) root samples for each cultivar were selected, washed, cleaned, marked and weighed. Physical properties such as diameter (head near the stock, middle, tail end) and peel thickness of cassava roots were measured using a vernier calliper. The mechanical properties determined were the force required to penetrate the peels and the roots of cassava using galvanized steel knives (Figure 1). Moisture content of the cassava roots was also determined using the gravimetric method (Krishnakumar *et al.*, 2021). Subsequently, the force required to penetrate the peel was also measured at 2 mm deep into the thickness of the peel. This was because it will provide data for machine developers to know the actual force required to remove the peel from the cassava root (Adetan *et al.*, 2005).

One full cassava root sample for the *Duade kpakpa* cultivar was placed directly on a sensory scale fixed under the developed cutting knife on the first day after harvesting (Figure 1b). The cutting knife which had calibrations of 2, 10, 20, 30, 40, 50 and 60 mm on the surface was pushed through the cassava root by turning the lever connected to the shaft holding the knife at a feed rate of 2 mm/s. The corresponding penetration resistance of the root reading from the sensory scale was measured. A camera was positioned in front of the set up to video the process and the readings corresponding to each calibration were taken with three replications. The same process was applied to the *Sika bankye* roots and the *Dudze* roots for three postharvest delays. The data collected was used to plot graphs to determine the variation in the cutting resistances for the three cassava cultivars. Subsequently, statistical models were developed using partial least square regression (PLSR) and the output was presented in the form of scatter plots. Finally, the correlation coefficient (R) and root mean square error (RMSE) between the

measured cutting resistance values and the predicted values were determined.

Experimental design and procedure

The experiment used a 3 × 3 × 3 × 3 factorial design with four independent variables of three levels each as described in Table 1.

This gave 81 experimental runs and there were three replicates of each run. The dependent variable was cutting resistance. The effect of treatment on the response variables was evaluated by factorial analysis to determine if there were any significant differences due to the effectiveness and advantage in finding optimal conditions faster and simultaneously.

Prediction of cutting resistance for the cassava root

To obtain adequate information on the cutting resistance for the cassava roots measured, partial least square regression (PLSR) analysis was performed. PLSR can simply treat data matrices in which each item is described by hundreds of variables like measured cassava roots resistance to cutting. This technique can extract the relevant portion of the information from a large data matrix and produce the most dependable models. The correlation coefficient (R) of the prediction set (R_p) and the root mean square error of the prediction set (RMSEP) are used to evaluate prediction precision. The (R_p) measures the degree of correlation between the predicted and the measured values. It is computed following equation (1) by Lu *et al.* (2023):

$$R = \frac{\sum_{i=1}^N (K_{is} - \bar{K}_{is})(S_{ip} - \bar{S}_{ip})}{\sqrt{\sum_{i=1}^N (K_{is} - \bar{K}_{is})^2} * \sqrt{\sum_{i=1}^N (S_{ip} - \bar{S}_{ip})^2}} \quad (1)$$

Where K_{is} and \bar{K}_{is} are the reference values of the i^{th} sample and the average values of the reference values respectively; S_{ip} and \bar{S}_{ip} are the predicted values of the i^{th} and the average values of the predicted values respectively; N is the number of the

samples. The RMSE of the predicted values S_{ip} for observations; i , of a regression's dependent variable K_{is} is computed for N different predictions as the square root of the mean of the squares of the deviations. RMSE is expressed in equation (2) as follows (Lu *et al.*, 2023):

$$RMSE = \sqrt{\frac{\sum_{i=1}^N (S_{ip} - K_{is})^2}{N}} \quad (2)$$

Results and Discussion

Variation in diameter and peel thickness

The diameters were measured at 50 mm, 100 mm and 150 mm

away from the stock and assigned Head, Middle and Tail, respectively. The average diameter values for all the cultivars used were computed and plotted (Figure 2a). The results showed that the *Sika bankye* root had the highest average diameter at all the positions where the measurements were taken and the *Duade kpakpa* root had the lowest except for the 50 mm away from the stock where the *Dudze* root recorded the highest. The average diameters for all the measuring positions were 52.52 (± 12.84) mm, 59.35 (± 15.53) mm and 60.40 (± 13.04) mm for the *Duade kpakpa*, *Sika bankye* and *Dudze* roots respectively with no significant differences ($p < 0.05$). The average diameter of the *Sika bankye* root was 11.52 % higher than the *Duade kpakpa* root but the *Dudze* root was only 1.74 % higher than the *Sika bankye* root. The average diameter values

