Pertanika J. Trop. Agric. Sci. **29 (1 & 2)**: 67-72 (2006)

ISSN: 1511-3701

### SHORT COMMUNICATION

# A Survey of Water Consumption and Product Output from Ten Sago Factories in India

[1*]A. MANICKAVASAGAN & [2]K. THANGAVEL
[1]*Department of Biosystems Engineering, E2-376 EITC, University of Manitoba,*
*Winnipeg, MB, Canada R3T 5V6.*
*E-mail: umannama@cc.umanitoba.ca*
[2]*Department of Agricultural Processing, College of Agricultural Engineering,*
*Tamil Nadu Agricultural University, Coimbatore, India*

**Keywords: Tapioca effluent, water requirement, product yield**

## ABSTRAK

*Kebanyakan unit pemprosesan ubi kayu India mengasingkan kanji dan sluri dengan menggunakan kaedah enapan graviti. Pengenapan yang berlaku dalam tangki enap membolehkan kontak antara kanji dan air. Proses ini menyebabkan penapaian berlaku dengan alkohol dan asid organik menjadikan persekitaran tercemar. Sisa air dari kilang pemprosesan ubi kayu mengandungi keperluan oksigen kimia yang tinggi (11,077-19,083 mgl*$^{1}$*), pH yang rendah (4.33-5.60) dan menyebabkan pencemaran. Efluen daripada industri ubi kayu adalah berasid dan berorganik secara semula jadi, membawa kepada keperluan oksigen biologi pada kadar 1500 hingga 2000gm*$^{-1}$*). Juzuk-juzuk tak organik seperti fosfat, sulfat, klorida, dan beberapa jenis logam terdapat dalam kuantiti surih. Kajian ini menerangkan penggunaan air, output produk, dan penjanaan efluen dalam industri pemprosesan ubi kayu. Kadar yang perlu untuk air adalah 4.512 m*$^{3}$ *untuk memproses 1000 kg ubi. Apabilá ubi-ubi tersebut digunakan untuk pengilangan kanji, 16.7% daripada hasil produk adalah kanji, 1.6% kanji kotor dan 7.0% 'thippi' terhasil dan 18.6% sagu, 1.8% kanji kotor, 19.1% kupasan dan 3.9% 'thippi' terhasil apabila ubi digunakan untuk pengilangan sagu. Sebanyak 95% air yang digunakan terhasil sebagai efluen.*

## ABSTRACT

*Most of the tapioca processing units in India separate starch from slurry by employing the gravity settling method. Sedimentation in settling tanks allows the contact of starch with water. This process leads to fermentation in which alcohols and organic acids are formed and polluting the environment. Wastewater from tapioca processing factories contain high chemical oxygen demand (11,077-19,083 mg l*$^{1}$*), low pH (4.33-5.60) and causes pollution. The effluent from tapioca industries is acidic and organic in nature, contributing biological oxygen demand in the range of 1500 to 2000 g m*$^{3}$*. Inorganic constituents like phosphate, sulphate, chloride, and several metals are also found in trace quantities. This paper explains the water consumption, product output and effluent generation in tapioca processing industries. The average water requirement was 4.512 m*$^{3}$ *to process 1000 kg of cassava tubers. When the tubers are used for starch manufacture, a product yield of 16.7% starch, 1.6% dirty starch and 7.0% thippi were obtained, and 18.6% sago, 1.8% dirty starch, 19.1% peel and 3.9% thippi were obtained when the tubers are used for sago manufacture. About 95% of the consumed water is leaving the factory as effluent.*

## INTRODUCTION

Tapioca is a productive crop in poor soils and requires the least labour in cultivation, and can tolerate drought, but the labour requirement in processing after harvest is high (Radhakrishnan, 1996). Dry tapioca root consists of 80 to 90% carbohydrate out of

