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Research Article

The Influence of Processing Parameters on the Physical Quality of Garri

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Abstract

Fermentation and dewatering of cassava mash are critical stages in processing of Garri in Sierra Leone and many other West African countries. This study examines the effect of grating band and dewatering pressure on the quality of Garri obtained from three improved cassava varietiesTR-0031, TR-01229 and TR-983, obtained from Njala Agricultural Research Centre, Sierra Leone Agricultural Research Institute (NARC, SLARI) using two locally made grating bands (4-inch nail size and 1.5-inch nail size). Five kilograms (5kg) of cassava mash was dewatered at pressures of 1422.33psi, 1066.748psi and 711.165psi. The resulting dewatered mash was roasted to obtain Garri. Samples of the Garri was used to conduct analysis for swelling index and particle size distribution. Data recorded was analyzed using Microsoft excel. Key findings: Water discharged by the different Pressing Pressure, pressure 1422.33psi discharged 1.42kg in four hours of pressing, pressure 1066.748psi discharge 1.20kg and pressure 711.165psi discharged 1.08kg. The swelling index for grating band 4" obtained a maximum of 57% and band 1.5" of 43% for variety TR-01229. On average grating band 4" swelled to a pick of 54.3% and band 1.5" obtained 45.7%. The statistical analysis conducted between varieties (TR-0983, TR-0031 and TR-1229) at 95% level of probability shows that no statistically significant difference of swelling index between varieties with p-value of 0.482185. For particle size distribution (PSD) maximum Garri retention was obtained by sieve 2 of 44% and minimum of 8% for sieve 5. A Pearson correlation shows a weak negative relationship (-0.709) between grating band and swelling index. The study leads to the conclusion that the nature of grating bands and magnitude of dewatering pressure are important factors in determining PSD and swelling power, which are key quality factors of Garri processing in Sierra Leone.

Keywords

Cassava, Garri Processing, Dewatering, Swelling Index, Particle Size

1. Introduction

Cassava (Manihot esculenta) is one of the tope most used root crop from the tropic that swims across Africa, Latin America and Asia countries [1]. One of the most important relationships about cassava which signifies it origin and the tropic is its adaptation to wide varieties of tropical ecology and tolerance to drought; [2, 3]. Over the years cassava production has increased drastically, this

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may be due to the advancement of processing technology and utilization of it products by the growing population of human.

Cassava industrial revolution has pick shape in Sierra Leone with massive investment in large scale/commercial farming and construction of mini industries and processing centers around the country. This advancement has confirmed the importance of Cassava (Manihot esculenta) as one of the staple foods of Sierra Leonean home based [4]. Cassava is considered as the top most important root crop and second staple food in Sierra Leone after rice [5] and the second most important root crop in West Africa [6-8].

Cassava root transformation into products such as garri, foofoo, cassava-flour etc., has become economic activities of Sierra Leonean farmers as demand in Africa increases by 61% from 2009 and 2019 [9]. Cassava root contained high moisture content ranging from between 61.00% to 90.15% which present favorable condition for deterioration upon harvest [10, 11]. Therefore, the need to transform for prolong shelf-life resulting in immediate processing after harvest to avoid quality loss [12].

Processing cassava root to garri has become the safest means of reducing and controlling it moisture content for long term storage and also reduce postharvest loss [13]. Garri is a product obtained from fermentation of cassava root by roasting and is one of the top most products from cassava root that is consumed more compare to foofoo in Sierra Leone and many other African countries, this is due to its ease of preparation into different dishes and low moisture content which make it simplicity of long term storage and transportation [14].

Garri process by an array of techniques but the most common techniques adopted by Sierra Leoneanal local farmers after root harvested are; peeling, washing, gartering, fermenting, dewatering, sifting and roasting [6, 15, 16]. The dewatering processing can be of two ways that is traditional method (use of sacks) and improve method (use of hydraulic jack). Traditional methods are more familiar with local farmers, while the improved methods are common with conversional farmer or large processing industries. However, the quality of garri depends largely on the processing method and equipment use during processing.

