Productivity and Efficiency of Cashew Processing : Comparison of Manual and Automated Systems

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Abstract

India is one of the leading producers, processors, and exporters of cashews in the world. Cashew processing units are primarily small and medium enterprises (SMEs) and are highly labor intensive. Productivity and efficiency of processing is a primary concern for cashew processing firms that operate with limited resources. Using a multiple-case study approach, this study compared the productivity and efficiency of automated cashew processing with the manual processing. Employees' perception towards automation was also examined. A comparative analysis was performed for the five stages of cashew processing : Sorting, shelling, peeling, grading, and packaging. Purposive sampling method was used to select five SMEs that used either manual or automated processing methods. The study identified the processing method that was the most efficient at each stage, taking into account both quantitative and qualitative data. It was found that automation of the cashew processing increased productivity by at least 10 times. It was also found that almost all the five stages required manual intervention as automation cannot completely replace humans. Due to high health hazards and fatigue, workers favored use of automated processing over manual processing. Health risk was high in the shelling and peeling stages of cashew processing. Fatigue due to repetitive work was high in sorting, grading, and peeling stages. Managerial implications for SME owners who plan to deploy automation technologies in their firms were also discussed.

Keywords : **productivity, process efficiency, SMEs, cashew processing, automation**

JEL Classification : D24, L66, M11, O14

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India is the second largest producer of cashew nuts in the world, closely following Vietnam. India produces around 0.4 million M.T. of cashew annually in a land area of 0.7 million hectares (Cashew Export Promotion Council of India, 2019). Cashew is one of the commodity groups, which are exclusively exported by Indian small and medium enterprises (SMEs). India is also one of the major processors and exporters of cashew nuts. Cashew kernels, cashew nut shell liquid, and processed cashew nuts are some of the most exported products of cashew fruit. In 2018 - 2019, India exported 0.07 million M.T. of cashew kernels and 4800 M.T. of cashew nut shell liquid (CEPCI, 2019). Cashew is primarily grown in the coastal states of India such as Andhra Pradesh, Goa,

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Karnataka, Kerala, Tamil Nadu, and others. In addition, India imported 0.8 million M.T. raw cashew nuts (RCN) (CEPCI, 2019) in the year 2018 - 2019. India imports raw cashew nuts from Africa and other cashew producing countries to meet its growing requirement.

In India, 82% of cashew processing units use manual processing (Kumar, Susmitha, Yamuna, & Yamini, 2016). Traditionally, cashew processing in India has been a labor - intensive industry. SMEs in this industry are primarily located in rural areas that have easy access to labor. Laborers, primarily women, are involved in manual cashew processing units. Manual processing is preferred due to less dependency on electricity and ability to retain the quality of the kernels. Due to increasing health hazards in manual cashew processing and labor problems, progressive SMEs in the cashew processing industry are adopting advanced manufacturing technologies (AMT) for cashew processing. Advanced manufacturing technologies refer to technologies that enhance efficiency and flexibility of manufacturing processes (Wu, 2012). The present study compares the productivity and efficiency of automated processing technologies and manual processing for different stages of cashew processing. The paper focuses on the following two research questions :

- Do advanced manufacturing technologies increase the productivity and efficiency of the SMEs in the cashew industry?
- What is the employees' perception towards advanced manufacturing technologies in the cashew industry?

Cashew Processing Stages and Technologies Used

Broadly, cashew processing involves five major stages : Sorting, shelling, peeling, grading, and packaging. These processes have several alternative technologies to replace few or all activities of manual processing. Cashew processing starts with the drying of raw cashew nuts (RCN) in the sun to reduce the moisture content. Processors take care that the raw cashew nuts procured do not have more than 17-18% of the moisture. The RCN is dried till its moisture level is reduced to 6 - 9%. The following sections provide a brief overview of the cashew processing stages :

(1) Sorting Raw Nuts : In this process, the dried cashew nuts are sorted and separated according to size. The impurities such as dust, stones are removed. The raw nuts are sorted depending upon the size that may be loaded into different shelling machines. Thus, for the effective shelling process, sorting of the raw nuts as per size is essential. Presence of impurities damages the shelling machine. The sorting may be done either manually or using a calibration machine. While manual sorting is more prevalent among rural SMEs, calibration/grader machine is an automated technology alternative. In this alternative, RCN are passed through different holes that separate the cashews of different sizes and collect them. The size of the holes varies from 17mm to 24 mm, which may result in 35 grades of RCN. After sorting, the nuts are cooked either using steam cooking or drum roasting methods. Steam cooking, a popular method to prepare the nuts, involves cooking RCN using steam for 20 - 30 minutes. The cooked nuts are cooled and then used for shelling the next day.

