Transformation Alimentaire du Manioc.
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Analysis of traditional food technology : case studies in cassava processing

Analyse de technologies alimentaires traditionnelles : études de cas dans le domaine de la transformation du manioc

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- *Abstract* -

Various indigenous techniques have been developed and practised over the years by rural communities for the processing and preservation of foods. The need to improve indigenous food processing techniques calls for the understanding of the scientific and technological principles involved. This work presents a mode of technology analysis that identifies resources, sub-processes, products; scientific and technological principles in a given process and points in the processing line for improvement. Case studies of cassava processing are selected and analyzed to produce technology profiles that expose bottlenecks in a process and suggest alternative operations for improvement. It is hoped that the technology profiling would facilitate the identification of problem areas for innovations.

- *Résumé* -

Diverses techniques autochtones pour la transformation et la préservation des aliments ont été développées et mises en pratique au cours des années par les communautés rurales. La nécessité d'améliorer les procédés de transformation traditionnels oblige à essayer de comprendre les principes scientifiques et technologiques mis en jeu. Ce travail présente une méthode d'analyse des technologies qui identifie les ressources, les opérations unitaires, les produits et les principes scientifiques et technologiques mis en oeuvre pour chaque type de transformation et examine l'ensemble en vue d'une amélioration.

Des études de cas dans le domaine de la transformation du manioc sont réalisées en vue de dresser des profils technologiques qui identifie les goulots d'étranglement pour chaque type de transformation et suggèrent des procédés alternatifs pour améliorer les opérations unitaires. L'objectif visé est que ces profils technologiques facilitent l'identification des obstacles aux innovations.

Introduction

Cassava (*Manihot esculenta Crantz*) is one of the major staple foods in Sub-Saharan Africa. It is estimated that Africa produces about 42 % of the total tropical world production of the crop (FAO, 1978).

Fresh cassava has a very short post-harvest storage life, and it must be used or processed into durable forms soon after harvest (Ayernor, 1981). It is documented that one of the main reasons for cassava processing is the removal of the toxic cyanide from the products (Ayernor, 1981 and 1985; Coursey, 1973). Various traditional techniques had been developed and practised over the years by African people for the transformation and preservation of food including cassava.

The need to upgrade the indigenous food processing techniques calls for the understanding of the fundamental scientific and technological principles involved (Ayernor, 1981; Sefa-Dedeh, 1989). This would be useful in fostering technology improvement.

The modes of food utilization of cassava appear in many varied forms across diverse ethnographies in Africa. However, in the processed and durable forms, two major products stand out prominently: cassava flour and gari (Ayernor, 1981). These two products are durable, and contain a reduced amount of cyanide, depending on the processing (Ayernor, 1981 and 1985; Coursey, 1973).

This work presents cassava flour and gari for case studies in the analysis of traditional food technology. The method of approach is to present in a format that identifies: resources, processes, products, scientific and technological components in a given process and identification of points in the processing line that need upgrading for more acceptable products.

1. Production of cassava flour

The variants of cassava flours are cassava products that have undergone various degrees and modes of pretreatments of the raw material prior to sundrying. Dried products are milled into a flour. Three main process variants are illustrated in Figure 1. The end-product of the dried cassava in the rural areas is a flour produced by pounding the dry pieces in a mortar with a pestle, and sieved through a mesh. In recent times, the availability of mechanical milling has facilitated the production of fine cassava flours (Ayernor, 1981) (Figure 1).

In the second pathway of cassava flour production [Figure 1 (II)] grating basically reduces the tissue into particles. It facilitates contact between cyanogenic glucosides and the hydrolytic enzyme, linamarase, to release hydrogen cyanide (Ayernor, 1981 and 1985; Coursey, 1973). This technique is traditionally practised.

