RECENT DEVELOPMENTS IN THE MANUFACTURE OF STARCH FROM CASSAVA ROOTS IN UGANDA

— *by* —

B. N. Ghosh

Makerere University College, Kampala.

The cassava is an important root crop throughout the tropics, and it is cultivated extensively by the peasant farmers as a source of starchy food and as a famine relief crop. Both the "bitter" and "sweet" varieties of cassava are grown in East Africa under varying soil and climatic conditions. Due to its high starch content it is considered suitable as a raw material for the manufacture of industrial starch, and in the present paper the broad details of a starch-extraction plant being set up in Uganda to supply the local market is described.

The results of a market survey indicate that the pre ent annual East African consumption of starch and glucose is of the order of 1500 and 1200 tons respectively. These figures, however, are likely to increase to 2400 and 1600 tons respectively by 1970. The bulk of the present demand is met by imports, notably from Europe and Far East and by a small plant in Kenya producing manioc starch. The Uganda plant would, in the first instance, manufacture only starch from cassava, although the possibility of starting glucose production at a later date is under investigation.

In considering the extraction of starch from cassava, the effects of maturity on the yields of cassava tuber and starch, the presence of poisonous prussic acid, enzyme action and the relative advantages of procuring raw cassava either from peasant farmers or from a plantation crop specially grown for the purpose is discussed. The results of a laboratory analysis carried out on a sample of locally grown cassava is given.

The background to the establishment of the Uganda plant and the viability of the starch project is discussed. It is felt that Government protection from imports would be necessary for the first few years to enable the plant to break even financially. The details of the modern extraction process to be followed is given, along with the specification sheet of the product to be manufactured.

The cassava plant (*Manihot esculenta* Crantz), also known as *ubi kettella* or *kaspe* in Indonesia, *manioca, mandioca* or *yuca* in Latin America and *manioc* in Madagascar (Holleman and Aten 1950), is second in importance only to the sweet potato as a root crop throughout the tropics (Cobley 1956). Of South American origin, it is now grown in every tropical country, including E. Africa, where it is believed to be introduced by the Portuguese (Vesey-Fitzgerald 1950). It is grown either as a famine relief crop or processed in various ways to form traditional articles of food, while due to its very high starch content, it is also considered suitable as a raw material for the production of industrial starch. The present article describes the plant being set up in the Lango District of Uganda for this purpose.

The cassava belongs to the Euphorbiaceae family, with over 150 known species of this genus (Cobley 1956) and a large number of varieties are known to exist in East Africa (Nichols 1950). Cassava varieties can be classified either as "bitter" or "sweet," the former containing the poisonous prussic acid. In the starch-extraction plant being set up in Uganda, the supply of raw material in the first instance would be by peasant farmers only, and hence a large number of varieties are likely to be included.

Cassava is propagated almost exclusively by vegetative means from stem cuttings, approximately 10 in long. It requires a warm humid climate and in tropical regions some varieties grow at altitudes of up to 5500 ft. It is usually planted at the beginning of the rainy season either as a single crop or inter-cropped with maize, legumes or vegetables. The crop is ready for harvest from about 10—12 months onwards, although Nigerian experience indicate a growing period of 22—24 months (U.S. AID 1965). The effect on yields of harvest at other than optimum age is discussed later. Harvesting is a manual operation: stems are cut and the roots pulled or dug by hand, sometimes with the help of a simple implement like a crowbar (Holleman and Aten 1950), although fairly elaborate harvesting equipment for a possible plantation crop for the Uganda plant is being considered (Fig. 1—2). Krochmal (1966), in a recent article has described some of the machinery used in South America in the farming of cassava.

East African market for cassava starch

A survey of the East African market for starch, modified starch, dextrin and glucose was carried out in June 1964 (Patel 1966), in order to establish manufacturing facilities for some or all of these products at the Lira plant in Uganda. An annual production rate of about 1000 tons of starch is envisaged in the first instance with effect from 1967, and the production of glucose at a later date is under consideration. In view of the low level of local consumption of dextrin it has been omitted from the present production programme.