(2) Shelling Process : Shelling involves separation of outer shell and the cashew kernel. Traditionally, the shelling is done manually using hand/leg operated tools. This involves placing the raw nuts individually in between a blade and pressing them against the blade and applying the leg force by pushing them upright to open up the nut. Then the cashew kernel is removed from the shell. Manual method requires two workers where one person shells the raw nuts and another worker de-shells kernel from the nut. Automated RCN shelling machines are being introduced, which open the shells automatically. Shell and kernel separator machine may be attached to the automated RCN shelling machine to separate shelled out kernels from those that are stuck to the nut. Further

manual processing is needed to separate the cashew kernel from the outer shell. After de-shelling, the cashew is further dried or roasted to reduce the moisture and facilitate easily peeling of the skin. The cashew kernels need to be roasted for appropriate time and temperature so that the kernels do not get affected. After this process, they are cooled before peeling.

(3) Peeling Process : In this stage, outer skin of the cashew kernel is peeled and removed. Peeling may be done either manually or by using an automated peeling machine. Manual peeling is done using bare hands, primarily by women workers. Due to the unavailability of labor, several SMEs are adopting machine peeling. Humidification process is applied before using the automated peeling. The moisture of the cashew kernel is enhanced to reduce breakage of nuts during the mechanical peeling process. These kernels are then put into the peeling machine. A rotating cylinder with a brush enables the peeling of the skin from the nuts, and air is blown to separate skin from the nuts. The unpeeled nuts are usually processed manually. After peeling, kernels are again dried to reduce the moisture content using a drier. Manually peeled kernels usually do not require drying of kernels.

(4) Grading Process : Grading of cashews is the next stage that separates cashew kernels based on size, texture, and color. There are more than 50 grades of cashew in the market, and their prices vary based on the grades. Grading may be done either manually or using automated grading with or without a color sortex machine. The manual graded cashews are inspected by a supervisor. In automated grading, broken and whole nuts are separated using vibrator separator machine. Once the wholes are separated from others, they are graded using the grading machine. The grading machine is then used to grade cashews up to eight different classes using a camera. These kernels are then separated based on color, which may be done manually or by color sorter machine. The size wise graded wholes are loaded into the machine and are then graded here on the basis of its color. The wholes are loaded into the machine where the camera scans each cashew kernel on the basis of its color and grades them differently. These nuts are then given for rework for workers to verify and cross check.

(5) Packaging Process : After the kernels are graded into different grades, the next stage is packaging as per required quantity and packaging material. Packaging may be done either manually or using vacuum tin packing machine. In manual packing, each tin is manually labelled, filled, and weighed. Finally, the tin is sealed off and packed into corrugated boxes. In the vacuum tin packing machine, the kernels are loaded into the machine and are filled into the tins by vibratory filling machine. Finally, the tin is sealed.

Review of Related Literature

With globalization and competition, Indian MSMEs are under pressure to adopt advance manufacturing technologies to thrive in the global market (Bhatt, 2016). With increasing alternatives, manufacturers are under pressure to decide which AMTs will give them the greatest benefits (Khan & Nasser, 2016). The investment in automation may be considerable for SMEs with limited resources. Efficiency and cost reduction are found to be key drivers of automation and adoption of advanced manufacturing technologies (Mishev, 2006 ; Nair, Ataseven, & Swamidass, 2013 ; Percival & Cozzarin, 2010 ; Sohal, Burcher, Millen, & Lee, 1999). Efficiency may be defined as the ability of a firm to optimally utilize resources in a cost - effective way to generate the desired business output (Teng, 2014). In cashew processing, Ojolo, Damisa, Orisaleye, and Ogbonnaya (2010) found that efficiency, whole kernel recovery, and throughput of automated shelling machine were higher than those of manual shelling. Prior research (Fagbemi, 2008) indicated that choice of processing technique used had a significant impact on nutritional content of cashew. The quality of the cashew kernel was found to influence the price that could be fetched in the market (Namdeo, Koulagi, & Wader, 2007).