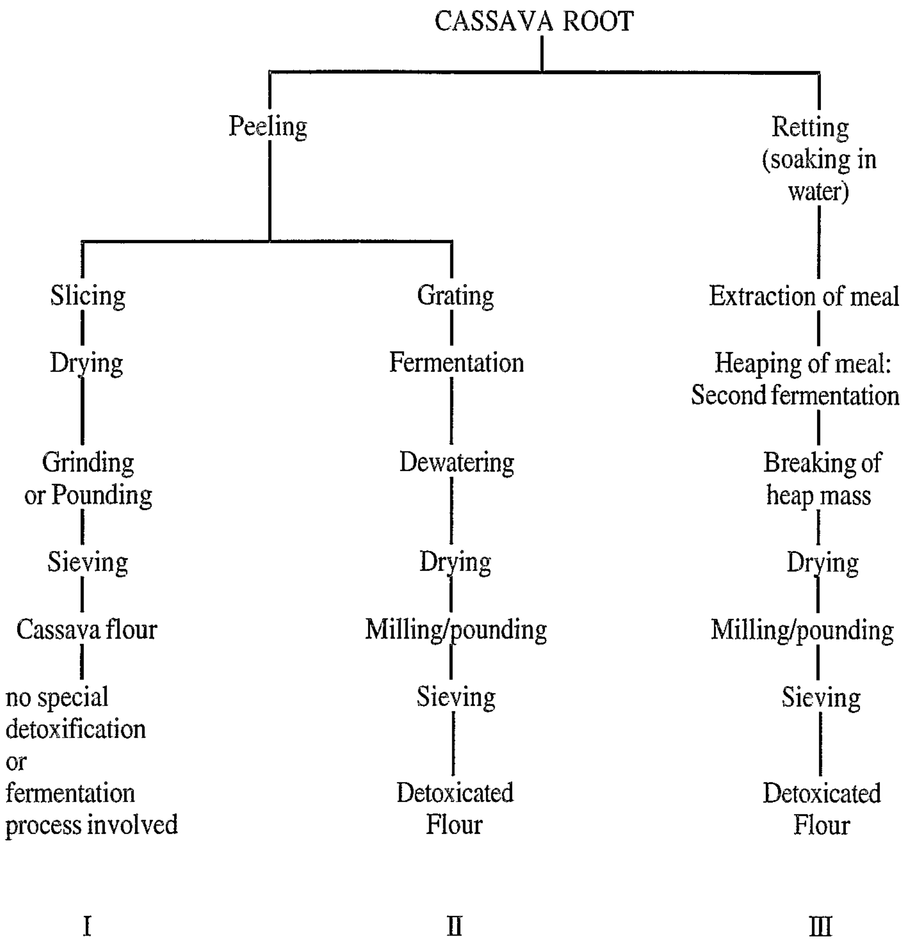

Figure 1
Flow diagram of village production of cassava flours

The retting of cassava, a technique of soaking cassava root in water to effect the breakdown of tissues and extraction of starch [Figure 1 (III)] has been investigated. It was found to effectively reduce cyanide content of cassava flour (Ayernor, 1985). Retting followed by sundrying was found to have removed up to 97% of the initial cyanide in the cassava and was over 20-fold more efficient than simple sundrying of cassava roots (Ayernor, 1985). The upgrading of processing facilities for cassava retting by improving material handling and raising production capacities have been achieved to some degree in the Congo (Nziffe, 1983).

At rural level grating is done manually by robbing the peeled root against the raised surface of nail-pierced metallic sheets (Ayernor, 1981). Mechanized grating is done by wet-grinding of the root in specially adjusted corn mills. Normally the fermentation process is carried out by placing the cassava pulp into jute bags weighted with heavy stones to drain excess water (dewatering). Fermentation and dewatering takes 2 to 5 days (Ayernor, 1981).

The upgraded mechanized processes use hydraulic processes or centrifuge to remove water after fermentation which is carried out in batches in large plastic tanks. A good dewatered cassava pulp has an intermediate moisture content of 40 to 50% (Ayernor, 1981; F.I.I.R.O.). After dewatering, the mash has to be broken and sieved to remove excess fibres from the semi-pulverized material before drying. (cf. the gari process).

2. Problems in the production of flours (Table 1)

The processing of non-gelatinized flours by sundrying is suitable only for small-scale household production. To scale up this operation, artificial drying (dehydration) has to be applied at industrial level. It must be noted that large-scale sundrying operations are difficult to manage especially when the product is intended for human consumption and quality requirements are expected to be high and in which case sundrying on floors or on the ground may not be permissible.

The basic problems of drying applies to roots and tubers, and any development to introduce efficient dehydration mechanisms can generally have a wide application.

In order to produce a cyanide-free cassava flour, the cassava roots have to be grated or reduced into a pulp so as to release the toxic principle [Figure 1(II)].

The drying of grated pulp, in the case of cassava presents a special problem. Sundrying is efficient on small scales but special dryers are needed to handle this form of material to produce a non-gelatinized flour at industrial levels.

Research and development is needed to improve rural sundrying operations so as to ensure good quality products. Dehydration techniques must also be developed especially in machinery design and temperature control where temperatures should not exceed 50°C to handle the dehydration of both slices and grated forms.

