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Physico-chemical profile of malt produced from two sorghum varieties used for local beer (*Tchakpalo*) production in Benin

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Abstract

The present work aimed to deepen knowledge on the properties of sorghum malt used for *tchakpalo* production in Benin. It focused on the physico-chemical characterization of white and red varieties of sorghum malt samples, compared to an imported Nigeria's variety named Farafara, selected for its brewing properties. The malts were produced and the physico-chemical parameters of malted and unmalted grains were performed. The efficiency of crushing using maize or hammer mill was also investigated and compared. Results obtained indicated that the dry matter of white and red sorghum varieties samples were respectively 89.44±0.21% and 90.15±0.20%. The thousand kernel weights were respectively 34.66±0.33g and 31.79±0.35gand the germination rates were 97.66±1.2% and 75.33±1.5%. The protein content of Benin's white and red varieties and imported variety ranged from 9.75±0.7 % to 12.21±0.1 % whereas ash content were ranged from 1.25± 0.02 to 1.4±0.04%. The phenolic compounds content of Benin and imported variety were 0.49±0.01, 1.77± 0.02 and 0.76g± 0.02/100gDM respectively while oxalate content of samples varied from 0.33± 0.01 to 1.39±0.06g/100g DM respectively. The crushing tests showed that the maize mill was not suitable for sorghum malt crushing. Based on the present study, sorghum varieties from Benin could present physico-chemical characteristics that predispose them for malting. However we recommend to producers constituting cooperative to acquire specialized mills which could enable them to get groat for good extraction during brewing.

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Introduction

Sorghum (*Sorghum bicolor*L.) Moench), a tropical plant belonging to the family of Poaceae, is one of the most important crops in Africa, Asia and Latin America. Sorghum while playing a crucial role in food security in Africa, it is also a source of income of house-hold (Anglani, 1998). More than 35% of sorghum is grown directly for human consumption. The rest is used primarily for animal feed, alcohol production and industrial products (Awika and Rooney, 2004). A part of Africa's yearly sorghum crop is allocated to opaque beer processing (Kayode *et al.*, 2007). The sorghum beer is a refreshing drink well appreciated by a large number of consumers throughout Africa. This beer takes different designations according to the country of origin. In Western Africa: Burkina Faso, Mali and Ivory Coast it is known as Dolo (Traore *et al.,* 2004). Cameroonians call it Amgba (Chevassus-Agnes *et al.* (1979)). Ghanaians and Nigerians call it Pito and Burukutu or Otika respectively (Odunfa, 1985). In Togo, approximately 60% of the national production of sorghum is used to produce two kinds of sorghum brew: Tchakpalo and Tchoukoutou (Osseyi *et al.*, 2011). Production and marketing of sorghum beer remain women's activities from which they derive a substantial income. In Benin, sorghum is usually transformed into a traditional beer called "tchakpalo" (Konfo *et al.*, 2012). This drink has a central role in peoples' cultures. Initially produced in the center of the country, this drink has spread throughout the country and especially in the economic capital where it knows a boom (Kayode *et al.*, 2007). The first stage of the manufacturing process of this beer is malting which is the germination of cereal grain in moist air under controlled conditions. The primary objective of malting is to promote the development of hydrolytic enzymes, which are not present in the ungerminated grain (lyumugabe *et al.,* 2012). Several studies focused on the nutritional value of malt and the use of sorghum grain as human food in Africa (Hulse *et al.*, 1980; Dicko *et al.,* 2006). Thus the protein content in whole sorghum grain wasin the range of 7 to 15% (FAO, 1995; Beta *et al.*, 1995). The fat in sorghum grain (mainly present in the germ) is rich in polyunsaturated fatty acids (Glew *et al.*, 1997).

