Quantification and traceability of mango by-products in the Hauts-Bassins and Cascades regions of Burkina Faso

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ABSTRACT

This study provides a regional analysis of mango by-product generation and traceability in the Hauts-Bassins and Cascades regions of Burkina Faso. Through field surveys conducted in samples of 89 processing units and stakeholder mapping, the study quantifies the volume and flow of mango residues and identifies key stakeholders and bottlenecks in the post-harvest chain. Although traceability practices remain largely manual, the study identifies opportunities for digital integration and the added value of utilizing by-products in agro-industrial applications. A total of 52,691 tons of fresh mangoes were processed, primarily from seven varieties. Five types of by-products were identified, with peels, kernels, and sorting waste being the most prevalent. These by-products represented 49.66% of the total processed mango mass. Most by-products were discarded indiscriminately, with only minimal portions allocated to livestock feed (1%) and agriculture (2%). Physical analyses conducted in drying units and laboratories revealed that processing methods significantly increased by-product generation, resulting in pulp losses of up to 31.8%. These results provide a foundation for optimizing the utilization of mango by-products in Burkina Faso through technological innovations. The findings support strategic planning for sustainable resource management and lay the groundwork for the future deployment of traceability systems in tropical agricultural contexts.

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1. INTRODUCTION

Agricultural by-products represent a critical yet underutilized resource in tropical economies [1]–[3]. In mango-producing regions, residues from processing and post-harvest handling contribute to environmental burden and economic loss [4]. These by-products constitute approximately 40–50% of the total processed mango mass [5], [6]. Mango by-product production is steadily increasing in Burkina Faso, as the figures show. Mango production increased from 243,358 tons in 2019 to 271,503 tons in 2020, reflecting an 11.56% rise [7]. Despite its economic importance, Burkina Faso's mango industry faces fundamental issues related to substantial by-product generation and inadequate management. Parrot *et al.* [8] reported that a significant amount of mango by-products is discarded into the environment. During the mango harvesting season, large accumulations of discarded peels, kernels, and sorting waste are commonly observed near processing units [9]. The inadequate valorization of these by-products in Burkina Faso remains a pressing issue. Furthermore, their high moisture and sugar content complicates waste management [10]–[12], while their decomposition attracts pests such as flies [9].

Despite the abundance of mango by-products in Burkina Faso, little data exists on this subject. Although experiments have been conducted to use these by-products in cattle and poultry feed, their adoption remains minimal [13]–[15]. It is crucial to determine the cause. Statistical data describing the field situation in the field are limited. Effective quantification and traceability of these by-products is essential for enabling circular economy models, optimizing supply chains, and unlocking value-added applications such as bioenergy, animal feed, and cosmetic ingredients.

This study aims to bridge the gap between field-level data and traceability frameworks by mapping mango by-product flows and identifying opportunities for digital traceability integration in Burkina Faso's agro-industrial landscape. First, it updates statistical data on mango processing and quantifies the volumes of processed mangoes and their by-products in the Hauts-Bassins and Cascades regions, which are the primary mango-producing areas of Burkina Faso due to their favorable climatic conditions. It then classifies the mango varieties and identifies the processing stages that generate more by-products in order to provide guidance for optimal correction solutions. Additionally, this study serves as a foundational step toward developing efficient agro-industrial strategies. This research contributes to sustainable agricultural engineering by providing baseline data, stakeholder insights, and traceability recommendations that can inform future deployment of geographic information system-enabled tracking systems.

2. METHOD

2.1. Study areas and period

The survey was conducted between February 2022 and March 2023 in the Hauts-Bassins and Cascades regions of Burkina Faso. Specifically, the survey was conducted in the provinces of Houet, Kénédougou, and Comoé. A total of 89 mango processing units were surveyed. Figure 1 illustrates the geographical locations of the study areas. These regions were selected due to their high mango production and processing intensity [16].