The estimates of market size for starch (Table I) are based on information provided by the principal endusers. The annual average growth rate in the demand for starches is also estimated to be 12%, leading to a demand of some 2400 tons by 1970.

Table I. East Africa: current annual starch requirements of the principal consuming industries

Industry	Quantity (Ton)	Percent of Total
Textiles	1140	76
Paper/packaging	250	16
Bags and cordage	100	6
Laundry	25	2
Total	1515	100

Source : *East Africa: The market for starch, modified starch and glucose.* Marketing Section, U.D.C., Kampala.

The principal sources of supply for starches at present are Europe, Indonesia and a plant in Kenya with an annual production of 400—450 tons of manioc starch. The imported starches are maize starch, sago and modified starch. The delivered price in East Africa varies widely between £32 to £130 per ton, while the Kenya produced starch sells at £35 per ton.

Glucose, a by-product in the production of starches, is used in East Africa mainly by the confectionery industry, and to a very limited extent by the pharmaceutical industry. Present annual consumption are 1200 and 13 tons respectively. The confectionery industry's demand is likely to rise to about 1600 tons per annum by 1970. The principal sources of supply for glucose is Europe, at a c.i.f. Mombasa port price varying between £45—58 per ton.

SOME BASIC CONSIDERATIONS IN EXTRACTING STARCH FROM CASSAVA

Optimum starch content

From the standpoint of starch production, the most profitable planting time is at the beginning of the wet monsoon, and harvesting either before or after the optimum age may lead to a loss of starch content to the extent of 40% or more (Holleman and Aten 1950). Fig. 3 shows the effect of maturity on the yields of cassava tuber and starch.

Poisonous acid

Cassava tubers contain a highly poisonous prussic acid, both in the free state and in a chemically bound form; when the cells are crushed the latter is set free through enzymic action. The amount of acid varies from a few mg up to 250 mg per kg of the fresh root. The presence of prussic acid is easily recognised by a 'bitter' taste, but the 'sweet' varieties may also contain appreciable amounts of acid which is not easily recognised. Most of the acid can be got rid of, however, during the processes used for the extraction of starch.

Time lapse between harvest and processing

Cassava should be procured within relatively short distances from the processing plant to allow processing within 24 hours after harvesting, and also to avoid excessive transport cost. If the tubers are left unprocessed for any length of time, enzyme action occurs in the cassava root and reduces the quality and yield of the starch.

Plantation crop vs. procurement from farmers

Procurement of the cassava from peasant farmers is likely to be more cumbersome and costly than a plantation crop specially grown for processing to extract the starch. The former needs proper arranging and scheduling of harvest and a possibly higher cost of transport from the farms, as they may not be located near by. Further, without a plantation crop being available as an alternative source of supply, the farm prices are unlikely to be stable.

Analysis of cassava chips

A laboratory analysis of locally available cassava was carried out to ascertain the percentages of the various constituents (Anon 1963). Circular discs, 5—8 mm in thickness were obtained by slicing the root perpendicular to the longitudinal axis. The chips were predominantly dead white in colour with occasional traces of coloured impurities on the root surfaces (faint yellow). The chips were free from coloured surface moulds, adhering soil and sand particles and also free from extensive 'browning' products as were displayed by sun-dried untreated whole roots. Milling to a fine powder gave a bright white flour comparable in brightness to a superior grade potato or maize starch. The flour had a faint pungent odour characteristic of all cassava flours.

