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# Impact of Heat on the Different Stages of the Production of Local Beer "Tchoukoutou" Made from Sorghum

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**ABSTRACT**

Tchoukoutou is a local alcoholic drink made from sorghum. The optimization and good quality of this drink depend on certain factors such as temperature that were the subject of our work. To carry out this study, we have set ourselves the general objective of structuring the production of Tchoukoutou. Specifically, the study aims to systematize the cooking of the wort, to verify the properties of the beer through tests and to produce a quality drink. An investigation was made on the influence of temperature on sorghum germination and wort cooking. The study of the effect of temperature on the germination of sorghum was carried out. It concerned four different temperature levels which are: 23°C, 26°C, 30°C and 35°C. A study of the influence of temperature on brewing was done with different varieties of sorghum and also at different temperature ranges: 78°C, 83°C, 89°C, and 92°C. The results showed that the ideal germination temperature is 30°C and for brewing it is 78°C. The soaking time during germination, for a good germination rate, is between 16 h and 26 hours. In conclusion, the temperature factor is a parameter that should not be overlooked when making Tchoukoutou. Our study thus made will serve as a basis for subsequent studies in the same direction to achieve a standardized industrial production of Tchoukoutou.

**Keywords:** Temperature, Sorghum, Beer, Tchoukoutou.

## INTRODUCTION

Tchoukoutou, a local alcoholic drink produced and consumed throughout Togo, is traditionally made from sorghum. It is a short shelf life beverage that varies in quality from production to production[1]. It is also consumed during field work and given abroad to cool off and welcome him[2]. This drink has nutritional values that help improve the diet of consuming populations. In addition, therapeutic virtues are attributed to it because of its laxative, antimalarial and anti-hemorrhoidal properties[3]. Its relatively low cost also makes it a product within the reach of all budgets[3–5]. The empirical technological process is as follows: malting, grinding, pre-cooking, souring or spontaneous fermentation, filtration, cooking, cooling, inoculation and alcoholic fermentation. Sorghum is a cereal, one of the food products grown mainly in northern Togo and used, among other things, to make Tchoukoutou. Cultivated sorghum is of paramount importance in the Sahelian zones of Africa where it represents one

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of the main food resources[5]. It is a monocotyledon plant about three meters high, cultivated either for its seeds or as fodder: the scientific name for fodder sorghum is Sorghum bicolor. The manufacture of Tchoukoutou consists of the transformation of the raw material which is sorghum into an alcoholic drink. The first step in this transformation is obtaining the must after drying and molding the sorghum, then comes the actual cooking step. All of these steps are influenced by the thermal effect. The objective of this study will focus on the study of the impact of heat on the different stages of manufacture of local beer (tchoukoutou), its structuring its production, the systematization of the cooking of the wort, the verification of the quality. by testing, and producing a quality standard beer. The study will improve the production and quality of local sorghum-based beer on an artisanal or semi-industrial scale. This study began with a field survey, then the study of the germination process of different varieties of sorghum before preparation and control of the impact of heat during the different stages from germination to cooking. First, we will research and evaluate the required temperature range that would allow better performance to be obtained, and secondly, we will assess the taste quality by consumers' appreciation.[2]

## MATERIALS AND METHODS

### Plant material

### Selection of varieties

The sorghum varieties used are selected and cultivated in the savannah region: white sorghum (Sorvato1) and red sorghum (kadag). They were collected at ITRA-TOGO. Sorghum (kadag), (Jerry), (Sorvato28 + Jerry) and (Sorvato1) have been studied to prepare beer and perform physicochemical tests. This will be followed by determining the ideal germination and cooking temperature.

### Germination rate

The germination rate indicates how many seeds of a particular plant species, variety or batch of seeds are likely to germinate in a given period (germination capacity). It is generally expressed as a percentage. For example, a germination rate of 85% indicates that about 85 out of 100 seeds will likely germinate under good conditions during germination. The germination rate is determined to control the effects of poor germination on a drink.