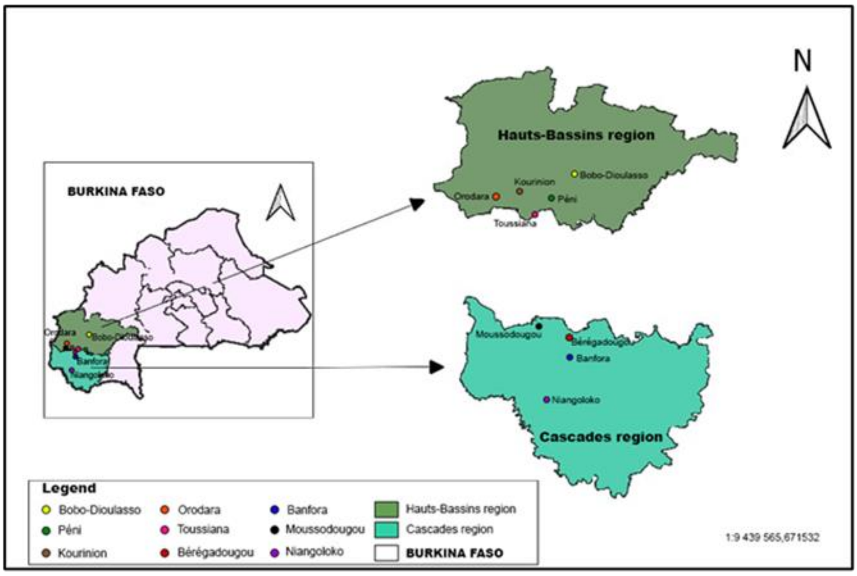

Figure 1. Geographical locations of the study area

2.2. Method of investigation and analysis

The study was conducted in three main stages. First, the Department of Industry and Trade provided a database of mango processing units in the target regions, ensuring that only officially recognized units were included in the survey. The National Union of Mango Producers of Burkina (UNPM-B) and the Professional Association of Mango Processors of Burkina (PTRAMAB) provided additional data on their respective members.

Next, a semi-structured approach [17] was used to interact with promoters of officially recognized mango processing units. A questionnaire was developed to assess the quantity of fresh mango processed, the types and volumes of by-products generated, and levels of ripening-related rot. Fresh mango and by-product evaluation was conducted using the transformation ratio while accounting for sorting waste variation among processing units [8]. Aggregating data from the different units made it possible to determine the total quantities of processed mangoes, sorting waste, and mango by-products. Data on processed mango varieties, varietal preferences, by-product traceability, and the adoption of innovations from previous research on by-product utilization were also collected. Traceability, which describes a product's journey from its initial point of manufacture to its final destination, was done manually in collaboration with production and transport agents responsible for by-products. Additionally, an accelerated participatory research method was implemented [8]. This method involved site visits to landfills and interviews with individuals living near processing units and disposal sites to evaluate the environmental and social impacts of mango by-products, as expressed in (1).

$$Quantity\ of\ fresh\ mango\ processed/by-products = QU1 + QU2 + \cdots + QU89 \quad (1)$$

Where $QU1$ is quantity of fresh mango or by-products processed unit 1; $QU2$ is quantity of fresh mango or by-products processed unit 2; and $QU89$ is quantity of fresh mango or by-products processed unit 89.

Finally, a physical analysis of mangoes was conducted to determine the proportions of pulp, kernel, and peel, allowing for an assessment of pulp losses at the drying unit level. The study was performed concurrently in the Food Technology Department (DTA) laboratory and at processing units. The mangoes were peeled and pitted, and the individual components were weighed. The pulp loss rate was determined by comparing the pulp yield obtained under laboratory conditions with the yield from the drying units. The proportion of each mango component was calculated using (2) [18].

$$\%Mango\ Constituent = \left(\frac{Px}{Po}\right) \times 100 \quad (2)$$

Where Px is weight of the constituent, and Po is total mango weight.

2.3. Data analysis

The survey data were processed using Sphinx Plus2-V5 software. Statistical analyses were conducted using Sphinx Plus2-V5 and R version 4.4.1. An analysis of variance (ANOVA) was performed, and the chi-square (χ^2) and Tukey post hoc tests were applied at a significance level of $p < 0.05$.

3. RESULTS AND DISCUSSION

3.1. Distribution of processing units and types of unit activity

Most mango processing units (82.02%) are in the Hauts-Bassins region, and the rest (17.98%) are in the Cascades region. Notably, 93.25% of these units operate in urban areas, primarily in modified residential courtyards. Bobo-Dioulasso has the highest concentration of processing units (43.82%), followed by Orodara (19.10%), Toussiana (14.60%), Banfora (8.99%), Niangoloko (5.61%), Bérégadougou (3.37%), Kourinion (2.25%), Péni (1.12%), and Moussodougou (1.12%). The number of processing units has increased. Kante-Traore [18] identified a lower number (65) in 2017. This increase is in response to the growth in mango production in Burkina Faso. The lower presence of processing units in other municipalities may be attributed to seasonal labor shortages during the agricultural peak in June. The variation in processing unit distribution among municipalities is statistically significant ($\chi^2 = 82.22$; $p = 0.0001$).

