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The Role of Mechanized Peanut Shelling in Reducing Post-Harvest Losses and Labor Intensiveness

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ABSTRACT

This study assesses the performance and user acceptability of a peanut sheller machine using Garvin's Eight Dimensions of Quality and the Technology Acceptance Model (TAM). A mixed-methods research design was employed, combining quantitative performance measurements with qualitative user perception assessments. Controlled shelling tests under three drying conditions (5–10 days, 10–15 days, and 15+ days) were conducted to evaluate efficiency, yield, and product quality. Expert judgment was used to rate the machine's reliability, durability, and serviceability, while perceived usefulness and ease of use were evaluated through focus group discussions and structured questionnaires. Results revealed that the peanut sheller machine was rated "Very Acceptable" (mean = 3.82) under Garvin's model, with durability receiving the highest rating (4.00). Under TAM, it received a "Highly Acceptable" rating (mean = 4.63), highlighting its efficiency and ease of use. Shelling efficiency improved with longer drying time, with the 15+ day condition achieving the highest output (653.75g) and the lowest unshelled rate (0.45%). In contrast, shorter drying times (5–10 days) were more effective in preserving peanut quality and minimizing damage (0.9%). Furthermore, a comparative performance analysis between machine and manual shelling showed that mechanized shelling significantly outperformed manual methods in terms of throughput, efficiency, labor savings, and post-harvest loss reduction. Machine shelling reduced shelling time by over 80%, increased throughput by more than 500%, and lowered post-harvest losses by 43.5%. These findings validate the peanut sheller machine's potential to improve post-harvest operations, reduce labor intensity, and enhance agricultural productivity in rural communities. Future research should focus on optimizing drying parameters, improving machine reliability, and developing user training and support systems to increase adoption.

Keywords: *peanut sheller machine, Garvin's quality dimensions, Technology Acceptance Model, agricultural mechanization, post-harvest efficiency*

INTRODUCTION

Peanut production is one of the primary agricultural activities that make great contributions to food security and economic stability in most rural areas ((Pokhrel et al., 2025). Peanuts are an important source of protein, essential oils, and essential nutrients, hence a very valuable crop for both subsistence and commercial farmers (Kaplan &; Yıldırım, 2024). Post-harvest activities, especially shelling, are serious issues for small-scale farmers. The conventional process of manual shelling is time-consuming, labor-intensive, and sensitive to variations in product quality. This post-harvest limitation negatively affects overall productivity and profitability (Assessment Of Post-Harvest Losses On Soybeans Profitability In Three Sectors Of Nyagatare District Of Rwanda," 2023). With constant technological innovation in changing agricultural processes, the construction and utilization of effective peanut shelling machines represent a potential solution to such challenges.

Mechanized shelling can potentially reduce the labor and time required in post-harvest processing considerably while improving the quantity and quality of the shelled commodity at the same time (Liao et al., 2024). Well-maintained shelling machines produce additional good-quality kernels with less damage and exposure of peanuts. These technologies are especially significant in rural settings, where labor shortages and increasing production pressures mean reliable mechanized options are as much as needed. Adoption of mechanized sheller can increase the economic returns of local farmers, improve production efficiency, and help them respond better to market needs (Nagarjuna et al., 2024).

Despite these benefits, mechanized peanut shelling remains underutilized in global rural farming societies. Investment cost, simplicity in operation, and subjective reliability are key indicators deciding the level of new technology uptake (Moreira et al., 2024). Technical efficacy of the machine itself is not enough; one must also prove the acceptability of the equipment to the farmers. It is important to understand the perceptions of local farmers and agricultural stakeholders for improving the effective adoption of mechanized technology (Panta et al., 2024). Moreover, incorporating the interdependent relationship between shelling efficiency and drying time plays a vital role in order to improve machine operation under real running conditions (Wang et al., 2022).

Farm machinery performance and acceptability measurement is needed to establish its practicability and efficiency (Zulhanafiah & Paman, 2024). In this sudy, the purpose is to ascertain the performance of a peanut sheller machine under different drying conditions and examine the attitude of the users using proven technology acceptance and quality models. Garvin's Eight Dimensions of Quality provide an overall framework to evaluate the performance, features, reliability, conformance, durability, serviceability, aesthetics, and perceived quality of the machine. At the same time, the Technology Acceptance Model (TAM) recognizes perceived usefulness and ease of use as determining factors of the use of new technology by farmers. The relevance of this study stems from the fact that the performance of the technology and user adoption continue in gap mode in the mechanization of agriculture. By the use of combined quantitative measures of performance and qualitative users' feedback, this study provides useful information regarding the effect of drying conditions on the machine performance and users' perception of the machine's utility. The findings are aimed at informing future enhancement in the design of peanut shellers and provision of insight on how to motivate technology adoption among small-scale farmers with the goal of improved productivity and labor burdens minimization.