Other studies have examined the effect of different technological processing (soaking, germination, sprouting, drying, fermentation ...) on nutrients composition of sorghum grain (Ikemefuna and Atii , 1991; Talor and Talor, 2002; Traore *et al.*, 2004).According to FAO, (1995) and Traoré *et al.*, 2004, germination induces the synthesis of hydrolytic enzymes, e.g. starch degrading enzymes, and proteases. The reduction of phytic acid, some flavonoids and proanthocyanidins has been observed during germination. In addition, other authors have investigated the biochemical profile of sorghum malt to access its diatasic power (Beta *et al.*, 1995), a capital parameter in the selection of sorghum varieties for brewing. Nowadays, there is no research paper on the quality of generated groats, by sorghum malt, after crushing to evaluate their brewing activity. Indeed, crushing in a brewery is an important operation. Bad process of this operation can affect the extraction of soluble compounds of the raw material (sorghum, barley malt and corn) or make difficult the wort filtration (Sunier, 2006). Furthermore, very little data exist on the characteristics of Benin sorghum varieties. The objective of this study was to produce and to make a physicochemical characterization of malt from two different sorghum varieties used for tchakpalo production in Benin to access their nutritional and brewing characteristics in order to make suggestions for their qualitiesimprovement.

Material and methods

Collection of raw material

White and red of sorghum grains were purchased from local markets in Glazoué (center of Benin). *Farafara* variety was obtained from Benin Brewery Company (SBB) based in Djeregbe, municipality of Seme podji (South Benin). This company exports it from Nigeria to produce sorghum beer.

Malting

Sorghum grains were steeped in water and dirt composed of weed seeds, dust and other were removed after floating to the water surface. After soaking for 12 to 24 h at the room temperature, grains were drained and left in baskets for 10 to 12 h in order to allow shoots initiation (*pregermination*). Then, there were spread out in thin layer (3-5 cm thickness), covered and germinated during 72 h. From time to time, grains were watered. The germinated grains were dried in a forced-air oven at 50°C for 24 h. The dried malt was cleaned and the roots and shoots were removed by winnowing. The malt manufacturing process is described by figure-1.

Physico-chemical characterization of sorghum grain and malt

For average size of sorghum grains determination, ten (10) grains of each sample were counted and the length, the width, and the thickness were measured using calipers. The grain size was the average of ten (10) measurements.

Moisture content of samples was determined by desiccation using the method of De Knegt and Brink (1998). A clean platinum dish was dried in an oven and cooled in a desiccator and weighed. From each sample, 5 g was weighed and spread on the dish, the dish containing the sample was weighed. It was then transferred into the air oven at 105°C to dry until a constant weight was obtained and the loss in mass was determined.

The thousand kernel weight (W) was determined using the AACC (1984)method. Hundred (100) sorghum grains were counted and weighed. The operation was repeated in quadruplet. The average weight was obtained by averaging the four weighing. The calculated average mass moisture basis (MH) was then brought back to the dry basis (DM).

Calculation:

$$W = \frac{100 \times MH \times 10}{DM}$$

Germination activity was determinedas described by Ballogou *et al.,* (2011). 50 seeds of samples in open Petri dishes lined with Whatman no. 4 filter paper, Water (4 ml) was added, and the dishes were placed in incubator at 28°C. Seeds that developed roots and shoots were counted after 72 h and the percentage was recorded.

The granulometry of the crushed malt samples using corn and hammer mill was determined by sievingas reported by Canales, (1979). One hundred (100) grams of crushed malt were sieved through a sieve granulometer through six meshes increasing from bottom to top: 0.18 mm, 0.3 mm, 0.6 mm, 1.18 mm, 2.5 mm, and 3.15 mm for 5 minutes. Sieves were disassembled one by one after sieving. Groats retained by different meshes were weighed and their percentages were deducted. The retentate masses by different meshes have been classified into four categories as summarized in Table 1.

The total sugar was determined according to phenol sulfuric acid method (Dubois *et al., 1965*). A standard curve was obtained using the following concentration of sucrose in (mg/ml) 2.5 2.0, 1.25, 1.0, 0.5 g of each sample with 9 ml of distillated water was measured into test-tube. 2 ml of phenol solution (1%) and 1 ml of H_2SO4 (98.07%) solution were added. This was shaken for 15 min and boiled at 100°C for 30 min. It was then allowed to cool and absorbance was read using spectrophotometer (spectrum lab 22) at 700 nm. The sugar concentration was then obtained by extrapolation from the standard curve.

Protein was analyzed by the Microkjedhal nitrogen method, using a conversion factor of 6.25.Ash was determined according to the standard methods described by the Association of Official Analytical Chemists (AOAC, 1990).The loss in mass was determined after calciationinto the furnace at 550°C during 24H.