There are also research studies in literature, which reported that implementing automation does not always influence productivity and efficiency (Mrugalska, Wyrwicka, & Zasada, 2016). Improper implementation also results in problems such as lower efficiency, more waste products, and down time (Mrugalska et al., 2016). There are also broader concerns such as reduction in employment, environmental degradation, and pollution (Khan & Nasser, 2016). Automation of manufacturing processes is suitable when a repetitive task has to be performed consistently and multiple tasks have to be performed simultaneously (Groover, 2005). Research has also indicated that humans cannot be removed from the manufacturing processes completely (Mrugalska et al., 2016). There are many processes that need manual intervention, and machines are unable to address those processes (Misztal, Butlewski, Jasiak, & Janik, 2015). Skilled workers are needed to operate machines and ensure that the input and output of the machines are as per the standard (Mrugalska et al., 2016). It is important to consider job and task design as the production outcome is influenced by interaction between humans and machines (Mishev, 2006). Automation would lead to instances where physical work and mental fatigue of humans are reduced (Mrugalska et al., 2016).

In this study, we compare the productivity and quality of output of the alternative processing methods and employee perceptions towards the processing methods in the cashew industry. Productivity is a ratio of the amount of inputs needed to produce a certain amount of outputs (Teng, 2014).

Methodology

The study uses multiple case study approach to compare and analyze the productivity and efficiency of SMEs. The purpose of using this method is to observe the processing stages, technology used, and collect detailed data on productivity. The study was carried out in the rural area of Udupi district in Karnataka state of India during the period from June - July 2017. Karnataka is one of the largest producers of cashew in India. The state has more than 300 cashew processing units, most of which are located in rural areas. List of SMEs were obtained from the Karnataka Cashew Manufacturers Association. Telephone calls were first made to 30 randomly selected SMEs to ascertain their willingness to participate in the study. Preliminary data on the type of processing method used were collected for the SMEs who provided consent to participate in the study. In the next stage, purposive sampling was used to select the SMEs to ensure that the SMEs that had manual processing and different automation technologies were included in the study. The criterion used to select the SME was that the SME needed to have a unique cashew processing method that would be useful for a comparative study.

The data were collected from five SMEs. The field work was carried out by visiting the units and collecting the data. In-depth interviews were conducted with the supervisors and workers to collect the production data. The interviews were based on semi-structured design and aimed to gain insights into the processes, impact of technology on productivity, and issues in automation. Interviews were conducted in person with the employees who were involved in different cashew processing stages. The Table 1 presents the characteristics of SMEs in the sample.

Table 1. Sample SME Characteristics

	Processing Method	Producon` Capacity (Per Day)	Employee Size
SME 1	All five processes manual	1000 kg	80
SME 2	Sorng` (Automated) Shelling (Automated)	3000 kg	50
SME 3	Grading (Automated)	2800 kg	60
SME 4	Shelling (Automated)	2500 kg	50
SME 5	Packaging (Automated)	2500 kg	50

Table 2. Processing Methods Used in the Sample SMEs

	Processing Method				
	Sorng`	**Shelling**	**Peeling**	**Grading**	**Packaging**
SME 1	**Manual***	**Manual***	**Manual***	**Manual***	**Manual***
SME 2	**Automated (Grader Machine)***	**Automated (Automated RCN shelling machine with shell and kernel separator)***	Automated	Automated Size Grading	Automated
SME 3	Manual	Automated (Automated RCN shelling machine with shell and kernel separator)	Automated	**Automated Size Grading with Color Sorter ***	Automated
SME 4	Manual	**Automated (Automated RCN shelling machine)***	Both Manual and Automated	Automated Size Grading	Automated
SME 5	Automated (Grader Machine)	Automated (Automated RCN shelling machine)	Both Manual and Automated	Automated Size	**Automated***

Note. *Data collected for comparative study

Among the five SMEs, one unit used completely manual method for all processing stages. The manual processing data were collected from SME1. The study employed a comparative approach to compare processing efficiency of manual and alternative automated processing methods. The Table 2 presents the processing method used in each SME. The highlighted method indicates the SME used for comparison with manual processing.

