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Determination of the best Shelling Efficiency, Speed and Moisture Content for three varieties of Bambara Groundnut (Sb1-1 "Mumuye", Ashemkungu or Shangedubu" and Soyabin) using the Bambara Groundnut Shelling Machine.

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ABSTRACT

This study investigates the optimal shelling efficiency, speed, and moisture content for three varieties of Bambara groundnut (Vigna subterranea)—SB1-1 "Mumuye," "Ashemkungu" or "Shangedubu," and "Soyabin"—using a mechanical shelling machine. Given the crop's nutritional value and adaptability to sub-Saharan Africa's challenging agro-ecological conditions, efficient post-harvest processing is crucial for maximizing its economic potential. The research systematically evaluates the impact of varying moisture levels (8-10%, 12-14%, and 16-18%) and machine speeds (250, 275, and 300 RPM) on shelling performance. Results indicate that the best shelling efficiency for the Ashemkungu variety was achieved at 250 RPM with 5% moisture content, while the Soyabin variety performed optimally at 275 RPM with 7% moisture content. The Mumuye variety also showed high efficiency at 275 RPM with 7% moisture content. The findings highlight the critical role of moisture content in shelling efficiency, with higher moisture levels leading to increased seed damage. This study provides valuable insights for optimizing mechanical shelling practices, ultimately enhancing the economic viability of Bambara groundnut production and contributing to food security in the region. Recommendations include tailored shelling practices, effective moisture management, training for farmers, further research on additional variables, and policy support for mechanical shelling technologies.

Keywords: Bambara groundnut, shelling efficiency, moisture content, mechanical shelling, food security, sub-Saharan Africa.

I. INTRODUCTION

Bambara groundnut (Vigna subterranea) is a leguminous crop that has gained prominence in sub-Saharan Africa due to its nutritional value and adaptability to diverse agro-ecological conditions. This crop is particularly valued for its high protein content, which can reach up to 30% of its dry weight, making it an essential dietary component for many communities (Murevanhema et al., 2018). Additionally, Bambara groundnut is known for its resilience to drought and poor soil conditions, which positions it as a viable option for enhancing food security in regions facing climate change challenges (Mavengahama et al., 2019). The cultivation of Bambara groundnut encompasses

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various varieties, including SB1-1 “Mumuye,” “Ashemkungu” or “Shangedubu,” and “Soyabin,” each exhibiting unique agronomic traits that can influence their processing characteristics (Adebayo et al., 2020).

Efficient post-harvest processing is crucial for maximizing the economic potential of Bambara groundnut. One of the key operations in this process is shelling, which significantly impacts the quality and yield of the edible seeds. Traditional shelling methods are often labor-intensive and can lead to considerable losses in both quantity and quality (Ogunleye et al., 2019). The introduction of mechanical shelling machines has the potential to enhance processing efficiency, but the performance of these machines can vary based on several factors, including the variety of the groundnut, the speed of the machine, and the moisture content of the seeds (Ogunwolu et al., 2021). Understanding the optimal conditions for shelling is essential for improving the overall value chain of Bambara groundnut production.

Previous research has indicated that shelling efficiency is influenced by the physical and mechanical properties of the seeds, which can vary significantly among different varieties (Akinola et al., 2020). Moreover, moisture content plays a critical role in determining the effectiveness of the shelling process. Higher moisture levels can lead to increased seed damage during shelling, while lower moisture levels may result in poor shelling efficiency (Ogunleye et al., 2019). Therefore, it is imperative to identify the optimal moisture content and shelling speed for each variety to maximize shelling efficiency and minimize seed damage.

This study aims to determine the best shelling efficiency, speed, and moisture content for three varieties of Bambara groundnut—SB1-1 “Mumuye,” “Ashemkungu” or “Shangedubu,” and “Soyabin”—using a Bambara groundnut shelling machine. By systematically evaluating these parameters, the research seeks to provide valuable insights into optimizing the mechanical shelling process, thereby enhancing the economic viability of Bambara groundnut production. The findings of this study will contribute to the existing body of knowledge on Bambara groundnut processing and may inform future research and development efforts aimed at improving post-harvest practices in the agricultural sector.

