HISTORY OF THE DEVELOPMENT OF THE FIRST MECHANIZED CONTINUOUS GARI MANUFACTURING PLANT

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SUMMARY

After reviewing various endeavours to manufacture gari in factories, the main characteristics of a factory in Gambia are described. This is claimed to offer the best and most economic means available to produce this staple food of West Africa. The factory line comprises of an eccentric drum peeler, trays for hand sorting of peeled roots, and a horizontal hammer mill. The mash is then pumped into 1 ton, low-density polyethylene vats for fermentation. The fermented mash, contained in nylon bags, is dewatered in hydraulic presses and the dewatered mash is dried in a cascade type rotary drier. The process designers, Newell Dunford, are constantly improving their process and can offer complete systems.

RESUME

Après avoir passé en revue les divers efforts pour fabriquer du gari en usines, les grands traits d'une usine en fonction en Gambie ont été exposés. Celle-ci, pense-t-on, offre les meillerus moyens économiques disponibles pour produire cette denrée propre a l'Afrique occidentale. L'usine se compose d'une éplucheuse excentrique à tambour, de plateaux pour dégager manuellement les recines épluchées et un moulin horizontal. Puis lat pâte est versée dans un tonneau, des cuves polyéthylènes a basse densité pour la fermentation. La pâte fermentée, contenue dans les sacs en nylon est asséchée dans des presses hydrauliques et séchée dans une sorte de séchoir rotatoire à cascade. Newell Dunford, companie qui a mis au point le procédé, lámeliore constamment et peut en faire un système complet.

RESUMEN

Se describen las principales características de una planta de manufactura de gari en Gambia, después de revizar varios intentos hechos previamente. Se dice que ella ofrece los mejores y mas económicos medios para producir este alimento de consumo básico en Africa Occidental. La línea de operación de la fábrica incluye un tambor descortezador excéntrico, bandejas de clasificación manual de la raíces descortezadas y un molino horizontal de martillo. La masa es entonces bombeada a tinas de fermentación de 1 ton, hechas de polietileno, La masa fermentado, contenida en bolsas de nylon se deshidrata en prensas hidráulicas y se seca en un secador rotatorio de tipo cascada. Los diseñadores del proceso, Newell Dunford, lo mejoran constantemente y pueden ofrecer sistemas completos.

INTRODUCTION

The original test work that led to the development of the gari plant was supervised by Mr. J.G. Purcell of Newell Dunford Engineering more than fifteen years ago. Roots were air freighted from Nigeria and the first preliminary tests were carried out at our Research and Development Department. The rapid deterioration of the roots made the work very difficult, but sufficient test information was obtained for a combined garifier/dryer of the rotary louvre type to be designed.

The first garifier/dryer was built and supplied to the Federal Institute of Industrial Research, Oshodi, Nigeria in late 1959, and after initial minor technical difficulties, an economic investigation was undertaken over a three month period in late 1961, running the plant on a semi-continuous basis.

In reports on this trial[3,4,5] it was concluded that, although good quality gari had been produced, it had been difficult to obtain the quantity of cassava roots required at a reasonable price. It was suggested

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that the minimum economic size of a factory would be ten tons of gari a day, at which size the price of the product should be able to be reduced from £30 per ton or less[6].

However, those to whom gari samples were sent for opinion on quality had given a misleading verdict and it was later realized that the factory product did not compare favourably with gari produced by the traditional method. Another report issued by the F.I.I.R. in 1964[1] suggested that the garifier and dryer should be operated as separate units, and during the next few years they investigated the principles of garifying with different designs.

Based on the data obtained, Newell Dunford submitted a revised garifier design in 1967. A unit of this type was installed in mid-1969 and, after trials lasting some six months, gari of excellent quality was produced without problems of sticking which had occurred earlier.

Simultaneously, discussions were taking place regarding the installation of the first commercial plant in the Gambia. Since the new F.I.I.R. was not erected until 1969, the designs for the Gambia plant could not be based on the results obtained there. The equipment initially did not meet capacity and it took two years to modify it until it could produce 1000 lbs. per hour or two tons per day output of gari.

The development of the fully mechanized continuous gari plant was thus quite slow, but the problems were greater than originally envisaged, and the cost of solving them very discouraging. In the meantime however, the price of gari had risen to a much higher level which gave further impetus to the developments.