---

* Correspondence author

which the most important is starch. Starch content in tapioca ranges from 78.1 to 90.1% on dry basis. Tapioca industry is an agro based seasonal industry with huge employment potential in India. Tapioca is mainly processed into starch and sago. There are more than 1000 tapioca processing units in India producing starch and sago in cottage and small scale sectors. The major unit operations involved in sago production are Peeling and washing, Rasping and pulping, Screening, Settling and purification of starch, Pulverization, Globulation, Sizing, Roasting, Sun drying, Polishing and Packing. The starch and sago factories in India use age-old technology, involving longer duration of extraction and unhygienic handling of the material leading to poor quality end products (Rangaswami, 1993). Padmaja *et al.* (1990) reported that the starch or sago factories were becoming obsolete and use of labour intensive indigenous technologies, which often imparted off colours, off odour and microbial contamination to starch. Since the enzymatic process are likely to develop as soon as the roots were dug up and during manufacture, which ultimately reduces the quality of the end product, it is necessary to process the roots immediately after harvesting (Grace, 1977). Almost all tapioca processing industries in India have two major problems. The first problem is the huge requirement of water for better extraction of starch from tubers. Second is the generation of large volumes of effluent. Many factories are being closed due to the unavailability of water. Hence there is a need for suitable methods or equipment and technology to reduce the water consumption in tapioca starch production without sacrificing the starch extraction efficiency. It is necessary to have a thorough knowledge on the different unit operations involved in the starch production, water requirement, product output and effluent generation to develop technology to solve the water problem. The objective of this paper is to quantify the water requirement, product output and effluent production in the tapioca starch processing industries.

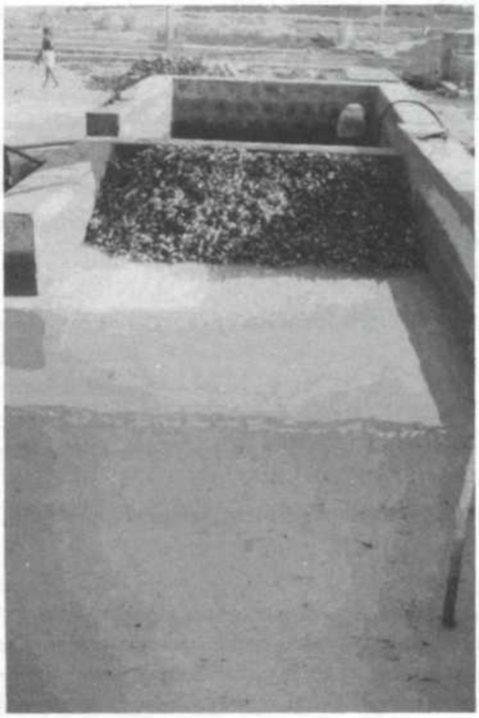

*Fig. 1: Addition of water for washing the tapioca roots*

*Conventional Method of Starch Production*

(i) Washing and Peeling

Root tubers are washed manually to remove adhering dirt. The tubers are then cut longitudinally and transversely to a depth corresponding to the thickness of the peel, which can be easily removed. Any dirt remaining on the smooth surface of the core of the tuber is then washed off and the peeled tubers are put in a concrete tank, where they remain immersed in water until taken out for rasping. The conventional method of washing is shown in *Fig. 1*.

(ii) Rasping

The peeled roots are subjected to high-pressure water jets during conveying for rasping. It is necessary to rupture cell walls in order to release the starch granules. Rasping

*Fig. 2: Addition of water while rasping the roots*

facilitates rupture of cell walls and release of starch granules (Ahmed, 1978). This is carried out by pressing the roots against a swiftly moving surface provided with sharp protrusions. A large quantity of water is added to the roots (*Fig. 2*) during this process. The cell walls get ruptured during rasping and the whole root is turned into a mass in which substantial portions of the starch granules are released. It is difficult to remove all the starch in a single operation even with efficient rasping devices. Therefore, the pulp is subjected to a second rasping process after straining. Rasping is usually done in machines using a wooden roller over which the sheet metal rasping surfaces are nailed with the burrs facing outward.

(iii) Straining

After rasping, the pulp is screened in the shaking screens (*Fig. 3*). In separating the pulp from the free starch, a liberal amount of water is added to the pulp as it is delivered by the rasper and the resulting dispersion is stirred vigorously before screening. The fresh pulp after mixing with water in distribution tanks is transferred by pipes to the higher end of the screen. During screening, the dispersion passes through a set of screens with increasing fineness, the first one retains the coarse pulp, the others the fine particles. The 'overs' from the first screen are returned to the fine rasp and then returned for re-screening.