II. STATEMENT OF THE PROBLEM

Bambara groundnut (Vigna subterranea) is an important leguminous crop in sub-Saharan Africa, recognized for its nutritional benefits and adaptability to challenging growing conditions. Despite its potential, the post-harvest processing of Bambara groundnut, particularly shelling, remains a significant challenge that affects the overall quality and yield of the edible seeds. Traditional shelling methods are often labor-intensive and inefficient, leading to considerable losses in both quantity and quality (Ogunleye et al., 2019). The introduction of mechanical shelling machines has the potential to enhance processing efficiency; however, the effectiveness of these machines can vary significantly based on several factors, including the variety of the groundnut, the speed of the machine, and the moisture content of the seeds (Ogunwolu et al., 2021).

Research has shown that different varieties of Bambara groundnut exhibit distinct physical and mechanical properties, which can influence their shelling performance (Akinola et al., 2020). For instance, variations in seed size, shape, and hardness can affect how well the seeds are shelled and the extent of damage incurred during the process. Furthermore, moisture content is a critical factor that impacts shelling efficiency. Higher moisture levels can lead to increased seed damage and reduced shelling efficiency, while lower moisture levels may result in poor separation of the seed from the shell (Mavengahama et al., 2019). Despite the importance of these factors, there is a lack of comprehensive studies that systematically evaluate the optimal shelling efficiency, speed, and moisture content for different varieties of Bambara groundnut.

The absence of such data poses a significant barrier to improving post-harvest processing practices for Bambara groundnut. Farmers and processors often lack the necessary information to optimize shelling conditions, which can lead to suboptimal processing outcomes and economic losses. Therefore, there is a pressing need to determine the best shelling efficiency, speed, and moisture content for the three varieties of Bambara groundnut—SB1-1 “Mumuye,” “Ashemkungu” or “Shangedubu,” and “Soyabin”—using a Bambara groundnut shelling machine. This study aims to fill this knowledge gap by providing empirical data that can inform best practices for mechanical shelling, ultimately enhancing the economic viability of Bambara groundnut production and contributing to food security in the region.

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III. METHODOLOGY

This study aims to determine the optimal shelling efficiency, speed, and moisture content for three varieties of Bambara groundnut: SB1-1 "Mumuye," "Ashemkungu" or "Shangedubu," and "Soyabin." The methodology is structured to systematically evaluate the impact of these variables on the performance of a Bambara groundnut shelling machine.

1. Materials

The study utilized three varieties of Bambara groundnut, sourced from local farmers in open markets within Benue state to ensure uniformity and quality (Adebayo et al., 2020). A movable Bambara groundnut shelling and cleaning machine was employed, calibrated according to the manufacturer's specifications to maintain consistent operational parameters (Ogunwolu et al., 2021). Moisture content will be measured using a moisture analyzer or a standard oven-drying method (AOAC, 2000).

2. Experimental Design

The experiment was designed to assess three moisture content levels for each variety: low (5%), medium (7%), and high (9%). These moisture levels were achieved by conditioning the seeds through controlled drying methods (Mavengahama et al., 2019). Each treatment consisted of 500 grams of seeds, and the experiment was replicated three times, resulting in a total of 27 experimental units (3 varieties × 3 moisture levels × 3 replications).

3. Shelling Procedure

The shelling process was conducted using the movable Bambara groundnut shelling and cleaning machine. Prior to shelling, the machine was calibrated to the recommended settings for Bambara groundnut processing. Each sample was shelled at varying speeds (e.g., low, medium, and high) to evaluate the effect of speed on shelling efficiency and seed damage. After shelling, the shelled seeds and remaining shells was collected separately for analysis.

4. Data Collection

The weight of shelled seeds was measured using a digital scale. Additionally, the percentage of completely shelled clean seed, shelled and broken seed, partially shelled nuts and damaged seeds was separated recorded.

5. Data Analysis

Data collected from the shelling efficiency and seed damage assessments was analyzed using statistical software (SPSS version 21). Analysis of variance (ANOVA) was conducted to determine the significance of differences in shelling efficiencies and seed damage across the different moisture content levels and shelling speeds.