This research was conducted to determine how the processing parameter influences on the quality of garri production. The study also identifies the relationship between parameter and how the influences each other.

2. Materials and Methods

2.1. Study Area and Source of Material

This study was conducted at the Postharvest Laboratory, Agricultural Engineering Department, Njala University. Materials used in the study were obtained from Sierra Leone Agricultural Research Institute (SLARI)/National Agricultural Research Center (NARC). Three cassava varieties of yellow flesh were used; TR-0983, TR-1229 and TR-0031.

Equipment's used were depending upon requirement and need at the different stages during the study. The Following equipment were key: Weighing balance, stainless knife, electronic scale, rubber bowl, stainless tray, pressing pressure block made of cement, sac, hot air oven, grating band locally made, roasting pan for Garri locally made, measuring cylinder, timer.

2.2. Sample Preparation

Samples were weighed according to objectives and methodology., The cassava was peeled, washed, cut in to two half and 5kg of samples was weighed for each variety and grated into mash using two different grating bands [18]. Grating or rasping was the second step after washing the peeled tuber to reduce the surface area to fine particle that can easily speed up the dewatering process and reduce the hydrogen cyanide content. Grating raptures the tissues and bring together the differentially compartmentalized substrate and enzyme to react and release toxic hydrogen cyanide content which can subsequently be removed.

Grating was followed by pressing and dewatering, where three different pressing weight were used to dewater the cassava mash for a couple of hours. For every hour the waste water collected were accumulated and weighed for each grating band, pressing force and varieties, resulting in a cake.

Pressing was followed by sifting the cassava cake to break up the particles and remove the fiber and lumps (pieces of improperly grated cassava). Sifting was followed by roasting, where the sifted cassava mash was roasted to form a final product called Garri [18].

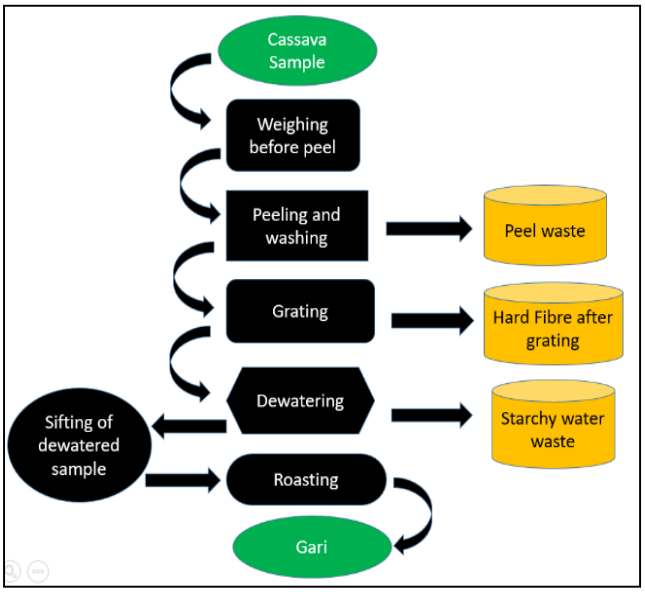

Figure 1. Flow chart of sample processing.

Garrification is a process of converting cassava mash with low moisture content with the application of heat and constant mixing of the mash till it become moisture free. The mixing

process was done with a wooden spatula. According to [19], sieving reduces the formation of lumps during roasting. An earthenware stove and a frying pan made of melded aluminum or stainless steel was used. The granules are fed in bits into the hot pan and stirred until an adequate quantity has been fed. The final product was obtained called Garri. Samples of the Garri were taken to the laboratory for further analysis. Below is a flow chat (Figure 1) showing Garri process method used.

2.3. Data Collection Procedure

Data collection was done at the Agricultural Engineering department, Njala University. The sample used were bio-fortified Cassava varieties from NACR/SLARI.