Three major mango processing activities were identified: drying, producing nectar, and exporting fresh mangoes. The processing season typically spans from April to August. Drying is the predominant activity, with 86 out of 89 units engaged in this process. Of these units, two combine fresh mango export with drying, and three specialize exclusively in nectar production. There is a statistically significant variation in the distribution of processing units by sector ($\chi^2 = 115.25$; $p = 0.0001$).

3.2. Processed mango varieties and unit varietal preference

Figure 2 shows the distribution of processed mango varieties in the study regions. The study identified seven (7) primary mango varieties that are processed in the Hauts-Bassins and Cascades regions: Amélie, Lippens, Brooks, Kent, Keitt, Valencia, and Springfield, as presented in Figures 2(a) to 2(g). Previous studies have reported that Amélie and Brooks are the most commonly processed varieties [19]. Kante-Traore [18] identified Amélie, Brooks, Kent, Lippens, and Springfield as the predominant varieties. The current findings indicate the recent inclusion of the Keitt and Valencia varieties, likely driven by evolving consumer demand. Although Burkina Faso cultivates numerous mango varieties [16], only seven are widely processed. This is likely due to market demand, sales policies, and limited awareness of other varieties in orchards [18]. The Brooks, Lippens, and Amélie varieties are the most frequently processed; 98.80%, 97.80%, and 96% of surveyed units engaged in their transformation, respectively. The variation in processing unit distribution by mango variety is statistically significant (χ^2 = 82.22; p = 0.0001). Among processed varieties, 83.10% of processing units prefer Lippens. This preference is attributed to its low susceptibility to rot during ripening, longer post-ripening shelf life, sweeter taste, and lower acidity [18]. The statistical variation in varietal preference among processing units is highly significant (χ^2 = 416.98; p = 0.0001). Table 1 shows the percentage of processing units by mango variety and their varietal preference.


(a) (b) (c) (d) (e) (f) (g)

Figure 2. Processed mango varieties with (a) Lippens, (b) Brooks, (c) Amélie, (d) Kent, (e) Keitt, (f) Valencia, and (g) Springfield

Table 1. Percentage of processing units by variety of mango processed and unit varietal preference

Variables	Lippens	Brooks	Amélie	Kent	Keitt	Valencia	Springfield
Processing units/processed mango varieties (%)	97.80	98.80	95.50	28.10	6.70	3.30	1.10
Processing units/varietal preference (%)	83.10	13.50	3.40	0.00	0.00	0.00	0.00

3.3. Types of by-products generated

The pulp is the primary component of interest during mango processing [20]. However, the process yields five by-products: peels, kernels, sorting waste, fibers, and tree leaves. The most predominant by-products are the peels, kernels, and sorting waste. All processing units produce kernels and sorting waste. A total of 87 out of 89 units generate peels, while two do not. The mango processing workflow involves multiple sorting stages. First, upon arrival, the mangoes undergo an initial sorting process before ripening. After ripening, the mangoes are sorted again, then washed, peeled, and pitted before being processed into various products. Only three units produce fibers, which result from pulp extraction and filtration during nectar production. In most cases, these fibers are combined with kernels during quantification. Additionally, two units dedicated to fresh mango exports generate tree leaves as a by-product. These leaves are used as cushioning material between mangoes in crates to reduce mechanical damage from shocks and jolts during transportation [21], [22]. Unlike other by-products, mango leaves do not emit strong odors and are usually discarded in nearby fields without quantification. However, they may contribute to soil enrichment for agricultural use. Figure 3 shows the number of processing units by type of by-product generated.

