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Effect of Rice's Biochemical Component Variation Induced by Reproductive Water Deficit on the Traditional Bread (*Ablo*) Quality

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A B S T R A C T

Ablo is a wet bread slightly salty-sweet, steamed, originally prepared from a semi-liquid paste fermented corn widely consumed in West Africa. Nowadays, corn is substituted by rice in this food manufacturing process. The objective of this study is to determine the effect of the variation of local rice's biochemical components induced by reproductive stage water deficit on the quality of *ablo.* The methodology consisted in conducting a survey in some localities in South Benin followed by the production of *ablo*'s samples from two varieties recently developed (ARICA 4 and NERICA 1) and the physicochemical, microbiological and sensory analyses of the samples. The survey revealed that *ablo* production is exclusively female's activity which is usually inherits from relatives. Also, the results showed that three production processes of *ablo* depending on the raw materials used, namely, corn, rice or mixture of corn and rice. The statistical analysis revealed that there was no significant difference (P > 0.05) between pH, titratable acidity, and the yield of all of the *ablo* samples. However, it was found that *ablo* samples from non-stressed grain contained more dry matter (31.92 % to 33.14%), more total sugar (10.59% to 10.78%) and produced more foam during the fermentation process than the *ablo* samples obtained from grain collected from stressed plants. Also, the study showed that the fermentation process is achieved by yeasts and lactic bacteria, which tend to multiply more in ablo samples obtained from non-stressed samples. A*blo* can be considered as a hygienic food because of the absence of pathogens due to its acidity and its cooking.

Keywords

Ablo,
biochemical composition,
quality,
rice,
water deficit.

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Introduction

In the Western Africa, maize, rice, millet and sorghum are the most consumed cereals. In Benin, maize is a stable food crop in both urban and rural areas.

Consumption of maize is estimated at 85 kg/capita/year (Nago, 1997; FAO, 2010). Its consumption rate vary according to the regions of the country; in the Northern part of Benin the consumption rate is less than 30 kg per capita per year while in the Southern and the central parts of the country the consumption rate is 100 and 150 kg per capita per year respectively (Hounhouigan, 1994; FAO, 2010). Formerly, rice was consumed only during special events such as festivals, wedding, naming ceremonies and funerals. Nowadays, this cereal is a staple food in Benin due to its quick and easy preparation. Rice consumption rate was estimated at an average of 14 kg per capita per year in 1999 (INSAE, 2000), it has experienced a growth rate of 46% between 2000 and 2005 and reached our days more than 40 kg per capita per year (FAO, 2011). Rice is used in several traditional recipes, the most known of these recipes in the west africa is *ablo*. *Ablo* ("bread in the Mina language") is a slightly salty-sweet wet bread, steamed (Nago and Hounhouigan, 1998), prepared originally from a semi-liquid paste fermented maize. *Ablo* was known as a street food that can be consumed during breakfast, lunch or dinner time. These days, this food is served in hotel restaurant, especially during popular celebrations (Ahokpe, 2005; Aholou-Yeyi, 2007, Bokossa *et al.*, 2013). To date, three cooking methods of *ablo* are known; the traditional method described by Nago and Hounhouigan (1998) which exclusively use maize as raw material, the modified method descripted by Ahokpe (2005) which use only rice as raw material and intermediate method descripted by Aholou-Yeyi (2007) mix rice-maize is used as raw material for this method. *Ablo's* quality and its acceptability by consumers strongly depend on the quality of the raw material and manufacturing process. In the pass, the scarcity of local rice imposed the use of imported rice which is costly as compared to local produced rice in the process of cooking *ablo*. These days with the increase of local rice production, imported rice is being replaced by local produced rice. However, due to climate change, rice production is subject to water stress which induces changes in physical and biochemical components on rice grains. The objective of this study is to determine the effect of changes in biochemical components of the grains of some local produced rice varieties induced by water stress occurred at reproductive stage on the quality of *ablo*.

Materials and Methods

Characteristics of the raw material

Two interspecific varieties of rice (ARICA4 and NERICA1) were used. The two rice varieties were grown under optimal growing condition where they were well watered throughout their life cycle and under stress condition where they were subjected to severe reproductive water deficit that induced significant changes in their grain's biochemical components (table 1).