During this fifteen year development period, we have had to compete with the village method, where the capital expenditure is very low, resulting in a low price of gari. Consequently, designs have been limited to maintain the balance between plant efficiency and capital cost. For example: –

(a) The root peeling section contains two batch peelers; proprietary continuous peelers using dry or steam methods would be about twice the price.
(b) Hydraulic bag presses, although simple, have proved to be the most economic means of dewatering the cassava mash. Centrifuges, as used in the pilot plant, are too expensive.
(c) The fermentation area could be more highly automated, but one of the simplest methods, using vats, pallet trucks and a cassava mash pump, has proved the least expensive.
(d) The garifier is a specialized piece of equipment where costs cannot be reduced by using alternatives. Marginal savings have been made by interconnecting the garifier exhaust gasses to the dryer, reducing the heat wasted.
(e) The dryer has been an item where considerable savings have been achieved. The substitution of a Cascade type dryer for the Rotary Louvre dryer has reduced costs.

There are, however, instances where cheaper equipment has been tried and proved unsuitable. Newell Dunford made a mistake in 1969 in trying to build the first commercial plant in the Gambia to an unrealistic target capital figure, and was eventually forced to subsidize it heavily to achieve success. However, an advantage of a simple low cost plant is that it should be reasonably easy to maintain by less skilled labour.

Due to the inflationary conditions in the United Kingdom, the present design has risen some 15% in price over the past year or so, but our policy is continually to re-appraise items of equipment with a view to reducing cost.

As mentioned earlier, the experimental pilot plant at F.I.I.R. Oshodi, has undergone considerable changes, and the present plant which is used for demonstrations, can be described as follows:

A pump delivers water to an eccentric drum type peeler. The peeled roots are then discharged onto wire sorting trays for hand sorting, and delivered via a ribbed belt conveyor into a vertical shaft grater. The grated cassava is discharged into an agricultural type mixer, has seed liquor added if necessary, and is discharged into 200 lbs capacity aluminum fermentation vats mounted on wheeled carriages. After two to three days fermentation, the cassava mash is transferred into press bags for dewatering in a hydraulic press. The dewatered cassava mash in the form of a cake, is fed into a sifter prior to entry into the single rotating drum garifier. After garifying, the gelatinized çassava is fed into a rotary louvre dryer. After drying, the product is stored in a bunker before being fed into a disc mill for grinding. The ground gari passes into a reciprocating two-stage sieve where the fines are removed and then the graded gari is weighed and packed into hessian bags for dispatch. This plant has now been running successfully for two to three years producing gari of an acceptable quality.

The garifier has proved to be a critical stage of the process, and so is worthy of more detailed discussion.

The garifier installed on the first pilot plant in 1959 was a combined garifier/dryer. The equipment consisted of a plain steel conical shaped garifying section heated externally by an oil fired air heater. Material fell onto this section and rolled in a spiral path into the remaining three quarters of the drum which consisted of a conventional rotary louvre dryer.

Although this followed the traditional idea where the garifying and drying are carried out in one operation by cooking the fermented mash in an open pan over a hot fire, the product from this plant was not of the same quality as the traditional gari. Further investigations revealed that two separate incompatible processes were occurring, namely (a) gelatinization which required high heat transfer and low mass transfer and (b) drying which required low heat transfer and high mass transfer.

A later F.I.I.R. report[1] describes investigations into the use of separate garifiers, designed to increase heat transfer efficiency. Whilst these investigations were successful as far as product quality was concerned, only limited success was achieved in reducing the number of lumps formed as a result of sticking in the chamber. However, these studies led to the design of a separate rotary kiln garifier, externally heated by a baffled jacket of hot air. Sticking of the cassava on the drum surface was eliminated by using stainless steel material and fabricating small lifting devices in the drum.

This equipment proved satisfactory in the pilot plant, but when scaled up for the commercial plant in the Gambia, insufficient heat transfer occurred in the large garifier installed. It was therefore necessary to increase the surface area. As factory space was limited a compact triplanetary drum garifier was developed, the active portion of the garifier consisting of several planetary drums rotating around the central axis with a common inlet and outlet section, all enclosed in a heating chamber.

This design, together with other modifications such as three burners to give equal heat distribution; variable speed drive to compensate the differing feed inputs, and atmospheric conditions; and recovery of waste heat into the dryer air heater for more efficient operation, is the basis of the present garifier.