As the production capacities of the SMEs were different, for the purpose of comparison, the output of 1000 kg was considered. The quantitative data on time taken to process 1000 kg of raw cashew, production rate for shift of 8 hours (throughput), number of output varieties made, cost incurred, manpower required were collected to analyze the efficiency of each processing method. The study compared the productivity for manual processing and the automated technologies prevalent in the region for all the five stages of cashew processing. Employees' perceptions towards the processing method used, for both manual and automated shelling, were also collected. Feedback from the supervisors and workers were analyzed to understand their perspectives on automation. Two supervisors and five workers from each processing method were interviewed, and data were compiled and analyzed. A comparison was made on the basis of time taken and cost incurred to produce an output of 1000 kg with manual and automated processing. The feedback of the employees on perceived ease of performing the work, perceived quality of output, and perceived risk involved in the processing method was collected using a 5 - point Likert scale. The interviewer translated the questions in local language (Kannada) to collect the data from the employees.

Analysis, Findings, and Discussion

(1) Sorting Process : Manual sorting was compared with the calibration machine sorting and the data is presented in the Table 3. Manual sorting can sort nuts into two - three different sizes, which shall result in uneven shelling of the nuts. Introduction of calibration machine increases the productivity by ten times. The machine sorts the nuts into five different sizes, which helps in effective shelling. In terms of throughput, time taken to sort and ability to

Table 3. Comparison of Manual Sorting vs Calibration Sorting Machine

	Manual Sorng`	Calibration Sorting Machine
Throughput (Kg)	600 - 800	6400 - 9600
(Rate of Sorting/Day/Employee)		
Number of Different Cashew Sizes Sorted	2	5
Time Taken (Hours)	10	0.8
(Output of 1000 kg)		
Cost/Output Rao`	251	2.41
(₹ per 1000 kg) *		
Employees' Rang`		
Perceived Ease of Work	1	4
Perceived Quality of Output	2	4
Perceived Risk	4	1

Note. * Cost included raw material cost, labor cost, machine depreciation cost, and other operang eạxpenses.

handle different sizes of raw nuts, the calibration machine is more efficient than manual sorting. However, in manual sorting, impurities in the raw material are removed completely.

The only disadvantage in the machine is that it is unable to identify large sized stone particles as it considers them as nuts. Therefore, manual inspection is required after machine sorting. The employees prefer machine sorting as manual sorting of varying sizes of nuts leads to exhaustion. The workers opined that manual sorting produces better quality in terms of clean sorting. However, in terms of grading and productivity, machines perform better as they grade the raw nuts into five grades compared to two grades in manual sorting. Workers responded that manual sorting is harmful for their hands as it contains shell oil and dust. They believed that the machine is easy to operate and is not harmful to use. The main reason for automation of sorting was the unwillingness of workers to perform the sorting task manually.

(2) Shelling Process : In this process, among the three alternative processing techniques, the automated shelling machine with kernel separator provides a better shelling rate. The Table 4 presents the comparison of the manual and the automated shelling alternatives.

In automated shell and kernel separator machine, the calibrating machine separates the kernels from the shells. The partially shelled nuts (if any) are given for manual rework to the workers ; 65% of the cashews are completely shelled. About 20% of the raw cashews are partially shelled. The machine puts the marks on the outer layer of the nuts and the workers have to detach the kernel from the nuts. The workers find this process difficult to pull the kernel out of the nuts as sometimes, the marking of the blades will be uneven. Around 15% of the output results in cashew kernels to be broken into pieces. This is a concern for several micro enterprises as breakage of cashew kernels results in a lower market price. The comparison shows that productivity of the automated shelling machine with shell and kernel separator is highest as it involves 30 times higher investment than the automated shelling machine, and hence, the production process should be carefully planned. Employees had a positive perception towards the use of automated shelling machine compared to the manual shelling, which has health risks due to exposure to oil.