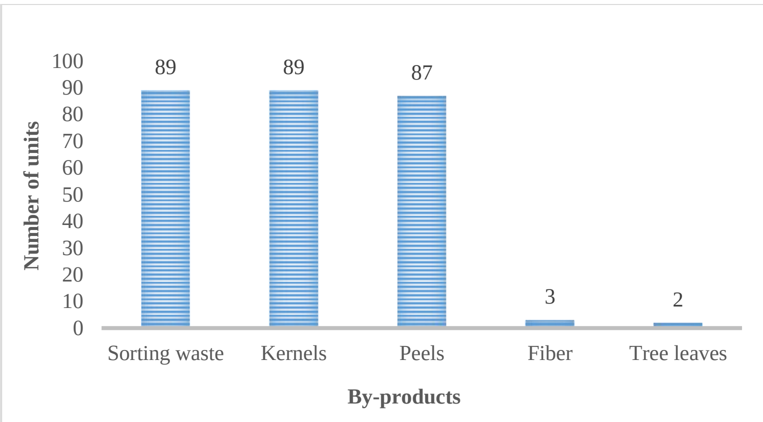

Figure 3. Number of processing units by type of by-products generated

3.4. Quantity of fresh mango processed, by-products generated and mango rot rate

A total of 52,691.06 tons of fresh mangoes were processed during the study. Of the processed varieties, Lippens accounted for the largest proportion (34.02%), followed by Brooks (31.61%) and Amélie (20.90%). These results differ from those of Kante-Traore [18], who reported that Amélie was the most processed variety in 2017 due to its early maturation, high availability, and abundance. According to data provided by PTRAMAB, the total quantity of mangoes processed in 2022 was 62,430 tons, higher than the quantity found in the present study. This discrepancy can be attributed to PTRAMAB's national scope, which covers a larger number of processing units. Furthermore, UNPM-B reported a total mango production of 244,666.93 tons in 2022, 21.54% of which was processed. The rest was exported or consumed domestically [9]. While the proportion of mangoes processed in 2022 remains low relative to total production, an upward trend is evident; the processing rate was 20% nationally in 2020 [7]. Given this rapid expansion, the sector needs industrial restructuring through the development of larger processing units and diversification of mango-based products, such as jam, syrup, and jelly.

A total of 26,169.39 tons of by-products were generated, representing 49.66% of the total mangoes processed. This value aligns with Rai *et al.* [6], who reported a by-product generation rate of 40–50%. However, it is higher than the rates reported by Wongkaew *et al.* [23], which range from 26.85% to 33.31%. By-products from juice and nectar production accounted for 23.76% of the mangoes used, while by-products from drying accounted for 53.58%. Processing mangoes into dried mangoes appears to produce the most by-products. This is because juice and nectar production units use juice extractors, which enable them to extract most of the pulp. In the Hauts-Bassins and Cascades regions, by-products account for 81.94% and 18.05%, respectively. The size and number of units in the Hauts-Bassins region reflect this percentage, underscoring the urgent need for a recovery system to absorb these by-products and clean up environment.

Waste sorting accounted for 37.79% of the total by-products, representing 18.51% of total mangoes processed. The spoilage rate ranged from 10.2% to 29.9%, with the Lippens variety showing the least spoilage. Conversely, the Kent, Brooks, and Keitt varieties, commonly referred to as "late mangoes" [16], [24], produced the highest levels of by-products. These varieties also exhibited increased susceptibility to fruit fly infestations, resulting in a high rotting rate [25]. The rot rate of mangoes during ripening in processing units was notably high, contributing to increased by-product generation. This issue is largely attributed to poor handling practices, particularly inadequate reception and storage conditions upon arrival at processing units. Mangoes are often unloaded in front of the units where they remain exposed until they are weighed and transferred to designated ripening areas.

Figure 4 illustrates the mango reception and ripening conditions observed in the processing units. Figure 4(a) illustrates these reception conditions. Additionally, these mangoes often serve as toys for children who accompany workers at processing units, as depicted in Figure 4(b). Other factors contributing to the high rot rate include poor hygiene in ripening tanks, inefficient layout of the ripening system, and improper handling of mangoes at different stages of maturity. Figure 4(c) depicts the ripening conditions observed in processing units. To reduce spoilage rates, preventive measures should be implemented, including proper sorting, improved hygiene standards, and ensuring that ripening bins are dry and well-ventilated [26]–[28]. To effectively control fruit flies, simultaneous treatment of different orchards must be applied [29]. Table 2 presents data on the quantity of fresh mango processed, by-products generated, and the mango rot rate.

(a) (b) (c)

Figure 4. Mango reception and ripening with (a) receiving the mango, (b) children playing with the mango, and (c) interior of a ripening tank

Table 2. Mango processing data in Hauts-Bassins and Cascades regions

Variables	Lippens	Brooks	Amélie	Kent	Keitt	Valencia	Springfield	Total
Fresh mango processed quantity (ton)	17,925.88	16,656.78	11,014.25	5,810.46	712.14	462.51	109.021	52,691.05
Mango processing rate by variety relative to the total quantity of mango processed (%)	34.02	31.61	20.90	11.02	1.37	0.88	0.2	100
By-product quantity (ton)	8,433.11	9,259.10	4,790.273	3,277.76	280.00	102.77	26.34	26,169.39
By-products rate per variety relative to the total processed per variety (%)	47.04	55.59	43.49	56.41	39.32	22.35	23.13	49.66
Mango rot rate relative to quantity processed by variety (%)	10.2	27.9	11.4	29.9	28.7	13.52	12.07	18.51