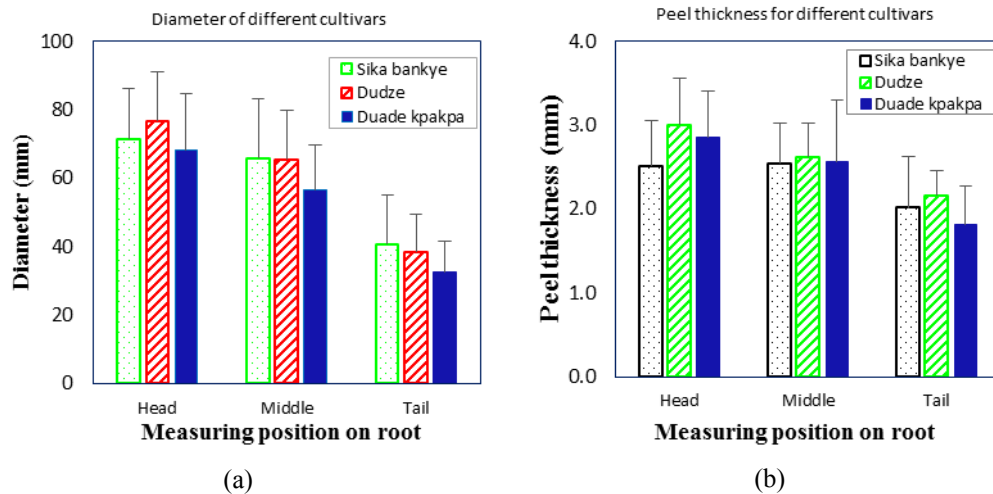


Figure 2 Physical properties at different positions on the root for (a) diameter, and (b) peel thickness

Table 2 Analysis of variance for Cassava cutting resistance

Sources	DF	F-value	P-value
Variety	2	13.630	0.000
Postharvest delay	2	77.615	0.000
Knife thickness	2	99.179	0.000
Cutting position	2	83.011	0.000
Variety * Knife thickness	4	12.466	0.000
Variety * Postharvest Delay	4	1.165	0.328
Variety * Cutting position	4	4.106	0.003
Knife thickness * Postharvest Delay	4	4.987	0.001
Knife thickness * Cutting position	4	2.877	0.025
Postharvest Delay * Cutting position	4	1.835	0.125
Variety * Knife thickness * Postharvest Delay	8	0.506	0.850
Variety * Knife thickness * Cutting position	8	0.778	0.623
Variety * Postharvest Delay * Cutting position	8	1.003	0.436
Knife thickness * Postharvest Delay * Cutting position	8	1.881	0.066
Variety * Knife thickness * Postharvest Delay * Cutting position	16	0.693	0.798
Error	1		
Total	81		
Corrected total	80		

Key: Values in the P-value column that are less than 0.05 indicate significant difference

agree with the finding of Krishnakumar *et al.* (2021). Similarly, the average thickness of the peel for all the cultivars was computed and plotted (Figure 2b). The results showed that average peel thicknesses of 2.36 (± 0.54) mm, 2.41 (± 0.58) mm and 2.60 (± 0.41) mm were obtained for the *Sika bankye* root, *Duade kpakpa* and *Dudze* root respectively with no significant differences ($p < 0.05$). Similar average values have been reported by Oriola and Raji (2013), Nwachukwu and Simonyan (2015) and Ilori *et al.* (2017).

Interactions between variables by analysis

The outcome showed that the differences in the cutting resistance for variety, postharvest delay, knife thickness and cutting positions were highly significant. However, there were no significant differences for the interactions of two treatments and above except the interaction of variety with cutting position and knife thickness with postharvest delay (Table 2). It could be concluded that significant differences generally decrease with increasing interaction.