MATERIALS AND METHODS

Research Design

The study used a mixed-method design entailing the conjoining of the quantitative and qualitative methods of gathering data in measuring the performance, efficiency, and acceptability of the Peanut Sheller Machine. Quantitative data were obtained via controlled experiments in measuring the efficiency of shelling, yield, and product quality, and the qualitative data came from expert scores and focus group discussions (FGDs) between local farmers.

Locale of the Study

cc. Philippine Autrement Website

Figure 1. Locale of the Study at Lazi and Maria, Province of Siquijor

The study was carried out in the municipalities of Lazi and Maria in the Province of Siquijor, where peanut farming serves as one of the primary sources of livelihood. This area was chosen to ensure the feasibility of the research and to obtain valuable insights from local farmers who are potential end-users of the Peanut Sheller Machine. Siquijor was selected as the study locale due to its notable engagement in peanut cultivation, making it a suitable site for evaluating the relevance and applicability of the technology.

Sampling Technique

A purpose sampling method was adopted to recruit subjects for quantitative tests and qualitative surveys. Ten shelling cycles of dried peanuts were performed for quantitative analysis. Farm machinery specialists and local peanut producers were invited for focus group meetings and guided interviews for qualitative analysis.

Research Instrument

The research used a mix of quantitative and qualitative tools to collect inclusive data. The performance assessment involved measuring shelled peanut yield, shelling time, and output quality in terms of good quality peanuts, damaged peanuts, and unshelled peanuts. Expert rating was conducted using a guided questionnaire on Garvin's 8 Dimensions of Quality that measured major parameters including performance, features, reliability, conformance, durability, serviceability, aesthetics, and perceived quality. The Technology Acceptance Model (TAM) of Davis was also employed to measure perceived usefulness and ease of use. Qualitative data were collected through interviews and focus group discussions (FGDs) with the local farmers, offering real-life feedback regarding the use of the machine and its efficiency.

Data Gathering Procedure

There were two phases of data collection: machine testing and user response. During the machine testing phase, ten shelling trials were conducted using 1 kg of peanuts per trial with three drying conditions (5-10 days, 10-15 days, and 15+ days). Careful records on yield, shelling time, and quality of the product were taken. For user response, expert ratings were collected using formal questionnaires. Focus group discussions (FGDs) and interviews with farmers were also conducted to understand the field use of the machine. All the data collected were recorded systematically and cross-checked for consistency prior to analysis.

Data Analysis

Quantitative data were analyzed with descriptive statistics, mean, and standard deviation to identify machine performance in varied drying conditions. Comparative analysis was employed to identify differences between yield, shelling efficiency, and quality. Expert ratings in terms of Garvin's 8 Dimensions of Quality and the Technology Acceptance Model (TAM) were analyzed through weighted mean scores to identify the acceptability of the machine. Qualitative data gathered from focus group discussion and interviews were transcribed and then analyzed with thematic analysis to identify recurring patterns and user perceptions. Double analysis enabled the comprehensive understanding of the machine's performance and potential agricultural adoption.

RESULTS AND DISCUSSION

Performance Analysis of the Peanut Sheller Machine

The peanut sheller machine was critically examined in a bid to measure its efficiency, usability, and acceptability by farmers and experts. The research utilized Garvin's 8 Dimensions of Quality and combined it with the Technology Acceptance Model (TAM) to assess its performance and user perception.

Machine's Performance Based on Garvin's 8 Dimensions of Quality

Table 1. Summary of the Extent of Acceptability Using Garvin's 8 Dimensions of Quality

Quality Dimension	Weighted Mean	Qualitative Scale
Performance	3.80	Very Acceptable
Features	3.90	Very Acceptable
Reliability	3.73	Very Acceptable
Conformance	3.80	Very Acceptable
Durability	4.00	Very Acceptable
Serviceability	3.87	Very Acceptable
Aesthetic	3.80	Very Acceptable
Perceived Quality	3.67	Very Acceptable
Overall	**3.82**	**Very Acceptable**

Table 1 gives a general rating of the peanut sheller machine based on expert ratings. The machine had a general weighted mean of 3.82, which indicates a performance level that falls under the category of Very Acceptable. The highest-rated quality factor was Durability (4.00), indicating that the machine is durable and can sustain extended use. Reliability (3.73), while still Very Acceptable, was the lowest among the factors, which means that there is still room for improvement in terms of consistent performance.