Total oxalate was determined as described by Day and Underwood (1986). 1 g of sample was weighed into 100 ml conical flask. 75 ml H2SO4 (3 mol/L) was added and stirred for 1 h with a magnetic stirrer. This was filtered using a Whatman No 1 filter paper. 25 ml of the filtrate was then taken and titrated while hot against 0.05 mol/L of KMnO4 solution until a faint pink colour persisted for at least 30 s. The oxalate content was then calculated by taking 1 ml of 0.05

mol/L of $KMnO_4$ as equivalent to 2.2 mg oxalate (Ihekoronye and Ngoddy, 1985; Chinma and Igyor, 2007).

The total polyphenol content was determined byFolin-Ciocalteu method (Singleton *et al.*, 1999). 0,1g of sample was diluted with 20 ml of distilled water and filtered using a Whatman paper. This solution (0.5 ml) was then mixed with 2.5 ml of Folin-Ciocalteu reagent (0.2 N)for 5 min and 2 ml of sodium carbonate (75 g / l) was then added. The tubes were then allowed to stand at room temperature for 120 min before absorbance at 760 nm was measured against methanol.The concentration of polyphenols in samples was derived from a standard curve of gallic acid ranging from 10 to 50 μg/mL.

Statistical analysis

Results from these studies were analyzed using statistical Analysis Software (SAS) and SYSTAT 5.05. The statistical analyses carried out were mean, standard deviation and analysis of variance (ANOVA) (Alder and Roessler, 1977; Ogbeibu, 2005).

Results

Physical characteristics of sorghum grain

Average size of sorghum grain

Figure 2 showed that the white sorghum variety is slightly thicker than the red sorghum variety. These appreciations were validated for the length and the width. So there is uniformity between sorghum grain varieties.

Table 1. Assessment grid of the size.

Retentate	Gradient (mm)
Sieve Refusal	T>3.15
Groats	2.5 < T < 3.15
Means groats	0.6 < T <2.5
Groats flour	T< 0.6

Physico-chemical profile of sorghum grains

The physico-chemical characteristics associated with acceptance testing and brewing potentialities allowed to assess the results presented in table 2.The moisture content of white and red varieties samples were respectively 10.56% and 9.85%.In addition, thousand kernel weight of used sorghum samples were respectively 34.66g and 31.79g. Finally, the germination rate was higher for the white variety sample (97.66%) than some of the red one (75.33%).

Physicochemical characteristics of sorghum malt granulometry

Particle size analysis has allowed the evaluating of the crushing of Beninese sorghum malt samples compared to the *farafara* variety imported from Nigeria.

Table 2. Physicochemical characteristics of sorghum grain.

Samples	Dry matter (%)	Moisture content (%)	Thousand kernel weight(g)	Germination rate (%)
White variety	89.44 ± 0.21a	10.56 ± 0.21a	34.66 ±0.33a	97.66 ± 1.2a
Red variety	90.15 ±0.20b	9.85± 0.20 b	31.79 ±0.35b	75.33 ± 1.5b

Values are mean ± SD (n=3). Means with the same letters in the same column are not significantly different ((p<5%).

The analysis of Table 3 showed that groats and means groats were more represented respectively in maize and hammer mill. However, for fractions coming from the maize mill, 18.2% of *farafara* variety malt was outside acceptable grits for brewing than 21.0 % for white variety sorghum malt and 13.4 % for some of the red variety. These grains were either whole or partially crushed. This rejection percentage was significantly improved by crushing with the hammer mill with respective values of refusal of 2.7%, 2.4% and 1.0% for white, red and *farafara* varieties.

Physicochemical characteristics

Table 4 showed that the red variety malt presented the highest (2.23%) total sugar rate; followed by *farafara* variety malt (2.20%) and the white variety malt (2.10%). So there is a significant difference at 5% between the three samples (P = 0.001 and F = 145.686). Ash contents were respectively 1.40 and 1.42 for Benin white and red sorghum malt while it was 1.25 for *farafara* variety. Moreover, protein content of white and red variety samples and *farafara* variety were respectively 9.75%, 12.28% and 10.29%.The red sorghum malt showed more phenolic compounds (1.775 g/100 g of dry matter (DM)) than the white and *farafara* variety which were respectively 0.497 and 0.768 g/100 g DM. By cons, white sorghum malt showed the highest oxalate content (1,399/100 g DM) against 1.320 g/100 DM for red sorghum malt and 0.337 g/100g DM for *farafara* variety.