### Physico-chemical characteristics of beer

### pH measurement

The pH of the drink was measured during the industrial preparation of Toutchoukou and Tchakpalo by an electronic pH meter of the MP522 type with precision ± 0.002 pH, previously calibrated. Toutchoukou produced based on Sorvato 1, at a pH of 5.19 (temperature between 55 and 65°C). For a temperature between 65°C and 70°C the pH has a value of 5.28. Brewing beer prepared from Kadag reveals a pH of 6.42 for the first level (55°C -65°C) and 6.45 for the second level (65°C -70°C). For the mixture of Jerry and sorvato28 varieties, the pH is 6.10 for the first stage and 6.21 for the second). For Tchakpalo made from Sorvato1, the pH is 5.19 for the first level and 5.28 for the second. The Kadag-based drink has a pH of 6.42 for the first stage and 6.45 for the second.

### Temperature measurement (T°C)

Temperature is a physical quantity measured with a thermometer. It is therefore important to control its impact on a beer. In our study it was determined during germination and cooking. It is expressed in several units such as: degree Kelvin (°K), degree Celsius (°C), degree Fahrenheit (°F).

### Determination of the alcoholic strength of beer

The alcoholic degree was determined by two methods.

### Densimetry

This is one of the techniques for measuring alcohol content by a hydrometer according to Archimedes' principle. Anybody immersed in a fluid undergoes a vertical thrust directed from the bottom to the top which is equal to the weight of the displaced liquid. The alcoholic degree is determined according to the equation below.

$$C_6H_{12}O_6 \rightarrow 2CH_3CH_2OH + 2CO_2$$

Sugar Alcohol Carbon dioxide

### Refractometry

Each sample or mixture of substances has a specific refractive index of light. The refractometer is used to measure the amount of sugar in a liquid sample on the Brix scale.

### Study of the impact of heat

The tests were carried out on two varieties of sorghum: Sorvato1 and Kadag. A set of 100 Sorvato1 and Kadag sorghum seeds arranged in pots is sorted and soaked in tap water at different temperatures T (23°C, 26°C, 30°C). The duration of the soaking varied over an interval of 2 h to 72 h (2 h, 4 h, 5 h, 6 h, 7 h, 10 h, 16 h, 20 h, 24 h, 26 h, 48 h, 72 h). The soaking water is not renewed. Three experimental trials ($1^{st}$, $2^{nd}$, $3^{rd}$) were carried out at these different times at the corresponding temperatures. These seeds were removed from the water, drained and laid out on Wattman filter paper. The seeds are soaked for three days and are moistened once a day until the germinated seeds are counted. The germination capacity and the germination rate are determined.

**Traditional preparation of Tchoukoutou**

The Kadag, Sorvato 1, Sorvato28 + Jerry sorghum varieties were used for the preparation of Tchoukoutou, the main stages of which are: malting, brewing and fermentation. The three main operations are: malting, brewing, and fermentation[6]. An 800 g mass of sorghum is soaked in water for 18 hours. Soaking provides the seeds with the water and oxygen necessary for germination[7]. Then the hydrated grains are washed and drained using a colander. After 24 h at a temperature of 30°C, a second washing is carried out and the germinating grains are drained and spread out in a cabinet in a thin mat and covered with a cotton cloth for 72 hours. The grains are dried for 12 h for the Kablè-missine in the laboratory and 48 h in the sun for the Tchakpalo. The resulting malt is then ground into flour for mashing, decocted and then filtered. After 12 to 15 h of lactic fermentation, the sour must is brought to the boil for 2 h 30 min to concentrate it, coagulate the protein materials and destroy the bacteria. At the end of cooking, the must is left at a temperature of 30°C for cooling. It emerges from the various studies that beer contains a diversity of yeast species varying according to the countries and the authors[8].

**Industrial preparation process for Tchoukoutou**

In this optimization process we will have a standard production bearing temperature. Each level will promote the action of an enzyme and will have a specific result on the quality of the beer. Protein level is the level that aims to make beer clear, less dense and less condensed. The sorghum and water mixture is brought to a boil at a temperature of between 50 and 55°C. In this temperature range, the proteins are transformed into amino acids by the combined action of water and the enzymes proteinases and peptidases. This level will last thirty (30) minutes. The second stage, the so-called saccharification stage, involves a biochemical reaction allowing the transformation of starch $(C_6H_{10}O_5)$ n. Starch consists of two homopolymers, amylose and amylopectin composed of D-anhydroglucopyranose (AGU) units which belong to the family of polysasaccharides (or polysaccharides) of general chemical formula $(C_6H_{10}O_5)$ n. Achievable between 55°C and 65°C, this saccharification stage allows the formation of fermentable sugars. Beta (β) amylase breaks down starch by fracturing the molecular chain and dextrins. This destruction thus creates dextrose and maltose which are fermentable sugars. This action takes place in combination with alpha amylase which breaks down starch chains at the center and beta amylases break down at the center. This step lasts at least one (1) hour. The lugol test is a test to confirm the presence or not of starch. In the saccharification stage (65°C and 70°C), the formation of fermentable sugars continues but under the action of alpha (α) amylases which break down starch into dextrins, this phase lasts thirty to one (1) time. The iodine test can also be repeated here to be sure all the starch has been processed. Finally, the level of inhibition of the enzymes consists in increasing the temperature to 78°C, the heat released during this increase makes it possible to destroy the enzymes, thus we will have a good stirring efficiency.