Conclusion

This methodology provided a comprehensive approach to evaluating the optimal shelling efficiency, speed, and moisture content for Bambara groundnut varieties. The findings contributed to improving mechanical shelling practices, enhancing the economic viability of Bambara groundnut production, and ultimately supporting food security in the Nigeria.

IV. RESULT

Determination for the Best Shelling Efficiency, Speed and Moisture Content for three Varieties

This section of the analysis takes into consideration the best shelling efficiency for the three varieties which is the Ashemkungu, Soyabin and Mumuye and the results are presented in table 1-3 and Figure 1-3 respectively.

a. Shelling Efficiency, Speed and Moisture Content in Ashe Mkungu

This section handled the best shelling efficiency, speed and moisture content of Ashemkungu and the result is presented in Table 1.

Table 1:
Mean and Standard Deviation Showing the Shelling Efficiency, Speed and Moisture Content of Ashemkungu

Shelling Efficiency	Moisture Content	Speed RPM	Weight (kg) of Ashemkungu	Mean (Efficiency Score)
Completely Shelled	5%	250	8.80	8.8000
Completely Shelled	5%	275	7.90	6.4600
Completely Shelled	5%	300	5.48	4.9000
Completely Shelled	7%	250	6.46	7.9000

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Completely Shelled	7%	275	8.20	8.2000
Completely Shelled	7%	300	6.17	4.1300
Completely Shelled	9%	250	4.90	5.4800
Completely Shelled	9%	275	4.13	6.1700
Completely Shelled	9%	300	8.44	8.4400
Completely Shelled and Broken	5%	250	1.46	1.4600
Completely Shelled and Broken	5%	275	1.72	2.7600
Completely Shelled and Broken	5%	300	2.38	1.6200
Completely Shelled and Broken	7%	250	2.76	1.7200
Completely Shelled and Broken	7%	275	1.04	1.0400
Completely Shelled and Broken	7%	300	1.72	1.1700
Completely Shelled and Broken	9%	250	1.62	2.3800
Completely Shelled and Broken	9%	275	1.17	1.7200
Completely Shelled and Broken	9%	300	1.04	1.0400
Partially Shelled	5%	250	.17	.1700
Partially Shelled	5%	275	.22	.3400
Partially Shelled	5%	300	.93	2.8400
Partially Shelled	7%	250	.34	.2200
Partially Shelled	7%	275	.07	.0700
Partially Shelled	7%	300	.96	1.9300
Partially Shelled	9%	250	2.84	.9300
Partially Shelled	9%	275	1.93	.9600
Partially Shelled	9%	300	.23	.2300
Not Shelled	5%	250	.02	.0200
Not Shelled	5%	275	.04	.0600
Not Shelled	5%	300	.54	.0300
Not Shelled	7%	250	.06	.0400
Not Shelled	7%	275	.08	.0800
Not Shelled	7%	300	1.11	1.0300
Not Shelled	9%	250	.03	.5400
Not Shelled	9%	275	1.03	1.1100
Not Shelled	9%	300	.05	.0500
Clogged in the Machine	5%	250	.29	.2900
Clogged in the Machine	5%	275	.12	.3600
Clogged in the Machine	5%	300	.67	.6100

Clogged in the Machine	7%	250	.36	.1200
Clogged in the Machine	7%	275	.61	.6100
Clogged in the Machine	7%	300	.04	1.7400
Clogged in the Machine	9%	250	.61	.6700
Clogged in the Machine	9%	275	1.74	.0400
Clogged in the Machine	9%	300	24.00	24.0000

Result in Table 1 shows the best shelling efficiency (completely shelled), best speed as well as the best moisture content for the machine across the three varieties. The result showed that, for Ashe Mkungu variety, the best shelling efficiency (completely shelled) was when the machine was set at the speed of 250 RPM and the moisture content of 5% (Mean = 8.80). This was followed by 300 RMP at 9% moisture content (Mean = 8.44) and then the next was 275 RPM of 7% moisture content (Mean = 8.20).