3.5. By-product management

Of the 89 mango processing units surveyed, 94.38% reported discarding their by-products directly into the environment. Figure 5 illustrates the different destinations and valorization practices of mango by-products in the Hauts-Bassins and Cascades regions. Figure 5(a) illustrates the extent of this practice. Villard *et al.* [9] have reported similar findings, observing that mango by-products are predominantly dumped in nature within the same regions studied. Of the 94.38% who discard by-products, approximately 30.95% offer them to local livestock farmers. Meanwhile, 13.09% utilize the by-products for compost production. A small fraction (1.19%) has experimented with producing soap and ointments from mango kernel extracts. Figure 5(b) depicts livestock feeding on these by-products, and Figure 5(c) shows a composting pit. Figures 5(d) and 5(e) depict the use of mango by-products in the cosmetics industry. Only 4.49% of the surveyed processing units reported actively converting their by-products into compost for use in agricultural fields or mango orchards. This aligns with previous findings [5], which documented the use of mango by-products as compost in agricultural practices on Réunion Island. Notably, 25% of the composting units integrate their by-products into biogas production before composting. Additionally, 1.12% of the surveyed units allocate their by-products for scientific research. Despite these efforts, the quantities of by-products repurposed for livestock feed and agricultural use are negligible at 1% and 2%, respectively. Overall, the valorization of mango by-products in Burkina Faso remains critically low, as evidenced by traceability and management practices, as shown in Figures 6 and 7.

(a) (b) (c) (d) (e)

Figure 5. Destination of by-products in regions of Hauts-Bassins and Cascades with (a) by-products discharge, (b) livestock feeding on by-products, (c) composting of by-products, (d) ointment enriched with mango butter, and (e) mango almond soap

The widespread disposal of by-products in nature poses significant environmental challenges, highlighting the urgent need for accessible, practical valorization strategies to improve the sustainability of the mango processing sector. This study reveals opportunities for added value in the livestock, agriculture, and cosmetics sectors. In Burkina Faso, for example, previous studies have demonstrated the successful use of mango by-products in feed for pigs, poultry, and dairy cows [13]–[15]. However, these solutions have not been widely adopted, primarily due to financial constraints and a lack of commercial demand for by-product-based feed, as processors have mentioned. Accessibility could be improved. Other areas requiring further study include the use of mango butter in cosmetic product formulations, as tested in Côte d'Ivoire, Nigeria, and Thailand [30]–[32]. Mango butter improves the quality and stability of formulations due to its fatty acid composition, which is rich in oleic acid and antioxidants (polyphenols). Improving the methodology of small-scale composting could reduce composting time and absorb large quantities of by-products, aligning with organic farming guidelines [33]–[35]. It would also be interesting to expand the potential for biogas recovery, as demonstrated by numerous studies on recovery of agro-industrial waste [36]–[38]. Implementing these opportunities requires simultaneous action by researchers, processors, and stakeholders.

