Reference No. R6316 Part B D/U

Wet cassava storage and preservation

Author A Graffham (FTR) / A Westby (PCSS)
Reviewer E. Cromwell

Purpose/s To evaluate improved starch storage technologies in starch/sago factories, to undertake pilot-scale testing and disseminate results.

Results/Outputs/Conclusions

1) Losses in storage (20%) caused by amylolytic acid bacteria
2) Lab and field tests show that 2% acetic acid controls bacteria effectively
3) Acetic acid also reduces weight loss during storage and reduces starch losses during processing from 10% to 3.75%
4) Quality of starch preserved as above easily meets Indian standards for textile starch. Unpreserved starch does not.
5) Technique successful under commercial conditions.

Dissemination to date

I Journal article
3 Journal articles to be submitted
1 Conference paper
2 Internal reports

Dissemination planned/suggested

AG	1 Demonstration workshop (Oct 96) - jointly with Part A
LTB	Video and leaflet demonstrating the technique and its benefits in local languages
LTB	NRI handbook describing technique
LTB	Article for 'New Scientist'

Follow-up planned/suggested

AG	Further technical co-operation with Tamil Nadu
LTB	Economic/financial analysis of technique
LTB	Adaption of technique to other cassava starch processing regions of the world
LTB	Adaption of technique to other starch extraction processes

Comments

EC	Report needs to be reviewed by cassava specialist/scientist
LTB	What is availability of acetic acid in rural areas?
LTB	Sponsorship of dissemination by local manufacturers of acetic acid?

Reference No. R6316 - Part A U

Hydrocyclone technology in cassava starch extraction

Author R Marder (FTR) / A Westby (PCSS)

Reviewer E Cromwell

Purpose/s To investigate the potential use of hydrocyclones in the extraction of starch from cassava, to make economic and environmental evaluations of the technology and, if appropriate, disseminate recommendations.

Results/Outputs/Conclusions

1) Field trials confirmed laboratory findings that total water consumption could be reduced by over 50%

2) These water consumption savings could be achieved under commercial operating conditions

3) As water is free the financial savings to the factory were minimal

4) The quality of starch produced was improved visibly though not reflected in selling price.

5) Widescale adoption of the technology would significantly decrease the negative environmental impact of cassava starch extraction.

6) Widescale adoption of the technology would release water for other uses in areas of water shortage.

Dissemination to date

- 2 Journal articles
- 1 Journal article to be submitted
- 1 Conference paper
- 3 Internal reports
- 1 Leaflet
- 1 Demonstration workshop

Dissemination planned/suggested

RM Demonstration Workshop (Oct 96) Jointly with Part B

LTB As there are no direct financial benefits for the processors then the environmental benefits will only occur once legislation forces them to install hydrocyclones. As such the dissemination must be targeted towards politicians. This would need sophisticated lobbying techniques with supporting videos, glossy brochures, demonstration models etc.

Follow-up planned/suggested

RM Further technical co-operation to encourage uptake.

Comments

EC Report needs to be reviewed by cassava starch specialist

EC Need for more local language publications

EC Outputs useful but hydrocyclone technology will not be taken up until legislation makes this necessary

LTB In order to assure processors, could a demonstration plant be established to run on commercial lines.

LTB Subsidised loans to processors to purchase hydrocyclones

LTB Sponsorship from UK Hydrocyclone manufacturers?

A0424

CONCEPT NOTE for a project extension - Purpose 4 Project 1
Component 1

COMPONENT TITLE:	Small-scale cassava starch extraction and storage to improve process efficiency
RNRRS PROGRAMME:	Crop Post-Harvest
RNRRS PROGRAMME PURPOSE:	Storage and processing losses reduced
PRINCIPAL INVESTIGATOR:	Food Security Group
ADDRESS:	Natural Resources Institute
COLLABORATOR(S):	SAGOSERVE, Salem, India Tamil Nadu Pollution Control Board
TOTAL COST OF PROJECT:	£84,900
DURATION OF PROJECT:	1 April 1995 to 31 March 1996
DATE OF SUBMISSION:	1 April 1995
LOCATION OF PROJECT:	India