However, the best shelling efficiency of completely shelled and broken was gotten at 275 RPM of 5% moisture content (Mean = 2.76), followed by 250 RPM at 9% moisture content (Mean = 2.38). Determining the partially shelled, it was higher on the speed of 300 RMP at 5% moisture content (Mean = 2.84). Highest not shelled was at the speed of 275 RPM and 9% moisture content (Mean = 1.11). Highest clogged in the machine was observed at the speed of 300 RPM and 9% moisture content, followed by the speed of 300 RPM and 7% moisture content. This result is presented graphically in figure 1.

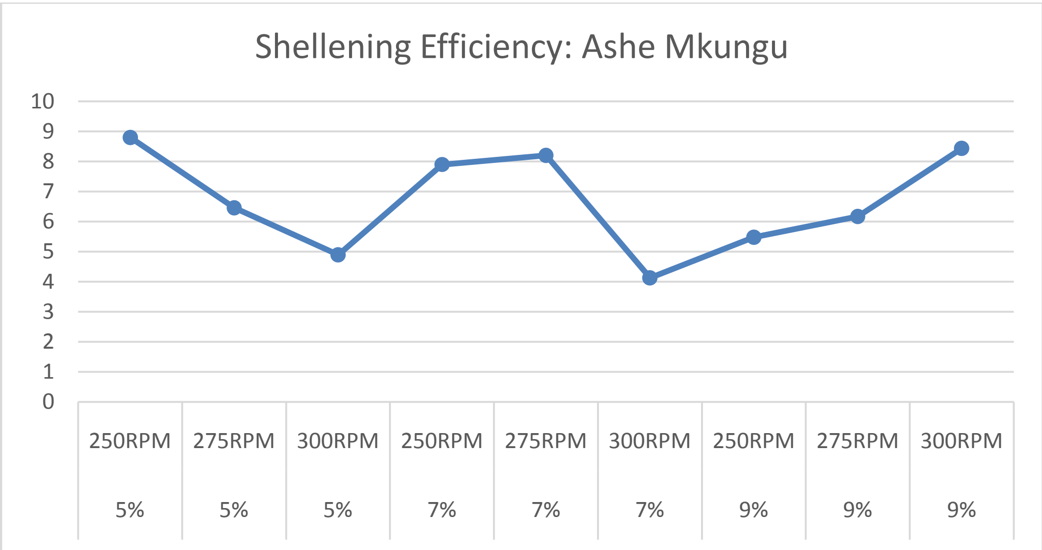

Fig 1: Figure representing the best shelling efficiency on Ashe Mkungu

b. Shelling Efficiency, Speed and Moisture Content in Soyabin

This section handles the best shelling efficiency, speed and moisture content of Soyabin and the result is presented in Table 2.

Table 2:Mean and Standard Deviation Showing the Shelling Efficiency, Speed and Moisture Content of Soyabin

Shelling Efficiency	Moisture Content	Speed RPM	Weight (kg) of Soyabin	Mean (Determinant)
Completely Shelled	5%	250	8.04	8.0400
Completely Shelled	5%	275	7.88	6.5100
Completely Shelled	5%	300	5.46	4.1100

Completely Shelled	7%	250	6.51	7.8800
Completely Shelled	7%	275	9.68	9.6800
Completely Shelled	7%	300	5.15	4.1200
Completely Shelled	9%	250	4.11	5.4600
Completely Shelled	9%	275	4.12	5.1500
Completely Shelled	9%	300	8.41	8.4100
Completely Shelled and Broken	5%	250	1.44	1.4400
Completely Shelled and Broken	5%	275	1.71	2.7300
Completely Shelled and Broken	5%	300	1.33	1.1500
Completely Shelled and Broken	7%	250	2.73	1.7100
Completely Shelled and Broken	7%	275	0.03	.0300
Completely Shelled and Broken	7%	300	1.71	1.1600
Completely Shelled and Broken	9%	250	1.15	1.3300
Completely Shelled and Broken	9%	275	1.16	1.7100
Completely Shelled and Broken	9%	300	1.02	1.0200
Partially Shelled	5%	250	0.13	.1300
Partially Shelled	5%	275	0.21	.3500
Partially Shelled	5%	300	0.92	1.9100
Partially Shelled	7%	250	0.35	.2100
Partially Shelled	7%	275	0.02	.0200
Partially Shelled	7%	300	1.92	1.9300
Partially Shelled	9%	250	1.91	.9200
Partially Shelled	9%	275	1.93	1.9200
Partially Shelled	9%	300	0.24	.2400
Not Shelled	5%	250	0.09	.0900
Not Shelled	5%	275	0.09	.3700
Not Shelled	5%	300	0.28	2.7100
Not Shelled	7%	250	0.37	.0900
Not Shelled	7%	275	0.04	.0400
Not Shelled	7%	300	1.13	2.7300
Not Shelled	9%	250	2.71	.2800
Not Shelled	9%	275	2.73	1.1300
Not Shelled	9%	300	0.22	.2200
Clogged in the	5%	250	0.3	.3000