The commercial plant in the Gambia has undergone several alterations since being installed in 1969, but is basically the same as the Oshodi pilot plant:

Peeling takes place in eccentric drum units and the roots are discharged onto wire sorting trays where they are hand trimmed. The peeled roots are conveyed by an inclined ribbed belt elevator into a 20 h.p. horizontal hammer mill. The mash passes into an agricultural-type mixer with paddles, where seeding can take place, and is discharged into nylon bags for fermentation. The plant is also experimenting with fermentation vats. After fermentation, the cassava is transferred in bags to hydraulic presses for dewatering, the liquor extracted being used to seed the unfermented mash.

The resultant cake, after being broken by hand, is fed via a bucket elevator. The product from the dryer is discharged onto a trash screen where any large lumps are removed, and then elevated to a double deck screen and separated into three sizes. The undersize portion is bagged off separately as fines whilst the oversize portion is fed into disc mills and the resultant product returned for re-cycling through the screen. The middle cut of product passes into a hopper prior to weighing and bagging off.

Throughout its lifetime, the Gambia plant has suffered many technical problems, but we consider that these have been overcome and that the plant produces gari of quality acceptable for sale.

The fermentation of cassava is a crucial step in the gari process. Fermentation normally takes four to six days in the traditional process whereas, by seeding the mash with fermented liquor, this period can be halved.

Preliminary runs on the 1959 pilot plant at F.I.I.R indicated that, due to imperfect stirring of mash in the bins, seeding produced unevenly fermented mash. This was overcome by using a mixer, which also acted as a holding hopper whilst the vats were being filled. However, seeding is often omitted in present production methods.

The fermentation containers used in the pilot plant were 2000 lbs capacity aluminum and stainless steel vats, but these proved too expensive for a commercial plant, and other systems were considered.

Traditionally, cassava mash was contained in hessian sacks. The Gambian plant uses nylon bags, holding 40–50 lbs each, but without strict hygiene control the bags soon develop fungal growth which contaminates the product.

Ferrous metals, apart from stainless steel, contaminated and coloured the product: in wooden barrels and formica-lined wooden vats, contamination again occurred, from the cracks and joints of the wood, while the cost of fabrication was not much less than for aluminum vats. Glass fibre vats were tested and have proved thoroughly acceptable: they are moulded and have no recesses where contamination can occur, and they are also relatively cheap. However, they tend to chip during constant handling. Vats moulded in polyethylene appear to have all the qualities of glass fibre vats but are less brittle and more robust for mechanical handling. Other ideas have included concentrate silos of 15-36 tons capacity, but although the cost appeared to be reasonable, until more tests were done, it was considered unwise to incorporate these in the commercial plant.

Thus, at present, fermentation is carried out in one ton capacity vats made of low density polyethylene, loaded and unloaded by a pump. This appears to be the most hygienic and cheapest system available.

Apart from the basic plant, Newell Dunford can offer the necessary ancillary equipment for an integrated process, including electricity generation systems for isolated sites; an effluent separation system; control laboratory equipment; and recommended maintenance equipment.

The areas in the gari process where future development can occur are the batch stages of peeling, fermentation and dewatering. Methods of making these continuous without increasing capital cost are currently being investigated.

In the peeling section, one, more continuous, machine would prove more desirable. There are several continuous peeling machines for such root crops as potatoes and carrots on the market: the basic problem is to modify these machines to peel the rather awkwardly shaped cassava roots.

Investigations have revealed the possibility of continuous fermentation in a column[2]. As a result of these a pilot plant continuous fermentation column has been designed, although not yet constructed.

The original pilot plant contained laboratory basket-type centrifuge which dewatered the cassava mash successfully, but trials with large commercial sized machines proved unsuccessful as the moisture reduction was insufficient to enable gelatinization to occur in the garifier. Similar small reductions in moisture content have been found with single and twin screw continuous presses. It appears that the only continuous machines capable of dewatering the mash is a complicated pneumatic design, which for a commercial size unit would cost some £30,000–£40,000, over fifteen times the cost of the present hydraulic presses. A possible answer may lie in the use of continuous vacuum filters if a cheaper design is to be developed.

Other developments on the plant will no doubt arise as practical experience with commercial plants is gained and, naturally, efforts will be made to improve the plants. However, we feel that the plant now offered the best and most economic means of producing the staple diet of Nigeria and West Africa.

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