BACKGROUND:

Earlier activities in this subject had focused on the starch industries of India and South America. In Tamil Nadu State, India cassava is mainly used by the starch and sago industries. The project commenced with process audits of the starch and sago industries. These identified two potential areas of research that would benefit the industry:

- development of technologies to reduce the volume of water used by the industry and hence the volume of effluent produced;
- development of technologies for overcoming the reduction in quality problems (and hence value) associated with the storage of wet starch. Starch is stored wet because the capacity to produce the main product sago is less in many factories than the capacity to extract starch. Cassava production is seasonal and storage of starch allows the processing season to be extended.

Previous research activities have addressed these identified constraints in the last two starch processing seasons. Hydrocylones (a physical method of concentrating starch when extracted from cassava and recycling a proportion of the water used) have been tested in the laboratory and in starch factories in India as part of an integrated approach to pollution control. The technology can reduce water consumption by up to 60% and thereby reduce the volume of effluent produced. An additional advantage of the technology is that there appears to be an improvement in starch quality which may have economic consequences.

Physico-chemical, functional and microbiological changes occurring during the storage of wet starch were determined in a typical sago factory in Salem during the 1993/94 season. The causes of the reduction of quality during storage were determined. Laboratory experiments determined possible approaches for reducing these changes. These have been tested on a small scale in one of the factories.

PROJECT PURPOSE:

To validate the economic and technical effectiveness of improved process and storage technology with the association of private sector starch processors in India and disseminate the findings to small-scale starch and sago factories.

RESEARCH ACTIVITIES:

Activities are divided into two areas:

1. Hydrocyclone technology

Activity 1 To complete an on-going economic evaluation of the technology.

Activity 2 Confirmation of the improvement of the quality of starch by determining price/quality relationships.

Activity 3 To determine the effectiveness of the hydrocyclone technology when stored starch is put through the processing method. A large proportion of the starch extracted is stored under water for processing into sago at the end of the season. This starch is washed and re-sedimented. The hydrocyclone technology could contribute to reducing the level of water usage and hence effluent produced. The effect of the technology on the quality of the starch needs to be determined.

Activity 4 Confirmation of outstanding aspects of the research work at the start of the next processing season and development of sectorial strategy to promote findings of research work.

Activity 5 Dissemination of research through preparation of appropriate technical specifications and publication in the scientific literature.

2. Starch storage

Activity 6 To complete evaluation of improved starch storage technologies in starch/sago factories.

Activity 7 To disseminate results of research to date.

Activity 8 To initiate pilot scale testing of new technology and monitor (mainly carried out by factory owners with some technical support).

OUTPUTS:

The outputs of the project will be technically and economically validated technologies for improved starch extraction and storage. These will have been identified as central issues to the viability of small-scale starch factories and will have been developed and tested in a range of factories through the coordinating association for these small businesses. Demonstration sites will have been established together with promotional literature to facilitate the wider dissemination of technologies. Publications in national and international journals will be prepared

CONTRIBUTION OF OUTPUTS:

Inefficiencies in starch extraction and high usage of water are known to all processors as being key constraints to the efficiency of their operations. The identification of demand in this area together with the adaptive transfer and development of technology used in other industrial applications has led to significant technical resolution of these constraints.

BENEFICIARIES:

Benefits of the research would accrue to the starch industries and indirectly back to producers of cassava through the provision and expansion of a market for the commodity. There are many hundreds of small-scale starch processing factories in Tamil Nadu and the project would lead to improved profitability of these industries, reduced water usage and reduced problems with disposal of effluent and associated environmental and ground water degradation.

RISKS AND ASSUMPTIONS:

Continued pressures upon the starch industry to prevent environmental damage through the excessive use of water and discharge of highly contaminating effluents. The continuing support of the major association in the State responsible for provision of support to the small-scale producers of starch and starch products.