ANALYSIS

Moisture	—	13.6 %		
Ash	—	0.31%		
Surface sand	—	nil		
Water soluble material	—	4.3 %	(d.b.)	
Soluble reducing sugars	—	0.16%	(„)	
Ether solubles	—	0.39%	(„)	
Crude Fibre	—	1.93	— 2.35%	(d.b.)
Starch	—	93.4 %		(„)
Nitrogen	—	0.48%		(„)
Ferricyanide Number	—	2.08%		(„)

Mass composition balance :

Starch	—	80.8 %
Fibre	—	1.8 %
Water solubles (ash, soluble sugars and most of the nitrogen containing constituents)	—	3.7 %
Ether solubles	—	0.3 %
Moisture	—	13.4 %
	Total :	100.0 %

THE STARCH FACTORY AT LIRA

Background

The Lango Development Company Ltd. was formed as a subsidiary of the Uganda Development Corporation Ltd. in November 1962 for commercial utilization of the large surplus cassava crop grown as a famine reserve in the Lango District of Uganda. The three-fold programme of work set up for the Company is (a) to process and export dried cassava roots and chips, for which there is a substantial market in Western Europe, the object being to build up a regular and substantial flow of cassava from farmers and co-operative societies; (b) to manufacture other cassava products like flour, animal food stuffs, starch and starch derivatives for which there is an assured but limited domestic market in E. Africa; and (c) to investigate the feasibility of manufacturing fuel alcohol for local use (Anon 1963).

Viability on the starch project

A viability study of the starch project was carried out during early 1966 to determine the future cash requirements of the L.D.C. and to decide whether Government protection from imports should be sought (Anon 1966). An analysis of capital and operating costs, profitability and estimated cash flows indicated that at current prices and envisaged rates of production, the company is likely to run at a loss for the first 6 to 7 years. The Uganda Government is being approached to provide necessary protection to the industry from imports for the duration of this period.

Plant description and flow-sheet

The starch extraction plant at Lira is designed to carry out the following sequence of operations, shown diagrammatically as a flow-sheet in Fig. 4.

(a) *Root cleaning* : The cassava tubers are prewashed to separate the coarse soil and then passed through a combined washing and peeling unit.

(b) *Grinding and washing* : The peeled tubers go through a selecting conveyor to remove damaged or diseased tubers, before being ground to a pulp by a mill equipped with scraping and breaking rotors. A generous addition of raw starch milk water, obtained from the process at a later stage (e), is fed to the pulping mill so that the fibrous material present in the pulp is left undamaged. The pulp is then washed before being passed through a wet, fine mill for fine-grinding and separating the starch grains. The free, milky, starch grains are re-washed on a counter-flow bed, while the pulp obtained from fine-grinding is pressed and sold as provender, after sun drying on open concrete floors.

(c) *Refining sieving* : The washed milky material is then pumped over a Rostant-sieving machine to separate the fine fibres from the starch milk. The extracted fine fibres are re-washed to separate further quantities of starch grain, and the cleaned starch milk is led over parallel, coupled, special, Rostant sieves to the separators.

(d) *Separation and concentration* : The processed starch milk, freed to a great extent from the fine fibre, is then passed through a multi-stage separator. In the first stage, a further amount of washing is carried out and the gluten is separated, during which the starch milk of about 3°Be is concentrated to about 10°Be. It is important to separate the gluten quickly and effectively in order to avoid decolorization of the starch. By adding fresh water, the starch milk is diluted to about 5°Be before being passed through the second stage of the separator, where a concentration up to about 21°Be is obtained.

(e) *Starch pre-desiccation* : The starch milk concentrate of about 21°Be has a dry substance content of about 415 kg/1000 litres. It is passed through a dewatering centrifuge, equipped with automatic, discharging devices and control gear for timing the charging and centrifuging operation, to reduce the water content to about 37%. The water freed by the centrifuge is repassed to the washing process (b) mentioned earlier.

