PRODUCTION OF GOOD QUALITY SORGHUM OR MILLET MALTS FOR SEMI-INDUSTRIAL FOODS PRODUCTION IN WEST AFRICA

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ABSTRACT

Sorghum or millet malt production is a traditional practice in West Africa where the product is used for lactic or alcoholic fermented beverages and infant food production. Nowadays, traditional knowledge is hardly adapted to the constraints of urban markets, due to the difficulty to implement traditional practices and to the variability of quality of the final malts to supply high quality demanding urban markets. Consequently, there is an evolution on the technologies used by the traditional producers of malt-derived products which, sometimes, is detrimental to the safety and the nutritional quality of the traditional products.

The objective of "Malto-Duras" project is to create the best conditions for small scale production and marketing of good quality sorghum or millet malt for beverages and infant foods enterprises in Benin and Burkina Faso. It is expected that the development of SMEs specialised in good quality malt production, marketing and utilization for traditional food production would improve food security of the populations in a sustainable way, facilitate the works of the women who are the traditional producers, improve the productivity and the access to the profit-earning but high quality demanding urban markets and increase the income of the producers.

The present paper will give an overview of the implementation of this project and the results obtained in West African context.

INTRODUCTION

Malting process, which involves soaking, germination and drying, aims to change grains into malt with high enzymes and vitamins contents. The malt obtained is one of the main raw materials used to prepare different traditional alcoholic beverages such as dolo (Burkina Faso) or tchoukoutou (Benin); non alcoholic beverages such as gowé and ran-noodo. Cereal malts may also be incorporated as amylase source to infant flour to reduce the viscosity of starchy porridges and allow their preparation at high concentration, and thus, high energy density.

Malting induces important beneficial biochemical changes in sorghum grains. Indeed, soaking generates grain softening and increases water availability. The enzymes produced during germination lead to the hydrolysis of starch and proteins with release of sugar and amino acids directly available. Proteolytic enzymes improve amino acid availability, particularly lysine, methionine and tryptophan that are lacking in cereals. Malt enzymatic power is highly variable with the variety of grain and according to soaking, germination and drying conditions. Many

studies showed that, by improving phytase activity, malting process can contribute to the reduction of phytate level of grain and improve iron[5,6,7,8] and zinc bioavailability. Others studies reveal that during the germination, there is a decrease in tannins and total phenols contents. Vitamins (A, B, C, and E) content increases significantly during germination[9]. Relative nutritive value of sprouted sorghum increases from 54.6 to 63% and protein efficiency index increases from 1.5 to 1.7. Germination synthesises flavour into the malt which leads to particular flavour given to the derived products [13,14]. Malting contributes to decrease oligosaccharides (stachyose and raffinose) content by the production and the activity of galactosidase in the grain.

However, during the malting process, particularly in the case of sorghum, dhurrine is hydrolysed to produce cyanhydric acid that is accumulated into rootlets. Moreover, some minerals are lost and this phenomenon could be attributed to solubilisation and leaching during soaking and utilisation of inorganic ions by rootlets during breathing. Moreover, as optimal germination conditions (about 30°C with high humidity) correspond to optimal conditions for the growth of bacteria and moulds, malt may not have a good sanitary quality.

The nutritional and enzymatic properties developed during malting confer to the malt some characteristics that are used in brewery, for the production of complementary foods for infant and young children, but also for the production of some local acid and non alcoholic beverages. Indeed, various processes from malted cereals were developed in many countries. Manufactures were built in some countries to produce malt for different utilisations. Despite the knowledge related to malting process and the importance of sprouted sorghum and maize consumption, malting process remains a really traditional process in West Africa. To develop a malting process for African small scale industries, there is a need to investigate the traditional system of malt production, to optimise the production conditions. In addition, sorghum and millet varieties that are suitable for malting in relation to the each derived product need to be selected.

Research-development problems and objectives of the project

Malting of sorghum or millet is a traditional process used in West Africa to prepare traditional beers, non alcoholic beverages and porridges for children. In Burkina Faso, 40% (500 000 tonnes) of sorghum produced are malted for *dolo* preparation. This african opaque beer prepared from cereal malt is also named *dolo* in Mali, *tchakpalo or tchoukoutou* in Benin and Togo, *burukutu* or *pito* or *kunu* in Nigeria and Ghana, Niger and Côte d'Ivoire. Some studies[8,17,18,19,20,21,22] showed that the process of malting is weakly used at high production level. Indeed,

- Malting process is hardly feasible by family and small scale industries, and is time consuming. In Benin and especially in urban areas, *gowé* producers have forsaken the malting step during *gowé* processing as it was done in the original technology. The modified technology involved sugar addition to replace the sweetened taste induced by malting. The nutritional value of *gowé* beverage is then reduced.
- Variability of the malt process causes also variability of enzymatic power and technological properties In addition the specific quality of malt generally produced for *dolo* is not appropriate for its utilization for infant food.
- Conditions in which traditional malt is processed involve the presence of cyanogenic compounds[13, 17], mould and Enterobacteria development, which needs to be avoided for infant flour production.

