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Essers, A.J.A.; Nout, M.J.R.

Raimbault M. 1995. Importance des bactéries lactiques dans les fermentations du manioc. In : Transformation alimentaire du manioc. Agbor, Brauman et al Ed., Doc Orstom Colloques et Séminaires Paris, 1995, p. 257–258

Raimbault M. 1996. "Valorisation des produits et sous-produits de la petite et moyenne industrie de transformation du manioc en Amérique Latine". Projet STD3 TS3-CT92-0110. Opération n°3 "Etude des bioconversions de farines et amidons par fermentation". Rapport final. Document ORSTOM

Soccol C., Iloki I., Marin B., Raimbault M. & Lebeault J. M. 1994. Comparative production of alpha amylase, glucoamylase and protein enrichment of raw and cooked cassava by *Rhizopus* strains in submerged and solid state fermentations. J. Food Sci. Technol., 31, (4), 320–323

Soccol C., Marin B., Raimbault M. & Lebeault J. M. 1994. Breeding and growth of *Rhizopus* in raw cassava by solid state fermentation. Apl. Microbiol. Biotechnol.41, 330–336

Soccol C., Marin B., Roussos S. & Rimbault M. 1993. Scanning electron microscopy of the development of *Rhizopus arrhizus* on raw cassava by solid state fermentation. Micol. Neotrop. Apl., 6, 27–39

Soccol C., Rodriguez L.J., Marin B., Roussos S. & Raimbault M. 1993. Growth kinetics of *Rhizopus arrhizus* on raw cassava by solid state fermentation of treated cassava. Biotechnol. Techniques, 7, (8), 563–568

Soccol C., Stertz S., Raimbault M. & Pinheiro J.M. 1995. Biotransformation of solid waste from cassava starch production in solid state fermentation. Part I : Screening of strains. Part II : Optimization of the culture conditions. Part III : Scale up studies in different bioreactors. Arq. Biol. Tecnol., 38, (4), 1303–1326

Takitane I.C., Vilpoux O., Cereda M.P. & Chuzel G. 1994. Present uses of cassava starch in Brazil. International Meeting on Cassava Flour and Starch - CIAT, Cali, 11–15/01/94

Vilpoux O. & Cereda M.P. 1995. Caracterizaçao das fecularias no Brazil, Centro Raizes Tropicais, 72 p.

Vilpoux O., Cereda M.P., Chuzel G. & Henry G. 1994. Caracterização das empresas de polvilho azedo em Minas Gerais. Rapport, Centro Raizes Tropicais, 1994, 67 p.

Vilpoux O., Cereda M.P. & Silva A.P. 1995. O mercado de amido no Brazil. Relatorio, Centro Raizes Tropicais, 53 p.

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Application of microbial starter cultures for new and traditional cassava products

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Abstract/Résumé

Traditional fermented cassava products are inventorized; only few novel products exist. Some research on traditional fermentation of cassava has been done, but this has rarely led to application of (improved) starter cultures in commercial practice. Possible reasons for this lack of implementation, such as shortage of insight into consumer demand and economic feasibility, are discussed. Basic questions on objectives, demand, and technological and organizational issues, need for viable implementation of new fermentation technology, are formulated; and ways for applybiotechnology to cassava processing are suggested.

Key words/Mots clés: cassava processing, fermentation, starter culture

Utilisation d'inoculums de depart microbiens dans les produits nouveaux et traditionnels a base de manioc

Une liste de produits traditionnels fermentés à base de manioc est présentée; il existe très peu de produits nouveaux. Quelques recherches ont été faites sur la fermentation traditionnelle du manioc, mais elles ont rarement abouti à l'application d'inoculum de départ (améliorés) dans la pratique. Les raisons possibles pour ce manque de concrétisation telles que le manque d'informations concernant la demande des consommateurs et la faisabilité économique, sont discutées. Les questions fondamentales au sujet des objectifs, la demande, les problèmes technologiques, d'organisation et économiques, nécessaires à la mise en oeuvre viable de la nouvelle technologie de fermentation, sont formulées. Des propositions d'application de la biotechnologie à la transformation du manioc sont faites.