Assessment of cutting resistance

Resistance of the peel to knife penetration

The resistance of the peel to knife penetration for all cultivars was measured at 2 mm inside the peel which is within the average peel thickness range of 1.81 – 3.01 mm. The cutting resistance assessed for the *Duade kpakpa*, *Sika bankye* and *Dudze* cassava roots were 44.85 N, 50.01 N and 53.53 N respectively with no significant differences ($p < 0.05$). This agrees with the findings of Ilori and Adetan (2013) who reported no significant difference ($p < 0.05$) between the peel penetration force using knife edges of the same thickness (1.5 mm and 2.0 mm). Furthermore, the strength of the peel for the *Sika bankye* root was 10.31 % higher than that of the *Duade kpakpa* root and the resistance of the *Dudze* peel was 6.58 % higher than that of the *Sika bankye* root. This means that the hardness which determines the maximum shear force required to pierce the peel (Krishnakumar *et al.*, 2022) is more pronounced in the *Dudze* cultivar. Therefore, the mechanical strength of the peel can be ranked as *Dudze* peel > *Sika bankye* peel > *Duade kpakpa* peel.

Effect of cutting position on root resistance to knife penetration

The cutting resistance assessed for the *Duade kpakpa*, *Sika bankye* and *Dudze* cassava roots was carried out at 50 mm, 100 mm and 150 mm from the stock for different postharvest delay conditions (Figure 3). The results showed that the cutting resistance of the roots increases sharply for a certain depth of knife penetration after which it almost plateaus with an increas-

ing knife penetration into the root for all the cultivars. In the case of *Duade kpakpa* roots, further analysis showed that the cutting resistance began to increase sharply to a maximum of 243.86 N, 198.72 N, and 155.19 N for 50 mm, 100 mm and 150 mm cutting positions from the stock, respectively (Figure 3a). The cutting resistance measured at 50 mm from the stock was 18.51 % higher than that at 100 mm and the value obtained at 100 mm from the stock was 21.91 %. Due to decline and upsurge after the resistance attained maximum, averages were computed and used to determine the actual differences.

Average values of 193.10 N, 164.83 N and 125.78 N were obtained at 50 mm, 100 mm and 150 mm cutting positions from the stock, respectively with significant difference ($p = 0.0146$). Increasing the cutting position from 50 mm to 100 mm and 150 mm away from the stock reduces the average cutting resistance by 14.64 % and 34.86 %, respectively. The trend showed that the average cutting resistance decreases with increasing distance away from the stock. This could be due to the closely packed root fibre near the stock which decrease towards the tail end and overall fermentation as postharvest delay increases. Similarly, the results for *Sika bankye* obtained at 50 mm, 100 mm and 150 mm cutting positions from the stock showed 255.52 N, 217.27 N and 194.69 N in maximum and 202.88 N, 176.01 N and 153.15 N in average respectively with no significant difference ($p = 0.5154$). Increasing the cutting position from 50 mm to 100 and 150 mm away from the stock reduces the average cutting resistance by 13.24 % and 23.80 % respectively (Figure 3b). In the case of the *Dudze* cassava root, a maximum of 249.66 N, 222.14 N and 205.97 N were obtained at 50 mm, 100 mm and 150 mm cutting positions from the stock respectively. Average values of 195.56 N, 184.93 N and 167.82 N were obtained at 50 mm, 100 mm and 150 mm cutting positions from the stock respectively with no significant difference ($p = 0.1385$). Increasing the cutting position from 50 mm to 100 mm and 150 mm away from the stock reduces the average cutting resistance by 5.44 % and 14.19 % respectively (Figure 3c).