Table 3. Influence of type of mill on granulometry of crushed malt.

Gradient (mm)	GroatsPercentage (%)					
	Maize mill			Hammer mill		
	White variety	Red variety	Farafara variety	White variety	Red variety	Farafara variety
T> 3.15	21.0±2.0	13.4±2.0	18.2±2.0	02.7±0.1	02.4±0.0	01.0±0.0
2.5 < T < 3.15	43.8±8.0	53.0±7.0	47.8±8.0	03.5±0.1	5.1±8.0	08.8±2.0
0.6< T <2.5	09.9±1.0	10.2±1.0	10.7±1.0	77.7±9.0	72.4±8.0	78.7±8.0
0.3< T < 0.6	25.2±3.0	23.3±3.0	24.1±2.0	14.8±1.0	19.2±2.0	12.3±1.5
0.18< T<0.3	-	-	-	-	-	-
T <0.18	-	-	-	-	-	-

-: Traces.

Discussion

The results of average size of sorghum grain were in accordance with the sorghum grain morphological characteristics reported by House (1987) stating that the length should be between 3.5 and 5 mm and the width between 2.5 and 4.5 mm. Also, thousand kernel weightwere in the limit (25-35 g) as reported by Serna-saldivar and Rooney (1995). Moisture content of sorghum grain samples was less than 13%, which is the maximum moisture content recommended for storage of cereals (Desobgo*et al.*, 2013). This relatively low water content could be explained by drying operations made by the vendor during storage of sorghum for sale. These low values of moisture content allowed expecting a long time for sorghum grains conservation. The Benin red variety germination rate was relatively low. The non-germination of some grains may be due to several parameters among which we could mention the non dormancy, the presence of weevils in the grain or the destruction of grain threshing. Statistical analysis revealed that there were significant difference between white and red samples for moisture content, thousand grain weight and germination rate (p<5%).High germination rate allows more enzymes which increase sugar production. So we could expect that Benin sorghum varieties could be suitable for malting and the quality of the extract obtained after mixing them could be substantial. However, investigations that can highlight the diastatic power of these varieties should be done to confirm our results.

Crushing test showed that rejection and groats flour percentage was significantly high for corn mill.It could therefore be deduce that thismill (used for the production of maize flour) could not be suitable for crushing malt. Indeed, the corn mill produced important part of sieve refusal and groats flour amount which may be the cause of poor extraction of sugars during brewing. This could justify the relatively low alcohol content of African traditional beers because alcohol production done by yeast that degrades the sweet substrate that is the wort. A low content of fermentable sugars in wort therefore inevitably bring low alcohol production at the end of fermentation. According to Canales (1979), a good grinding must contain no more that1.5% of particles having a size below 0.253 mm but no greater than 3 mm diameter. Also, we have noted a high proportion of flour groats generated by the various mills.

Table 4. Physico-chemical profile of sorghum malts.

Samples	Sugar rate (%)	Ash content (%)	Protein content (%)	Phenolics content (g/100g DM)	Oxalate content (g/100 g DM)
White variety	2.10±0.1a	1.40± 0.03 a	9.70± 0.7 b	0.49± 0.01c	1.39 ± 0.06a
Red variety	2.23±0.1b	1.42 ± 0.04 a	12.21± 0.1 a	1.77± 0.02a	1.32 ± 0.08c
Farafara variety	2.20±0.2c	1.25 ± 0.02 b	10.29± 0.00b	0.76± 0.02b	0.33 ± 0.01b

Values are mean ±SD (n=3). Means with the same letters in the same column are not significantly different ((p<5%).

Sugar content values were lower than those reported by Chevassus-Agnes *et al.* (1979), which was 3.7 g/100g of dry matter of sorghum malt for sorghum beer "amgba" (Cameroon) production and that obtained by Trust *et al.* (1995) . This could be explained by the difference in used sorghum varieties and malting conditions.Several others parameters may explain the low sugar content of sorghum grains. Apart from the quality of used groats for brewing (as mentioned above), diastatic power of different varieties could also be the basis of a low sugar production during malting. Indeed during germination, enzymes (α and β -amylase) produced in the germ spread in the grain endosperm (Dirar, 1993), and degrade starch to mono and disaccharides (Hulse *et al.*, 1980).

