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REVIEWER'S REPORT

Manuscript No.: IJAR- 58720

Title: ***Technological upgrading and performance comparison of artisanal, semi-industrial, and industrial cashew processing systems in Benin, West Africa*.**

Recommendation:
Accept as it is .....
Accept after Minor revision.....
Accept after major revision
Do not accept (*Reasons below*)

Rating	Excel.	Good	Fair	Poor
Originality		✓		
Techn. Quality		✓		
Clarity			✓	
Significance			✓	

Reviewer Name: **ANAPANA GOPAL**

Reviewer's Comment for Publication.

General Comments
The manuscript addresses an important and relevant topic: the comparison of artisanal, semi-industrial, and industrial cashew-processing systems in Benin. The study has a clear comparative framework and combines field observations, interviews, process mapping, material-flow analysis, productivity indicators, and product-quality measurements. The reported differences among the three processing categories are potentially valuable for understanding technological upgrading in the cashew sector.
However, **Minor methodological, statistical, and internal-consistency issues need to be addressed before the manuscript can be considered for publication**. The most important concern is that several values reported in Table 4 do not appear to agree with the material-flow data and the equations defined in the Methods section. In addition, the very small sample size (**n = 3 processing units per category**) makes the statistical interpretation and generalization of the findings difficult.

Minor Comments
1. Minor internal inconsistency between material-flow data and Kernel Recovery Rate
This is the most important issue in the manuscript.
The Methods section defines Kernel Recovery Rate (KRR) as:
KRR (%) = total kernel weight / raw nuts processed × 100.
However, Table 4 reports:

- Artisanal: whole kernel = 178.0 kg, broken = 62.0 kg, defective = 85.4 kg
- Semi-industrial: whole = 230.0 kg, broken = 75.3 kg, defective = 46.7 kg
- Industrial: whole = 248.0 kg, broken = 82.6 kg, defective = 27.2 kg.

Since the input is standardized at 1,000 kg, the total kernels based on these values would be:

- Artisanal = 178.0 + 62.0 + 85.4 = **325.4 kg = 32.54%**
- Semi-industrial = 230.0 + 75.3 + 46.7 = **352.0 kg = 35.20%**

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- Industrial = 248.0 + 82.6 + 27.2 = **357.8 kg = 35.78%**

These values do **not** correspond to the reported KRR values of 24.0%, 30.5%, and 33.1%.
The authors must verify the raw calculations, formulas, and table values and correct the inconsistency throughout the manuscript.

2. Whole Kernel Rate also appears inconsistent with Table 4
The manuscript reports Whole Kernel Rate values of:

- 62.3%
- 68.6%
- 78.6%.

However, if WKR is calculated from whole kernels divided by total kernels:

- 178 / 325.4 = approximately **54.7%**
- 230 / 352 = approximately **65.3%**
- 248 / 357.8 = approximately **69.3%**

Thus, the reported WKR values do not appear to be directly derived from the material-flow quantities shown in the same table.
The authors should provide the exact formula used for WKR and verify all underlying calculations.

3. Broken-kernel percentages are also not clearly consistent with the material-flow data
Table 4 reports broken-kernel rates of approximately 25% for all three systems.
However, the corresponding broken-kernel weights are 62.0, 75.3 and 82.6 kg per 1,000 kg input. If the denominator is total kernel production, the resulting percentages would be different.
The manuscript should clearly define the denominator for:

- broken-kernel rate;
- defective-kernel rate;
- whole-kernel rate;
- kernel recovery rate.

The calculations should then be reproducible directly from Table 4.

4. Very small sample size: only three units per processing category
The study includes only:

- 3 artisanal units;
- 3 semi-industrial units;
- 3 industrial units.

Thus, each category has **n = 3**.
This is a very small sample for one-way ANOVA, particularly when the manuscript also reports normality and homogeneity tests.
The authors should provide a stronger justification for the statistical approach and explicitly acknowledge the limitations associated with n = 3.
The conclusions should not be generalized to the entire Beninese cashew-processing sector without qualification.

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5. The use of Shapiro–Wilk and Levene tests with n = 3 requires careful justification

The manuscript states that normality and homogeneity were assessed using Shapiro–Wilk and Levene tests before ANOVA.

