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# Biochemical, Microbial and Processing Study of *Dèguè* a Fermented Food (From *Pearl millet dough*) from Burkina Faso

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**Abstract:** *Dèguè* was a traditional fermented food (*pearl millet dough*) which consumed in Burkina Faso. In this work, the traditional processing of pearl millet into *dèguè* was investigated in 18 traditional production units. This study was followed in Ouagadougou and Bobo-Dioulasso. The main steps of diagram of production were dehulling, winnowing, washing, drying, milling, sieving, kneading, cooking, pounding, shaping and fermentation. Before fermentation, crude protein, crude fat, ash, starch and carbohydrates content were respectively 5.43; 3.00; 1.13; 33.37 and 41.81 %. After 72 hours of fermentation only protein content (6.12 %) was increased; starch content was(23.6 %) decreased. pH and titratable acidity were respectively 6.75 and 0.12 before the fermentation and after 72 hours pH (4.49) was decreased and titratable acidity (0.57 g of 100 grams of lactic acid) was increased. Microbiology analyses indicated that the number of lactic acid bacteria, yeasts and moulds increased during the course of fermentation. The number of coliforms was decreased slightly after 72 hours of fermentation.

**Key words:** *Dèguè*, fermentation; traditional diagram of production, lactic acid bacteria

## INTRODUCTION

More than 60 % of the total world food production is provided by cereals which, along with pulses and oils seeds, contribute significantly to the dietary protein, energy, mineral and vitamin requirements of the world population in general and the developing world in particular (Chavan and Kadam, 1989a, b). As a cereal for human food, pearl millet sustains the lives of the poorest people in Africa and Asia, and is often considered highly palatable and a good source of protein, minerals and energy.

The processing technologies employed for cereal commonly found in the developing world include cooking, milling, fermentation and combinations of these. Fermentation is the most commonly practiced particularly in Africa, although the type of raw material, type and conditions of fermentation and sensory qualities of the finished products, may varied from culture to culture. Fermentation is especially important to the developing world because it is inexpensive and simple method of improving the nutritional and organoleptic qualities of otherwise monotonous cereal products (Hesseltine, 1983; Cooke *et al*., 1987; Chavan and Kadam, 1989a). It does not require expensive equipment or special expertise and can be achieved in a very short period of time (Lay and Fields, 1981). In high temperature and humid regions such as Africa, where cooling facilities are not readily available, fermentation provides a cheap but effective of food preservation (Hesseltine and Wang, 1979; Umoh and Field, 1981; Chavan and Kadam, 1989a).

In Africa most of fermented foods are based on cereals. Most of these fermentations are spontaneous, and involve lactic acid bacteria, yeasts or mixture of these as the functional microorganisms. A wide range of cereal-based fermented foods exits such as *mawè* in Benin (Hounhouigan *et al*., 1991), *Kenkey* in Ghana, *poto-poto* in Congo (Blandino *et al*., 2003), *ogi* and *Kwunu-zaki* in Nigeria (Oyewole, 1997), *injera* in Ethiopia, *uji* and *togwa* in Tanzania, *kisra* in Sudan (Tomkins *et al*., 1998).

In Burkina Faso many fermented foods are prepared with pearl millet that is still prepared in small-scale and family sized processing units. The mains fermented foods from pearl millet in Burkina Faso are: *ben-saalga* and *ben-kida*, gruels and the balls of *dèguè*. A great deal of information about processing, biochemical and microbiological characteristics of *ben-saalga* and *ben-kida* exists (Tou *et al*., 2006). But there is no information about *dèguè*. *Dèguè* is the name in bambara, it called *fura* in mooré and *tchobal* in fulani (bambara, mooré, fulani are language of main etnics groups in Burkina Faso). *Degue* can consume by children, adults and old persons and it was accompanied with sugar, milk, honey, tamarind juice, citron juice etc the balls of *dèguè* are sold to factory workers and workers sites by small-scale producers. The study was interested two towns of Burkina Faso: Ouagadougou and Bobo-Dioulasso. There were the two mains centers of Burkina Faso.