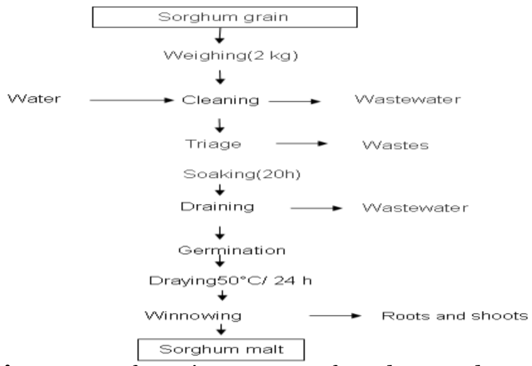

Fig. 1. Manufacturing process of sorghum malt.

The ash contents of Beninese sorghum malt samples were higher than this of imported sorghum malt from Nigeria. However, values were lower than those obtained by, Maoura and Pourquie (2009) on sorghum malt produced for bilibili production in Chad, which was 1.7%. This difference could be explained by the decrease in ash content during soaking. Indeed, minerals, particularly the thin film of dirt and dust that usually covers the grains were dissolved or entrained by this operation (Chevassus-Agnes *et al.*, 1979). Several other parameters as the variety, the type of soil etc. could also explain the observed variabilities.

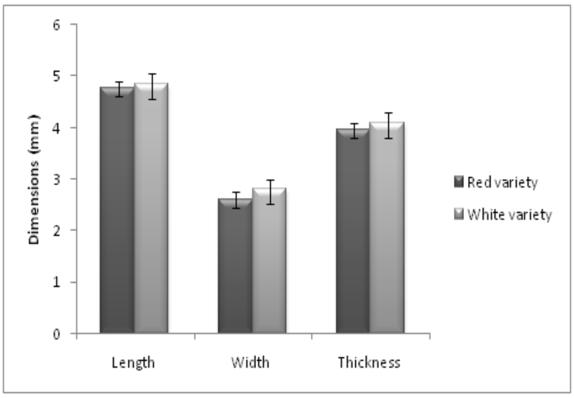

Fig. 2. Average size of sorghum grains.

Protein values were in accordance with Codex Alimentarus standards (Codex Stan, 1989). for sorghum malt which indicate that a the minimum protein content of sorghum malt is 7% and approximate the results obtained (11.4% and 9,8%) respectively by Ballogoun *et al.* (2011) and Lyumugabe *et al.* (2012) for tchakpalo (Benin) and amgba (Cameroon) production.

Polyphenols and oxalate content values were higher than those obtained by Khady *et al.* (2010) on two varieties of sorghum (CE 180-33 and CE 145-66) which were 0.57 ± 0.01 and 0.56 ± 0.03 respectively. Some varieties of white sorghum among the 50 studied by Dicko *et al.* (2002) had similar polyphenols contents to obtained values in our survey.Polyphenols play an important agricultural role in sorghum grain. They could protect the plant against attack by birds, pathogenic fungi, insects and parasitic weeds (Beta *et al.*, 2000). Harris and Burns (1970) found that the presence of polyphenols in the seeds also prevents losses due to premature germination and damage from mold. There is also a potential to produce a significant impact on human health (Awika and Rooney, 2004) However, these anti-nutritional factors (oxalates and polyphenols) can complex certain nutrients (proteins, mineral salts ...) and make them non bio available for human consumption.

Malt determines the taste and quality of tchakpalo. The brewing value of malt is mainly determined by its diastatic power and water-soluble extract. Biochemical characterization of Beninese sorghum malt samples that can highlight their diastatic power could be very interesting for the future.

Conclusion

This survey underlined the brewing and nutritional potentiality of sorghum malt from two varieties used for *tchakpalo* production in Benin. According to results obtained, the physico-chemical characteristic of malts from white and red sorghum varieties of Benin were similar to those obtained with *Farafara* variety from Nigeria. The maize mill used by the producers doesn't generate wheat flours suitable for good extraction. It is therefore important for the scientific research to finalize a model of crusher adapted to the crushing of sorghum malt. Further studies may be done to investigate their diastatic power.

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