With only three observations per group, these diagnostic tests have very limited ability to establish whether assumptions are satisfied.

The authors should:

- provide the actual diagnostic results, or
- justify why these tests were considered appropriate;
- consider reporting effect sizes and confidence intervals;
- consider whether a non-parametric alternative is more appropriate;
- avoid presenting p-values as the sole evidence of meaningful differences.

6. Independence and experimental unit need clarification

The manuscript appears to treat processing units as the experimental units, but this needs to be stated explicitly.

For example, if multiple measurements were collected from workers, machines, batches, or processing days within the same facility, those observations cannot automatically be treated as independent replicates.

The authors should clearly specify:

What constitutes one independent experimental observation?

If the true experimental unit is the processing facility, then **n = 3 per group** must be used for statistical inference.

7. The sampling strategy limits representativeness

The authors used purposive sampling because industrial processors were limited and production records were required.

This is understandable, but it introduces selection bias.

The sample consists of nine units across only three municipalities:

- Tchaourou: 4;
- Parakou: 4;
- Djougou: 1.

The authors should explain why these nine units can reasonably represent the broader processing sector in Benin.

The conclusion appropriately acknowledges this limitation, but the limitation should also be reflected in the strength of the claims throughout the Results and Discussion.

8. The manuscript claims economic performance without presenting economic analysis

The conclusion states that industrial processors achieved the lowest **unit processing costs** and refers to economic performance.

However, the Methods section does not describe a cost-analysis methodology, and Table 4 does not present:

- labour costs;
- energy costs;
- equipment costs;
- maintenance costs;
- raw-material costs;

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- processing cost per kg;
- profitability;
- return on investment.

Therefore, the statement concerning lower unit processing costs appears unsupported by the reported dataset.
Either provide the relevant economic analysis or remove/modify these claims.

9. "Energy efficiency" is discussed without adequate energy measurements
The Introduction identifies energy efficiency as an important performance dimension. However, the study does not appear to measure:

- fuel consumption;
- electricity consumption;
- energy input per tonne;
- energy use per kg of kernel;
- energy efficiency.

The manuscript should avoid presenting technological upgrading as demonstrating improved energy efficiency unless energy data were actually collected.

10. The causal language should be moderated
The manuscript frequently states that higher performance **is attributable to** mechanization, improved infrastructure, quality control, storage, market linkages, etc. Because this is a cross-sectional observational study, the results demonstrate **associations**, not necessarily causal relationships.
For example, instead of:
"The superior capacities observed in industrial units can be attributed to…"
consider:
"The superior capacities observed in industrial units may be associated with…"
This distinction should be maintained throughout the Discussion.

11. The classification of processing systems needs objective criteria
The manuscript compares artisanal, semi-industrial and industrial systems, but the classification appears to be based primarily on the observed technology and organizational characteristics.
Table 3 provides useful information about:

- cooking;
- shelling;
- drying;
- peeling;
- grading;
- electricity;
- energy source;
- certification.

However, the authors should explicitly define the criteria used to classify a processing unit as:
artisanal / semi-industrial / industrial.
A clear classification framework would improve reproducibility.

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12. The process-flow figure requires better presentation and clarification

Figure 1 provides useful information about the three processing pathways, but the figure is difficult to read and contains several unclear elements. The figure shows different technologies, including roasting, steaming, shelling, drying, peeling and classification.

The authors should:

- improve figure resolution;
- standardize terminology;
- clarify arrows;
- explain abbreviations;
- ensure that all temperatures, pressures and times are clearly defined;
- remove unnecessary background/watermark elements if this is the authors' own figure.

13. The industrial processing conditions need methodological detail

Figure 1 includes specific conditions such as steam treatment at **10 bar for 10 min** and drying around **80°C**.

The manuscript should explain:

- whether these were directly measured or obtained from factory records;
- whether conditions were constant across the industrial units;
- how temperature and pressure were monitored;
- whether these conditions represent typical or average operating conditions.

14. Moisture-content methodology needs additional detail

The manuscript states that moisture content was determined by oven drying at **105°C until constant weight**.

The authors should provide:

- sample mass;
- number of replicates;
- oven type;
- duration or criterion for constant weight;
- sampling point in the processing line.

This is particularly important because moisture content is used as an indicator of product quality.