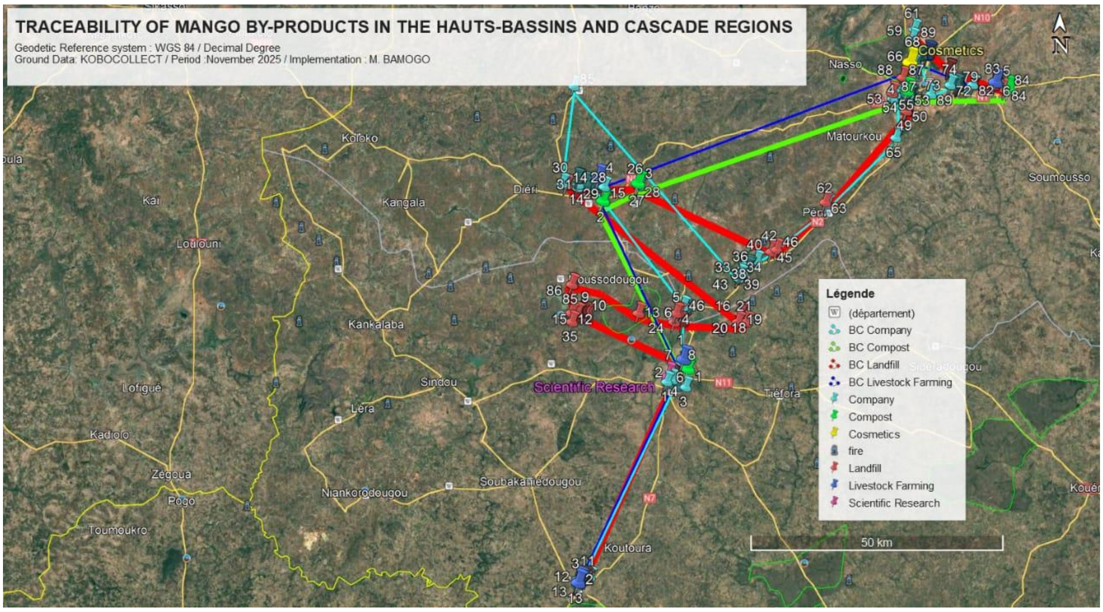

Figure 6. By-products flows in the Hauts-Bassins and Cascades region

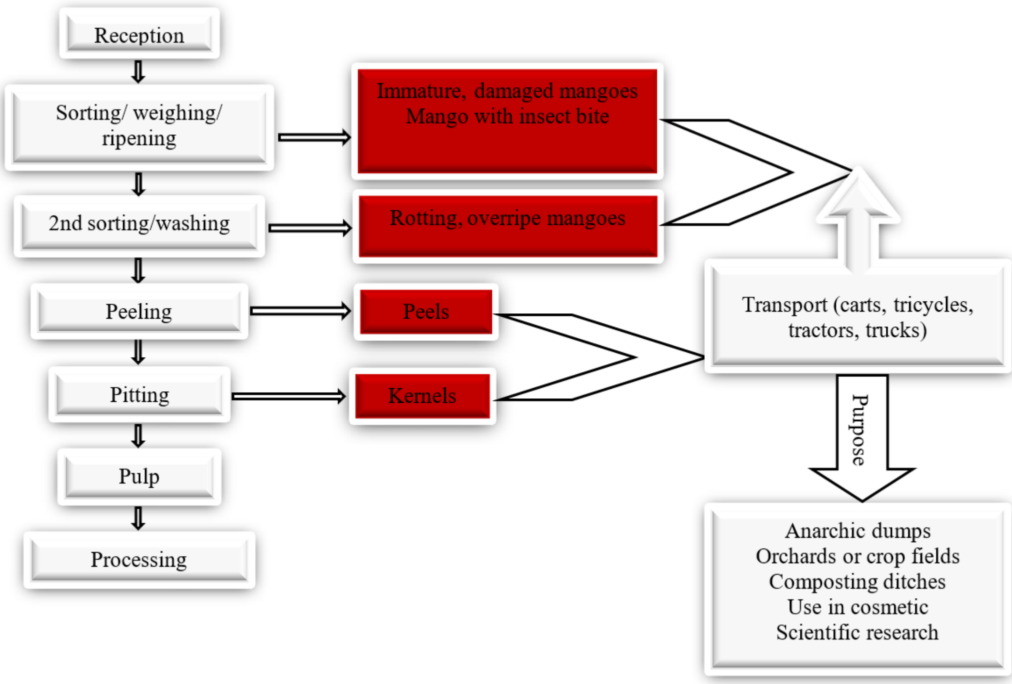

Figure 7. Production levels and destinations of by-products in the Hauts-Bassins and Cascades regions

3.6. Social and environmental impacts of non-recovery of by-products

Mango by-products are often disposed of improperly near processing units, resulting in informal waste disposal sites. Often located in front of processing units, near schools, and in recreational areas, these sites lead to environmental, health, and social issues, as well as conflicts between processing unit operators and local communities. One major environmental concern associated with uncontrolled mango by-product disposal is soil degradation. The large volume of accumulated waste prevents air from penetrating the soil, which leads to asphyxiation and plant deterioration [39]. Additionally, decomposing mango waste emits strong odors that attract pests, such as flies and mosquitoes [9], which pose health risks to nearby residents. Children living near these processing units are at an increased risk of health problems, as some of them consume the fleshy mango kernels left behind by tractors and motorcycle taxis parked at the unit entrances. Furthermore, the fermentation of mango waste produces liquid runoff that contaminates the surrounding area, creating unsanitary living conditions.

Improper management of by-products has also led to social conflicts. Disputes often occur between processing unit operators and local residents because of uncontrolled dumping in open spaces. While some operators acknowledge the Ministry of the Environment's designated landfills for mango by-products, these sites are inconvenient and costly to access due to their location on the outskirts of urban areas. Consequently, many processing unit operators illegally dispose of by-products in nearby unoccupied areas to avoid transportation costs. To address these challenges, each municipality should establish a centralized industrial zone for mango processing, which would allow for better waste management and improved living conditions. While this study highlights the environmental and social implications of by-product mismanagement, it did not assess the economic impact of this issue, which should be explored in future research.