Promotion of malt having good quality at small and medium scales could contribute to the improvement of the processors income, would generate jobs, facilitate utilization and

development of malt derived products such as *gowé, dolo* and complementary foods in West Africa.

The main objective of this project is to promote the production of malt from sorghum or millet with high technological quality usable for specific applications in West Africa at small and medium scale. The specific objectives are:

- To collect endogenous knowledge, in Benin and Burkina Faso, describing sorghum and millet varieties, traditional processes for malt, *gowé*, *dolo* and complementary food production.
- To assess quantitative and qualitative demand of sorghum malt in Benin and Burkina Faso.
- To develop and validate flexible processes to produce specific malts for small and medium scale enterprises and for specific applications and to improve nutritional and sanitary qualities of derived products.
- To promote malt and derived products production and marketing in Benin and Burkina Faso.

METHODOLOGY

The project was conducted by three different research development teams:

- The team of Benin including CERNA (research development centre) and ALITECH (a cottage industry enterprise).
- The team of Burkina Faso including IRSAT (research centre) and UMAO (a cottage industry enterprise).
- The supporting teams including IRD (French research centre) specifically involved in the study on the assessment of the quality of millet malt produced for the incorporation in infant flour in Burkina Faso and CIRAD involved in the development and assessment of the quality of sorghum malt.

The project was carried out in three stages:

- **First stage: Assessment of malt demand, identifying sorghum or millet varieties in use and malt and derived product processes**

During the first stage a survey was conducted in both field work countries (Benin and Burkina Faso) to collect all the data related to the socio-economical environment of the production, the varieties of sorghum or millet in use and the traditional processing methods used for sorghum malt, *gowé* and *dolo* production. Concomitantly, the potential market demand of malt was assessed and samples of malt, gowé and dolo were collected to characterise the products and assess their qualities.

- ***Second stage: optimisation of malt process***

The malting, gowé and dolo processes were optimised firstly at laboratory level and secondly at cottage industries level. Good Manufacturing Practices (GMP) were developed and transferred to the personal through training.

- ***Third stage: Production of malt and derived products, quality control and marketability***

The production will be followed at cottage industries level. The quality of the products will be regularly assessed by the research partners. The marketability of the products will be assessed.

RESULTS ACHIEVED BY THE PROJECT

Sorghum/millet varieties and quality, traditional malt and derived product processes and market demand

The survey conducted revealed that the market demand of malt in 2006 is around 22 000 tons for dolo in Burkina and 250 tons for gowé and tchoukoutou production in Benin urban area. In Benin, the annual importation of malt for industrial beverage varies between 3500 and 7000 tons. Concerning the infant flour production, the market is rather limited and has been estimated by 12 tons/year, in the case of the generalization of the practice of malt incorporation in Burkina Faso.

In Benin urban areas, colour and size are the parameters used to describe sorghum varieties. The "red big sorghum" is the most used sorghum variety for the production of malt to be processed into gowé and tchoukoutou/dolo. The "red big sorghum with white spots" and the "red small sorghum" are also used. Kayodé (2006) has identified ten (10) sorghum varieties that are used for tchoukoutou production. The varieties used for tchoukoutou like chabicouma1 and agbani have significantly bigger kernels (Thousand kernel weight of 42 g).

In Burkina Faso, six (06) sorghum varieties and seven (7) millet varieties were discovered for their ability to be used for dolo and complementary food production respectively. Among the sorghum varieties, five (05) varieties are white and one (1) is red. Five (5) millet varieties are "white" ones; the two (02) others are "black".

Only two sorghum grains over 18 collected in the traditional malt production area in Benin have an aflatoxin B1 level over 8 µg/kg (Codex Alimentarius recommended limit). However, aflatoxin B1 could be detected in most traditional derived malts, among which six had levels over 8 µg/kg, with two over 28 µg/kg. It appeared thus clearly that the traditional processing promotes the production of aflatoxins during malting.