Investigation

A survey was conducted in four localities namely; Cotonou, Porto-Novo, Comè and Bohicon in Benin. A total of one hundred and twenty (120) individuals were interviewed. The survey consists in collecting, sociocultural information concerning those who usually are involved in cooking the *Ablo*, the nature of the raw material used and the reason of the choice of a specific raw material.

Production and chemical analysis of ablo samples

Ablo samples were developed following the improved technology described by Aholou-Yeyi, (2007) (figure 1). Fermented dough and *ablo* samples were taken in three repetitions, for the study of the fermentation's dynamics and analyses of nutritional and sensory quality. For fermentation dynamics, fermented dough samples were taken during the duration of fermentation at 0 h, 2 h, 4 h and 6 h according to an arithmetic result of 2 h.

Determination of growth (change in height of the foam)

Initial and final dough front levels were marked with horizontal lines at the level of fermentation materials. At the end of fermentation, the deviation or variation in height (cm) representing the lifting of the dough (the level of foam) was measured using a ruler.

Yield

Dough's yield, was determined according to Decock and Cappelle (2005) method

Physicochemical analysis

The dry matter content was determined according to the method of AACC, 44, 15 A (AACC, 1984), from 5 g of fresh sample, by differential weighing, after crossing the Heraeus T 5042 oven at 105 ° C for 72 h. The pH and titratable acidity were determined according to the modified Nout method (AOAC, 1984). Total sugars were determined by the Luff-Schoorl method (Lees, 1968), after extraction of the sugars with ethanol at 40% (v/v), defecation using Carrez 1 and 2 Carrez reagents, the inversion of sucrose then the titration of total sugars with the 0.1 N sodium Thiosulphate.

Microbiological analyses

Microbiological analyses consisted in counting the total mesophilic flora (NF ISO 4833, 2003) on PCA (Oxoid CM 0325) at 30°C, lactic bacteria on MRS-agar CM 0361 at 30 ° C , yeasts and molds (NF ISO 21527-2, 2008) on Sabouraud Dextrose Agar (Oxoid CM 0041) at chorampphénicol (0.05g/l) at 25°C, total coliforms (NF ISO 4832 (V 08-015), 2006) and thermotolerant coliforms (NF ISO 4832 (V08-060), 2009) on VRBA-Oxoid CM 0107 (Violet Red Bile Agar) at 37°C and 44°C respectively. Lactic bacteria and yeasts have been chosen because they are the ones which provide mainly the fermentation of cereals, while total and thermotolerant coliforms reflect the hygienic quality of the product.

Sensory analysis

The sensory analysis of *ablo* samples was conducted using a panel of 33 tasters. They were randomly selected and trained for the purpose. The ranking of the *ablo* samples was based on criteria such as taste, color, texture, and acceptability. Scores ranging from 1 to 5 have been attributed to these criteria according to the methodology described by Larmond (1977) quoted by Bokossa *et al*., (2011).

Statistical analyzes of data

The Excel software was used to perform the calculations. Analysis results were processed using Minitab 14.0 software that permitted to make analysis of variance (ANOVA) and Tukey's test for comparison of means. The significance level of 5% is selected ($p < 0.05$).

Results and Discussion

The results of the survey revealed that the production of *ablo* is an exclusively female activity. Also, it this business was found to be a family affair and that the methodology was transferred from mother to daughter or other close relative. The results of the survey are consistent with those of Dossou *et al*., (2011), Banon (2012) and Bokossa *et al*., (2013). These authors stated that in Benin, the *ablo* production technology was transferred from mother to daughter from one generation to another. Three *ablo* manufacturing processes were identified at the end of the investigation. These manufacturing processes differ mainly by raw material used; an original process using maize, a modified process using rice as raw material and an intermediate method using a mixture of maize and rice as raw material. The most widely used method by the surveyed transformative is the modified process. The toughness and the too long duration of the original process forced the majority of producers to gradually replace the rice by maize. *Ablo* production time varies from one process to another, but also based on the experience of the producer since the technology is not standardized. The average cooking time of *ablo* is six (6) hours when the mawe is already available. The imported rice is the type of rice used by most of the transformative surveyed. Hundred percent (100%) of the transformative explained the use of imported rice because of the non-availability of local rice.