Table 1
Technology Profile of cassava processing into Flours

TECHNOLOGY ANALYSIS:	TECHNOLOGY PROFILE
Reference:	
SUBJECT	DEFINITION/DESCRIPTION
Resource	Cassava
Identification	Processing of cyanide-free cassava flour.
Objectives	To process toxin-free cassava flour of high quality, suitable for the various forms of cassava flour utilization in Africa.
Technologies	Available cottage technologies: Simple sundrying of roots Fermentation followed by drying of material Milling, pounding.
The Process	See Figure 1 Up-graded process based on village models must be developed.
Principles	Transformation principles: Detoxification Dehydration Size reduction/milling.
Inputs	Inputs regarding processing hardware to be upgraded or developed: Processing machinery Energy requirements Levels of manpower
Manpower	Various: Research and development capabilities Unskilled, semi-skilled Highly skilled.
Remarks (example)	(a) Cottage operations are unsuitable for modern industrial production (b) The retting process is upgraded to intermediate level (c) Process II (Figure 1) is adaptable for upgrading.

3. Gari production and product (Table 2)

Gari is a popular product and its production is the most improved technology in cassava processing. It is a pre-gelatinized grit with particle size ranging from below 0 µm (fines) to over 2000 µm (coarse) (Ayernor, 1981; F.I.I.R.O.). The process involves peeling, grating, fermentation, dewatering and finally roasting. All the unit operations involved contribute to the detoxification of cassava (Ayernor, 1981; Coursey, 1973). Gari with a moisture content of 6 to 10% has a long shelf-life when appropriately packaged. Another variant of gari is *attieke* which is produced in the Ivory Coast.

Gari was mainly a product of cottage industries. Modern high capacity gari processing plants had appeared on the West African industrial market in the last two decades (Ayernor, 1981; Idusogie *et al.*, 1977). The adaptability of traditional processes to modern and advanced technologies is a positive factor in industrialization based on local raw materials and products. The unit operations used in the processing of cassava into gari are many and each of them needs a careful control in order to yield a product of good quality (Figure 2).

The first operation is peeling of the roots which at the rural industrial level is done by hand. On a relatively large scale, hand peeling is labour-intensive.and attempts have been made to mechanize cassava peeling with varying degrees of success (Ayernor, 1981).

After peeling and trimming, the roots are thoroughly washed to remove dirt which would otherwise impair the quality of the end-product. Mechanization of washing on a large scale does not present problems. It is done in rottery drums with large quantities of water (Ayernor, 1981).

4. State of the art on Gari production

The technology profiles on the production of gari and industrial peeling of cassava are to illustrate the state of the art on a major cassava transformation process and to point out some of the constraints, especially the peeling of cassava (Table 3).

The peeling of cassava, the first stage in cassava processing in general, remains a bottleneck. Hand-peeling is slow and labour-intensive though it yields the best results. Attempts made to mechanize cassava peeling as a means to increase the production rate and minimise labour intensity have met only with marginal success (Ayernor, 1981). Particular attention must be given to machinery design that would facilitate not only batch but also continuous feeding of material into the peeling machine, efficient peeling in terms of rate and quality as well as continuous discharge of the peeled material from the machine. The feasibility of chemical peeling or the combination of chemical treatment and mechanical peeling should also be investigated.

Table 2
Technology Profile of Gari production

TECHNOLOGY ANALYSIS:	TECHNOLOGY PROFILE
Reference:	
SUBJECT	DEFINITION/DESCRIPTION
Resource	Cassava
Identification	Gari Processing
Objectives	Efficient processing of cassava into Gari to achieve high product yield, quality, storability, proper packaging and marketing.
Technologies	Available technologies: Village cottage technologies Intermediate technologies Advanced technologies.
The Process	Raw cassava root i Peeling ii washing iii grating (rasping, granulation) iv fermentation v dewatering vi decaking vii garification viii drying (dehydration) ix size-sorting x packaging.
Principles	Major principles: Granulation, particulation Starch gelatinization Dehydration Removal of toxic cyanogenic glucosides.
Inputs	Physical inputs: Cottage processing assemblage Tools, implements Equipment, processing plant Energy (sources): fuelwood, charcoal, coal, gas Energy (requirements), e.g. Kilocalorie per tonne of gari produced: i.n.a. (information not available). Packaging: Traditional, cloth, papersacks, flexible packaging "polythene bags".
Manpower	Varied: Household (Mother and children) Intermediate and advanced processes need more labour.
Remarks	PEELING: needs technological improvement ENERGY: more information needed. See technology profile of cassava peeling See comparison of peeling efficacy by (a) traditional (b) intermediate and (c) advanced technologies See comparison of technologies.