Data was collected on moisture content before and after dewatering.

a) Particle size distribution (PSD)
b) Swelling Index
c) Data was analyzed with Microsoft excel
d) Comparison was done between grating bands, variety and dewatering pressure
e) Results was presented in the form of line chart, pie-chart and column chart
f) Pearson correlation was used to statistically test for level of significance between parameters

2.3.1. Laboratory Analysis

Determination of particle size: The sieving analysis was done according to [19] with little modification. Three hundred grams (100g) of Garri from each variety was sieved through a set of known aperture size Tyler sieves diameter ranging from 2.36mm to 300µm (Sieve1=2.36mm, Sieve2=1.18mm, Sieve3=600um, Sieve4=300um, Sieve5=150µm) with the aid of mechanical shaker set at frequency of 50 Hz for 30 minutes. Fractions retained on each were then weighed and the particle size distribution calculated.

2.3.2. Determination of Swelling Index

The swelling index was measured using the method of [23], with modifications. 50g of each Garri samples were put into a 500 mL measuring cylinders. 300 mL of cold water were added to the 50g Garri into the 100mL measuring cylinder and it was gently shake and allowed to stand for 4 hours, before observing the level of swelling. The swelling indexes were then calculated as the multiple of the original volume.

2.4. Data Analysis

Data collected during the study were analyzed using Microsoft office excel 2013 version.

3. Result and Discuss

3.1. Result

3.1.1. Pressing Pressure Effect on Dewatering of Cassava Mash

The average rate of water loss by pressing pressure shows uniform curve with slight different between the pressing pressures during the first 2 hours as shows in Figure 2. From the result presented (figure 2) below, 65% of the accumulated water was lost during the first one hour of pressing for all the three-pressing pressure. Pressure 1422.33psi discharged more water on accumulation 1.42kg compare to 1066.748psi and 711.165psi with averages loss of 1.20kg, 1.08kg respectively. The discharge of water from the cassava mash by the various pressure declines as time increases on accumulated bases till it reaches a constant rate of discharge. The highest water loss was observed between 0 to 1 hour for 1422.33psi of 1.05kg, 1066.748psi of 0.86kg and 711.165psi of 0.73kg.