In order to compare their nutritional value, following parameters were determined; potential of Hydrogen (pH), titratable acidity, yield in dough and dry matter. The statistical analysis of the results showed that there was no significant differences ($p > 0.05$) between the pH, titratable acidity, and the dough's yield of the two categories of *ablo* (*ablo* cooked using stressed and non-stressed grain) (table 2). However, it was found that samples of *ablo* from non-stressed grain contained more dry matter, total sugar and produced more foam during the fermentation than those obtained from stressed grains (table 2). pH values of the *ablo* samples cooked using the stressed grains were between 4.94 and 4.98; These values are higher but not significantly ($p > 0.05$) than the pH values of *ablo* samples from non-stressed grain which vary between 4.91 and 4.95 (table 2). Nout *et al.*, (1989) and Adjigbey-Tasas (2003) showed that below pH = 5, life becomes impossible for the pathogens. The values of the titratable acidity of the two categories of *ablo* varied between 1.24 and 1.27% (table 2). The values obtained were close to those obtained by Dossou and *al*., (2011).

The initial dough yield averaged 178%, indicating the semi-liquid state of *ablo* paste, in accordance with the classification of Decock and Cappelle, (2005). The dry matter content varied from 31.92 to 33.14% from fermented pulp non-stressed grain and 25.52 % to 27.25 % percent from stressed grain paste. These values are lower than those reported by (Decock and Cappelle 2005) (i.e. 57.2 to 59.9% of water content, or 41.1 % to 42.8% dry matter) on a similar Chinese steamed bread dough. The average values of dry matter in *ablo's* samples from non-stressed grain was significantly ($p<0, 05$) superior to the average values of the dry matter from *ablo's samples* of stressed grain, no matter the variety of rice. The difference between the rate of dry matter is justified by the change of amylose's rate in stressed and non-stressed grain. A significant difference ($p < 0.05$) was also between the two categories of *ablo* regarding the variation of foam. *Ablo* samples from non-stressed grain produced more foam during the fermentation compared to samples from non-stressed grain (table 2). According to (Ahokpe, 2005), the amount of foam produced would be in relation with the textural quality of *ablo*, therefore, *ablo* from non-stressed grain will have a good texture compared to *ablo* from the stressed grains.

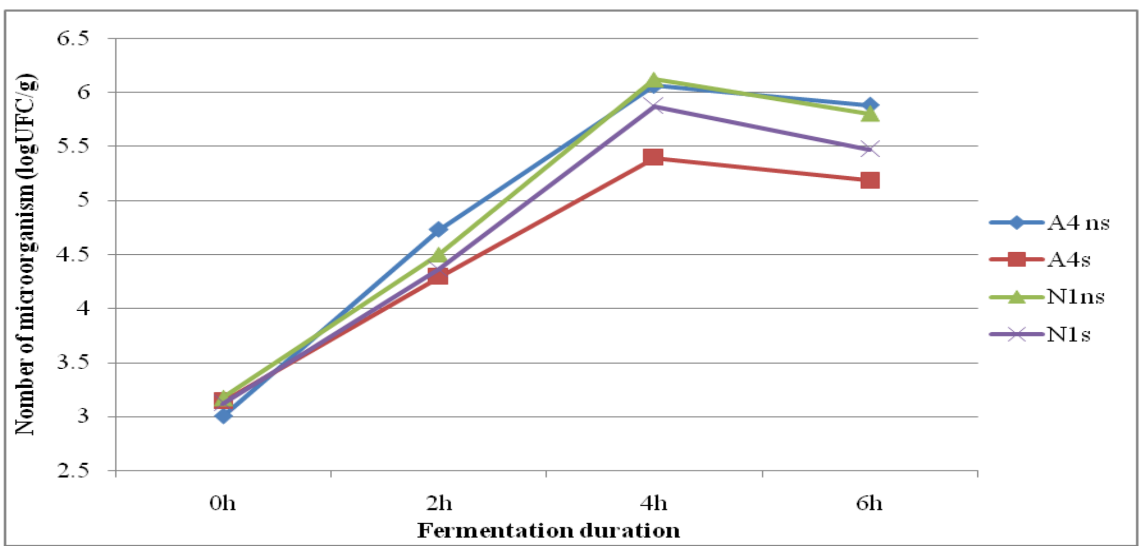
Table.1 Biochemical characteristics of varieties