3.7. Physical study of mango

3.7.1. Yield of by-products in the laboratory and in drying units

Analysis of mango component yields revealed statistically significant differences among varieties ($p < 0.05$). Laboratory experiments showed that the peel yield ranged from 8.94% to 12.38%, and the kernel yield varied from 6.45% to 11.45%. These peel yield results are consistent with those reported in [18], which ranged from 8.17% to 13.93%. However, these findings differ from those of Wongkaew *et al.* [23], who reported a higher peel yield rate of 14.39% to 16.64%. The kernel proportion results are also lower than those reported by Wongkaew *et al.* [23], who reported kernel yields ranging from 12.43% to 18.29% of the fresh mango weight. Among the processed varieties, Valencia had the highest almond content relative to its kernel (63.38%), while Amélie had the lowest almond yield (30.30%). These findings differ from those of Mas'ud *et al.* [40], who reported almond yields ranging from 45% to 85%. Characterizing these almonds will enable their use in butter production [31]. Table 3 presents data on the yield of mango components in the laboratory. The observed differences in peel, kernel, and almond yields can be attributed to varietal differences. Experiments conducted in drying units revealed that the Lippens variety had the highest peel content, while the Amélie variety had the lowest yield, with values of 27.33% and 21%, respectively. However, the Amélie variety had the highest kernel yield, unlike the Brooks variety. The respective values were 26.00% and 23.01%. These values are significantly higher than those obtained in the laboratory. However, pulp yield was lower in the drying units than in laboratory experiments, resulting in higher by-product generation rates. This discrepancy is attributed to adherence to processing specifications, which require particular cutting techniques [41].

Table 3. Proportion of mango parts determined in the laboratory

Variety	Average weight	Pulp (%)	Peel (%)	Kernel (%)	Shell/kernel (%)	Almond/kernel (%)
Amélie	499.2 ± 80.8^{b}	81.76 ± 03^{b}	10.85 ± 0.1^{a}	7.39 ± 0.05^{e}	69.70 ± 0.12^{b}	30.30 ± 0.01^{f}
Lippens	381 ± 79.9^{c}	79.8 ± 0.07^{c}	11.96 ± 0.03^{b}	8.23 ± 0.01^{d}	59.66 ± 0.3^{d}	40.34 ± 0.03^{d}
Brooks	482.6 ± 59.83^{b}	76.16 ± 0.07^{e}	12.38 ± 0.04^{a}	11.45 ± 0.01^{a}	53.31 ± 0.05^{f}	46.69 ± 0.01^{b}
Kent	641.4 ± 77.91^{a}	78.47 ± 0.11^{d}	11.37 ± 0.03^{d}	10.14 ± 0.01^{b}	54.86 ± 0.2^{e}	45.14 ± 0.02^{c}
Keitt	540.2 ± 48.11^{b}	81.86 ± 0.1^{b}	11.58 ± 0.07^{c}	6.54 ± 0.01^{f}	78.75 ± 0.08^{a}	21.25 ± 0.01^{g}
Springfield	450 ± 46.36^{bc}	82.01 ± 0.3^{b}	8.94 ± 0.1^{g}	9.04 ± 0.08^{c}	60.15 ± 0.06^{c}	39.75 ± 0.04^{e}
Valencia	471.1 ± 67.62^{bc}	83.88 ± 0.11^{a}	9.66 ± 0.09^{f}	6.45 ± 0.06^{f}	36.62 ± 0.10^{g}	63.38 ± 0.01^{a}
P value	< 2e - 16	< 2e - 16	< 2e - 16	< 2e - 16	< 2e - 16	< 2e - 16

Means with the same letters in the same column are not significantly different ($p < 0.05$)

Table 4 presents data on yield of mango components in drying units. Several recent studies [40], [42] on chemical composition of mango peels and almonds have demonstrated the presence of phenolic compounds, including flavonoids, which contribute to high antioxidant activity. Additionally, mango by-products are rich in dietary fibers [43], [44], minerals such as potassium, calcium and magnesium [45], and carbohydrates [46]. Several studies have explored the fortification of cereals [47]–[49], dairy products, such as yogurt [50], and meat products [51], [52] with mango by-products. A promising avenue for future valorization would be to incorporating mango by-products into local food fortification programs, thereby opening new opportunities for sustainable utilization.