**Field survey**

A field survey, including six (6) districts of the city of Lomé (Tokoin doumasséssé (Adéwi), Baguida, kpogan, Agoè, Agbalépédo, and vakpossito) allowed us to understand the different stages of the production of the local drink. Then the work in the laboratory made it possible to study the impact of temperature on germination and on cooking.

## RESULTS

**Equipment used for cooking**

The wood is the most used in the preparation of tchoukoutou due to the fact that it was used by the first producers. In addition, it is economical and within the reach of the population than gas and electricity. For these reasons, 51 people out of 59 surveyed use wood or 86.44% and 6 people use gas or 10.16% and 2 people or 3.39% use charcoal more specifically called (kpévika).

The results on the impact of heat on the germination of sorghum are contained in the following tables.

**Table 1: Germination rate for sorvato1 and kadag at 23°C**

| Duration | Germination rate (Sorvato1) | Germination rate (Kadag) |
|---|---|---|
| 02 h | 32% | 70.33% |
| 04 h | 37% | 70.33% |
| 05 h | 38% | 71% |
| 06 h | 45.67% | 72% |
| 07 h | 40.33% | 73% |
| 10 h | 45% | 73.33% |
| 16 h | 48% | 73% |
| 20 h | 47.67% | 82.33% |
| 24 h | 45.33% | 82.67% |
| 26 h | 46.63% | 83% |
| 48 h | 37.33% | 72.67% |
| 72 h | 23.67% | 69.33% |

An effect of heat on the seeds of Sorvato1 and Kadag will be studied in the following table at a temperature of 26°C.

**Table 2: Germination rate for sorvato1 and kadag at 26°C**

| Duration | Germination rate (Sorvato1) | Germination rate (Kadag) |
|---|---|---|
| 02 h | 42.33% | 80.33% |
| 04 h | 47.33% | 82.67% |
| 05 h | 46% | 82.67% |
| 06 h | 52.33% | 85% |
| 07 h | 49% | 83.33% |
| 10 h | 53.67% | 82.33% |
| 16 h | 61% | 83.33% |
| 20 h | 59.67% | 83.33% |
| 24 h | 52.67% | 85.33% |
| 26 h | 53% | 85.33% |
| 48 h | 43.33% | 83% |
| 72 h | 34% | 74.33% |

**Table 3: Germination rate for sorvato1 and kadag at 30°C**

| Duration | Germination rate (Sorvato1) | Germination rate (Kadag) |
|---|---|---|
| 02 h | 54.67% | 82.33% |
| 04 h | 54.67% | 90.33% |
| 05 h | 54% | 89.67% |
| 06 h | 56.67% | 91.33% |
| 07 h | 61.67% | 92% |
| 10 h | 56% | 92.33% |
| 16 h | 62.33% | 93% |
| 20 h | 63.67% | 93.33% |
| 24 h | 63% | 93.33% |
| 26 h | 54% | 93.67% |
| 48 h | 48% | 93.67% |
| 72 h | 41.67% | 88.67% |

The impact of heat on Sorvato1 and Kadag seeds germinated at a temperature of 35°C is summarized in the following Table.