Varieties	Amylose (%)	Protein (%)	Dry matter (%)
ARICA4 (well-watered)	27.33	9,02	86.84
ARICA4 (stressed)	18.29	11,00	89,14
NERICA1 (well-watered)	28,32	9,41	83,29
NERICA1 (stressed)	18.72	10.83	87.57

Table.2 Physicochemical characteristics of the different types of ablo table

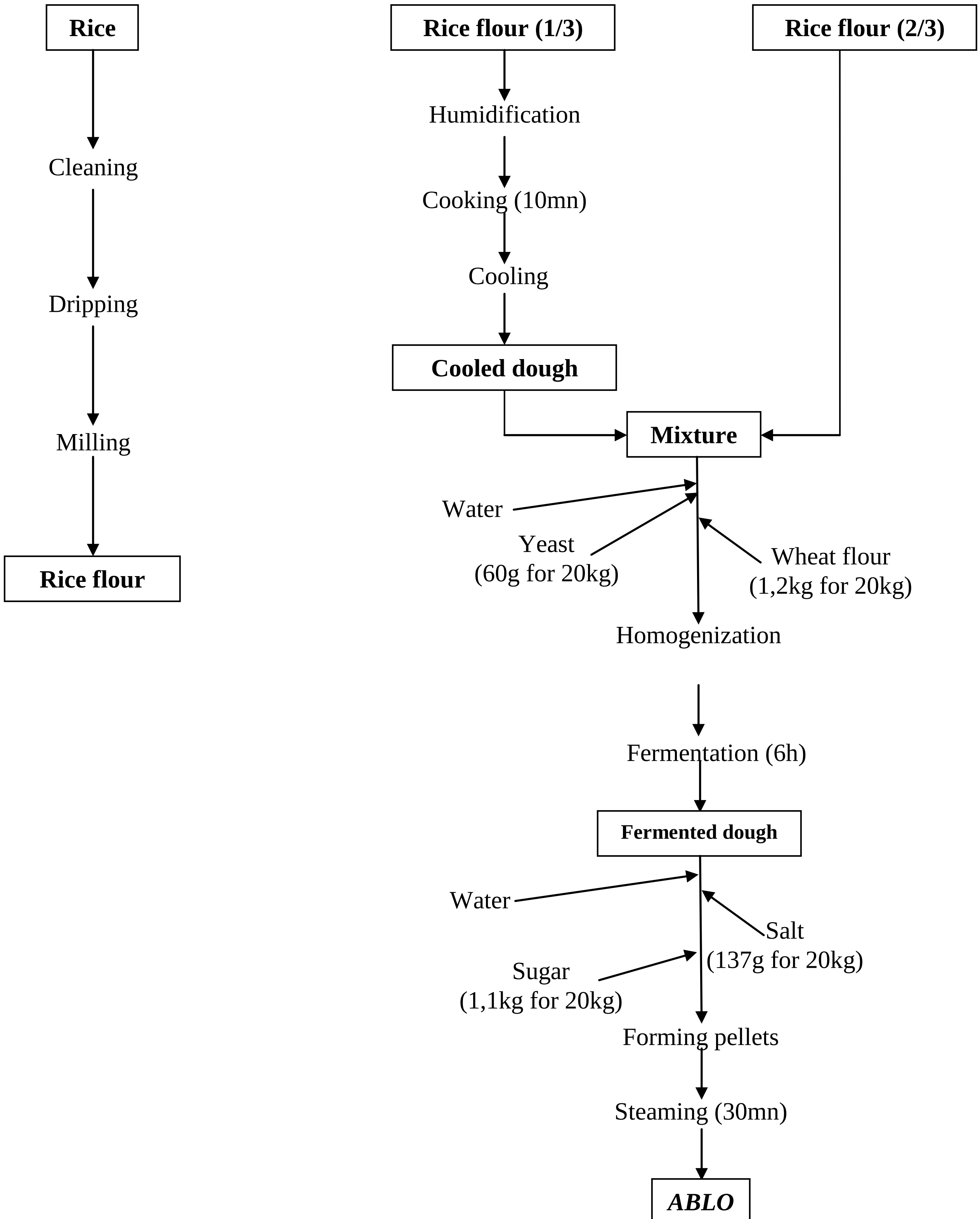
Ablo type	pH	Titrable acidity (%)	Height (cm)	Yield (%)	Dry matter (%)	Total sugars (%)
Ablo based ARICA4 well watered	4. 91±0. 03	1.27±0. 02	3.64±0. 05	175±0. 03	33.14±0. 68	10.78±0. 58
Ablo based ARICA4 stressed	4. 98±0. 02	1.24±0. 01	2.93±0. 17	180±0. 02	27.25±0. 82	8.64±0. 29
Ablo based NERICA1well watered	4.95±0. 03	1.27±0. 01	3.65±0. 02	179±0. 02	31.92±0. 86	10.59±0. 39
Ablo based NERICA1 stressed	4.94±0. 03	1.26±0. 02	2.96±0. 08	179±0. 02	25.52±0. 59	8.96±0. 33
P value	0.224	0.339	0.001	0.471	0.001	0.001