In the present work, the technology of the traditional processing of pearl millet (*Pennisetum glaucum*) into *degue*, physical chemical and microbiology parameters are presented. The aim of this study was to better know of this traditional product, in order to further develop adapted and simple techniques to improve the nutritional and microbiology qualities of *degue*.

## MATERIALS AND METHODS

**Raw material and aromatics ingredients used in *dèguè* production:** The raw material used in the preparation of *dèguè* in the traditional production units was pearl millet (*Pennisetum glaucum*) together with ingredients like aromatics ingredients as ginger, pepper and others like salt and dried flour of *Ipomea batata*. The producers purchased these ingredients in the local market.

**Selection of traditional producing units:** An exhaustive inventory of producers was performed in the old sectors of Ouagadougou and Bobo-Dioulasso (360 km of *Ouagadougou*). The inventory identified 34 producing units in Ouagadougou and 30 producing units in Bobo-Dioulasso.
A total of 9 traditional producing units (TPUs) in each town were randomly selected from a list of 34 and 30 producing units respectively in Ouagadougou and Bobo-Dioulasso, for detailed characterisation of the different steps of the processing.

**Technology of *dèguè*.:** To describe the technology of production of *dèguè*, the time of each step was taking, all ingredients and intermediary product were weighting. Chronometer was using for duration and electronic balance was using for the weight.

**Microbiology analysis:** Sample treatment, packing and preservation: samples were collected in the 9 randomly selected producing units in each town and were brought at laboratory for microbiology analyses and proximate composition. After 0, 24, 48, 72 h of fermentation, one plastic bag of *dèguè* was taken for microbiological analysis. Sub-Samples were used for moisture determination. Portions (100 g) were used for measurement of colour and determination of pH, titratable acidity. The remainder of the sample was freeze-dried and packed in polyethylene bags, and held at-50°C for latter analysis.

**Enumeration of lactic acid bacteria, yeast and moulds:** during 72 hours of fermentation the microbial count were determined. Ten grams (wet wt) of *dèguè* was added to 90 ml sterile 0.1 % (w/v) peptone water contained in a new plastic bag. The homogenization was doing by mixer during 120 seconds and further dilutions were made as required in 0.1 % (w/v) peptone water.
Mesophilic lactic acid bacteria were counted in MRS agar petri dishes containing 0.1 % (w/v) Natamycin ("Delvocid") overlaid with MRS agar without Delvocid. Petri dishes were incubated at 30°C for 48 h in the anaerobic conditions.
Yeasts and moulds were enumerated in Yeast Glucose Chloramphenicol agar (YGC). The plates were incubated at 30°C for 3 days.
Coliforms were enumerated in Bouillon Lactosé Bilié au Vert brillant (B.L.B.V.B) and were incubated at 30°C for 3 days to count total coliforms.

**pH and titratable acidity:** During 72 h of fermentation, pH and titratable acidity (% lactic acid) were measured. The pH was given according to the potentiometric method 943.02 (AOAC, 1990) by using the electrode of a pH meter (WTW pH 526).
For the determination of titratable acidity, we proceeded by a titrimetric dosage (Obiri-Danso *et al*., 1997).
Moisture content, protein, lipids, starch, and ash determination.

**Moisture content:** Moisture content was estimated by desiccation with the drying oven at 103°C (method 925-10, AOAC, 1990).

**Lipids content:** Fat content is made according to the method of extraction by the soxhlet Aa 4-38 (AOCS, 1990) by using hexane as solvent.

**Crude protein content:** The total proteins content were determined by the method of KJEDAHL Ba 4c-87 (AOCS, 1990).

**Ash content:** the ash content was estimated by incineration with the furnace at 550°C (method 923-03, AOAC, 1990).

**Starch content:** the dosage of the starch was carried out according to spectrometric method described by (Jarvis and Walker, 1993).

**Carbohydrate content:** the content of total carbohydrates was determined by difference (Egan *et al*., 1981) according to the formula:
H.C (%) = 100 – [% water + % proteins + % lipids + % ashes].