(f) *Starch drying:* The starch output from the centrifuge is led by a worm conveyor to a pneumatic rapid dryer, which reduces the final moisture content to a value between 10 and 13%. Drying is effected by hot air, produced by a set of 3 special oil burners working on atomized burning principle, and compressed air. The burners are designed for the food industry and they burn with a gas-like flame which does not contaminate the starch in anyway, provided a special grade of extra light oil is used. The required quantities of fresh air is sucked into the hot-air generator through an air filter and heated to about 150°C. During the drying process, the starch is pneumatically conveyed from the bottom to the top of the drier and then deflected downwards. Starch particles which are not quite dry are returned to the drying unit located at the bottom, while the dry starch is separated in the cyclone from the conveying air, and is led through a rotary pocket seal, by means of a worm conveyor, into a starch powder sifter equipped with two exchangeable screens. The first sifter has a 100 mesh screen and the second a 140 mesh screen. The resulting starch powder which is of high purity and fineness, is then packed in bags, weighed, and the bags sealed. The dried starch powder failing to pass through the sieve is treated by an attrition mill to grind the powder to the required size.

Sulphuric acid required for the starch production is obtained by burning raw sulphur in a sulphur burning installation consisting of a kiln, air filter, compressor, sublimator, water coller and gas absorption column. The acid is added to the process mentioned above during the stages (a) and (c).

Plant power-consumption and capacity

The total motor-capacity of the plant, required to drive the various machines, is about 24,000 kw. The total water consumption is of the order of 40 cubic meter/hour (24 cu. ft/min.) and the total sulphur consumption 0.8 kg/hour for a maximum starch capacity of 7.5 tons/24 hours.

The plant is designed to produce approximately 5 tons of cassava starch daily with a final moisture content of 10-13%, working on a two-shift basis of 16 hrs/day. The starch content of the cassava tubers varies between 18 and 36%, and affect the amount of tuber treated per day (Fig. 2). The plant can also be operated on a continuous 3 shifts/day basis, thus increasing the output to 7.5 tons/day or approximately 2,100 tons/year.

Starch specification

The analysis of the final product to be manufactured should be as follows:

Appearance	:	Low speck count, clean odour, uniform white colour although a trace of yellow colour would be acceptable for average requirements.
Mesh	:	99% to pass through 100 mesh screen 95% " " " 140 " "
Moisture	:	10—13% maximum
Ash	:	0.35% maximum
Pulp	:	0.8% "
Protein	:	0.4% "
pH	:	4.5 to 5.5
Acidity	:	2.5 ML of N/10 acid to reach pH 3.0 for a 25 gm sample.
Viscosity	:	(a) Inherent viscosity (one point) 2.80 — 3.00 (fresh roots). Inherent viscosity (one point) 2.40 — 2.60 (processed dry roots). (b) Corn Industries Viscometer: Fresh root, at maximum peak, at least 270 gm/cm; less in viscosity on holding at 92°C for 15 min. Less than 35% of max. value. Concentration 4% (dry basis).
Sulphur dioxide	:	Less than 45 p.p.m.
Speck count	:	5 cm sq. decimeter—min. 100.

Cassava starch of the quality mentioned above is also suitable for the production of glucose, dextrose, couleur and dextrin.

Acknowledgement:

Grateful thanks are due to Mr. N. Laurens of the Uganda Development Corporation for making available the various L.D.C. reports from which some of the material in this paper has been drawn. Dr. W.H. Boshoff of the Makerere University College initiated thc study.

REFERENCES

1. Holleman, L.W.J. & A. Aten, (1950) Processing of Cassava and Cassava Products in rural industries. **F.A.O., Agricultural Development Paper No.** 54, Rome, Italy.
2. Cobley, L.S. (1956) An introduction to the botany of tropical crops. **Longmans, Green & Co.,** London. pp. 174—177.
3. Vesey-Fitzgerald, D. (1950) Brazilian methods of preparing cassava **E. Afr. Agric. J.,** Kikuyu, Kenya, **15** (3) 165.
4. Nichols, R.F.W. (1950) The brown streak disease of Cassava. **E. Afr. Agric. J.,** Kikuyu, Kenya, **15** (3) 154—160.
5. U.S. AID (1965) **Feasibility of a cassava starch industry in Nigeria Report CID/IPE/D.** 28, U.N. Centre for Undus. Develcp., Prague, Czechoslovakia.
6. Krochmal (1966) Labour input and mechanisation of cassava. **World Crops.** London **18** (3) 28—30.
7. Patel, K. (1966) **East Africa: The market for starch modified starch and glucose.** Marketing Section, U.D.C., Kampala.
8. Anon (1963) Manufacture of fuel alcohol from cassava. **Lango Dev. Co., Ltd., Report S/LDC/E.7,** Kampala, Uganda.
9. ———— (1966) Starch project: reassessment of viability. **Lango Dev. Co., Ltd. Report LDC/29,** Kampala, Uganda.