User Acceptance Based on Technology Acceptance Model (TAM)

Table 2. Summary of the Extent of Acceptability Using Davis's Technology Acceptance Model (TAM)

TAM Dimension	Mean Rating	Interpretation
Perceived Usefulness	4.75	Highly Acceptable
Ease of Use	4.51	Highly Acceptable
Overall	**4.63**	**Highly Acceptable**

The acceptability and usability of the machine were assessed using the Technology Acceptance Model (TAM). Table 2 shows the findings, with a general mean of 4.63 and therefore Highly Acceptable user perception. The findings imply that the peanut sheller machine was efficient and easy to operate, hence making it a suitable tool for agricultural use

Peanut Sheller Experiment Results

Table 3. Trials for Shelling Peanuts Under Different Drying Conditions Were Carried Out

Trial	Drying Condition	Amount (kg)	Duration (seconds)	Yield (g)	Good Condition (%)	Damaged (%)
1	5-10 days dry	1	60.19	630	99.1	0.5
2	5-10 days dry	1	56.72	615	96.1	1.2
3	5-10 days dry	1	57.88	635	98.2	1.0
4	10-15 days dry	1	53.35	645	94.7	3.0
5	10-15 days dry	1	54.33	630	97.8	1.1
6	10-15 days dry	1	48.46	620	95.9	2.7
7	15+ days dry	1	36.48	660	96.7	3.0
8	15+ days dry	1	41.16	645	97.0	2.6
9	15+ days dry	1	39.22	650	97.1	2.3
10	15+ days dry	1	42.35	660	97.6	1.9

In an attempt to further evaluate the performance of the machine, trials for shelling peanuts under different drying conditions were carried out. The results of these experiments are shown in Table 3. The experiment on peanut shelling discovered that drying peanuts for 15 days and above provided the highest mean yield (653.75g) with the least variability, hence the implication that longer drying times improve the consistency of the yields. In quality, peanuts dried for 5 to 10 days had the highest percentage of peanuts in good condition (97.8%), although the same condition had higher variability as far as the percentage of unshelled peanuts is concerned. Surprisingly, it is the 5 to 10 days drying condition that resulted in minimum damage to the peanuts (0.9%), while longer drying times resulted in higher damage levels. The shelling efficiency was highest in the 15+ days drying condition, as this resulted in the lowest percentage of unshelled peanuts (0.45%), hence implying the highest efficiency of the shelling process. The results show that although longer drying times improve the yield and the shelling efficiency, the shorter drying times are more effective in maintaining peanut quality and reducing damage.