**Colour determination:** Colour parameters L, a, and b representing whiteness, redness and yellowness, respectively were measured using a DR LANGE Microcolor Arbeitsstandart chromameter calibrated with a standard white tile (X= 84.2; Y= 89; Z= 93.8). Two measurements were made of the surface of each sample.

**Statistical analysis:** All determinations were in duplicate and repeated 3 times. The data were analyzed by Excel.

## RESULTS AND DISCUSSION

**Description of the traditional processing of pearl millet into *dèguè*:** *Dèguè* is a popular traditional, fermented millet product, still prepared commercially on a small artisan scale in Burkina Faso. Pearl millet was the main material of production of *dèguè*. The daily quantity of pearl millet usually processed into *dèguè* was around 2.82 kg and 2.19 kg respectively in Ouagadougou and Bobo-Dioulasso (Table 1). The production of *dèguè* was lower than the production of *ben-saalga* which quantity of pearl millet was around 6.8 kg (Tou *et al*., 2006).

**The main steps of *dèguè* production are:** Dehulling, winnowing, washing, milling, sieving, mixing, cooking, pounding, shaping, wrapping in dried flour and fermentation (Fig. 1). All steps were performed under natural conditions of producers except dehulling and milling which were not performed by the producer himself but in small community milling units and small community dehulling units.

**Dehulling:** It is the first step of transformation of pearl millet into *dèguè*. It consists to eliminate hulls. Two methods of dehulling were using by producer: small community dehulling units and the mortar.

**Winnowing**: This step was not necessary. It was doing with metal sieve or through a bambou fibre. It consists to spare hulls and grains.

**Washing:** The grains were washed with potable water to eliminate all impurity. It was doing three times.

**Drying:** The grains were dried for few minutes at sun after the step of washing.

**Milling:** This step consists to transform grains into flour. Two techniques were using in Burkina Faso: small community milling units, mortar. At Ouagadougou, producers added ingredients for milling.

**Sieving:** Flour was sieved with metal sieve. The residues were washing and adding in the sieve flour.

**Kneading:** It consists to add some water and to knead the flour. This step transforms flour into dough for cooking. The technique of kneading depends to the method of cooking. The average quantity of water used during the kneading was 250g in the method of steam and 200g in the method of immersion per kg of raw millet. For giving the aspect of granules, producers added some dehulled and washed millet grains during kneading.

**Cooking:** Two different methods of cooking noticed in Ouagadougou and Bobo-Dioulasso. In Ouagadougou all producers used the method of immersion (100 %). In Bobo-Dioulasso the great part of producers used the method of steam (88.88 %).

Table 1: Mass balance of dèguè processing method

| | Ouagadougou | | Bobo-Dioulasso | |
|---|---|---|---|---|
| | TPU | Mean Value (g) | TPU | Mean Value (g) |
| Pearl millet | 9 | 2190 | 8 | 2800 |
| Dehulled, washed grains | 9 | 2720 | 8 | 2500 |
| Flour | 9 | 2760 | 8 | 2200 |
| Ingredients | | | | |
| Salt | 5 | 21 | 0 | 0 |
| Black pepper | 5 | 1.6 | 0 | 0 |
| Patate douce | 6 | 84.2 | 0 | 0 |
| Sugar | 5 | 189.2 | 0 | 0 |
| Final products | | | | |
| Humid flour | 9 | 3060 | 8 | 2600 |
| Cooked paste | 9 | 3850 | 8 | 2900 |
| dèguè | 9 | 4050 | 8 | 2700 |

In the cooking by immersion the producers made big balls (10-15cm of diameter) with the dough. These balls were immersed in water and boiled in a large iron pot. For balls immersion the quantity of water was 1kg per kg of raw millet. This was similar in the traditional *kenkey* process (Muller, 1970; Muller and Nyarko-Mensah, 1972) where balls are shaped, wrapped and are immersed in water for boiling.

In the cooking of steam no ball was made, dough was cooking by the steam.