FINANCIAL SUMMARY:

Staff inputs	(4 months LTTC Band 3)	£16,000
	(5.5 months Band 4)	£34,000
	(1 month Band 3)	£ 7,400
	(1 month Band 2)	£ 8,700
	(0.5 month SRO Band 3)	£ 3,800
Travel and subsistence		£10,000
Consumables/items required		£ 5,000
TOTAL		**£84,900**

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WATER CONSERVATION AND EFFLUENT REDUCTION IN THE CASSAVA STARCH EXTRACTION INDUSTRIES USING HYDROCYCLONE TECHNOLOGY

Richard Marder, David Trim

Development through science

WHAT IS A HYDROCYCLONE?

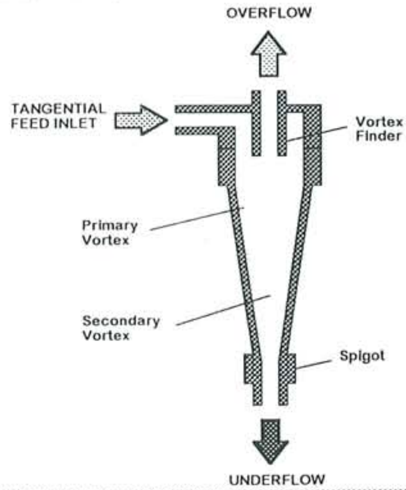
A hydrocyclone divides a solid/liquid suspension into two output streams:

- **underflow** - containing the majority of the solid particles
- **overflow** - of comparatively low solids concentration

Development through science

OPERATING PRINCIPALS

Solid/liquid suspension is fed tangentially around a central opening called the ***vortex finder***. High centrifugal forces create a ***primary vortex*** into which solid particles migrate. Solids are forced downwards and discharge with water via a ***spigot***. An upward ***secondary vortex*** is developed in which fine particles are discharged with water.



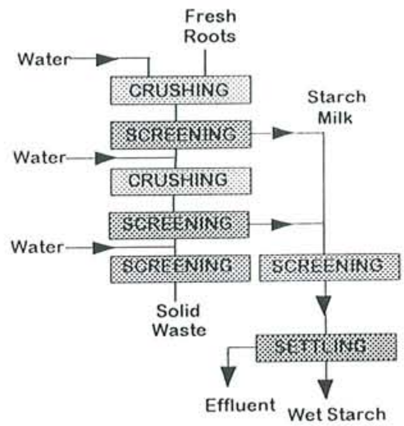
Development through science

As shown above a hydrocyclone consists of a cone shaped body and upper cylindrical section, usually made of polyurethane. The feed slurry or suspension is fed tangentially to the top of the cylindrical section under pressure around a central opening called the vortex finder. The motion of the liquid fed into the cyclone develops high centrifugal forces creating a primary vortex adjacent to the cone wall into which the suspended particles migrate and are forced downwards to the discharge point via a spigot. A secondary upward moving vortex is developed along the central axis of the hydrocyclone in which fine material discharges with the majority of water via the vortex finder. The diameter of the cylindrical section, the internal diameters of the spigot and vortex finder, and the pressure at which the suspension is introduced into the hydrocyclone are the key parameters controlling the performance of the hydrocyclone. Essentially they act as a static centrifuge in which the liquid suspension is concentrated into the underflow, with low solids in the overflow stream.

CASSAVA STARCH EXTRACTION

Starch extracted by process of crushing, screening and settling

- **uses large volumes of water**
  - 30 - 35 m^3 /t of starch
- **generates large volumes of effluent**
  - BOD_5 4,500 - 5,700 mg/l



Development through science

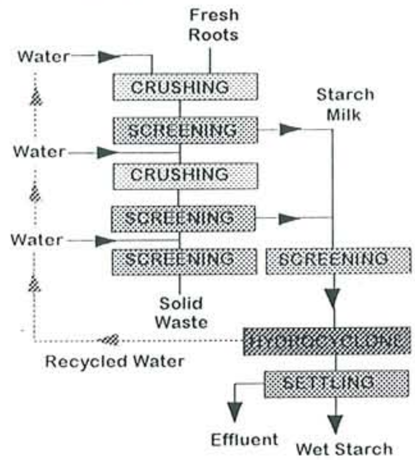
Fresh roots are washed in large open tanks, mechanical crushed in a rotating drum fed continuously with water, and the resultant slurry sieved over a series of reciprocating screens to separate the starch 'milk' from the fibrous pulp. The milk then flows into granite lined settling tanks or tables. After a period of settling and compaction, assisted by labourers walking on the settled starch, the waste water is drained away to secondary settling tanks. The settled starch 'cake' is dried on large concrete sun drying yards, before finishing and bagging. The fibrous residue from the screening process and starch from secondary settling is dried and sold for animal feed.