Drying Duration

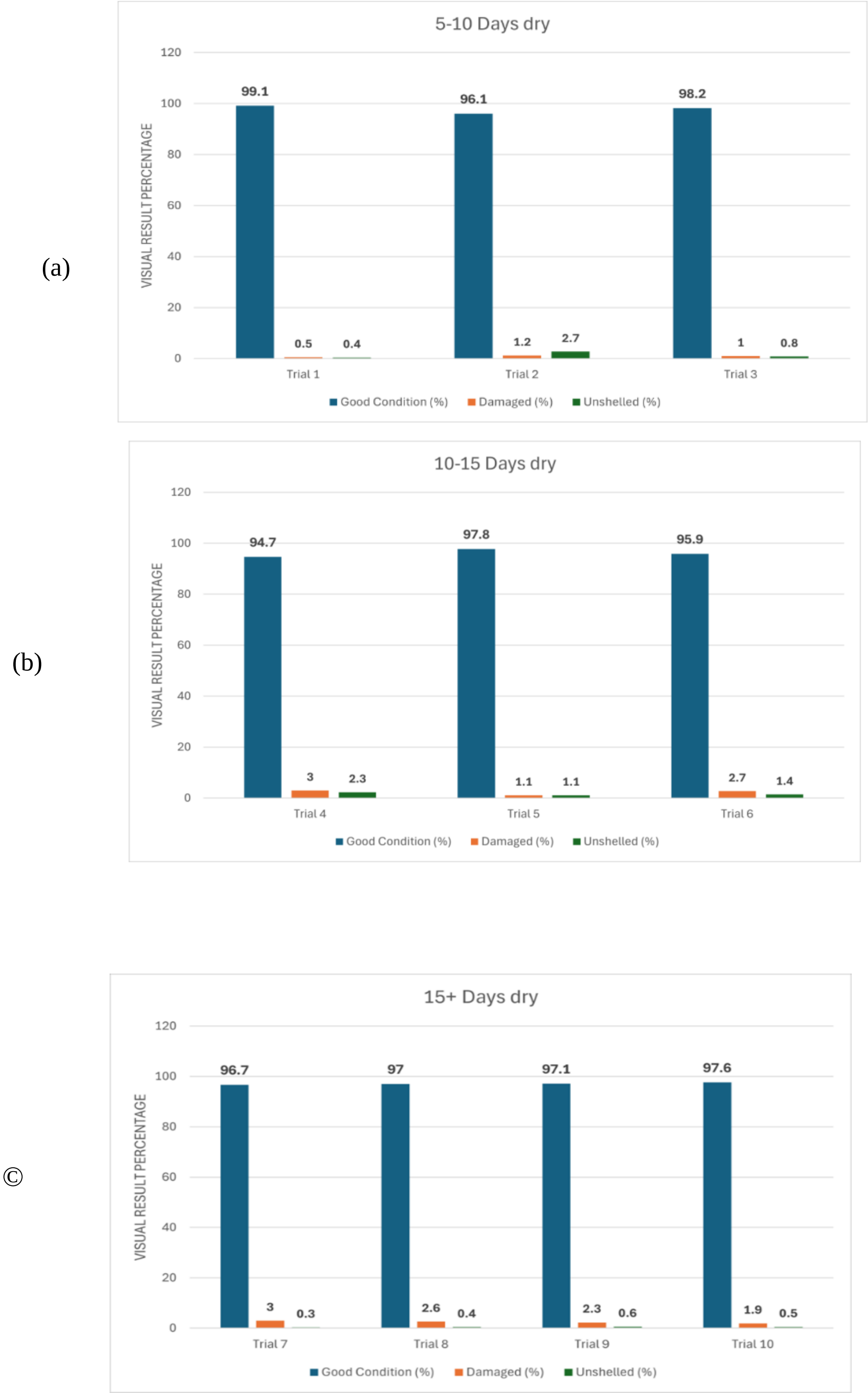

Figure 2. Visual percentage for (a) 5-10 days; (b) 10-14 days; and (c) more than 1
days peanut drying duration

Data from Figures 1 to 3 show the influence of drying duration on the visual quality of the samples. Within the range of drying time from 5-10 days (Figure 2), the best reading comes from Trial 1 which was 99.1%, while that of Trial 2, although slightly lower still at 96.1%, suffered from a higher proportion of unshelled portions (2.7%). Between the 10-15 days drying range (Figure 2), Trial 5 keeps the upper hand at 97.8% in good condition with equal percentage towards damaged and unshelled (1.1%), while Trial 4 at the lower end had quality reserved: only 94.7% with high damage rate 3%. In the 15+ drying days category (Figure 3), quality was fairly consistent across the trials; good condition values fell between 96.7% and 97.6%. Damage was lowest on Trial 10 (1.9%) although with very little unshelled (0.5%). It can be concluded in general that control over drying beyond 10 days improved quality by ensuring consistent good condition and lower proportions of unshelled and damaged.

Statistical Summary of the Peanut Sheller Experiment Data
In yield per gram

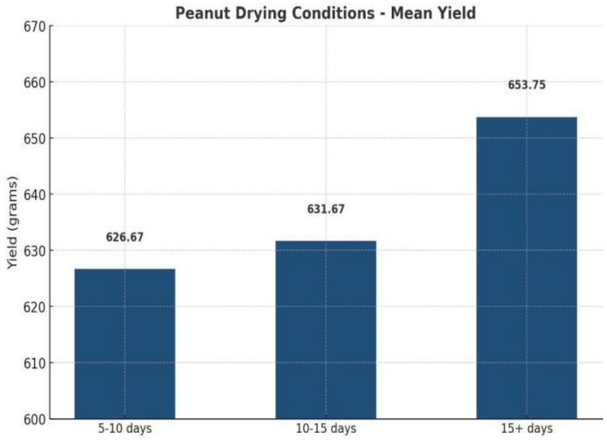

Figure 3a. Effect of drying duration on peanu

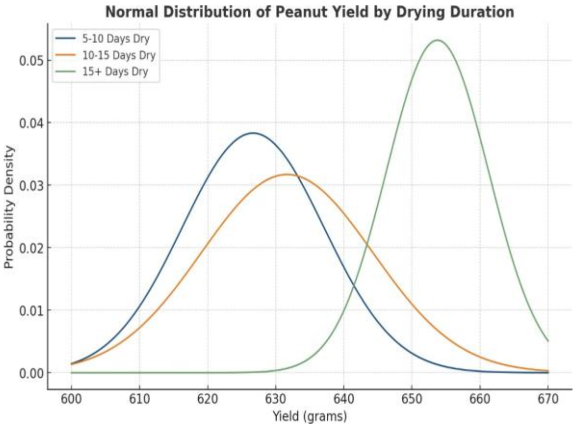

Figure 3b. normal distribution parameters of peanut yield by drying duration

The bar chart shows how drying time affects peanut yield with higher mean yields with advancing drying time in figure 3a. Those dried between 5 to 10 days yielded a mean of 626.67 grams, 631.67 grams between 10 and 15 days, while 653.75 grams was obtained after 15 or more days. The implication is that there is higher yield with longer drying times, perhaps by higher evaporation of water, thereby reducing spoilage without affecting quality. The results show the possible utility of longer drying times to yield maximum peanut yields, although experiments would be necessary to determine an optimum drying time under different climatic conditions.

Figure 3b shows the normal distribution of peanut yield for three drying periods: 5-10 days, 10-15 days, and greater than 15 days. The distribution shows that longer drying periods are associated with greater yields. The more than 15 days drying period group has the highest peak of 650 grams, showing that it produces the most peanuts. The 5-10 days drying group, on the other hand, has a lower mean yield of about 625 grams. The 10-15 days drying period is between these two groups with a mean yield of about 630 grams. These results suggest that longer drying periods can enhance peanut yield because of potentially better drying duration moisture removal and retention.