Ten (10) malt samples collected in traditional infant flour production units or at IRD in Burkina were aflatoxin B1 free, except one sample of red sorghum malt which contained about 8 ppb. Ten sorghum malt samples over 15 collected at *dolo* production units in Burkina Faso contained aflatoxins with four over passing 8 µg/kg and one containing 55.6 ppb aflatoxin B1.

Total aerobic germs, coliforms, yeast and filamentous fungi of malt in Benin and Burkina Faso are higher than the Codex Alimentarius recommended limits, showing that sanitary quality of traditional malt is not good for infant food formulation.

Traditional malting processes were investigated both in Benin and Burkina Faso. In all cases, it involved three main operations which were: soaking, germination and drying. The duration and the conditions of each operation were highly variable, which resulted in a highly variable quality of the malt or derived products. In particular, the amylolytic activity was low and very high malt incorporation rates were needed in infant flours in order to prepare porridges with the high energy density that is required to adequately feed young children.

Improvement of the traditional process of malt, gowe and dolo production

Multivariate analysis of the quality characteristics of 19 malts from sorghum and 4 from millet produced in the same conditions at laboratory level allow ranking them according to their end uses. Five (5) varieties of sorghum were found really suitable in Benin (*Sotakaman*, *Zomoaha2*, *Natisoya1*, *Chassisoya*, *Chabicouman*), and two in Burkina Faso (*Kioedre*, *Mewin*) for beer production. Millets were identified to be appropriate for infant flour production. Duration of water absorption of sorghum or millet grain (6-16hr) during soaking at different temperatures depends on the vitrosity of the grains. Amylase activities of sorghum grains increase with the duration of germination with an optimum after 55-60h of germination before decreasing. Drying

reduces by a half the amylases activities of malt. These optimal conditions need to be implemented at cottage industry level.

Technology Transfer to cottage industry and promotion of malts at commercial level

Benin

Improved malting process has been transferred to ALITECH Industry by using a newly built tiled malt germinator. Production of malt with the equipment reveals that optimum time for soaking is 12h, optimum time for germination is 48h and drying could be done at 45°C during 17 to 24h. The malt obtained is characterised by diastasic activity of 212 UPD (SD = 0.03) versus 98 (SD = 37) for malt produced in traditional process conditions. The α/β amylase ratio for malt produced with optimized process is 1.56 (SD = 0.15) versus 0.74 (SD = 91) obtained with malt produced in traditional process conditions. The malt obtained with optimized process has a good and constant physico-chemical quality compared with the malt obtained from traditional process but its microbiological quality still needs to be improved for infant flour preparation. Gowé obtained with improved process malt has a pH (3.8 ± 0.1) and a titratable acidity (3.7 ± 0.3) similar to gowé produced with traditional process malt. Sensory characteristics of the improved gowé are also similar compared with the gowé prepared with traditional malt. In addition, the improved gowé is sweeter than the traditional one.

Burkina Faso

A standardised process was tested by IRD in Burkina Faso to produce millet malt for incorporation in infant flour. It enables to obtain malt which has relatively high and constant fluidifying activity. However, microbiological quality of malt for weaning flour production still needs improvement.

Further studies will focus on the mycotoxin content of improved malt for infant food, gowe and dolo production as well as the commercial interest of the production at cottage industry level.

REFERENCES

1. Aisien, A. O. (1982) Enzymic modification of sorghum endosperm during seedling growth and malting. *Journal of Science, Food and Agriculture* 33, 754-759.
2. Ahmed, S. B., Mahgoub, S. A. and Babiker, B. E. (1996) Changes in tannin and cyanide contents and diastic activity during germination and the effect of traditional processing on cyanide content of sorghum cultivars. *Food chemistry* Vol 56, n° 2, pp. 159 - 162.
3. Sripriya, G., Antony, U. and Chandra, T. S. (1997) Changes in carbohydrate, free amino acids, organic acids, phytate and HCL extractability of minerals during germination and fermentation of finger millet (*Eleusine coracana*). *Food Chemistry* Vol. 48, n° 4, 345-350.
4. Uvere, P. O., Adenuga, O. D., and Mordi, C. (2000) The effect of germination and killing on the cyanogenic potential, amylase and alcohol levels of sorghum malts used for burkutu production. *J Sci. Food Agric* 80: 352 - 358.
5. Malleshi, N. G., Desikachar, H. S. R. and Venkat Rao, S. (1986) Protein quality evaluation of a weaning food based on malted ragy and green gram. Qual. PLANT. *Plant Foods Hum. Nuta*. 36, 223 - 230.
6. Elkhalil, E. A. I., El Tinay, A. H., Mohamed, B. E. and Elsheikh, E. A. E. (2000) Effect of protein digestibility of sorghum flour. *Food chemistry* 72, 29 - 32.
7. Mahgoub, S. E. O., Elhag, S. A. (1998) Effet of milling, soaking, malting, heat- treatment and fermentation on phytate level of four Sudanese sorghum cultivars. *Food chemistry*. Vol 61. N°12. P77 - 80.