In this method, two pots were using. In all the traditional processing units, the longest steps were cooking (mean 29 minutes in the steam cooking and 27 minutes in the immersion cooking). For cooking 1 kg of pearl millet 13 minutes were used in the cooking by steam and 10 minutes were used in the cooking by immersion. The steam cooking took a most time and used a most quantity of wood.

**Pounding:** The balls were pounded with motar. Only the producers of Bobo-Dioulasso used aromatics ingredients during this step. The most often used was the dried flour of *Ipomea batata* (66.66 %), followed by sugar (55.5 %), black pepper (55.5 %) and ginger (11.11 %). This is giving of product the consistency aspect.

**Shaping:** The cooked dough was shaped into little balls (5-7 cm of diameter).

**Wrapping:** The balls were wrapped with dried flour of millet or maize and stored for fermentation in the room temperature (25-37°C).

**Fermentation:** It is the last step of *dèguè* production. The time of fermentation depend to the degree of acidity that the consumer prefers. It can take one week but for most

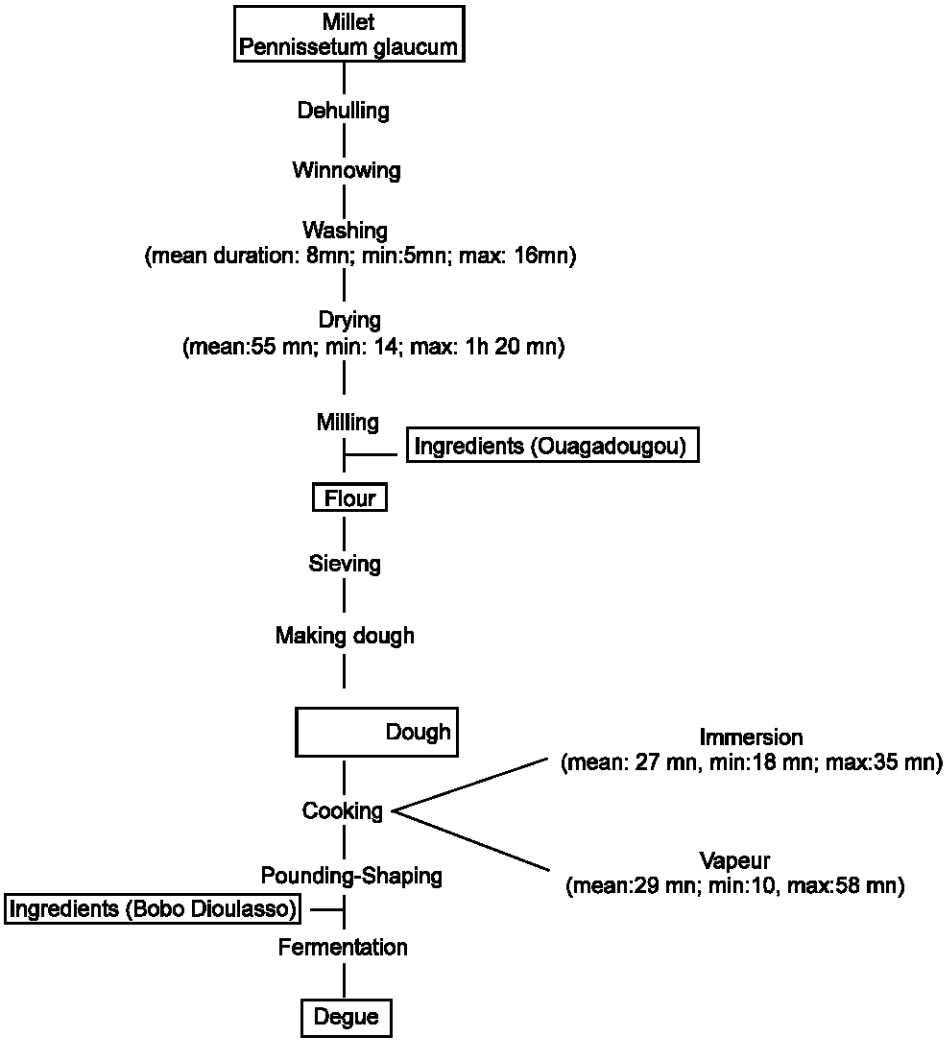


Fig. 1: Diagram of production of degue

of consumers it was 2 or 3 days of fermentation. The balls of *dèguè* were keeping at ambient temperature (25°C). At the third day the pH of *dèguè* was 450.

