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Quantification of the Material Flow of Raw Cassava Tubers Processing for Export Market

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Abstract: Cassava (*Manihot esculenta*), is one of the most important calorie crops in the tropics, having multiple commercial and industrial uses. Sri Lanka has a surplus production of cassava and has high demand in both local and export markets. The total quantity of raw cassava export of Sri Lanka in year 2014 is 4,229 Metric tons. Therefor e improving the processing line of raw cassava for export market will be beneficial to increase the raw cassava export industry in Sri Lanka. This study was a case study, designed to carry out a material flow analysis of a processing plant of raw cassava roots export, to characterize and quantify the inputs and outputs of the process and to identify the hotspots in the processing line. The processing line includes raw cassava receiving, sorting, washing, fungicide treatment, packaging and sealing. The MFA revealed that the hotspots of raw cassava processing for export market were sorting, washing, fungicide treatment and packaging. From the raw cassava roots purchased 12.2±2.1% of the total raw cassava weight was wasted and 7.1±0.5% of total coco peat purchased were wasted during the processing. The amount of waste water generation was 415±20L per 1000kg of raw cassava roots weight.

Keywords: Cassava, Raw cassava tuber export, Cassava waste, Material flow analysis.

1. Introduction

Cassava (*Manihot esculenta*), also called manioc, tapioca or yuca, is one of the most important food crops in the humid tropics [1].It can be grown in conditions of low nutrient availability and drought [2]. Cassava is the fourth most important food calorie crop in the tropics, and has been growing in importance both for food security (especially in Africa) and for multiple commercial and industrial uses (mainly in Latin America and Asia) [3].

Cassava tuber which is a swollen root is the main harvested organ and also cassava leaves are sometimes consumed. A major limitation of cassava production is the rapid post-harvest deterioration of Its roots which usually prevents their storage in the fresh state for more than a few days [4].

According to the National Statistics in the Department of Census and Statistics, Sri Lanka, The estimated annual production of cassava in year 2014 is 302,767 Metric tons and the area of land under cultivation of cassava is 23,970 Hectares [5]. Sri Lanka has a surplus production of cassava and it is an unexploited tuber crop while having high demand in both local and export markets [6].

In year 2014, the total quantity of raw cassava export of Sri Lanka is 4,229 Metric tons and has earned more than 325 million of Sri Lankan rupees through cassava exporting [5].Cassava is exported with incorporating sterilized husk cortex of coconut (coco peat) which performs as water "sponge" [7].

Material flow analysis (MFA) examines the materials flowing into a given system, the stocks and flows within this system and the resulting outputs from the system to other systems [8].The purpose of a material flow analysis is to follow and quantify the flow of materials in a defined situation and over a set period of time. MFA is a necessary pre-requisite to operationalize the concept of sustainability and to support the effective planning and management of natural resources [9]. The end product of the MFA will be a detailed input-output table for processing line of raw cassava root packaging for export, showing all materials that enter and leave the production.

This study was designed to carry out a material flow analysis of a processing plant engaged in processing of raw cassava roots for export plant to characterize and quantify the inputs and outputs of the process.

2. Materials and methods

Both the primary and secondary data obtained was used for this study as information necessary for analysis. Primary data was obtained by interviewing the production staff of the processing plant, onsite observations and sampling. Secondary data relevant to this study were obtained from research reports, journals and textbooks. A multistage

random sampling method was used when collecting samples from the process over 30 working days.

2.1. Goal definition

The main goal of the case study was to identify "hot spots" which are the steps of the raw cassava roots processing for export market which give rise to the most significant environmental input and output flows.

2.2. The product and the Process description

The plant selected for conducting the case study was one of the few market leaders in raw cassava exporting in Sri Lanka. The final product is in 11kg five ply cardboard boxes. The final product contains 8.5-9kg of raw cassava roots and 2.5-3.0kg of Coco peat. The production capacity of the plant was 600 boxes of raw cassava roots per day. About 20 workers were engaged in the processing.

The processing line of raw cassava tubers for export market included raw cassava receiving, sorting, washing, fungicide treatment, packaging and sealing. The processing plant only used the cassava of MU51 variety which is a recommended cassava variety by the Agriculture ministry, Sri Lanka. Billet Carbendazim 50% w/w (MBC= methyl 2-benzimidazolecarbamate) (figure 01) was used as the fungicide for the fungicide treatment which prevents the plant diseases caused by various fungi [10].

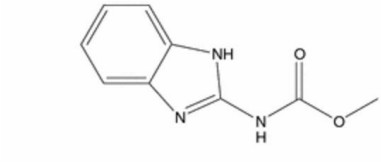

Figure 01 Carbendazim (MBC= methyl 2-benzimidazolecarbamate)

The processing line was completely manual. The subset of processes in the production line is illustrated in Figure 02.

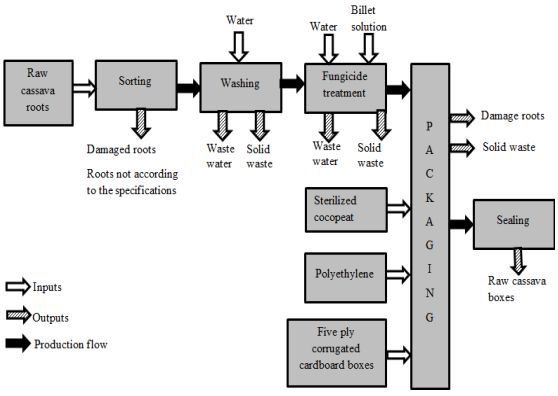

Figure 02- Production chain of raw cassava root packaging for export market

2.3. The inventory analysis and Data collection

For the inventory analysis, site specific data and information were gathered using open ended questionnaire, personal interviews and environmental reports. The process was observed over 30 working days and inputs and outputs of the process were measured. Water consumption of the process was measured daily through the water meter attached to the water supply. Multiple stage random sampling was used when gathering the observations.