8. Traoré, T. et al., 2003. Variation de l'activité a-amylasique et des teneurs en certains nutriments et facteurs anti-nutritionnels au cours de la préparation de farines de céréales germées par les dolotières de Ouagadougou, 2ème Atelier International "Voies alimentaires d'amélioration des situations nutritionnelles en Afrique de l'Ouest: le rôle des Technologues alimentaires et des nutritionnistes", Univ. Ouagadougou/Univ. Wageningen/IRD/FAO, Ouagadougou, Burkina Faso.
9. Taur, A. T., Pawar, V. D. and Ingle, U. M. (1984) Effect of fermentation on nutritional improvement of grain sorghum (sorghum bicolor (L) Moench). Indian *J. Nutr. Diet.* 21: 129.
10. Wang, Y. D. and Fields, M. L. (1978) Germination of com and sorghum in the home to improve nutritive value. *J. Food Sci.* 43: 1113 - 1115.
11. Hough, I. S., Briggs, D. E. and Stevens, R. 1971. Malting and brewing science. London. Chapman and hall. 98p.
12. Savita, S., Nagi, H. P. S. and Sekhon, K. S. (1988) Effect of blending laboratory sprouted grains on milling and baking properties of wheat. *Journal of Food Science and Technology* 25, 330 - 334.
13. Lasekan, O. O., Lasekan, W. O. and Idowu, M. A. (1997) Flavour volatiles of “malt. beverage” from roasted sorghum. *Food chemistry* Vol.58, 341 - 344.
14. Mtebe, K., Ndabikunze, B. K., Bangu, N. T. A. and Mwemezi, E. (1993) Effect of cereal germination on the energy of togwa. *Food Sciences and nutrition.* 44, 175 - 180.
15. Daiber, K. H. (1975) Enzyme inhibition by polyphenols of sorghum grain and malt. *Journal of Science, Food and Agriculture*. 26, 1399-1411.
16. Journe B. 1997. Production, vente et consommation de bière de mil (dolo) à Ouagadougou (Province de Kardiogo, Burkina Faso), aspect économique, technique et culturel. Mémoire de maîtrise de géographie. Université Paris IV, Sorbonne.
17. Traoré, T., Mouquet, C., Icard-Vernière, C., Traoré, A. and Trèche, S., 2004. Changes in nutrient composition, phytate and cyanide contents and a-amylase activity during cereal malting in small production units in Ouagadougou (Burkina Faso). *Food Chem.*, 88(105-114).
18. Michodjèhoun-Mestres L., Hounhouigan D.J., Dossou J. Mestres C. 2005. Physical, chemical and microbiological changes during natural fermentation of "gowé", a fermented beverage from sprouted or non-sprouted sorghum (*sorghum bicolor)* in west-africa. African Journal of Biotechnology. (In press).
19. Kayode P., Adegbidi A., Linnermann A., Nout R., Hounhouigan J.D. 2003. Consumers’ quality perception of farmers’varieties of sorghum and derived foods in Benin. 2ème Atelier International "Voies alimentaires d'amélioration des situations nutritionnelles en Afrique de l'Ouest: le rôle des Technologues alimentaires et des nutritionnistes", Univ. Ouagadougou/Univ. Wageningen/IRD/FAO, Ouagadougou, Burkina Faso.
20. Houndélo M.E.S. 2004. Amélioration de la qualité et test de mise en marché du *gowé*, pâte fermentée à base de sorgho. Mémoire de fin d’étude d’ingénieur. INP/ESA Yamoussokro – FSA/UAC Bénin.
21. Zohoungbogbo M.A. 2004. Etude comparative de deux technologies de production de gowé à base de sorgho au Bénin. Thèse de fin d’étude d’ingénieur agronome. FSA/UAC. Bénin.
22. Agbigbey-Tasas R. 2003. Contribution à la valorisation des aliments traditionnels béninois : étude comparative de deux technologies à base de sorgho malté pour la production de gowé. Thèse de fin d’étude d’ingénieur agronome. FSA/UAC. Bénin.