The processing of production of *dèguè* has not using a large quantity of water. The water was used mainly for kneading, cooking, pounding steps.

During processing, a loss of dry matter (DM) was observed, mainly during winnowing, sieving, pounding and cooking by immersion steps. During winnowing and sieving steps it is necessary to discarding hulls but sometimes the germs of millet grains followed hulls. This was used for animal feed. In cooking by immersion there was a great part of loss in the water of immersion. Water of cooking was giving animal. Quantity of water varied with method of cooking. In the method of immersion the dry matter decreased most than the other method. In the dough before cooking step, the dry matter was around 56 % and 55.7% respectively in the cooking by steam and cooking by immersion. After cooking dry matter was 57% in the cooking by steam and 47% in the cooking by immersion. But for giving *dèguè* its veritable consistency, producers added water or dried flour during the pounding step.

**Microbiological, physico chemical analysis:** Table 2 presents the evolution of pH and titratable acidity during the fermentation of *dèguè*. Before the step of fermentation the pH was 6.75 and titratable acidity was 0.12 (% of lactic acid). After 72 hours of fermentation pH was 4.49 and titratable acidity was 0.57 (% of lactic acid) Table 3 presents the result of microbiological analyses during 72 h of fermentation. The number of mesophilic lactic acid bacteria was 6.96 $Log_{10}$ (c.f.u./.g)before fermentation and 9.91 $Log_{10}$ (c.f.u. /.g) after 72 hours of fermentation. The number of yeasts and moulds was 5.93 $Log_{10}$ (c.f.u. /.g) before fermentation and was 8.59 $Log_{10}$ (c.f.u. /.g) after 72 hours of keeping. The number of total coliforms was 5.11 $Log_{10}$ (c.f.u. /.g) before keeping

Table 2: pH and titratable acidity (TA) of 72 hours of fermentation

| Time (hour) | 0 | 24 | 48 | 72 |
|---|---|---|---|---|
| pH | 6.75 | 5.82 | 5.00 | 4.49 |
| TA (% lactic acid) | 0.12 | 0.17 | 0.37 | 0.57 |

Table 3: The microbial counts ($Log_{10}$ (c.f.u./.g) during fermentation of dèguè

| Fermentation time (h) | Lactic acid bacteria ($Log_{10}$ CFU/g) | Yeasts and moulds ($Log_{10}$ CFU/g) | Total coliforms ($Log_{10}$ CFU/g) |
|---|---|---|---|
| 0 | 6.96 | 5.73 | 5.11 |
| 24 | 8.71 | 8.80 | 6.11 |
| 48 | 8.71 | 7.72 | 6.26 |
| 72 | 9.91 | 8.59 | 5.88 |

and was 5.88 $Log_{10}$ (c.f.u. /.g) after fermentation. During the keeping, the pH decreased when the titratable acidity increased. This drop of pH was increased after 48 hours.

During the course of fermentation, counts of lactic acid bacteria and yeasts and moulds increased. The number of coliforms was high. They increased during 48 hours of fermentation then they decreased at three days of fermentation.

High counts of lactic acid bacteria and yeasts at the initial stage of the fermentation were probably due to the commercial mill used, acting as inoculants during wet milling (Wacher *et al*., 1993).

Lactic acid bacteria (LAB), yeast and moulds and coliforms grew together during at least 24 to 48 h fermentation of *dèguè*, contributing to the characteristics of the final product by the production of organic acids, alcohol (ethanol), $CO_2$ and other volatile flavour compounds. The development of LAB is also stimulated by the presence of yeasts which provide soluble nitrogen compounds and factors e.g. B-vitamin (Nout, 1991). As LAB counts increased, more acid was produced, as shown by increasing titratable acidity (TA) and the decline in pH. This drop in pH is presumed responsible for the very low levels of coliforms. Some authors (Mensah *et al*., 1991) believe that other substances (bacteriocin) produced by dominating LAB may contribute to the disappearance of Enterobacteriaceae. But after 72 h of fermentation of *dèguè* the number of coliforms was yet high. These explain that the drop of pH is not sufficient to eliminate all coliforms.