Effect of knife thickness on cutting resistance

The cutting resistance assessed for the *Duade kpakpa*, *Sika bankye* and *Dudze* cassava roots was carried out using 1.0 mm, 1.5 mm and 2.0 mm thick cutters (Figure 4). The results showed that the cutting resistance of the roots increases sharply and occurs between 10 mm and 25 mm depth of knife penetration after which it declines and upsurge as the knife penetrates further into the root for all the cultivars. Further analysis showed that the *Duade kpakpa* roots yielded 181.51 N, 192.58 N and 248.15 N maximum cutting resistance for the 1.0 mm, 1.5 mm and 2.0 mm knife thicknesses, respectively (Figure 4a). Subsequently, average cutting resistances of 140.71 N, 163.69

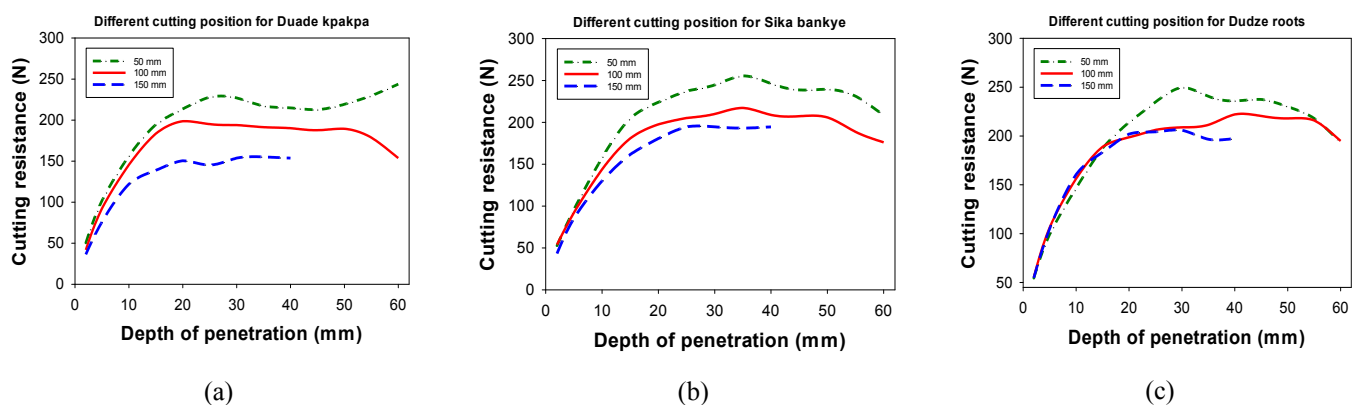


Figure 3 Cutting resistance at different positions on the root for (a) *duade kpakpa*, (b) *sika bankye*, and (c) *dudze*

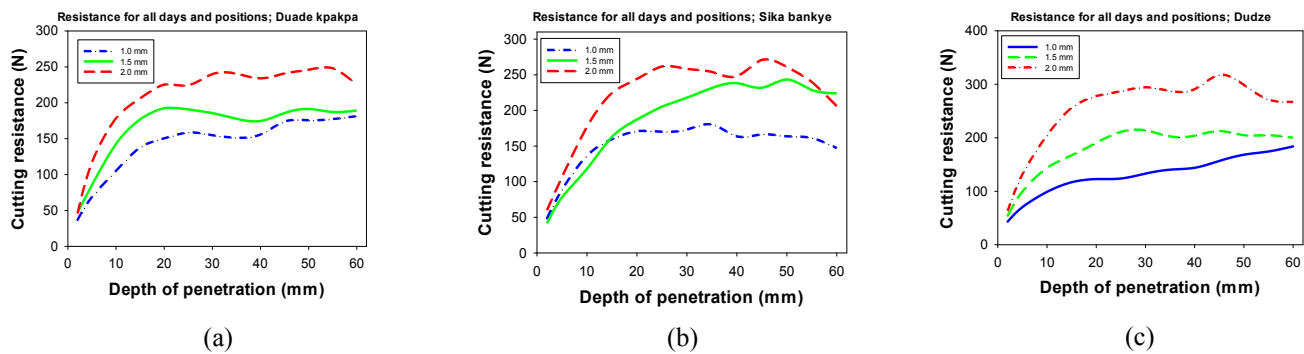


Figure 4 Cutting resistance for different knives for (a) *duade kpakpa*, (b) *sika bankye*, and (c) *dudze*