*Fig. 3: Addition of water when straining the tapioca pulp*

(iv) Settling and Purification of Starch After the separation of starch by screening, the starch milk is subjected to a settling process. The starch milk is pumped to a tank fitted with effluent outlets at varying heights. Settling takes about 6 to 20 hours depending on the quantity as well as the size of the settling tank (Radhakrishnan, 1996). Settling is an important unit operation in cassava processing where the extracted starch is separated from its aqueous dispersion under gravity (Sajeev *et al.*, 2002). The upper layer of sediment flour, which has a yellowish green tint, contains many impurities and is generally scraped off and discarded. The remaining moist flour is then stirred up with water and transferred to another tank where starch is settled. The final settled moist floor is removed by using a crowbar. Sreenarayana *et al.* (1990) reported that a rapid separation of starch from the milk and the removal of impurities from the colloidal material could be achieved by centrifugation. Hydraulic jack may be used as dewatering technique by putting cassava starch pulp in a bag of woven cloth and subjected to high compressive pressure (Igbeka *et al.*, 1992).

(iv) Drying

Drying of starch is generally done by sun drying in the drying yards and then sent for further processing for the production of sago.

(v) Hydrogen Cyanide (HCN) in Tapioca

According to Mkpong *et al.* (1990) cited by Zoe *et al.* (1998), cyanagenic glucosides are synthesized in the cassava leaves and stored in the roots. The problems of inherent nutritional hazard (fresh roots contain 50 to 400 mg cyanide $kg^{-1}$ root) and high perishability of the roots call for elaborative processing prior to consumption (Chinyere *et al.*, 1997). The major factor which limits or affects the utilization of cassava as a food for man is its content of the toxic hydrogen cyanide in both free and bound forms (Edijala *et al.*, 1999). Effective processing can reduce all cyanogens in cassava products to below the safe level of 10 mg HCN equivalent per kg dry weight set by FAO in 1988 (Mlingi *et al.*, 1995).

(vi) Effluent from Cassava Industries

Because of the rapid chemical changes occurring in the solution of starch dispersion, fermentation takes place resulting in the production of alcohol and organic acids especially butyric acid. Hence the process of separation of pure starch from starch milk should be done without time delay. Wastewater from tapioca processing factories containing high chemical oxygen demand (COD) (11,077-19,083 mg $l^{-1}$), and low pH (4.33-5.60) causes water pollution (Hien *et al.*, 1999). Belliappa (1990) found that the effluent from tapioca industries was acidic and organic in nature, contributing biological oxygen demand (BOD) in the range of 1500 to 2000 g $m^{-3}$. He also stated that inorganic constituents like phosphate, sulphate, chloride, and several metals were also found in trace quantities. Most factories dispose of the effluent into the nearby rivers, streams or lakes. It releases undesirable odour, pollutes the environment and surface ground water. The volatile solid content estimated for this industry effluent was 1.2 (Periasamy, 1996).

## MATERIALS AND METHODS

The study was conducted in the tapioca processing units at Namakkal taluk of Rajaji district, Tamilnadu, India, where most of the tapioca processing industries in India are present. Ten factories of different production capacities (15 to 45 ton of root per day) were selected. The water requirement, product output and effluent production were measured in each factory for three days continuously and the average value recorded for analysis. For ease and clarity, all values were expressed per ton of cassava root.

## RESULTS AND DISCUSSION

The process of extraction of starch from cassava tubers requires a huge volume of water. The wastewater arising out of washing of the roots and the supernatant from the starch settling tanks constitute the effluent. The average water requirement was 4.512 $m^3$ to process one ton of cassava root. Out of this, 4.31 $m^3$ and 4.27 $m^3$ of water was released as effluent, when the tubers were used for starch production and sago manufacture respectively. The product output during manufacture of starch and sago are shown in the Table 1. When the tubers were used for starch manufacture, a product yield of 16.7% starch, 1.6% dirty starch and 7.0% *thippi* were obtained and 18.6% sago, 1.8% dirty starch, 19.1% peel and 3.9% *thippi* were obtained when the tubers were used for sago manufacture. In both processes, about 95% of

TABLE 1
Water consumption and product output in sago factory (mean of 10 factories)

| Raw Material | | |
|---|---|---|
| Product | Quantity | CV |
| Cassava root | 1 ton | |
| Water | 4.512 m$^3$ | 7.3 |
| **Output – During Manufacture of Starch** | | |
| Product | Quantity | CV |
| Starch | 167.40 kg | 9.7 |
| Dirty starch | 16.32 kg | 9.9 |
| Thippi (Dried) | 69.65 kg | 13.7 |
| Effluent | 4.310 m$^3$ | 6.9 |
| **Output – During Manufacture of Sago** | | |
| Product | Quantity | CV |
| Sago | 186.14 kg | 13.6 |
| Dirty starch | 18.32 kg | 13.2 |
| Peel | 190.53 kg | 8.5 |
| Thippi (Dried) | 38.60 kg | 8.5 |
| Effluent | 4.272 m$^3$ | 8.3 |