15. Food-safety claims need stronger supporting evidence

The manuscript reports that industrial processors were the only units implementing HACCP and ISO 22000 systems.

This is potentially important, but the authors should clarify whether certification was:

- independently verified;
- self-reported;
- current at the time of the survey.

The manuscript should distinguish between **having documented certification** and **actual observed food-safety performance**.

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16. The discussion should distinguish technological improvement from scale effects

Industrial processors differ from artisanal processors not only in technology but also in:

- scale;
- capital availability;
- workforce;
- infrastructure;
- storage;
- market orientation;
- operating season.

Therefore, the observed differences cannot necessarily be attributed exclusively to technology.

The authors should discuss **scale effects and organizational factors** as potential confounders.

17. Labour productivity deserves deeper interpretation

The manuscript reports labour productivity of:

- 12.4 kg worker^{-1} day^{-1} for artisanal;
- 56.2 kg worker^{-1} day^{-1} for semi-industrial;
- 48.3 kg worker^{-1} day^{-1} for industrial systems.

Interestingly, semi-industrial processing has numerically higher labour productivity than industrial processing, although industrial systems have much greater overall processing capacity.

This is an important finding and should be discussed rather than simply describing industrial processing as superior overall.

18. The conclusion should be more closely aligned with the measured variables

The study directly measures technological characteristics, material flows, processing efficiency, productivity and some quality parameters.

The conclusion should focus primarily on these measured outcomes.

Claims regarding:

- economic competitiveness;
- sustainable development;
- investment requirements;
- employment creation;
- long-term industrial development

should be framed as **implications** rather than direct empirical findings unless corresponding data were collected.

Minor Comments

19. Language and grammar require substantial editing

There are several grammatical and typographical issues, for example:

- "processing efficiency, productivity, and product quality of nine…";
- "Industrial processing showed significantly…";
- "The studycomprised…";
- "The mass balance equation" is misspelled as "masse balance";
- missing spaces between words;

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- inconsistent use of hyphens.

A professional English-language revision is recommended.

20. Standardize units and formatting

The manuscript alternates between:

- t year^{-1};
- tyears^{-1};
- kg day^{-1};
- kg h^{-1};
- kg worker^{-1} day^{-1}.

All units should follow a consistent SI-style format.

21. Correct "Standard erreur"

Table 4 uses "Standard erreur."
This should be:
Standard error
throughout.

22. Check the annual and daily processing capacity calculations

The reported annual and daily capacities should be cross-checked.
For example, the relationship between annual processing capacity, daily capacity and number of operating days should be explicitly stated because the reported values imply different operating schedules.

23. Clarify the meaning of "processing time"

Processing time is reported as h tonne^{-1} RCN.
The authors should clarify whether this represents:

- actual machine operating time;
- elapsed processing time;
- labour time;
- total throughput time.

24. "Energyomic performance" appears to be an inappropriate term

The Introduction uses the term **"energyomic performance."**
Unless the authors have a specific definition and methodology for "energyomics," this should probably be replaced with **"energy performance"** or **"energy efficiency."**

25. Reference quality and consistency should be checked

The reference list contains a mixture of:

- peer-reviewed journal articles;
- institutional reports;
- websites;
- industry sources.

The authors should ensure that Minor scientific claims are supported primarily by peer-reviewed literature or authoritative institutional sources.

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Recommendation to the Editor
Decision: Minor Revision
The manuscript has a worthwhile research question and potentially useful empirical findings. The comparison among nine processing units across artisanal, semi-industrial and industrial systems is clearly structured, and the material-flow framework is potentially valuable.
However, the numerical inconsistencies in Table 4 are a Minor concern that must be resolved before the scientific conclusions can be evaluated reliably. In particular, the reported kernel recovery and whole-kernel rates do not appear to follow from the material-flow values and the definitions provided in the Methods.
The statistical analysis also needs stronger justification given the n = 3 units per category, and conclusions concerning economic performance, energy efficiency and causal effects should be appropriately restricted to the variables actually measured.
The manuscript should not be accepted in its current form, but a substantially revised version could be reconsidered after the authors correct the numerical calculations, clarify the methodology and strengthen the statistical and scientific interpretation.

Final Recommendation: MINOR REVISION