N and 205.67 N were obtained for the 1.0 mm, 1.5 mm and 2.0 mm knife thicknesses respectively with significant difference ($p = 0.0081$). Increasing the knife thickness from 1.0 mm to 1.5 mm and 2.0 mm increased the average cutting resistance by 14.04 % and 31.58 %, respectively which indicates that increasing the thickness of the cutter increases the resistance substantially. In the same way, the results for *Sika bankye* had 181.41 N, 243.48 N and 270.94 N in maximum as well as 148.53 N, 185.29 N and 216.34 N in average for 1.0 mm, 1.5 mm and 2.0 mm knife thicknesses respectively with significant difference ($p = 0.0185$). Increasing the knife thickness from 1.0 mm to 1.5 mm and 2.0 mm increased the average cutting resistance by 19.84 % and 31.34 %, respectively. This suggests that there is not much difference in the percentage change for the 2.0 mm knife thickness as compared to the *Duade kpakpa* cassava root (Figure 4b). In the case of the *Dudze* cassava root, a maximum of 183.91 N, 214.12 N and 317.72 N were measured for the 1.0 mm, 1.5 mm and 2.0 mm knife thicknesses, respectively (Figure 4c). Average values of 128.96 N, 177.76 N and 205.06 N were obtained for the 1.0 mm, 1.5 mm and 2.0 mm knife thicknesses respectively with significant difference ($p = 0.0000$). Increasing the knife thickness from 1.0 mm to 1.5 mm and 2.0 mm increased the average cutting resistance by 27.45 % and 48.43 %, respectively. The high percentage increase in the cutting resistance for the 2.0 mm could be due to a significant reduction in the moisture content as postharvest delay increases for the *Dudze* cultivar leading to increased penetration resistance of the cutter.

Effect of postharvest delay on cutting resistance

The effect of postharvest delay on the root cutting resistance assessed for the different cassava cultivars averaged over the entire cutting positions and knife thicknesses are shown in Figure 5. The results showed that the average cutting resistance of the *Duade kpakpa* cassava root were 200.73 N, 172.43 N and

135.69 N for day 1, day 2 and day 3 postharvest delays, respectively (Figure 5a). Furthermore, delaying the cutting for 2 and 3 days decreases the cutting resistance by 14.10 % and 32.40 %, respectively with a significant difference ($p = 0.0091$). This indicates that as the postharvest delay increases, fermentation increases which weakens the root tissue and reduces the toughness of the root fibre. Similarly, the average cutting resistance of the *Sika bankye* root were 221.79 N, 178.07 N and 145.52 N for 1 day, 2 days and 3 days postharvest delays, respectively (Figure 5b). Additionally, delaying the cutting for 2 days and 3 days decreases the cutting resistance by 19.71 % and 34.39 %, respectively with significant difference ($p = 0.0059$). In another development, average cutting resistances of 201.92 N, 163.32 N and 139.42 N were measured for 1 day, 2 days and 3 days postharvest delays, respectively using the *Dudze* cassava cultivar as an experimental sample (Figure 5c). Analysis of variance showed there were significant difference in the results ($p = 0.0093$). The result has shown clearly that the cutting resistance of the cassava root decreases with increasing postharvest delay. Postharvest delay results in moisture loss, which is reported as the most critical quality in the degradation of fresh agricultural produce like cassava (Atieno *et al.*, 2018). In assessing the effects of moisture on the compressive strength of cassava, Oriola and Raji (2015) reported a similar trend as realized in this study.

Cultivar response to cutting resistance

The cutting resistance assessed for the different cassava root cultivars averaged over all treatments were plotted (Figure 6). Comparing the results, a maximum cutting resistance of 229.02 N, 223.09 N and 204.43 N were obtained for the *Dudze*, *Sika bankye* and *Duade kpakpa* cassava roots respectively with no significant difference between the cultivars ($P = 0.7181$). Similarly, averages of 183.83 N, 183.39 N and 169.05 N were obtained for the *Dudze*, *Sika bankye* and *Duade kpakpa* cassava