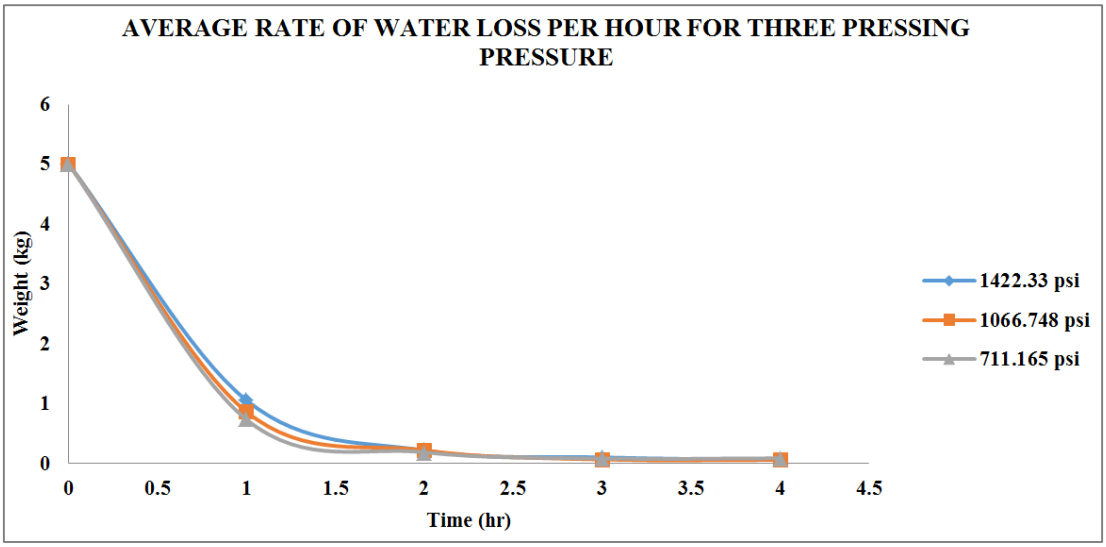

Figure 2. *Shows average rate of water loss from cassava mash per hour.*

Dehydration of cassava mash is very important to achieve high quality Garri. Figure 3 below presented the average rate of water loss by grating Bands 1.5" and 4" per hour. The average water discharge during the pressing period was recorded as 1.28kg from cassava mash that was gartered using Band 1.5" and Band 4" with total of 1.18kg. The rate at which water loss from cassava mash was observed for the two grating band on hourly bases, where Band 1.5" recorded 0.95 kg for the first one hour and Band 4" discharged 0.81kg. From observation the rate at which water discharge depend largely on the particle size as band 1.5" particles are smaller discharged a total on accumulation of 1.28 kg compare to Band 4" which particles size are grater and discharged 1.18kg of water.

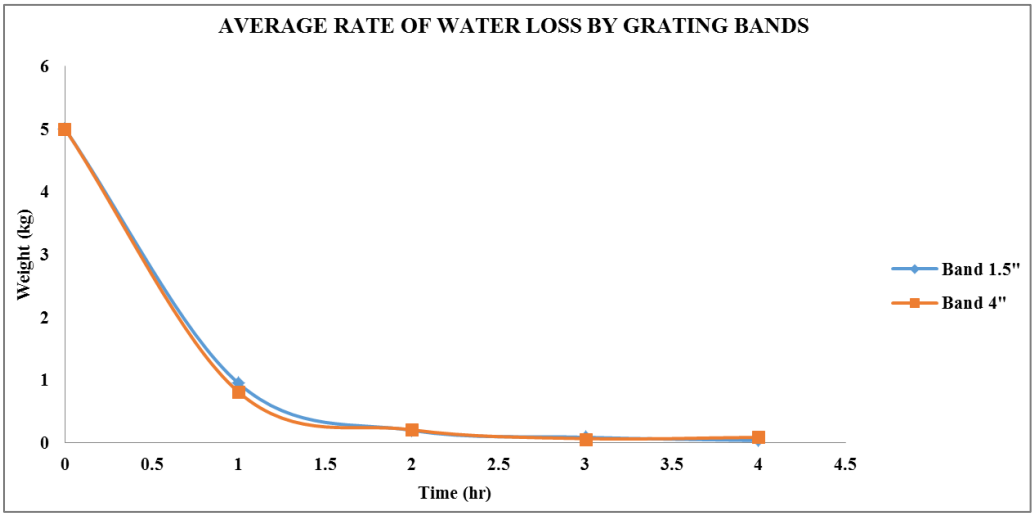

Figure 3. Shows average rate of water loss by two grating bands.

3.1.2. Result of Swelling Index of Garri

Swelling index is one of the key attribute that defines the marketability and the quality largely depend on the variety and it starch content. Since starch component makes enable garri to swell [23]. Values in Figure 4 present result of swelling index for the three varieties used, where graph A=TR-0983, B=TR-0031 and C=TR-1229 that is from right to left). Swelling index play grater row in gari quality, where the starch content and the particular size is key factor for swelling index. Varieties TR-0983 (graph A) and TR-0031 (graph B) presented similar swelling index, but Band 4" obtained higher swelling index for the three varieties with TR-1229 (graph C) been the highest of 57% and both TR-0983 and TR-0031 obtained similar percentage of 53%. From statistical analysis, the Anova test conducted between varieties (TR-0983, TR-0031 and TR-1229) at 5% level of probability shows that the result is not statistically significant difference between the varieties with p-value of 0.482185 (Supplementary Material Table 5). On the other hand, a T-test conduct between grating bands at 5% level of probability shows that there is significant different between grating bands.