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Machine			
Clogged in the Machine	5%	275	0.11	.0400
Clogged in the Machine	5%	300	2.01	.1200
Clogged in the Machine	7%	250	0.04	.1100
Clogged in the Machine	7%	275	0.23	.2300
Clogged in the Machine	7%	300	0.09	.0600
Clogged in the Machine	9%	250	0.12	2.0100
Clogged in the Machine	9%	275	0.06	.0900
Clogged in the Machine	9%	300	0.11	.1100

Result in Table 2 presents the best shelling efficiency (completely shelled), its related speed and moisture content for the Soyabin variety in the modified machine. The result showed that the best shelling efficiency for the modified machine using Soyabin variety is gotten at the speed of 275 RPM with the moisture content of 7% (Mean = 9.68), which was followed by speed of 300 RPM at moisture content of 9% (Mean = 8.41) and then, closely followed by speed of 250 RPM at moisture content of 5% (Mean = 8.04).

Moreover, highest efficiency at completely shelled and broken was gotten at the speed of 275 RPM with the moisture content of 5% (Mean = 2.73). For partially shelled, the highest was at the speed of 300 RPM with 9% moisture content (Mean = 1.93). Moreover, highest not shelled was at the speed of 300 RPM at the moisture content of 7% (Mean = 2.73). Lastly, highest on clogged in the machine was observed at the speed of 250 RPM with moisture content of 9% (Mean = 2.01). This result is presented in Figure 2 for further understanding.

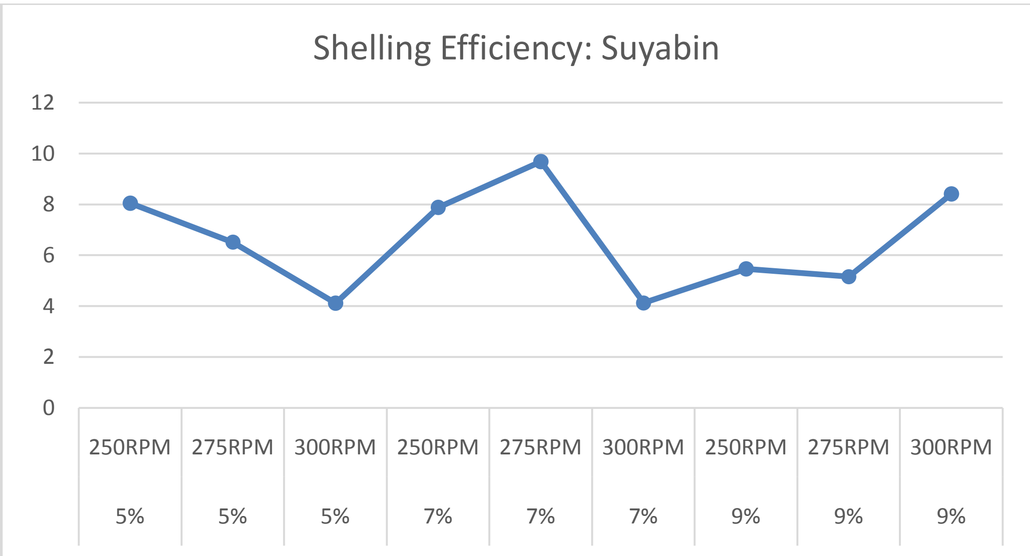

Fig 2: Figure representing shelling efficiency of Soyabin

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c. Shelling Efficiency, Speed and Moisture Content in Mumuye

This section handles the best shelling efficiency, speed and moisture content of Mumuye and the result is presented in Table 3.