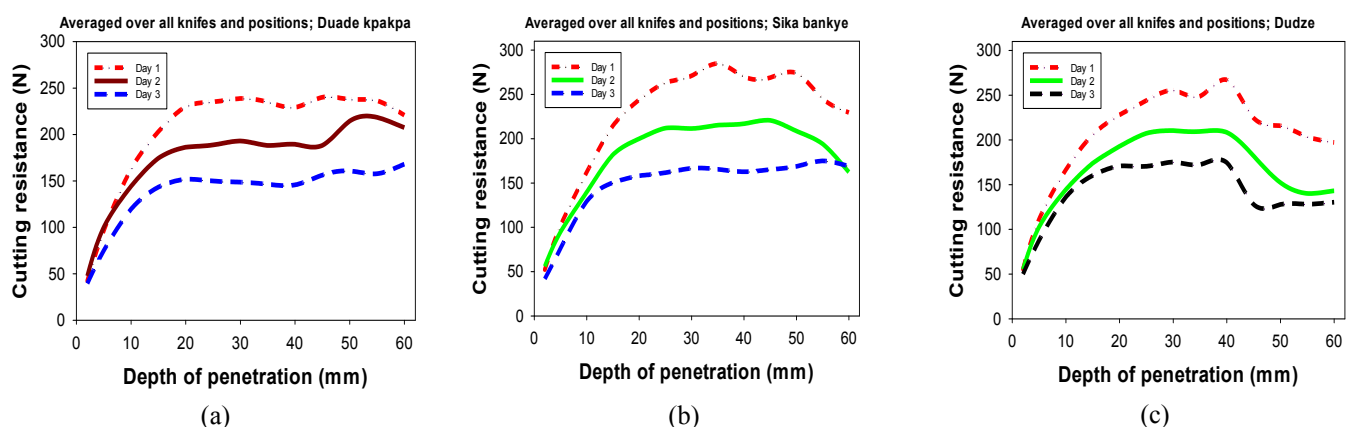


Figure 5 Cutting resistance at different postharvest delays for (a) *duade kpakpa*, (b) *sika bankye*, and (c) *dudze*

roots, respectively. The average cutting resistance of the *Dudze* cassava root was 0.24% higher than the value for the *Sika bankye* root and the value for the *Sika bankye* root was 7.82 % higher than the *Duade kpakpa* cassava roots. It is therefore

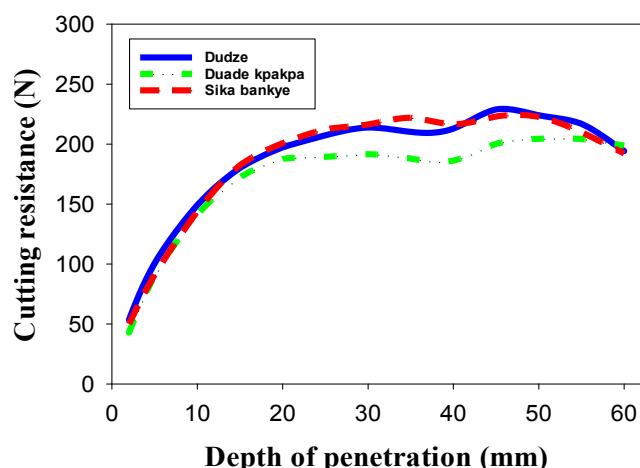


Figure 6 Cutting resistance for different cultivars averaged over all treatments

clear that the resistance of the cassava cultivar to compressive cutting using the average cutting resistance could be ranked as:

Dudze cassava root > *Sika bankye* root > *Duade kpakpa* cassava root.

Evaluation of root resistance to cutting by PLSR Model

The changeability features in the root resistance to cutting make it difficult to segregate the resistance curve changes with different postharvest delays and knife thickness. The cutting