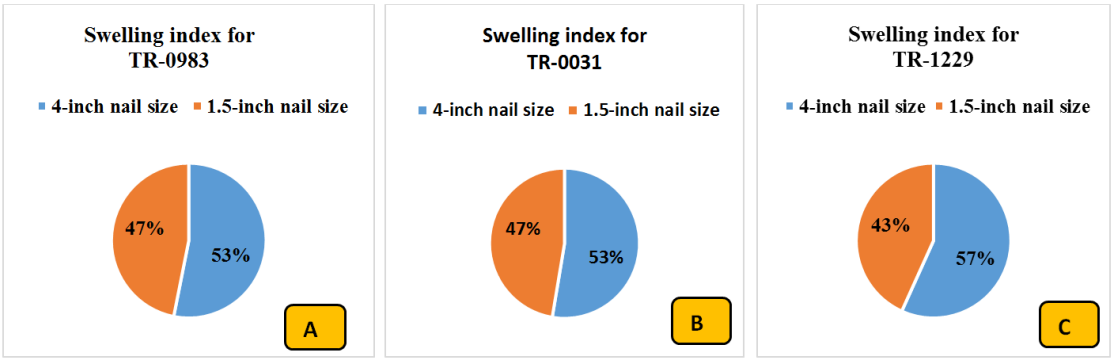

Figure 4. Shows swelling index of Garri tested for three cassava varieties using two grating band for each.

3.1.3. Particle Size Retention Analysis

Results obtained for particle size retention by sieve sizes are presented in figure 5. From the pie chat it was observed that Sieve2 retained greater amount of 44% of the total, follow by Sieve 4 with a total of 25%. The minimum quantity of garri was obtained by Sieve5 of 8% and Sieve3 of 9%.

Results presented (figure 6) shows particle size accumulation for both bands (1.5" and 4"). The test was conducted to determine the achievement of 50% of particle size on accumulated bases of the first two sieve sizes. From the analysis it was observed that band 1.5" obtained 49% which is below the bench mark, where band 4" obtained 66% of particle size on accumulated bases.

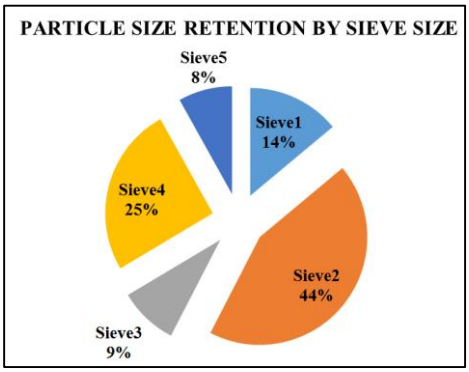

Figure 5. Shows particle size distribution by Sieve sizes.

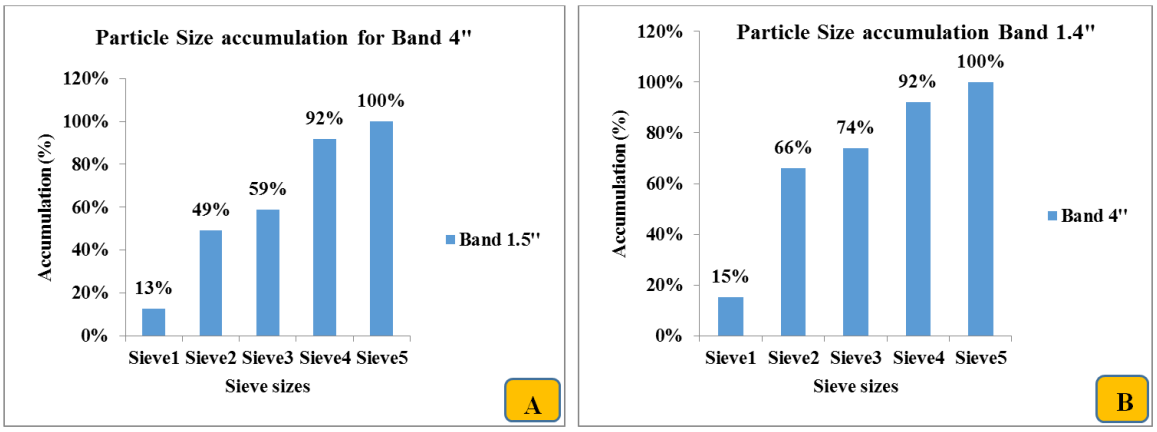

Figure 6. Shows particle size accumulation for Band 1.5" and 4".