Table 3: Mean and Standard Deviation Showing the Shelling Efficiency, Speed and Moisture Content of Mumuye

Shelling Efficiency	Moisture Content	Speed RPM	Weight (kg) of Mumuye	Mean (Determinant)
Completely Shelled	5%	250	8.05	8.0500
Completely Shelled	5%	275	7.91	6.5200
Completely Shelled	5%	300	5.47	8.4400
Completely Shelled	7%	250	6.52	7.9100
Completely Shelled	7%	275	9.3	9.3000
Completely Shelled	7%	300	5.19	8.4400
Completely Shelled	9%	250	8.44	5.4700
Completely Shelled	9%	275	8.44	5.1900
Completely Shelled	9%	300	4.13	4.1300
Completely Shelled and Broken	5%	250	1.47	1.4700
Completely Shelled and Broken	5%	275	1.72	2.7700
Completely Shelled and Broken	5%	300	0.94	.0500
Completely Shelled and Broken	7%	250	2.77	1.7200
Completely Shelled and Broken	7%	275	0.22	.2200
Completely Shelled and Broken	7%	300	1.11	1.0500
Completely Shelled and Broken	9%	250	0.05	.9400
Completely Shelled and Broken	9%	275	1.05	1.1100
Completely Shelled and Broken	9%	300	1.16	1.1600
Partially Shelled	5%	250	0.16	.1600
Partially Shelled	5%	275	0.11	.3600
Partially Shelled	5%	300	1.38	.2200
Partially Shelled	7%	250	0.36	.1100
Partially Shelled	7%	275	0.25	.2500
Partially Shelled	7%	300	1.72	.2200
Partially Shelled	9%	250	0.22	1.3800
Partially Shelled	9%	275	0.22	1.7200
Partially Shelled	9%	300	1.94	1.9400
Not Shelled	5%	250	0.3	.3000
Not Shelled	5%	275	0.22	.3300

Not Shelled	5%	300	2.19	.2700
Not Shelled	7%	250	0.33	.2200
Not Shelled	7%	275	0.22	.2200
Not Shelled	7%	300	1.97	.2700
Not Shelled	9%	250	0.27	2.1900
Not Shelled	9%	275	0.27	1.9700
Not Shelled	9%	300	2.75	2.7500
Clogged in the Machine	5%	250	0.02	.0200
Clogged in the Machine	5%	275	0.04	.0200
Clogged in the Machine	5%	300	0.3	.0200
Clogged in the Machine	7%	250	0.02	.0400
Clogged in the Machine	7%	275	0.01	.0100
Clogged in the Machine	7%	300	0.01	.0200
Clogged in the Machine	9%	250	0.02	.3000
Clogged in the Machine	9%	275	0.02	.0100
Clogged in the Machine	9%	300	0.02	.0200

Result in table 3 shows the best shelling efficiency for Mumuye, considering the speed and moisture content of the machine. There result showed that the best shelling efficiency (completely shelled) for Mumuye is gotten when the machine is set at the speed of 275 RPM and moisture content of 7% (mean = 9.30). This was followed by speed of 300 RPM at moisture content of 7% (Mean = 8.44), which is closely followed by speed of 250 RPM at moisture content of 5% (Mean = 8.05).

On the other hand, shelling efficiency conducted at completely shelled and broken showed that the highest of Mumuye's completely shelled and broken was gotten at the speed of 270 RPM at 5% moisture content (Mean = 2.77). Partially shelled of Mumuye was gotten at the speed of 300 RPM and moisture content of 9% (Mean = 1.94). Not shelled of Mumuye got its highest at the speed of 300 RPM with moisture content of 9% (Mean = 2.75) while those that were clogged in the machine for Mumuye are excess at the speed of 250 RPM and moisture content of 9% (Mean = .300) as showed in figure 3