In Good Condition (%)

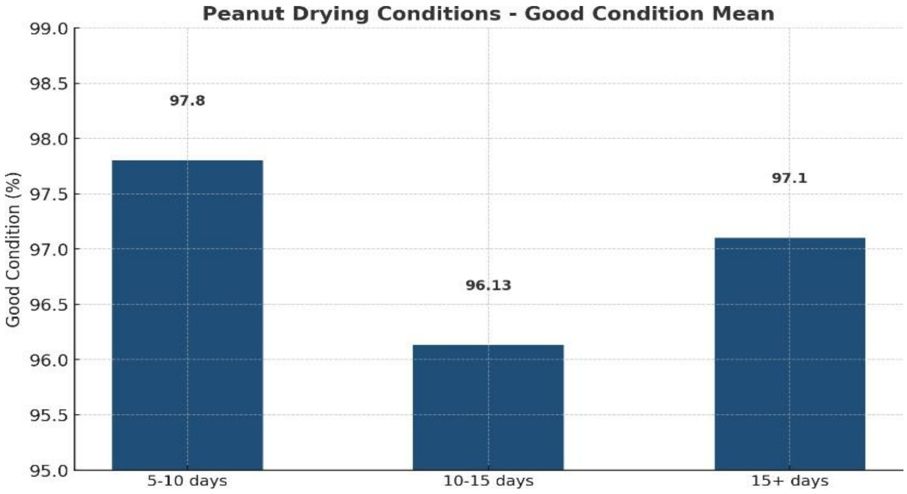

Figure 4a. Effect of drying duration on peanut quality

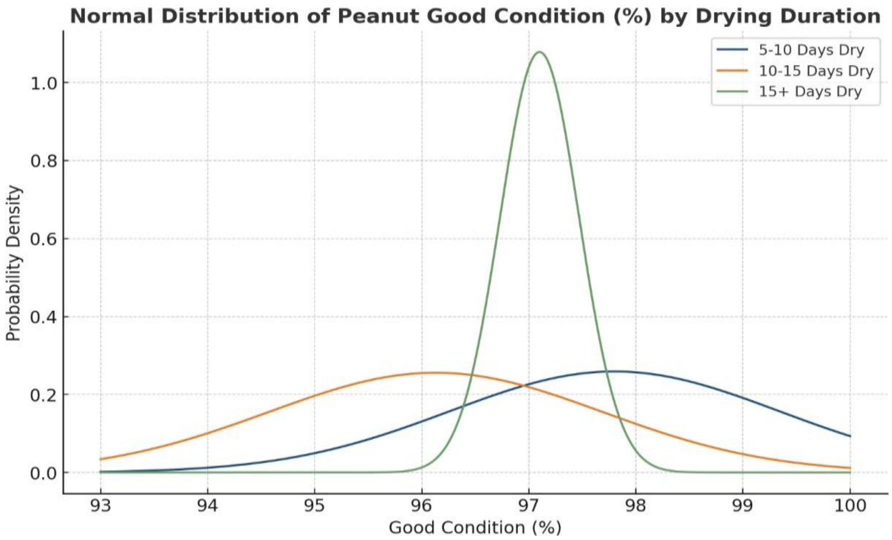

Figure 4b. Normal distribution of peanut condition (%) by drying duration

Figure 4a illustrates the correlation between the drying time of peanuts and the percentage of peanuts in good condition. The statistics indicate that the best quality is obtained when peanuts are dried for 5-10 days (97.8%), followed by 15+ days (97.1%), and the worst quality is obtained when peanuts are dried for 10-15 days (96.13%). This indicates that shorter drying times (5-10 days) are more efficient in preserving the quality of peanuts, while longer drying times of more than 10 days can reduce slightly. Monitoring drying conditions is crucial in maintaining peanut quality because longer or erratic drying can affect the end product.

Figure 4b shows the normal distribution of peanut good condition (%) for three drying times: 5-10 days, 10-15 days, and over 15 days. The distribution for the longer drying time of over 15 days is extremely concentrated at 97%, indicating a greater degree of consistency and better condition. The 5-10 day and 10-15 day drying times have broader distributions, indicating higher variability in the quality of peanuts. Although the 10-15 day drying time has a higher probability density at 96-97%, the 5-10 day interval has the widest extent, thus indicating lower consistency in the preservation of peanut quality. These results show that a longer drying time of over 15 days results in more stable and optimal conditions for peanuts.