**Table 4: Germination rate for sorvato1 and kadag at 35°C**

| Duration | Germination rate (Sorvato1) | Germination rate (Kadag) |
|---|---|---|
| 02 h | 45.67% | 81.33% |
| 04 h | 47.67% | 81.33% |
| 05 h | 44.75% | 81.67% |
| 06 h | 47.67% | 82.33% |
| 07 h | 47.67% | 82% |
| 10 h | 48% | 82% |
| 16 h | 50.33% | 84.67% |
| 20 h | 49.67% | 86.33% |
| 24 h | 51% | 89.33% |
| 26 h | 41% | 89.33% |
| 48 h | 40.67% | 81.67% |
| 72 h | 35.67% | 77.67% |

## Impact of temperature on brewing

**Table 5: Physicochemical and organoleptic characteristics according to the variety of sorghum used (T = 78°C)**

| Types of sorghum | Mass (g) | Amount of water (l) | Cooking time | Initial density | Final density | Alcohol level | Appreciation |
|---|---|---|---|---|---|---|---|
| Sorvato1 | 500 | 5l | 2 h | 1060 | 1028 | 3.11%mass 4%. vol | Good but fermentation is slow |
| Kadag | 500 | 5l | 2 h | 1058 | 1025 | 3.22%mass 4.1%. vol | Excellent, beer no fault |
| Mélange Sorvato28 et Jerry | 500 | 5l | 2 h | 1082 | 1048 | 3.34%.mass 4.24%.vol | Good |

**Table 6: Physicochemical and organoleptic characteristics according to the variety of sorghum used (T = 83 ° C)**

| Types of sorghum | Mass (g) | Amount of water (l) | Cooking time | Initial density | Final density | Alcohol level | Appreciation |
|---|---|---|---|---|---|---|---|
| Sorvato1 | 500 | 5l | 2h | 1082 | 1048 | 3.3%mas 4.2%. vol | Sour |
| Kadag | 500 | 5l | 2h | 1060 | 1028 | 3.11%mas 4%. vol | Sour and bad |
| Mélange Sorvato28 et Jerry | 500 | 5l | 2h | 1082 | 1048 | 3.34%.mas 4.24%.vol | Sweet |

**Table 7: Physicochemical and organoleptic characteristics according to the variety of sorghum used (T = 89°C)**

| Types of sorghum | Mass (g) | Amount of water (l) | Cooking time | Initial density | Final density | Alcohol level | Appreciation |
|---|---|---|---|---|---|---|---|
| Sorvato1 | 500 | 5l | 2h | 1060 | 1038 | 2.12%mas 2.69%. vol | Bitter |
| Kadag | 500 | 5l | 2h | 1058 | 1035 | 2.22%mas 2.82%. vol | Alcohol-free beer, sweet |
| Sorvato28 et Jerry | 500 | 5l | 2h | 1058 | 1035 | 2.22%.mas 2.82%.vol | Bad |

**Table 8: Physicochemical and organoleptic characteristics according to the variety of sorghum used (T = 92 ° C)**

| Types of sorghum | Mass (g) | Amount of water (l) | Cooking time | Initial density | Final density | Alcohol level | Appreciation |
|---|---|---|---|---|---|---|---|
| Sorvato1 | 500 | 5l | 2h | 1083 | 1058 | 2.36%mas 3%. vol | Bad, very sour and white |
| Kadag | 500 | 5l | 2h | 1084 | 1059 | 2.36%mas 2.3%. vol | Very sweet |
| Mélange Sorvato 28 et Jerry | 500 | 5l | 2h | 1082 | 1057 | 2.36%.mas 2.3%.vol | Sour and bad aroma |

**Table 9: Summary table**

| The main factor | Temperature |
|---|---|
| Soaking time in water (16 to 26 hours) | 30°C |
| Germination time (72 hours) | 30°C |
| Drying time (24 hours) | 30- 35°C |
| Brewing temperature | 78°C |
| Type of ferment used (Sc) | 30°C |
| Fermentation temperature | 30°C |
| Initial density(Kadag) | 1058 |
| Final density (Kadag) | 1025 |

## DISCUSSION

### Impact of heat

### Impact of heat on germination

The results obtained show that there is a correlation between the germination of sorghum and the quality of the beer obtained. Temperature plays a big role throughout the brewing process. The influence of temperature on germination was studied on different levels which are: 23°C, 26°C, 30°C and 35°C. Morrall *et al.,* in 1986 studied the germination of sorghum at a temperature range of 24 to 36°C[9]. They found that the germination temperatures of 24°C and 28°C were both equally good. At higher temperatures the germination results are not significant[9]. Singh *et al.,* in 2017 germinated sorghum at different time intervals (12, 24, 36 and 48 h) and at different temperatures of: 25, 30 and 35°C. They reported that germination for 48 h at 35°C results in a higher foaming capacity and emulsion activity[10]. The ideal germination temperature in our study for obtaining a good beer is 30°C (Table 3). For a period of 2 h, the germination rate of kadag is 82.33% while for the same period, these rates are respectively 80.33% and 70.33% at 26° and 23°C respectively. Under these same conditions, the germination rate of Sorvato 1 is 54.67% at 30°C but only 42.33 and 32% for temperatures of 26 and 23°C. Raising the temperature to 35°C does not give a better result. The germination rate is 81.33% and 45.67% for Kadag and Sorvato1 respectively for a period of 2 h of soaking. At temperatures of 26 and 23°C the qualities of the brewed beer are not good. Note that at 26°C and 35°C the beer produced is acceptable but of lower quality than that produced at 30°C. The optimum germination temperatures of sorghum and millet collected are between 25°C and 30°C which would be close to our results.