the consumed water is coming out as effluent. Since each factory is using different types of machinery, there was a variation in product output between the factories. The coefficient of variation (CV) in the product output ranged between 6.9 and 13.7 in starch the manufacturing process and between 8.3 and 13.6 in the sago manufacturing process. In both cases, the CV was less for effluent generation. The pattern of effluent production was almost similar in all factories when compared to other products. Since the quality of waste water released from the starch settling tank is not suitable for reuse in the production process, almost all factories are facing severe problems in treating the huge volume of effluent. Quick separation of water from starch milk in the settling tank will retard the deterioration in water and hence the released water may be reused in the production process. The dual problems (high water requirement and effluent production) in the starch factories may be solved by the quick separation of water from the starch milk with the help of equipment and reusing the water in the production. A solid-liquid separation equipment such as, hydrocyclone may be used for the quick separation in order to replace the conventional gravity settling method.

## REFERENCES

AHMED, S.A. (1978). Starch. In *Food industries* (p. 1-25). New Delhi, India: Indian Council of Agricultural Research Publications.

BELLIAPPA, P.M. (1990). Pollution from sago industries and the treatment process. *Green Book on Tapioca* (p. 60-65). Salem, India: Sagoserve.

CHINYERE, I. I., BANIGO, E.O.I. and OKWELUM, F.C. (1997). Cyanide content and sensory quality of cassava root tuber flour as affected by processing. *Food Chemistry, 58,* 285-288.

EDIJALA, J.K., OKOH, P.N. and ANIGORO, R. (1999). Chemical assay of cyanide levels of short-time – fermentated cassava products in the abraka area of delta state, Nigeria. *Food Chemistry, 64,* 107-110.

GRACE, M.R. (1977). Cassava flour and starch. In *Plant production and protection series* (No. 3). Rome: FAO.

HIEN, P.G., OANH, L. T. K., VIET, N.T. and LETTINGA, G. (1999). Closed wastewater system in the tapioca industry in Vietnam. *Water Science and Technology, 39,* 89-96.

IGBEKA, J.C., JORY, M. and GRIFFON, D. (1992). Selective mechanization for cassava processing. *Agricultural Mechanization in Asia, Africa and Latin America, 23,* 45-50.

MKPONG, O.E., YAN, H., CHISM, G. and SAYRE, R.T. (1990). Purification, characterization and localization of linamarase in cassava. *Plant Phys. 93,* 176-181.

MLINGI, N.L.V., BAINBRIDGE, Z.A., POULTER, N.H. and ROSLING, H. (1995). Critical stages in cyanogens removal during cassava processing in southern Tanzania. *Food Chemistry, 53,* 29-33.

PADMAJA, G., BALAGOPALAN, C., KURUP, G.T., MOORTHY, S.N. and NANDA, S.K. (1990). Cassava processing, marketing, and utilization in India. *Cassava Breeding, Agronomy and Utilization Research in Asia, 24,* 327-338.

PERIASAMY, M. (1996). Study on aerobic digestion of cassava wastes. (Unpublished M.E. Thesis, Department of Bio Energy, Tamil Nadu Agricultural University, India, 1996).

RADHAKRISHNAN. (1996). Mechanical stirrer for tapioca starch settling tanks. (Unpublished M.E. Thesis, Department of Agricultural Processing, Tamil Nadu Agricultural University, India, 1996).

RANGASWAMI, G. (1993). Tapioca based industrial complex. *Prosperity - 2000* (p. 123 - 137). Salem, India: Sagoserve.

SAJEEV, M.S., KAILAPPAN, R., SREENARAYANAN, V.V. and THANGAVEL, K. (2002). Kinetics of gravity settling of cassava starch in its aqueous suspension. *Biosystems Engineering, 83,* 327-337.

SREENARAYANAN, V.V., SWAMINATHAN, K.R. and VARADARAJU, N. (1990). Tapioca processing - Problems and prospects. *Green Book on Tapioca* (p. 24-27). Salem, India: Sagoserve.

ZOE B, HARDING, S., FRENCH, L., KAINGA, R. and WESTBY, A. (1998). A study of the role of tissue disruption in the removal of cyanogens during cassava root processing. *Food Chemistry , 6,* 291-297.