Table 4 presents the results of biochemical analyses in the raw material, *dèguè* before fermentation and *dèguè* after 72 hours of fermentation. The crude protein content was 5.43% and 6.12% after 72 hours. The lipid content was 3% before keeping and after keeping.

Ash content was 1.13% before and 1.06% after keeping. The starch content was 33.37% before and 23.60% after keeping.

Table 4 shown that the proximate composition of millet decreased during the processing into *dèguè*.

During fermentation a slight increase in protein content was observed. The process of fermentation does not have any significant effect on total protein content, but can result in the qualitative modifications of proteins often resulting in the water soluble proteins and free essential amino acids. These changes can be effected by endogenous proteases, but have also been attributed to the proteolytic activity of some of bacteria responsible for cereals fermentations (Kao and Robinson, 1978; Hamad and Fields, 1979; Zamora and Fields, 1979, Chavan and Kadam, 1988, 1989a,b). This apparent increase in protein content during fermentation could be attributed to reduction in starch content.

Table 4: Biochemical composition of millet, dèguè before fermentation ($t_0$) and after 72 h ($t_{72}$) of fermentation

| | Millet | Degue ($t_0$) | Degue (72 h) |
|---|---|---|---|
| Moisture (%) | 7.8±2 | 48.63±2.3 | 46.34±2.01 |
| Crude protein (% dwb) | 11.86±2.48 | 5.43±2.37 | 6.12±0.39 |
| Lipid (% dwb) | 7.81±0.97 | 3.00±2.8 | 3.00±0.1 |
| Ash (% dwb) | 2.76±.45 | 1.13±0.14 | 1.06±0.07 |
| Starch (% dwb) | 65.61±8.90 | 33.37±5.75 | 23.6±7.41 |
| Carbohydrates (% dwb) | 69.77±3.33 | 41.81±5.37 | 43.48±8.12 |

dwb: dry weigh basis

Table 5: Influence of fermentation time on the colour parameters of dèguè

| | Millet | dèguè | dèguè 72 h |
|---|---|---|---|
| L | 53.16±1.51 | 42.5±0.13 | 48.9±0.2 |
| a | 6.86±1.9 | 3.5±0.7 | 2.4±0.6 |
| b | 26.04±2.82 | 15.5±2.1 | 15.2±3.8 |

The lipid and ash contents were not changed after fermentation. These results have not shown an effect of fermentation in the lipid, ash contents.

But the starch content decreased during 72 hours of keeping. The decrease of starch may be attributed to $\alpha$ and $\beta$ amylases produced by microorganisms (El tinay *et al*., 1979), or are indigenous to the flour.

**Colour parameters recorded of pearl millet:** *dèguè* before fermentation and *dèguè* after 72 hours of fermentation are given in Table 5. The value of L was 42.50 before fermentation and was 48.90 after 72 hours. The values of a and b were respectively 3.50 and 15.50 before fermentation and 2.40 and 15.20 after fermentation. In the pearl millet the values of L, a, b were respectively 53.16; 6.86; 26.04.

The fermentation period and the processing method both affected the colour parameters L* (luminosity), a* (greenness at redness) and b* (blueness at yellowness). During the processing of *dèguè* production all parameters of millet were decreased. But during the course of fermentation the luminosity (whiteness) of the product became more intense.

**Conclusion:** This study has tried to know by people this interested traditional product that was wanted to disappear, to know the processing of pearl millet into *degue*, and microbiology characteristics in order to improve nutritional quality and hygienic quality of the product.

However, if some information has been obtained on changes in nutritional characteristics during processing, a more detailed study is required to improve not only production conditions but also nutritional characteristics. Particular attention will have to be paid to identifying methods to improve the hygienic and nutritional qualities of traditional food.

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