In Damaged (%)

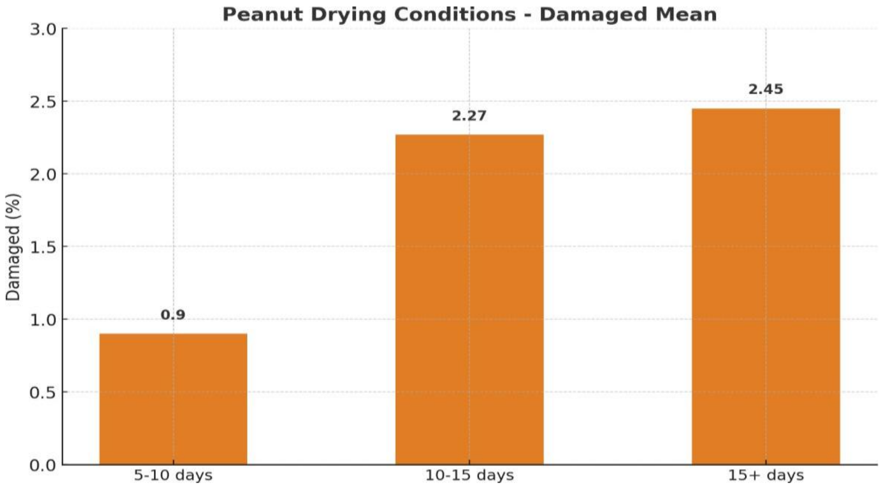

Figure 5a. Effect of drying duration on peanut damage (%)

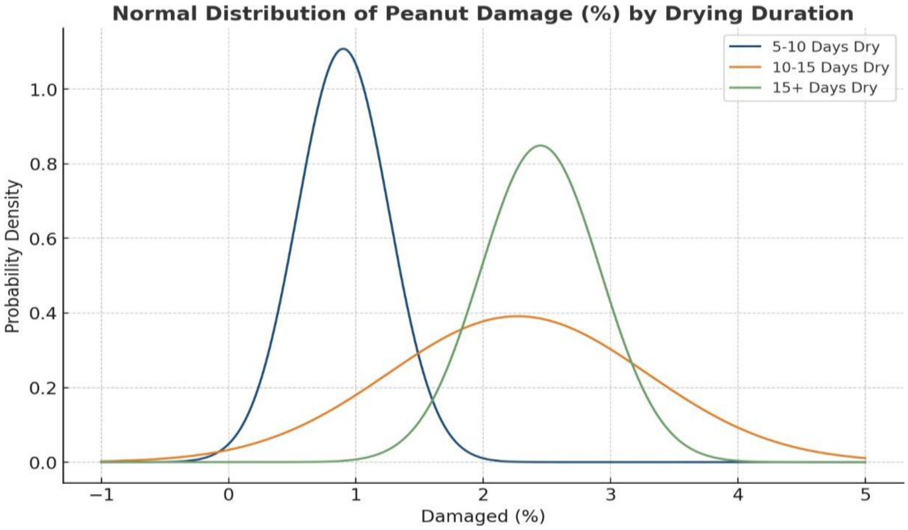

Figure 5b. Normal distribution of peanut damage (%) by drying duration

Figure 5a illustrates the mean percentage of peanut damage based on three drying period ranges: 5-10 days, 10-15 days, and over 15 days. The results indicate a proportional relationship between drying period and the percentage of peanut damage. In particular, drying periods of 5-10 days have the least damage level (0.9%), and drying periods with over 15 days have the greatest damage level (2.45%). This tendency shows that longer drying periods are able to increase the risk of structural damage or exposure damage. Efficient drying periods are needed in order to reduce peanut damage without sacrificing the effectiveness of post-harvest operations.

The density plot, Figure 5b, is a characteristic display of the normal distribution of percent damage in peanuts across the same three drying duration groups. The distribution for 5-10 days drying duration is steep and peaks at a lower percent damage, indicating lower variability and uniformly lower damage levels. The distributions for the 10-15 days and 15+ days drying durations, however, indicate a rightward shift, with the latter indicating a larger spread, and thus greater damage and variability. Such findings validate the hypothesis that longer drying increases the risk and uncertainty of peanut damage, and thus the importance of optimizing drying conditions to ensure product integrity.

In Unshelled (%)

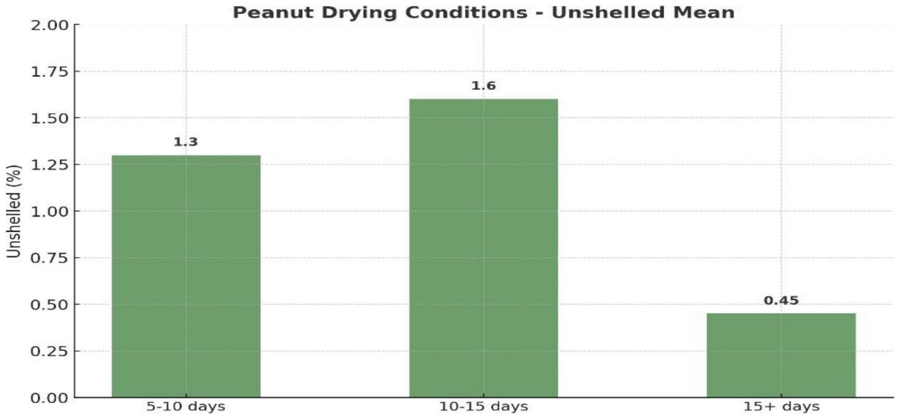

Figure 6a. Effect of drying duration on peanut unshelled (%)