### Impact of heat on soaking time

Singh et al had carried out a study allowing to report that the soaking time is 48 hours[10]. These results are also similar to those of Esechie *et al.,* in 1994 (48 h at 30°C), in the study of the interaction of salinity and temperature on the germination of sorghum[11]. Tchuenbou *et al.,* in July 2006, had observed that the water content and the diastatic power increase with the duration of germination. The duration of soaking determines the degree of hydration of the beans. The steeping temperature and water content are the main factors influencing the optimum soaking time for sorghum. In some works, the duration of soaking grains such as sorghum and millet varies from 8 h to 51 h at temperatures between 25°C and 35°C. The results of the present study show that Kadag sorghum begins to germinate after 16 h in water. The duration of soaking the grains should not exceed 48 h, because beyond this time, the majority of these grains spoil as a result of excessive water absorption. Exceeding the soaking time of certain grains can cause a transformation of the color of the various grains studied, which changes from their fundamental color to black. It is also observed that the duration of soaking depends among other things on the nature of the grain and has an influence on the germination rate. Thus between 4 p. m. and 26 p. m., we have a better germination rate of sorvato1 and kadag sorghum grains. For example, at 30°C (Table 3) for a period of 2 h, sorvato1 and kadag have a respective germination rate of 54.67% and 82.33% while at 4:00 p.m. at the same temperature the rate increases to 62, 33% and 91.33%. It emerges from all of the above that the best soaking time is between 4 p.m. and 26 p.m.

**Impact of heat on brewing**

Igyor *et al.,* did a study on the effect of temperature, malting and brewing methods on sorghum wort composition and beer flavor. The brewing methods adopted included an infusion at 65°C, decantation at 80°C and a second decantation at 100°C. Over 80% of sorghum wort constituents showed a significant correlation between time and temperature of malting on the one hand and the composition of sorghum wort on the other. The composition of the wort in fermentable sugars and the development of aromatic compounds were higher in sorghum malt crushed with decantation at 80 or 100°C than in infusion at 65°C[12]. The brewing carried out by Taylor *et al.,* in 1992 made it possible to obtain extracts rich in fermentable sugars at a constant temperature of 75°C[13]. The study of the influence of temperature on brewing is done with different varieties of sorghum and at different temperature ranges: 78°C, 83°C, 89°C, and 92°C. The present study shows that beer obtained at a brewing of 78°C is better according to consumers. The initial densities are between 1058 and 1082 and the final densities between 1025 and 1048. However, the alcohol content does not vary practically for Sorvato1, Kadag and the Sorvato28 and Jery mixture. It is 3.11% for Sorvato1, 3.22% for the Kadag variety and 3.34% for the Sorvato 28 and Jery mixture. The tasters favorably appreciated the different beers brewed at this temperature. At other temperatures (83°C, 89°C, and 92°C) qualifiers such as "sour, bad, very sweet, lack of cooking" were put forward by the tasters. From all of the above it can be seen that brewing at 78°C is ideal.

## CONCLUSION

After the investigations made and following the investigations carried out, as part of the present study of the impact of heat was investigated with the aim of improving this beer. The study showed that at every stage of production, from germinating sorghum to cooking, the optimum temperature is required for good yield. Based on consumer feedback and with the aim of enhancing our local products, a standard cooking temperature has been obtained. The steeping temperature, the germination rate of the different varieties of sorghum and the different temperature ranges were studied. It is with this in mind that we have sought the best conditions for optimizing the various stages in order to obtain a better quality of the drink. More work could be done in order to industrialize this local drink with greater economic benefits.

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**Conflict of Interests**

The author(s) have not declared any conflict of interests.

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