Material flow analysis of Cassava crocket manufacturing process from raw cassava (*Mannihotesculenta*) roots

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***Abstract*- Cassava (*Manihot esculenta*) is the third most grown plant in subtropical and tropical countries with short post-harvest life. This study was carried out to increase the Utilization of cassava as processed products and minimize the waste generated during the cassava processing. Cassava crocket is a convenient product which uses cassava root as main raw material. Main objective of this study was to carry out a material analysis of the production process of cassava crocket to characterize and quantify the inputs and outputs of the process. Primary data obtained through interviewing production staff and Secondary data was used for the analysis and the samples for analysis were collected using online multistage random sampling method over 60 working days of a cassava crocket manufacturing plant. According to results the wastes generated at peeling, grating, squeezing and storage were 21.5±1.3%, 5.0±1.0%, 20.8±1.7% and 5±1% of the raw cassava root weight respectively. The other waste generated waste water 2480L per annum. Results obtained from the proximate analysis of raw cassava tuber showed, the moisture content as 63.07±0.4%, protein content as 1.5±0.3%, fat content as 0.5±0.03%, crude fibre content as 3.7±0.4%, ash content as 1.0±0.2% and carbohydrate content as 30.23±0.2%. Proximate composition of cassava peel (cortex) had moisture content of 7.5±0.3%, protein content of 8.2±0.1%, fat content of 3.1±0.4%,crude fibre content of 12.5±0.2%,ash content of 6.5±0.2% and carbohydrate content of 71.6±0.5%.This case study reveals that there is a considerable amount of waste occurred in the production of cassava crocket from raw cassava roots and the cortex of the cassava root as a good source of nutrients.**

***Index terms*- Cassava, Cassava crocket, Cassava waste, Proximate analysis, Material analysis.**

I. INTRODUCTION

Cassava (*Manihotesculenta*) is a perennial vegetatively propagated shrub commonly cultivated within the lowland tropics [1].With rice and maize being the first and second most significant source of calories respectively, cassava is the third most grown plant in the subtropical and topical areas of Africa, Latin America and Asia around 262,585,741 tonnes of cassava was produced worldwide in 2012 where Nigeria, Thailand, Brazil and Indonesia topped the producer list [2].

According to the National Statistics in the Department of Census and Statistics, Sri Lanka, The estimated annual production of cassava in year 2013 is 292,194 Metric tons. 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 [3].

It is cultivated mainly by resource-limited small farmers for its starchy roots, which are used as human food either fresh or in many processed forms and products, mostly starch, flour, and for animal feed [4]. Developing of proper technologies is needed to increase the utilization of cassava as processed foods. That helps to increase the potential utilizations and minimize the postharvest losses of the crop. When cassava is sold at raw, the prospects for cassava as a source of income are limited. Diversification of cassava into value added products seems to be a way to increase the demand [3].

Cassava crocket also called cassava croquette is one of the convenient processed product, which uses cassava root as main raw material. It is available as deep fried, ready to serve and unpacked form. Improving the productivity and profitability of cassava crocket process will increase the potential utilization of cassava as processed food and improve the market demand.

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[4].The purpose of a material flow analysis (MFA) 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 [5]. The end product of the MFA will be a detailed input-output table for cassava crocket process showing all materials that enter and leave the production.

This study was designed to carry out a material flow analysis of a Cassava crocket processing plant to characterize and quantify the inputs and outputs of the process.

II. MATERIALS AND METHODS

The study involved the use of both primary and secondary data in obtaining 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 60 working days.

A. Process description

Undamaged fresh cassava roots were sorted and peeled and washed twice with well water. Then roots were grated manually with graters having 4mm diameter cutters. Grated cassava was squeezed to remove excess moisture. The solid residues then mixed with scraped coconut, salt and spice mixture with 3:1:0.02:0.01 ratios respectively. Then the mixture was sized in to 40g and shaped in to oval shapes. Then deep frying was done in hot coconut oil pan (170^{o}C for 10 minutes. The final product was then stored at room temperature without packaging and the shelf life of the product is only two (02) hours. The flowchart of cassava crocket manufacturing, inputs and outputs of each process step are shown in figure 1.