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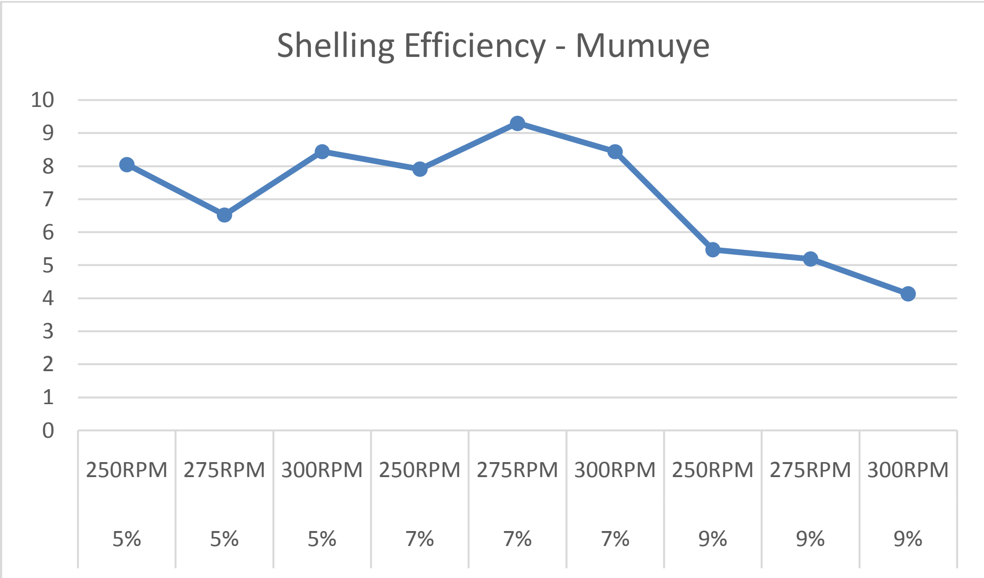

Fig 3: Figure representing shelling efficiency of Mumuye

V. CONCLUSION

This study successfully determined the optimal shelling efficiency, speed, and moisture content for three varieties of Bambara groundnut—SB1-1 "Mumuye," "Ashemkungu" or "Shangedubu," and "Soyabin"—using a movable Bambara groundnut shelling and cleaning machine. The findings revealed that each variety exhibited distinct shelling characteristics influenced by the machine's operational speed and the moisture content of the seeds. For the Ashemkungu variety, the best shelling efficiency was achieved at a speed of 250 RPM with a moisture content of 5%. In contrast, the Soyabin variety demonstrated optimal performance at 275 RPM with 7% moisture content. The Mumuye variety also showed the highest efficiency at 275 RPM with 7% moisture content. These results underscore the importance of tailoring shelling conditions to specific varieties to maximize efficiency and minimize seed damage.

The study highlights the critical role of moisture content in the shelling process, as higher moisture levels were associated with increased seed damage and reduced efficiency. Conversely, lower moisture levels sometimes resulted in poor separation of seeds from their shells. The data collected provides valuable insights into the mechanical shelling process, which can significantly enhance the economic viability of Bambara groundnut production and contribute to food security in sub-Saharan Africa.

VI. RECOMMENDATIONS

Based on the findings of this study, the following recommendations are proposed:

1. **Tailored Shelling Practices**: Farmers and processors should adopt tailored shelling practices that consider the specific variety of Bambara groundnut being processed. This includes adjusting the shelling machine's speed and monitoring moisture content to optimize efficiency and minimize damage.
2. **Moisture Management**: It is essential to implement effective moisture management strategies during the post-harvest phase. This may involve using controlled drying methods to achieve the optimal moisture content for each variety before shelling.
3. **Training and Capacity Building**: Training programs should be developed for farmers and processors to enhance their understanding of the mechanical shelling process and the importance of moisture content. This will empower them to make informed decisions that improve post-harvest processing outcomes.
4. **Further Research**: Additional research is needed to explore the effects of other variables, such as seed size and shape, on shelling efficiency. Long-term studies could also assess the economic impact of implementing optimized shelling practices on the livelihoods of Bambara groundnut producers.
5. **Policy Support**: Policymakers should consider supporting the adoption of mechanical shelling technologies in rural areas, providing access to

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affordable machines and training to enhance the efficiency of Bambara groundnut processing.

By implementing these recommendations, stakeholders in the agricultural sector can improve the post-harvest processing of Bambara groundnut, ultimately enhancing its contribution to food security and economic development in the region.

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