Introduction

Cassava roots are consumed shortly after harvest, or processed, e.g., by drying, grating, roasting, transformed by fermentation, or by a combination of these processes. This has led to a multitude of products. An estimated 75% of the cassava for human consumption in Africa is fermented (Nweke 1991). Reasons for cassava fermentation may be a.o. improved storability, modified texture or removal of toxins. Fermentation in traditional processes often occurs spontaneously by microorganisms present in the environment. This may have the disadvantage of leading to unpredictable product quality and even food spoilage or toxin formation. Such disadvantages can be avoided by optimizing and controlling the fermentation conditions. The initial dominance of certain microorganisms, provided by a starter, can play a crucial role herein.

In principle, a starter contains a high concentration of live microorganisms which is added to food raw materials with the intent to speed up and direct a process of fermentation. Starter cultures are applied both consciously and unconsciously in traditional fermentations. At the household level several starters are practicable. These include batches of previously fermented product (also referred to as back-slopping), e.g., yoghurt, or specially prepared dry starters such as the Ghanaian inoculation belt; and Indonesian *ragi* and *usar*. An example here in Uganda is the custom of smearing the scraped-off mycelium of solid-substrate fermented (ssf) roots on the floor where the next batch will be fermented, or using the same gunny bag for covering the next heap (Essers et al. 1995).

Food processes involving microflora have always attracted attention of food scientists and technologists, which led to a number of improvements in processes and (new) products, but this is not the case with cassava. Although some traditional cassava fermentation processes have been studied, this acquired knowledge is not applied. This is possible so because:

- There was no demand for improvements, or the improvements did not coincide with demands;
- Laboratory-based improvements were not reproducible in practice;
- Lack of economic feasibility;
- Traditional processing has mainly been studied for academic, not economic interest;
- Implementation has not yet been sought: Little scientific glory can be obtained from the muddling-through process of adapting improved starter cultures to other people's interest, and who cares anyway?

Some traditional fermented cassava products

- Heap-fermented flour (from SSF roots, staple) in Uganda, Tanzania, Zaire and Mozambique
- Waragi (distilled beverage) in Uganda
- Cassiri (opaque beer) in Surinam
- Tapé (sweet soft delicacy) in Malaysia and Indonesia
- Farinha seca (roasted granules, convenience staple) in Brazil
- Gari (roasted granules, convenience staple) in West Africa
- Attièke (steamed granules, staple) Côte d'Ivoire
- Lafun or Kondowoole (flour from soaked cassava, staple) in Africa
- Foofoo (mashed or grated soaked cassava, staple) in West Africa
- Polvilho azedo (sour starch, for textured food uses) in Brazil and Colombia
- Chikwangue or Baton de manioc (steam-boiled paste from soaked roots, staple) in Zaire and Cameroon
- Malemba (short-soaked slices of blanched cassava, snack) in Malawi and Zaire

New fermented products

- Large scale ethanol production in Brazil
- Mycelial protein (enriched mass by SSF) in Burundi (Daubresse et al. 1987)
- Single cell protein (enriched mass by soaking) in Thailand (Varavinit et al. 1996)

Use of starter cultures for traditional products

Ragi, a dry pelleted starter for tapé in Malaysia and Indonesia, is made on a cottage commercial scale already for a long time. Selection of microorganisms by laboratory methods does not take place, but empirical product improvement is widely practised through variation of ingredients.

A fast process for gari production was proposed by Sokari & Karibo (1996). Flavour development was sped up by adding older fermentation juice. We do not know if this process has been put into practice or exploited commercially. If so, it may be known under the name 'FIIRO process'.

The microflora of sour starch in Brazil and Colombia has been studied, and improved starters have been developed, but they are not yet in use outside the laboratory. It seems that the irregular quality is mainly due to the sun-drying, not to the fermentation stage.

Reasons for the lack of application of starter cultures in specific products

Gari processing

The level of endogenous linamarase, released during the grating of roots, is sufficient to degrade the linamarin within a short period. The fineness of grating is a more important determinant of residual linamarin levels in rapidly fermented pulp, compared with the addition of the enzyme linamarase (shown by Giraud et al. 1993; and seen in our own-unpublished - experiments).