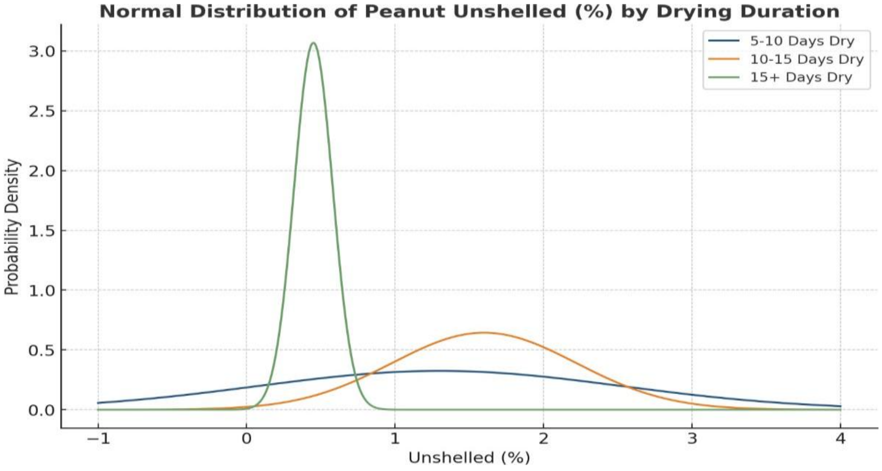

Figure 6b. Normal distribution of peanut unshelled (%) by drying duration

Figure 6a presents the mean percentage of unshelled peanuts for three drying periods: 5-10 days, 10-15 days, and over 15 days. The highest unshelled rate of 1.6% is recorded in the 10-15 days drying period, while the lowest rate of 0.45% is recorded in the over 15 days period. Interestingly, the percentage of unshelled peanuts is reduced with longer drying over 15 days, which suggests that longer drying can increase shell stability or reduce the likelihood of incomplete shelling. This observation suggests that although moderate drying generates a higher incidence of unshelled peanuts, longer drying can improve shell integrity and hence minimize losses from unshelled peanuts.

Density plot in figure 6b defines the distribution for unshelled peanut percentages along different drying intervals. The long drying interval spanning more than 15 days illustrates a sharp spike around zero that indicates lower rates of unshelling with much less variability. The drying time of 10 to 15 days shows distribution with a bigger spread, presenting higher unshelling rates coupled with more variance. The intermediate drying time 5 to 10 days reflects more evenly spaced distribution, representative of moderate-level unshellings with fewer consistencies. These trends infer that longer durations of drying in excess of 15 days decrease the probability of unshelling peanuts consistently, while shorter periods of drying expose more variability alongside higher percentages unshelled.

Performance Metrics Comparison Between Mechanized and Manual Peanut Shelling

Table 4. Comparative Efficiency of Machine vs. Manual Peanut Shelling

Parameter	**Machine Shelling**	**Manual Shelling**
Number of Trials	5	5
Average Sample Weight (kg)	5	5
Avg. Shelling Time per Trial (minutes)	9.6 ± 0.3	58.2 ± 2.1
Avg. Kernel Recovery (kg)	3.85 ± 0.05	3.72 ± 0.04
Shelling Efficiency (%)	77.0 ± 1.2	74.4 ± 1.0
Kernel Damage (%)	2.1 ± 0.3	1.2 ± 0.2
Post-Harvest Losses (%)	3.5 ± 0.2	6.2 ± 0.3
Throughput (kg/hr)	31.25 ± 0.8	5.20 ± 0.5
Labor Requirement (man-hr/kg)	0.03	0.58
Energy Consumption (kWh)	0.22 ± 0.02 (electric)	N/A
Estimated Cost per kg (PHP)	1.80 (electricity, amortized)	6.50 (labor cost at PHP 39/hr)
Operator Fatigue Level	Low	High

To further contextualize the machine's performance, a comparative analysis between mechanized and manual peanut shelling was conducted under controlled 5-trial settings using a 5-kg average batch. The table below summarizes the key performance parameters:

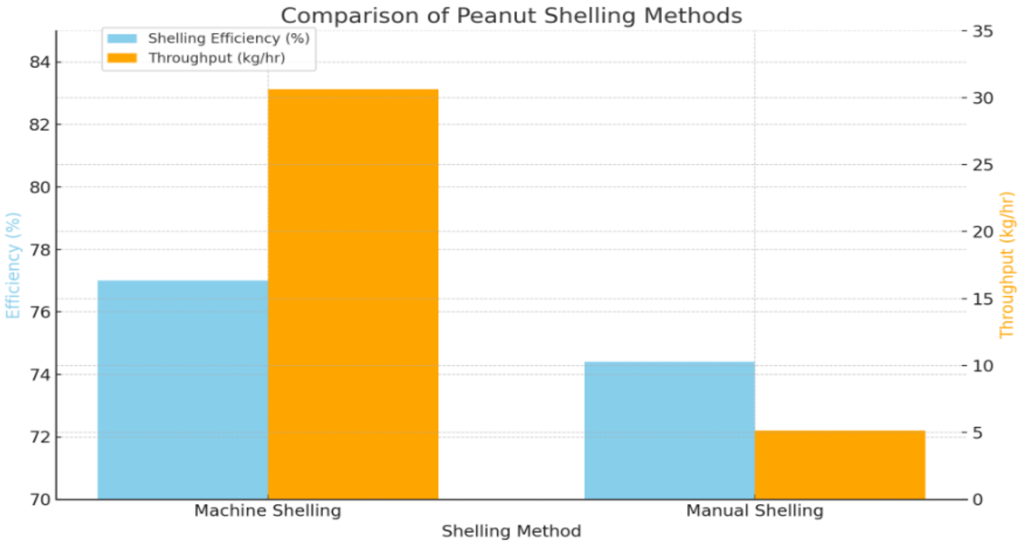

Figure 7. Comparison of peanut shelling methods through manual versus machine

Machine shelling demonstrated superior performance across several key parameters compared to manual shelling as seen in Table 4 and Figure 7. It achieved a slightly higher shelling efficiency of 77.0% versus 74.4% and processed peanuts approximately six times faster, reducing the shelling time from nearly one hour to under ten minutes per 5 kg batch. While manual shelling resulted in slightly lower kernel damage (1.2%) compared to machine shelling (2.1%), both values remained within acceptable limits. Mechanization significantly reduced post-harvest losses by 43.5%, lowering them from 6.2% to 3.5%. In terms of labor and cost efficiency, machine shelling required only 0.03 man-hours per kilogram, a dramatic improvement from the 0.58 man-hours required for manual shelling, and brought the estimated cost down by over 70%, showcasing its potential for substantial savings in time, effort, and resources.

Table 5. ANOVA (Analysis of Variance) results comparing machine vs. manual peanut shelling across four key performance metrics

Parameter	**F-value**	**p-value**	**Interpretation**
Shelling Time (min)	25,127.23	< 0.0001	**Significant difference** (p < 0.01)
Shelling Efficiency (%)	57.316	0.0001	**Significant difference** (p < 0.01)
Post-Harvest Losses (%)	729	< 0.0001	**Significant difference** (p < 0.01)
Throughput (kg/hr)	30,916.66	< 0.0001	**Significant difference** (p < 0.01)

The ANOVA results presented in Table 5 reveal statistically significant differences between machine and manual peanut shelling across all four key performance metrics. Shelling time showed the most pronounced difference, with an exceptionally high F-value of 25,127.23 and a p-value of less than 0.0001, indicating that machine shelling significantly reduces processing time. Similarly, shelling efficiency exhibited a significant difference ($F = 57.316$, $p = 0.0001$), confirming that mechanized methods yield a more efficient shelling process. Post-harvest losses also differed markedly between the two methods ($F = 729$, $p < 0.0001$), with mechanization substantially minimizing losses. Throughput showed the second-highest F-value at 30,916.66 ($p < 0.0001$), affirming the considerable increase in processing speed achieved through mechanization. These results strongly support the hypothesis that mechanized peanut shelling offers measurable advantages in efficiency, productivity, and waste reduction over traditional manual methods.

CONCLUSION

The findings of this study prove that the peanut sheller machine operates to a "Very Acceptable" level according to Garvin's Eight Dimensions of Quality, with durability being the highest at 4.00. Moreover, the Technology Acceptance Model shows a "Highly Acceptable" rating for perceived usefulness at 4.75 and ease of use at 4.51. These findings prove that the machine is efficient and easy to operate, hence an effective tool for enhancing peanut shelling operations in rural agricultural communities. Experimental findings prove that longer drying times, especially those above 15 days, greatly enhance shelling efficiency by providing the highest output of 653.75 grams and lowest unshelled percentage of 0.45%. Conversely, shorter drying times, between 5 and 10 days, are more effective in preserving peanut quality and reducing damage. These findings prove the importance of achieving a balance in drying time to enhance efficiency and product quality. In conclusion, the study proves that the peanut sheller machine is an effective tool to enhance post-harvest efficiency and has the potential for extensive use to ease labor-intensive operations in rural agricultural communities.

RECOMMENDATIONS

To improve the efficiency and uptake of the peanut sheller machine, future studies should focus on the optimization of drying time to balance efficiency in shelling and quality of peanuts under different climatic conditions. Machine design should focus on the improvement of reliability and reduction of variability under different operating conditions. The introduction of training schemes for users can facilitate proper usage and maintenance of the machine, hence ensuring long-term performance and user satisfaction. Extended field testing across different geographic and climatic conditions is recommended to confirm the effectiveness of the machine and determine context-specific modifications. Policymakers should also consider the use of financial incentives, e.g., subsidies or loans, to encourage the uptake of peanut shelling machines, especially in smallholder farming communities where manual labor is common.

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