B. Material Analysis

This Study on Material Flow analysis (MFA) provide comprehensive description of material flows with in the manufacturing plants of cassava crocket from raw material receiving up to the dispatching of the final product. MFA is carried out according to the method described in Brunner. and Rechberger. (2004). The principle of mass conservation which the MFA is based, 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. Assumptions- The cassava crocket processing plant utilizes 1440kg of raw cassava root per annum and has the production capacity of 34320 cassava crockets per annum.

The inputs involve cassava roots, scraped coconut, salt, spice mixture, coconut oil, water and energy.

C. Analysis of Proximate composition

The proximate composition (Moisture, crude protein, crude fibre, fat content and ash content) of the main cassava waste (cortex/ muscular peel of the cassava root)and cassava flesh was analysed according to AOAC methods.

III. RESULTS AND DISCUSSION

A. Material flow analysis of cassava crocket production

At raw material receiving only sorted roots with no physical damages were bought thus had not caused any waste at the raw material receiving process. According to the results of material flow analysis the amount of wastes generated at peeling process was 21.5±1.3%. The hand peeling can constitute 20 to 35% of the total weight of tuber [9]. The further analysis of peel wastes revealed that from the peel waste 3.6±0.5% of total cassava root is the brownish peel which is the periderm and 17.7±1.0% of the total cassava root is thick peel which is the cortex.

The output of washing was the washed and peeled root which showed a significant increase in its weight, which was 2.5±0.8% from the initial weight

Table 01. Proximate composition of the raw cassava root flesh and the muscular peel

	Raw cassava root (starchy flesh) (%)	Muscular peel/ Cortex (%)
Moisture	63.07±0.4	7.5±0.3
Protein	1.5±0.3	8.2±0.1
Crude fibre	3.7±0.4	12.5±0.2
Fat	0.5±0.03	3.1±0.4
Ash	1.0±0.2	6.5±0.2

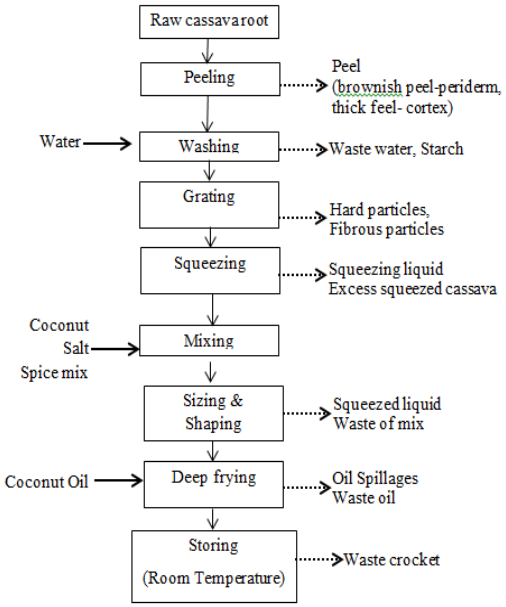

Fig. 1. Production flow of cassava crocket

of the peeled root after the washing process. The amount of waste water generated annually was 2480L which also contain starch leached out from the tubers. The results of the material flow analysis showed that 5.0±1.0% and 20.8±1.7% from the raw cassava weight was wasted as fibrous hard materials while grating and by squeezed liquid while squeezing. The inputs of mixing process are scraped coconut, spices mixture, salt and squeezed cassava and no significant waste was observed at mixing. The sizing process results the shaped cassava crocket as main output and 0.5±0.1% and 0.03±0.015% from the raw weight was wasted as the squeezed liquid and cassava crocket mixture.