The starch extraction process requires extremely large volumes of fresh water. With many factories the availability of fresh water of the necessary quality is an increasing problem due to expanding domestic, agricultural and industrial demand for water. Furthermore all the water consumed in starch production in many factories is discharged as highly polluting effluent, often with minimal treatment to adjacent water courses. Water authorities, in most locations, are extremely concerned about the situation, but the lack of effective and affordable treatment technology and the socio-economic implications of enforced factory closures mitigate against remedial action. The introduction of technology to reduce water consumption in starch production would have two advantages; firstly, an alleviation of the restriction on processing capacity imposed by shortage of fresh water and, secondly, a reduction in the volume of waste waters produced.

USE OF HYDROCYCLONES IN STARCH EXTRACTION

Water use, and effluent produced, can be reduced if the starch milk is passed through a hydrocyclone prior to settling.

- **underflow,** containing the majority of the starch can be ducted to the settling tanks.
- **overflow**, containing fine starch and dirt, re-cycled for crushing fresh roots.



Development through science

Hydrocyclones have been used for many years in large-scale starch manufacture from maize, potato and cassava to separate the extracted starch from fibre and other impurities (Van Esch, 1991). Starch purification rather than water conservation is the prime objective (Verberne, 1977; Caransa, 1980) and in many factories banks of hydrocyclones are used in parallel in order to achieve the large throughputs and high separation efficiencies necessary. Van Esch (1991) evaluated the performance of hydrocyclones with certain starches and concluded that they are effective in washing potato and maize starches but not suitable for use with rice and wheat starches. This research did not consider cassava starch, however, previous research (Johnson and Lescano, 1970) has studied the design of a hydrocyclone for use in the cassava starch industry. This suggesting that the volume of water required for crushing and sieving could be considerably reduced if the starch milk flowing from the sieving system were passed through a hydrocyclone. The underflow containing the bulk of the starch particles would be ducted to the settling tanks and the overflow of relatively low starch concentration re-cycled to the crushing and sieving plant.

The cost and operation of hydrocyclones are considered potentially feasible for medium-scale starch factories. Compared with, for example, centrifuges hydrocyclones are inexpensive, and with the exception of a pump there are no moving parts. Cleaning and maintenance are extremely simple and hydrocyclones can be constructed of plastic with little risk of corrosion or discolouration of the starch.

FIELD TRIALS OF THE HYDROCYCLONE

★ **Water consumption can be reduced by 60%**
- 85-90% of starch concentrated into 36-38% of original volume

★ **Effluent generated can be reduced by 50%**
- BOD_5 4,300 - 5,900 mg/l, overall pollution load is reduced

★ **No loss in the overall recovery of starch**
- quicker settling, less starch lost in runoff from settling tables

★ **Starch is brighter with visibly less impurities**

Development through science

Two full scale pilot hydrocyclone units, consisting of a pre-assembled cluster of twelve and eight hydrocyclones respectively, were installed and evaluated at starch and sago factories in Salem, India. These were matched to the full capacity of the factories normal output.

Performance was such that 85-87% of the starch present in the feed milk into 36-38% of the original volume in the underflow. The was recycled to the crushing section which amounted to a water saving within the process and an effluent reduction of 49-53%.

Analysis of the waste waters showed little difference in the characteristics of measured in terms of the BOD and other parameters. This was unexpected as it was considered that the use would have little effect on the total pollution load (kg of BOD) thus it was anticipated that the concentration of pollutants in the reduced volume of waste waters should have been considerably higher than those in the waste waters produced under normal operation.