Table 3
Technology Profile of Cassava Peeling

TECHNOLOGY ANALYSIS:	TECHNOLOGY PROFILE
Reference:	Sub-analysis - Peeling of Cassava
SUBJECT	DEFINITION/DESCRIPTION
Resource	Cassava
Identification	Peeling of Cassava.
Objectives	Efficacious peeling of cassava for industrial processes.
Technologies	Available technologies/experiments: Hand peeling Mechanical peeling Lye-peeling.
The Process	Available processes: Hand (manual) peeling Rotary drum: abrasive attritive peeling with metallic brushes Chemical - (lye) treatment followed by abrasive peeling.
Principles	Underlying principles: Complete removal of peel via cambium layer Systematic removal of peel by abrasion Chemical digestion of peel followed by abrasion.
Inputs	Various: Labour intensive (manual) Mechanical, electrical Chemical/Mechanical.
Manpower	Unskilled, semi-skilled.
Remarks	The peeling processes require upgrading and promotion.

The grating process is far from standardized. It is the step that establishes the granulation and the particular nature of the gari products. Industrial processes need to standardize this mechanical operation to ensure particulate uniformity of the product.

Fermentation relies on natural microflora. In processing industries it may be necessary to identify the important micro-organisms and use them to develop cultures for inoculation and to minimise the range of microbes, especially contaminants. This would ensure a product of standardized flavour and acidity.

The degree of dewatering of cassava pulpand the roasting stage have a rather complex interplay. Moisture content in the cassava grits, the amount of material to be garified as a batch unit, and temperature control have a combined effect on the quality of the product. Process improvement programmes in industries must take note of the above factors that are relative to material and energy balance in these unit operations.

Cassava for Processing
100 Units Raw Cassava Roots
|
Peeling
|
Washing
|
Cutting
|
Grating
|
Fermenting
|
Dewatering
|
Sieving
|
Roasting, Frying (Garifying)
|
Sieving
|
Packaging
|
GARI

(25 units of gari, 8% moisture content
Extraction ratio: 4:1)

Figure 2
Flow sheet of gari production
100 units raw cassava roots

Conclusion

We have examined the state of the art in the production of cassava flour and gari and especially the peeling operation. The technology profiles are intended to point out general and critical points on the process line. The objectives of each unit operation in the overall process have been illustrated.

Any upgrading of a given unit operation in the traditional process must be linked with the objectives of process and product improvement. The production of cassava flour and gari brings about a reduction in moisture content from over 65% to below 10%, and cyanide reduction to innocuous levels (Ayernor, 1981, 1985) (Tables 4 & 5). Thus, any improvements in upgrading the village technologies must aim at production facilitation. In general, peeling the first stage in cassava processing remains a bottleneck. Its upgrading will contribute to process facilitation in modern industrial productions.

The processing of a generally acceptable cassava flour suitable for various forms of food utilization would be commendable. Production of cassava flour by simple sundrying does not effect considerable reduction in cyanogenic glucosides from the product as compared to the retting process (Ayernor, 1985). However, the alternative retting process leaves a strong fermentation odour in the product. The other pathway (Figure 1 (II)), where the grated cassava is fermented can be improved through enzymatic action to effect cyanide detoxification with minimal fermentation.

Gari as mentioned above, is a product obtained from one of the most advanced technologies in cassava processing. It appears that the major thrust in technological innovation is mechanization. There is a need for the design and manufacture of intermediate-capacity processing equipment for gari processing in rural industries.

Collective endeavours in upgrading cassava processing must critically examine the state of the art in the traditional setting. This would make it possible to identify the areas that needed upgrading to meet modern demands for agro-industrial processing in rural development.

Table 4
Changes in moisture content during Gari production

Operation	Product	Moisture (%)
Grating	Slurry (pulp)	60-65
Fermentation	Fermented pulp	-
Dewatering	Pulp	47-50
Roasting	Semi-dry gari	30-35
Final drying	Gari	8-10

Table 5
Cassava detoxification during Gari production

Process	Material	HCN (µg/kg)	% Detoxification
-	Whole cassava root	306	-
Peeling	Peeling	660	-
	Peeled root	184	-
Grating	Pulp	104	16-92
Dewatering	Pulp	52	71.74
Fermentation	Pressed juice	86	53.26
Roasting	Gari	10	94.56

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