Results presented in Table 1 shows Pearson correlation between grating band and swelling index. It was observed that a weak negative correlation (-0.709) between grating band and swelling index, which means there is weak relationship between the two.

Table 1. Correlations coefficient shows relationship between variety, grating bands and swelling index.

Correlations				
		Variety	**Grating Band size**	**Swelling Index**
Variety	Pearson Correlation	1	0.000	-0.579
	Sig. (2-tailed)	6	1.000	0.228
	N		6	6
Grating Band size	Pearson Correlation	0.000	1	-0.709
	Sig. (2-tailed)	1.000	6	0.114
	N	6		6
Swelling Index	Pearson Correlation	-0.579	-0.709	1
	Sig. (2-tailed)	0.228	0.114	6
	N	6	6	

3.2. Discussion

Pressing pressure effect on dewatering of cassava mash

Different pressing pressure (1422.33psi, 1066.748psi and 711.165psi) were exacted on the different gartered cassava mash obtained from the two grating band (4" and 1.5") and three varieties and the water loss was calculated on accumulation bases. It was observed (Figure 2) that above 65% of water was discharge in the first hour of pressing for all the different pressure used, where the water loss was inversely proportional to the pressing pressure this mean that the higher the pressing pressure the more loss of water from the cassava mash where pressure 1422.33psi discharged the highest amount of water 1.42kg, follow by 1066.748psi which discharge 1.20kg of water and the list discharge recorded was 1.08kg for pressure 711.165psi. The rate of discharge at the final hours (4th hours) was observed to be uniform. This support the finding of [17] which stated that the speed of water loss will enhance the making of Garri.

Following the observation from Figure 3 which presented a comparison of water loss by cassava mash between grating bands, the result clearly indicated that the rate of water loss is higher in grating band 1.5" compare to grating band 4". This is a result of the cassava mash particle sizes where band 1.5" has fine particle sizes and less surface area compare to band 4" which has quartz particle sizes with greater surface area.

Result of swelling index of Garri

From the laboratory test grating band was observed to influences swelling index where Garri obtained from grating band 4" swelled more than Garri obtained from grating band 1.5" this is because the particle has more surface area to accumulate water. Also variety TR-1229 and TR-0031 obtained similar percentage of swelling index for the two grating band with band 4" reported the highest of 57% and 43% for band 1.5". However, a statistical analysis (Supplementary Material Table 5) conducted clarify that was not statistically significant difference between the varieties in term of swelling. Also Pearson correlation test shows that there is weak or poor relationship between swelling index and grating band, which mean grating band raspier size has no effect of the swelling index of a Garri.

Result of particle size distribution of Garri

As observed from the results presented, it clearly shows that sieve size 2 retained the highest amount of Garri particle of 44% of the overall total follow by sieve4 (25%). On accumulation both sieves (2 and 4) obtained more than 50% this is because of the distribution of the particle sizes where the two grating bands average lies between the two sieves. Also grating band 4" particle sizes lies between sieve 1 and 2 which attained more than 60% retention of Garri on accumulation bases this is because of particle sizes are more quartz. On the other hand band 1.5" particle retention were partially distributed among the various sizes of the sieves due to it fine particle sizes.