Fig.2 Evolution of lactic bacteria during the fermentation



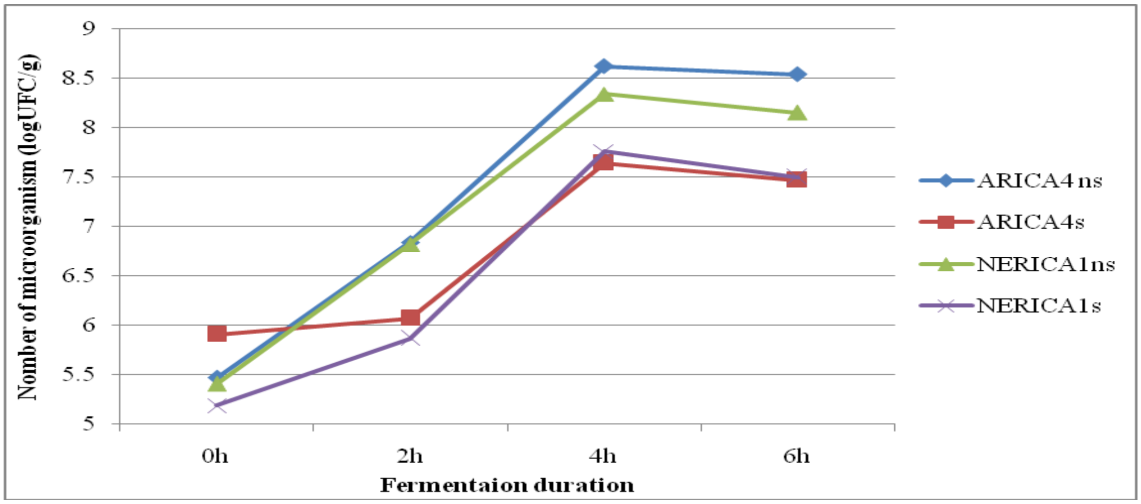
Note : ns = non stressed ; s= stressed

Fig.1 Diagram of production of ablo following the modified process



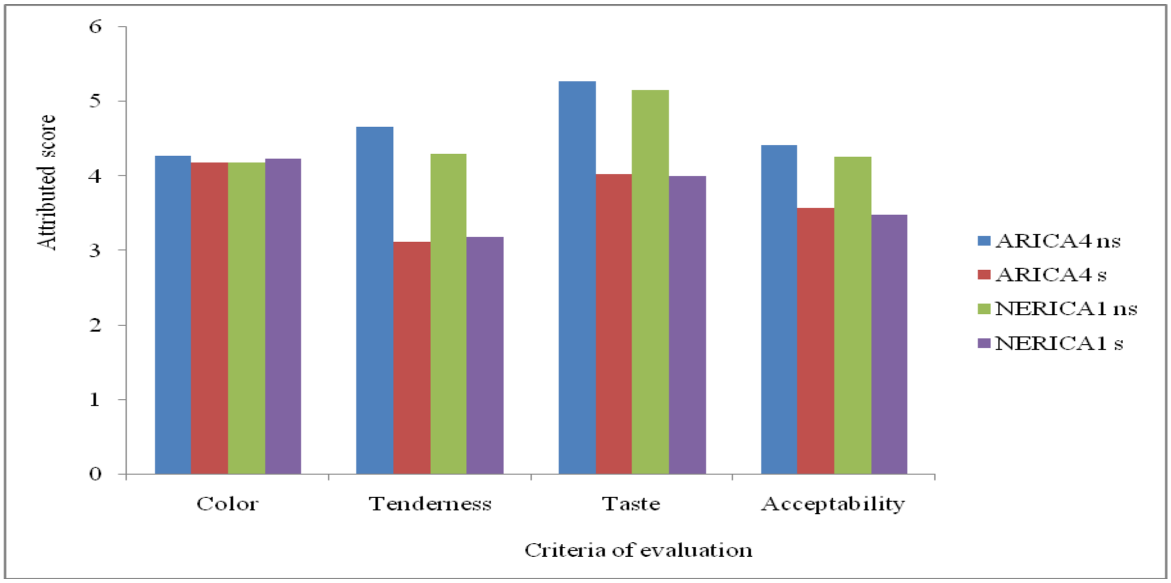
(**Ref:** AholouYeyi, 2007)

Fig.3 Evolution of yeast/fungi during the fermentation



Note: ns = non stressed; s = stressed

Fig.4 Comparison of the sensory parameters of different types of ablo



Note: ns = non stressed; s = stressed

The results showed that yeast/mold and lactic bacteria increased gradually until the fourth hour regardless to the type of *ablo* (figures 2 and 3). This increased could be related to the logarithmic phase of microorganisms' growth, which corresponds to the stage of maximum output of carbon dioxide (CO_2), from the oxidation of fermentable sugars; then comes a slight slowing in the growth of the microorganisms from the fifth to the sixth hour. However, during the entire fermentation process, the microbial load (in yeast/mold and lactic bacteria) was more important in the *ablo* cooked from the grains of non-stressed plants as compared to samples from the grains of stressed plants (figure 2 and 3). This may be due to the reduction of biochemical composition that broke the multiplication of microorganisms during the fermentation of *ablo* of the stressed grains. The Aerobic mesophilic flora of *ablo* samples was relatively high but did not vary depending on the treatment receive by grain (stressed or well-watered). The results showed the absence of total and thermotolerant coliforms in all *ablo's* samples developed; these results are consistent with those of Dossou *et al*., (2011). These results indicate that according to the hygienic qualities, the standards were respected during the manufacturing process.

The results (figure 4) reflected the sensory analysis of the two categories of the *ablo* adjusted. The figure showed that the two categories of *ablo* were identical in terms of color regardless the variety. The water stress didn't influence on this feature of *ablo*. Mean while, based on the tasters' responses, the *ablo* samples developed from the grains of non-stressed plants were softer and taster. Results of sensorial analysis showed that all of the *ablo* manufactured were accepted by the tasters. However, panelists preferred the *ablo* from non-stressed grain. Also, the results showed that *ablo* from ARICA varieties have been slightly more appreciated by the tasters than from the NERICA varieties (figure 4).

In conclusion, *Ablo* is a food that has much value in West Africa and especially in Benin, it is originally produced from corn, but hardness and too long duration of this original process lead to technological changes, resulting in partial or total substitution of maize by rice especially in urban areas. The changes in the biochemical composition (mainly the decline in the rate of amylose) of rice have a negative influence on the quality of *ablo*.

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