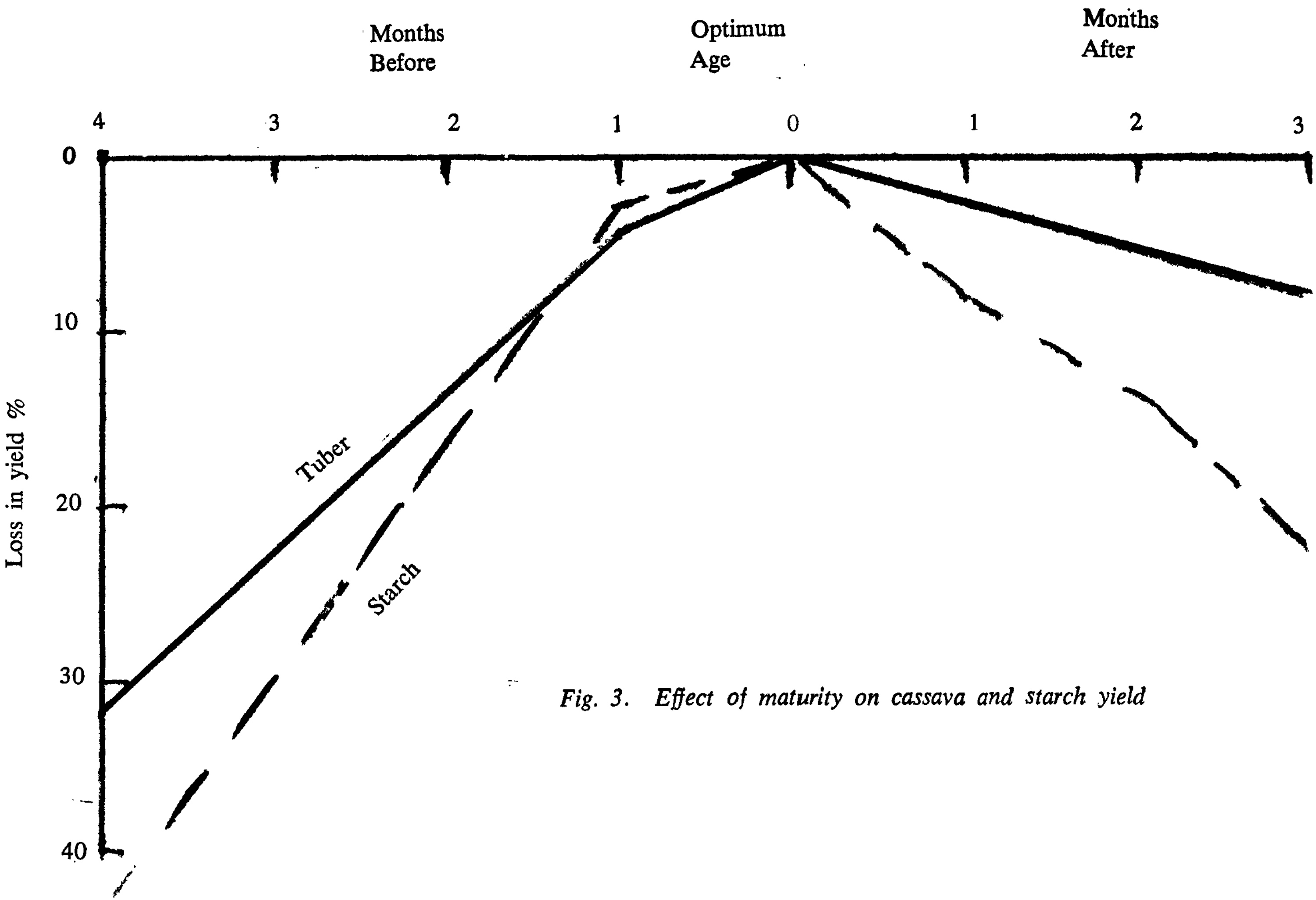

Fig. 3. Effect of maturity on cassava and starch yield