resistance is proportional to the degree of root damage due to postharvest delay period and thickness of the cutting blade. This is because the root could have more tissue damage at longer postharvest delay which weakens the resistance to the penetration of the knife than at a shorter postharvest delay. It was required to select the sub-intervals which contain the most information on cutting resistance changes instead of the whole interval to reduce the impact of instability features. In this study, four intervals for the depth of knife penetration were selected as follows: 2.6–6.8 mm, 17.4–25.6 mm, 35.6–41.8 mm and 50.6–56.8 mm. PLSR models were built after the interval selection, and the performances in the forms of scatter plots are shown in Figure 7 for knife thickness and Figure 8 for postharvest delay. The specific comparisons of the evaluation parameters were the R_p and RMSE as shown in Table 3. The quantitative assessment result obtained for the PLSR model of the *Dudze* cassava root ($R^2 = 0.9796$; RMSE = 1.8532), is considerably better than the PLSR model of the *Duade kpakpa* cassava root ($R^2 = 0.9679$; RMSE = 2.0180) and the PLSR model of *Sika* root cultivar ($R^2 = 0.9591$; RMSE = 2.4348). However, the performance of the PLSR models developed under the postharvest delay indicated that the *Duade kpakpa* root ($R^2 = 0.8082$; RMSE = 3.5285), is significantly better than the PLSR model of the *Dudze* cassava root ($R^2 = 0.7848$; RMSE = 4.3115) and the PLSR model of *Sika bankye* root ($R^2 = 0.7604$; RMSE = 4.2148). It can be seen that the trend for knife thickness effect on the model performance was not the same as the postharvest delay due to deterioration difference in root tissue damage.

Further analysis of the PLSR indicated that average correlation coefficient of 0.9689 and 0.7845 were obtained for the knife thickness and postharvest delay, respectively. The consistency of knife thickness effect on cutting resistance was

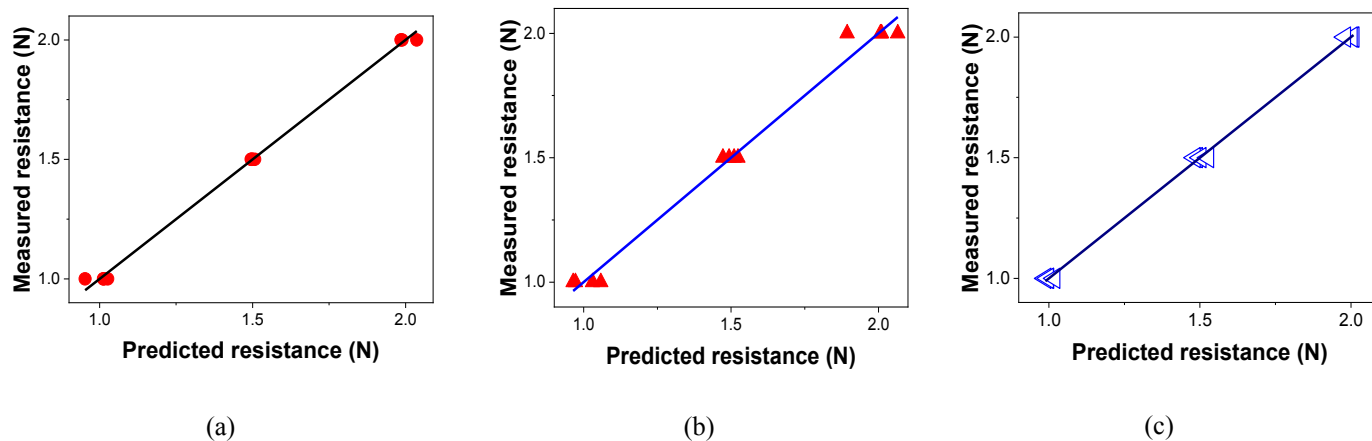


Figure 7 Cutting resistance of the different knife thicknesses for (a) *duade kpakpa*, (b) *sika bankye*, and (c) *dudze*