The major importance of the fermentation is for development of flavour, taste and texture. Funding from development agencies is easier to obtain for dramatic health considerations than for adding flavour to the product.

Scales of operation are small: due to transport problems of the bulky, perishable roots, processing is done near the production area. This does not allow increased centralization of the processing, which would make technological improvements economically interesting to entrepreneurs.

Protein enrichment

Economic viability. For protein enrichment of cassava by e.g. fungal fermentation, a nitrogen source and other nutrients should be added, which involves financial sacrifice. The cheapest source is nitrogen fertilizer (NH_4NO_3). The fermentation product can be used for animal feed, but is not as cheap as vegetable protein sources such as soy residues.

For human food applications, a food grade nitrogen source as well as hygienic processing equipment would be required to comply with official health standards, which will further increase the price.

Crude protein level in dry cassava is about 4%. As during fermentation approx 20–50% of the carbohydrate source is degraded and used as energy, inflated figures for protein levels on dry weight basis due to fermentation occur, which have to be interpreted with some caution.

Ethanol

Several large scale plants for ethanol for fuel have been operational in the seventies in Brazil. However, this has stopped because of not being economically viable under present conditions (Kennedy et al. 1987).

In 1996 a factory has started production of alcohol from cassava in Nigeria with an estimated production of 4 million litres per year (M. Bokanga, personal communication). Because of the lack of application in practice, this paper further discusses how research in this area could be directed to be more applicable.

Basic Questions

As with all technology, social, cultural and economic factors should be taken into account when considering the possible improvement of a fermentation. One should be keen on the demand and capacity of the present and future target groups, both the processors and consumers. Basic questions to ask when considering how to improve starter cultures relate to:

1) Objectives of the fermentation

In the first place one should find out why people ferment the cassava, what is the purpose of the fermentation process to them consciously, what could be the possible unconscious reasons, and what are the benefits that scientists see in it. What are the desired product characteristics, and between which margins are these allowed to fluctuate. What are the margins for the process in terms of flexibility in time and changing process conditions, such as surrounding temperature and humidity.

2) Demand

Why do we want to 'improve' starter cultures? If for application by traditional processors, then we should find out if they are sensitive to the same reasons as we are, or if they have different objectives and priorities. If there is no clear advantage to the processors, the exercise is likely to remain academic and turn out fruitless.

Science-driven reasons may be:

- Improving hygiene and safety of the end product (cyanogen removal; avoidance of formation of pathogens and mycotoxins; protection against infectious pathogens);
- Increasing shelf life (stability) of the end product;
- Increasing stability and uniformity of the product quality characteristics;
- Increasing nutritional value (protein quality and quantity; reducing levels of phytotoxins and anti-nutritional factors; increasing digestibility);
- Facilitating the process, reducing labour input or increasing labour flexibility;
- Speeding up a slow process;
- Increasing the economic viability;
- Increasing the attractiveness of the product;
- Making it suitable for upscaling and marketing;
- Diversification of the food basket and increasing market opportunities by product innovation and quality control.

3) Technological questions

- Is there one simple mix of micro-organisms that can give the desired characteristics?
- Is this starter stable or can it be stabilized to work under rural conditions (e.g., yoghurt or sour-dough method or Indonesian tapé dried starter culture: ragi)?
- Can the improvement be made without much effort?
- Can a simple delivery system be developed? Preferably a delivery system is dry, easily packaged, stable for at least 6 months at ambient temperature and very cheap; e.g., the Indonesian *ragi* and *usar*: dried fungal spores on plant leaves.
- The starter culture should be considered as part of the process to optimize. Do the advantages of the new starter culture outweigh the extra effort? Hereby one should also consider the benefits that can be gained by improving other process variables.

4) Similarity

For an improved or new product it is crucial how the product compares with the corresponding traditional one with respect to the above criteria and to organoleptic characteristics like taste and consistency, if for food purposes.

5) Organizational questions

Organizational questions are equally important. Who is interested in putting effort in extension, etc. to have the new method implemented? Or how are entrepreneurs stimulated? Often there is a gap between the research and practical application of the research.