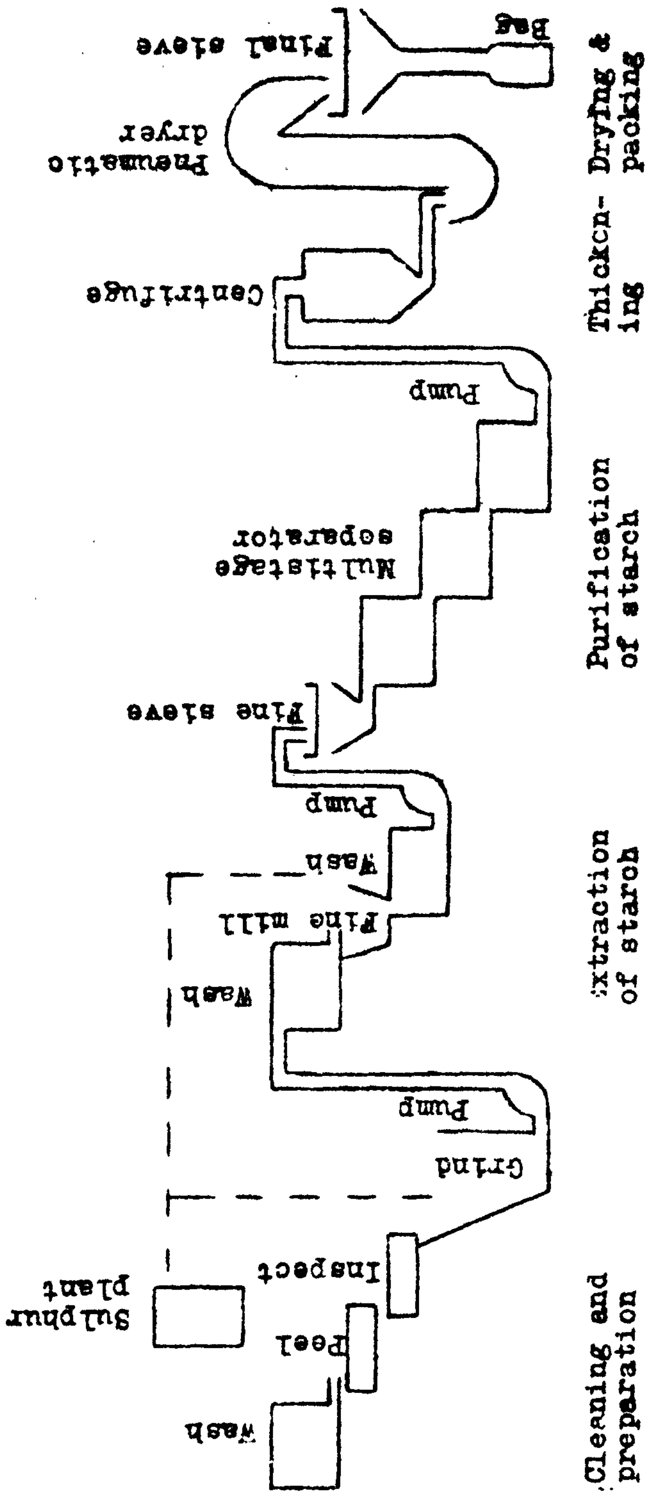

Fig. 4. Flow sheet for manufacture of cassava starch