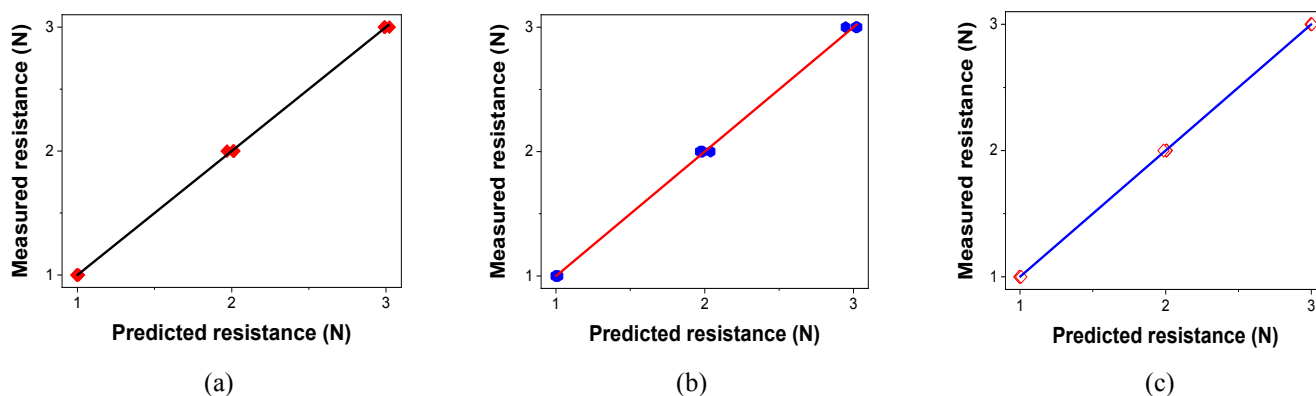


Figure 8 Cutting resistance for different postharvest delays for (a) *duade kpakpa*, (b) *sika bankye*, and (c) *dudze*

Table 3 PLSR Model performance indicators

Model	Knife thickness		Postharvest delay	
	R ²	RMSE	R ²	RMSE
<i>Dudze</i>	0.9796	1.8532	0.7848	4.3115
<i>Duade kpakpa</i>	0.9679	2.0180	0.8082	3.5285
<i>Sika bankye</i>	0.9591	2.4348	0.7604	4.2148

19.03 % higher than the postharvest delay. Subsequently, the RMSE value for the knife thickness was 47.69 % less than the postharvest delay. This happened mainly because there was a high variation in root tissue response to fermentation due to different cultivar resistance to environmental stress.

Conclusion

A mechanical model for the assessment of cassava root cutting resistance has been developed and evaluated under compression cutting using three cassava cultivars as experimental samples. The average values for the diameter and peel thickness of the cassava cultivars assessed were, 52.52 mm and 2.41 mm, 59.35 mm and 2.36 mm, and 60.40 mm and 2.60 mm respectively for *Duade kpakpa*, *Sika bankye* and *Dudze*. The cutting resistance of the roots increases sharply and occurs between 10 mm and 25 mm depth of knife penetration after which it declines and upsurge as the knife penetrates further into the root for all the cultivars. Increasing the cutting position away from the stock reduces the average cutting resistance. Increasing the knife thickness increases the average cutting resistance with significant difference ($p < 0.05$). The effect of postharvest delay on the root cutting resistance assessed for the different cassava cultivars showed that delaying the cutting for 2 days and 3 days decreases the cutting resistance with significant difference ($p < 0.05$). This indicates that as the postharvest delay increases, fermentation increases which weakens the root tissue and reduces the toughness of the root fibre.

Comparing the different cassava cultivars, average values of 183.83 N, 183.39 N and 169.05 N were obtained for the *Dudze*, *Sika bankye* and *Duade kpakpa* cassava roots, respectively with no significant differences ($p < 0.05$). The average cutting resistance of the *Dudze* cassava root was 0.24 % higher than the value for the *Sika bankye* root and the value for the *Sika bankye* root was 7.82 % higher than the *Duade kpakpa* cassava roots. It is therefore clear that the resistance of the cassava cultivar to compressive cutting using the average cutting resistance could be ranked as: *Dudze* cassava root > *Sika bankye* root > *Duade kpakpa* cassava root. The quantitative assessment by the PLSR model averaged under the knife thicknesses ($R^2 = 0.9689$; RMSE = 2.1020) was significantly better than the PLSR model under postharvest delay ($R^2 = 0.7845$; RMSE = 4.0183). The technique employed in assessing the cutting resistance gave emphasis to the cultivar differences, provided a measuring sequence and outstanding quantitative analysis.

Conflict of Interest Declarations

The authors declare that there is no conflict of interest with the information presented in this paper.

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