(3) Peeling Process : The peeling process is the most tedious and time - consuming process. Automated peeling increases the productivity (throughput) by 100 times compared to manual peeling as shown in the Table 5. Cost/output ratio is also lower for the automated peeling process. The employees had a positive perception

Table 4. Comparison of Manual vs Automated Shelling Process

	Manual Shelling	Automated RCN Shelling Machine	Automated with Shell and Kernel Separator Machine
Throughput (Kg) (Rate of Shelling/Day)	75 - 100	240 - 320	1800 - 2500
Quanty` of Kernels Output (Kg)	15 - 20	50 - 70	320 - 440Kg fully shelled, 80 - 110Kg parally` shelled
Quality of Output	96% fully shelled, 4% pieces	90% fully shelled, 10% pieces	65% fully shelled, 20% parally` shelled, 15% pieces
Time Taken (Hours) (to shell 1000 kg)	80	25	3.2
Cost/Output Rao` (₹ Per 1000 kg)*	10, 294	3, 095	476
Employees' Rang`			
Perceived Ease of Work	1	3	5
Perceived Quality of Output	2	4	5
Perceived Risk Involved	4	1	1

Note. *Cost included raw material cost, labor cost, machine depreciaon` cost, and other operang` expenses.

Table 5. Comparison of Manual vs Automated Peeling Process

	Manual Peeling	Automated Peeling
Throughput (Kgs) (Rate of Peeling/Day)	8	500-800
Variees` Made	5	4
Quanty` of Kernels Output (kgs)	Wholes - 6, Pieces -1	Wholes - 560, Pieces - 80
Quality of Output 10% pieces, 10% wastage	85% cleaned wholes, 10% pieces, 5% wastage	75% cleaned wholes
Time Taken (Hours) (to peel 1000kg)	1000	10
Cost/Output Rao` (₹ per 1000 kg)*	95,921	1,511
Employees' Rang`		
Perceived Ease of Work	1	4
Perceived Quality of Output	5	2
Perceived Risk	4	1

Note. *Cost included raw material cost, labor cost, machine depreciaon` cost, and other operang` expenses.

towards automated peeling. However, the amount of whole cashews is found to be slightly higher in manual peeling. As the whole cashew kernels fetch a higher market price than the broken pieces, manufacturers use a mix of manual and automated peeling depending on the availability of labourers. Peeling work is given as a take-home task and primarily women are involved in this process. Employees had a positive perception towards the ease of work in automated peeling and perceived that quality of output is lower. The perceived risk, in terms of health hazards, was higher for manual peeling.

(4) Grading Process : The different alternatives in this process are manual grading, size grading machine, and colour sorter machine. Comparative analysis (refer Table 6) shows that automated size grading is found to be the most effective, both in cost/output ratio and throughput. The employees had a very positive response towards the automated grading system. Employees preferred to work in the grading process compared to other processes. Automated size grading with colour sorter is found to be the most productive. The Table 6 presents the comparison of the manual and automated grading processes.

(5) Packaging Process : Packaging is the final stage of the manufacturing process where the kernels are loaded into a tin weighing 10 kg each and are then packed into a corrugated box with labelling. Automated packing is found effective compared to manual packing. The Table 7 shows the comparative analysis of manual and automated packing processes. The employees had a positive perception towards automated packing.

Overall, from the comparative analysis, it is found that advanced manufacturing technologies are more productive than manual work in all stages of cashew processing. However, it does not completely replace the

Table 6. Comparison of Manual vs Automated Grading Process

	Manual Grading	Automated Size Grading	Automated Size Grading with Colour Sorter
Throughput (kg)	75 - 100	600 - 1000	1200 - 2400
(Rate of Grading/Day)			
Variees` Made	8 grades	6 grades	2 grades at a me` with 15 varieties
Time Taken (Hours)	80	8	3.4
(To grade 1000kg)			
Cost/Output Rao`	10,050	1,253	626
(₹ per 1000kg)			
Employees' Rating			
Perceived Ease of Work	1	3	5
Perceived Quality of Output	2	4	5
Perceived Risk Involved	4	1	1

Note. *Cost included raw material cost, labor cost, machine depreciaon` cost, and other operang` expenses.