If health considerations would urge a change of the process to avoid food-borne diseases by applying or modifying a starter culture, implementation is not very likely to occur, as the necessary actions would not be confined to the health sector itself. Also, an improved method may have some small advantages in all the aspects mentioned above, but each of the Ministries of Agriculture, Health and Economy have more important issues within their own domain to work on. Less sectorized institutions like NGDO's may be more apt to disseminate such technologies, but those are usually not the ones that develop them. The delivery system also determines if it can be economically distributed, possibly commercialized.

Opportunities and Recommendations

- Many examples exist of improved starters for added value products of other sources. E.g., sake, tempe, soy sauce, etc. (A network on tropical fermented foods will soon be started on Internet. For information: Rob.Nout@algemeen.lenm.wau.nl)
- In Latin America many useful fermentation practises exist which may be transferred to Africa and tested locally.
- Local solid-substrate fermentation processes should be explored further on safety aspects and opportunities for improvement. Useful techniques for food or feed (from cassava waste) may be transferred to other African countries.
- Introduction of several capacities in microorganisms (e.g. amylase and glucosidase in yeast), to simplify the starter culture. These additional tasks might weaken the survival capacity of the m.o. in nature, but in modern industry the conditions can be controlled to minimise competition.
- Fermentative treatment of waste water from cassava processing industries.
- Enzyme production using cassava waste as a cheap substrate.
- Organizational possibilities for integrating research, development and implementation need to be explored.
- It is useful to study the existing traditional fermentation practices and knowledge before they erode, even if only from a scientific point of view. This may lead not only to suggestions for improvements, but also yield valuable knowledge for eventual implementation in other areas or conditions. Study not only the microbiological, chemical and technical aspects, but also the relation with the sociological, economic, and organizational aspects and preferences of the processors and consumers.

Thorough studies may indicate the demand and directions for viable improvements, of which (improved) starter cultures may be part. After a first inventory of the traditional process, considering processors' hows and why's, a participatory approach, involving the future applicant of the improved technology, will help to direct the research and applications of results. This is principally how it works in advanced food industries, and it may serve as well with home-processors, provided that the issues of application and organizational structure, are taken serious.

References

Daubresse P., Ntibashirwa S., Gheysen A. & Meyer J.A. 1987. A process for protein enrichment of cassava by solid substrate fermentation in rural conditions. Biotechnology and Bioengineering 29(8):962–968.

Essers A.J.A., Ebong C., Van der Grift R.M., Nout M.J.R., Otim-Nape W. & Rosling H. 1995. Reducing cassava toxicity by heap-fermentation in Uganda. International Journal of Food Science and Nutrition 46(2):125–136.

Giraud E., Gosselin L. & Raimbault M. 1993. Production of a Lactobacillus plantarum Starter with linamarase and amylase activities for cassava fermentation. Journal of the Science of Food and Agriculture 62(1):77–82.

Kennedy J.F., Cabral J.M.S., Sa-Correia I. & White C.A. 1987. Starch biomass: A chemical feedstock for enzyme and fermentation processes. In: Galliard T. (ed.). Starch: Properties and potential. Critical reports on applied chemistry. Society of Chemical Industry 13:115–248.

Nweke F.I. 1994. Processing potential for cassava production growth in Africa. Collaboratory study of cassava in Africa. Working paper no. 11.

Sokari T.G. & Karibo P.S. 1996. Short duration processing for high quality gari production. Journal of the Science of Food and Agriculture 70(4):427–432.

Varavinit S., Srithongkum P., De-Eknamkul C., Assavanig A.& Charoensiri K. 1996. Production of single cell protein from cassava starch in air-lift fermenter by *Cephalosporium eichhorniae*. Starch/Staerke 48: 379–382.

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Enhancement of cassava fermentation: Tanzanian village experience

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Abstract/Résumé

Cassava is an important food security crop in Tanzania. It forms a secondary staple in ten out of the twenty five regions in the country. Traditional cassava processing methods and ways of consumption are reviewed with respect to four agro-ecological zones. Submerged and heap fermentation practices which involve microbial activity are discussed. Drawbacks and limitations of the methods in relation to safety and quality of the end products are pin-pointed. Future outlook and possible areas of research for the purpose of improvement and promotion of indigenous processing methods are highlighted.

Key words/Mots clés: cassava processing, fermentation, safety and quality