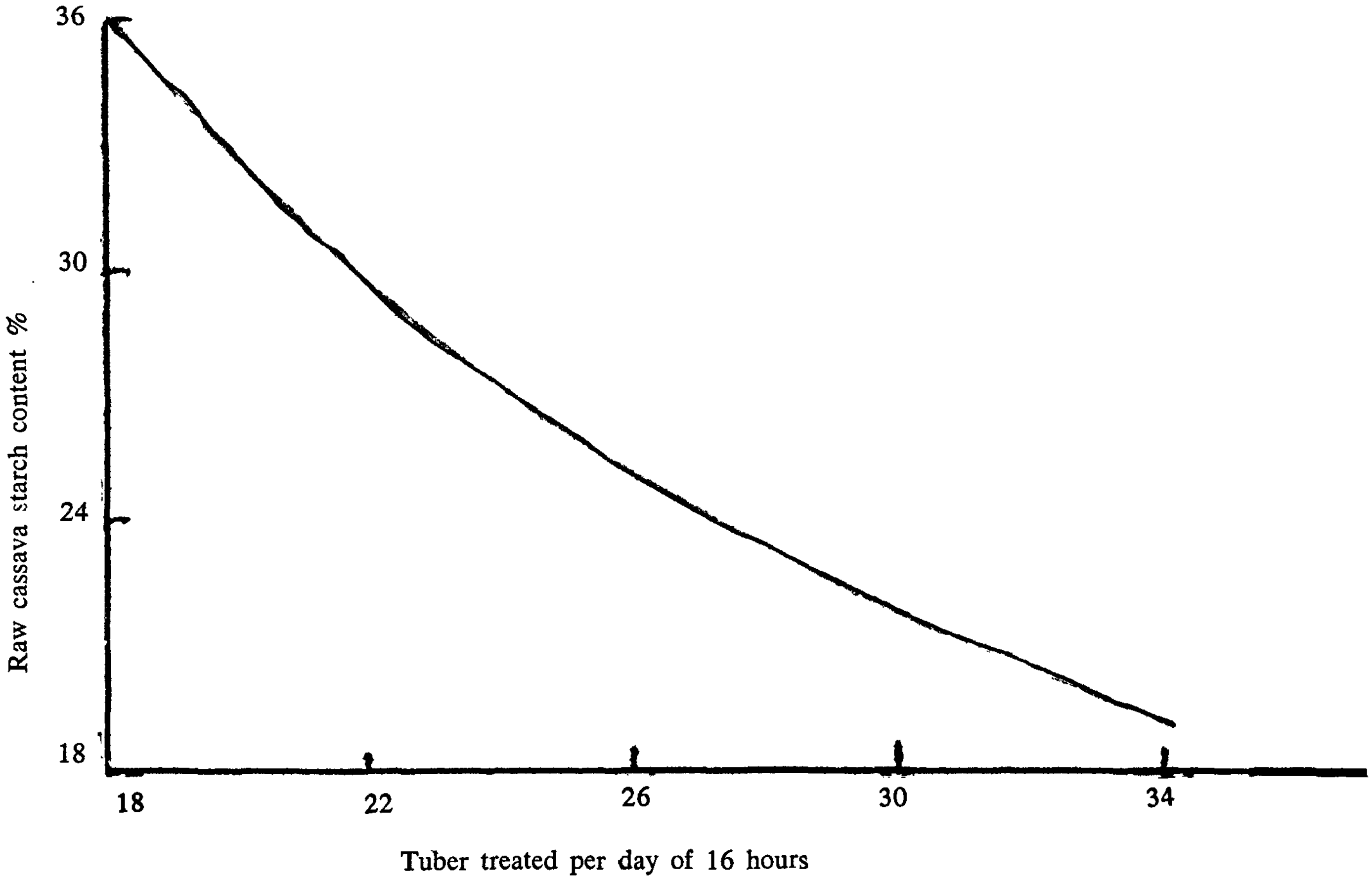

Fig. 5. Effect of cassava starch content on quantity treated per day.