Table 7. Comparison of Manual vs Automated Packing Process

	Manual Packing	Automated Packing
Throughput (No of Tins)	500	3500 - 3800
(Rate of Packing/Day)		
Time Taken (Hours)	16	2.1
(to pack 1000 tins)		
Cost/Output Rao`	1750	250
(₹ Per 1000 n)`		
Employees' Rang`		
Perceived Ease of Work	1	4
Perceived Quality of Output	2	5
Perceived Risk Involved	4	1

Note. *Cost included raw material cost, labor cost, machine depreciaon` cost, and other operang` expenses.

workers in all processes. In the shelling process, the shelling of the nuts is done by the machine and separating the kernels from the nuts is done manually. For the shelling process, automation is highly recommended as it removes the burden of shelling each nut. The output can be doubled as workers can only focus on picking the kernels from the nuts. However, contradicting the findings of Ojolo et al. (2010), it is found that whole kernel recovery is better in the manual shelling process. For the sorting process, automation improves the quality of the output. In the peeling stage, the output from the machine should be inspected and be reworked by the manual workers. For the peeling process, automation reduces the health risks for the employees along with boost in productivity. The investment in peeling machine is high, thus the firms having a production capacity of 2000 kg of raw nuts per day can opt for installing it. The firms having lower production capacity may adopt manual approach for this process. For the grading process, automated grader with color sorting is most efficient as it grades several varieties that may be sold at appropriate prices in the market.

Automation reduces fatigue among workers as workers have to do only the inspection and rework to ensure the quality of the output. In the packaging process, the modern packaging is necessary so as to precisely pack the tins and the corrugated boxes. As the machine cost is also low, automation of packaging is feasible for the SMEs to improve quality and throughput of the packaging process.

Managerial Implications

The study has several managerial implications, primarily for owners of cashew processing SMEs. First, the study provides the comparative data for SME managers considering to automate their processes. The study provides ample evidence for an increase in productivity through automation and adoption of automated manufacturing technologies. SMEs considering automation need to increase their production capacity in order to bring efficiency in their operations and recover costs of automation. For small scale processors below the production capacity of 2000 kg, automation would not result in significant cost reduction. Automation should be initiated for all the stages as these are interlinked processes in order to increase the throughput of the processed cashews. Careful planning of production capacity and training & incentives for employees to ensure quality of output is required. Proper planning of task and machine roles is also required.

Automation leads to improving the morale of workers and provides them with a good work environment. Automation also reduces monotony of repetitive and boring work. The study also found that employees supported automation, primarily due to health hazards of handling cashew nuts.

The vendors of the AMT may use comparative data from the study to market their technologies. There is clear evidence that there is considerable increase in the throughput with automation compared to manual processing. Vendors need to develop technologies that would help in recovering the whole kernels in shelling and peeling processes. The Government of India and Cashew Council of India must extend their support to SMEs to increase adoption of advanced manufacturing technologies. Government - sponsored technology mediation programs may facilitate in reducing barriers that SMEs face in automation and new technology adoption (Gunasekara, 2011). Government support may come in the form of soft loans, grants, training programmes, and schemes to boost faster automation of SMEs.

Conclusion, Limitations of the Study, and Scope for Further Research

The study has few limitations. First, the study includes selected alternative technologies that are prevalent in the region for comparison. Second, the study uses case study based approach to draw conclusions. A large scale empirical study may provide insights into SME owners' perception and employees' attitude towards automation and problems faced by them. Future studies may explore these issues. Based on the comparative analysis, it may

be concluded that automation will help SMEs to increase their productivity. The SMEs may increase their competitiveness by implementing AMTs and modernize their units. Moving from labor-intensive industry to automated industry would enable Indian cashew processing SMEs to meet increasing global demand for cashews.

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