Table 4. Proportion of mango parts determined in drying units

Variety	Pulp (%)	Peel (%)	Kernel (%)
Amélie	53.00 ± 1.00[a]	21.00 ± 1.73[b]	26.00 ± 1.73[a]
Brooks	51.33 ± 1.15[ab]	25.66 ± 1.15[a]	23.01 ± 0.57[b]
Lippens	48.00 ± 2.00[b]	27.33 ± 1.15[a]	24.67 ± 1.15[ab]
P value	0.014	0.003	0.045

Means with the same letters in the same column are not significantly different ($p < 0.05$)

3.7.2. Evaluation of residual pulps

The Lippens variety results in the greatest pulp loss during the drying process, with a loss rate of 31.8%. These losses are primarily distributed between the peels and kernels. Peel-related losses range from 10.15% to 15.36%, while kernel-related losses vary from 11.56% to 18.61%. A study by [53] estimated that mango processing waste from frozen mango production contains about 20% residual pulp. Pulp losses in drying units are high primarily due to strict compliance with processing specifications that require specific cutting techniques [53]. Additionally, the manual peeling process, which is still rudimentary, prevents efficient pulp recovery and optimization. These residual pulp losses represent a valuable resource for alternative uses, including the production of nectars, wine and vinegar [9], and the supplementation of livestock and poultry feed and insect farming applications [14], [15]. Implementing these improvements would minimize pulp waste, enhancing productivity and resource utilization. Figure 8 illustrates pulp loss and depicts residual pulp loss from peels and kernels per variety.

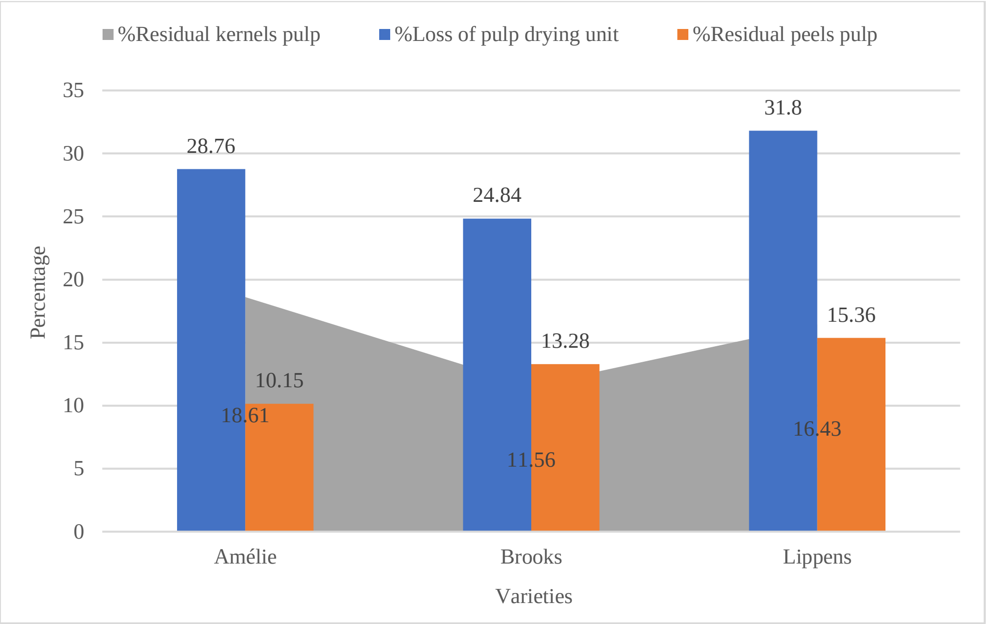

Figure 8. Pulp loss and residual pulp of peels and kernels per variety

4. CONCLUSION

This study provides a comprehensive statistical analysis of mango processing in Burkina Faso's Hauts-Bassins and Cascades regions, both of which are high-potential mango-producing areas. The study identified the varieties of mangoes processed and evaluated the quantities and traceability of the resulting by-products. Consistent with previous research, the findings confirm that mango processing by-products are largely discarded, with minimal effort toward recovery or valorization. Additionally, the study identified the primary concerns of processing unit promoters regarding the implementation of research-based valorization strategies. The main obstacles cited were financial constraints, which hinder the establishment of parallel feed production units and the acquisition of large, suitable land areas outside residential zones. Furthermore, the study highlights several health and environmental challenges associated with the poor management of mango by-products. These challenges include olfactory nuisances, pest proliferation, unsanitary conditions around processing units, and vegetation destruction at landfill sites. This survey lays the groundwork for a broader, nationwide socioeconomic study aimed at structuring the mango sector in Burkina Faso and promoting research-based valorization strategies for utilizing by-products. The findings also underscore the potential of valorizing mango by-products by developing functional foods, such as cereal products and meat formulations enriched with almonds and mango peels. This form of agri-food valorization would reduce waste, enhance the nutritional value of foods, contribute to food security, and help to mitigate certain health conditions. Further studies analyzing the biochemical, physicochemical, and toxicological properties of these by-products are necessary to ensure their safe and effective integration into the food industry.

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AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
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CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

DATA AVAILABILITY

The authors confirm that the data supporting the findings of this study are available within the article.

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