4. Conclusion and Recommendation

4.1. Conclusion

The study evaluated influence of processing parameters on the physical quality of garri. Based on our finds it was clearly indicated by statistic evaluation that processing parameters such as pressing pressure, grating band raspier influences the physical quality of garri. The study shows that pressing pressure of cassava mash have significant improvement effect on the Garrification (roasting) of Garri by the degree of fineness of the mash particle of Garri, wherein if the pressing pressure is too low, roasting the dewatered cassava mash will result in larger particle sizes of Garri. Therefore, heavy pressing force is needed to obtain a better quality of Garri for a short period of time. Garri with larger particle size has the tendency of obtaining higher swelling index than smaller particle size, hence maintaining smaller fine particle size of Garri with lower swelling index is necessary.

4.2. Recommendation for Further Study in This Area

1. Further investigation is needed to integrate sensorial quality evaluation on this type of study.
2. Pressing pressure field assessment for commercial producers need to be done to determine the final moisture content of dewaters mash before roasting in different regions of Sierra Leone.

Supplementary Material

Table 2. *Water loss per hour under different pressing pressure.*

Results of water loss per hour under different pressing pressure										
	0 hr.		1 hr.		2 hrs.		3 hrs.		4 hrs.	
	Band 1.5"	Band 4"	Band 1.5"	Band 4"	Band 1.5"	Band 4"	Band 1.5"	Band 4"	Band 1.5"	Band 4"
1422.33 psi	5.00	5.00	1.20	0.90	0.21	0.22	0.12	0.08	0.04	0.07
1066.748 psi	5.00	5.00	0.86	0.86	0.20	0.23	0.07	0.06	0.03	0.08
711.165 psi	5.00	5.00	0.79	0.67	0.18	0.19	0.08	0.08	0.06	0.11

Table 3. Shows weight loss by Cassava mash during pressing.

	Weight loss by Cassava Mash									
	0 hr		1 hr		2 hrs		3 hrs		4 hrs	
	Band 1.5"	Band 4"	Band 1.5"	Band 4"	Band 1.5"	Band 4"	Band 1.5"	Band 4"	Band 1.5"	Band 4"
1422.33 psi	5.00	5.00	3.63	3.66	3.30	3.34	3.00	3.23	2.83	2.90
1066.748 psi	5.00	5.00	3.82	3.83	3.07	3.53	3.00	3.35	2.85	3.02
711.165 psi	5.00	5.00	3.93	3.80	3.62	3.47	3.43	3.31	3.20	3.08

Table 4. T-test on swelling index between grating bands.

t-Test: Paired Two Sample for Means	*4-inch nail size*	*1.5-inch nail size*
Mean	3.8666667	3.266666667
Variance	0.1733333	0.093333333
Observations	3	3
Pearson Correlation	0.5765567	
Hypothesized Mean Difference	0	
Df	2	
t Stat	3	
P (T<=t) one-tail	0.047733	
t Critical one-tail	2.9199856	
P (T<=t) two-tail	0.095466	
t Critical two-tail	4.3026527	

Table 5. Anova analysis on swelling index between varieties.

Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
TR-0031	2	7.6	3.8	0.08		
TR-1229	2	7.4	3.7	0.5		
TR-0983	2	6.4	3.2	0.08		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.413333333	2	0.206667	0.939394	0.482185	9.552094
Within Groups	0.66	3	0.22			
Total	1.073333333	5				

Abbreviations

NARC	Njala Agricultural Research Centre
TR	Typically Stands for "Tropical Root
PSD	Particle Size Distribution
SLARI	Sierra Leone Agricultural Research Institute
BMI	Body Mass Index
psi	Pounds per Square Inch

Author Contributions

Sallu Karteh: Supervision, Resources, Writing–review & editing, Methodology, Formal Analysis, Validation, Investigation

Georgiana Allie: Data curation, Writing – review & editing, Methodology, Formal Analysis

Joseph Sherman-Kamara: Project administration, Resources, Writing – original draft, Conceptualization, Formal Analysis, Validation, Funding acquisition

Amis Cecelia Nah: Investigation, Data curation, Funding acquisition

Dominic Musa Ibrahim-Sayo: Writing – review & editing, Validation

Conflicts of Interest

The Authors declare no conflicts of interest.

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