2.4. Material flow Analysis

This Study on Material Flow analysis provide comprehensive description of material flows with in processing plant of the raw cassava root for export market from raw material receiving up to the dispatching of the final product. The system boundary of the analysis is shown in figure 02.

The method described by Brunner. and Rechberger. (2004) was used to carry out the MFA[11]. The principle of mass conservation supports the establishment of materials balances. It serves as a means of control in cases where all flows are known (input = output ± storage). It can be used to determine one unknown flow per process.

The functional unit (FU) is processing of 1000kg of raw cassava roots in to final product. The inputs of the process were raw cassava roots, fungicide (billet solution), polyethylene, five ply cardboard boxes, and water. The summary of inputs and outputs are shown in figure 03.

3. Results and discussion

3.1. Material flow analysis of raw cassava roots processing for export market

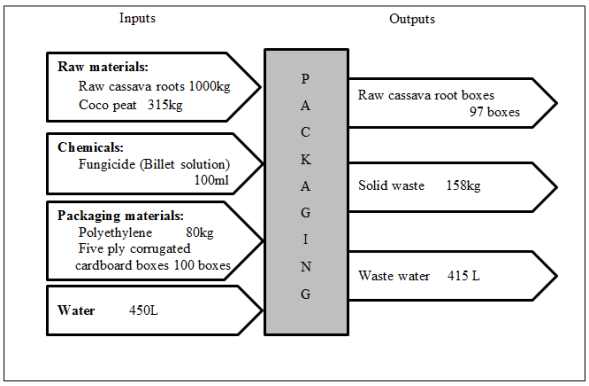

Figure 03- Summary input/output table of raw cassava root packaging for export market

The raw cassava transported through Lorries was unloaded in to the raw material receiving area of the processing plant. Secondly the raw cassava roots were sorted to remove the damage roots, and roots that are not comply with the specifications. According to the results of material flow analysis the amount of wastes generated as damaged roots

Table 01-The quantity of waste generated at the hotspots in the raw cassava processing for export market

Process step	Quantity of Waste Generated	
	Solid waste (kg per 1000kg of raw cassava roots weight)	**Waste water (Liters per 1000kg of raw cassava roots weight)**
Sorting	Total- 115.0±28.0 Damaged- 15±7 *Other- 100±21	0
Washing	**Total- 12.0±3.0	200±15
Fungicide Treatment	**Total- 0.9±0.1	230±10
Packaging	Total- 34.0±6.6 Cassava roots- 7.0±1.1 Coco peat- 22.0±5.0 Polyethylene- 0.5±0.1 Five ply Cardboard- 4.5±0.5	0

* -Not comply with the specifications **- Sediments of waste water (mud particles and peel particles)

and roots did not comply with specifications were 1.5±0.7% and 10.0±2.1% of the total weight of raw cassava roots respectively.

The sorted roots are washed once with tapped water and consumption of water was 200±15L per 1000kg of raw cassava roots. The outputs generated in washing were waste water and solid waste which were 185±10 L and 12±3kg per 1000kg of raw cassava roots respectively. The solid waste contained the sediments of waste water which include mud particles, and peel parts of raw cassava.

Then the washed cassava was dipped in a0.4mll^{-1} aqueous billet solution. The inputs of the fungicide treatment processing step were water, Billet Carbendazim 50% w/w and washed raw cassava roots. The amounts of water and Billet Carbendazim 50% w/w were 250L and 100ml per 1000kg of raw cassava roots weight respectively. The outputs of Fungicide treatment were waste water containing Billet Carbendazim and solid waste which was the sediments of waste water. The waste amount of waste water and solid waste were 230±10L and 0.9±0.1kg per 1000kg of raw cassava roots weight respectively.

Then the treated raw cassava roots are packed in to the five ply cardboard boxes. A polyethylene layer was kept inside the cardboard box which had ventilation spaces and two layers of raw cassava roots were placed in it. Wet sterilized coco peat was laid in between and on top of the tuber layers.

Then the box is closed. The outputs of packaging were damaged raw cassava tubers while processing, damaged cardboard boxes, polyethylene parts and coco peat. According to the results of MFA it was observed that 0.7±0.1% of raw cassava roots were wasted as damaged roots and 7.1±0.5% of coco peat was wasted, due to improper housekeeping practices in the plant.

At last the cardboard boxes were sealed and there was no any waste generated while sealing.

A summary of the quantity of waste generated at the "Hotspots" of the production process is given in table 01.

4. Conclusion

The MFA revealed that the hotspots of raw cassava processing for export market were sorting, washing, fungicide treatment and packaging.

From the raw cassava roots purchased 12.2±2.1% of the total raw cassava weight was wasted and 7.1±0.5% of total coco peat purchased were wasted during the processing. The amount of waste water generation was 415±20L per 1000kg of raw cassava roots weight.

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