Settling of the starch from the concentrated milk was reported to be much quicker. Typically this would take between 8-10 hours but was completed in half the time. Quicker settling also led to less starch being lost in the runoff from settling tables. This amounted to a overall increase in recovery of the primary product of up to 1.5-1.8% by weight.

It was visibly noticeable that there much less discoloured fine starch and impurities collected on top of the settled starch when using the hydrocyclone. These were separated in the overflow stream from the hydrocyclone and separated with the waste pulp. There appeared to be no detrimental effect on the quality of the starch (colour; purity; viscosity) produced when using the hydrocyclone.

FINANCIAL APPRAISAL OF HYDROCYCLONE IN INDIA

		Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 10
COSTS		(All costs and benefits in Indian Rupees)						
Hydrocyclone	cost	70,000	3,500	3,500	3,500	3,500	3,500	- 35,000
	operation	-	13,790	13,790	13,790	13,790	13,790	13,790
Total Cost		70,000	17,290	17,290	17,290	17,290	17,290	- 21,210
BENEFITS								
Water	Usage (cost saving)		750	750	750	750	750	750
	Extraction costs saved		17,483	17,483	17,483	17,483	17,483	17,483
Total Benefits		-	18,233	18,233	18,233	18,233	18,233	18,233
Net Cost/Benefit		- 70,000	943	943	943	943	943	39,443
IRR		-4%						

(All costs and benefits in Indian Rupees)

Development through science

A financial appraisal was carried out for a model factory based on information gathered from the starch and sago factories where the implications of the use of hydrocyclone technology were monitored. These were middle range factories producing around 7,000 bags of starch/sago per annum (630 tonnes). Both factories use ground water extracted from open wells and are powered by electricity from the State grid system.

The appraisal assumes a cost of 70,000 rupees for the purchase of the hydrocyclone, pump and pipework, based upon estimates for a locally manufactured unit. A further cost of 5% p.a. of the purchase price will need to be spent on maintenance and it is assumed the hydrocyclone is worth 35,000 rupees after 10 years.

Operational costs are estimated to be Rs 13,790 based a unit price of electricity of Rs 2.5 and based upon the use of a 7.5 hp pump used on average of up to 5 hours per day over a 200 day season.

Processing requires 50% less water compared to the original process and so there will be an associated financial saving in extraction of less water. The estimated cost of extraction would be Rs. 34,965 based on utilisation of 30 m3/tonne of starch/sago produced. Thus with a hydrocyclone the saving in extraction would amount to Rs 17,483.

The financial analysis shows that the savings made from the reduced extraction of water which can offset to some extent the cost of installation and operation. However the introduction of hydrocyclone technology is associated with an internal rate of return of around -4%. It is therefore concluded, that there is no financial benefit to be obtained from operating the hydrocyclone.

SUMMARY

Hydrocyclones can be effectively utilised as part of an **integrated pollution control strategy** in the cassava starch industries by:

- ★ **conserving water through re-cycling**
- ★ **reducing the volume of effluent generated**

whilst maintaining production and quality levels.

Development through science

The use of the hydrocyclone has demonstrated positive benefits not only in terms of reduced water consumption (which proved invaluable to one factory who experienced severe water shortages during the period of study), but also in terms of product recovery and perceived quality. Practical observations have shown that:

there is no loss in product through recycling a small amount of starch.

the concentrated starch milk from the hydrocyclone gives rise to quicker

the colour of the settled starch, and subsequent dried starch, is visibly improved and there is a reduction in the fine starch and impurities collected in settling tanks n over tables, these impurities are recycled and eventually lost with the solid waste fibre stream; and,

The implication of these results is that not only does the use of a hydrocyclone reduce the quantity of water required for crushing and sieving, and therefore the volume of waste waters produced, but there is also a considerable reduction in the overall pollution load.

With over 1,000 cassava starch processing units within south India the widescale adoption of the technology would considerably reduce the environmental impacts and benefit producers in areas of water scarcity.

Also, this would have a major effect on the capacity and cost of effluent treatment plants now being considered for implementation by factories and local authorities.