The results of material flow analysis revealed that 45.1±5.0%, 10.0±2.5% ,8±3% of the total coconut oil was waste as discoloured liquid fried oil, spillages and evaporation while frying. About 35±7% of the total coconut oil was wasted while frying as absorbing to the fried cassava crocket which even cause for poor quality and reduced shelf life in the final product.

The waste occurred at the storage and dispatch was the returned poor quality cassava crockets due to moisture absorption and it accounts 5±1% from the final cassava crocket production.

The results of the material analysis revealed that 47.83% of the raw cassava root weight was wasted during the production process of cassava crocket processing.

B. Analysis the Proximate composition.

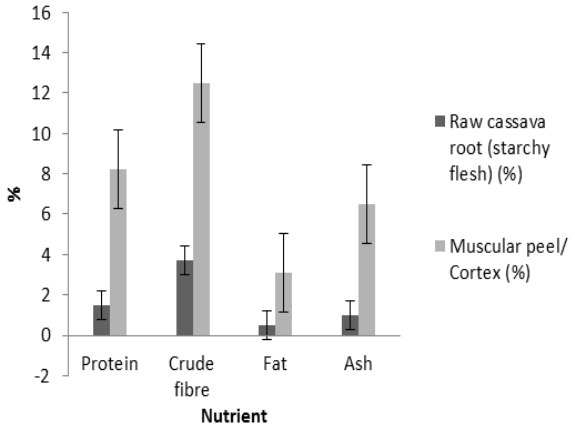

Fig. 2. Percentage of proximate composition of raw cassava root (starchy flesh) and Muscular peel.

The results of proximate composition of the raw cassava root flesh and the muscular peel is tabulated in the Table 01.

According to the results protein content of the cassava muscular peel was 8.2±0.1% where in raw cassava root it was 1.5±0.3%. And the crude fibre content was 12.5±0.2% and 3.7±0.4% in the cortex and starch flesh respectively. The figure 2 illustrates the comparison of nutrients of raw cassava root and the muscular peel.

The Results revealed that the cassava muscular peel as a good source of nutrients compared to the starch flesh.

IV. CONCLUSION

This case study reveals that there is a considerable amount of waste occurred in the production of cassava crocket from raw cassava roots and the cortex of the cassava root is a good source of nutrients.

REFERENCES

[1] S.O. Jekayinfa, J.O. Olajide,Analysis of energy usage in the production of three selectedcassava-based foods in Nigeria,Journal of Food Engineering 82 (2007) 217–226.

[2] W.A.J.P. Wijesinghe and K.H. Sarananda, "Utilization of Cassava Through Freezing", Journal of Food and Agriculture,pp. 17-29, January 2008.

[3] L.R. Castilho, C.M.S. Polato, E.A. Baruque, G.L. Sant'AnnaJr.,D.M.G. Freire, Economic analysis of lipase production by *Penicilliumrestrictum*in solid-state and submerged fermentations, Biochemical Engineering Journal 4 (2000),pp. 239–247.

[4]U.Ihemere, D. A.Garzon,S.Lawrence,R. Sayre,ation
Genetic modification of cassava for enhanced starchproduction,*Plant Biotechnology Journal*(2006)4, pp. 453–465.

[5]J. Barrett, H.Vallack,A. Jones and Gary Haq, A Material Flow Analysis and EcologicalFootprint of York, JANUARY 2002, Stockholm Environment Institute, pp 28.

[6]MabroukA.El-Sharkawy, Cassava Biology and physiology, Plant Molecular Biology 56; 481-501,2004.

[7] B. Nunes and D. Bennett,Green operations initiatives in the automotive industry: An environmentalreports analysis and benchmarking study, Benchmarking: An International Journal, Vol. 17 No. 3, 2010, pp. 396-420.

[8]Practical Handbook of Material Flow Analysis, Brunner.P.H and Rechberger.H, CRC Press, Oct 16, 2003,pp. 1-44.

[9]Ubalua. A.O, "Cassava wastes: treatment options and value addition alternatives", African Journal of Biotechnology Vol. 6 (18), pp. 2065-2073, 19 September 2007.